ROYAL AIR FORCE YEARBOOK 1980

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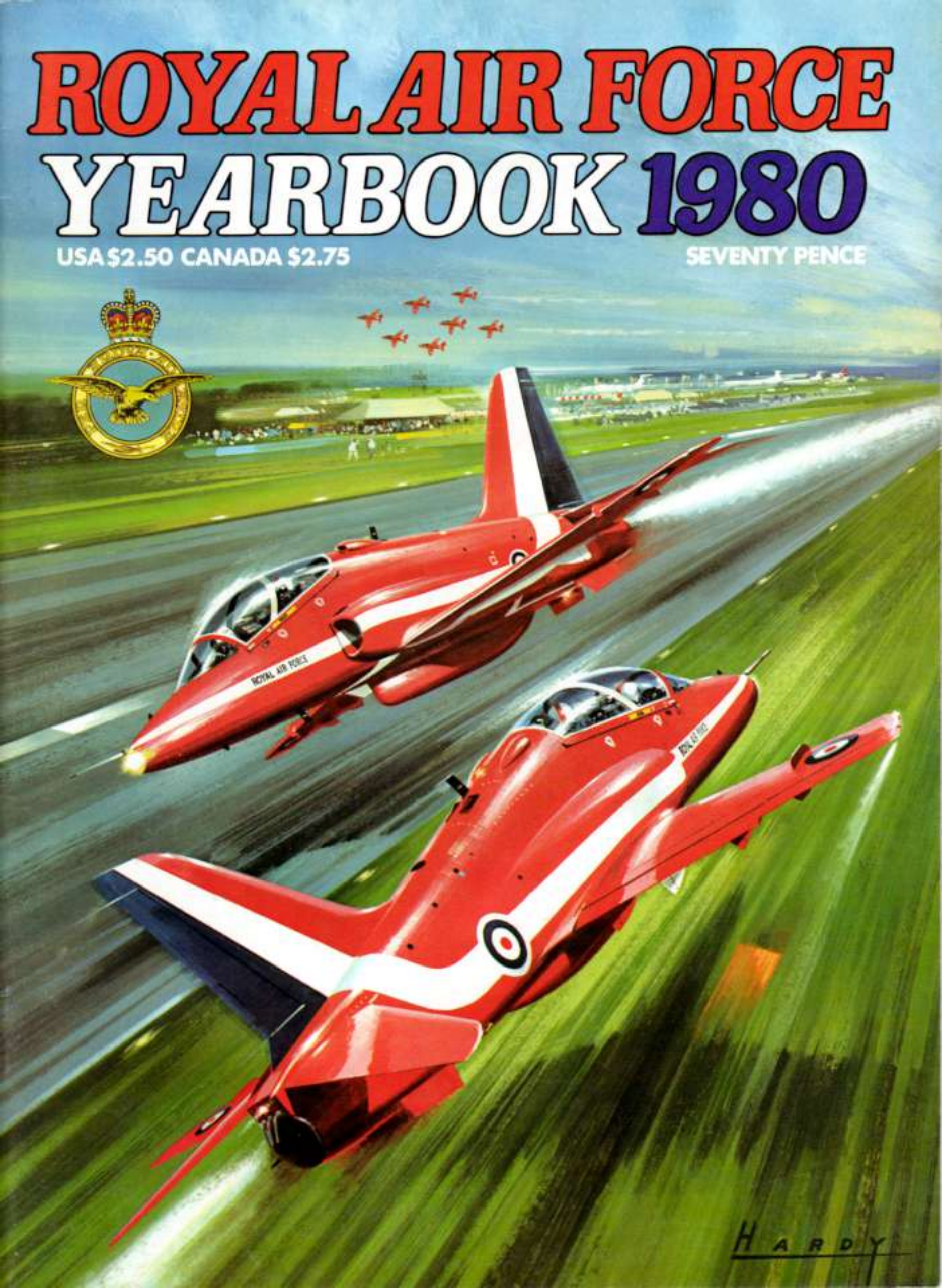

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ROYAL AIR FORCE YEARBOOK 1980

INTRODUCTION

by the Chief of the Air Staff, Air Chief Marshal Sir Michael Beetham GCB, CBE, DFC, AFC, ADC

THE Royal Air Force enters the 1980s with a major re-equipment programme. Tornado enters service in the bomber version this summer at RAF Cottesmore, home of the new Tri-National Tornado Training Establishment. Meanwhile the fighter version, Tornado F Mk 2 — which will be the backbone of our future air defence system for the mid '80s — is now well into its development flying programme.

In this issue of the Yearbook you can read of the many other changes we have in train for the RAF's front line. Underpinning the strength of that front line, as always, is our training system, now considerably strengthened in terms of both manpower and new equipment, prominent among it being the new Hawk advanced trainer. The RAF, in common with its sister-Services, suffered an outflow of experienced people in 1977 and 1978, and although this period is now behind us, we have increased the throughput of the training system to make good the shortages which occurred as a result. Both in terms of personal opportunity and of value to the nation, therefore, there could be few better times for young men and women of determination and spirit to join the Royal Air Force. That many have seen this for themselves was reflected in a most satisfying recruiting year in 1979. May it continue so.

Given the right equipment and the right people, the other essential component of an operational force is its level of expertise — its readiness and its effectiveness. The end products are demonstrated even in peace in such diverse ways as the almost daily interception of unidentified aircraft many miles from our shores, the airlift and resupply of our monitoring force in Rhodesia, or in search and rescue missions around our coast. To achieve the standards we require in every rôle means constant practice — and in few tasks more than low flying. This remains one of the keys to penetration of hostile airspace, and therefore contributes directly to a credible deterrence. In a crowded island this low flying training inevitably causes some noise nuisance and we are grateful for the support and understanding we receive from the nation at large whom we exist to serve.

To enable you to see more of our work, I draw your attention to this year's Battle of Britain "At Home" days, at RAF Abingdon on 13 September, and at RAF Coltishall and RAF Finningley on 20 September. At these and at the other displays and open days around Britain, we shall be demonstrating as much as possible of the activities and equipment of the Royal Air Force.

Michael Beetham

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The views expressed in RAF Yearbook 1980 are those of the authors alone and should not be taken as an expression of official policy.

RAF YEARBOOK 1980

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THE RAF LOOKS AHEAD

BY JOHN FRICKER

TIME-SCALES of combat aircraft have changed. In less than six years of World War II, their operational deployment spanned the era from biplanes to the first jets. Since then, however, the useful lives of combat aircraft before reaching complete obsolescence has become considerably longer. The Canberra, for example, has already been in RAF service for 29 years, since 1951, and is forecast to be around for some considerable time to come — perhaps even to AD 2000. It is still first-line equipment in many air forces, a situation that on a similar timescale would be like the Sopwith Camel remaining operational in 1944.

It is a salutary thought, therefore, that the combat aircraft to emerge from current RAF planning can be expected still to be in operational service in the year 2010 and beyond. Despite this futuristic prospect, however, no spectacular increases in performance are currently foreseen. In fact, the current generation of fighters, as represented by the GD F-16, are somewhat slower than many of their predecessors, being limited to less than Mach 2 by their fixed intake geometry and the fuel consumption characteristics of their engines. But if aircraft speeds and heights have reached something of a plateau, major advances are imminent in structural materials, making aircraft lighter and more fatigue resistant, and in sensor and nav/attack systems, particularly for night and all-weather operation, and related areas of weapon development. The emphasis on performance has correspondingly shifted away from pure speed, at around Mach 2, towards extremes of manoeuvrability (now more often referred to as agility), active control technology, and acceleration.

After substantial decreases in procurement, because of greater unit costs and improved potency, the number of combat aircraft required by the world's air forces also seems to be stabilising. There appears to be a cross-over point below which no amount of quality will compensate for the weight of numbers. In the case of the RAF, the Air Staff intention is at least to maintain the present aircraft inventory — totalling almost 1800 in 1979, including about 650 first-line types in 40 or so squadrons — while improving their capabilities. About 430 of the first-line types have some weapons capability, and this number of aircraft is not expected to change significantly over the next few years, apart from the planned increase in the UK air defence force.

Similarly, no major change in RAF rôles is foreseen before the end of the century, with NATO commitments still the main basis of government policies. The RAF is the only air force within NATO to commit units to all of the latter's commands, including the ACE mobile force, as well as the Channel and Atlantic elements, and it has not abandoned any of its major rôles despite successive and stringent defence reviews which inevitably resulted in considerable contraction.

Long-range strike-reconnaissance

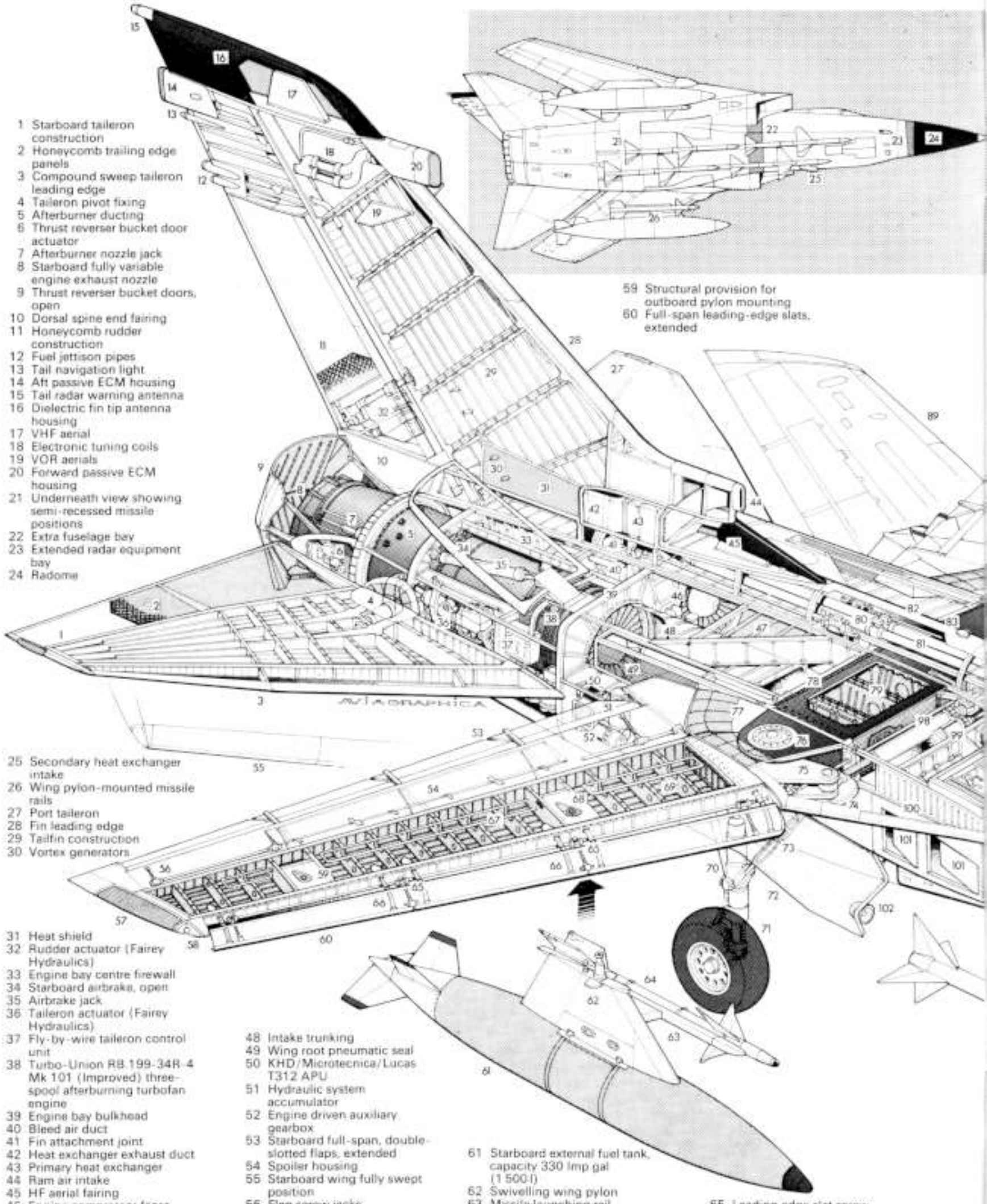
The RAF, of course, has not had a strategic nuclear rôle since UK deterrent delivery was taken over by the RN's Polaris submarine fleet, but its force of seven Vulcan squadrons now comprises, apart from one unit (No 27 Sqn) committed to maritime radar reconnaissance, a purely long-range theatre nuclear system for deep-penetration attacks at low level against targets supporting the land battle. The survivability of the Vulcan in this rôle is obviously becoming questionable, although, with the F-111, it is still the only aircraft available to SACEUR with full blind-bombing and all-weather capabilities. Re-equipment of the six strike squadrons of Vulcans at Waddington and Scampton is scheduled from 1982 onwards with the first of the 220 Tornado GR Mk 1 IDS (interdictor/strike) aircraft to be ordered for the RAF through Air Staff Requirement 392. Marham and Honington have recently been named as the first two bases to receive Tornado IDS operational squadrons.

Replacement of both the Vulcan and the Buccaneer strike aircraft currently equipping a further five squadrons, including two (Nos 12 and 216) with NATO anti-shipping strike/attack rôles, will be on a one-for-one basis and should be completed by 1986. The Tornado will also offer extra flexibility in having dual nuclear strike/conventional attack capabilities, in contrast with the Vulcan's current restriction, in the NATO context, to purely nuclear rôles. The two anti-shipping squadrons, which are to move from Honington to Lossiemouth, will maintain their assignment to SACLANT after replacing their Buccaneers with Tornadoes.

During the 'eighties, the maritime reconnaissance Vulcans (No 27 Sqn) and all but a handful of Strike Command's Canberra PR force (Nos 13 and 39 Sqns at RAF Wyton with PR Mk 7s and PR Mk 9s) will vanish from the front line. Their rôles may, in part, be taken over by Nimrod maritime and AEW aircraft and by Tornadoes suitably modified for reconnaissance.

(Heading photo) The first production model Tornado GR Mk 1. Present plans call for the RAF to receive 220 of these interdictor/strike aircraft (including 68 with dual control for operational conversion and continuation training) to replace the Buccaneers, Vulcans and Canberras in operational rôles. (Below) Six squadrons fly the Vulcan B Mk 2, including No 35, one of whose aircraft is seen here during its participation in the 1979 Red Flag combat exercises with the USAF in Nevada.

Panavia Tornado F Mk 2 Cutaway Drawing Key



1 Starboard taileron construction
2 Honeycomb trailing edge panels
3 Compound sweep taileron leading edge
4 Taileron pivot fixing
5 Afterburner ducting
6 Thrust reverser bucket door actuator
7 Afterburner nozzle jack
8 Starboard fully variable engine exhaust nozzle
9 Thrust reverser bucket doors, open
10 Dorsal spine end fairing
11 Honeycomb rudder construction
12 Fuel jettison pipes
13 Tail navigation light
14 Aft passive ECM housing
15 Tail radar warning antenna
16 Dielectric fin tip antenna housing
17 VHF aerial
18 Electronic tuning coils
19 VOR aerials
20 Forward passive ECM housing
21 Underneath view showing semi-recessed missile positions
22 Extra fuselage bay
23 Extended radar equipment bay
24 Radome
25 Secondary heat exchanger intake
26 Wing pylon-mounted missile rails
27 Port taileron
28 Fin leading edge
29 Tailfin construction
30 Vortex generators
31 Heat shield
32 Rudder actuator (Fairey Hydraulics)
33 Engine bay centre firewall
34 Starboard airbrake, open
35 Airbrake jack
36 Taileron actuator (Fairey Hydraulics)
37 Fly-by-wire taileron control unit
38 Turbo-Union RB.199-34R-4 Mk 101 (Improved) three-spool afterburning turbofan engine
39 Engine bay bulkhead
40 Bleed air duct
41 Fin attachment joint
42 Heat exchanger exhaust duct
43 Primary heat exchanger
44 Ram air intake
45 HF aerial fairing
46 Engine compressor faces
47 Rear fuselage bag-type fuel tank
48 Intake trunking
49 Wing root pneumatic seal
50 KHD/Microtecnica/Lucas T312 APU
51 Hydraulic system accumulator
52 Engine driven auxiliary gearbox
53 Starboard full-span, double-slotted flaps, extended
54 Spoiler housing
55 Starboard wing fully swept position
56 Flap screw jacks
57 Wing tip antenna
58 Starboard navigation light
59 Structural provision for outboard pylon mounting
60 Full-span leading-edge slats, extended
61 Starboard external fuel tank, capacity 330 Imp gal (1 500 l)
62 Swivelling wing pylon
63 Missile launching rail
64 AIM-9L Sidewinder air-to-air missile
65 Leading edge slat screw jacks
66 Slat rails

In addition to the Tornado GR Mk 1s (see previous page), the RAF is to receive 165 of the F Mk 2 air defence variant, the prototype of which is seen above. As the photograph and cutaway drawing show, the Tornado F Mk 2 has a longer fuselage, longer nose radome, revised weapons system and other changes.

67 Wing torsion box construction
68 Swivelling pylon mounting
69 Starboard wing integral fuel tank
70 Main undercarriage leg strut
71 Starboard mainwheel
72 Mainwheel door
73 Undercarriage breaker strut
74 Wing pivot sealing fairing
75 Sweep actuator attachment horn
76 Starboard wing pivot bearing
77 Flexible wing seals
78 Wing pivot carry-through, (electron beam welded titanium box construction)
79 Wing pivot box integral fuel tank
80 Pitch and roll control non-linear gearing mechanism
81 Air conditioning supply ducting
82 Dorsal spine fairing
83 Anti-collision light
84 UHF aerials
85 Port wing pivot bearing
86 Flexible trailing edge seals
87 Spoiler actuators (Fairey Hydraulics)

88 Port spoilers
89 Port wing fully swept position
90 Full span double-slotted flaps, extended
91 Wing tip antenna
92 Port navigation light
93 Full span leading-edge slats, extended
94 Port wing integral fuel tank
95 Pylon swivelling linkage

96 Port wing sweep actuator
97 Wing flap and leading edge slat drive motors
98 Starboard wing sweep actuator (Microtecnica)
99 Hydraulic drive motor and gearbox
100 Extended wing root glove fairing
101 Supplementary "blow-in" intake doors
102 Landing/taxying lamp
103 Starboard fully variable engine air intake
104 Formation light

105 Variable intake ramps
106 Ramp hydraulic jacks
107 Bleed air exit louvres
108 Automatic intake control system (Nord-Micro)
109 Enlarged forward fuselage bag-type fuel tank (Uniroyal)
110 Cockpit canopy pivot
111 Air conditioning plant (Normalair-Garrett)
112 Port intake bleed air outlet fairing
113 AIM-9L Sidewinder air-to-air missile
114 Port external fuel tank, capacity 330 Imp gal (1 500 l)
115 Intake lip
116 Navigator's cockpit enclosure
117 Navigator's ejection seat (Martin-Baker Mk 10A "zero-zero" seats)
118 Canopy jack strut
119 Cockpit rear pressure bulkhead
120 Engine air intake curved inboard sidewall
121 Missile system electronics
122 BAe Skyflash air-to-air missile

123 Ventral, semi-recessed missile housing
124 Cannon ammunition box
125 Navigator's side console panel
126 Canopy arch
127 Navigator's instrument panel
128 One-piece cockpit canopy cover (Kopperschmidt)
129 Pilot's ejection seat
130 Side console panel
131 Ammunition feed chute
132 Mauser 27-mm cannon
133 Instrument pressure sensor
134 Cannon barrel
135 Radome open position
136 Nosewheel leg strut
137 Twin nosewheels
138 Nosewheel doors
139 Cannon muzzle blast tube
140 Control and Stability Augmentation system (CSAS) equipment bay
141 Control column
142 Instrument panel shroud
143 Pilot's head-up display (Smiths)
144 Windscreen panels (Lucas Aerospace)
145 Windscreen rain dispersal duct
146 Cockpit front pressure bulkhead
147 Avionics bay, communications and navigation equipment
148 Angle of attack probe
149 IFF aerial
150 In-flight refuelling probe, extended
151 Marconi-Elliot *Foxhunter* airborne interception radar
152 Scanner tracking mechanism
153 Cassegrain radar antenna
154 Radar unit hinged to starboard for access to Line Replaceable Units (LRUs)
155 Extended radome
156 Pitot tube

Representative aircraft from the RAF's five Jaguar squadrons in Germany are seen together in this unique photograph. Nearest the camera is a Jaguar GR Mk 1 from No 2 Squadron carrying a recce pod; other squadrons represented are Nos 14, 17, 20 and 31. The possibility of developing an aircraft to replace the RAF's Jaguars and to meet Luftwaffe *and* Armée de l'Air *requirements for a new combat aircraft was under discussion during 1980.*

The RAF is very much alive to the startling possibilities becoming apparent in sensor development, although research funding in this country is necessarily limited. Infra-red sensors could be particularly fruitful in improving all-weather attack capabilities, to which a number of Air Staff Targets are directed, although UK experience in the field of electro-optics has a relatively short history. Radar also presents some interesting development prospects in such areas as synthetic aperture radars and, over the longer-term, possible millimetric wavelengths. Within its financial limitations, the RAF will continue to encourage exploration of the entire electromagnetic spectrum, from lasers to long-wave radio surface propagation, although it is well aware that some apparently-promising leads could turn out to be expensive blind alleys.

Tactical aircraft plans

Much thought has been devoted by the RAF over the past few years to the replacement of its Harrier and Jaguar tactical fighters in the 1990s, for which the well-known Air Staff Target (AST) 403 was evolved. Ideally this would have resulted in procurement of a single type with both supersonic and V/STOL characteristics, but it has become increasingly apparent that current technology does not permit a cost-effective combination of these qualities. RAF experience of V/STOL operations with the Harrier has convinced the Air Staff of the value of its combat flexibility, particularly in not being tied to vulnerable long runways, but an aircraft with high performance in the air is also going to be essential for the 1990s. So AST 403 has been retained as a short field aircraft with excellent transonic performance, and a decision made to separate the Harrier replacement requirements to achieve the full range of desired capabilities.

Current RAF plans are therefore to confine AST 403 solely to produce a Jaguar successor, whilst defining a new programme, known as Air Staff Requirement 409, devoted to updating and improving the existing Harrier design. In passing, it may be mentioned that the differences between Air Staff Targets and Requirements appear to be relatively slight. An AST starts as a broad statement of need, to act as a discussion document, and its refinement by subsequent studies eventually changes it to a firm requirement in an ASR.

Since Britain is naturally keen to develop new combat aircraft in collaboration with her European partners, the rationalisation of AST 403 as a straight Jaguar replacement has enabled the UK to align its tactical aircraft requirements more closely with those for the TKF-90 in Germany and the ACT-92 in France, for which successful Air Staff talks have already led to collective industrial studies. At the moment, however, many difficulties remain to be resolved before anything approaching a common design seems likely to emerge.

Whereas the TKF-90 specification will be aimed at producing an air superiority replacement for the *Luftwaffe*'s McDonnell Douglas F-4F Phantoms in the mid-1990s, both the RAF and the French Air Force have a different primary mission in mind for their aircraft, which will be optimised for low-level penetration. A good gust response for these conditions makes for poor high-altitude interception capabilities, although the RAF recognises that its offensive support aircraft will need to have an air combat potential to survive among the hordes of red-starred fighters in the Central Region of Europe. This potential could also be useful in the air defence battle, so that AST 403 will be looking for rôle flexibility to improve its cost-effectiveness.

Basically, for ground attack, its cruise and penetration speed performance will be similar to that of the Jaguar although payload will be handsomely improved. For air combat it will need to be highly agile, and its overall capabilities will be substantially enhanced from improved systems, range and air-to-air weapons. Field requirement will be considerably less than the Jaguar's, with a good off-airfield and short strip capability. The RAF insists on balancing take-off and landing field requirements, although limiting the latter is more difficult to achieve. Experience with operation of the Jaguar from stretches of motorway have shown that this is a viable option, but the use of very short and narrow landing surfaces may be less attractive. Carrier-type approach training is needed by the pilot, using some sort of visual landing aid or glide-path indicator. While low approach speeds are desirable, they accentuate the effects of cross-winds, so that road width eventually becomes the limiting factor.

Meanwhile, pending their planned replacement by about the end of the decade, the 165 or so Jaguars in the current RAF inventory, including two-seat trainers, will undergo modest updating improvements directed mainly towards extending their attack capabilities. Improvements will therefore mostly concern the Jaguar's nav/attack systems, although the RAF is also interested in extending capability beyond the normal hours of daylight and visual limitations.

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Air-to-air refuelling plays a vital rôle in RAF planning, especially in respect of the air defence of the UK. The only tanker currently in service is the Victor K Mk 2, an example of which is seen here refuelling the first prototype Tornado F Mk 2 and the last of the pre-production batch of Tornado GR Mk 1s. Starting in 1982, the RAF will receive five VC10K Mk 2s and four VC10K Mk 3s to form a third AAR squadron.

Defensive air-to-air missiles are also a possible requirement, and the Jaguar powerplant, the Adour Dash 26 engine, will continue to be developed and improved. A start on the systems updating programme, not connected with BAe Warton's long term research work on the Super Jaguar project, has already been made with the recent award to Ferranti of a contract for application of its FIN 1064 Digital Inertial Navigation and Weapon Aiming Equipment to replace major elements of the present NAVWASS equipment in the RAF Jaguars. Included in the contract is an option for over 200 production systems for Jaguar retrofitting.

Harrier improvement programme

Whereas the Jaguar is scheduled for replacement in the 1990s by the aircraft developed to AST 403, the Harrier is currently planned to continue in RAF service through a mid-life improvement programme which is expected to take it to the end of this century, pending the attainment of supersonic V/STOL technology. Both the Improved Harrier and the AST 403 Jaguar follow-on will then become successively due for replacement by a completely new tactical fighter combining supersonic speed performance with short take-off and vertical landing (STOVL) capabilities. The same aircraft might also serve as a Sea Harrier replacement, with even wider export prospects.

The ASR 409 programme for the Improved Harrier has been based on preliminary studies undertaken by BAe Kingston/Dunsfold since 1975 to rectify the current limitations of this pioneer V/STOL design imposed by its high wing loading and lack of defensive capability through the absence of air-to-air missile pylons. These studies have been directed towards attainment of high subsonic speed performance, together with improved range, payload and manoeuvrability, and have concentrated on a new and larger wing with a relatively thick section which also provides additional fuel capacity and pylon space. To minimise cost and design changes, the aim was that the wing should be capable of retrofitting to the RAF's existing Harriers with minimum modifications. However, this has proven difficult to achieve so that this particular improvement is likely to be limited to new build aircraft, similar in many respects to the AV-8B aircraft developed by McDonnell Douglas. The possibility of a joint Anglo-US development and production of the Harrier is therefore currently being studied as an alternative to an all-British programme.

Both the AV-8B and the BAe big-wing Harrier make use of a new wing that incorporates supercritical technology involving a very much thicker section. Combined with increased span, this wing offers a major increase in internal fuel capacity, of the order of 245 Imp gal (1 114 l), and its thicker cross-section also reduces structural weight penalty. Extra span allows the installation of two additional weapons pylons and — although four of the new total of six wing pylons would be plumbed for long range tanks — the extra internal fuel capacity means that on many missions much greater offensive loads can be carried. The extra (outboard) pylons provide for the carriage of the required AIM-9L Advanced Sidewinder AAMs, and in designing a new wing both McDonnell Douglas (on the AV-8B) and BAe have moved the undercarriage outrigger legs inboard, to improve operational capability from narrow roads. Leading-edge strakes (LERX), researched at Kingston, might also be applied to a new wing which, with improved single-slotted flaps of increased span, could offer better STO performance, even with additional missiles, and an increase in manoeuvring lift by up to 50 per cent at typical operating speeds.

Apart from the addition of wiring and controls for the outboard pylons, fuselage modifications for the new-build Improved Harrier — sometimes referred to as the Mk 5 — to accommodate the new wing mainly involve the provision of new wing fairings and engine access doors, and a raised cockpit similar to that of the Sea Harrier, which offers extra room as well as greatly improved combat visibility. Other main changes are confined to a retractable dam across the gap between the forward gun pods to minimise re-circulatory losses at the hover, and to allow VTO at maximum hovering weights.

Extending the Harrier's planned service life by at least a further 10 years through the mid-life improvement programme will mean additional procurement to maintain squadron strength against attrition, plus training and reserve requirements. With the necessary surplus for engineering programmes, the procurement of Improved Harriers may reach as many as 60 new aircraft for the RAF, which would allow one or more additional V/STOL squadrons to be formed to meet Britain's tactical commitments to NATO.

In addition, a similar number of existing aircraft will remain available to be retrofitted with a range of other improvements. These will include updating the nav/attack system and further development

Among the overseas deployments of RAF units during 1979/80 was the provision of a number of Puma helicopters and Hercules transports to support the ground forces monitoring the cease-fire and general election in Zimbabwe. One aircraft of each type is seen here over the Rhodesian countryside, bearing the white cross identity markings of the monitoring force.

of the Pegasus Mk 103 engine which, in a new-build aircraft, will be complemented by improving intake efficiency, while provision might also be made to improve VIFF (vectoring in forward flight) for a further transformation of the Improved Harrier's agility.

New weapons and prospects

Associated with the plans for the RAF's new tactical fighters is a new generation of advanced conventional weapons, which received brief mention in the UK Defence White Paper published during 1979. Collaboration is already being achieved between the UK and the US for priority development of the JP 233 advanced airfield attack weapon, which is understood to be extremely radical and to comprise special anti-runway heads, combined with the distribution of small delayed-action anti-personnel bombs from the rear part of the store, to be scattered around the crater and complicate its repair. JP 233 is being developed primarily for use by the RAF Tornadoes and USAF F-111s, but will also be suitable for launching from other types.

Studies are also continuing, according to the White Paper, into a range of defence suppression weapons under AST 1228, although these are believed to be at a relatively early stage, and of the ASR 1227 anti-armour area weapon. AST 1228 will apparently be designed to home on to hostile radar sites, while ASR 1227 will dispense a large number of sub-munitions such as small anti-tank charges over enemy vehicle concentrations. The results of joint feasibility studies in conjunction with several NATO allies are also under consideration for the development of a family of anti-ship missiles capable of being launched from a variety of platforms — ships, aircraft and submarines — and coming into service from about 1990 onwards. As an immediate follow-on to Martel, the RAF is awaiting the BAe Dynamics P3T Sea Eagle sea-skimming anti-ship missile (ASR 1226), for which a production go-ahead was recently received. The turbojet powered launch-and-leave P3T missile will also arm RAF Tornadoes and the RN's Sea Harriers. Other anti-ship developments include improvements planned for the navigation systems of the Buccaneers in the two RAF maritime strike squadrons, and the introduction of the Pave Way/Pave Spike laser-guided weapon system. The RAF is likely to seek "strap-on" laser guidance kits for most of its current conventional bombs.

For the longer-term, the RAF is continuing to assess the possible applications of unmanned aircraft and remotely-piloted vehicles for a wide variety of rôles ranging from target and reconnaissance drones to cruise missiles. Remarkably, it seems that from the cost-effectiveness aspect, it is still difficult to replace the Mk 1 *homo sapiens* by systems which can be quickly and cheaply produced by unskilled labour, for many operational rôles, although one or two areas are currently under consideration for further exploration. These include limited reconnaissance of the battlefield and the development of a decoy drone on a collaborative basis in Europe.

Still looking into the further future, the RAF is party to the world-wide search for means to penetrate hostile air defence systems. At the moment, high speeds at minimum levels appear to offer the best prospects, but many other possible windows are being explored, and it could be that something like Mach 3 at extreme altitudes of 60,000 ft (18 288 m) or more could present new air defence problems early in the 21st Century.

The air defence scene

Recent discussions of acknowledged shortcomings in the UK air defence situation have resulted in interim measures being announced (in July 1979) to plug the interceptor gap pending delivery of the first Tornado ADVs or F Mk 2s to operational squadrons in the mid-1980s, but the RAF has also been considering several additional options to reinforce its fighter strength before that time. At the moment, the RAF is scheduled to receive 165 Tornado F Mk 2s to re-equip its five squadrons of Phantoms and two of Lightnings (to be joined by a third from 1981-82) in the UK, plus two more Phantom air defence units in Germany, and the Air Staff has made it clear that whatever changes are made to strengthen this force, the ADV will remain its keystone. As Vice-Chief of Air Staff, Air Marshal Sir John Nicholls said during the roll-out ceremony of the prototype Tornado ADV on 9 August 1979 at Warton, "The F.2 is central to our plans for the future air defence of Britain and NATO's western seaboard. We made our choice several years ago in 1975, when we evaluated every available type of fighter. We see no reason to change that choice now."

According to Sir Frederick Page, chairman of BAe Aircraft Group and deputy chairman of Panavia, at the same occasion, the Tornado ADV represented a new concept of interceptor for the long-range air defence of Britain's maritime forces and NATO's Central Region. For its specialised tasks, a two-man crew was necessary to utilise its extensive avionics, including the Marconi Avionics track-while-scan AI radar, capable of handling multiple targets simultaneously at ranges in excess of 100 naut mls (185 km). The ADV possesses a genuine long-range autonomous capability which gives it the ability to operate more than 400 miles (644 km) away from base at night, in bad weather and in heavy ECM conditions against multiple targets at low level. It will also be able to launch its Sky Flash advanced AAMs over its full flight envelope, thus avoiding limitations inherent in other similar weapons systems. Because of its comprehensive avionics, electronic surveillance equipment and data link systems, the Tornado F Mk 2 will be able, in addition, to contribute significantly to the transfer of vital information over the entire tactical area.

Because of these qualities, the only current US fighter which could come close to duplicating the rôles of the Tornado F Mk 2 would be the Grumman F-14A, but procurement of new Tomcats to reinforce the RAF air defence fleet would be out of the question because of their cost. Another option that was studied during 1979 as a means of boosting Britain's fighter defences was the lease or purchase of two or three squadrons of McDonnell Douglas F-15s, which would have been useful particularly in re-equipping the two Phantom squadrons in Germany pending the availability of Tornadoes. However, the F-15 proposal has now been officially abandoned.

The new Binbrook-based Lightning squadron is expected to become operational as planned in about two years time, a timescale that is related to availability of airframe spares, engines and trained pilots. Current RAF Lightning strength comprises 61 F Mk 3/6 and ten T Mk 5 variants, all of which operate from Binbrook. Of this total, 34 are held by the Lightning Storage Unit and the remainder are allocated to Nos 5 and 11 Sqdns, the Lightning Flight (formerly No 226 OCU) or are available for issue at short notice by the Instant Readiness and Repair Unit.

Among the other interim air defence expansion measures, the precise number of Hawk trainers to be armed with AIM-9L Advanced Sidewinders as stop-gap day interceptors has still to be determined.

To maintain the RAF's V/STOL capability — in which it has a world lead — the Harrier force is to be updated and possibly increased in the course of the next decade. One of the options under study is the production of the "big-wing" Harrier projected by British Aerospace (above). Meanwhile, the RAF continues to deploy a detachment of four Harrier GR Mk 3s in Belize, where one of the V/STOL fighters is seen (below) in its hide alongside the runway.

Unequalled...

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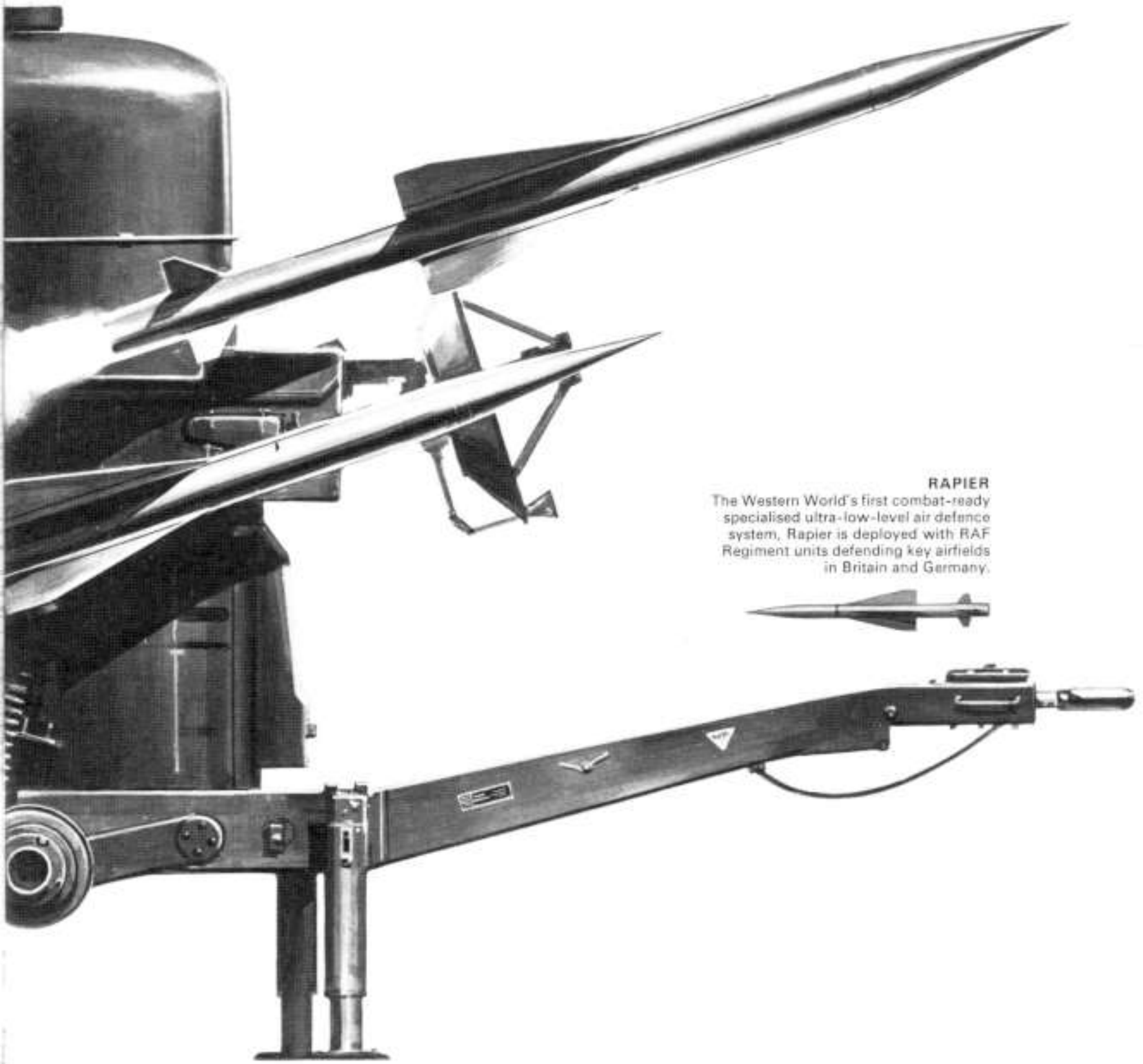

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unequalled in its range of aerospace programmes

The RAF's airlift capability is to be increased by some 12 per cent by modification of 30 Hercules C Mk 1s to C Mk 3 standard, with 15-ft (4,57-m) fuselage extension. The first stretched aircraft is seen here (right) in company with a standard C Mk 1.

but will comprise a substantial part of the RAF's force of 175 aircraft. There is also Air Staff interest in the offensive capabilities of the Hawk, which can carry a useful weapon load, including a ventral 30-mm Aden cannon, but no procurement is currently contemplated of the projected single-seat strike version. Rumours of additional RAF procurement of the Hawk are likely to be substantiated in due course by orders for a further 18-20 aircraft, but these are required mainly for the normal training rôles.

Weapons system improvements are also to be made to the RAF's Phantom FG Mk 1 (of which one squadron is committed to shore-based fleet defence) and Phantom FGR Mk 2 interceptors, which will be equipped with second-generation AIM-9L Sidewinder and Sky Flash AAMs. Procurement by the RAF of AIM-9L, which is considered to have some advantages over weapons such as the Matra 550 Magic, particularly so far as minimum-range performance is concerned, will be from licensed production by the European consortium. Looking further ahead, the RAF is examining the prospects for the collaborative development and production of next generation air-to-air missile projects.

The RAF's intention to form a squadron of VC10 tankers to supplement the two squadrons with a total of 23 Victor K Mk 2s (16 in first-line service, plus the remainder with the OCU or in reserve) comprising its current air-to-air refuelling (AAR) force, was announced in parliament early in 1978, when the Under-Secretary of State for Defence said that the unit would have a significance out of all proportion to its size. "Effectively" he added, "it is equivalent to increasing our fighter and strike-attack forces, but at markedly less cost." Training and support will be assisted by the fact that the RAF already operates 13 VC10s in transport rôles.

To meet ASR 406, the Aircraft Group of British Aerospace was awarded a contract by the MoD during 1979 for the conversion of the nine VC10 airliners bought in 1978 from Gulf Air (five VC10s) and East African Airways (four Super VC10s), as AAR (air-to-air refuelling) tankers for Strike Command. Design, development, and production in connection with the conversion are now well advanced at the Weybridge-Bristol Division of BAe at Filton, where the VC10s were stored for some months. Like the Victor tankers, the AAR VC10s — designated K Mk 2 (for the standard VC10) and K Mk 3 (Super VC10) — will remain under national control, and will probably operate from Brize Norton or other southern transport bases in the UK in support of Strike Command's combat element, and particularly its air defence force. The Victor tanker squadrons, Nos 55 and 57, meanwhile will move to Scampton to make room at Marham for two of the first squadrons of Tornado GR Mk 1s.

Another integral part of the UK air defence forces are the RAF's surface-to-air missile units, currently comprising Bloodhound 2s of No 85 Sqn deployed along the east coast, and further Bloodhounds of No 25 Sqn in the process of moving from Germany back to Britain, plus the low-level Blindfire Rapier squadrons for air base protection at Leuchars and Lossiemouth. Studies to achieve improvements to, or replacement for, these systems, will be a continuing process. Possible options include a collaborative programme in Europe or procurement of an alternative system from the US.

