ROYAL AIR FORCE

HISTORICAL SOCIETY

JOURNAL

37

First published in the UK in 2006 by the Royal Air Force Historical Society

ISSN 1361 4231

Printed by Advance Book Printing
Unit 9 Northmoor Park
Church Road
Northmoor
OX29 5UH

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SELECTED ABBREVIATIONS

A&AEE	