Further moves planned to improve Britain's air defence system include the replacement of all the ground radars and the introduction of a modern, hardened ADP-based command and control system at a cost of some £100-plus million, much of which should be provided from NATO's collective funds for military infrastructure. These improvements have been prompted by the realisation within the Alliance that around 40 per cent of all NATO's combat aircraft would be assembled in the UK at the start of a European war, coupled with the increasing long-range capabilities of Soviet strike aircraft.

All other existing radar sites in the UK are to be modernised, and linked by new computers to underground operations centres (each capable of operating independently), and to various HQ. Other links are planned to the air traffic control centre at West Drayton, near Heathrow, to co-ordinate civil and military air space surveillance. Two international consortia (both of which include British companies) will be making contract submissions for this modernisation work.

AEW and MR

As another vital part of the UK air defence organisation, the RAF's airborne early-warning force, comprising 12 venerable Shackleton AEW Mk 2s of No 8 Sqn, will be modernised when the squadron of Nimrod AEW Mk 3s begins to form at Waddington in 1983. Eleven suitably-converted Nimrods are being developed to meet the specifications of ASR 400. Like the Tornado F Mk 2 (ASR 395), the Nimrod AEW Mk 3 is a key programme for the RAF, which had originally sought to participate in the NATO AWACS (Boeing E-3A) project but was unable to wait for a collective agreement to be reached within the Alliance for a go-ahead before it reached its decision cut-off time. The wisdom of the UK decision for a unilateral approach to fulfil its AEW requirements as part of a mixed NATO force has become evident from the uncertainties still surrounding the AWACS programme in Europe, particularly from the point of view of national contributions and compensating offset contracts.

The AEW Nimrod, with its pulsed-Doppler radar scanner, is being optimised primarily for over-water operation, and will have a better capability in this respect than the Boeing E-3A. Nevertheless, it will have effective overland capability.

In addition to the 11 Nimrods now being converted for AEW use, 32 Nimrod MR Mk 1s are currently being uprated to Mk 2 standard by late-1983, and the first was recently handed over to start the Nimrod 2 conversion of No 206 Sqn at Kinloss. Eventually, each of the RAF's four Nimrod MR squadrons will operate eight Mk 2s which, with average airframe times of about 4,000 hours each, possess sufficient fatigue life for continued service to the end of the century. Realising an upgrading potential incorporated in the Nimrod 1, the Mk 2 profits from advances in avionics since its predecessor entered service 10 years ago, and is a classic example of the mid-life improvement process. This results from a typical combat aircraft

our contribution

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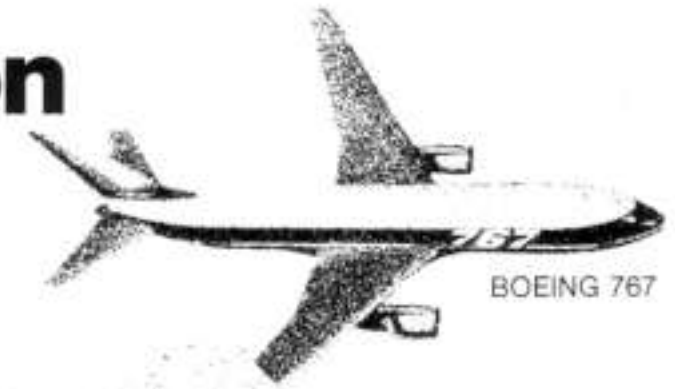
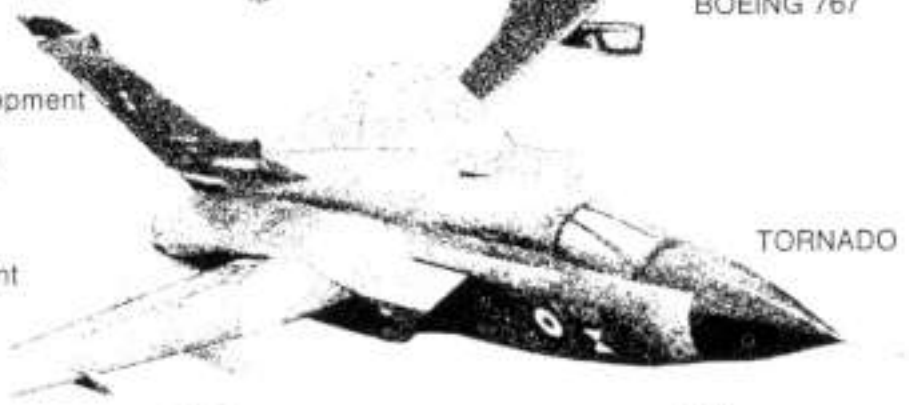
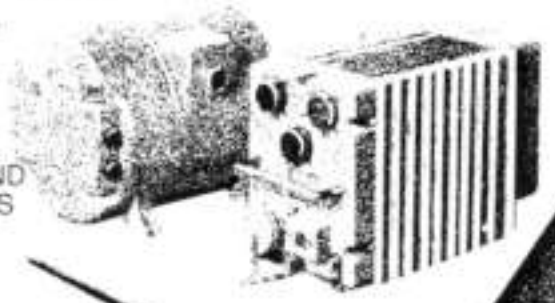


BOEING 767



TORNADO

It is involved in major space programmes: Spacelab, Ariane, Sirio, OTS, ECS, Marecs, the ESA-NASA space telescope, the Utex telescope, as well as in the design and



INSTRUMENTS AND AVIONIC SYSTEMS

G 222

integration of complete avionics systems and in applied electronics. In addition, it designs and produces aircraft instruments, automatic and inertial navigation systems for civil and military applications, and military optical systems.

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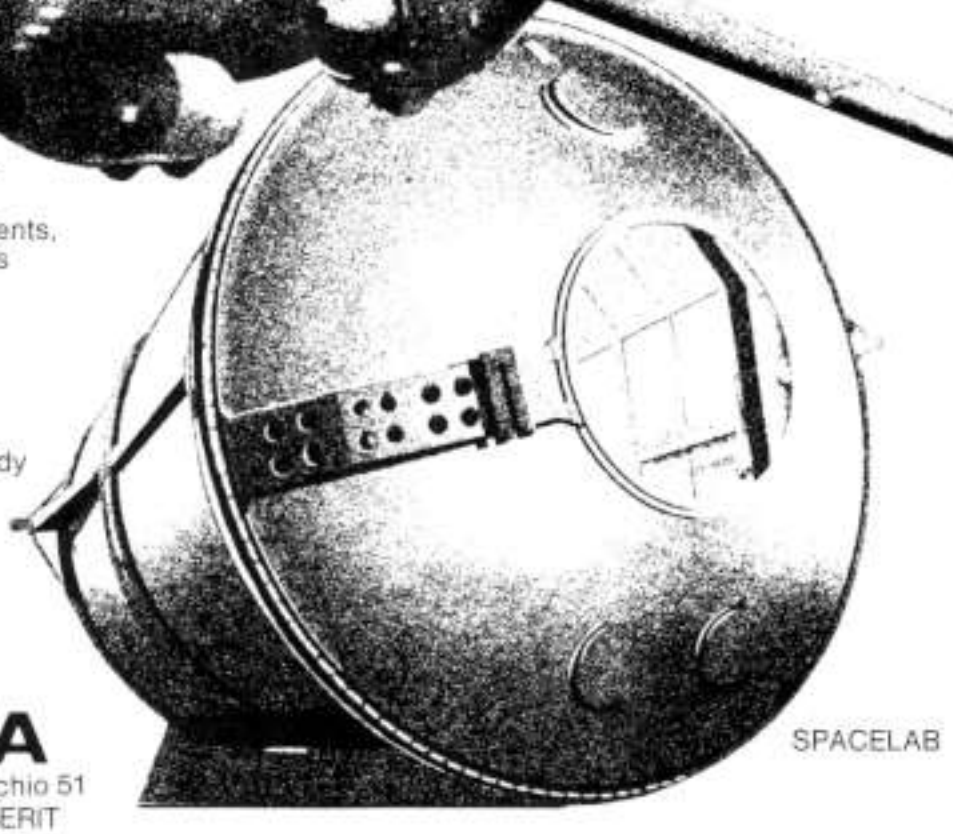

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design service life of about 20 years, and the way technology appears to advance significantly in steps of about 10 years.

At the heart of the Nimrod 2's re-designed tactical station is the new AQS 901 sonics processor, operating in conjunction with the Australian-developed Barra sonobuoy, representing what is claimed to be a major advance in acoustic technology. The system is also compatible with sonobuoys currently used by other NATO forces and has an inherent capability to process other sonobuoys now under development in the USA and Canada.

The new EMI Searchwater radar provides improved periscope-detection capability in rough-sea conditions prevalent in the North Atlantic. Electronic Support Measures (ESM) equipment will be retrofitted within the next three years. However, the current MAD system will remain, although a semi-automatic calibrating system will shortly be introduced. All sensor inputs are processed by an on-board computer with a capacity 60 times greater than that of the Mk 1. New communications/teletype systems have already been retrofitted to earlier aircraft. Offensive anti-submarine weapons will include the new lightweight Sting Ray torpedo, previously known as the NASR 7511, which has a drag-chute for aircraft release. Earlier plans to arm the Nimrod with Martel ASMs in wing pylons were abandoned by the RAF, which does not envisage an anti-ship strike rôle for its MR force, so far as surface vessels are concerned; nor are further major refits currently envisaged, although new systems and sensors, including possible IR applications, will continue to be explored.

Transports

Mention has already been made of the 13 VC10s that form the RAF's long-range transport force, operated by No 10 Squadron from Brize Norton. These, together with the RAF's airlift support force of 60 or so Lockheed C-130K Hercules, will continue operating well into the 1990s. Capability will be improved by the current programme to stretch the fuselages of 30 Hercules C Mk 1s by 15-ft (4,57-m). This programme, which will be completed in 1983, is being undertaken by Marshall of Cambridge, which in addition to major overhauls of the RAF Hercules, has also been completing centre-wing changes and a new wing refurbishing programme. The last few centre-wing change Hercules will have this work done when the fuselage stretch takes place.

The first stretched RAF Hercules C Mk 3 was modified by Lockheed at its Georgia plant, where it made its first flight on 3 December 1979; the remaining 29 will be completed by Marshall over the next four years from manufacturer's kits. Completion of the modification programme will result in the equivalent of adding at least six new aircraft to the RAF Hercules fleet, but without attendant costs of additional crews, training, ground support and spares.

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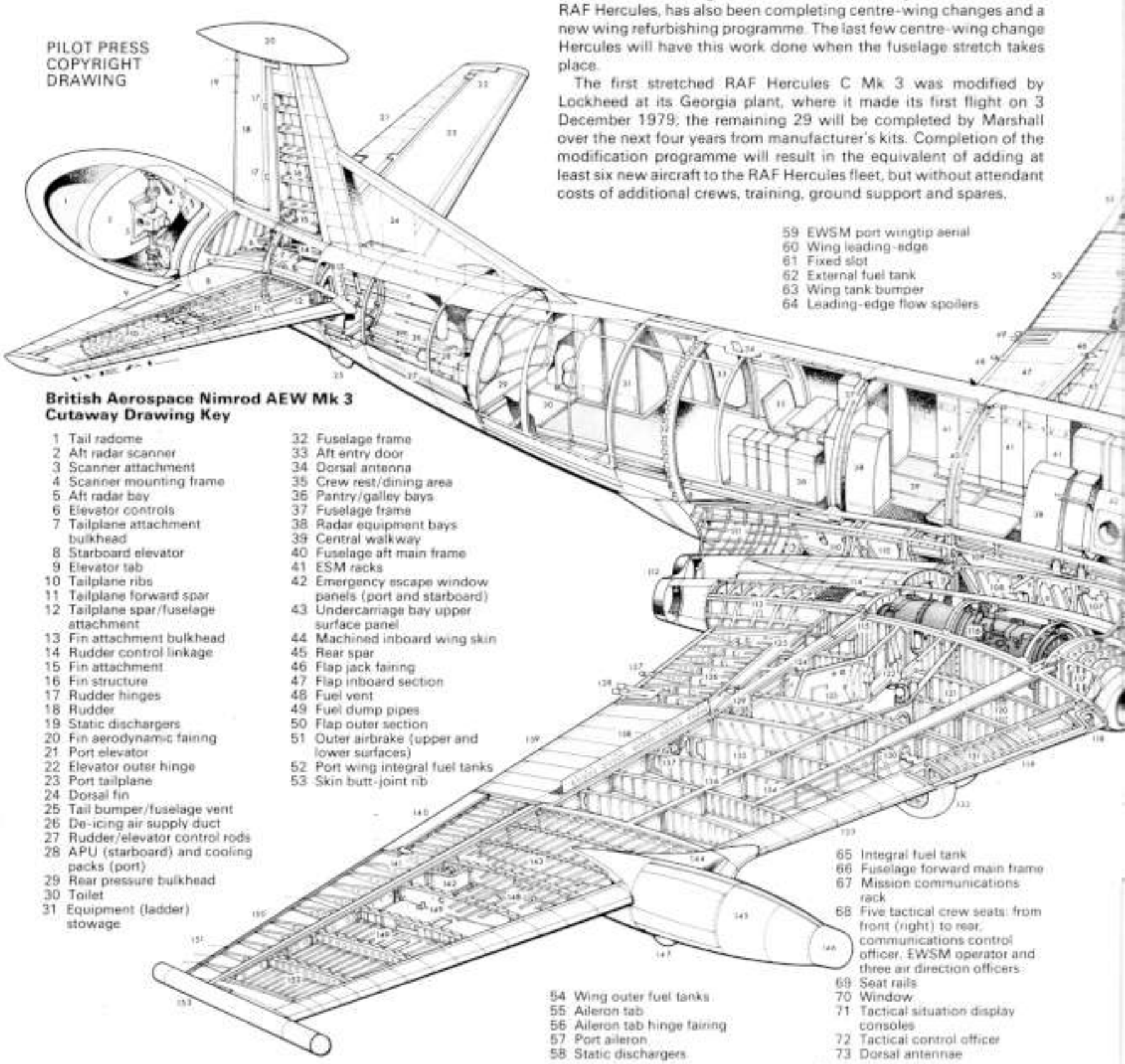


British Aerospace Nimrod AEW Mk 3 Cutaway Drawing Key

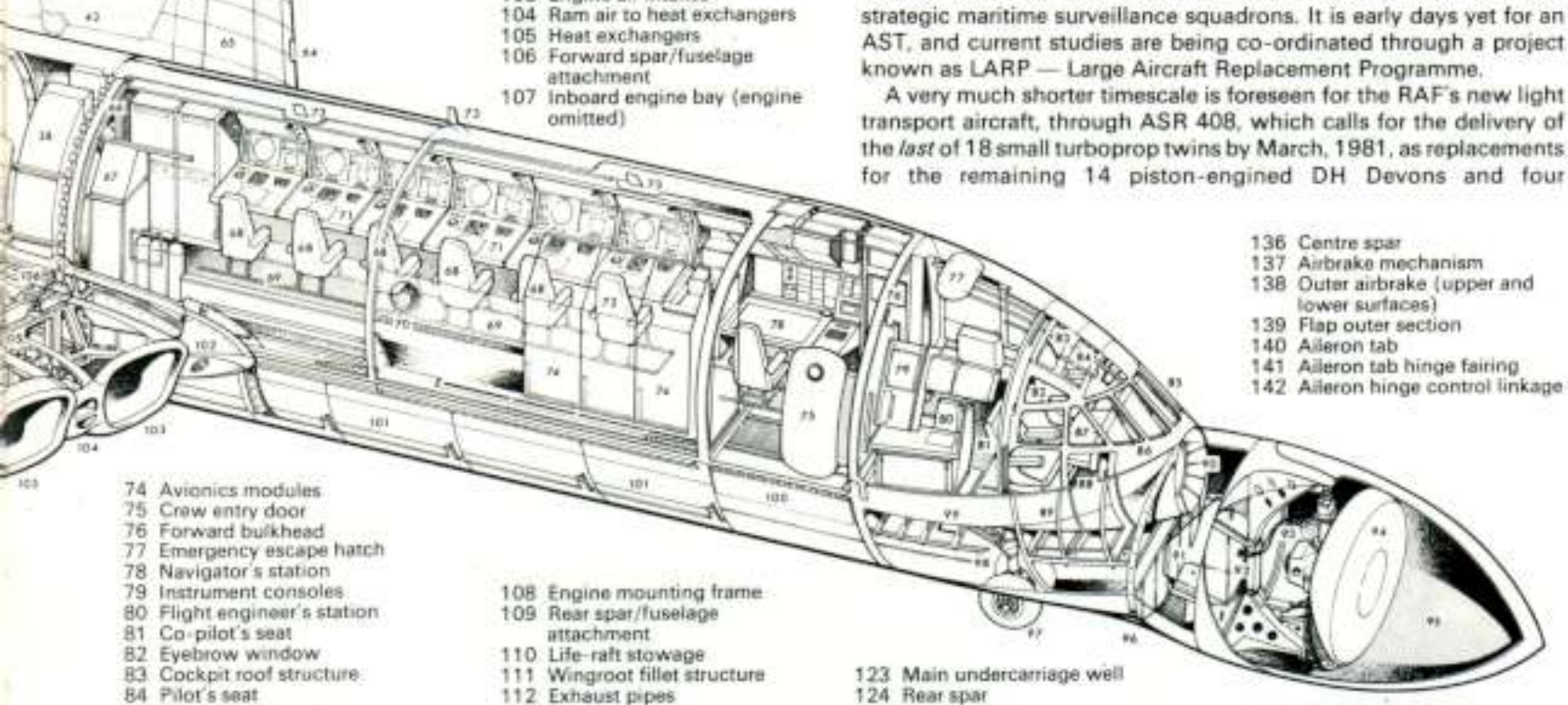
1 Tail radome
2 Aft radar scanner
3 Scanner attachment
4 Scanner mounting frame
5 Aft radar bay
6 Elevator controls
7 Tailplane attachment bulkhead
8 Starboard elevator
9 Elevator tab
10 Tailplane ribs
11 Tailplane forward spar
12 Tailplane spar/fuselage attachment
13 Fin attachment bulkhead
14 Rudder control linkage
15 Fin attachment
16 Fin structure
17 Rudder hinges
18 Rudder
19 Static dischargers
20 Fin aerodynamic fairing
21 Port elevator
22 Elevator outer hinge
23 Port tailplane
24 Dorsal fin
25 Tail bumper/fuselage vent
26 De-icing air supply duct
27 Rudder/elevator control rods
28 APU (starboard) and cooling packs (port)
29 Rear pressure bulkhead
30 Toilet
31 Equipment (ladder) stowage
32 Fuselage frame
33 Aft entry door
34 Dorsal antenna
35 Crew rest/dining area
36 Pantry/galley bays
37 Fuselage frame
38 Radar equipment bays
39 Central walkway
40 Fuselage aft main frame
41 ESM racks
42 Emergency escape window panels (port and starboard)
43 Undercarriage bay upper surface panel
44 Machined inboard wing skin
45 Rear spar
46 Flap jack fairing
47 Flap inboard section
48 Fuel vent
49 Fuel dump pipes
50 Flap outer section
51 Outer airbrake (upper and lower surfaces)
52 Port wing integral fuel tanks
53 Skin butt-joint rib
54 Wing outer fuel tanks
55 Aileron tab
56 Aileron tab hinge fairing
57 Port aileron
58 Static dischargers
59 EWSM port wingtip aerial
60 Wing leading-edge
61 Fixed slot
62 External fuel tank
63 Wing tank bumper
64 Leading-edge flow spoilers
65 Integral fuel tank
66 Fuselage forward main frame
67 Mission communications rack
68 Five tactical crew seats: from front (right) to rear, communications control officer, EWSM operator and three air direction officers
69 Seat rails
70 Window
71 Tactical situation display consoles
72 Tactical control officer
73 Dorsal antennae

While 11 of the original RAF fleet of 46 Nimrods undergo conversion to AEW Mk 3 standard as depicted in the cutaway drawing here, the balance of the maritime reconnaissance aircraft are in process of being updated to Nimrod MR Mk 2s (above) featuring a new equipment fit and new colours.

Prospects for VC10 and Hercules replacement in the early part of the next century are now receiving attention through conceptual studies by the MoD and British Aerospace, and current thinking is to explore the possibility of a minimum number of different types for the long-term re-equipment of not only the RAF's transport force, but also its Nimrod 2 and 3, Victor and VC10 tanker and Vulcan SR Mk 2 strategic maritime surveillance squadrons. It is early days yet for an AST, and current studies are being co-ordinated through a project known as LARP — Large Aircraft Replacement Programme.

A very much shorter timescale is foreseen for the RAF's new light transport aircraft, through ASR 408, which calls for the delivery of the *last* of 18 small turboprop twins by March, 1981, as replacements for the remaining 14 piston-engined DH Devons and four

97 Twin nosewheels
98 Nosewheel leg strut
99 Nosewheel well
100 Underfloor equipment bay
101 Fuel cells (3) under cabin floor
102 Taxi light
103 Engine air intakes
104 Ram air to heat exchangers
105 Heat exchangers
106 Forward spar/fuselage attachment
107 Inboard engine bay (engine omitted)



74 Avionics modules
75 Crew entry door
76 Forward bulkhead
77 Emergency escape hatch
78 Navigator's station
79 Instrument consoles
80 Flight engineer's station
81 Co-pilot's seat
82 Eyebrow window
83 Cockpit roof structure
84 Pilot's seat
85 Windscreen panels
86 Windscreen wipers
87 Control console
88 Instrument panel
89 Support frames
90 Forward pressure bulkhead
91 Nose radar bay
92 Scanner mounting frame
93 Scanner attachment
94 Nose radar scanner
95 Nose radome
96 Fuselage/radome fairing

108 Engine mounting frame
109 Rear spar/fuselage attachment
110 Life-raft stowage
111 Wingroot fillet structure
112 Exhaust pipes
113 Tailpipe frames
114 Thrust reverser (outboard engines only)
115 Rear spar frames
116 Rolls-Royce Spey 250 turbofan
117 Intake duct frames
118 Landing lamp
119 Leading-edge flow spoilers
120 Wing integral fuel tank
121 Forward spar
122 Main undercarriage pivot

123 Main undercarriage well
124 Rear spar
125 Auxiliary spar
126 Flap structure
127 Fuel vent
128 Fuel dump pipes
129 Flap jack fairing
130 Wing skin joint strap
131 Leading-edge de-icing ducts
132 Four-wheel main undercarriage bogie
133 Wing leading-edge
134 Abbreviated spar
135 Integral fuel tanks

136 Centre spar
137 Airbrake mechanism
138 Outer airbrake (upper and lower surfaces)
139 Flap outer section
140 Aileron tab
141 Aileron tab hinge fairing
142 Aileron hinge control linkage

143 Wing stringers
144 Fixed slot
145 External fuel tank
146 Weather radar
147 Wing tank bumper
148 Outboard fuel tank bays
149 Fuel tank access panels
150 Starboard aileron
151 Static dischargers
152 Outboard wing structure
153 EWSM starboard wingtip aerial

Pembrokes in the current inventory. Coupled with the operating and maintenance problems now being experienced with the Devons and Pembrokes, the RAF has the strongest possible compulsion to re-equip its light communications force, and tenders for 18 aircraft have been invited from British Aerospace and leading US general aviation manufacturers. Since the RAF and RN already operate the BAe Scottish Division's Jetstream turboprop twin, which is being re-launched for the corporate market with Garrett AiResearch powerplants, its procurement at a competitive price to meet ASR 408 would make a good deal of sense, if it can be produced within the required timescale. The alternative would seem to be an off-the-shelf purchase of something like the Beech Super King Air.

Helicopter plans

One of the most active areas for the RAF so far as re-equipment is concerned is its helicopter force, which is in the process of being modernised and expanded. A batch of 33 Chinook HC Mk 1 medium support helicopters is being purchased from the Boeing Vertol Company of Philadelphia, USA. These aircraft are based on the US Army's CH-47C model, but have an increased take-off weight of 50,000 lb (22 680 kg), an automatic flight control system, three hooks for underslung loads, and a comprehensive suite of British avionics. Later production deliveries will have pressure refuelling facilities and fibre composite rotor blades with de-icing provisions, and these features, developed for the US Army's new CH-47D model Chinook, will also be incorporated in the RAF's early aircraft by subsequent modification in the UK.

The introduction of the Chinook HC Mk 1, with its ability to lift loads of 10 tons, will substantially increase the RAF helicopter force's capacity to support British Army operations. Deliveries to the RAF's OCU at Odiham will commence in late 1980 and lead to the formation of two squadrons, one in Germany and the other in the UK.

Replacement of most of the RAF's Wessex helicopters in the support rôle will release them for redeployment in those rôles currently undertaken by the remaining Whirlwinds, while the Puma force is also being progressively updated by modifications to improve performance and extend component lives, as well as being expanded. Changes planned for the RAF Pumas include the introduction of fibre composite main rotor blades (as developed by Aérospatiale for its SA 330L version) and an ice and snow protection system. Delivery of the TANS tactical navigation system started towards the end of last year. The eight more Pumas which the RAF has ordered as attrition replacements to support the current fleet will also be to the SA 330L improved standard.

Looking further ahead, the RAF has written a Staff Target (AST 404) for a completely new light support helicopter (LSH) with a gross weight of around 15,500 lb (7 tonnes) as a Wessex/Puma replacement for the 1990s. This helicopter is one of several projects being studied in Europe with a view to the creation of a new family of collaborative projects to fulfil the needs of the armed forces of Europe for the next generation of military helicopters. Possible other members of this family could include the Sea King replacement (Westland's WG 34), the Franco/German PAH 2 anti-tank helicopter, and a replacement for the Gazelle and Alouette class of light observation type helicopter. Being studied in parallel are the advances in avionics that are likely to have a significant impact on the capability of all helicopters in this timescale. □

Among the RAF's current commitments overseas is the provision of a squadron of Wessex HC Mk 2s (No 28) for a troop and policing rôle in Hong Kong.

(Above right) Puma HC Mk 1s, flown in rotation by crews detached from Nos 33 and 230 Squadrons at Odiham, operate in Belize in support of the ground forces stationed there as a deterrent to Guatemalan incursions. This Puma is landing at a hilltop observation point only yards from the southern border with Guatemala. (Below) One of the seven Hercules C Mk 1s based in Rhodesia during the period running up to the general election in February 1980, drops supplies over one of the guerilla assembly points. Crews were drawn from Nos 47 and 70 Squadrons.

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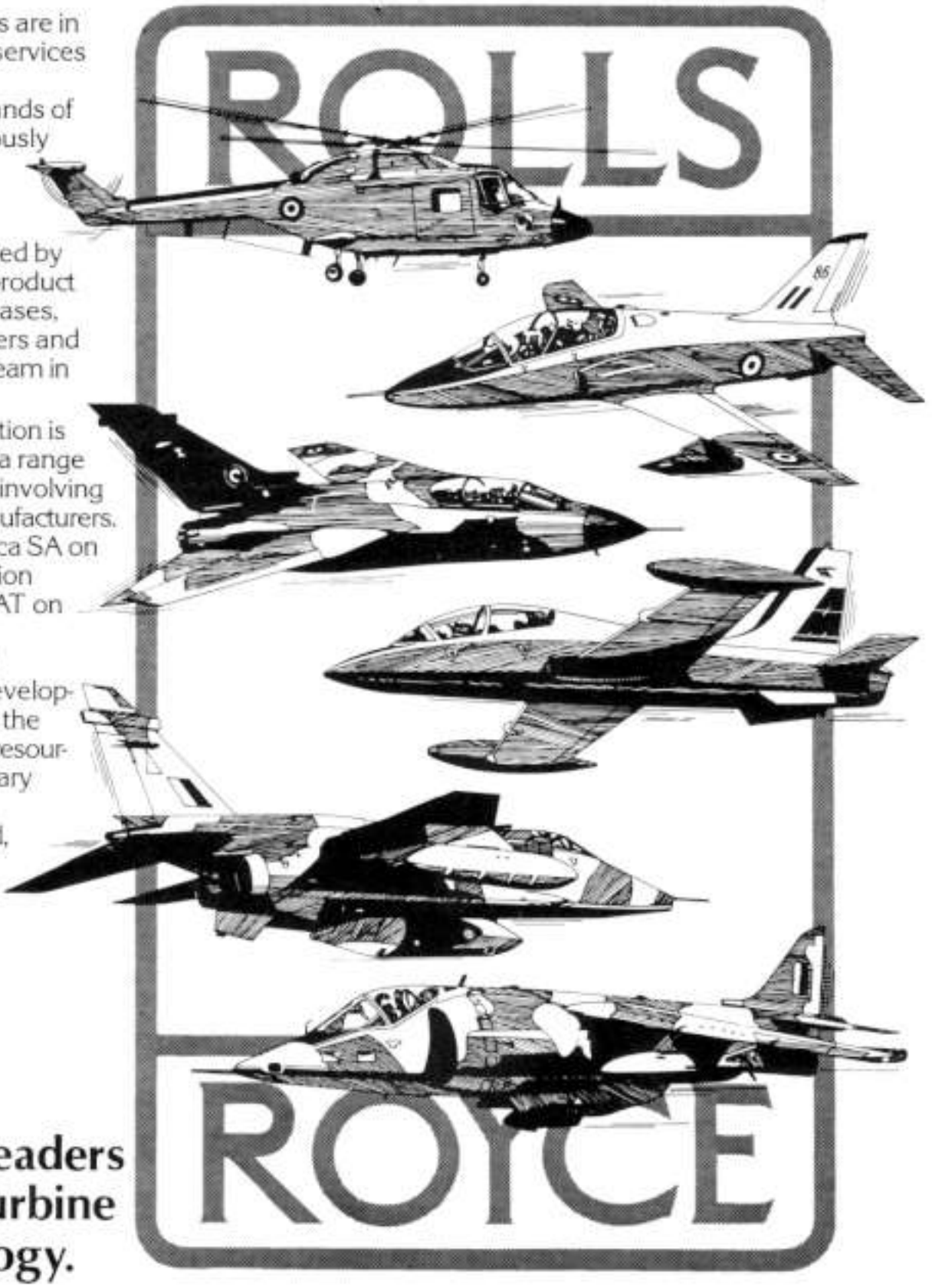

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HELICOPTERING IN THE '80S

Of the three British armed forces, the Royal Air Force is still the smallest user of helicopters: its rotary-winged inventory at the end of 1979 totalled 184, compared with 351 for the Royal Navy and 309 for the Army. Nevertheless, the helicopter is firmly established as an important component of the RAF's equipment, fulfilling several rôles that could not be performed with equal efficiency by fixed-wing types. In this article, Elfan ap Rees, managing editor of "Helicopter", discusses the current and future status of the helicopter in the RAF.

HELICOPTERING has always been regarded by the traditionalists as a bit of a fad, somehow lacking the glamour of a jet fighter and being a darned sight more dangerous to boot! As a result, the helicopter has had a hard time trying to prove that it deserves a place in the strategist's thinking and in the modern man's armoury. Only in the last ten years has come the real evidence that all this has changed.

The success of helicopter support operations in Vietnam, the publicity given to daring life-saving missions, and the visible growth of the commercial as well as military market attributable to the maturity of the new helicopter generation have combined to bring home to all but the gloomiest of pundits the significance of the "new-fangled whirlybird" that, in truth, has been a practical proposition now for all of 40 years. But more than 40 years ago is where this story should begin, for, to put the modern Royal Air Force helicopter into perspective, one must first glance briefly at the scrapbook and explain its evolution.

The Royal Air Force first encountered rotating-wing aircraft in 1934, when the Cierva Autogiro was introduced for Army co-operation work. A few C.30As built by Avro entered service and by 1940 their rôle included radar calibration. In 1944, the first Sikorsky R-4 Hoverfly I helicopters arrived in Britain; too small and underpowered to do anything really useful, they were used, like the slightly later and larger R-6 Hoverfly IIs, only for odd jobs and trials, pending the arrival of something better, but were useful in training a nucleus of pilots to think in "vertical" terms.

(Heading) A Puma HC Mk 1 of No 33 Squadron at low level near its home base at Odiham, Hants. Note that this example has de-icing protection for the intakes. (Below) A Westland Wessex HC Mk 2 of No 72 Squadron, also based at Odiham.

As it happened, the Malayan Emergency was first to provide an opportunity for the helicopter to prove itself in the eyes of the RAF when it was realised that this type of aircraft represented the only means of safely evacuating injured troops from a jungle where it could take a full day to advance 800 yards (732 m) on foot. Three Westland Dragonflies (licence-built Sikorsky S-51s) were therefore hurriedly acquired and pressed into service. These were followed by more Dragonflies, then Whirlwinds (Sikorsky S-55s) and Bristol Sycamores, as a crash programme got underway to meet the rapidly-expanding need to move troops and equipment, evacuate the wounded and also to set up search-and-rescue detachments in yet another new rôle for which the helicopter had been found ideal.

The "bush wars" of Suez and Cyprus in the 'fifties served to reinforce a need to provide these machines with more power and lifting capacity; this requirement was eventually solved by the advent of powerful but lightweight turbine engines, which allowed the Royal Air Force to re-engine some of its Whirlwinds and to enter the 1960s with a new generation in the pipeline, machines, such as the Wessex and Puma, which saw their users through such crises as the Radfan campaign and the Indonesian confrontation, and have subsequently supported operations in Belize and Northern Ireland.

Essentially, these same types still equip the Royal Air Force helicopter squadrons and units today, although new replacement types are at last on the horizon. Meanwhile, the Air Force rôles have become well defined and, whilst new helicopters will certainly hone the edges of reliability and performance, their work is unlikely to

substantially change. Trial (and the occasional error!) have now proved that the helicopter excels at search-and-rescue and the precise positioning of front-line troops and heavy equipment. In these rôles it is very much a battlefield machine and in consequence the majority of RAF helicopters come under the aegis of Strike Command.

Search and rescue

The Royal Air Force currently has eight operational helicopter squadrons, three of which are based in Hampshire, at RAF Odiham. Three more are based overseas and two are scattered around the UK coastline in small detachments, operating in the search-and-rescue capacity. The SAR rôle is that which, quite deservedly, attracts the most attention from the popular media and the two squadrons so engaged in the UK, Nos 22 and 202, have a long history of heroic deeds and consequent awards. Both also have long experience of operating SAR helicopters, having been formed in the pioneering days of the mid-'fifties.

Today, the two squadrons fly mainly twin-engined helicopters, which offer obvious safety advantages over inhospitable waters, but No 22 Sqdn still has a small number of Whirlwind HAR Mk 10s based at Chivenor and Leconfield, where their rapid inshore reaction time and ability to move in close on cliff rescues make them ideal for the predominantly civil SAR incidents at these two locations. Whirlwinds also operate at RAF Valley in the SAR training rôle, originally part of the CFS (H) Wing (described later in this account) but now totally under the control of SAR Strike Command.

Also at Valley is one of the Wessex HAR Mk 2 detachments of No 22 Sqdn; other Wessex flights are based at Manston and Leuchars and more are likely to be converted to the SAR rôle in the 1982-84 time period to replace the last Whirlwinds. In addition to having the advantage of twin-engined safety, the Wessex also extends the operational capability of each detachment with minimum risk and is ideal for medium-range rescue flights in major shipping areas, where its higher cruising speed outweighs the quicker reaction time of the Whirlwind and where its larger cabin capacity and greater endurance time gives it far more flexibility. Compared with its predecessor, the Wessex is still relatively new to the SAR scene and corrosion problems and spares shortages have played a part in aggravating its operational efficiency, but the pedigree of this magnificent and original Sikorsky S-58 turbine conversion seems to guarantee that it will win through in the end.

Pending the introduction later in 1980 of the Chinook, the newest helicopter to enter RAF service is the Sea King HAR Mk 3, also specialising in the SAR rôle. First flown by Westland in September 1977, this licence-built derivative of the Sikorsky S-61 incorporates all the lessons learned with earlier British-built versions of this helicopter, in particular the specialised SAR variants developed for the West German, Norwegian and Belgian Governments. As a result, it is capable of carrying out rescue sorties at up to 250 miles (402 km) from base, in weather that would ground most other helicopters. Automatic flying controls and advanced radar navigation will direct the aircraft and bring it to the hover at any pre-determined point on the chart without human help and, once in position, the winch operator can himself "fly" the aircraft through small degrees of horizontal movement in order to position the rescue cable to advantage.

No 202 Squadron operates a total of 15 Sea Kings, each fitted with 22 passenger seats and equipped with a full range of rescue equipment. The first detachment to convert to the new aircraft was "D" Flight at Lossiemouth, which relinquished its Whirlwinds in August 1978. Now there are Sea King HAR Mk 3s also based at Boulmer, Coltishall and Brawdy, the latter having become operational as recently as October 1979.

A brief study of a map of the UK will show that, with the three types equipping the SAR units, the Royal Air Force can give full rescue cover to any of its aircraft operating in all its main training areas, be it the highlands of Scotland or low level over the North Sea. Whilst the helicopters are rarely called out to fulfil this, their prime rôle, the great British public and those who go down to the sea in ships give their crews plenty of live practice.

The Royal Air Force does have one other SAR unit, this being "A" Flight of No 84 Squadron, based at Akrotiri in Cyprus and operating Whirlwinds. Although Akrotiri is no longer the big operational base it once was, it still serves as a staging post for Support Command and as a weapons training camp for visiting fighter squadrons, and this gives "A" Flight good reason to keep itself in peak condition. Last

(Above right) A Whirlwind HAR Mk 10 of No 22 Squadron on exercise with the Holyhead lifeboat. The Valley detachment of No 22 Squadron now flies the Wessex HAR Mk 2 but Whirlwinds are still used by this unit at some other UK bases. (Below) The other UK-based unit dedicated to search-and-rescue duties, No 202 Squadron, has now re-equipped with the Westland Sea King HAR Mk 3, of which the RAF has acquired a total of 16.

September one of the Whirlwinds delivered a Lightning pilot to the local hospital within 20 minutes of his calling a "mayday" whilst out on the firing range south of Cyprus. He actually spent only four minutes in the water and yet "A" Flight had not had a military call-out for nearly a year.

The other half of No 84 Squadron, "B" Flight, operates uniquely as part of the United Nations Forces in Cyprus from a base at the deserted Nicosia International Airport. This Flight is the last RAF unit to use the Whirlwind in its original troop support rôle and the four aircraft on charge are therefore the last to be seen in camouflage colours, albeit over-painted with UN flashes. Their task is to support UN troops manning observation posts along a 110-mi (180-km) buffer zone which has separated Greek and Turkish factions on the island since 1974.

The Cyprus Whirlwinds, like their UK counterparts, also support the civil population in SAR and medical evacuation work, although with the island being an independent republic — split in two by the warring factions — procedures are naturally somewhat different from those for a call-out at home.

As long ago as 1963, the RAF's Whirlwinds were first supplemented by the Wessex HC Mk 2s, from the same Westland stable out of Sikorsky but with a vast improvement in both trooping and sling-load capacity. Today the Wessex remains very much in the front-line, with No 72 Squadron and an Operational Conversion Unit at Odiham, No 18 Squadron at Gütersloh in West Germany and No 28 Squadron in Hong Kong.

No 72 Squadron has the task of supporting trooping exercises throughout the UK; this means particularly in the Salisbury Plain and Aldershot training areas, but aircraft are also regularly detached to Northern Ireland, where they play an unspectacular but nonetheless important rôle in anti-terrorist operations. A similar troop support rôle is performed with British and NATO forces on the Rhine by No 18 Squadron.

Troop support in the European theatre, where the probable front line is close to home and likely to be fast moving, requires the Wessex squadrons to be highly flexible. Consequently they spend a fair amount of time out in the field, particularly in West Germany, camouflaging camps and aircraft to blend with the local topography, flying nap of the earth to avoid enemy missiles, and transporting all essential equipment including fuel in frequent changes of operating sites.

No 28 Squadron in Hong Kong has a somewhat different environment in which to operate. Now based at Sek Kong in a purpose-built facility opened in early 1978, this unit's eight Wessex helicopters are employed in a troop and policing rôle in support of the Colony security forces, and in the last year attempts by Vietnamese refugees and Republican Chinese to enter Hong Kong illegally have put the squadron very much into the local front line. Because the Colony is made up of 236 islands and a peninsula of mainland China, it is very susceptible to invasion from the sea, and the Wessex are much in demand ferrying supplies to observation posts in the mountains and on off-shore islands, checking suspicious-looking junks and sampans, and assisting ground troops to round up illegal immigrants before transporting them to detention camps.

Last year also saw the squadron sling-lifting 90,000 coils of barbed wire, weighing some 200,000 lb (90 720 kg), into the New Territories to build a new fence along the mainland border, and taking part in the *"Huey Fong"* incident, when its aircraft flew 340 sorties in just under a month to feed and clothe the 3,400 Vietnamese refugees aboard this cargo ship, which had sailed illegally into Hong Kong harbour.

Both No 28 and No 18 Squadrons also occasionally get involved in fire fighting. In Hong Kong, the Chinese tend to take to the hills at weekends to commune with their ancestors; as this involves lighting joss sticks all over the grassy slopes, the dry season can very easily see half the colony alight. The squadron has therefore been issued with two 500-Imp gal (2 273-l) fire-buckets which are slung externally beneath the Wessex and, filled to half-capacity, can be used to douse 70 yards (64 m) of fire at a time. In West Germany, No 18 Squadron is based within striking range of the Luneburg Heath and, although German day-trippers don't habitually light joss sticks, their camp fires tend to produce the same end result!

Despite the ruggedness and suitability of the Wessex for many of the RAF's helicopter tasks, its basic technology is now 25 years old

(Below) Westland/Aérospatiale Puma HC Mk 1s of No 33 Squadron at RAF Odiham — the first of two RAF squadrons to equip on this type. (Above right) The oldest type of helicopter currently in RAF service is the Westland Whirlwind HAR Mk 10; this photo shows one of the aircraft of No 84 Squadron's B Flight in Cyprus ferrying supplies to a UN observation post in the Troodos Mountains (photo, "Helicopter" Magazine).

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and it is beginning to become outmoded. More up-to-date is the Aérospatiale Puma, ordered in the mid-'sixties to replace the remaining front-line Whirlwinds and expand the RAF helicopter force. Today, the Puma equips two squadrons, Nos 33 and 230, both based at Odiham although their duties take them far and wide. Whilst the Puma rôle is basically similar to that of the Wessex, the advance in technology means that the two squadrons so equipped are able to carry more, further and faster than when equipped with the Wessex. Originally 40 Puma HC Mk 1s (to SA 330B standard) were part-built and assembled by Westland for the two squadrons but attrition has reduced numbers somewhat and eight new aircraft (to SA 330L standard) are currently under construction in the UK for delivery this year.

Overseas detachments for the Puma squadrons in recent years, if one excludes Northern Ireland and exercises in Norway and Germany, have centred on Belize, a tiny ex-British colony in Central America which has been involved for many years in a territorial dispute with neighbouring Guatemala. Here the Pumas are used to resupply troops spaced out along the border and separated by rather inhospitable jungle in a typical Central American climate. The country is slightly larger than Wales and the helicopters can just reach the furthermost outposts and return to their base at Belize City on their internal fuel capacity. More recently, in December 1979, a small number of Pumas was sent to Rhodesia, to assist in the establishment of guerilla assembly points and subsequently the cease-fire monitoring. Once again the quick reaction and varied abilities of a modern helicopter unit were ably demonstrated.

Training

Having helicopters in the right place at the right time is only of value if their pilots and other crew members are also at a high pitch of training. The task of training the RAF's helicopter pilots is now the responsibility of the Central Flying School Helicopter Wing at RAF Shawbury, close to Shrewsbury, the county town of Shropshire. Although the immediate area is largely rolling farmland, the Wing is within easy flying range of the Welsh mountains and would-be helicopter pilots can therefore complete all their *ab initio* training at the one base. Students arrive at Shawbury without "wings" but having had some basic fixed-wing experience, aimed at sorting out "the wheat from the chaff" as inexpensively and quickly as possible.

At Shawbury, CFS (H) Wing is divided into three squadrons, of which No 1 is the student's first home. There, he completes 76 hours basic training on the Westland-Aérospatiale Gazelle HT Mk 3, an extremely speedy helicopter with excellent cockpit vision and manoeuvrability but with a more basic fit than its immediate predecessor, the Whirlwind HAR Mk 10. Although the Gazelle joined No 1 Sqdn as recently as August 1979, it was already apparent that its introduction would bring changes to the training curriculum. The lack of a winch and a big cabin immediately ruled out some of the exercises previously performed with the Whirlwind, and the Gazelle therefore does not permit the student to learn the full range of "helicoptering".

In all, 22 Gazelles are allocated to the CFS at Shawbury and No 1 Sqdn calls on aircraft as required, sharing the fleet with the School's No 2 Sqdn, which uses the Gazelle for instructor, conversion and refresher training. This unit has in fact been operating the Gazelle for

(Above) A Wessex HC Mk 2 of No 28 Squadron, based in Hong Kong and seen here during operations to search for illegal immigrants in the New Territories. (Below) A Westland/Aérospatiale Gazelle HT Mk 3, serving in the training rôle in CFS(H) Wing at RAF Shawbury (photos, "Helicopter" Magazine). The RAF has acquired a total of 25 Gazelles including a single HCC Mk 4 for communications duty.

instructor training since it was first introduced to service in 1973, and is responsible for all such training, not only for the RAF but also for the Army Air Corps, Royal Navy and, from time to time, various overseas countries. This programme is therefore well established, with 28 exercises in 25 sorties over a period of 75½ flying hours required for qualification as a QHI (excluding a conversion course for those not familiar with the Gazelle).

Meanwhile, the successful student-pilot will have moved on from the Gazelles of No 1 Sqdn to the Wessex HU Mk 5, introduced as part of the advanced training syllabus in 1977 when it was concluded that twin-engined and large helicopter experience should become part of the CFS curriculum. The Wessex certainly fulfills its purpose in this respect, presenting the student with a number of new problems. He is seated higher up and has less visibility; the main rotor turns in the opposite direction to that of the Gazelle, the aircraft has a more complex and prolonged starting procedure (in fact a new student, used to starting up a Gazelle in less than five minutes, may find himself spending a whole hour in the Wessex before he is in a position to take-off!) and, of course, the large cabin, the sling hook, the winch, and the facility to do both instrument and mountain flying are all features not present on the smaller aircraft. Six Wessex are now based at Shawbury and after 47 exercises, including a final Navex, the student pilot receives his wings and can be posted to an operational unit.

Other courses that CFS (H) Wing provides include crewman training (by No 2 Sqdn) on the Wessex; and, although the long-serving Whirlwind has been cut out of the *ab initio* rôle, seven of these aircraft are still based at Shawbury (with No 3 Sqdn) for "peripheral duties" which include senior officer familiarisation, some conversion training and a course for Harrier pilots. The last-mentioned come for one week to receive training in confined-area operations and to familiarise themselves with the quirks of flying sideways, backwards, vertically and in the hover, experience that is invaluable to anyone converting to VTOL flight from a conventional fixed-wing aircraft.

Completing the catalogue of helicopter operations in the RAF, brief mention must be made of the Queen's Flight, which operates two VIP-equipped Wessex HCC Mk 4s on Royal and high-ranking Government communications flights from its base at RAF Benson in Oxfordshire. Although very much a specialised unit, like No 32 Squadron at Northolt, which operates a handful of Whirlwinds and a

single Gazelle HCC Mk 4 on more mundane VIP flights, the Queen's Flight would have a secondary ambulance and rescue rôle in wartime.

Enter the Chinook

The beginning of a new decade, then, sees the Royal Air Force equipped with five types of helicopter fulfilling the training, communications, SAR, troop supply and medium-lift rôles. The last-mentioned is, however, a relative term, for the maximum underslung load of a Wessex or a Puma, 5,500 lb (2 495 kg), is a very light lift compared with the 32,000 lb (14 370 kg) sling-load of a Sikorsky CH-53E or the 33,000 lb (15 000 kg) of a Mil Mi-10.

The gap in this area of RAF helicopter capability arose in 1969 when the tandem-rotor Belvedere was retired from service. Although much-maligned, the Belvedere could sling-carry a load of some 6,000 lb (2 720 kg), a reasonable figure for its day and more than any other RAF helicopter could manage, before or since. Its retirement left a gap during the 'seventies and on several occasions the British military has had to call on US Army CH-47 Chinooks or West German *Heeresflieger* CH-53s to recover downed aircraft or extract ground equipment from sticky situations.

Within the next two years, the balance will be redressed as No 18 Squadron re-equips with the Boeing Vertol Chinook HC Mk 1, a variant of this versatile tandem-rotor US Army helicopter developed especially for the RAF. There is little doubt that the arrival of this new helicopter will greatly improve the RAF's ability to support ground

Boeing Vertol Chinook HC Mk 1 Cutaway Drawing Key

1 FM homing aerials
2 Pitot tubes
3 Nose compartment access hatch
4 Vibration absorber
5 IFF aerial
6 Windscreen panels
7 Windscreen wipers
8 Instrument panel glare shield
9 Rudder pedals
10 Yaw sensing ports (automatic flight control system)
11 Downward vision window
12 Pilot's footboards
13 Collective pitch control column
14 Cyclic pitch control column
15 Co-pilot's seat
16 Centre instrument console
17 Pilot's seat
18 Glideslope aerial
19 Forward transmission housing fairing
20 Cockpit overhead window
21 Doorway from main cabin
22 Cockpit emergency exit doors
23 Sliding side window panel
24 Cockpit bulkhead
25 Vibration absorber
26 Cockpit door release handle
27 Radio and electronics racks
28 Sloping bulkhead
29 Stick boost actuators
30 Stability augmentation system actuators
31 Forward transmission mounting structure
32 Windscreen washer reservoir
33 Rotor control hydraulic jack
34 Forward transmission gearbox
35 Rotor head fairing
36 Forward rotor head mechanism
37 Pitch change control levers
38 Blade drag dampers
39 Glassfibre rotor blades
40 Titanium leading edge capping with de-icing provision
41 Rescue hoist/winch
42 Forward transmission aft fairing
43 Hydraulic system modules
44 Control levers
45 Front fuselage frame and stringer construction
46 Emergency exit window
47 Forward end of cargo floor
48 Fuel tank fuselage side fairing
49 Battery
50 Electrical system equipment bay
51 HF/SSB aerial cable
52 Stretcher rack (up to 24 stretchers)
53 Cabin window panel
54 Cabin heater duct outlet
55 Troop seats stowed against cabin wall
56 Cabin roof synchronising shaft
57 Formation keeping lights
58 Rotor blade cross-section
59 Blade balance and tracking weight socket
60 Leading edge anti-erosion strip
61 Fixed tab
62 Fuselage skin plating

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forces and its own Harrier squadrons in the field. It would also be a mistake to regard it as an "old" aircraft just because the first example of the CH-47 flew on 21 September 1961.

Whilst it is true that the original Chinook design is therefore 20 years old, the aircraft has been in production throughout the last two decades and has amassed a considerable number of flying hours (more than 1,600,000) in actual combat and under a wide range of climatic conditions. The lessons learned have successively been incorporated in the newer export models, as has technology originally developed for retrospective modification of early US Army

63 Maintenance walkway
64 Transmission tunnel access doors
65 VHF/AM — UHF/AM aerial
66 Troop seating, up to 44 troops
67 Cargo hook access hatch
68 VOR aerial
69 Cabin lining panels
70 Control runs
71 Main transmission shaft
72 Shaft couplings
73 Centre fuselage construction
74 Centre aisle seating (optional)

85 Oil coolers
86 Cooling air intake grilles
87 Oil cooling air fan
88 Fire extinguisher bottles
89 Fan drive shaft
90 Cooling air outlet louvres
91 Maintenance step
92 Aft pylon construction
93 Swash plate fixed link
94 Aft rotor drive shaft
95 Aft rotor bearing mounting

75 Main cargo floor: 1,440 cu ft (40,78 m³) cargo volume
76 Ramp-down "dam" for water-borne operations
77 Ramp hydraulic jack
78 Engine bevel drive gearbox
79 Transmission combining gearbox
80 Rotor brake

81 Transmission oil tank
82 Engine drive shaft fairing
83 Engine intake screen
84 Starboard engine nacelle

96 Rotor head fairing
97 Aft rotor head mechanism
98 Main rotor blades, glassfibre construction
99 Rotor control hydraulic jack
100 Hydraulic filters and reservoirs

101 Pylon aft fairing construction
102 Blunt trailing edge section
103 Tail navigation light

104 Solar T62-T2A1 auxiliary power unit (APU)
105 APU-driven generators
106 Maintenance walkways
107 Engine exhaust duct
108 Lycoming T55-L-11E turboshaft engine

109 Detachable engine cowlings
110 Rear fuselage frame and stringer construction

111 Rear cargo doorway
112 Ramp extensions
113 Cargo ramp, lowered
114 Ramp ventral strake
115 Fuselage side fairing aft extension
116 Ramp control lever
117 Ramp hydraulic jack
118 Rear undercarriage shock absorber
119 Undercarriage leg strut
120 Single rear wheels
121 Rear wheel optional ski fitting
122 Maintenance step
123 Rear crashproof fuel tank
124 Fuel tank interconnections

125 Ventral strake
126 Main crashproof fuel tank; total system capacity 1,042 US gal (3 944 l)
127 Floor beam construction
128 Fuel tank attachment joint
129 Fuel system piping
130 Fire suppression bottles
131 Forward crashproof fuel tank
132 Fuel filler caps
133 Fuel capacity transmitters
134 ADF sense aerial rail
135 Front undercarriage mounting
136 Twin forward mainwheels
137 Forward wheel optional ski fitting
138 Triple cargo hook system, forward and rear cargo hooks: 20,000-lb (9 080-kg) capacity
139 Main cargo hook: 28,000-lb (12 712-kg) capacity

Chinooks and the company's now frozen heavy-lift helicopter project.

Thus, the Chinook HC Mk 1 enjoys a 50,000 lb (22 680 kg) gross weight, allowing it to carry up to 28,000 lb (12 700 kg) externally on a triple hook cargo system or an internal payload of 19,547 lb (8 867 kg) — virtually the equivalent of the gross weight of its Belvedere predecessor. The ramp access at the rear of the 30-ft (9,1-m) long cabin and the generous CG limits that characterise the tandem-rotor philosophy allow a wide variety of mixed loads to be carried; so much so that a sheer lack of room is usually the only reason to stop loading. Land-Rover-type vehicles can be driven straight in, a winch mounted at the forward end of the cabin will haul in 3,000 lb (1 360 kg) of freight at a time, or folding trooping seats can be fitted to take up to 44 passengers. The aircraft is also amphibious and an inflatable water dam permits the ramp to be powered down, when the aircraft is on the water, to facilitate maritime operations.

Providing the power to lift all this weight are two 3,300 shp Lycoming T55-L-11E engines, driving the two 60-ft (18,3-m) diameter metal-bladed rotors, although these will later be replaced by more advanced glassfibre rotor blades with increased chord and a 3,000 hour mean time between removal. Brand new on the RAF's Chinook is a rotor brake, which will help rough-weather starting and allow ground crew to quickly fold the blades and hide the aircraft during field operations.

A new automatic flying control system, already proven on Canadian Armed Forces Chinooks, has also been chosen for the RAF version and provides airspeed and height hold, sideslip sensing, coupled ILS approach, and automatic cyclic trim. It will also turn the aircraft accurately to any selected compass heading. The communications and navigation system is largely of British origin, and cockpit lighting has been laid out so that one pilot can fly on instruments whilst the other is using night vision goggles.

The first RAF Chinook was rolled out at Boeing Vertol's Philadelphia plant on 31 January 1980 and after completing manufacturer's flight trials was to be delivered later in 1980 to A&AEE Boscombe Down for UK tests, as will the second aircraft. Subsequent airframes will be shipped via Southampton to RAF Odiham where the OCU will be formed. A new helicopter squadron will form on Chinooks, also at Odiham, and in RAF Germany. No 18 Squadron is expected to replace its Wessex HC Mk 2s with Chinooks. All 33 Chinooks should be in service by 1982.

Whether the addition of the Chinooks and the proposed acquisition of enough Aérospatiale AS 332 Super Pumas to re-equip one of the Wessex squadrons will be sufficient to maintain the RAF's rotary-wing credibility into the 1990s is open to speculation. Certainly the trend on both sides of the Iron Curtain is to expand the helicopter force, but one of the problems facing the RAF at the present time is a shortage of pilots, as well as a shortage of hardware. There would therefore appear to be good opportunities for qualified youngsters, who fancy a flying career that still offers some of the thrills experienced by their grandfathers in the 'thirties. How else in the 1980s will you really get to sleep next to your aircraft in a woodland glade and be up at dawn to fly it across the countryside — at 20 ft (6,1 m) altitude all the way! □

(Above right) A prototype of the military version of the Aérospatiale AS 332 Super Puma. The RAF is expected to acquire a batch of these helicopters under the designation Puma HC Mk 2 to re-equip No 72 Squadron. (Below) The first of 33 Boeing Vertol Chinook HC Mk 1 medium lift helicopters for the RAF, photographed on its first flight at Philadelphia on 23 March 1980.

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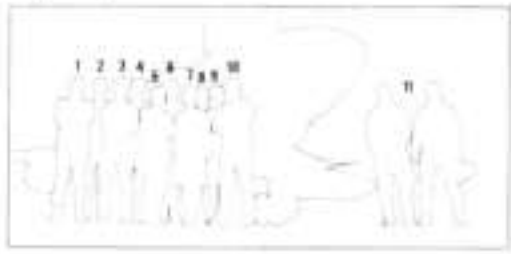

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AIR WAR OVER FRANCE—1940

Forty years ago, squadrons of the Royal Air Force encountered the *Luftwaffe* in strength for the first time, in the air over France. As this account by W J A "Tony" Wood shows, the period of the Phoney War was soon followed by the bitter experience, for the RAF fighter and bomber crews, of being outnumbered, outgunned and outfought. The evacuation at Dunkirk was a minor victory in a major defeat, but it gave the RAF a breathing space in which to regroup for the battle that was to come — a battle that would have a very different outcome.

AT 04.45 hours on 1 September 1939, without prior declaration of war, the air and ground forces of the *Wehrmacht* invaded Poland. Supported by eleven *Panzerdivisionen* and 40 *Infantrie-divisionen*, Army Group North (General von Rundstedt with III and IV *Armee*) launched the attack from Pomerania and East Prussia, while Army Group South (General von Bock with VIII, X, and XIV *Armee*) debouched from the borders of the Wartheland, Silesia and Slovakia. The *Luftwaffe*, fielding a force of 1,500-1,600 combat aircraft, was given two objectives: first, the Polish Air Force was to be totally neutralised in the air and on the ground by a massive pre-emptive strike by bombers, dive-bombers and long-range fighters, and, secondly, on the successful completion of this task, the *Luftwaffe*'s resources were to be turned to the general support of the armies in the field.

Because of the need to keep a strategic reserve in Germany and on the Western Front, only eight *Gruppen* (about 320 aircraft) of fighters and long-range fighters were allocated to the campaign: most of these units were equipped with the latest Messerschmitt Bf 109E fighter and the Bf 110C-1 twin-engined *Zerstörer* (Destroyer), which were considered to be far superior to the Polish PZL 7 and PZL 11c fighters. The bomber force consisted of modern medium bombers, such as the Dornier Do 17Z and the He 111, supplemented by a strong component of Junkers Ju 87B *Stuka* dive-bombers, which had proved their worth in the Spanish Civil War. In summary, the equipment of the *Luftwaffe* was superb in comparison with that of the small Polish Air Force. It was not surprising, therefore, that the *Luftwaffe* was able to achieve its primary task within three days of the start of hostilities. Fighter strafing and medium- and dive-bombing attacks on the airfields at Cracow, Lwow, Radom, Lublin, Wilna, Lida Grodno and elsewhere destroyed aircraft, barracks and fuel and ordnance dumps. The few Polish aircraft encountered were effectively dealt with by the Bf 109s and the Bf 110s in combats wherein the *Luftwaffe* fighter pilots displayed the tactical experience gained in Spain.

The land campaign proceeded with great speed. By 9 September 1939 the IV Pz Div had reached the outskirts of Warsaw but there met with spirited resistance: the Polish counter-offensive on the Bzura River, which started on this day, was repelled. In the East the Soviet Army launched its invasion on 17 September, to capture Lwow a few days later. After savage bombing, Polish resistance crumbled at Warsaw on 24 September, with the last pockets surrendering to the Germans 13 days later. The success of the campaign was overwhelming. Of the *Luftwaffe*'s effort the most outstanding contribution had been afforded by the *Stuka* dive-bomber which, with tanks and mobile personnel carriers on the ground, carved its way through enemy resistance. These tactics of concentration in force and close tactical air co-operation produced a new and terrifying facet in the art of warfare: *Blitzkrieg!*

The RAF goes to France

Hitler's invasion of Poland was a gamble of monolithic proportions. Propaganda, that insidious but vital factor in war, had proclaimed to the world that the might of the *Wehrmacht* outmatched any of its potential foes. It is known that when Hitler committed his forces to the invasion of Poland, his main concern was that the Anglo-French Allies would launch a spoiling action in the West. But it had become apparent during the years prior to the outbreak of war that Allied strategy lay in the defence of France and Flanders along a static line in much the same manner as had been the case in the War of 1914-18. By prior agreement, the British and French forces were, in the event of war with Germany, to deploy the main axis of their defence in North-East France and Flanders and advance to the Dyle River to link up with the Belgian forces. The Franco-German border was defended by the Maginot Line, from Longuyon to Basle, behind which was massed the 2nd French Army. The weakest link in the Allied defensive line was athwart the rugged and wooded Ardennes: here, it was reasoned, rapid movement of enemy troop and tank concentrations was impossible.

With the outbreak of war, Field Marshal Lord Gort's British Expeditionary Force, which was to reach a strength of nine Divisions, established its line on the Bailleul-Maulde sector in North-East France. The Royal Air Force, with a strength of 1,660 first-line

(Heading photo) A Fairey Battle of No 88 Squadron in company with an Armée de l'Air Morane-Saulnier MS 406 C1, at Auberive-sur-Suippes in April 1940. (Below) Junkers Ju 87Bs at an unidentified airfield in France. Wrecked RAF aircraft are seen dumped in the foreground; note that souvenir hunters have removed the RAF markings and serial number from the Hurricane.

(Right) Gloster Gladiator II N2304 of No 615 (County of Surrey) Squadron, one of the two AAF squadrons that took their biplane fighters to France as part of the Air Component of the BEF in 1939. The squadron converted to Hurricanes before the German offensive began in May 1940. (Below) A Hawker Hurricane I of No 56 Squadron, as serving at North Weald in 1938; this was one of the units that provided detachments in France in May 1940 to help cover the BEF evacuation.

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combat aircraft based at home, was also committed to the establishment of a small force in France for the tactical support of the BEF, and another to act in a retaliatory bombing capacity.

One day prior to Britain's declaration of war against Germany, on 2 September 1939, the first elements of the Advanced Air Striking Force (AASF), under Air Vice-Marshal P H L Playfair, CB, CVO, MC, left Britain for makeshift landing grounds in France. The rôle of the AASF was to act as deterrent bombing force by threatening the Ruhr and the industrial Saar from advanced bases in Alsace and the Rheims area. Whilst subordinated to the AOC-in-C RAF Bomber Command, Playfair's HQ at Rheims commanded five light-bomber Wings, each consisting of two squadrons, which were drawn from No 1 (Bomber) Group in the United Kingdom. These were No 71 Wing (Gp Capt H S P Walmsley) with Nos 15 and 40 Squadrons at Betheniville; No 72 (Gp Capt H S Kerby) with Nos 105 and 226 Squadrons at Rheims-Champagne; No 74 (Gp Capt R T Leather) with Nos 103 and 150 Squadrons at Challerange; No 75 (Gp Capt A H Wann) with Nos 88 and 218 Squadrons at Auberive-sur-Suippes, and No 76 Wing (Gp Capt R M Field) with Nos 12 and 142 Squadrons at Berry-au-Bac. The equipment of these squadrons of the AASF was the Fairey Battle.

In addition to the strategic bombing force of the AASF, the Air Component of the Field Force (later termed the Air Component of the BEF) was allocated to the support of Lord Gort's ground forces. Commanded by Air Vice-Marshal C H B Blount, OBE, MC, the leading elements of the Air Component reached their bases in North-East France on 15 September 1939. Initially, the establishment of the Air Component, which was subordinated to the GOC of the British Expeditionary Force, consisted of four fighter units, Nos 1, 73, 85, and 87 Squadrons (Hurricane Mk I), four GR/bomber squadrons,

(Below) An Armstrong-Whitworth Whitley of No 77 Squadron, which flew night bombing raids against targets in Germany and France in May/June 1940.

(Below) Fairey Battle K9353 of No 218 Squadron at Auberive-sur-Suippes as part of the AASF in France in 1940.

Vickers Wellington IA of No 37 Squadron, as used for night bombing operations during the German offensive in the Low Countries.

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Nos 18, 57, 118 and 139 with Blenheim I-IVs and four squadrons of Lysanders for army co-operation. In addition to the AASF and the Air Component, No 1 British Air Mission liaised between the RAF Chief of the Air Staff and Gen Vuillemin, the C-in-C *Armée de l'Air*. No 2 Air Mission provided a similar service between the AOC-in-C RAF Bomber Command and Gen Mouchard of the French 1st Army (North-East Front).

On 31 December 1939, the Air Ministry ordered the formation of the British Air Forces in France (BAFF). Instituted on 15 January 1940, the BAFF, commanded by Air Marshal A S Barratt, CMG, MC, co-ordinated the operational activities of the AASF and the Air Component from its headquarters at Coulommiers, to the East of Paris. By January 1940 the establishment of the RAF in France had stabilised. The Advanced Air Striking Force (Rheims) controlled the five Wings of Battles, and No 67 (Fighter) Wing under Wg Cdr C Walter: subordinated to the latter were Nos 1 and 73 Squadrons based at Vassincourt and Rouvres respectively. The Air Component (Maroeuil) controlled the aforementioned Blenheim and Lysander units, and No 60 (Fighter) Wing, to which Nos 85 and 87 Squadrons were subordinated: these Hurricane squadrons had been joined by Nos 607 and 615 Squadrons (Gladiator) during the previous November. The fighter units of the Air Component were located at Lille-Seclin and Merville. Up to and including the month of April 1940 the average serviceability of the BAFF was 83%, with 94 Hurricanes, 84 Battles, 82 Lysanders and 72 Blenheims being available daily.

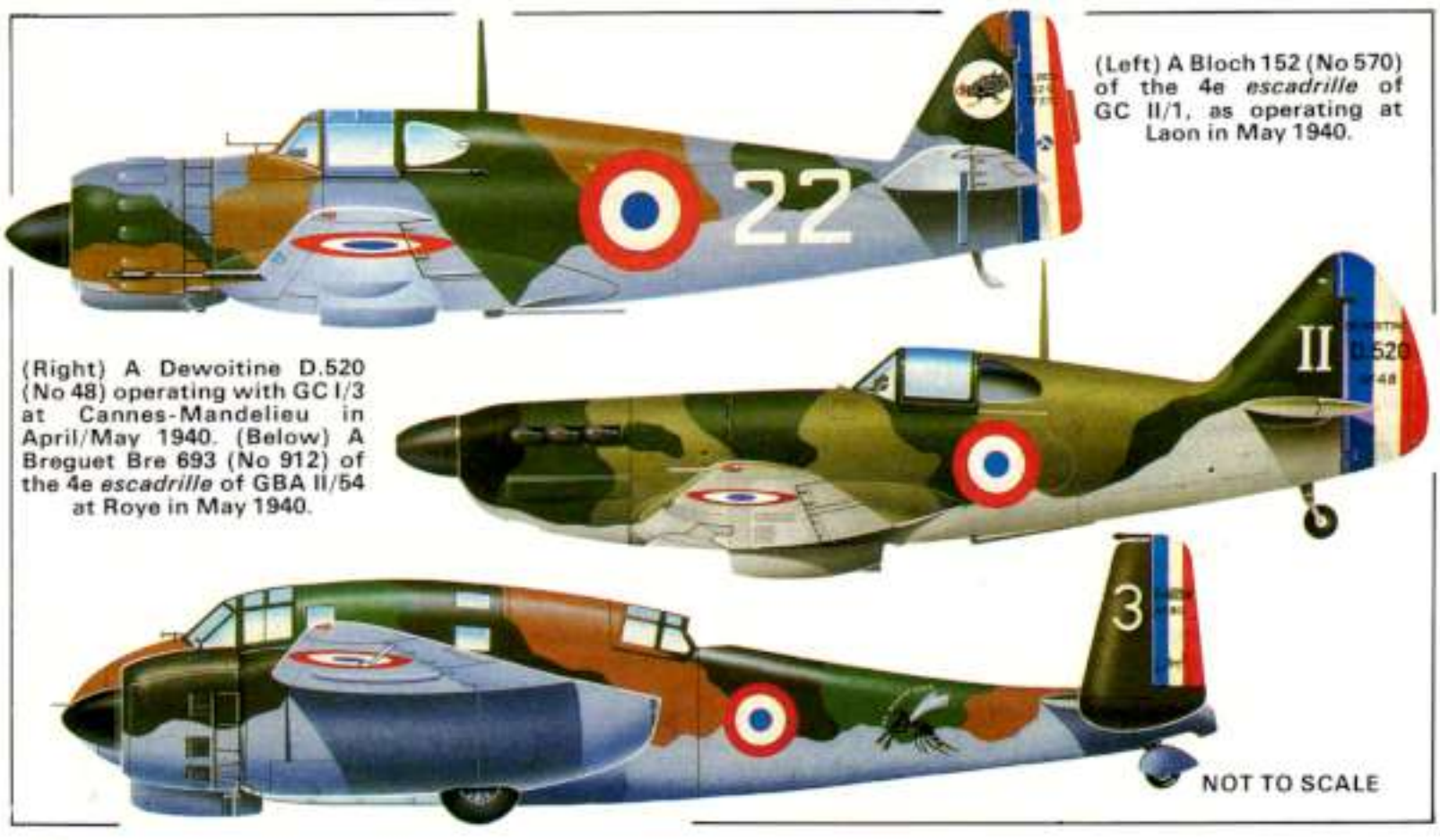
Early operations

Following upon the German invasion of Poland and the establishment of British forces in France there ensued a period of total inactivity on the ground. This period, a time of great tension, lasted until May 1940 and became known by the British as the "Phoney War": the Germans called it the "*Sitzkrieg*" or sitting war. In the air, however, both the Allies and the Germans were active: the *Luftwaffe* operated a high level of reconnaissance missions to form a coherent picture of British and French dispositions. The AASF was active from the start, sending small formations of Battles some 10-20 miles (16-32 km) across the Franco-German border: on 20 September 1939, the Battles scored the RAF's first combat kill of the war when Sgt F Letchford, the gunner in Fg Off L H Baker's aircraft (K9243), shot down a Messerschmitt Bf 109. Baker's crew, however, was the sole surviving one out of the formation of three. Ten days later five Battles of No 105 Squadron, flying an armed-reconnaissance at 20,000 ft (9 750 m) over the Saarland, came under heavy and accurate 88-mm *Flak*. While they weaved to avoid the bursts, a *Staffel* of Bf 109s bounced them from out of the sun, and shot down three Battles, while a fourth was forced to crash-land. The fifth, piloted by Sqn Ldr W M L Macdonald, was hounded by 109s and ended up in a vicious combat at tree-top height. The outcome of the fight was inevitable, and Macdonald's Battle, by now riddled with 7,9-mm bullets, crashed and cartwheeled in a French field: the crew survived.

These, and other similar incidents, offered stark evidence of the vulnerability of the Battle. Even by the standards existing in 1939 the Fairey Battle was obsolete. It was a large, unwieldy single-engined monoplane powered by a Merlin III (Battle Mk III) of 880 hp for take-off and rated at 1,440 hp at 5,500 ft (1 677 m): its all-up weight was 10,792 lb (4 896 kg) with full fuel and bomb load, making it ponderous and slow. The maximum speed at sea level was a mere 210 mph (322 km/h). Notwithstanding the fact that heavy fighter armament had been the order of the day since 1935, the armament of the Battle was similar to that of the Bristol FB.2 Fighter of the First World War: the pilot aimed a single 0·303-in (7,7-mm) machine-gun fitted in the starboard wing, while the gunner operated either a Browning or a Vickers-K gun of similar calibre from the rear cockpit. A hand-operated ventral machine-gun was also sometimes fitted. The Messerschmitts that these Battles encountered were either Bf 109E-1s each with four 7,92-mm (0·310-in) MG 17s or twin MG 17s and two Rheinmetall MG FF 20-mm (0·78-in) cannon in the Bf 109E-3s. In addition to the threat from the air, the liquid-cooled Merlin of the Battle had proved to be susceptible to the effects of ground fire. After No 105 Squadron's incident of 30 September the AASF wisely opted to use the type by night when on operations, and to practice low-level tactics where the risk of fighter attack were lessened.

During the long autumn and the bitterly cold winter that followed, the Hurricanes of the AASF and the Air Component flew armed patrols over the lines and short penetrations into enemy airspace, in addition to several interception sorties against high-flying reconnaissance Do 17s and He 111s. No 1 Squadron flew its first patrol on 15 October 1939: at 11.00 hrs Sqn Ldr P J H Halahan led five sections, each of three Hurricanes, from Etain for a patrol over the Saarlautern sector. The patrol penetrated 40 miles (64 km) into German airspace, where it came under heavy *Flak* and saw its first Messerschmitts: these did not accept combat and dived away. No 1's first kill occurred on 30 October 1939, when Plt Off P W O Mould, flying Hurricane L1842, shot down a Do 17P near Toul: several successful interceptions followed, with kills being claimed by No 1 and the other fighter units in Nos 60 and 67 Wings.

When the commitment of six fighter squadrons to the BAFF is considered in the light of Fighter Command's weak strength at this



(Left) A Bloch 152 (No 570) of the 4e *escadrille* of GC II/1, as operating at Laon in May 1940.

(Right) A Dewoitine D.520 (No 48) operating with GC I/3 at Cannes-Mandelieu in April/May 1940. (Below) A Breguet Bre 693 (No 912) of the 4e *escadrille* of GBA II/54 at Roye in May 1940.

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time, then the objections voiced by Air Marshal H C T Dowding, the AOC-in-C RAF Fighter Command, appear to be entirely reasonable. For example, at 18.00 hrs on 29 September 1939 the initial establishment (IE) of Fighter Command stood at 710 aircraft. Of this respectable figure, however, upon which the defence of the United Kingdom rested, only 272 were Hurricanes and 176 were Supermarine Spitfire Mk Is: and of these, a combined total of 232 and 184 were on strength and serviceable respectively. The remainder were Blenheims (112), Gladiators (64), Gauntlets (16), Hinds (16) and 54 Lysanders. It was true that production of the Hurricane and Spitfire — the only types capable of facing the Messerschmitt Bf 109 — was in full sway, and that squadrons were undergoing a steady conversion to type: by 31 December 1939 the Command had 265 Hurricanes and 259 Spitfires on strength. But even this in no way compared to the overwhelming numbers of Messerschmitt Bf 109s available to the *Luftwaffe*: on 1 September 1939, 235 Bf 109B and C types, and no fewer than 850 Bf 109Es, were on strength in the *Jagdgeschwader*. In France it was inevitable that the Messerschmitt would be encountered in fighter-versus-fighter combat and to Dowding, who had reasonably accurate intelligence concerning *Luftwaffe* strength, it seemed clear that a piece-meal fighter force would be annihilated. In the face of political pressure he could do little but voice his grave concern for the commitment of fighter units to France. He was adamant that no Spitfire squadrons would be posted to the BAFF, and that new aircraft, weapons, ammunition, and POL would be supplied to his Command as first priority. As a result, the Hurricane and Gladiator squadrons based in France often went short of essential spares, guns and equipment.

The Hurricane Mk Is of the BAFF proved to be ideal in the tough operating conditions prevailing in France, with their rugged construction and fine handling characteristics. Some were fitted with Merlin IIs driving the two-bladed Watts propeller, while the Merlin III-engined aircraft had DH three-bladed props, although the valuable constant-speed mechanisms for the latter were not fitted until May 1940. With the Watts propeller, the Mk I was capable of 308 mph (495 km/h) at 15,450 ft (4 704 m), and with the DH propeller, 324 mph (522 km/h) was attained at 15,650 ft (4 760 m). Time to 20,000 ft (6 100 m) was 12·4 minutes. The eight Browning Mk II 0·303-in (7,7-mm) machine-guns were aimed by a GM.2 reflector sight and harmonised to about 450 yards (411 m). Highly manoeuvrable in all axes of flight, the Hurricane was to prove to be a worthy opponent to the early Bf 109Es.

On 22 November 1939, a Messerschmitt Bf 109E-3 (W Nr 1304) of II/JG 54 fell into French hands when its pilot force-landed at Wörth, Bas-Rhin, some 12 miles (20 km) on the French side of the border. After evaluation at Orleans-Bricy, RAF and *Armée de l'Air* pilots were permitted to fly it and assess its qualities. Pilot Officer M H Brown, of No 1 Squadron, was one such pilot and flew the aircraft at Orleans on 3 May 1940: the Adjutant of No 1 recounted the experience as follows:

"Having decided to some purpose, and having gotten used to its vagaries, had a practice skirmish with a Hurricane, P/O P P Hanks mounted. One gathers that the spectators were considerably more shattered than the pilots concerned. From this exhibition several facts emerge. The Hurricane is infinitely more manoeuvrable at all heights and, at ground level, is slightly faster. The Me 109E, however, is unquestionably faster at operating heights and, although apparently tricky to fly and not particularly fond of the ground, possesses many fine features. To offset its disadvantages it has an excellent view to the rear."

Encounters between BAFF Hurricanes and the elusive Bf 109s were rare during the early spring of 1940 but by March No 73 Squadron had shot down its first Messerschmitt and then added four more to its tally by the end of the month. Three kills fell to Fg Off E J "Cobber" Kain, of No 73 Squadron, who was awarded one of the first DFCs in Fighter Command. With limited and sporadic chances of encounter there was no gainsaying which fighter, Hurricane or Messerschmitt, had the upper hand in combat. This situation was to remain as such until the early hours of 10 May 1940.

Force and counterforce

With the securing of his Northern flank by the invasion of Norway and Denmark on 8 April 1940, Hitler felt at liberty to proceed with the final campaign in the West, aimed at defeating France and Great Britain: this had to be achieved before any adventures took place in the East. *Fall Gelbe* (Plan Yellow), the operations plan for the invasion of Holland, Belgium and France, was a massive undertaking and contained a grave element of risk for Germany. After securing the

(Above) Two squadrons of Gloster Gladiators served in France with the Air Component of the BEF. Illustrated here is a Gladiator II of "B" Flight, No 615 (County of Surrey) Squadron at Merville in November 1939. (Below) Among the more elderly types serving the Luftwaffe *during its push through France and the Low Countries was the Henschel Hs 126 observation monoplane.*

Northern flank by the invasion of Holland and Belgium, the bulk of the *Wehrmacht* was to strike through Luxembourg to the Ardennes and broach the French border between Namur and Montmedy: crossing the Meuse, the army forces, using armour and close *Luftwaffe* support, were to thrust across France and cut the Anglo-French forces in two by reaching the coast at the Somme Estuary. Air operations were in the hands of *Luftflotten* 2 and 3: the former, under Gen d Lw Albert Kesselring, with *Fliegerkorps* I and IV, covered the northern area for the attack by Army Group B (Bock) on the Dutch-Belgian sector; to *Luftflotte* 2 were added the maritime and sea-mining forces of *Fliegerdivision* 9. The central and southern sector was covered by Gen d Lw Hugo Sperrle's *Luftflotte* 3, with *Fliegerkorps* II and V, and the tactical *Fliegerkorps* VIII, concentrated in the centre for the attack in the Ardennes-Luxembourg sector. Here, the 45 *Divisionen* of von Rundstedt's Army Group A were poised, while in the south only 19 *Divisionen* of von Leeb's Army Group C faced the static defences of the Maginot Line.

Not counting the German preponderance in men and material on the ground, the *Luftwaffe*, by amassing units and re-equipping new formations, fielded some 3,530 combat aircraft in the West out of its total strength of 4,500: this force included 860 Bf 109s, 1,300 He 111s and Do 17s, 380 Ju 87 *Stukas* (mostly in Fl Kps VIII), and 350 Bf 110 *Zerstörern*, and was backed up by 475 Ju 52/3m troop-carriers and 45 DFS 230 gliders for airborne operations. A vital part in the impending attack was to be played by the dive-bombers and close-support aircraft of Fl Kps VIII, commanded by Gen Lt Wolfram Frhr von Richthofen, who had pioneered the art of tactical support in Spain and later in Poland. With the *Luftwaffe*, Göring and the *Lw Führungsstab* (Operations Staff) had overlooked nothing. The crews were the best trained and, thanks to rotation with the Condor Legion in Spain from 1937 to 1939 and combat experience in Poland and Norway, were the most tactically proficient in the world. Their aircraft were modern, and the quality of their weapons, ordnance and equipment superb. Conceived and moulded as the servant of the army in the field, the *Luftwaffe* was the finest tactical air force extant.

The forces of *Luftflotten* 2 and 3 faced a numerically strong, but otherwise divided and obsolescent, air force of the Anglo-French component aided by the wavering neutrality of Belgium and the Netherlands. The French *Armée de l'Air* had been sadly neglected during the inter-war period and comprised a total of some 1,200 aircraft: on 10 May 1940 its fighter *Groupes de Chasse* had a total of 552 Morane-Saulnier MS 406, Dewoitine D.520, Bloch MB-151/152 and Curtiss Hawk 75A fighters on strength. With the exception of the fine D.520, of which there were 36 on strength, all

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GENERAL DYNAMICS

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A Junkers Ju 87B-1 of 7./St.G.51 (subsequently 4./St.G.1) as used during the French campaign in May/June 1940.

(Below) A Messerschmitt Bf 109E-1 of III/JG 51 in April 1940; this was one of the many *Jagdgruppen* committed to the operations against France in May.

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the French fighters were inferior to the Bf 109E. The remainder of the *Armée de l'Air*'s forces consisted of some 100 Potez 63 twin-engined fighters, 150-175 obsolete bombers (with the exception of a few LeO 45s), and 350-400 reconnaissance types. The pilots and crews of the *Armée de l'Air* were to maintain their efficiency and bravery to the end of the impending campaign, but the late service introduction of their two best combat types, the Dewoitine D.520 and the LeO 45, encapsulated the bungling and inertia of that nation's politicians and generals.

The strength of the Dutch and Belgian air forces was negligible. The Dutch Air Force could muster about 132 combat aircraft, mostly Fokker D XXIs, and a few of the fine Fokker G Is. Of the Belgian Air Force, the three *Regiments d'Aéronautique* had 82 Fairey Foxes, 21 Renard R.31s, 15 Gladiators and 23 Fiat CR.42 biplanes: the only concession to modernity was to be found in the Hurricane Mk Is of le *Groupe*/2e *Regiment* at Diest-Schaffen, and 14 Fairey Battles. Therefore, of the 650-odd Allied fighters facing the *Luftwaffe* in May 1940, few could match the latest Messerschmitt Bf 109Es while the vast majority were incapable of tackling even the Bf 110C-1 *Zerstörer*, upon which the *Luftwaffe* was to rely for deep-penetration interdiction work: the biplane fighters would be outstripped in speed and performance by the German bombers. The *Luftwaffe*, therefore, had a 2:1 numerical superiority along with excellent experience, aircraft and equipment; this superiority was to be used along the now proven lines of the *Blitzkrieg* technique — first, nail the enemy air force to the ground, then support the armoured thrusts of army at localised points of concentration.

The May blitz

At first light on the morning of 10 May 1940, the *Wehrmacht* struck in the West. The Heinkels and Dorniers of *Fliegerkorps* I, II, IV and V bombed their primary targets: the bases, landing strips and depots of the Allied air forces in France, Belgium and Holland received medium- and high-level attacks by bombers escorted by Bf 109s and Bf 110s. The element of surprise was excellent, and heavy damage was done — in particular to the French air bases at Metz-Frascaty, Nancy-Essey, Toul/Croix de Metz, Dijon and Romilly. Fighter reaction by the Allied forces was prompt and valiant but, in the first major fighter battles of the war, it was soon apparent that the strength and efficiency of the *Jagdgruppen* overwhelmed all but the most able. Of this first momentous day, the diarist of No 1 Squadron can again be called upon to note:

"10 May 1940. It has come! Today, for us, war broke out and there was ceaseless activity. A patrol consisting of F/Lt P R Walker, F/O M H Brown, F/O J I Kilmartin, F/O P H M Richey and Sgt F J Soper accounted for a Dornier 215 near Longuyon. The bomber's objective was apparently the railhead and the station nearby. Later in the morning F/Lt Hanks and F/Lt Lewis brought down a Do 17. Pilot Officer Mould and F/O Drake each destroyed a Me 110, but Mould's machine was shot about but he managed to reach the airfield where his machine passed out. P/O Mould's overalls were ripped by a bullet at the ankle although he, himself, was untouched. Flight Lieutenant Walker, in a later engagement, was shot about and landed wheels-up East of Verdun; F/O Lorimer, in the same flight, was set on fire and baled-out. Meanwhile, at Neuville, droves of Dorniers were passing overhead at regular intervals, and orders were received to take every machine that was flyable into the air and circle madly around the aerodrome. One Hurricane had no guns. F/O Salmon departed by car to pick up F/Lt Walker and F/O Lorimer, and at mid-day the Squadron moved to Berry-au-Bac at Rheims. Half-an-hour after our arrival at the new airfield the Boche came over and left his visiting card in the form of 14 anti-personnel bombs. Unfortunately three French labourers and three horses were killed. The Ops tent was immediately moved to a more salubrious position. This proved to be a wise precaution.

"11 May 1940. Rear party left at Neuville in case of return. Nothing to report in the morning. But two patrols went out and considerable embarrassment was caused by the Huns. Blue Patrol had a combat NE of Rethel at 17,000 feet with Me 110s, and three were definitely shot down: one Me 110 forced-landed at Chemery and two POWs were taken by the French. Later in the afternoon Patrol A-1 took-off to patrol Mezieres at 7,000 feet and, at 19.15 hours, encountered 40 bombers with an escort of 110s: the patrol attacked the escort, and the enemy bombers turned North.

"Questioning the pilots immediately after combat it has been found extremely difficult to obtain concise information as to what actually happened, as most pilots, after aerobatting themselves into a stupor, were still pressing imaginary buttons and pulling plugs an hour or so after landing. Wreckage of eight 110s and one Hurricane found. Numerous enemy raids on Vassincourt, and No 1 Squadron now raided nightly."

Nos 1 and 73 Squadrons escaped lightly on the first morning of the invasion, but other Allied units, both bomber and fighter, were badly mauled on the ground and in the air. As the Germans struck in the north, with paratroop drops by *Fliegerdivision* 7 at Moerdijk, Waalhaven, Valkenburg and Fort Eben-Emael, the French 7th Army Group and the BEF moved forwards to the River Dyle. In the centre, von Rundstedt's *Heeresgruppe* A was feeling its way through Luxembourg and the wooded Ardennes towards its first obstacle, the River Meuse between Sedan and Maastricht. During the period 12-

15 May 1940 the *Panzerdivisionen* of *Heeresgruppe* A penetrated the French line near Sedan to cross the River Meuse: by 15 May the leading elements of Reinhardt's PzKw III tanks had blasted their way through the defences to a position 37 miles (59 km) west of the Meuse: the air support by the Stukas of *Fliegerkorps* VIII was efficient and devastating.

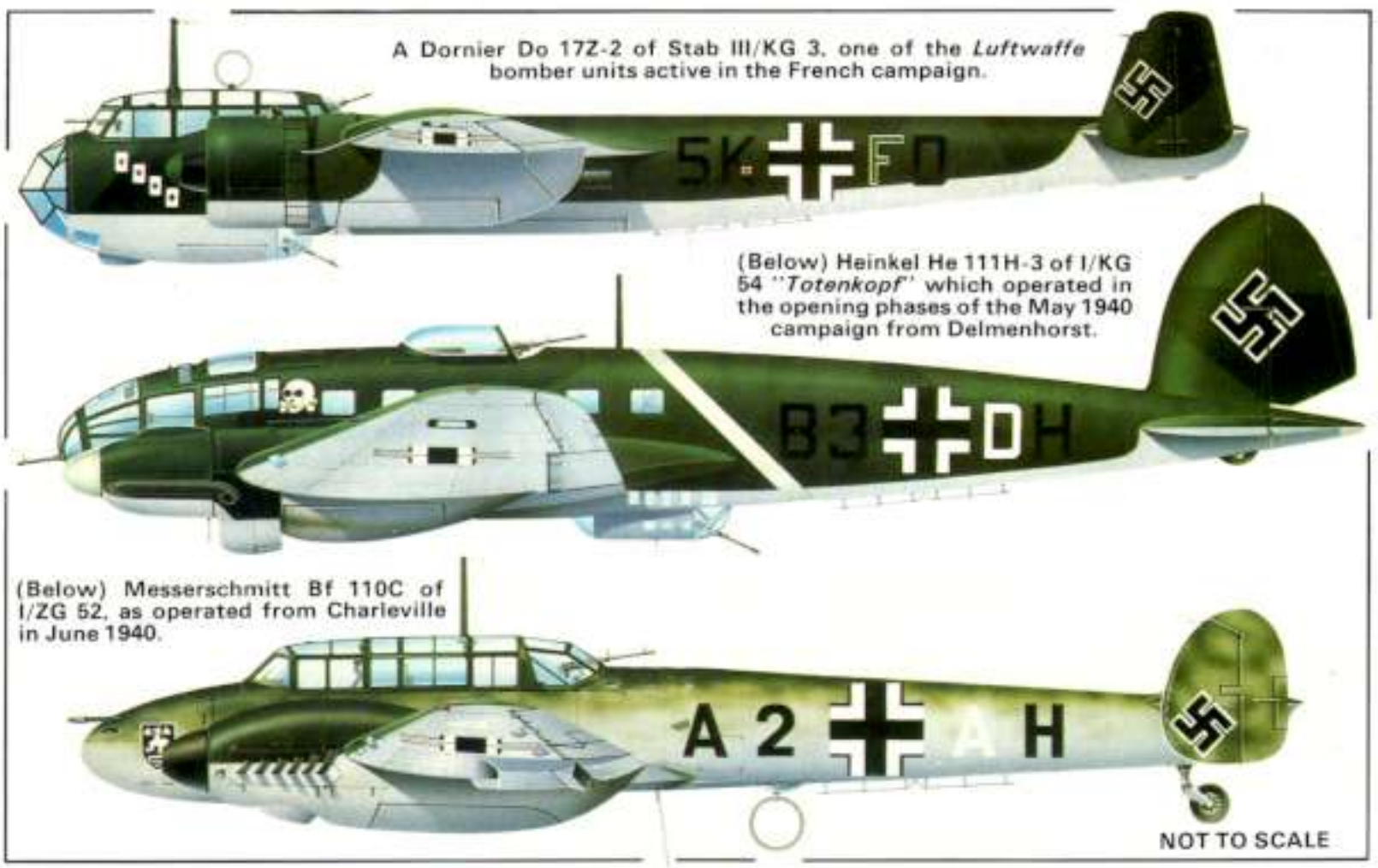
The first four days of the German assault saw the evisceration of the AASF in a series of gallant attacks in an attempt to stem the advance. Unbelievable though it seemed, the French air force *supremo* placed an embargo on all Allied offensive operations over enemy-held territory on 10 May: that afternoon, however, Air Marshal A S Barratt decided to ignore this restriction and authorised a maximum effort attack by the Battles of the AASF on German road traffic in Luxembourg. No fighter escort was available, so the attack was planned at 250 feet (76 m) with the 250-lb (113-kg) GP bombs fused for 11 secs delay: in the first wave three Battles were shot down, and a similar fate was experienced by the second wave. Thirteen Battles were lost out of the 32 despatched this day. No 2 Group's Blenheims were also active with raids on Ypenburg and Waalhaven, while Wellingtons of Bomber Command, flying from their bases in the UK, followed up the attacks at night. On the following day seven out of eight Battles, of Nos 88 and 216 Squadrons, were lost. On 12 May, in an attempt to knock out the bridges at Veldwezelt and Vroenhoeven, on the Albert Canal, five volunteer crews of No 12 Squadron set out. Not one returned. Later, when it was learned that the Veldwezelt bridge had been badly damaged in the attack, the crew deemed responsible, Fg Off D E Garland and Sgt T Gray, received posthumous Victoria Crosses — the first to be awarded to a RAF crew in the Second World War.

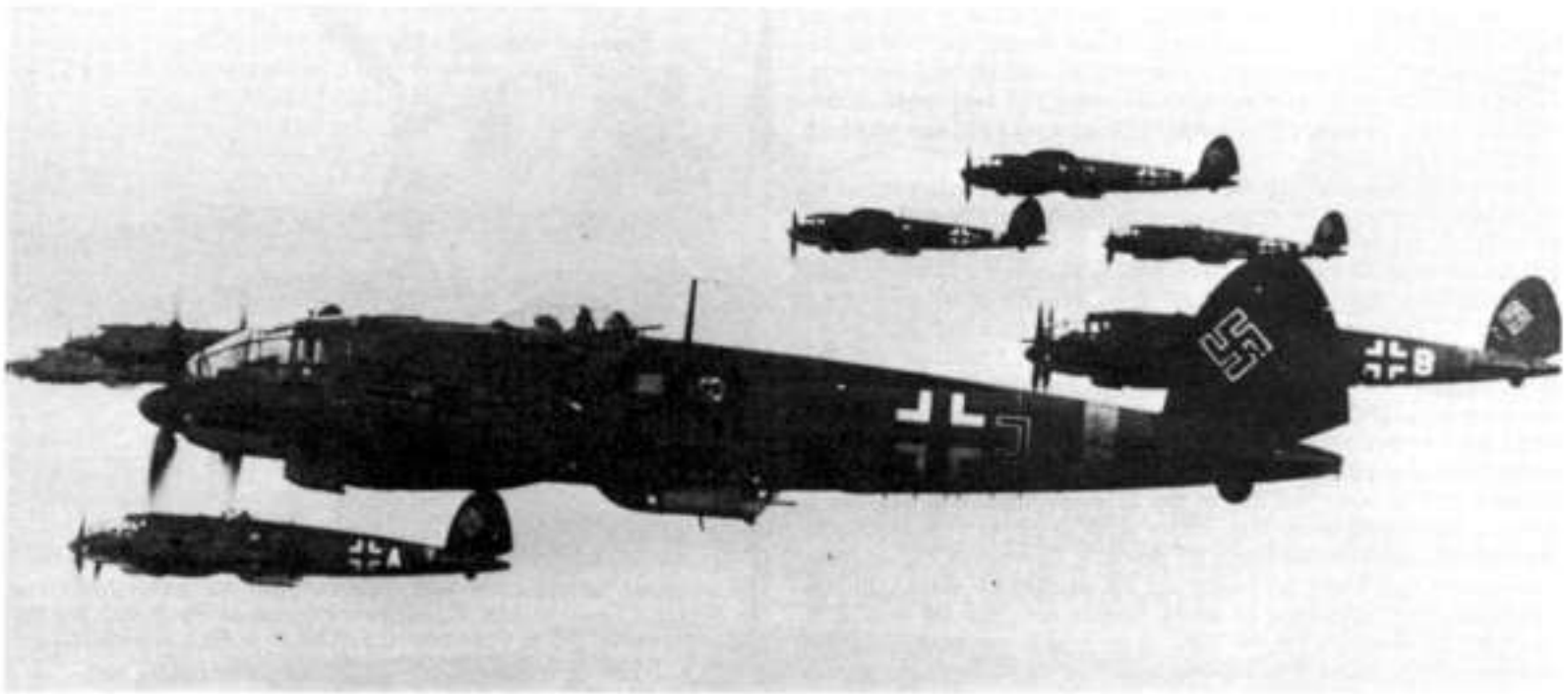
The *Luftwaffe Flakbattalionen*, attached to the army, were amongst the most efficient: they were armed with automatic 20-mm (0·78-in) or 37-mm (1·45-in) guns, and these, in addition to the standard infantry weapons, made low-level attacks extremely dangerous. With the serious situation developing in the Sedan area, the French High Command made energetic appeals to the AASF for the destruction of pontoon bridges across the Meuse at Mouzon and Sedan. Early in the morning of 14 May 1940, 10 Battles of Nos 103 and 150 Squadrons were despatched to attack these targets: flying at medium-level, they avoided *Flak* and encountered no opposition from the *Luftwaffe*. Between 15.00 and 16.00 hrs, the AASF launched every available aircraft on a mission to the Sedan bridges. On this occasion the Messerschmitts were waiting. Of the 63 Battles

The principal fighter serving with the Armée de l'Air *in May 1940 was the Morane-Saulnier MS 406 C1, which proved no match for the* Luftwaffe*'s Bf 109Es. Captured MS 406s at a French airfield here come under the scrutiny of a German soldier.*

of Nos 12, 142, 226, 105, 150, 88, 103 and 218 Squadrons despatched, 35 were either shot down or rendered Cat E by *Flak* and fighters. In addition, five of the eight Blenheims of Nos 114 and 139 Squadrons sent to the same target were lost. The casualty rate of 56% (40 aircraft Cat E out of 71 sent) was never again to be experienced in the annals of the Royal Air Force in the war. After this attack, what remained of the AASF operated by night, and on days only when heavy fighter escort was available.

In response to repeated demands by Air Marshal A S Barratt, Nos 1 and 73 Squadrons of the Air Component were reinforced by Hurricanes of Nos 3 and 79 Squadrons on 10 May, and by No 504 Squadron on 12 May 1940: on the following day 32 pilots (without aircraft) were also sent to France. The AASF received Nos 3 and 501 Squadrons on 11 May 1940. The BAFF fighter Wings operated at a disadvantage thanks to the delay encountered before the receipt of reinforcing squadrons from England. From 10 to 15 May 1940, the Hurricanes of the BAFF were forced to operate at maximum pressure in the defence of their own airfields and, during this time, an





Heinkel He 111 bombers drawn from the Fliegerkorps *I, II, IV and V played a major rôle in the* Luftwaffe*'s attacks launched on the morning of 10 May 1940 against air bases in France, Belgium and Holland. A formation of He 111Hs is seen here returning from a sortie.*

unsubstantiated claim of 78 enemy aircraft (E/A) destroyed, four probably destroyed, and four damaged was made for the loss of four Hurricanes.

During the period 16-22 May 1940, the Germans reached the Aisne, turned West, and lunged for the St Omer-Amiens area. With the AASF Battles operating by night, the Blenheims of No 2 Group continued to attack by day with heavy losses: on a raid against enemy columns at Gembloux, 11 out of 12 were shot down. Commitments of the BAFF fighters included escort cover for day bombers operating against targets at Namur, Gembloux, Dinant, Givet, Amiens, Abbeville, Arras and Cambrai, along with airfield defence, offensive patrols against Stuka operations in the Cambrai area, and escort for reconnaissance aircraft to the North of Rheims. But, despite counter-attacks, there was no stopping the armoured thrusts of the *Wehrmacht*. By 20.00 hours on the evening of 20 May 1940, the leading elements of II Pz Div of Gen von Kleist's *Panzergruppe* had reached the Somme Estuary at Noyelles-sur-Mer, thus cutting in two the Anglo-French forces. From 19 May 1940 it became clear that the RAF Air Component could no longer operate from French airfields, and it was withdrawn to Southern England with the evacuation completed by 21 May 1940: in the meantime, the AASF withdrew steadily westwards in the face of the German advance.

Operation Dynamo

During the period 21-28 May 1940, air support for Gort's BEF by day was furnished by No 2 (Bomber) Group and Air Vice-Marshal K R Park's No 11 (Fighter) Group, based in the South of England. The military situation in Artois and Flanders was by now deemed to be untenable and, after suitable preparation, "Operation Dynamo", the mass evacuation of British and French troops from the beaches of Dunkirk, was commenced by the Admiralty at 18.57 hours on 26 May 1940. In the nine days of the evacuation, a total of 338,226 exhausted men were recovered from Dunkirk. With Hitler's order to cease the forward movement of armour, it was left to the *Luftwaffe* to thwart the evacuation and *Fliegerkorps* I, II, IV and VIII were diverted to this task. With the RAF's Spitfires now committed to the battle for the first time, No 11 Group flew standing patrols over the beaches and inland of the Dunkirk perimeter. These sorties were operated without the systemised Fighter Control provided by CH/CHL radar, HF/DF Pipsqueak and IFF aids, so the squadrons operated in a freelance capacity. The relays of standing patrols, although highly wasteful, successfully interfered with the *Luftwaffe*'s attempts to bomb shipping and troop concentrations on the ground. Sometimes, however, the bombers and Stukas did break through. The air battles inland, and above the smoke and clouds, went unseen by the beleaguered troops and an understandable, but mistaken, bitterness was felt at Dunkirk over the apparent lack of activity by the Royal Air Force.

Bloch 152s of the Armée de l'Air *GCII/9 3rd* Escadrille *in June 1940. Like the MS 406, the Bloch fighter was found to be outclassed in air-to-air combat with* Luftwaffe *aircraft.*

Fourteen of Park's fighters were lost on 27 May 1940 when No 11 Group launched 287 sorties: 321 were flown on the following day in support of shipping off the beaches. On 29 May, in an attempt to counter the strength of *Luftwaffe* formations the Air Ministry authorised Park to fly four squadrons at a time over the beach-head. The first use of Hurricanes and Spitfires flying in formations of up to Wing strength proved to be effective in meeting force with force. During the savage fighting of 1 June 1940 some 30 E/A were claimed as destroyed in return for a similar number of RAF fighters, but 15 of the latter's pilots were recovered: the air battles continued at a similar pace until the Dunkirk evacuation came to an end in the early hours of 4 June 1940. At 09.00 hours on the following day, as a result of the demands made by the BAFF and the Dunkirk evacuation, the strength of Fighter Command had ebbed to a mere 466 machines, of which 331 were Spitfires and Hurricanes. The Dunkirk battles witnessed the loss of over 100 fighters and 80 pilots, while the Battle of France, which was not yet over, would ultimately result in the loss of 320 pilots missing or killed, and 115 as prisoners and internees.

The last days

With the completion of the evacuation at Dunkirk, an act that Hermann Göring had failed to prevent despite his assurances to Hitler, the *Luftwaffe* reverted to the tactical support of the ground forces in the thrust to Paris and into the South-East interior of France. *Unternehmen Paula* ("Operation Paula") was a massive fighter interdiction operation that started on 5 June 1940 and was aimed at the final obliteration of the remnants of the *Armée de l'Air* and the BAFF. On this day, the HQ BAFF was located at Orleans, with HQ AASF at Muides, near Blois: No 67 (Fighter) Wing of the AASF, with Nos 1, 73, and 501 Squadrons, was located at L'Aigne and Chateaudun. Of the bomber force, only No 75 Wing (with Nos 88 and 103 Squadrons) and No 76 Wing (with Nos 12, 142, 150 and 226 Squadrons) remained, located at Rocheux, Herbouville, Montonoire, Souge and Houssay. Despite the emphatic objections of Air Marshal Dowding, the AOC-in-C Fighter Command, two more squadrons — destined to be the last — were sent to France, Nos 17 and 242 arriving at Le Mans and Chateaudun on 8 June 1940. By

now the *Luftwaffe* had complete control of the skies, and the losses suffered by both new arrivals were great.

On 14 June 1940 the Germans entered Paris, and two days later the Reynaud Cabinet fell at Bordeaux, to be replaced by the Petain administration. At 05.00 hours on 15 June 1940, Air Marshal Barratt received instructions from the Air Ministry: he was to consult with the GOC of the BEF for the withdrawal of the British forces to England, and shortly afterwards the first troops embarked at the Bay ports. The AASF was transferred to Brest to cover the evacuation. Nos 75 and 76 Wings made for Brest, while No 67 (Fighter) Wing took Nos 1, 73 and 242 to Nantes to cover the embarkation of troops there. By 25 June 1940, with the signing of the armistice, the campaign in France had ended.

During tempestuous weeks since the start of the invasion on 10 May 1940 to the withdrawal of RAF units from France on 20 June, the Royal Air Force lost 944 combat aircraft, including 386 Hurricanes and 67 Spitfires. Machines could be replaced and, in the forthcoming months, the RAF was never to be denied replacement aircraft for those lost on operations. The credit here was to be placed with Lord Beaverbrook — who became the country's first Minister of Aircraft Production in May and co-ordinated what was a buoyant airframe and engine industry — and with the unrelenting efforts of RAF Maintenance Command and the Civilian Repair Organisation. The tragedy of France and Dunkirk lay in the loss of irreplaceable Regular Officers and Non-Commissioned Officers, whose service dated back to the inter-war years when the training standards were extremely high. They were young, professional and would soon have been promoted to command: but in the embers of the British Air Force in France lay the cream of No 1 (Bomber) Group; No 2 (Bomber) Group had also fought relentlessly, with appalling losses in experienced crews.

For RAF Fighter Command, on the eve of its greatest test that was to come in the summer of 1940, little had been brought back from France save the shattered remnants of squadrons, with pilots and ground crews exhausted and demoralised, and their aircraft and equipment strewn over the fields of France. "France — the whole thing had been a bloody shambles" said one fighter pilot, and he echoed much of what was felt within the ranks of the squadrons on their return. What had been gained, however, despite justifiable unawareness at the time, was of inestimable value. There was, and is, no substitution for combat experience. Training can prove techniques and refine tactics, but nothing can give the cut-and-thrust, the wily sense of self-preservation and the grim determination to kill, as the experience of shooting or being shot at.

The *Luftwaffe* had blooded its crews in Spain, Poland, Norway and now France, and stood poised after suitable relaxation for the final task of obliterating RAF Fighter Command to make way for the invasion of Great Britain. The fighter pilots of the *Jagdgeschwader*, upon whom rested the responsibility for the protection of the bombers and the combating of RAF fighters, were confident of their tactics, their machines and their ability to fulfil their task. Already the posts of *Staffelkapitän* (Squadron Leader) and *Gruppenkommandeur* (Wing Commander) within the fighter units, held up to this time by the old peace-time officers, were passing to such young, successful professionals as Adolf Galland, Walter Oesau, Günther Lützow, Wilhelm Balthasar and others who had won their spurs in combat. But now RAF Fighter Command had the men with the essential qualities with which to meet these *Experten* in the forthcoming battles over Southern England. The experience over Dunkirk and in the battles over France brought about desperately needed changes in tactical flying with which to counter the deadly *Rotten* and *Schwärme* (finger-four) formations that gave the *Luftwaffe* pilots such an element of fluidity and at the same time cohesion in combat. Harmonisation of guns was reduced to 220 yards (201 m) to increase hitting power; the improved Browning Mk II Star was hurried into service, with improved Ball and de Wilde Incendiary Tracer rounds; constant speed propeller mechanisms were urgently fitted to the DH and Rotol airscrews to give improved rates of climb and acceleration in the dive on the Spitfires and Hurricanes. But nothing could compare with the experience gained in combat of the pilots of Nos 1, 3, 73, 79, 85, 87, 242, 501, 504, 607 and 615 Squadrons who had fought in France; men such as Halahan, Richey, Brown, Nowell, Beamont, Orton, Hogan and many others; or the pilots such as Deere, Bader, Tuck, Malan, Allen and Leathart who had fought the 109s over Dunkirk in their Spitfires. It was upon these men, the surviving band of Officers and NCOs of France and Dunkirk, that RAF Fighter Command — and ultimately the nation itself — would rely for its survival in the most crucially strategic air campaign of the Second World War. □

(Above top) A Messerschmitt Bf 110C of Stab I/ZG 52 over France in June 1940 and (immediately above) a similar aircraft of 1./ZG 2 shortly after making a forced landing during operations in France. (Right) Bf 109E-1s of 8./JG 2 "Richthofen" at an advanced airfield in France in late May, 1940. This unit was in the thick of the fighting over France, then re-equipped on later Bf 109E variants before joining in the Battle of Britain.

COLOURS OF THE DAY

A feature shared by all types of aircraft operated by the RAF today, whatever their rôle, is that they sport an external finish that is often eye-catching and always related to their operational environment. The finishes range from those that seek to camouflage or hide front-line aircraft from enemy eyes to those adopted to make their bearers conspicuous, as in the case of trainers and SAR helicopters. Some of the factors that have to be taken into account when selecting a finish for military aircraft are here discussed by Sqn Ldr J D Armstrong, RAF.

THE SHIFT in emphasis towards low-level tactical operations which took place in the mid-1960s rekindled interest in aircraft camouflage, a topic which had largely lain dormant since the end of the Second World War. In the interim, natural aluminium finishes were the order of the day for most fighters and bombers, but today the use of aircraft camouflage is almost universal among air forces. There appears to be little agreement as to the most suitable colour schemes for modern operations, with several major air forces (and naval air arms) now engaged in experiments with alternative finishes.

Perhaps the only common factor is the belief that camouflage to defeat visual observation is still worthwhile, even though a variety of sensors cover ever-widening bands of the electro-optical spectrum. It is difficult to back this faith in the value of camouflage with conclusive evidence because the evaluation of camouflage schemes — even by simple comparison — depends upon subjective judgement derived from human vision and perception, factors which are complex to say the least. Nevertheless, the aircrew who see the effects first hand are firmly in favour of camouflage.

Camouflage considerations

The development of any camouflage scheme begins with a definition of the background against which that scheme will be viewed. Clearly, this is a major problem where aircraft camouflage is concerned: clear sky, cloud, sea, woodland, urban development, airfield surfaces — the variations in background are limitless. The range of options can be narrowed by determining the degree of camouflage protection necessary when the aircraft is on the ground, an important consideration for the RAF in view of the conventional air threat to its airfields both in Germany and the United Kingdom. These bases are themselves subject to camouflage and tone-down measures and the

The latest offensive support camouflage scheme in the RAF is shown on the Jaguar (top right) and the Hawk (opposite page, centre) from the Tactical Weapons Unit at RAF Brawdy. The importance of detail in an effective camouflage scheme is shown by the photograph of a Buccaneer (top left) flying in hazy conditions over Germany. Aircrew equipment is normally finished in dark green. Air defence aircraft in the RAF are soon to convert to a light grey/medium grey countershaded scheme, and the Tornado F Mk 2 will have a similar finish. The Tornado 2 prototype is shown below.

(Below) McDonnell Douglas Phantom FGR Mk 2 of No 111 Squadron in the current camouflage scheme for air defence aircraft, but soon to be changed to a two-tone grey scheme.

(Right) A Panavia Tornado GR Mk 1 in the overall disruptive camouflage finish used for offensive support aircraft.

NOT TO SCALE

presence of inappropriately camouflaged aircraft would be self-defeating. Within NATO, airfield camouflage is part of a package of survival measures which includes the provision of hardened shelters for tactical aircraft. If an aircraft is to be "sheltered" when on the ground, then its camouflage can be optimised for the airborne environment, which in general terms requires light colours with relatively high reflectance for medium/high-level operations or dark matt finishes of lower reflectance for low-level operations in the European theatre. Matching the reflectance value of a camouflage finish to the background is more important than matching the colour, unless the background happens to be both uniform in colour and devoid of features.

The selection of suitable colours leads to another controversial aspect of camouflage, the value of disruptive patterns. Such patterns are prevalent in nature, of course, but the high contrast examples are effective only when the subjects are static in specific locations. Experience shows that low-contrast disruptive patterns, which can only be effective at close range, are of value in aircraft camouflage although many of the theories which have been advanced to support this fact are obscure. An aircraft finished in a uniform colour can be seen and recognised against a matching background because different parts of its surface receive and reflect differing amounts of light. The air intakes and the wing and tailplane root areas, for example, tend to appear dark in contrast to the fuselage top and wing leading edges. The use of a different colour to increase the reflectance of these dark areas can improve the camouflage not only by making it more difficult to see the aircraft but also by making it more difficult to determine its orientation, a most important factor in air combat. Countershading, as this technique is termed, might be regarded as a more advanced form of disruptive patterning which attempts to eliminate distinctive features rather than disguise them.

Practical aspects

Turning now to camouflage materials, one of the few technical developments in camouflage in recent years has been the introduction of finishes to defeat the use of false colour photography. A green finish with the correct degree of infra-red reflectance to

(Below) The first of the RAF's stretched Hercules C Mk 3s, with camouflaged upper surfaces and grey under surfaces.

(Below centre) A Victor K Mk 2 with camouflage upper surfaces and white undersides.

(Below) A Nimrod MR Mk 2 in the new hemp and white finish.

NOT TO SCALE

Tornado, the all-weather strike fighter already in production for three NATO air forces and one navy, meets "a vital need for all-weather interdiction and the ability to operate in hostile air space", said General William J. Evans, then Commander-in-Chief of Allied Air Forces, Central Europe. He said Tornado will provide this capability "which is fundamental to our task".

'Fundamental to our task'

GENERAL WILLIAM J EVANS, USAF

- Mach 2.2 performance from 3,000ft runways;
- two-crew, two-engine survival ability;
- long range and ultra-low-level penetration in all weathers;
- advanced electronics and small size, minimising chance of detection and vulnerability to counter-measures;
- wide choice of weapons options, including most advanced air-to-surface and air-to-air weapons;
- high-precision, all-weather navigation and weapon delivery;
- over 800 aircraft being produced for air forces of Great Britain, West Germany and Italy and for German navy;
- setting the pattern for full-scale NATO standardisation and inter-operability.

TORNADO

The NATO multi-role combat aircraft

PANAVIA

Panavia Aircraft GmbH, München, Arabellastrasse 16, Germany.

AERITALIA
BRITISH AEROSPACE
MESSERSCHMITT-BÖLKOW-BLOHM

Sporting the latest "all-over" camouflage scheme of matt dark green and matt dark sea grey, this Vulcan stands out like a sore thumb in the predominantly desert colours of Nevada, where it was participating in one of the "Red Flag" combat exercises late in 1979.

match that of natural vegetation has been adopted by NATO as a standard for military equipment of all kinds, and at the other end of the spectrum it may be possible to develop a white finish with the correct level of ultra-violet reflectance to match that of snow. These finishes will be used for aircraft camouflage, particularly for those aircraft which can operate from field locations.

In addition to the theoretical and technical aspects of camouflage, there are some practical considerations such as fleet management which can affect the choice of colour scheme. As a matter of routine, RAF aircraft are withdrawn from squadron service and sent to a maintenance unit for modification or deep servicing at regular intervals, and subsequently they may be re-issued to another squadron at a different location. In addition, some squadrons have a mobile rôle and must be prepared to execute one of a number of deployment options at short notice. In order to avoid frequent refinishing it is necessary to standardise camouflage schemes within an aircraft fleet, and consequently the scheme must be optimised for a theatre rather than for a specific location or rôle. Despite this standardisation there is still a need for a rapid means of changing camouflage to cater for snow conditions in a European winter, and here removable paints can be used when the occasion demands.

Present camouflage schemes

The camouflage schemes used by the RAF today have been developed by combining the practical experience of the aircraft rôle specialists with research conducted by the Royal Aircraft Establishment and by the industry. Fifteen years ago the camouflage scheme for tactical aircraft combined an upper surface disruptive pattern of dark green and grey to blend with a woodland background when viewed from above, with a light grey lower surface to achieve a measure of protection when viewed from below. This scheme was effective at medium and low levels in Europe, although initially such features as the white portion of the RAF roundel and uncamouflaged external stores were relatively conspicuous and emphasised the need to take account of even minor details in a comprehensive scheme. The roundel was subsequently changed to the Second World War red/blue version.

Further experience with this dual scheme, particularly in low-level exercises with defending fighters, showed that there could be an eye-catching contrast effect between upper and lower surfaces when aircraft manoeuvred while contour flying, and that on balance it would be preferable to optimise the scheme for low-level operations against an air-to-air threat. The scheme for offensive support aircraft is therefore now an overall disruptive pattern (including the undersides) of matt dark green and matt dark sea grey, with red/blue national markings and black airframe serial identification. External stores are camouflaged to match the airframe and conspicuous safety signs and markings are kept to a minimum.

At present, air defence aircraft serving in the RAF are finished in a disruptive pattern of matt dark green and matt dark grey on the upper surfaces, with the lower surfaces either matt light grey or natural finish depending upon aircraft type. However, the Phantom force will shortly convert to a light grey/medium grey countershaded scheme and this will also be used on the air defence version of the Tornado in due course.

The VC10 strategic transports and the RAF's communication aircraft sport light colour, high reflectance schemes suited to medium/high level operations. Fuselage tops are finished in heat-reflective white, with the remainder of the airframe either natural

To cater for locally changing conditions, such as snow, the RAF has stocks of removable paints for use when the occasion demands. Short-term schemes are sometimes adopted for non-operational reasons, such as, for example, the yellow "tiger" stripes on this No 230 Squadron Puma participating in the regular "Tiger Meet", a gathering of NATO and other squadrons that have a tiger emblem in their respective badges.

metal or painted with a pale grey anti-corrosion finish. A similar scheme with lower reflectance value is used on the Nimrod although a new scheme has been developed for the latter which improves protection given to the aircraft when on the ground, while retaining the effectiveness of the present scheme in the maritime environment. The upper surface colour is being changed to a nominal shade of brown, officially called "hemp", which lies between light stone and dark earth in the British Standard colour guide. Lower surfaces are matt white.

RAF support helicopters were originally considered to be part of the tactical transport fleet and were finished accordingly in a scheme of dark green and dark sea grey on the upper surfaces with light grey lower surfaces. In the present rôle of support to the Army in the field, however, the lower surfaces of the aircraft were found to be too conspicuous and have now been overpainted black, as are the lower surfaces of the main rotor-blades. The upper surfaces of the main rotors are dark green, as are both surfaces of the tail rotor-blades. For obvious reasons, safety markings have to be given greater prominence on this type of aircraft.

The disruptive pattern on the upper surfaces of tanker aircraft combines dark green and medium sea grey; the lower surfaces are white gloss for maximum reflectivity, and feature fluorescent markings to assist the pilots of receiver aircraft with their line-up.

For those aircraft serving in rôles that do not bring them into the

(Below) New for the 1980 season, a British Aerospace Hawk in the Red Arrows' attractive new colours.

(Below) A Scottish Aviation Jetstream T Mk 1 of No 3 FTS displays the standard training aircraft colours and (bottom) the same colours adapted to an Andover E Mk 3 calibration aircraft.

NOT TO SCALE

(Right) Like the fixed-wing trainers, the RAF's Aérospatiale/Westland Gazelle HT Mk 3s, used by the CFS(H) Wing at Shawbury, have a high-visibility red-and-white finish.

(Left) Operating in support of the Army in the field, the RAF's support helicopters, such as this Aérospatiale/Westland Puma HC Mk 1 of No 230 Squadron, have camouflaged upper surfaces and black undersides.

(Right) A Westland Sea King HAR Mk 3 in the overall bright yellow finish adopted to make search-and-rescue helicopters highly visible.

NOT TO SCALE

combat zone, there is often a need for a high visibility finish rather than one that seeks to hide. The largest group in this category comprises the trainers, both single and multi-engined fixed-wing and rotary-wing types, which have a basic high-gloss white finish with large areas of the wings and fuselage in bright red. A variation of this scheme is used by the Andover E Mk 3s used for calibration duties. Helicopters assigned to search-and-rescue duties are bright yellow overall, again for maximum visibility, and the same consideration has dictated the use of a bright orange finish for the Wessex helicopters of the Queen's Flight. Special mention is also warranted here for the eye-catching red-white-and-blue finish adopted for the new Hawks introduced this year by the Red Arrows, the RAF's official aerobatic demonstration team.

Aircraft refinishing is expensive, and it is the usual practice in the RAF to change the camouflage scheme on individual aircraft only when that aircraft is due for refinishing in the normal cycle, which is every two to four years depending upon type and rôle. Consequently, some time will elapse before a change becomes effective throughout an aircraft fleet.

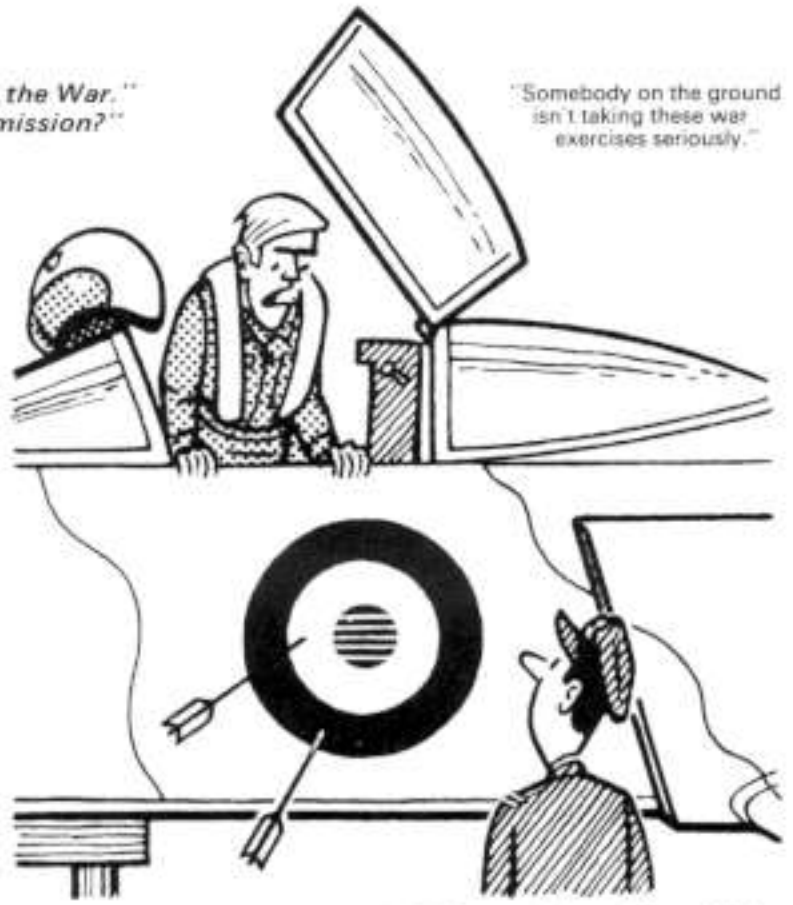
The science of camouflage has not kept pace with developments in the science of surveillance, and in recent years RAF aircraft camouflage has evolved from changes in operational concepts and refinements to previous schemes rather than from technical innovation. For the future, it is probable that camouflage protection for parked aircraft against visual observation from the air will continue to be the most important aspect of the subject, and the achievement of a reasonable compromise between this requirement and that of camouflage while airborne will remain the challenge. □

As Britain's defence commitments changed, the "worldwide" camouflage scheme originally applied to the RAF's Lockheed Hercules fleet was replaced by one of lower reflectance more suited to the European theatre. Both schemes are shown in this photograph.

Laugh with the RAF!

by Loren

"I was in the RAF in the War."
"Did you get a commission?"
"No, just my pay."



Sergeant to young man in RAF recruiting office: *"Why do you want to join the RAF?"*

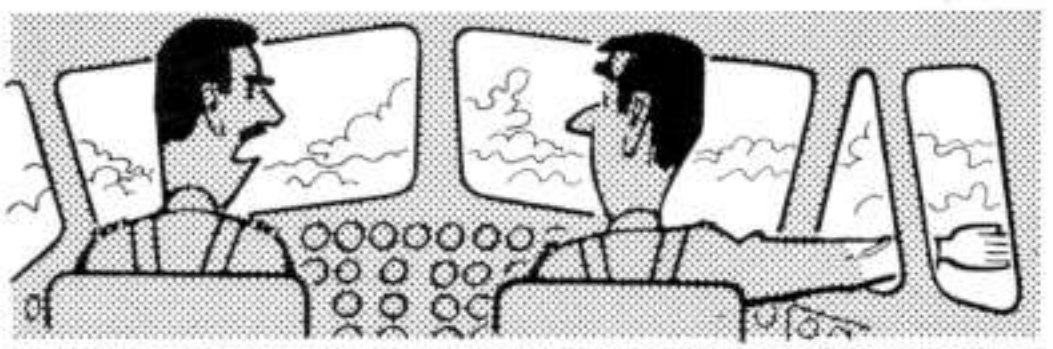
"I've always wanted to wear a uniform. I had no opportunity to join the Boy Scouts and I'm not tall enough for the police, so it's you or the Traffic Wardens."

*

"They say it's so quiet on the VC-10's flight deck that you can hear the sweat dripping onto the navigator's maps."

World War I requiem:

Returning from my morning fly,
I met a Fokker in the sky
And judging from its swift descent
It had a nasty accident.
On thinking further of the same,
I rather think I was to blame.


"Who the hell taught you to fly?"

*

"What kind of a pilot is he?"

"Well, put it this way — he can put the fear of God into more people in five minutes than Billy Graham has done in twenty years."

*

"With all these maps, I feel that I can now get lost anywhere."

*

"We are now fully operational — that is, we are in a constant flap instead of only having isolated confused situations."

*

Captain: *"I have a simplified landing system — I watch my co-pilot and when I see him stiffen in his seat, I pull the stick back — works like a charm."*

*

LAC "Shiny" Bright, squadron comedian, at church service parade: *"Look — the padre's wearing his Government surplice!"*


"What's all this about gnats and hawks and arrows? I can only see those pretty aeroplanes."

On the notice board:
"Absolutely no flying permitted over nudist camp 14·7 statute miles SSW on a true course of 187·5 degrees."

*

In 1945 an RAF Dakota transport was landing in England with a load of freed prisoners-of-war who had been so well looked after by the corporal cabin attendant that the senior passenger, an Army sergeant-major, complimented the corporal, adding "If you were in the Army, you'd be a sergeant". Without hesitation, the corporal said "If I was in the Army, I'd be a bloody general!"

*

"Security's very tight at this place — you won't get in without a pass — here, borrow mine."

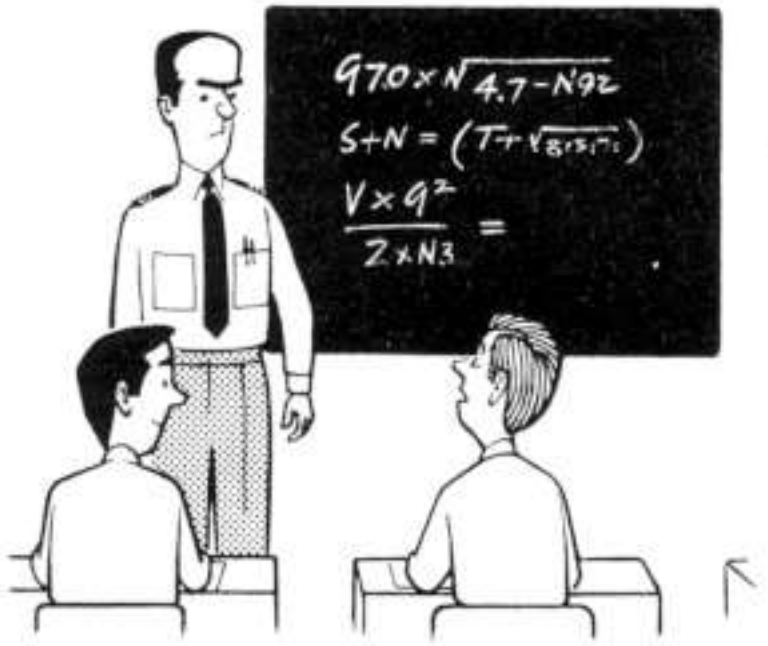
"Not much gets past the boss . . ."

*

"The most difficult thing about that new fighter is trying to land it with your fingers crossed."

*

During World War 2, the pilot of a DH Dominie, a small twin-engined transport biplane, frequently flew other pilots from here to there. Before starting up, he always circulated a neatly printed card among his passengers. It said: "Passengers are advised that the control mechanisms in this vehicle are arranged in such a manner that it can only be driven from the front seat by one man. Anyone objecting to this arrangement is invited to put his complaint through the proper channels."



"Pass."

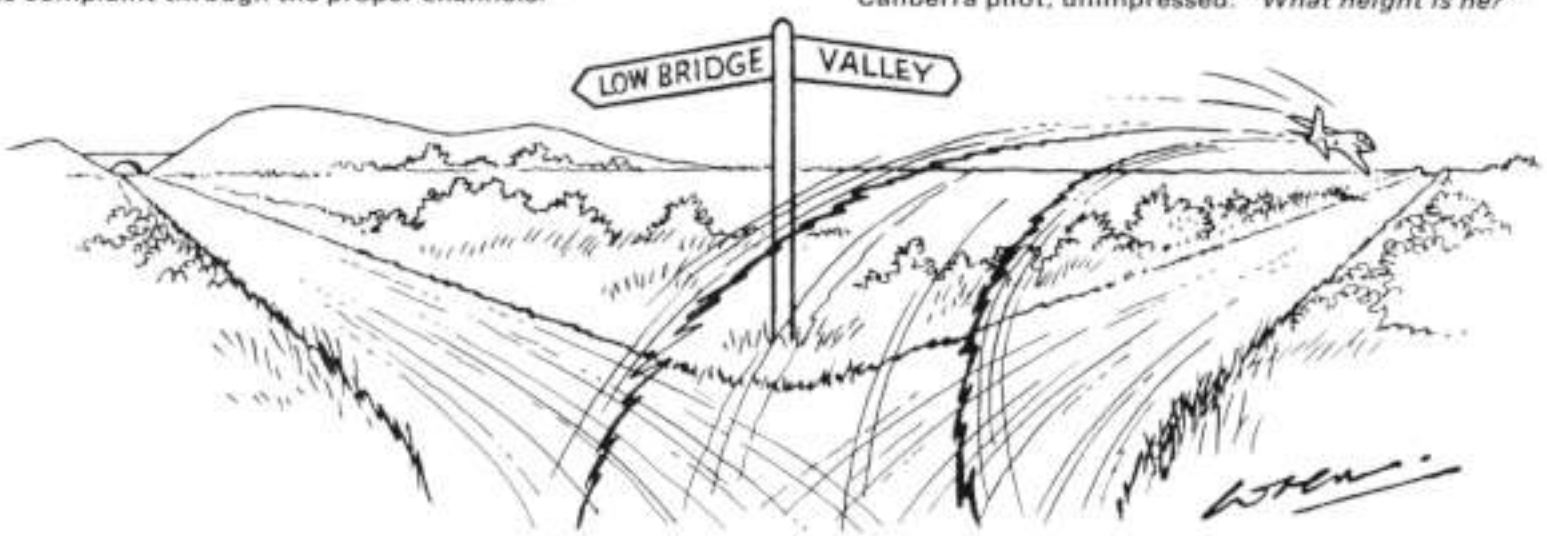
"Sergeant Green is not so much a leader of men as a follower of women."

*

"It wasn't until I joined the RAF that I realised that there were degrees between the fives and the tens on a compass."

"The Chairman has complete faith in our new guidance system."

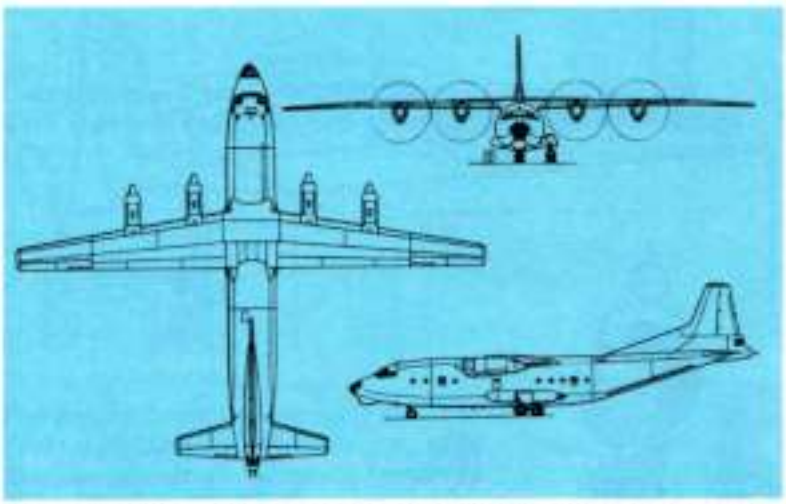
Malta Air Traffic Control to Canberra approaching to land: *"Sub. on your starboard side."*
Canberra pilot, unimpressed: *"What height is he?"*



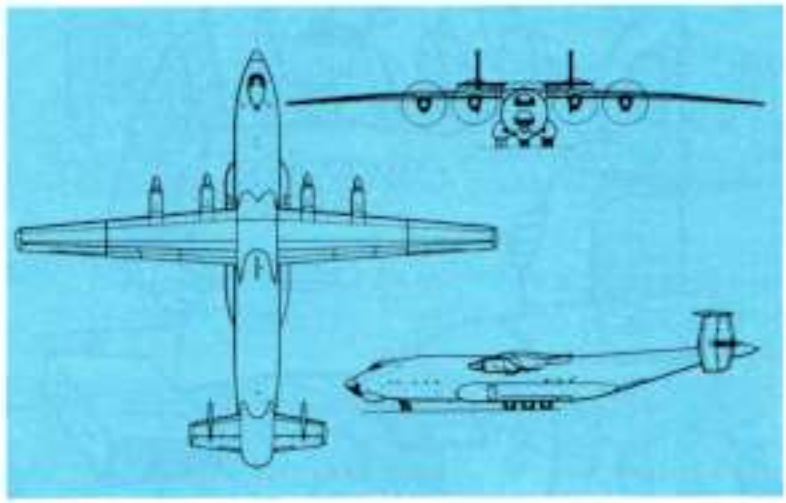
SOVIET WARPLANE DIRECTORY

THE LONG-HELD ASSUMPTION that Warsaw Pact quantitative advantages are offset by the superior quality of NATO equipment may no longer be valid, stresses a recent Federal German Ministry of Defence assessment of the tactical air balance in NATO's Central Region. WarPac currently possesses 2,800 operational combat aircraft facing the central sector of Czechoslovakia, East Germany and Poland, and an additional 1,100 tactical aircraft are allocated to Soviet Frontal Aviation Armies in the Soviet Union's western military districts. Of these 3,900 tactical combat aircraft, 1,800 — almost half — are tasked with offensive operations in support of ground forces, while a further 1,200 have a primary air defence mission with secondary ground attack capability. The remaining 900 aircraft have a dedicated air defence rôle. Numerically, NATO is inferior to WarPac in the Central Region by 1,200 combat aircraft! Facing the WarPac threat, NATO has 1,100 tactical aircraft, including those based in the UK, and can augment these with a further 500 aircraft from the USA within a few days. If the tactical element of the *Armée de l'Air* is added, then the total figure is swelled by an additional 480 aircraft. Thus, the numerical ratio in favour of WarPac is almost 1·5:1·0.

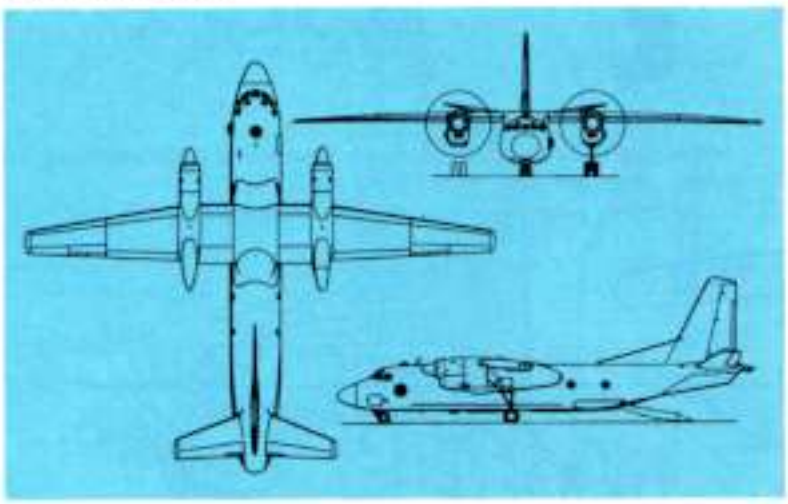
Ten years ago ... even five years ago, such numerical imbalance was acceptable owing to the technological superiority of NATO equipment, but the situation has now changed dramatically; of late, the erosion of NATO's technological lead has accelerated alarmingly. Every facet of the Soviet military establishment has been subjected to a major rate of growth and modernisation, and none more so than the Soviet Air Forces. About 80 per cent of Frontal Aviation has now re-equipped with advanced, efficacious combat aircraft, such as the MiG-23 and -27, the Su-17 and -19; many have all-weather capability and advanced weapons-delivery systems. Soviet airborne radars are now believed to have acquisition capability at ranges up to 100 km and there are now Soviet air-to-air missiles with effective ranges of up to 50 km. In addition, WarPac has a dense and diversified air defence system, which, in addition to 2,100 fighters either optimised for air defence or possessing air defence as their primary task, has a formidable array of surface-to-air missiles and anti-aircraft gun systems. The danger is manifestly obvious; the concern that it is generating *must* be translated into a determined effort to eradicate this imbalance.



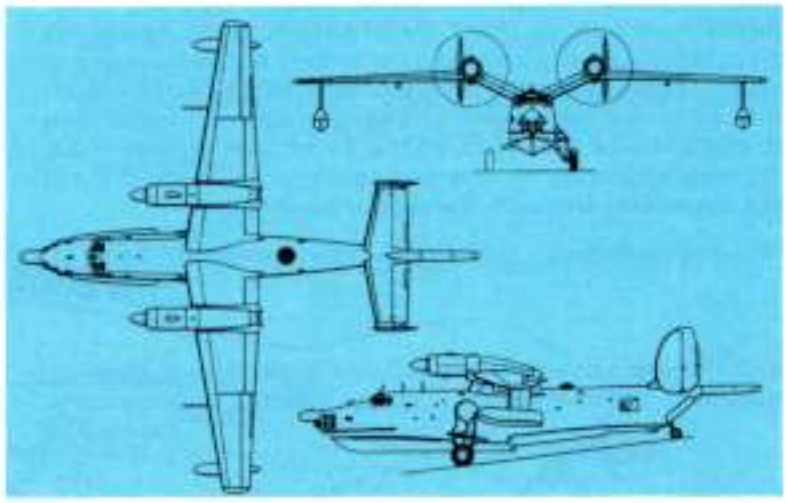
ANTONOV AN-12 (CUB): Although *Cub* has now come of age in the V-VS, having entered service in 1959, it remains the backbone of Transport Aviation (V-TA) with more than 600 of the basic An-12BP, or *Cub-A*, on strength. The *Cub-B* elint (electronic intelligence) and *Cub-C ECM* (electronic countermeasures) models, with various blister fairings, pods and antennae, also serve in some numbers. *Cub-A* can carry 100 paratroops and was active during Afghan operations.



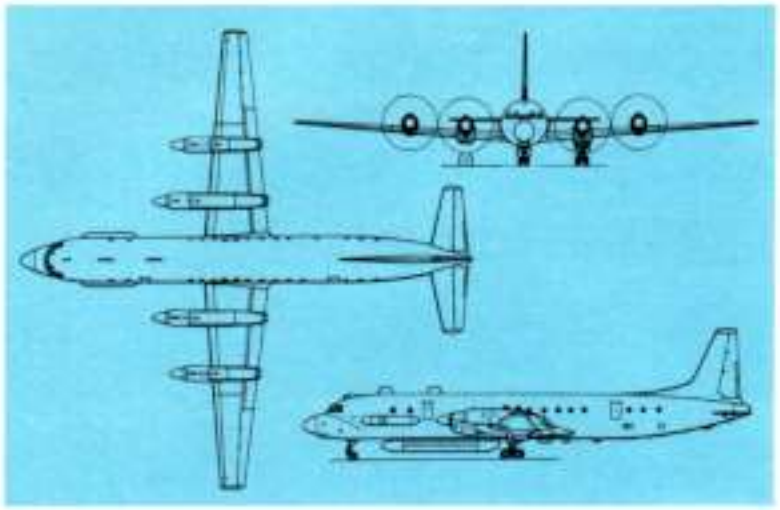
ANTONOV AN-22 (COCK): Largest transport in service with the V-TA, which has some 40 on strength, *Cock* is the only Soviet aircraft capable of transporting the T-62 tank, and loads can include *Ganef* and *Scud-A* missiles on their tracked launchers. Comparable in size with the USAF's C-5A Galaxy, *Cock* has a maximum payload of 176,350 lb (80 000 kg) and can carry this over 3,100 mls (5 000 km), maximum range is 6,800 mls (10 950 km) with a 99,200 lb (45 000 kg) load.



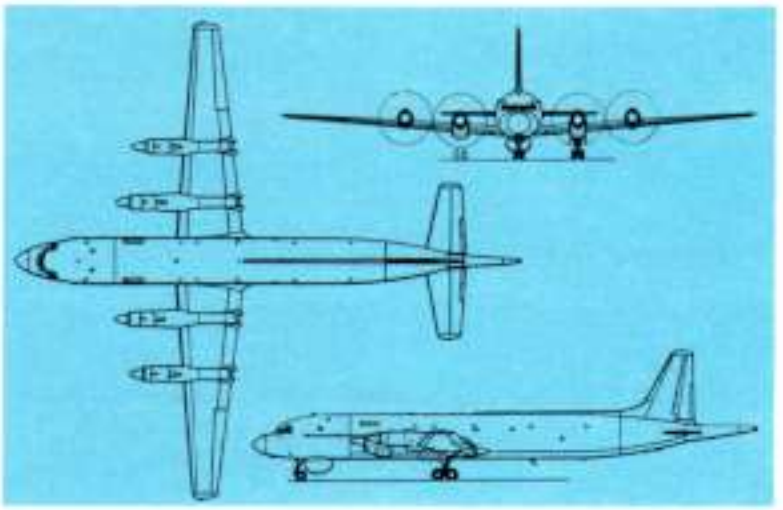
ANTONOV AN-26 (CURL): Derived from the An-24RT *Coke*, its redesigned rear fuselage with "beaver-tail" endowing it with airdrop capability, *Curl* is extensively used by the V-VS, with between two and three hundred in service. It is also used by other WarPac countries. Capable of transporting up to 40 paratroops, *Curl* can also accommodate various motor vehicles (eg, UAZ-469, GAZ-69) and in the aeromedical rôle will carry up to 24 casualty stretchers. A derivative, the An-32 *Cline*, is intended for hot-and-high conditions.



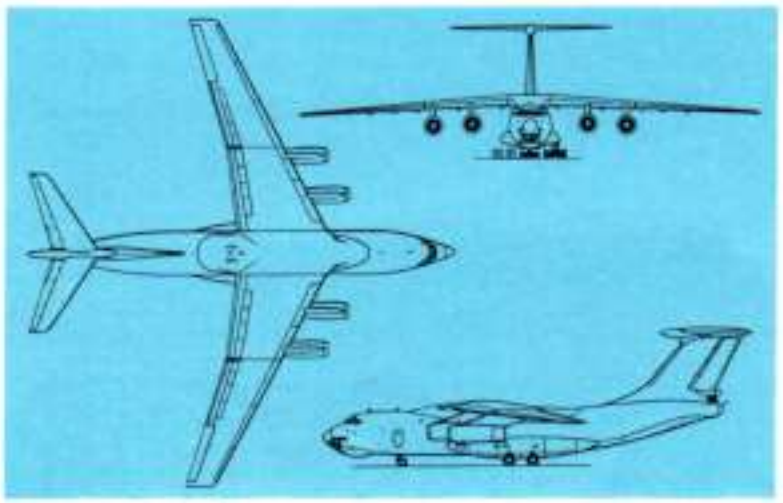
BERIEV BE-12 (MAIL): Serving with the Naval Air Force (AV-MF) and primarily the Northern and Black Sea Fleets in the near-zone maritime patrol and anti-submarine rôles since the mid-'sixties, *Mail* is currently the only large military amphibian serving in substantial numbers. About 80 are reportedly in AV-MF service and a variety of weapons and stores for its maritime rôles are carried on four wing pylons and within a bay aft of the hull step. For a period, *Mail* operated over the Mediterranean from Egyptian bases.



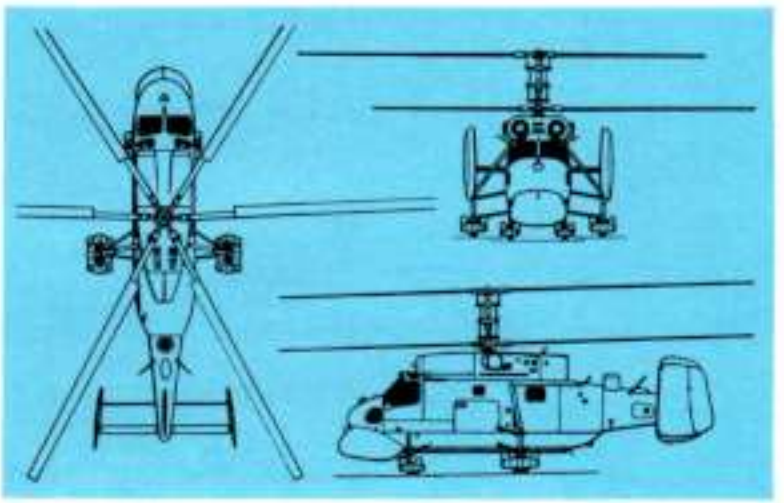
ILYUSHIN IL-18 (COOT-A): An adaptation of the Il-18D commercial transport for electronic countermeasures or electronic intelligence tasks, *Coot-A* carries a variety of sensors in a long ventral pod (SLAR), forward-fuselage fairings and various blisters. Revealing no fundamental changes from the basic transport, *Coot-A* is probably a reworked Aeroflot aircraft withdrawn from commercial service and is usually encountered around the European periphery of the Soviet Union.



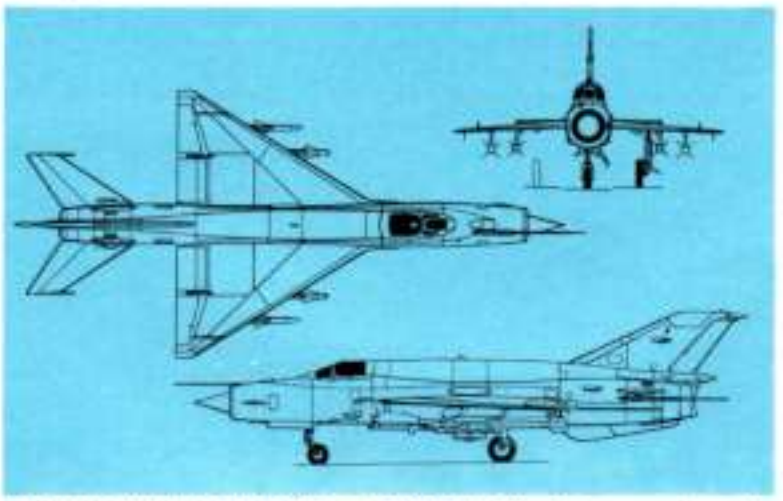
ILYUSHIN IL-38 (MAY): Another derivative of the Il-18 transport but embodying more fundamental changes than *Coot-A*, the maritime surveillance *May* is the AV-MF equivalent of the US Navy's P-3 Orion and possesses comparable patrol endurance. The standard Soviet Navy open-ocean patroller with upwards of 60 currently in service, *May* is operated regularly over the Mediterranean, the Atlantic and elsewhere, three ex-AV-MF *Mays* having been supplied to India.



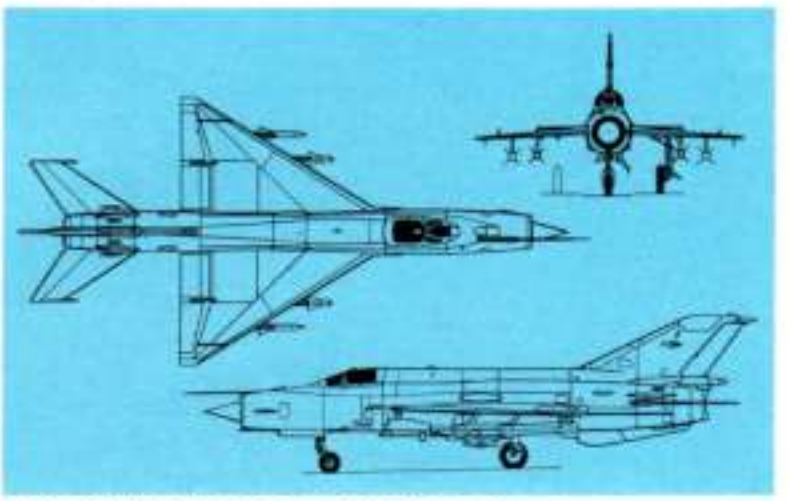
ILYUSHIN IL-76T (CANDID): Rapidly becoming the most important transport in the inventory of the V-TA, with more than a hundred now in V-VS service, *Candid* played a major rôle in the invasion of Afghanistan. Comparable with the USAF's C-141B StarLifter but more powerful and capable of higher payloads, *Candid* has extemely good short-field characteristics and can operate from poor surfaces. A flight-refuelling tanker version of *Candid* has been developed.



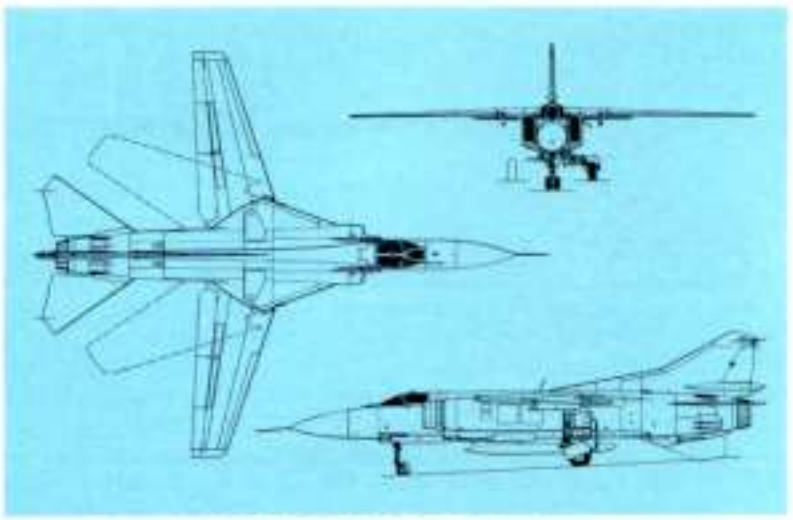
KAMOV KA-25 (HORMONE): Standard AV-MF shipboard anti-submarine warfare helicopter, *Hormone* serves aboard the carriers *Kiev* and *Minsk*, and the helicopter cruisers *Leningrad* and *Moskva*. The basic ASW version is *Hormone-A* while *Hormone-B* is equipped for over-the-horizon missile targeting. At least 200 of these helicopters are in AV-MF service and their internally-housed torpedoes and depth charges are being supplemented with "fire-and-forget" ASMs.



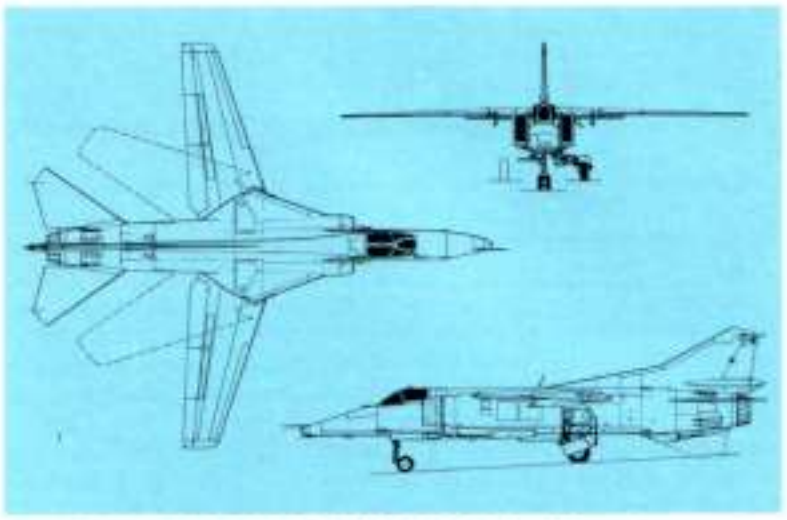
MIKOYAN MIG-21SMT (FISHBED-K): Representing the second-generation series MiG-21 multi-rôle fighter, *Fishbed-K*, characterised by its deep, fuel-housing dorsal fairing, has seen almost a decade of V-VS service, but, together with other second-generation models (eg, *Fishbed-H* and *-J*), still provides a substantial proportion of the 1,500-plus force of MiG-21s included in the V-VS tactical aircraft inventory. All WarPac forces include second-generation *Fishbed* models.



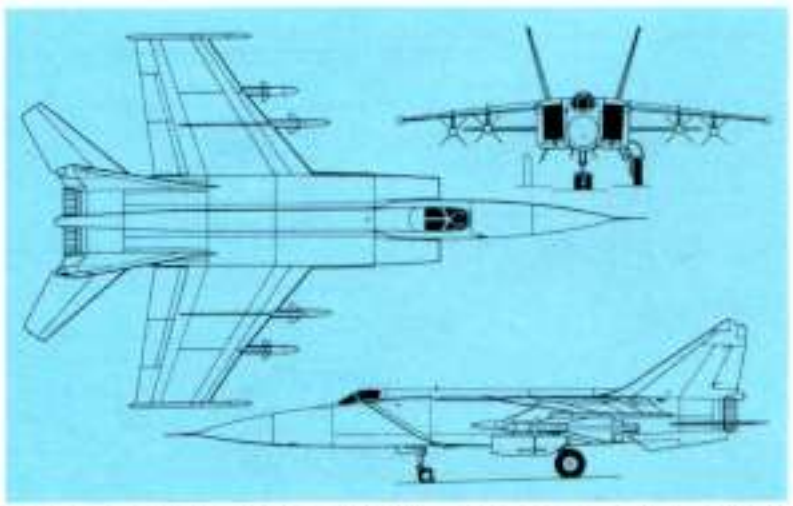
MIKOYAN MIG-21BIS (FISHBED-N): A third-generation derivative of the basic MiG-21, with upgraded avionics, improved structural standards and a more powerful Tumansky R-25 turbojet, *Fishbed-N* is a limited all-weather multi-rôle aeroplane but is progressively becoming the primary dogfighter of the V-VS with increasing availability of *Flogger*. Application of a more efficacious radar with some look-down capability and new dogfight missiles is believed imminent.



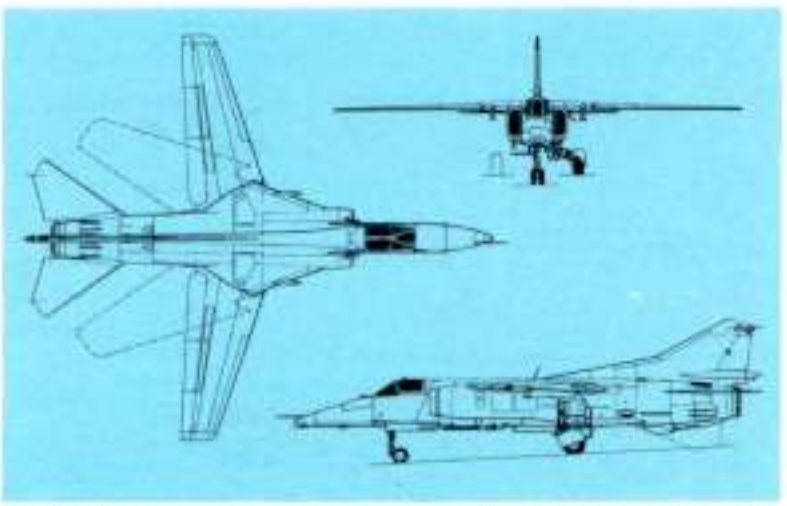
MIKOYAN MIG-23MF (FLOGGER-B): Now deployed in very large numbers by V-VS Frontal Aviation and by air forces of other WarPac countries, *Flogger* has appeared in a variety of versions, early models having the lower-rated Tumansky R-27 turbofan, the MiG-23MF having introduced the now-standard R-29B. *Flogger-B* is a single-seat air combat fighter with *High Lark* intercept radar, a twin-barrel GSh-23L cannon and a quartet of AA-7 *Apex* and AA-8 *Aphid* AAMs.



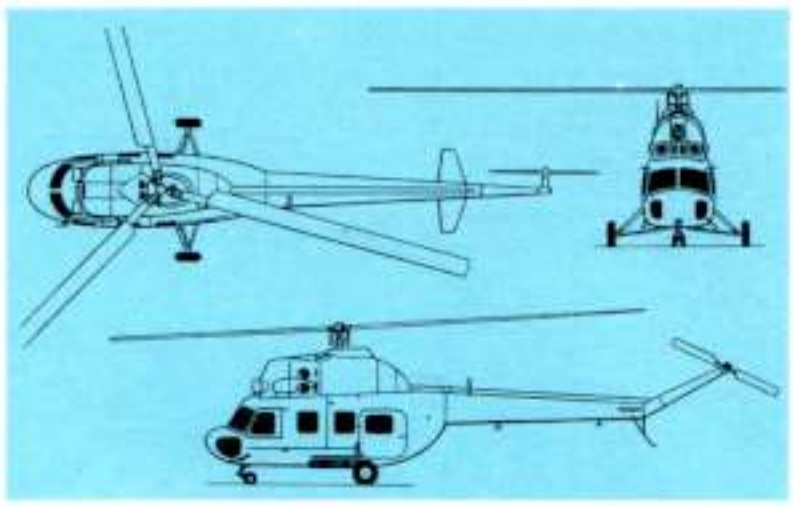
MIKOYAN MIG-23BM (FLOGGER-F): Although possessing essentially the same airframe and power plant as *Flogger-B*, the MiG-23BM is a multi-rôle version with the ogival radome replaced by a redesigned nose (similar to that of *Flogger-D*) incorporating a laser rangefinder and marked target seeker. With a primary air-ground mission, this *Flogger* variant has a secondary air-air rôle and should not be confused with *Flogger-D* which is a dedicated ground attack aeroplane.



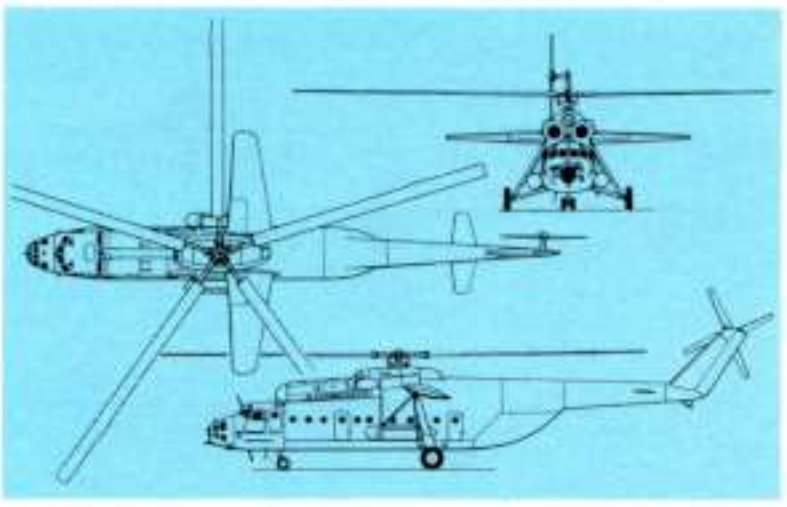
MIKOYAN MIG-25 (FOXBAT): With between 300 and 400 *Foxbat-A* interceptors, together with some 150 photo and radar reconnaissance *Foxbat-Bs* and electronic intelligence *Foxbat-Ds*, in the V-VS inventory, this M=3·0 category warplane retains its importance after a decade in Soviet service and is believed to be providing the basis for an advanced two-seat interceptor with lookdown-shootdown capable radar and new long-range AAMs for service in the next two-three years.



MIKOYAN MIG-27 (FLOGGER-D): A dedicated tactical strike derivative of the MiG-23 air combat fighter, with a similar redesigned drooped nose (to improve ground target acquisition) to that of the MiG-23BM, *Flogger-D* has simplified fixed-ramp air intakes, a shorter, fixed reheat nozzle, a broader aft section of the centre fuselage (to house revised undercarriage with larger, low-pressure tyres for grassfield operation), repositioned pylons, additional cockpit armour and a six-barrel 23-mm Gatling-style rotary cannon.

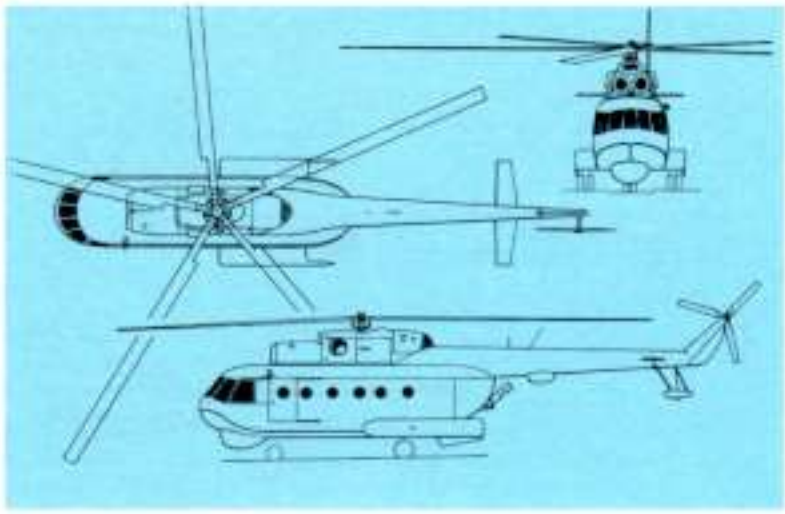


MIL MI-2 (HOPLITE): Developed in the Soviet Union with all manufacture being undertaken in Poland where production has exceeded 3,000 examples over a 15-year period, *Hoplite* is numerically the second most important helicopter in the V-VS inventory, the bulk of 2,000 plus exported by Poland to the Soviet Union being for military liaison, utility, LOH and training rôles. Carrying eight passengers, *Hoplite* serves in numbers with most WarPac air forces.

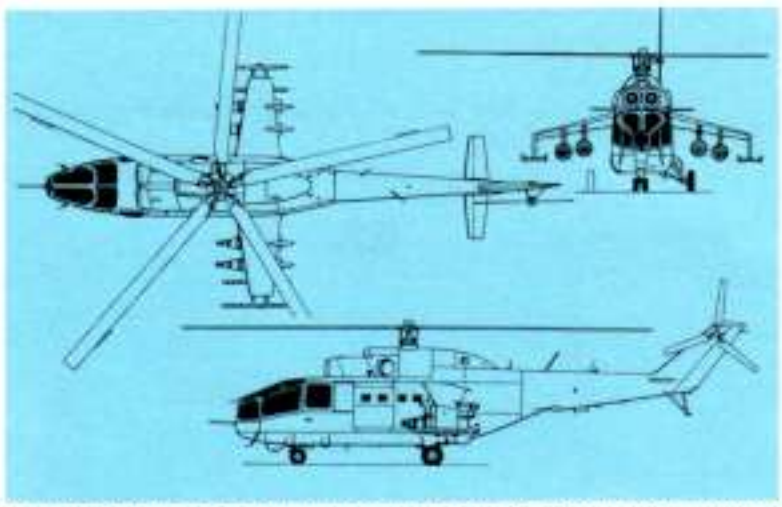


MIL MI-6 (HOOK): A fleet of about 500 *Hook* heavy transport helicopters is available to the Soviet tactical forces. *Hook* can accommodate 65-70 fully-equipped troops or 41 casualty stretchers plus medical attendants, and two helicopters of this type can move the entire payload of a *Cub* transport. Tactical SSMs and a wide variety of wheeled and tracked vehicles may be carried externally, and a 23-mm cannon is usually mounted in the extreme nose for suppressive fire.

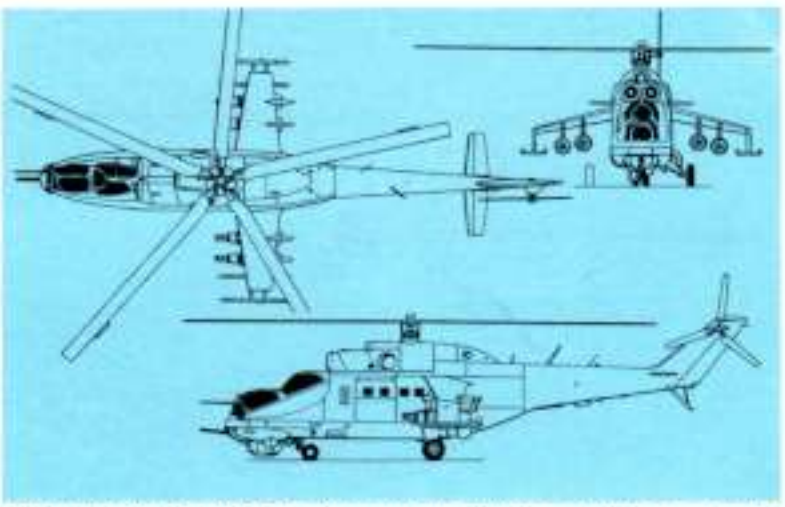
MIL MI-8 (HIP-E): Used in larger numbers than any other helicopter type by the Soviet forces, *Hip* serves as both a utility transport *(Hip-C)* and assault transport *(Hip-E)*, the latter having been described as the world's most heavily armed helicopter. *Hip-E* features a nose-mounted gun and usually triple weapon-carriers on outriggers capable of carrying 192 rockets in six pods and four AT-2 *Swatter* IR-homing missiles, but as many as eight ordnance carriers per side in two rows of four have been applied.



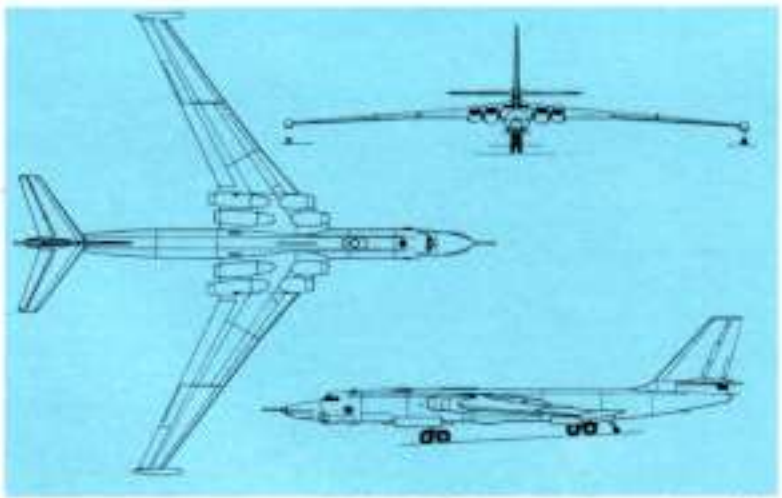
MIL MI-14 (HAZE): The standard AV-MF shore-based anti-submarine helicopter, *Haze* was derived from *Hip* and features a boat-hull planing bottom and sponsons providing amphibious capability, but retains the power plant and dynamic components of the earlier helicopter. It may be assumed that *Haze* has internal stowage for ASW torpedoes and depth charges, search radar is mounted beneath the nose and a sonar "bird" is stowed beneath the tailboom root.



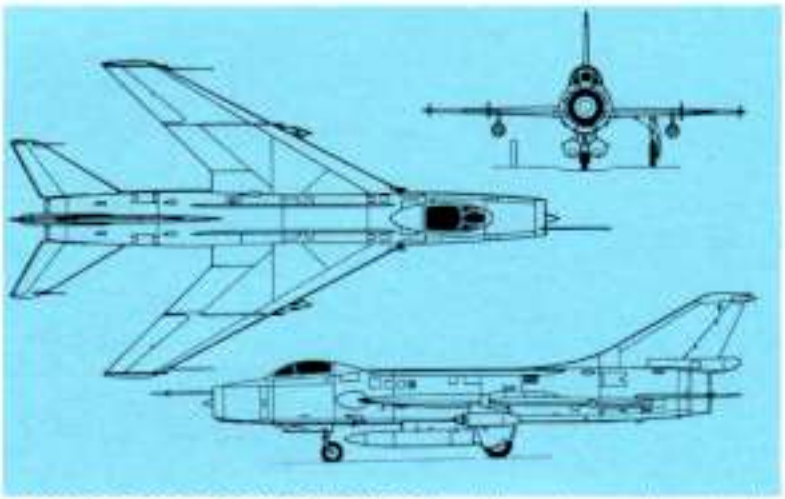
MIL MI-24 (HIND-A): A formidable armed assault helicopter of which several hundred serve with Frontal Aviation Armies based around the Soviet Union's European periphery. *Hind-A* accommodates a crew of four and a squad of eight fully-equipped troops. A 12.7-mm gun is mounted in the nose, and the auxiliary wings carry pylons for four rocket pods, while rails for four *Swatter* anti-armour missiles are attached to vertical wingtip extensions. Export model carries the less sophisticated *Sagger* anti-armour missile.



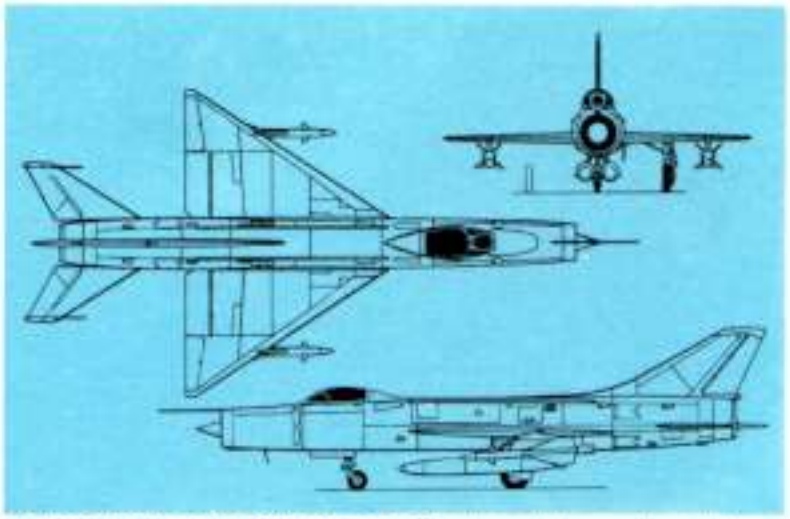
MIL MI-24 (HIND-D): A derivative of *Hind-A* with an entirely redesigned forward fuselage, *Hind-D* is optimised for the gunship rôle and has tandem stations for the weapons operator (in the extreme nose) and pilot with individual canopies. A four-barrel Gatling-type large-calibre machine gun is mounted in an offset chin turret. 32 rockets of 55-mm calibre are carried in each of four underwing pods, and the wingtip rails can carry four *Swatter* or *(Hind-E)* launch-and-leave type *Spiral* anti-armour missiles.



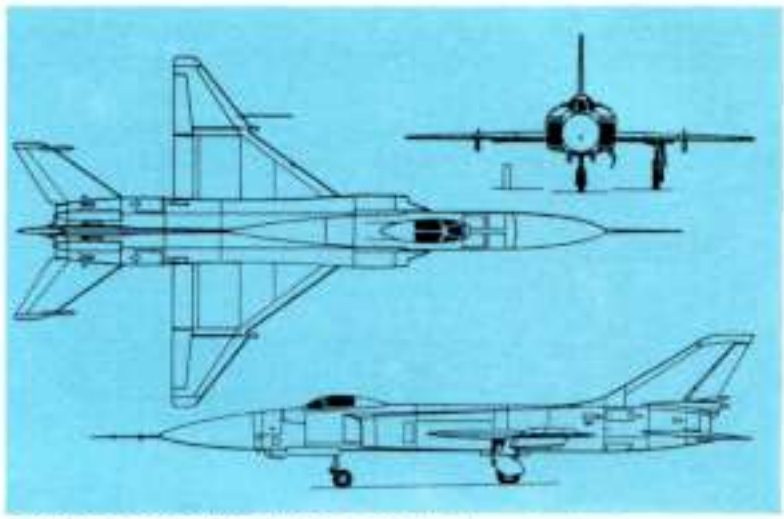
MYASISHCHEV M-4 (BISON-C): The definitive version of the M-4, originally conceived as a strategic bomber, *Bison-C* still serves in the offensive rôle in small numbers with Soviet Long-Range Aviation, but most now operate in the tanker rôle, as do also the earlier *Bison-A* and *-B* versions. Between 70 and 80 *Bisons* are believed to remain in service, the internal hose-and-reel refuelling unit of the tanker model being compatible with *Backfire* as well as with *Bears* and *Bisons* still configured for offensive rôles.



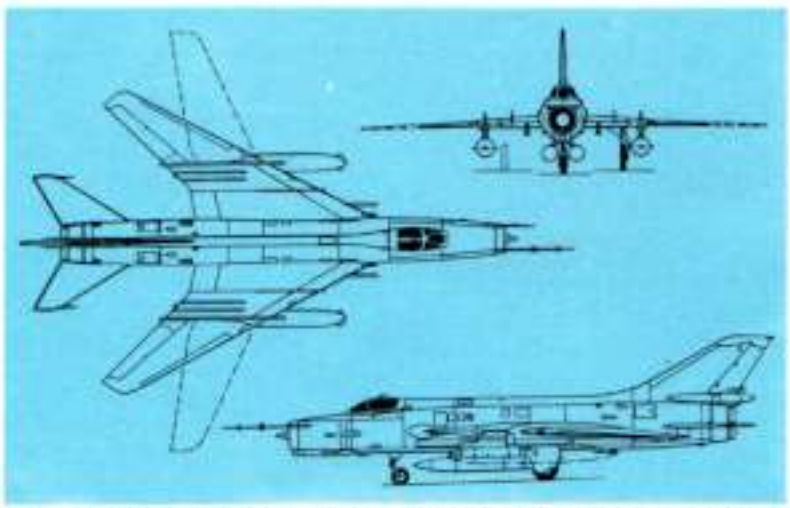
SUKHOI SU-7BMK (FITTER-A): Although now largely displaced in Frontal Aviation regiments and phasing out of other WarPac air arms, *Fitter-A*, which has seen 21 years of V-VS service as a ground attack fighter, still possesses some numerical importance in its Su-7BMK version despite obsolescence, but is likely to have given place to its variable-geometry derivative, at least in first-line units deployed in the West, over the next year. The tandem two-seat training version is known as *Moujik*.



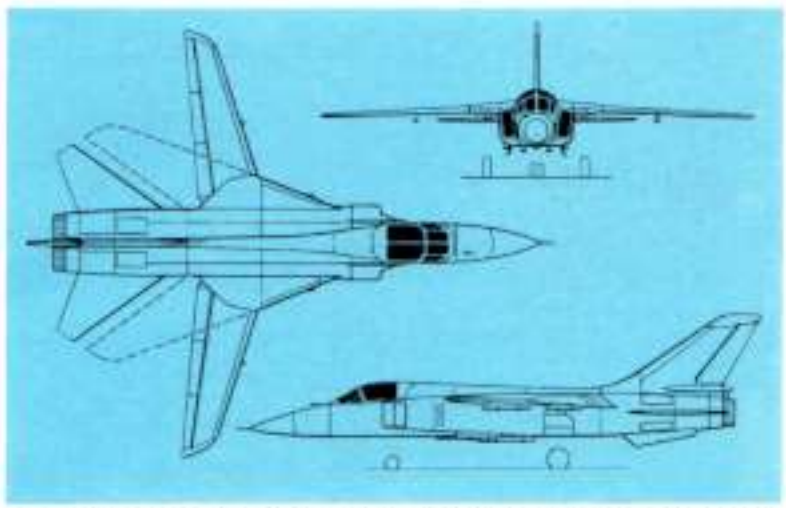
SUKHOI SU-11 (FISHPOT-C): The limited all-weather *Fishpot-C* interceptor remains in service with the Air Force of the Anti-aircraft Defence (IAP-VO Strany) in steadily diminishing numbers, having largely given place to *Flogger-B* and other types. Carrying a pair of AAMs and lacking cannon armament, *Fishpot-C* will, like its close relative, *Fitter-A*, probably be phased out over the next year. Evolved from *Fishpot-A* (Su-9), *Fishpot-C* has seen a dozen years service with the IAP-VO Strany.



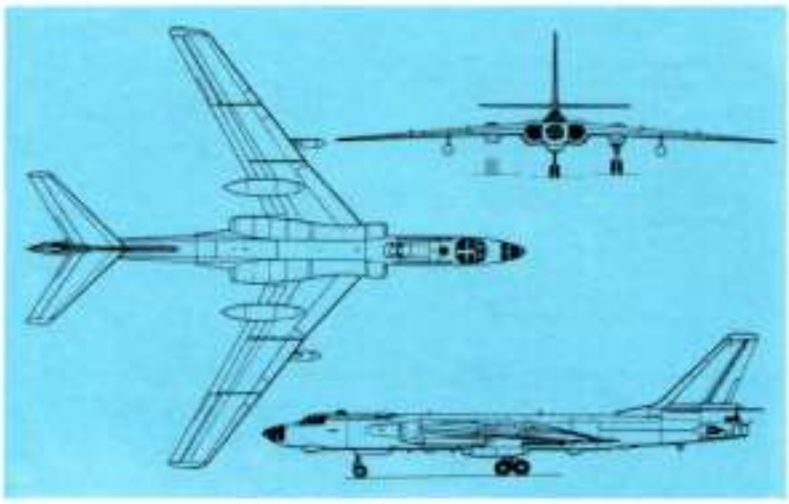
SUKHOI SU-15VD (FLAGON-F): Numerically the most extensively deployed home defence interceptor, with upwards of 1,000 in service with IAP-VO Strany, *Flagon* has been produced in a number of versions, the last of these built in quantity being *Flagon-F*. This has a more advanced radar than earlier models and it may be assumed that it now carries a pair of more advanced AAMs than the AA-3 *Anab*, which, for many years, was standard armament of this all-weather fighter.



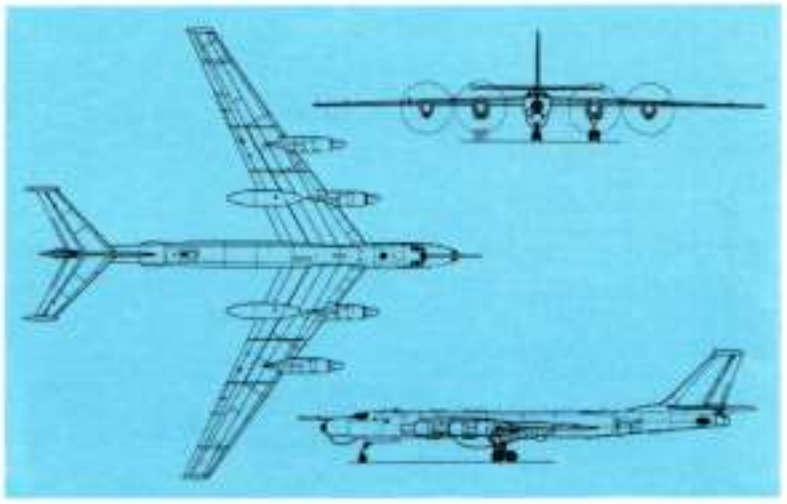
SUKHOI SU-17 (FITTER-D): A variable-geometry derivative of *Fitter-A* fulfilling the close air support, battlefield interdiction and counterair rôles, *Fitter-D* is one of several versions of this aircraft (including *Fitter-C*, *-G* and *-H*) and has a laser target seeker beneath a lengthened nose. Export versions with differing equipment standards have been referred to as Su-20 and Su-22, and the v-g *Fitter* is used by AV-MF for limited anti-shipping strike and amphibious operation support.



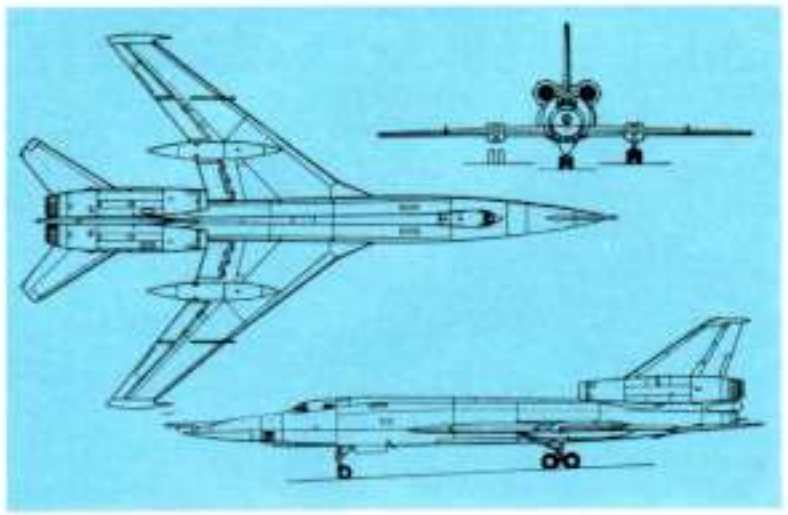
SUKHOI SU-19 (FENCER-A): Having now served with Frontal Aviation for some six years, with upwards of 250 being deployed at bases in western Military Districts, *Fencer* is an extremely potent two-seat ground attack fighter and recent reference to this type as the 'Su-24' suggests that it is now being offered for export (possibly with a less sophisticated equipment fit) to selected countries. *Fencer* provides the FA for the first time with the range and payload capability for deep-penetration interdiction missions.



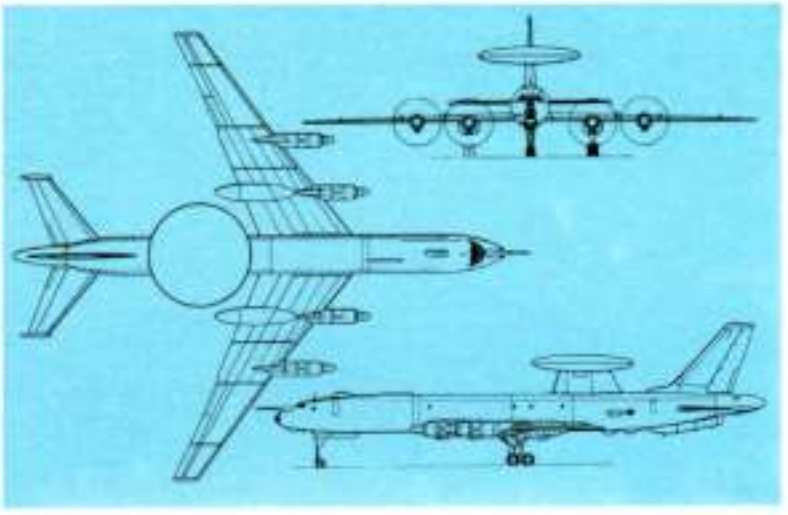
TUPOLEV TU-16 (BADGER): Despite its considerable age — having entered service more than a quarter-century ago — *Badger* still retains its importance, with upwards of 800 fulfilling a variety of rôles, from medium-range strategic bombing, anti-shipping attack, maritime surveillance, photo and electronic surveillance, to flight refuelling. About half of the *Badgers* now in service fulfil various maritime missions with the AV-MF. The drawing depicts the Elint *Badger-F*.



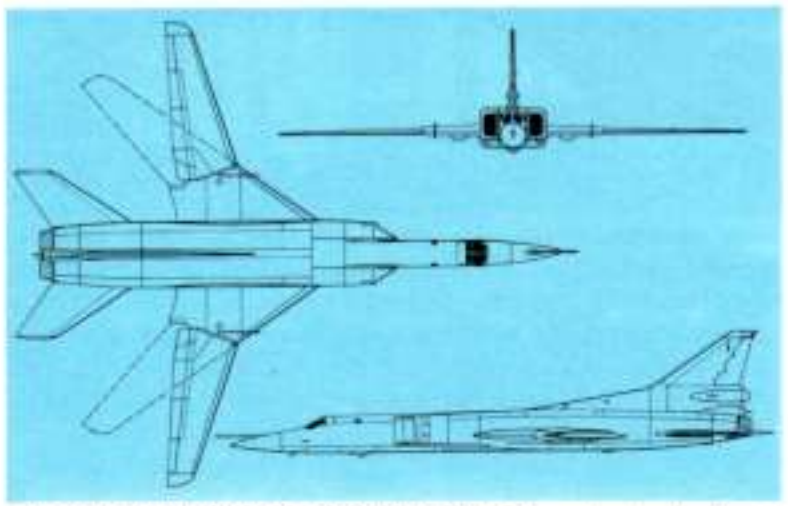
TUPOLEV TU-142* (BEAR): Developed contemporaneously with *Badger* and phased into service only a year or so later, *Bear* has proved almost as versatile and equally long-lived, new versions (eg, *Bear-G* with revised, elongated nose) continuing to appear. Some 200 remain, with tasks ranging from strategic bombing (Tu-95) to missile targeting, elint and maritime surveillance (Tu-142). *The design bureau designation is used here owing to latent doubts as to correct service designation. Illustrated is missile-targeting *Bear-D*.



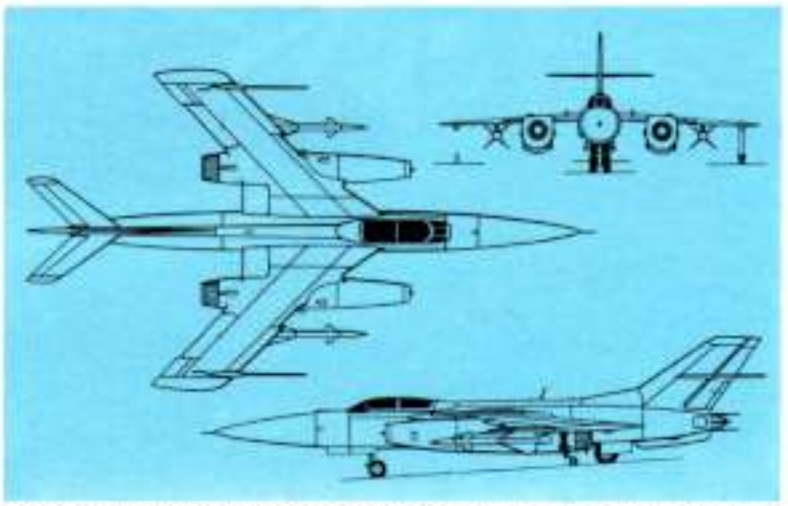
TUPOLEV TU-105* (BLINDER): With about 150 in service with Long-Range Aviation in reconnaissance-bomber *Blinder-A* and missile-carrying *Blinder-B* versions, and upwards of 50 maritime recce *Blinder-Cs* with AV-MF, this warplane has not been one of the more successful of Soviet warplanes, lacking the desired range with load capability. *Like *Bear*, latent doubts as to *Blinder's* correct service designation have necessitated use of the design bureau designation. Illustrated is the *Blinder-A*.



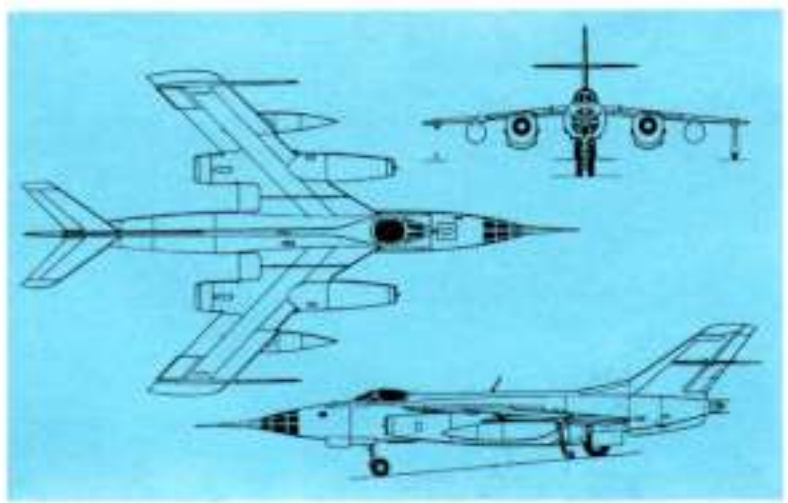
TUPOLEV TU-126* (MOSS): An airborne early warning and control system (AWACS) aircraft derived from the Tu-114 *Cleat* commercial transport now phased out, *Moss* is believed to as yet possess only limited effectiveness over water and to be relatively ineffectual over land. It is utilised in conjunction with IAP-VO Strany interceptors and about a dozen are reportedly in service. *Tu-126 is a design bureau designation, the service designation as yet being uncertain.



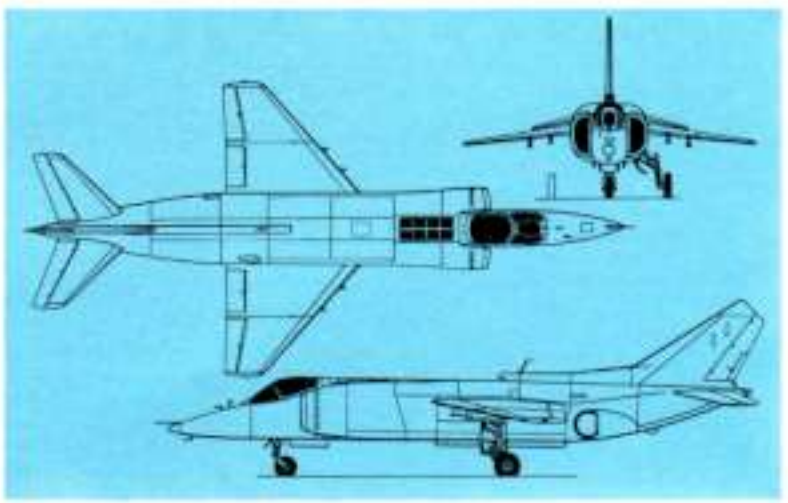
TUPOLEV TU-22M (BACKFIRE-B): Referred to by the Soviet delegation during SALT 2 treaty talks as Tu-22M, *Backfire-B* serves with both Long-Range Aviation as a strategic missile carrier and with AV-MF as a maritime reconnaissance and attack aircraft, the approximately 150 aircraft of this type so far delivered being divided about evenly between the two. For the anti-shipping rôle a pair of the new AS-6 *Kingfish* 150-mile (240-km) range missiles may be carried.



YAKOVLEV YAK-28P (FIREBAR): With probably in excess of 200 remaining in service with IAP-VO Strany, *Firebar* tandem two-seat interceptor equivalent of *Brewer* was first deployed in 1963-64. It may be assumed that the two AAMs normally carried by *Firebar* are of a later generation than the *Anabs* with which it was equipped for many years, but it may be assumed that the days of this fighter in first-line service are now numbered and that it will be withdrawn during the course of 1981-82.



YAKOLEV YAK-28 (BREWER-E): Derived from the *Brewer-A*, *-B* and *-C* tactical attack aircraft deployed by Frontal Aviation between the mid-'sixties and mid-'seventies, the *Brewer-E* variant of this supremely versatile warplane remains in service as an electronic countermeasures escort aircraft, together with the photographic reconnaissance *Brewer-D*. The *Brewer-E* has an active ECM pack built into its weapons bay, the *Brewer-D* having a similarly-housed camera pack.



YAKOLEV YAK-36MP (FORGER-A): Combining a vectored thrust lift/cruise engine with fore and aft lift engines, *Forger-A* is a single-seat shipboard air defence and strike fighter currently serving with AV-MF units aboard the carriers *Kiev* and *Minsk*. *Forger-A* is restricted to VTOL operation and has no attack radar or internal armament, four underwing pylons being provided for ordnance. A tandem two-seat conversion trainer, *Forger-B*, has a lengthened and drooped nose.

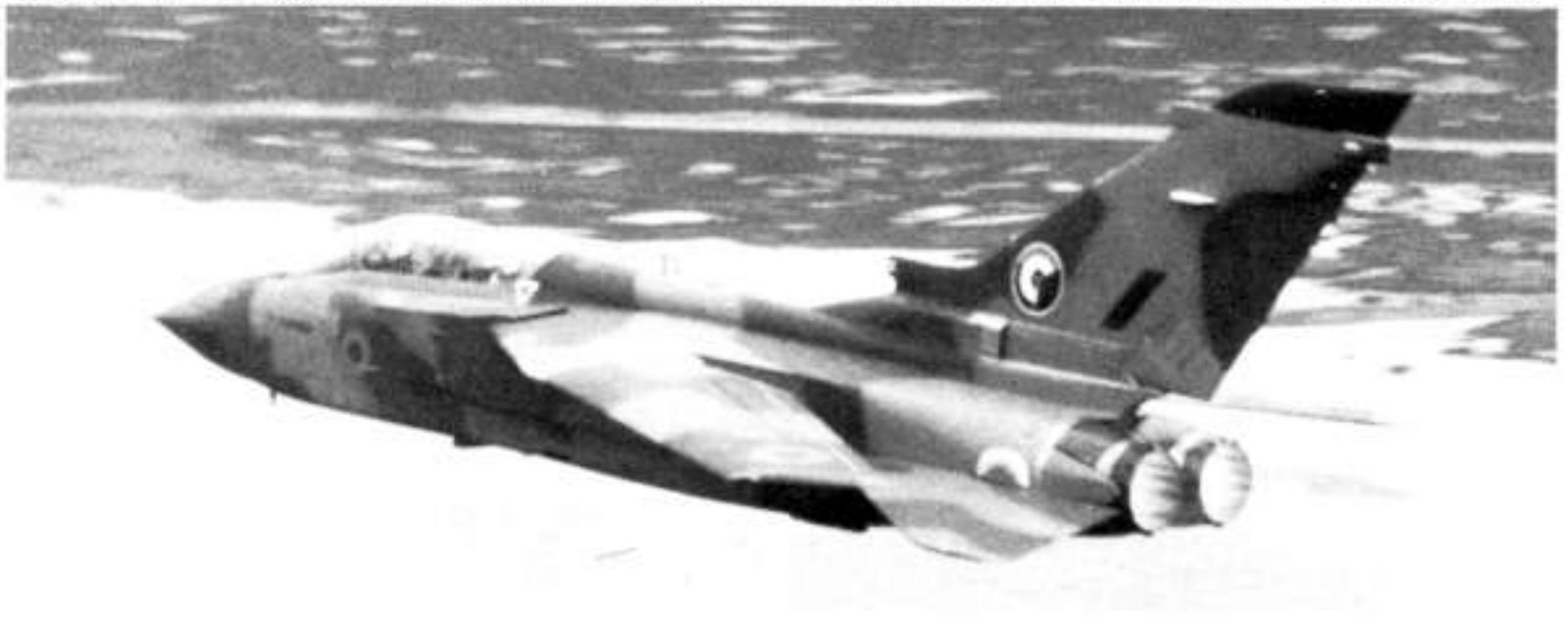
LOW-LEVEL OVER THE UK

The number of people in the United Kingdom who hear and see low flying military aircraft is increasing, and the noise produced by the present generation of aircraft inevitably causes a degree of annoyance and disturbance to those on the ground. The question is often asked, therefore, why does the RAF fly at low level and why can't it do so only over unpopulated areas? The purpose of this article by Sqn Ldr A H Jones, RAF, is to explain the need for low flying and the precautions taken by the RAF to minimise disturbance to the public.

LOW flying is of fundamental importance to the operational efficiency of the Royal Air Force. As part of NATO, the Service's primary rôle is to maintain peace by remaining sufficiently strong to deter any potential enemy from overt aggression. For this policy of deterrence to be effective, the RAF must have the ability to hit back swiftly and accurately. During the last few years, the development of radar and anti-aircraft missile systems has greatly increased the risks to aircraft attacking at medium or high levels. Therefore, should deterrence fail, the RAF's strike, attack, offensive support and reconnaissance aircraft would need to be flown at high speed and at very low level to be able to penetrate and evade the highly sophisticated defences of today.

As an alternative to the present policy of continuous low-level flying practice, it has been suggested that the RAF should carry out intensive training programmes, at the heights and speeds it would need to use in war, only at periods of heightened international tension. There are two drawbacks to such a policy: first, it is unlikely that there would be sufficient warning time to mount a realistic training programme and, secondly, such training initiated at a moment of tension could be interpreted as a degree of escalation and therefore be ruled as unacceptable on political grounds. Standards achieved in peacetime are those which the RAF would need to use if it ever went to war; the Service, like the nation as a whole, must above all be seen to be ready.

The RAF's current and future generations of combat aircraft includes five types committed to operations at high speed and low level. They include (top) the Buccaneer, of which there are currently three squadrons based in the UK, and (below) the Tornado GR Mk 1, the first operational units on which will begin to form within the next 12 months, to replace Buccaneers and Vulcans in the low-level strike rôle.



(Above) Jaguars at low level over the British countryside. Five squadrons fly this type from UK bases. (Left) On this map of the British Isles, the red patches show avoidance areas, in which a 1,000 ft (305 m) minimum applies, and magenta shows the transit route in which larger and less agile military aircraft fly, usually between 500 ft (152 m) and 1,000 ft (305 m).

As a relatively small force today, the RAF must depend more on quality than on quantity and, to be cost-effective, must train as realistically as possible. Ideally, therefore, its aircrews should train at speeds of well over 500 kts (926 km/h) and at heights around 100 ft (30 m) above ground level. However, the resultant noise levels experienced by people on the ground would be unreasonable. Peacetime training is therefore conducted at slower speeds and generally not below 250 ft (76 m), representing a compromise between operational training needs, flight safety and the levels of nuisance and disturbance which low flying can inflict on the public. There remains a requirement to permit suitably experienced and proficient crews to do some flying below the 250 ft (76 m) limit, and although remote and very thinly populated parts of the United Kingdom have occasionally been used for such training, the major opportunities during the last two years for practice at operationally realistic heights and speeds have been in North America.

The exercises "Red Flag" in Nevada and "Maple Flag" in Northern Canada in particular have given the opportunity to try out some of the RAF's low flying tactics and weapon attacks in a most realistic simulation of likely wartime conditions against heavily defended targets and employing advanced electronic counter-measures. The successes achieved by RAF crews, flying Buccaneers, Jaguars and Vulcans, have confirmed the validity of its training and tactics.

Operating a complex weapons system at low level is extremely demanding, and it does not take long for aircrews to lose currency and the last few points of "fine tuning" that can make the difference between operational success and failure. If crews are to acquire the basic skills and develop and maintain their operational expertise on front-line squadrons, they need regular and realistic practice in the techniques of low level formation flying for mutual offensive and defensive support, tactical routeing to exploit terrain screening and in weapons delivery.

Choice of terrain

The RAF has considered the possibility of conducting more of its training in flight simulators, but the present state of the art cannot realistically simulate conditions required for operating at low level

over representative terrain with the necessary depth of vision and all-round field of view. Low flying over the sea does not provide worthwhile training except for those squadrons with a maritime rôle; nor is there much scope for "exporting" more of the RAF's low flying elsewhere. Apart from the training done by RAF Germany squadrons, opportunities on the mainland of Europe are restricted to NATO exercises and occasional squadron exchange visits, since the crowded airspace and population densities there pose similar problems to those experienced at home.

Some use is already made of the large, very sparsely populated areas in Canada and the United States, and an increased use of such overseas areas was currently being investigated when this article was written; but any large-scale training in Canada or elsewhere would be a costly undertaking in financial, manpower and logistic terms. The RAF has concluded, therefore, that, while it must continue to explore and exploit opportunities for low flying abroad, it will never be possible to carry out the majority of its low flying overseas. There is no alternative but to make the best use possible of United Kingdom airspace for the essential low flying training.

From the noise disturbance point of view, it would be ideal if all low flying could be performed over uninhabited areas. Unfortunately, there simply are not enough areas in the United Kingdom of the size to permit flying at high speeds for long enough to be of any real training value to the crews of the current clutch of combat aircraft, and the arrangements for low flying have been revised to make the necessary provision for today's operational needs. Prior to 1 January 1979, the UK Military Low Flying System comprised a number of small areas joined by a network of narrow link routes. Not only did this produce considerable concentrations of noise and therefore an unfair burden on certain parts of the population, but the restrictions of the system led to aircrew familiarity and progressively reduced training value for low flying. The present, larger, system was therefore devised to spread the load more evenly by reducing the noise concentrations of the previous system and to provide more flexibility for aircrew as well as giving them more effective low flying training.

The structure of the system is shown on the accompanying map. Although most of the United Kingdom is now available for low flying down to 250 ft (76 m) above the surface, certain areas are not normally used. First, military low flying does not take place in controlled airspace or over major centres of population (these are called avoidance areas), nor does it normally take place in promulgated danger areas. These are all coloured red on the map. Secondly, some slightly less densely populated areas are necessary to allow access below cloud from one low flying area to another. These are termed transit areas (coloured yellow on the map) and are not overflown below 1,000 ft (305 m). In principle, the rest of the country is available to the RAF for low flying.

However, although the extent of the remaining airspace looks considerable, aircrews have to avoid a myriad of restricted areas. Flying over the larger towns is prohibited, as it is also in the vicinity of civil and military airfields, air traffic control zones, hospitals, atomic energy installations and many other places. The longer this list grows, the more constricted the remaining airspace becomes. In order to prevent a return to the problems of concentration of low flying which, as already explained, lead to considerable noise nuisance and degradation of training, it is essential to use all the suitable areas left in the UK.

The noise problem

The RAF's low flying arrangements are kept constantly under review in an attempt to minimise noise disturbance to the public while still achieving adequate training. No more low flying is done than is absolutely essential and the vast majority of this takes place during

Although the photographs below of (left) a Tornado and (right) two Harriers were taken largely for their dramatic effect, they clearly demonstrate the low-level manoeuvres routinely performed by RAF aircraft in the course of regular training exercises by squadron pilots.

daylight hours on weekdays only. However, some low flying has to take place at weekends for the benefit of the training requirements of units of the Territorial Army and others who cannot be available at other times. A certain amount of training must take place at night, but this low flying does not normally occur during the "quiet hours" between 11 pm and 7 am. Other ways have been considered of reducing the noise disturbance, such as allocating aircrews to certain areas on certain days, but the vagaries of the United Kingdom weather and the varying requirements of each flying station's training programme make this idea unworkable. For similar reasons, and because of the random distribution of low flying throughout the system, it is impracticable to publish schedules in advance for the routine day to day training. However, special exercises which involve activity of an unusual nature or at unusual times do have to be planned in advance, and on these occasions, everything practicable is done to warn the public.

A question of safety

There was considerable publicity about RAF aircraft accidents in 1979. While it was not statistically one of the better years, the total *number* of accidents was not significantly greater than suffered in previous years; and the possibly more telling indicator of the accident *rate* per 10,000 hours flown was up only fractionally, from 0·51 in 1978 to 0·52 in 1979. It is significant also to note that very few accidents can be attributed to low flying; perhaps three of the accidents in 1979 will eventually turn out, after investigation, to have been directly associated with operation of the aircraft at low altitude — and not all those were in the United Kingdom. Certainly, it is incorrect to imply that low flying represents a serious risk to members of the public. At the date of writing, the last accident directly attributable to low flying which involved a civilian fatality occurred in August 1974. The probability of a civilian being killed as a result of an RAF aircraft accident is about one in 50 million, compared to a probability of one in 24,000, as a pedestrian, of being killed in a road accident.

The other aspect of low-altitude flying by military aircraft that is a frequent cause of public concern is the possibility of a mid-air collision between military and civil aircraft. It must be remembered in this connection that, except during take-off and landing, the vast majority of civil flying must legally take place above 500 ft (152 m). A chart is published of the military low flying system (as reproduced here), so that civil operators now know where they may expect to see military low flying aircraft. For those civil operators (such as crop sprayers) who need to operate below 500 ft (152 m) and have CAA dispensation to do so, the routine Civil Aircraft Notification Procedure provides a degree of co-ordination with military movements, thereby improving flight safety. Under this system, civil operators are urged to notify their planned activities below the normal minimum altitude to one of 11 nominated RAF stations or, preferably, to the London Air Traffic Control Centre (Military). The information is then disseminated so that military pilots can take it into account when planning their low flying exercises.

The Ministry of Defence has devised arrangements to ensure that any complaints received are properly investigated. All low level flights are recorded so that tracing action can be taken when required. If a breach of the regulations is suspected, or if damage or injury has been reported, a thorough investigation is conducted by the RAF Police and the Ministry of Defence. To ensure that operators of the system are kept separate from the individuals responsible for investigating complaints, the investigations are primarily controlled by a civilian branch of the Ministry of Defence, which reports direct to the Parliamentary Under Secretary of State for the RAF.

For the foreseeable future, low flying will remain one of the essential elements of the RAF's military contribution to the NATO deterrent. To be credible in this, the Service needs to achieve the highest standards possible in peacetime commensurate with an acceptable level of noise nuisance to the public. While continuing to minimise this disturbance and spread it as fairly as possible, RAF crews must have the facilities to be able to train realistically at low level. Without constant low flying practice, aircrews of the present decade would be like sailors who never went to sea. In the view of those engaged in this essential activity the disturbance caused by military low flying is a comparatively small price to pay for helping to maintain the peace. □

'BOATS FOR AIRMEN

A survey of the development and use of flying boats in the RAF, by Chris Cole

AMONG the wide-ranging inter-war aviation prophesies none seemed likelier of fulfilment than that of a golden future for the flying boat. Military value apart, it was hailed as the natural vehicle for linking the far-flung territories of the British Empire and operating where aerodromes were few and far between. The flying ship concept aroused deep emotions — enhanced, it may well be, by Britain's nautical traditions — and there was no more stirring spectacle than that of a flying boat taking off or sailing majestically overhead.

Despite the portents of World War II a few flying boat protagonists survived into the 'fifties — and then suddenly an era had ended. The RAF flew its last Sunderland sorties in 1959 and the civil Princess slumped from the great white hope to a great white elephant. Thanks only to the zeal of a private individual who acquired a French-operated Sunderland after the casual scrapping of all RAF machines, young visitors to Hendon may still admire one of the last aerial "tall ships" which graced an era before they were born. To tell their story, we must go back sixty years and more.

By the outbreak of the Great War in 1914 aviation progress had dispelled early doubts about the aeroplane's value for maritime operations, but specialised machines were slow to emerge and most designers favoured landplanes with floats ("seaplanes") rather than boats with wings ("flying boats"). Contrary to a popular impression that the flying boat was a peculiarly British invention, two of the three best examples available in 1914 were foreign; and ironically, the British design, which pioneered a formula employed until the 1930s, saw only limited service. This was the 1913 Sopwith Bat Boat amphibian, with a 21-ft (6,4-m) hull and the tail carried on booms, powered by a 90 hp Austro-Daimler or 100 hp Green engine. It was followed in 1914 by a larger 225 hp Sunbeam-powered version which achieved 78 mph (126 km/h). Three Bat Boats were bought for the RNAS (Royal Naval Air Service), one making the first British night flight from water. Otherwise they created little impact, and Sopwith thereafter concentrated on fighters and floatplanes, leaving development of the short hull-and-boom layout to foreign firms.

The RNAS had acquired its first flying boat in October 1912, a French Donnet-Lévêque powered by an 80 hp Gnome rotary, which set the pattern for small single-engined machines of the next 25 years. The design was developed by Franco-British Aviation and early in the war the Admiralty ordered the larger 80 mph (129 km/h) FBA type "B" for close patrol work. This had 45-ft (13,7-m) two-bay wings, and the 100 hp Gnome pusher installation left pilot and observer, seated side by side and armed with a Lewis gun and small bombs, unbothered by the proximity of a propeller. The hull had a slightly concave bottom, and the lavishly-strutted tail gave the machine a deceptively flimsy appearance. FBAs frequently scrambled from Dover against daylight tip-and-run raiders, but the only recorded combat victory was by a Dunkirk-based example in November 1915. Some 150 FBAs were used by the RNAS.

More significant were the flying boats built by the American, Glenn Curtiss, which stood out among the generally unimpressive US designs and strongly influenced future trends. Successful British demonstrations in 1913 led to the Curtiss licence being acquired by White and Thompson of Bognor, whose board included a leading British aviator, Lt John Cyril Porte. Invalided out of the Navy with tuberculosis, Porte had learned to fly in 1911, and in 1914 he left White and Thompson to assist Curtiss with his contender for the *Daily Mail* £10,000 transatlantic prize. After various permutations, the Curtiss "America" emerged as a clean two-bay biplane with two 90 hp Curtiss engines and an enclosed cabin, well ahead of its time. With the contest cancelled because of the war, this boat's ability to reach Britain was not tested, and Porte returned home to be accepted into the RNAS.

Two imported single-engined Curtiss boats were impressed into the RNAS, and White and Thompson, the British agents for Curtiss, received a small order for their own flying boat of similar design, known as the No 3. One of these from Calshot vainly attempted to reach the Zeppelin L31 over Portsmouth in September 1916. From 1915, when the firm became the Norman Thompson Co, the further developed N.T.28 was widely used as a trainer.

Clearly the twin-engined type had greater potential and the Admiralty ordered 12 shortly after the outbreak of war. Six sent to Dunkirk revealed various shortcomings, and in April 1915 they went to Felixstowe for extended trials aimed at improving the additional 50 that had by then been placed on order. Porte, in command of the base, had already operated the America with some distinction and was aware of the problems. Replacement of the 90 hp Curtiss engines with 100 or 125 hp Anzani radials still left it underpowered, though some later deliveries had the 160 hp Curtiss. The type was designated the H.4, but colloquially known as the America.

To confuse the picture, modified Norman Thompson versions — the N.T.4 and N.T.4a — were also called Americas. These retained the Curtiss hull but had Hispano Suiza engines installed as pushers, and generally cleaner lines. Thirty were built, and the N.T.4a with 200 hp Hispanos had a top speed of 95 mph (153 km/h).

During 1915, Porte investigated the H.4's fundamental hull weaknesses. The shallow-V bottom had poor hydrodynamic performance and a tendency to fracture aft of the single step, limiting operations to moderate seas. After much experimentation he fitted a longer, two-stepped planing bottom having a deeper V, and thus

(Above) Yarmouth-based F.2A serial N4283, the first to carry "dazzle painting". This was the result of a Sunday morning inspiration in the spring of 1918 by its pilots, Flt Lts Bob Leckie and Gerry Livock, who personally applied the black-and-white paint scheme. (Below) Curtiss H12 No 8666, the first flying boat to shoot down a Zeppelin, and later the hero of a classic North Sea rescue drama.

produced the Felixstowe 1 (or F.1). With two 150 hp Hispano engines, the F.1 achieved 85 mph (137 km/h) — 10 mph (16 km/h) faster than the H.4 — and showed much improved hydrodynamic behaviour.

H.4 shortcomings had not prejudiced an order for 50 of the larger Curtiss H.8s, and the first of these arrived from the USA in July 1916. Apart from similar hull weaknesses and inadequate rear armament, the 92-ft (28-m) span H.8 was underpowered by its 160 hp engines. However, substitution of the 250 hp Rolls-Royce (which later became the Eagle) transformed flying performance, with a maximum speed of 85 mph (137 km/h), and 24 more were ordered. In this form it became the H.12, or Large America, reducing the H.4s and N.T.4s to Small Americas.

Boats operational

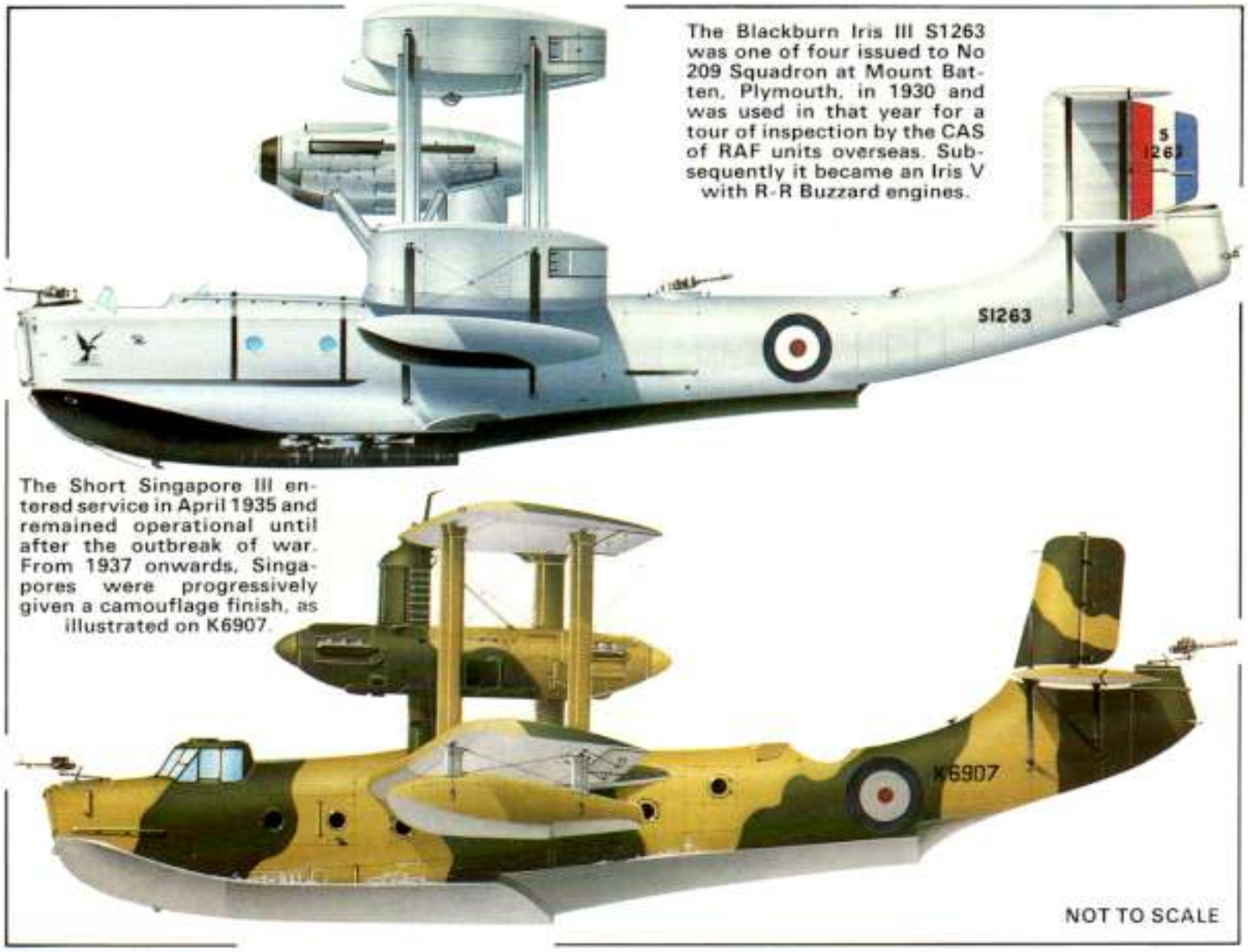
The H.12 made an operational impact comparable with that of the Fokker monoplane in 1915, achieving high success against submarines and in the unlikely rôle of Zeppelin hunter. Its assets were a 350-mile (563-km) radius of action, a 10,800-ft (3 292-m) ceiling, paired Lewis guns in the bow cockpit and a 460-lb (209-kg) bomb load. In April 1917, the Admiralty evolved a scheme whereby H.12s were despatched to flush out reconnoitering Zeppelins located by intercepted wireless messages. Before the enemy fully appreciated this threat to a hitherto unopposed North Sea activity, the L22 was shot down on 14 May by Yarmouth-based H.12 No 8666 flown by Flt Lt C J Galpin and Flt Sub Lt R Leckie, and the L43 on 14 June by Felixstowe-based No 8677 flown by Flt Sub Lts B D Hobbs and R F L Dickey.

No 8666 had six subsequent encounters with Zeppelins, that of 5 September ending with a classic rescue. The alerted Zeppelins now comfortably outclimbed the flying boats, so a heavily armed D.H.4 accompanied 8666. The L44 was sighted and attacked, then the D.H.4 developed engine trouble and ditched. Alighting despite combat damage to pick up its crew, the H.12 was unable to take off in

(Right) A Felixstowe F.5 flying boat as used by No 230 Squadron from Felixstowe and later Calshot. The wooden hulls were varnished and polished; superstructure, and the planing bottoms of the hulls, were doped white.

(Below) The Supermarine Southampton replaced the F.5 at Calshot in 1925, where No 230 Squadron had meanwhile become No 480 (Coastal Reconnaissance) Flight; they also served in the Far East Flight, later No 205 Squadron. S1123 is depicted as a wooden-hulled Mk I; it was later converted to a metal-hulled (silver-finished) Mk II.

NOT TO SCALE



The Blackburn Iris III S1263 was one of four issued to No 209 Squadron at Mount Batten, Plymouth, in 1930 and was used in that year for a tour of inspection by the CAS of RAF units overseas. Subsequently it became an Iris V with R-R Buzzard engines.

The Short Singapore III entered service in April 1935 and remained operational until after the outbreak of war. From 1937 onwards, Singapores were progressively given a camouflage finish, as illustrated on K6907.

NOT TO SCALE

the heavy sea, so taxied for the English coast until fuel ran out. The W/T was useless, but thanks to carrier pigeons the drifting boat was found three days later.

The H.12s became operational shortly after the start of Germany's unrestricted submarine warfare campaign in February 1917. On 24 April, a Calshot-based H.12 inconclusively attacked the UB-39 off Portland, and on 20 May No 8663 flown by Flt Sub Lts C R Morrish and H E Boswell on the Spider's Web patrol from Felixstowe sank the UC-36, the first U-boat destroyed from the air. Between April and September, flying boats made some 30 attacks on North Sea U-boats, claiming several more sinkings. On 28 September, Hobbs and Dickey achieved the unique double, sinking the UC-6 with two well-placed 230-lb (104-kg) bombs.

In 1915, Porte had designed a substantially bigger flying boat for long patrols. Spanning 124 ft (37,78 m) and powered by three 250 hp Rolls-Royces — two tractors and a central pusher — the Porte Baby, as this giant was somewhat ironically named, was the largest British aircraft operational in World War I. The first was completed early in 1916, and on 17 May made the original "composite aircraft" experiment, launching a Bristol Scout from the top wing. This potential method of intercepting Zeppelins was not further tested. Early operations in the spring of 1917 revealed the Baby as unwieldy and vulnerable, and only 11 were built.

While the Baby was under trial, Porte adapted an H.12 with a scaled-up version of the F.1 hull to produce the F.2, with improved strength and water performance, and beam guns to cover previous blind spots. The definitive F.2A, powered by 345 hp Eagles, was slightly larger than the H.12, spanning 95 ft 7½ in (29,14 m) and at 10,970 lb (4 980 kg), some 300 lb (136 kg) heavier. It was 10 mph (16 km/h) faster, with improved ceiling and an eight-hour endurance.

F.2As were built by various companies and before the first of nearly 100 was delivered in November 1917, Porte had produced developed versions. He captained an F.2C prototype which helped to sink the UC-1 on 24 July 1917. Then came the heavier, longer-range F.3 carrying four 230-lb (104-kg) bombs against the F.2A's two, but less manoeuvrable and 10 mph (16 km/h) slower. About 100 were delivered, starting in early 1918.

Much vital F-boat work went unsung, consisting of routine anti-submarine patrols, which increased four-fold in the final year of war. The F.2A was capable of surprisingly brisk evasive action and could absorb extensive combat damage. Additional guns were often mounted, and fighting capacity was well demonstrated during the war's biggest seaplane engagement, on 4 June 1918.* Four F.2As and an H.12 were patrolling off Terschelling when one F.2A put down with a broken petrol pipe and taxied for neutral Holland (where it was beached and burned). This was a chronic failing, and the force leader, Robert Leckie (later CAS of the RCAF) reported acidly: "our greatest foes are not the enemy, but our own petrol pipes."

While the remaining boats were escorting the lame duck, 15 Brandenburg floatplane fighters assembled. The H.12 chased one of these and was driven down, but Leckie scattered the enemy force with a head-on attack by his three aircraft. In the subsequent 40-minute combat six fighters were destroyed or damaged. An F.2A was forced down with petrol feed trouble — and its co-pilot shot dead — but got off again despite a damaged wing float, and the surviving boats returned after a six-hour sortie.

A few improved Curtiss H.16s were operating by the end of the war, often officially categorised with H.12s and F-boats simply as "Large Americas". To further confuse identification, some F-boats had open and others closed cockpits. During 1918 many carried

**Until April 1918, the flying boats had been operated by units of the RNAS. When the RAF was formed on 1 April 1918 by a merger of the RNAS and the RFC, the former's squadrons were renumbered in the 200 series (ie, No 1 RNAS Squadron became No 201 RAF, No 2 became No 202 and so on). The naval origins of the RAF's flying boat force was to be perpetuated by their continued use by squadrons with 200-series numbers.*

bizarre fuselage paint schemes, originated at the spontaneous whim of Flt Lts Bob Leckie and Gerry Livock to emulate the "dazzle painting" of warships, and officially adopted on appreciation that it assisted mutual identification in the air, and location after forced alightings.

Lesser-known wartime flying boats included a few AD (Admiralty Air Department) machines built by Supermarine, featuring the wooden monocoque hull designed by Lt J Linton Hope. This was adopted for the Supermarine Baby single-seater, built to a 1917 specification for a seaplane fighter to deal with the German Brandenburgs. Prototypes were also made by Blackburn and Norman Thompson, but the war ended before production decisions were reached.

An impressive late war project which extended into peacetime was Porte's vast Felixstowe Fury triplane with five Eagle engines, envisaged as the ultimate in long-range patrol craft. It was wrecked in 1919, after Porte himself left the service and his death late that year effectively brought to an end the series of Felixstowe designs.

Another heavyweight, designed by Fairey to the 1917 N.4 Specification and built by widely separated firms, was the four-Condor Atalanta, completed in 1919 but not flown until 1923. Two were produced, followed by the improved Titania. The Phoenix Cork, a promising twin-Eagle design, was developed by English Electric as the Kingston with Napier Lions and five were constructed. Post-war economies ruled out production orders for these aircraft, but they performed useful research functions.

A significant step was taken in January 1918 by Short Brothers Ltd of Rochester, best known for the series of ungainly floatplanes built for the RNAS. Already building Porte machines, the company embarked on its first house-designed flying boat to Specification N.3, and the Cromarty, with two Condors, appeared in 1921. The Vickers Valentia was built to the same specification, but neither proceeded beyond the prototype stage.

Post-war development

In the event, a straightforward F-boat development, the Felixstowe F.5, was chosen for post-war service with the RAF. Powered by two 350 hp Eagles, the prototype achieved 102 mph (164 km/h) during trials in early 1918. It reverted to open cockpits since most pilots preferred unimpeded vision, and horn-balanced ailerons increased span to 103 ft 8 in (31,60 m) — two feet more than that of the F.3. Some F.2As and F.3s under construction were converted to F.5 standard, and because economies dictated maximum use of F.3 parts, production models were heavier. Top speed slumped to 88 mph (142 km/h) and ceiling was a modest 6,800 ft (2 073 m), but bomb load remained four 230-lb (104-kg). The number built is obscure, but in all nine squadrons were equipped.

During a brief post-war euphoria over RAF transport prospects, ambitious plans were made to start F.5 services to the Azores, USA and Egypt in September 1919. One aircraft made a 14-hour endurance trial before the project was abandoned. In 1923, two Malta-based F.5s visited North African ports and Gibraltar, but the bread-and-butter work was fleet co-operation and anti-submarine exercises.

The first RAF flying boat of wholly post-war origin, the single-engined Seagull deck-landing amphibian of 1922, marked the emergence of Supermarine as an important military constructor. However, that company's activities remained principally civil until the twin-engined Swan prototype transport inspired the Air Ministry to order a development to Specification R.18/24. This entered service in 1925 as the Southampton, replacing the F.5.

The Southampton was the first major military design of the brilliant R J Mitchell, appointed Supermarine's chief designer in 1919 when only 24 and destined to create the Spitfire before his untimely death in 1936. Spanning 75 ft (22,86 m) and powered by two 470 hp Napier Lions, the Southampton had a range of 700 miles (1 126 km), a maximum speed of 108 mph (174 km/h) and cruised at 83 mph (134 km/h). Smaller and neater than the old F-boats, it was a clean and curvaceous two-bay biplane, with the pilots' cockpits in tandem ahead of the wireless cabin. There were gun rings in the nose and, staggered port and starboard, in the hull aft of the wings. It had basic domestic facilities and was designed for easy maintenance.

No 480 Coastal Reconnaissance Flight at Calshot received Southamptons in August 1925 and demonstrated their efficiency during the autumn naval exercises. In 1926 two Southamptons flew to Egypt, returning via Cyprus and Greece. In 1927 the wooden-hulled Mk I was followed by the metal-hulled Mk II, with a range of 900 miles (1 450 km). Its duralumin hull was 500 lb (227 kg) lighter, and eliminated water soakage which could increase the weight of a wooden hull by 400 lb (182 kg). Most of the 20-odd Mk Is in service were converted to Mk II standard, and production continued until in all the RAF had 68 Southamptons.

Highlight of the Southamptons' 12 years service was the historic 27,950-mile (44 970-km) Far East Flight of 1927-28 to Singapore, round Australia, Hong Kong then back to Singapore, led by Gp Capt H M Cave-Brown-Cave. The principal object was to allow the RAF to gain operating experience away from main bases over a period long enough to study progressive problems, ranging from corrosion to barnacles — these being found to increase take-off time from 30 to 50 seconds. Four Southampton IIs left Plymouth on 17 October 1927 and had staged through 68 places, with major breaks at Karachi, Singapore and Melbourne, when they ended their task at Seletar, Singapore, on 11 December 1928. They averaged 80 mph (129 km/h) ground speed and the only diversion was over Iraq, where head winds enforced an unscheduled stop at Ramadi. There were planned engine changes after returning from Australia, and one Southampton was shipped home for detailed technical examination, being replaced on station by the pre-positioned reserve aircraft.

For reasons which remain obscure, while Fairey and English Electric expertise was kept alive with prototypes unlikely to enter service, the Air Ministry treated Shorts as intruders into the esoteric flying boat world. Having pioneered metal stressed-skin construction with a landplane in 1920, the company had to wait for four years before it obtained grudging approval to produce a metal monocoque hull for the F.5. As the Short S.2, this performed so well that a metal-hulled Cromarty development was ordered to Specification 13/24, appearing as the Singapore I in August 1926, powered by two 675 hp Rolls-Royce Condors.

Boats by Blackburn

However, the RAF was then seeking a more powerful, longer range machine and the prototype Blackburn Iris flew a month later, built to Specification 14/24 with three Condors against the Singapore's two. This handsome boat, with equal span 95-ft (28,96 m) wings was designed by Maj J D Rennie, formerly Porte's right-hand man, but with metal construction becoming respectable the RAF had lost interest in the wooden Iris and similarly-powered Saunders Valkyrie. Next came the metal-hulled Iris II, and eventually the all-metal Iris III went to No 209 Squadron in 1930 when the Condor engine was nearing obsolescence. Within two years the four built were re-engined with 825 hp Rolls-Royce Buzzards to become Iris Vs.

In 1933, the fractionally larger Mk VI to Specification R.20/32 brought minor hull and engine installation changes, an enclosed cabin and a 37-mm COW gun in the bow cockpit. This became the Perth and four were built. Maximum weight increased from the 31,000 lb (14 074 kg) of the Iris V to 32,500 lb (14 755 kg), range

The first flying boat of post-war design to enter RAF service was the Supermarine Southampton, one of R J Mitchell's first military aircraft designs. About 20 Southampton Is had wooden hulls (below) but most were converted to metal-hulled Mk IIs (above) and about 50 more were built as such.

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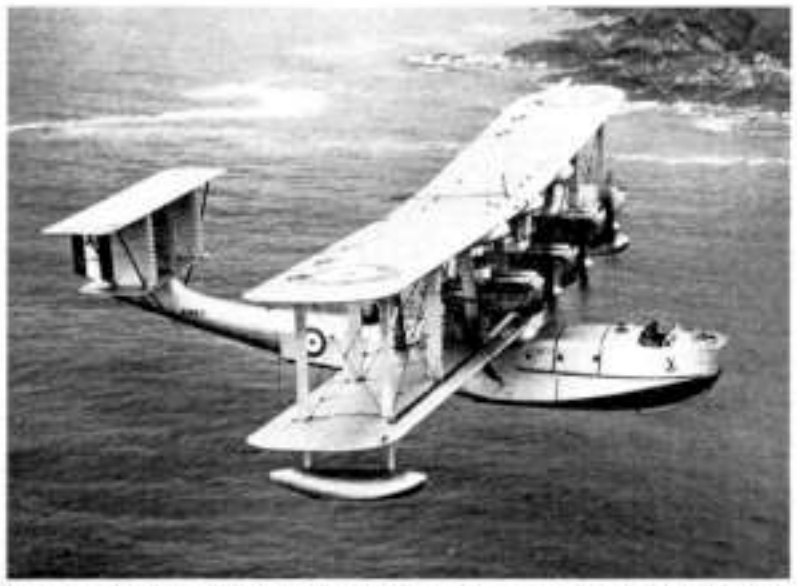


The Blackburn company made a relatively small but important contribution to RAF flying boat operations between the wars with the Iris and Perth three-engined boats. The Iris III S1263 (above right) was one of the pair that made a return flight to Egypt in 1931, carrying the then CAS, Sir John Salmond, on an inspection of the RAF overseas. Most important of the Short biplane boats used by the RAF was the Singapore III (above left), of which 37 entered service.

was 1,300 miles (2 092 km) while bomb load remained at 2,000 lb (907 kg); top speed went up from 118 to 132 mph (190 to 212 km/h).

The Iris established new standards for crew accommodation and a reputation for sturdy reliability, maintained by the Perth. It made a few long-range prestige flights, but, as the largest RAF aircraft, gained greater publicity from two spectacular accidents, neither caused by design faults. With ten aircraft built to maintain a squadron strength of four, the 12-year Iris/Perth saga appears as one of the least cost-effective exercises in RAF history.

Reverting to the 1920s, Shorts' RAF disappointments were mitigated by Cobham's notable 23,000-mile (37 000-km) African survey in the "civilianised" Singapore I. Then the company's Calcutta was so successful with Imperial Airways that a military version, the Rangoon, was ordered when a larger, more powerful aircraft was needed quickly for air control duties in the Persian Gulf which, to the Admiralty's fury, had been allotted to No 203 Squadron's Southamptons. The first of six Rangoons entered service in 1931; spanning 93 ft (28,35 m) and powered by three 540 hp Jupiters, the 24,000 lb (10 896 kg) Rangoon had a top speed of 115 mph (185 km/h) and good two-engined performance. No 203 Squadron's routine work from Basrah was relieved by a 19,000-mile (30 570-km) flight to Melbourne and back by three Rangoons in 1934. Equally creditable was the return to England of all six original aircraft when obsolescent in 1935.

The Singapore saga

Meanwhile, Specification R.32/27 for something between the Iris and Southampton produced several three-engined prototypes. Supermarine built the Jupiter-powered Southampton X — quite unlike the basic aircraft — while Saro offered the similarly-engined Severn. Blackburn's Sydney monoplane with Kestrels broke new ground, its purposeful air enhanced by a battleship-grey finish — perhaps to reassure naval diehards. It achieved a respectable 127 mph (204 km/h) — but the day of the monoplane had not arrived.

In the event, the Ministry preferred Shorts' four-engined Singapore II, flown in March 1930, to three-engined contenders offering little advance over the Rangoon. After various changes had been made, including an enclosed cockpit and replacement of the single fin and rudder by a triple arrangement, the definitive Singapore III was ordered in August 1933, and the first production model flew 10 months later.

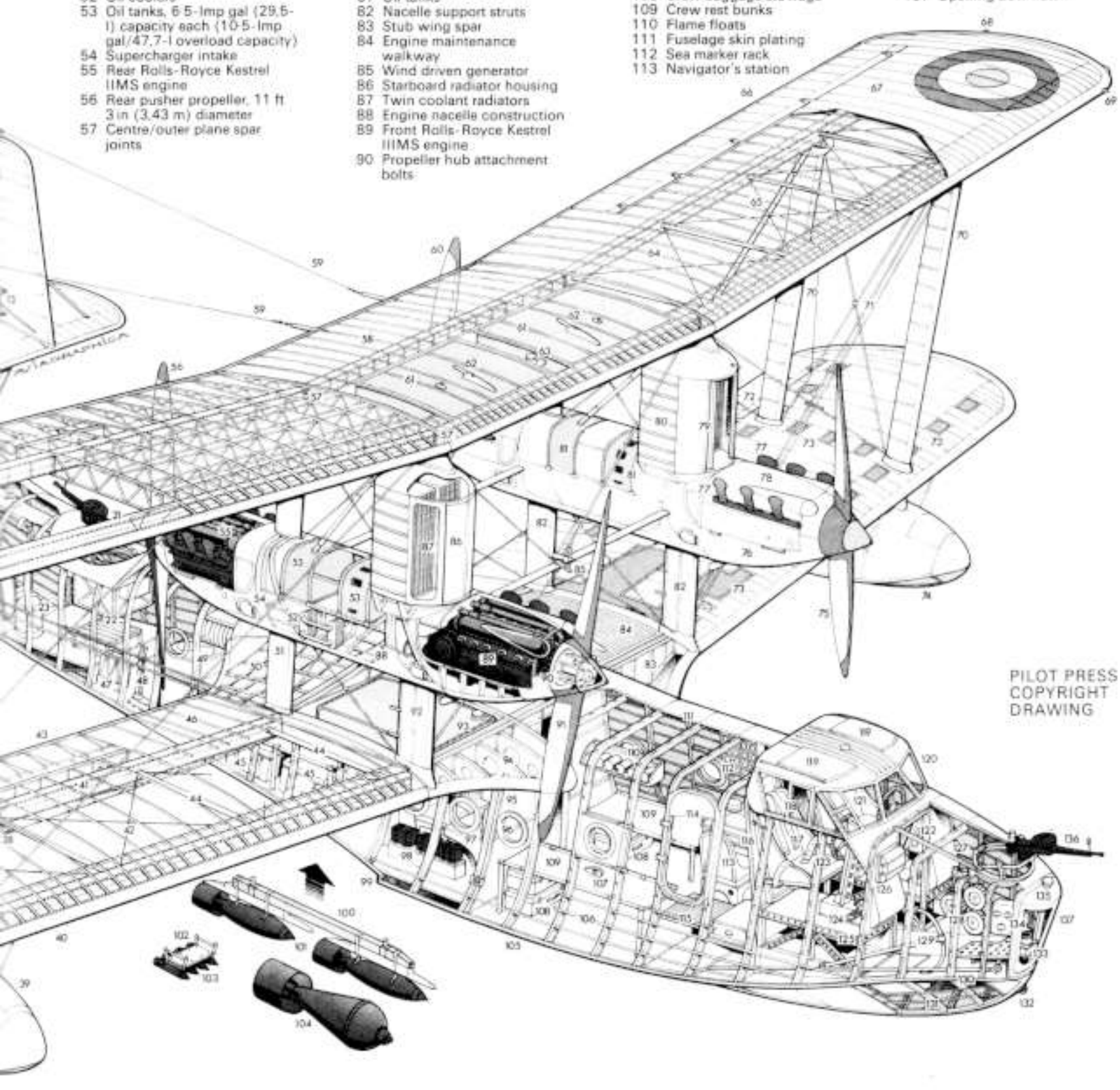
With four 560 hp Kestrels in tandem pairs between slightly swept back, single-bay wings, the Singapore III was a compact, well-proportioned machine. It spanned 90 ft (27,4 m) and the 750 hp Kestrels of later versions gave it a top speed of 145 mph (233 km/h). Maximum take-off weight was 31,500 lb (14 288 kg), and range at 105 mph (169 km/h) was 1,000 miles (1 610 km).

The Singapore III had a tragic RAF debut, one crashing near Messina on 15 February 1935 while en route to No 205 Squadron, Seletar. Singapores equipped six squadrons and operated in the Mediterranean during the Abyssinian crisis and the period of the Spanish civil war. They were popular despite a few early tail incidence gear failures, one causing a hasty descent on to a small lake at Hever Castle, Kent — a feat that can only instil wonder in any latter-day visitor to the site — and another, over Iraq, being rectified by a lash-up repair from the tail cockpit. Singapore production ceased in 1937 after 37 had been built — the biggest run of flying boats for the RAF since the Southampton. Most were retired early in

Short Singapore III, Cutaway Drawing Key

1 Starboard elevator
2 Tailplane rib construction
3 Fin bracing strut
4 Fin construction
5 Rudder tab
6 Triple rudders
7 Fin horizontal struts
8 Tail Lewis 0·303-in (7,7-mm) machine gun
9 Gun mounting Scarff ring
10 Elevator control links
11 Port elevator
12 Port tailplane
13 Rudder control links
14 Tailplane bracing struts
15 Fin trimming screw jack
16 Tailplane attachment double frame
17 Tailplane trimming screw jack
18 Catwalk to tail gunner's cupola
19 Dinghy oars
20 Spare propeller stowage
21 Midships Lewis 0·303-in (7,7-mm) machine gun
22 Gunner's firing platform
23 Toilet
24 Inflatable dinghy
25 Dinghy inflation bellows
26 Upper wing panel main spars
27 Wing rib construction
28 Starboard upper aileron

29 Formation light
30 Wing tip construction
31 Light alloy leading edge
32 Starboard navigation light
33 Leading-edge nose ribs
34 Upper-to-lower aileron interconnecting cables
35 Interplane struts
36 Diagonal wire bracing
37 Starboard lower wing panel
38 Aileron hinge control links
39 Starboard wing-tip float
40 Light-alloy leading edge
41 Rolled tubular wing spars
42 Wing internal wire bracing
43 Starboard lower aileron
44 Inter-spar compression struts
45 Tropical medical panniers
46 Fixed portion of trailing edge
47 Parachute stowage
48 Bilge pump
49 Galley compartment and food lockers
50 Stub wing trailing edge construction
51 Engine nacelle rear strut
52 Oil coolers
53 Oil tanks, 6·5-Imp gal (29,5-l) capacity each (10·5-Imp gal/47,7-l overload capacity)
54 Supercharger intake
55 Rear Rolls-Royce Kestrel IIMS engine
56 Rear pusher propeller, 11 ft 3 in (3,43 m) diameter
57 Centre/outer plane spar joints
58 Centre plane construction
59 Aerial cables
60 Starboard pusher propeller
61 Main fuel tanks, 393-Imp gal (1 787-l) capacity each
62 Fuel tank vents
63 Filler cap
64 Port upper wing panel
65 Wing internal wire bracing
66 Port upper aileron
67 Wing fabric covering
68 Formation light
69 Port navigation light
70 Port interplane struts
71 Diagonal wire bracing
72 Port lower aileron
73 Lower wing panel reinforced walkways
74 Port wing-tip float
75 Tractor propeller, 12 ft 6 in (3,81 m) diameter
76 Port engine nacelle
77 Exhaust pipe shrouds
78 Detachable engine cowlings
79 Radiator shutters, open
80 Port coolant radiators
81 Oil tanks
82 Nacelle support struts
83 Stub wing spar
84 Engine maintenance walkway
85 Wind driven generator
86 Starboard radiator housing
87 Twin coolant radiators
88 Engine nacelle construction
89 Front Rolls-Royce Kestrel IIIMS engine
90 Propeller hub attachment bolts
91 Starboard tractor propeller
92 Forward nacelle strut
93 Overload fuel tank, 240-Imp gal (1 091-l) capacity each side
94 Stub wing leading edge construction
95 Wing/fuselage attachment double bulkhead
96 Cabin window panels
97 Flight engineer's station, radio operator on port side
98 Batteries
99 Planing bottom step
100 Bomb rack mounting beam, two per side
101 Two 250-lb (113,5-kg) bombs
102 Light series bomb carrier
103 Four flame floats
104 Single 500-lb (227-kg) bomb
105 Hull chine member
106 Fuselage frame and stringer construction
107 Mooring light
108 Crew baggage stowage
109 Crew rest bunks
110 Flame floats
111 Fuselage skin plating
112 Sea marker rack
113 Navigator's station
114 Crew entry door
115 Entry step
116 Cockpit sloping bulkhead
117 Co-pilot's seat
118 Opening side window panel
119 Sliding cockpit roof hatches
120 Windscreen panels
121 Pilot's seat
122 Instrument panel
123 Control column handwheels
124 Rudder pedals
125 Pilot's floor level
126 Parachute stowage
127 Front gunner/bomb aimer's compartment
128 Spare ammunition drums
129 Anchor stowage
130 Boat hook
131 Hull planing bottom construction
132 Towing ring
133 Bomb sight
134 Bomb release panel
135 Mooring post
136 Front Lewis 0·303-in (7,7-mm) machine gun
137 Opening bow hatch



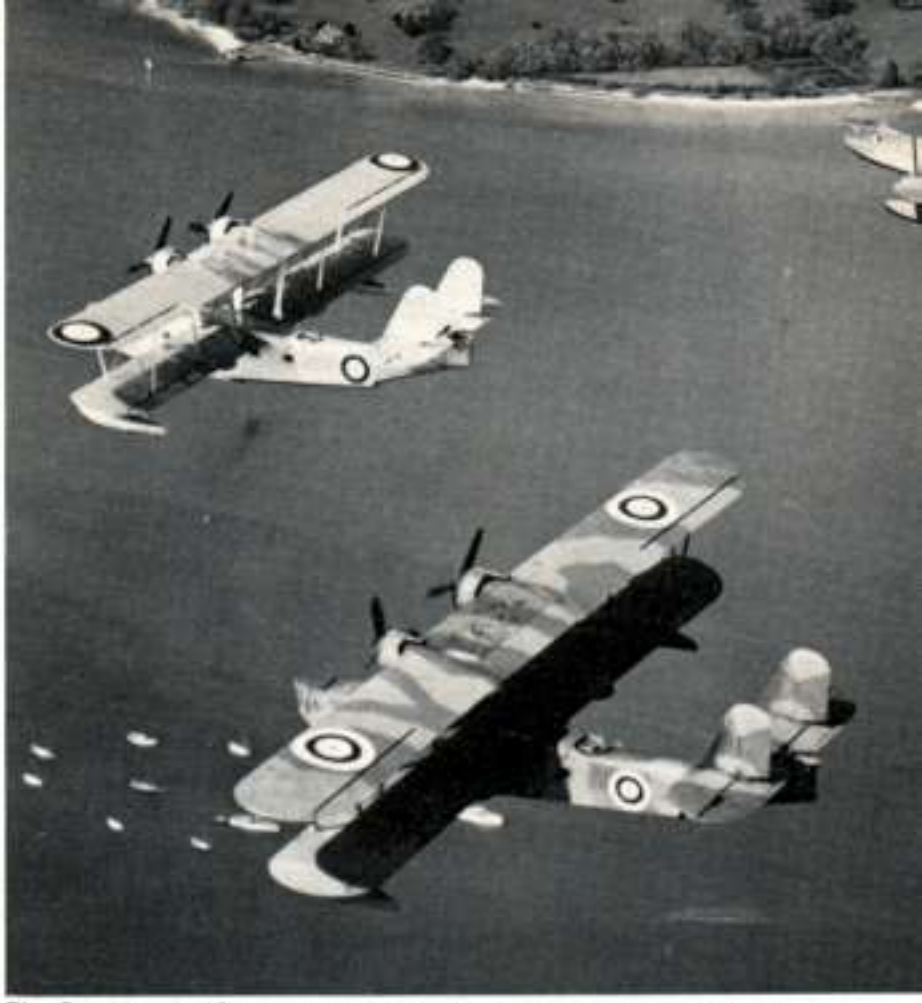
the war, but a few transferred to the RNZAF operated from Fiji until 1945.

One other impressive Short biplane bearing RAF roundels deserves mention — the 70,000-lb (31 752-kg) Sarafand built to Specification R.6/28 with six Buzzards, which flew in 1932 and achieved an impressive 153 mph (246 km/h). It was something of an anachronism, and despite early talk of transatlantic capability, made no notable long-range flights and was scrapped in 1936.

With the Rangoon serving as one stop-gap Southampton replacement, the Air Ministry ordered a proliferation of types for remaining squadrons. First was the Supermarine Scapa, to Specification R.20/31, originally the Southampton IV, though the only common factors were the 75-ft (22,86-m) span and staggered aft gun cockpits. It was a tidy single-bay design, with two 525 hp Kestrels mounted on the underside of the top wing, and the 141 mph (227 km/h) maximum speed was a big advance. The pilots sat side by side in an enclosed cabin, and the roomy straight-sided hull provided generous stowage space. Despite successful completion of demanding prototype trials, including a 15,000-mile (24 140-km) flight to Port Sudan and back, only 14 were built, entering service in 1933.

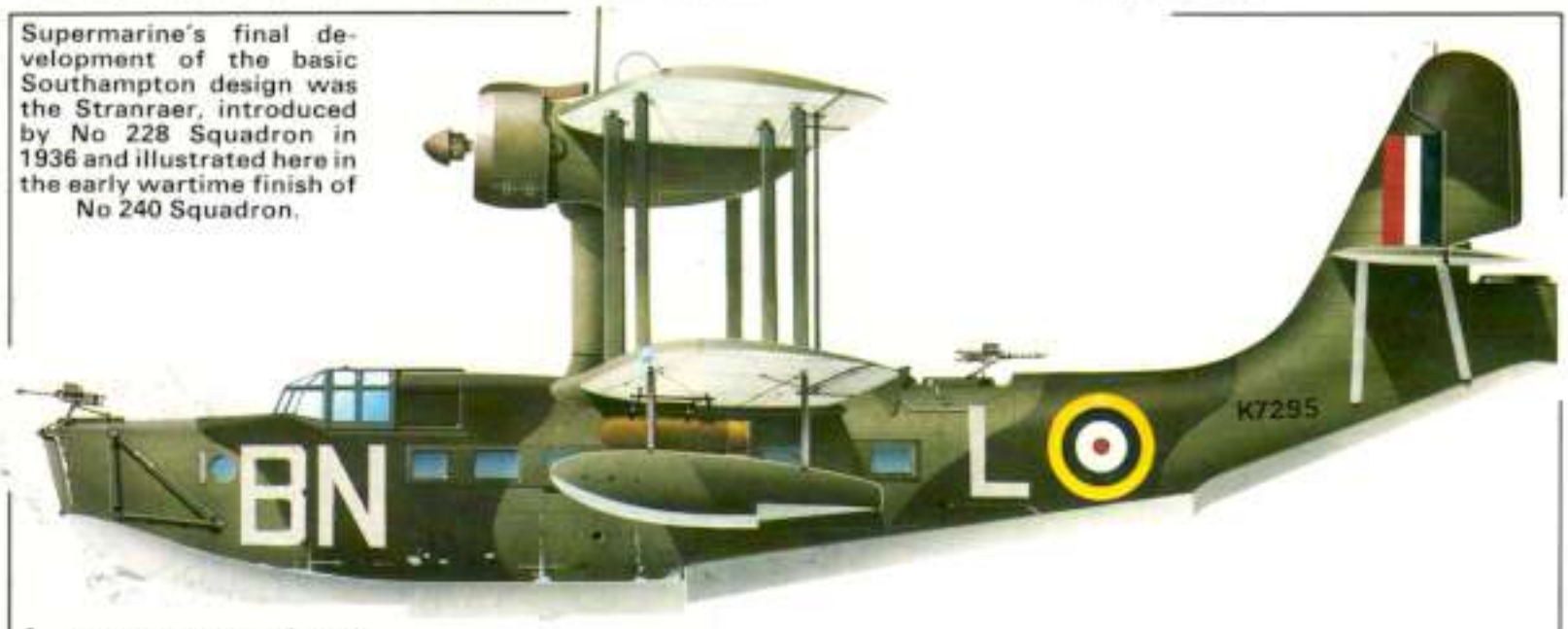
The main Southampton replacements, the Supermarine Stranraer and Saro London, resulted from Specification R.24/31. Shorts' alternative angular "Knuckleduster" monoplane was ruled out by a combination of factors including the unsatisfactory Goshawk engines.

The Stranraer, built in prototype guise as the Southampton V, was the last of Mitchell's flying boats and appears a somewhat pedestrian creation beside his immortal Spitfire. Nevertheless, the 85-ft (25,91-m) span two-bay Stranraer was a clean machine, and with two neatly-cowled 920 hp Bristol Pegasus radials driving Fairey-Reed metal propellers it achieved 165 mph (266 km/h) — the RAF's fastest biplane flying boat. Normal range was 1,100 miles (1 770 km). The first of 23 entered service in December 1936 and some were flying North Sea patrols early in the war. The example now preserved in the

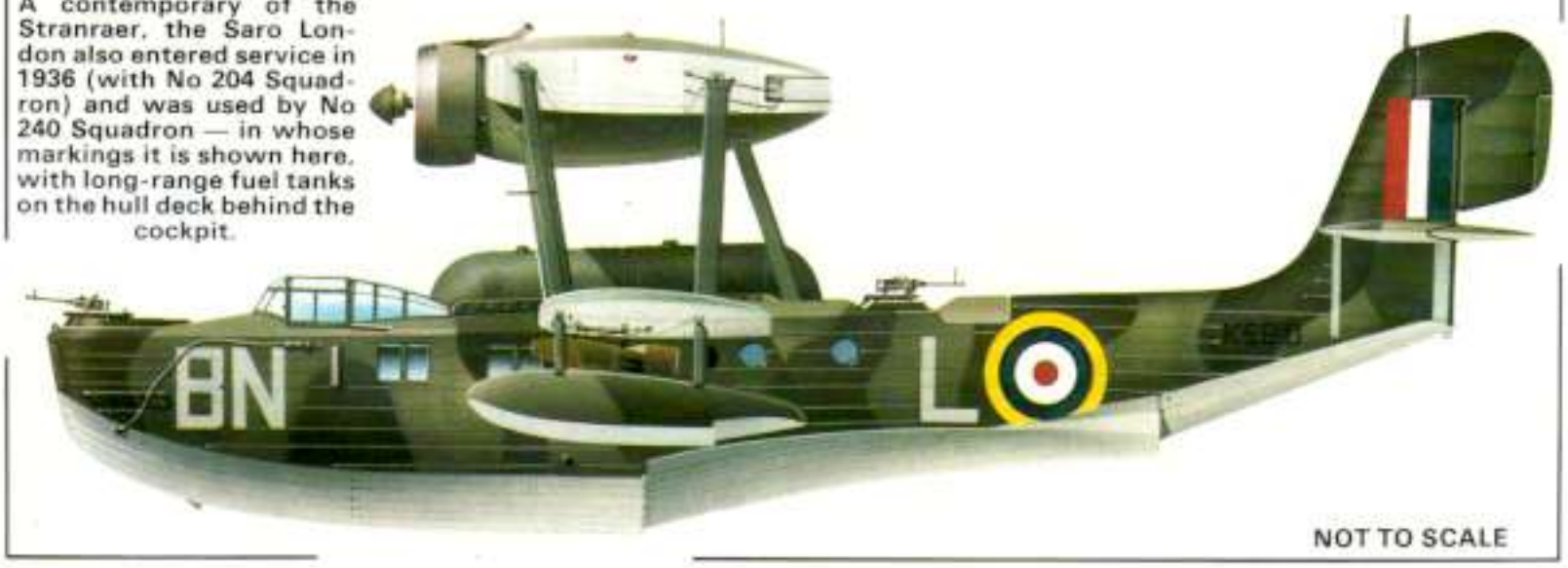


The Supermarine Stranraer was the last of the company's biplane flying boats and one of Mitchell's last designs to reach service. Twenty-three entered service with three home-based squadrons of Coastal Command, from 1936 onwards, at first in natural metal and silver dope finish but later acquiring full camouflage, as this illustration shows.

Supermarine's final development of the basic Southampton design was the Stranraer, introduced by No 228 Squadron in 1936 and illustrated here in the early wartime finish of No 240 Squadron.



A contemporary of the Stranraer, the Saro London also entered service in 1936 (with No 204 Squadron) and was used by No 240 Squadron — in whose markings it is shown here, with long-range fuel tanks on the hull deck behind the cockpit.



NOT TO SCALE

Short Sunderland III, Cutaway Drawing Key

1 Twin Vickers 0·303-in (7,7-mm) machine guns
2 Bomb aiming window, retractable
3 Bomb aimer's station
4 Retractable nose turret
5 Front entry/mooring hatch
6 Mooring cable stowage
7 Hull planing bottom
8 Anchor
9 Parachute stowage
10 Anchor winch
11 Dinghy
12 Front turret rails
13 Cockpit bulkhead
14 Mooring ladder
15 Toilet compartment door, starboard side
16 Nose gun turret hydraulic reservoir
17 Instrument panel
18 Windscreens
19 Cockpit roof glazing
20 Overhead control panels
21 Co-pilot's seat
22 Signal cartridge rack
23 Pilot's seat
24 Control column
25 Raised cockpit floor level
26 Autopilot controllers
27 Stairway between upper and lower decks
28 Front entry door
29 Fuselage chine member
30 Crew luggage locker
31 Rifle rack
32 Wardroom door
33 Planing bottom hull construction
34 Wardroom bunks
35 Window panels
36 Folding table
37 Upper deck floor level
38 Parachute stowage
39 Fire extinguisher
40 Navigator's seat
41 Chart table
42 Forward ASV radar aerial mast
43 Navigator's instrument panel
44 Flight engineer's aft facing seat
45 Radio operator's station
46 Air intake duct
47 Wing/fuselage attachment main frames
48 Wing root rib cut-outs
49 Air conditioning plant

69 Exhaust collector ring
70 Oil filter
71 Oil tank, 32-Imp gal (145-l) capacity
72 Flame suppressor exhaust pipe
73 Leading edge de-icing
74 Starboard ASV aerial array
75 Starboard navigation light
76 Aileron hinges
77 Starboard aileron
78 Fixed tab
79 Aileron control horns
80 Control cable runs
81 Starboard "Gouge-type" trailing-edge flap

95 Turret fairing
96 Mid-upper gun turret, offset to starboard
97 Twin Browning 0·303-in (7,7-mm) machine guns
98 Fuselage skin plating
99 Spare propeller blade stowage
100 Fire extinguisher
101 Rear entry door
102 Maintenance platform stowage
103 Observation window
104 Fuselage frame and stringer construction
105 ASV Mk II search radar aerial array
106 Leading edge de-icing
107 Starboard tailplane
108 Starboard elevator
109 Fin root attachments
110 Fin construction
111 Leading edge de-icing
112 Fin tip construction
113 Fabric covered rudder construction
114 Rudder tabs
115 Tail gun turret
116 Four Browning 0·303-in (7,7-mm) machine guns
117 Elevator tab
118 Fabric-covered elevator construction

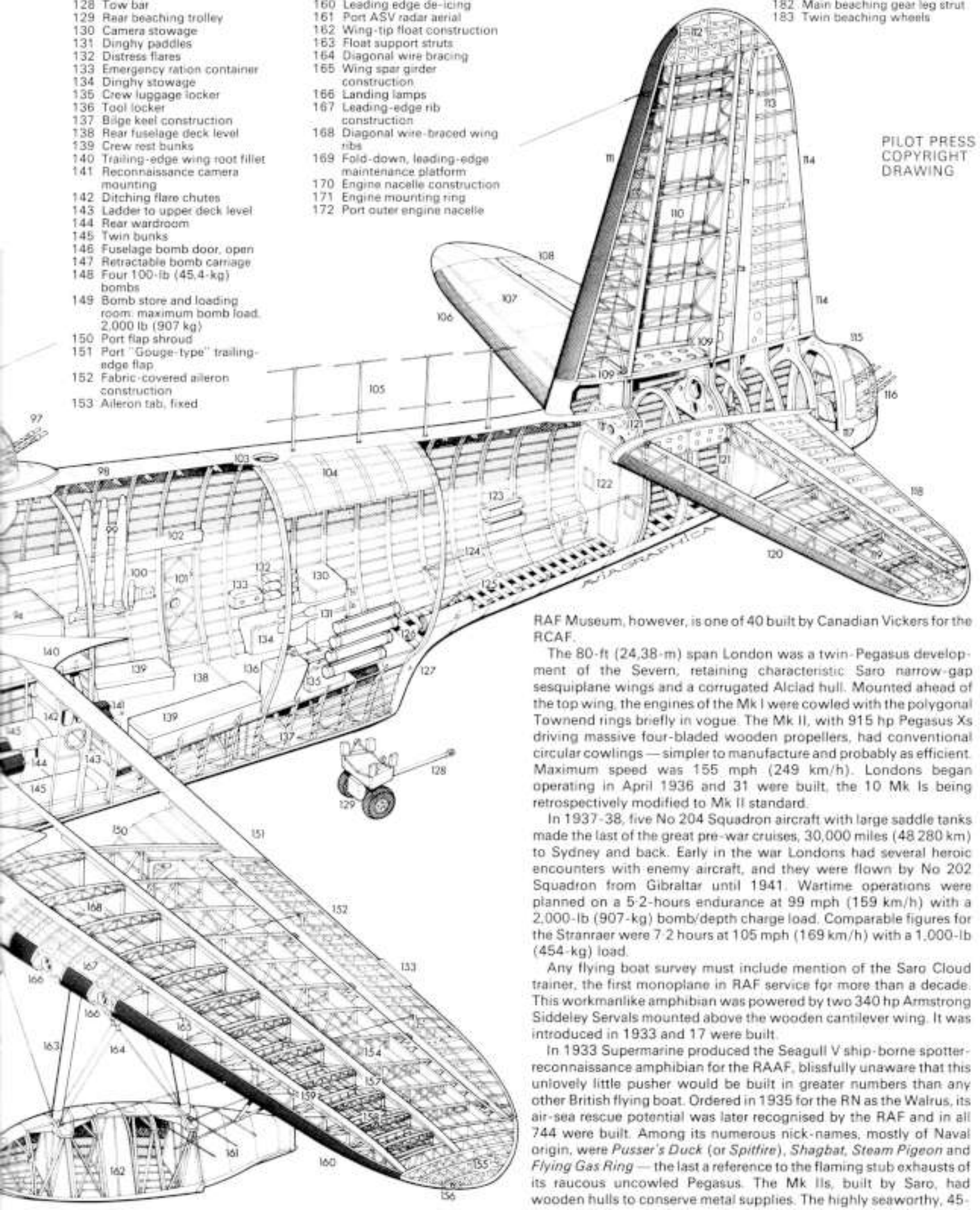
50 Engineer's control panels
51 Carburettor de-icing fluid tank
52 D/F loop aerial
53 Astrodome observation hatch
54 Auxiliary Power Unit
55 Forward inner fuel tank, 529-Imp gal (2 405-l) capacity
56 Fold-down, leading-edge maintenance platform
57 Starboard inner engine nacelle
58 Cowling air flaps
59 Detachable engine cowlings
60 Flame suppressor exhaust pipe

61 Forward inner fuel tank, 325-Imp gal (1 477-l) capacity
62 Oil coolers
63 Forward outer fuel tank, 132-Imp gal (600-l) capacity
64 Starboard wing tip float
65 De Havilland three-bladed, constant speed propeller, 12 ft 9 in (3,89 m) diameter
66 Propeller hub pitch change mechanism
67 Engine reduction gearbox
68 Bristol Pegasus XVIII, nine cylinder radial engine, 1,065 hp

82 Flap guide rails
83 Rear outer fuel tank, 147-Imp gal (668-l) capacity
84 Flap jack
85 Rear inner fuel tank, 111-Imp gal (505-l) capacity
86 Pitot tubes
87 Aerial mast
88 Observation window
89 Propeller de-icing fluid tank
90 Windscreen de-icing fluid tank
91 Bomb carriage traversing drive motor
92 Smoke floats and flame floats
93 Tailplane control cable runs
94 Reconnaissance flares

119 Port tailplane construction
120 Leading edge de-icing
121 Tailplane spar fixing fuselage double frames
122 Tail fuselage fabric draught screen

123 Smoke and flame floats
124 Handrail
125 Tail fuselage walkway
126 Reconnaissance flare chute, stowed
127 Mooring shackle
128 Tow bar
129 Rear beaching trolley
130 Camera stowage
131 Dinghy paddles
132 Distress flares
133 Emergency ration container
134 Dinghy stowage
135 Crew luggage locker
136 Tool locker
137 Bilge keel construction
138 Rear fuselage deck level
139 Crew rest bunks
140 Trailing-edge wing root fillet
141 Reconnaissance camera mounting
142 Ditching flare chutes
143 Ladder to upper deck level
144 Rear wardroom
145 Twin bunks
146 Fuselage bomb door, open
147 Retractable bomb carriage
148 Four 100-lb (45,4-kg) bombs
149 Bomb store and loading room: maximum bomb load, 2,000 lb (907 kg)
150 Port flap shroud
151 Port "Gouge-type" trailing-edge flap
152 Fabric-covered aileron construction
153 Aileron tab, fixed
154 Trailing-edge lattice ribs
155 Wing tip construction
156 Port navigation light
157 Rear spar
158 Wing rib construction
159 Front spar
160 Leading edge de-icing
161 Port ASV radar aerial
162 Wing-tip float construction
163 Float support struts
164 Diagonal wire bracing
165 Wing spar girder construction
166 Landing lamps
167 Leading-edge rib construction
168 Diagonal wire-braced wing ribs
169 Fold-down, leading-edge maintenance platform
170 Engine nacelle construction
171 Engine mounting ring
172 Port outer engine nacelle
173 Oil cooler intakes
174 Oil coolers
175 Exhaust shroud heat exchangers
176 Port inner engine nacelle
177 Emergency escape hatch
178 Ice chest
179 Drogue container
180 Galley compartments, port and starboard
181 Watertight trailing aerial socket
182 Main beaching gear leg strut
183 Twin beaching wheels



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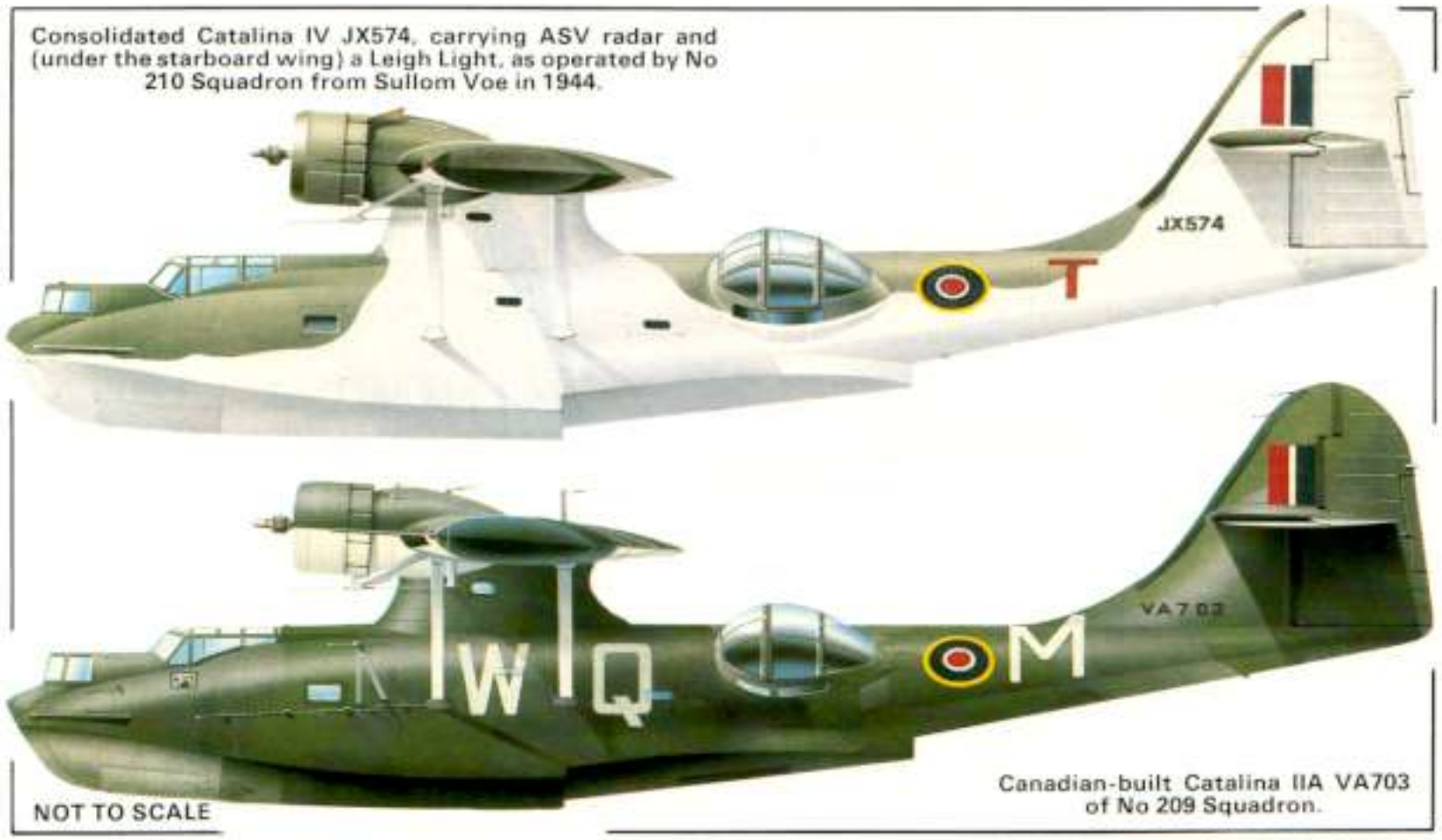
RAF Museum, however, is one of 40 built by Canadian Vickers for the RCAF.

The 80-ft (24,38-m) span London was a twin-Pegasus development of the Severn, retaining characteristic Saro narrow-gap sesquiplane wings and a corrugated Alclad hull. Mounted ahead of the top wing, the engines of the Mk I were cowled with the polygonal Townend rings briefly in vogue. The Mk II, with 915 hp Pegasus Xs driving massive four-bladed wooden propellers, had conventional circular cowlings — simpler to manufacture and probably as efficient. Maximum speed was 155 mph (249 km/h). Londons began operating in April 1936 and 31 were built, the 10 Mk Is being retrospectively modified to Mk II standard.

In 1937-38, five No 204 Squadron aircraft with large saddle tanks made the last of the great pre-war cruises, 30,000 miles (48 280 km) to Sydney and back. Early in the war Londons had several heroic encounters with enemy aircraft, and they were flown by No 202 Squadron from Gibraltar until 1941. Wartime operations were planned on a 5·2-hours endurance at 99 mph (159 km/h) with a 2,000-lb (907-kg) bomb/depth charge load. Comparable figures for the Stranraer were 7·2 hours at 105 mph (169 km/h) with a 1,000-lb (454-kg) load.

Any flying boat survey must include mention of the Saro Cloud trainer, the first monoplane in RAF service for more than a decade. This workmanlike amphibian was powered by two 340 hp Armstrong Siddeley Servals mounted above the wooden cantilever wing. It was introduced in 1933 and 17 were built.

In 1933 Supermarine produced the Seagull V ship-borne spotter-reconnaissance amphibian for the RAAF, blissfully unaware that this unlovely little pusher would be built in greater numbers than any other British flying boat. Ordered in 1935 for the RN as the Walrus, its air-sea rescue potential was later recognised by the RAF and in all 744 were built. Among its numerous nick-names, mostly of Naval origin, were *Pusser's Duck* (or *Spitfire*), *Shagbat*, *Steam Pigeon* and *Flying Gas Ring* — the last a reference to the flaming stub exhausts of its raucous uncowled Pegasus. The Mk IIs, built by Saro, had wooden hulls to conserve metal supplies. The highly seaworthy, 45-



Consolidated Catalina IV JX574, carrying ASV radar and (under the starboard wing) a Leigh Light, as operated by No 210 Squadron from Sullom Voe in 1944.

Canadian-built Catalina IIA VA703 of No 209 Squadron.

NOT TO SCALE

(Above) A Saro London II of No 240 Squadron, with long-range saddle tank and underwing bombs, as in service for coastal patrol when the war started.

(Above) The famous "Shagbat" – a Supermarine Walrus amphibian. Although often thought of as a Naval aircraft, the Walrus gave distinguished service in the air-sea rescue rôle with seven home-based RAF squadrons and four in the Middle East. (Below) A Saro Lerwick of No 209 Squadron, the only RAF unit to attempt to use this undistinguished flying boat operationally.

ft (13,7-m) span Walrus, which cruised at 95 mph (153 km/h), achieved an unparalleled record of rescue work, much of it in atrocious weather.

Enter the Sunderland

And so to the most famous flying boat of all, the peerless Short Sunderland, which established new records for long service and versatility. The popular belief that the Sunderland was simply a military version of the C-class Empire boat is not strictly true. Unimpressed by the ponderous Sarafand, the Air Ministry had issued Specification R.2/33 calling for something smaller, with comparable or better performance, several months *before* Imperial Airways approached Short Brothers for a flying boat to operate the new Empire Air Mail scheme. The company decided upon a common design.

The Sunderland prototype was ordered in 1934 but the C-class boats were given priority and the first flew in 1936. Air Ministry forebodings over the high wing loading were dispelled when the ingenious Gouge flaps helped it to get airborne in half the time stipulated for the Sunderland. By following the C-class, the Sunderland benefited from design refinements, notably the knife-edged rear step which reduced drag. It was also slightly larger and the control cabin was moved back to allow for a bow turret. The belated abandonment of a nose-mounted 37-mm quick-firing gun in favour of increased tail armament shifted the CG and required wing and step alterations to be made on a development batch of 11 aircraft ordered in 1936. The unmodified prototype first flew on 14 October 1937, the first development aircraft on 21 April 1938 and two squadrons were equipped by September of that year. Soon afterwards the Sunderland's only competitor, the Perseus-engined Saro A33, was abandoned when the prototype came to grief.

The Sunderland Mk I, powered by four 1,010 hp Pegasus XXIIs, spanned 112 ft 9½ in (34,38 m) and weighed 50,100 lb (22 725 kg). Maximum speed was 210 mph (338 km/h) and at 132 mph (212 km/h) endurance was 12 hours. The 2,000-lb (907-kg) bomb load was carried internally, the racks extending through hull panels under the wing. Nose and tail turrets, with single and quadruple 0·303-in (7,7-mm) guns, were supplemented by two manually-operated beam guns of the same calibre. The Sunderland offered spaciousness hitherto unknown in military aircraft, and below the flight deck was a ward room and galley. The bomb room and a small workshop lay aft of the wing, and a cat-walk gave access to the tail turret.

Following production of 89 Mk Is came a batch of 43 Mk IIs with two-stage supercharged Pegasus XVIIIs, introducing the dorsal turret, improvements to the rear turret, ASV Mk II radar and increased all-up weight.

A modified planing bottom which reduced drag at the expense of hydrodynamic performance characterised the Mk III of 1941, this being the main production version, with 456 built. During service some Mk IIIs gained major armament improvements — a four-gun nose turret, invaluable for tackling surfaced U-boats, and 0·5-in (12,7-mm) guns in additional galley hatches — earning the German name of *Stachelschwein* (porcupine). Cruising endurance was increased to 13½ hours.

The Hercules-powered Mk IV was virtually a new design, requiring protracted development, so the short-term need for greater power and range was met by giving the basic Sunderland 1,200 hp Pratt and Whitney Twin Wasps, to become the Mk V, with deliveries starting early in 1945. All-up weight increased to 65,000 lb (29 484 kg) and cruising endurance to 15 hours, while top speed of 213 mph (343 km/h) was 10 mph (16 km/h) better than the Mks II and III. The 150 built brought total Sunderland production to 739 — excluding the Mk IV.

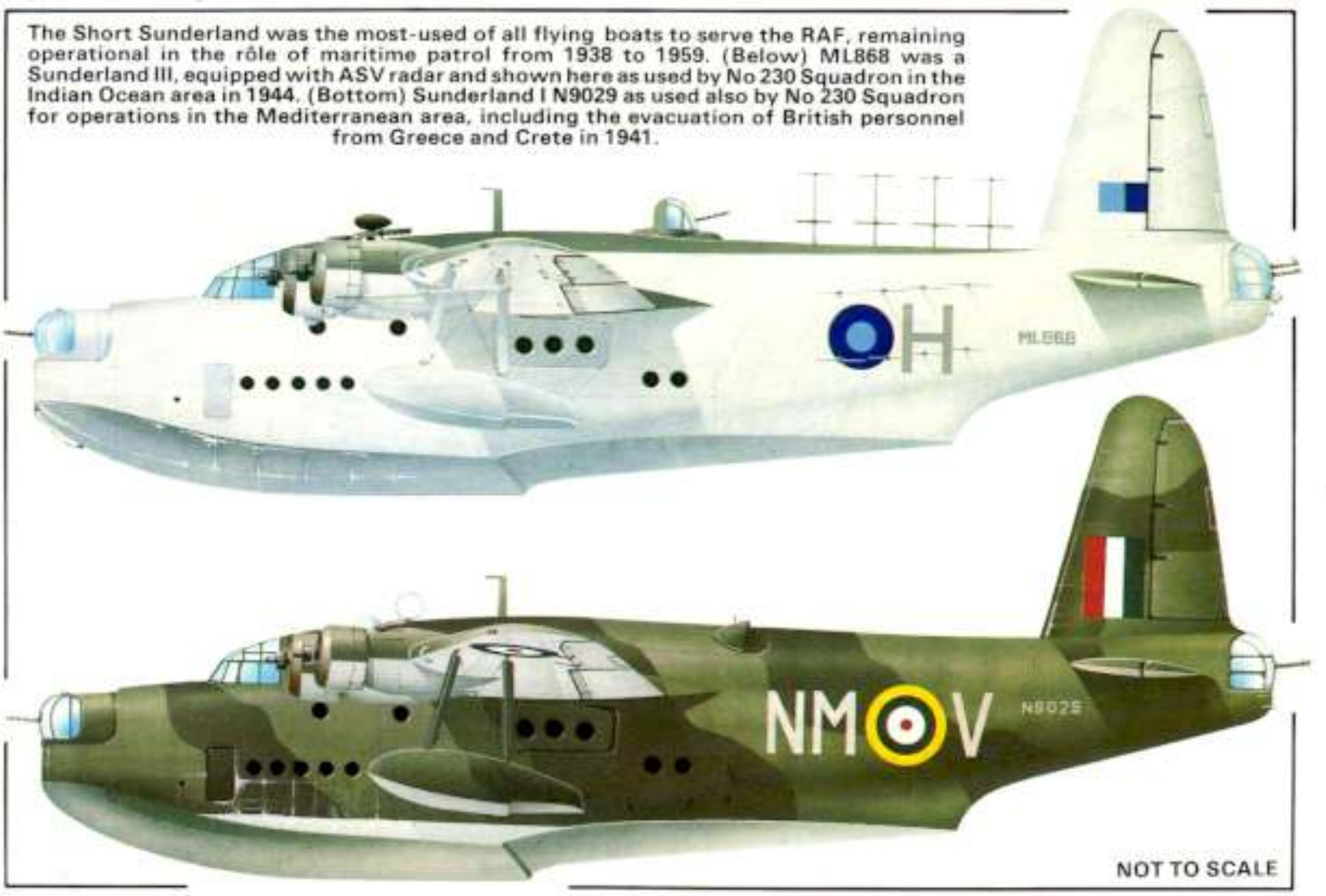
A much modified Mk IV appeared in 1945 as the Seaford and underwent squadron trials in 1946. However, the Sunderland V was considered adequate for post-war tasks and the eight Seafords were converted as civil Solents. Earlier the reverse had happened, a few C- and G-class boats being impressed into the RAF for anti-submarine and transport duties.

Seldom seen inland, the Sunderland made less public impact than the famous fighters and bombers, but has a secure place among the all-time great aircraft. Operational headlines came early in the war when two Sunderlands picked up 34 survivors from the torpedoed *Kensington Court*. January 1940 saw the first of 31 U-boat sinkings credited to Sunderlands, and there were many gallant open-sea rescues and notable victories over enemy fighters. They flew more than 1,000 people out of Greece and Crete — one alone packing in 84 — and in 1944 evacuated 509 sick and wounded Chindits from behind enemy lines in Burma.

After the war Sunderlands maintained transport services for the occupation forces in Japan, and operated throughout the Korean conflict of 1950-53. In 1948 they carried 4,500 tons of freight and 1,113 passengers on the Berlin Air Lift, and in 1951-54 supported the North Greenland Expedition. In all, 28 squadrons flew Sunderlands, and the final RAF sortie was made by ML797 of No 205 Squadron on 20 May 1959.

(Above) The Short Sunderland was not only the best-known of all RAF flying boats; it also set a record of longevity for service in a single front-line operational rôle of 21 years. This post-war photograph shows a Sunderland GR Mk 5 of No 230 Squadron; the heading photo on page 57 shows a Mk I of the same squadron. (Below) "Big brother" of the Sunderland, the mighty Shetland never achieved production.

The Short Sunderland was the most-used of all flying boats to serve the RAF, remaining operational in the rôle of maritime patrol from 1938 to 1959. (Below) ML868 was a Sunderland III, equipped with ASV radar and shown here as used by No 230 Squadron in the Indian Ocean area in 1944. (Bottom) Sunderland I N9029 as used also by No 230 Squadron for operations in the Mediterranean area, including the evacuation of British personnel from Greece and Crete in 1941.



NOT TO SCALE

Consolidated PBY-5A Catalina Cutaway Drawing Key

1 Starboard tailplane
2 Tailplane leading edge de-icing
3 Tail navigation light
4 Starboard fabric-covered elevator
5 Elevator tab
6 Rudder trim tab
7 Fabric-covered rudder construction
8 Tailcone
9 Elevator push-pull control rod
10 Rudder control horn
11 Tail mooring point
12 Lower fin structure integral with tail fuselage
13 Tailplane centre section attachment
14 Upper fin construction
15 Aerial cables
16 Fin leading edge de-icing
17 Port tailplane
18 Cooling air intake
19 Rear fuselage frame and stringer construction
20 Ventral tunnel gun hatch
21 0·3-in (7,62-mm) machine gun
22 Fuselage skin plating
23 Target-towing reel
24 Flare launch tube
25 Rear fuselage bulkhead
26 Bulkhead door
27 0·5-in (12,7-mm) beam machine gun
28 Starboard beam gun cupola
29 Cupola opening side window
30 Flexible gun mounting
31 Port beam gun cupola
32 Gunner's folding seat
33 Semi-circular gun platform
34 Walkway
35 Hull bottom V-frames
36 Wardroom bulkhead
37 Crew rest bunks
38 Wardroom
39 Starboard mainwheel
40 Hull planing bottom step
41 Planing bottom construction
42 Fuselage skin plating

43 Mainwheel housing
44 Hydraulic retraction jack
45 Telescopic leg strut
46 Fore and aft wing support struts
47 Wing mounting centre pylon construction
48 Pylon tail fairing
49 Starboard wing integral fuel tank, capacity 875 US gal (3 312 l)
50 Fuel jettison pipe
51 1,000-lb (454-kg) bomb
52 Smoke generator tank
53 Trailing edge ribs
54 Fabric covered trailing edge
55 Rear spar
56 Aileron trim tab
57 Starboard retractable wing-tip float

58 Float support struts
59 Retraction linkage
60 Fabric-covered starboard aileron
61 Static discharge wicks
62 Wing-tip aerial mast
63 Float up-lock
64 Float leg housing
65 Starboard navigation light
66 Leading edge de-icing boot
67 Float retracting gear
68 Front spar
69 Wing rib/stringer construction
70 ASV radar aerial
71 Outer wing panel attachment joint

72 Wing lattice ribs
73 Bomb carrier and release unit
74 Two 500-lb (227-kg) bombs
75 Leading-edge nose ribs
76 Position of pitot tube on port wing
77 Landing lamp
78 Landing lamp glare shield
79 Starboard engine nacelle fairing
80 Hydraulic accumulator
81 Engine oil tank

82 Fireproof bulkhead
83 Exhaust stub
84 Engine bearer struts
85 Detachable engine cowlings
86 Curtiss Electric three-bladed constant-speed propeller, 12-ft (3,66-m) diameter
87 Propeller hub pitch-change mechanism
88 Pratt & Whitney R-1830-92 Twin Wasp two-row radial engine
89 Aerial cable lead-in
90 D/F loop aerial
91 Oil cooler

92 Control runs through pylon front fairing
93 Pylon step
94 Engineer's control panel
95 Flight engineer's seat
96 Wing mounting fuselage main frame
97 Radio and radar control units
98 Cabin heater
99 Front cabin walkway
100 Port main undercarriage leg strut

101 Torque scissor links
102 Port mainwheel
103 Mk 13-2 torpedo
104 450-lb (204-kg) depth charge
105 Forward fuselage frame construction
106 Navigator's seat
107 Radio/radar operator's seat
108 Radio rack
109 Cabin side window
110 Autopilot servo controller

While the first Sunderlands were under construction, Specification R.1/36 called for a Stranraer and London replacement using the most powerful engines available, but the outcome proved a failure. The neat and compact Saro Lerwick, with two 1,375 hp Bristol Hercules, looked good, but looks proved deceptive. The long planing bottom emphasised the depth of hull, which in turn made the 80 ft 10 in (24,64-m) wing appear inadequate. In fact, the wing loading of 33·5 lb/sq ft (163,6 kg/m²) was much the same as the Sunderland's. Though certainly fast — the prototype achieved 235 mph (378 km/h) — it showed undesirable handling characteristics which modifications failed to cure. From the summer of 1939 Lerwicks operated sporadically in Nos 209 and 240 Squadrons, at least five of the 21 built being lost from various causes, and they were withdrawn in 1942.

The remarkable twin-Vulture Blackburn B.20 to the same Specification featured a retractable planing bottom to combine adequate water clearance for the propellers with small frontal area, and top speed was estimated at 288 mph (463 km/h). The system worked, but clearly much development was necessary and the project was abandoned after the prototype crashed in April 1940.

Early warning of these problems prompted second thoughts about

A Consolidated Catalina IVA, one of several variants of this famous American flying boat to enter service with the RAF, initially through British Direct Purchase contracts and later by Lend-Lease. The amphibious PBY-5A variant, shown in the cutaway drawing, served in the RAF as the Catalina III.

111 Navigator's chart table
112 Fuselage chine member
113 Cockpit bulkhead
114 Co-pilot's seat
115 Pilot's seat
116 Pilot's electrical control panel
117 Sliding side window
118 Engine cowling cooling air gills
119 Port engine nacelle
120 Cockpit roof escape hatch
121 Overhead throttle and propeller controls
122 Windscreen wipers
123 Curved windscreens
124 Instrument panel
125 Control column yoke and handwheels
126 Rudder pedals
127 Cockpit flooring
128 Nose undercarriage hatch doors
129 Nosewheel bay
130 Port aileron
131 Nosewheel
132 Port retractable wing-tip float
133 Float support struts
134 Port navigation light
135 Leading edge de-icing boot
136 Nosewheel forks
137 Nose undercarriage retraction jack
138 Front gunner/bomb aimer's station
139 Curtained bulkhead
140 Gunner's footboards
141 Spare ammunition containers
142 Front rotating gun turret
143 0·3-in (7,62-mm) machine gun
144 Bomb aimer's instrument panel
145 Drift sight
146 Bomb aiming window with protective blind
147 Anchor cable

(Above) Designed to supersede the Walrus — with which it shared many features — the Supermarine Sea Otter was the last biplane to enter RAF service (late 1943), although not the last in service. (Below) The Supermarine Seagull amphibian, a post-war design that did not proceed beyond two prototypes.

an American type that had been rejected as too slow by the 1938 British Purchasing Commission, the Consolidated PBY-1 used by the US Navy since 1936. RAF evaluation of an example bought in 1939 led to an initial order being placed for 30 of the PBY-5 version with two Twin Wasps. Given the RAF name Catalina, its chief features were the broad, seaworthy hull and pylon-mounted 104-ft (31,7-m) wing with retractable floats. The quoted 190 mph (306 km/h) maximum speed was generous for an aircraft in full war trim, and operational cruising speed was 115 mph (185 km/h). However, the Catalina's main asset was its great endurance. At maximum take-off weight of 34,000 lb (15 422 kg), patrols of 15-20 hours were commonplace and with extra tankage it remained airborne for 27 hours.

Production of the Catalina and Canadian-built Canso totalled 3,290 — more than any other flying boat. From 1941 some 600 were used by the RAF, mostly supplied through Lend-Lease, and they equipped 22 squadrons in various parts of the world.

While the Catalina's endurance was invaluable for convoy work, its slow speed and puny armament left it highly vulnerable to surfaced U-boats. Two Catalina pilots, Flt Lt D E Hornell and Fg Off J A Cruickshank, won VCs for pressing home attacks and sinking U-boats despite crippling damage and severe crew injuries. The single 0·303-in (7,7-mm) bow gun and paired weapons of the same calibre or a single 0·50-in (12,7-mm) gun in each of the beam blisters were equally inadequate for facing enemy fighters. A Catalina highlight was the spotting of the *Bismarck* in May 1941 prior to her destruction by naval forces.

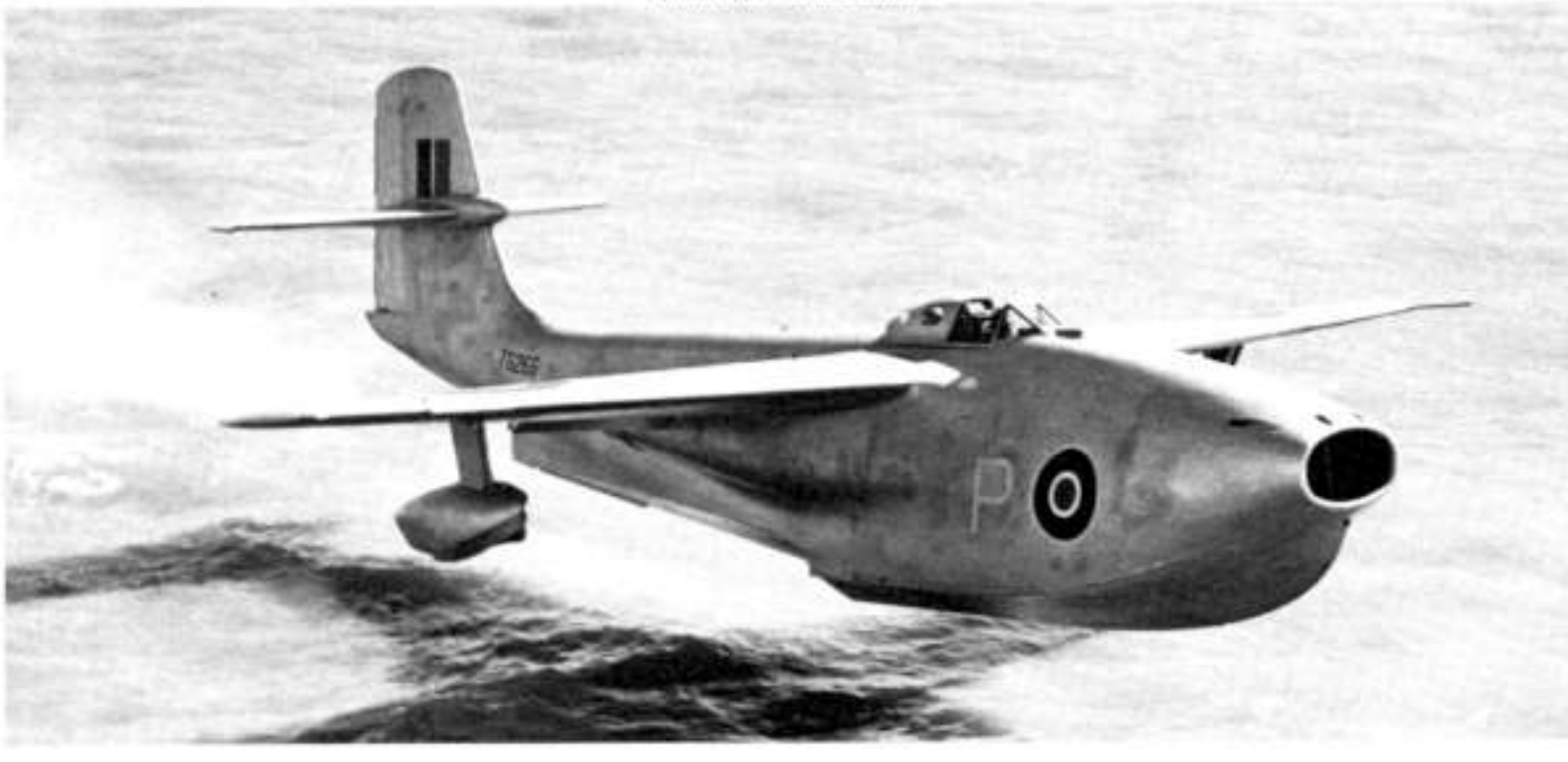
The four-engined Coronado from the same manufacturer also saw RAF service, but only 10 of 32 allocated under Lend-Lease were delivered, and used as transports rather than the patrol mission for which they were designed.

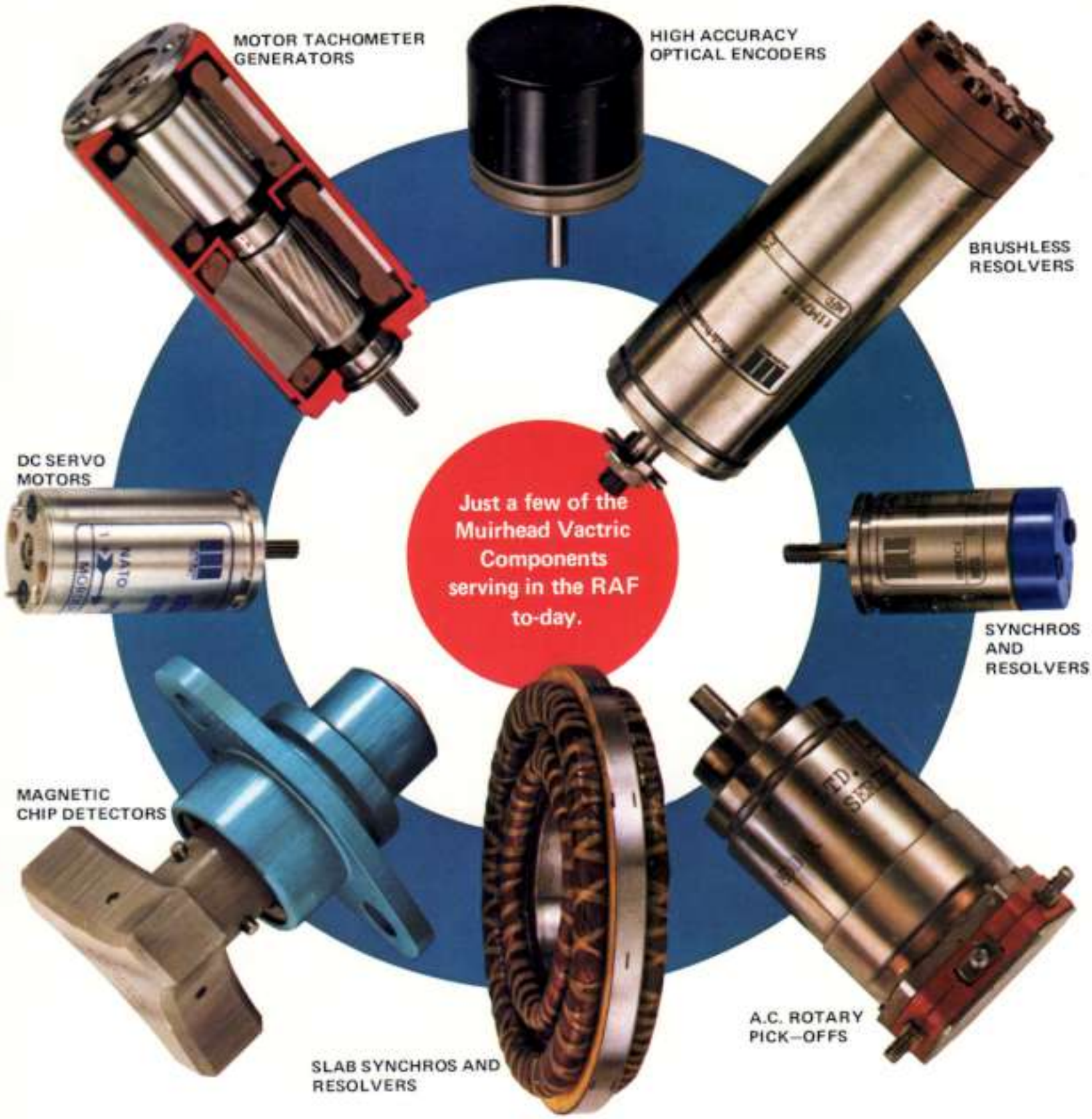
A little publicised wartime aircraft was the Supermarine Sea Otter rescue amphibian. Intended as a Walrus replacement, the prototype flew in 1938 and production models eventually appeared in 1943. With an 855 hp Bristol Mercury installed as a tractor, it had better all-round performance than the old *Shagbat* and did valuable work in the Far East. Production totalled 290.

In 1945 it seemed inconceivable that the ending of World War II had finished the long line of RAF flying boats. But sadly this proved the case, and neither the 125,000-lb (56 700-kg) Short Shetland nor the single-engined Supermarine Seagull amphibian was chosen for service. Nor was the beautiful Saro A/1 twin-jet single-seat fighter which, in the hands of Geoffrey Tyson, shattered the image of flying boats as stately vessels for stolid, pipe-puffing introverts. His remarkable aerobatics hypnotised some spectators at the 1948 SBAC show, moving one popular magazine feature writer to a graphic description of the little flying boat's take-off from the Farnborough runway!

World War II developments foreshadowed the demise of the large flying boat. Landplanes crossed the seas with great regularity and flew from tiny, remote air-strips activated with less effort than a lake or riverside base. Adapted bombers performed long-range reconnaissance tasks previously considered the exclusive province of the flying boat. The landplane philosophy continued in peacetime with the Shackleton and Neptune. In commercial operations the switch to landplanes was equally decisive, and the flying ship of the old prophets seems lost for ever — unless salvaged by fanciful future circumstances such as banishment of airports to the coast to coincide with some radical change in aircraft design or propulsion. □

One of the most dramatic flying boats ever conceived, the Saro A/1 was a single-seat jet fighter, developed to meet an RAF Specification drawn up when it seemed that a prolonged war was in prospect in the Pacific, with its many opportunities for water-based operations. Three prototypes were built.





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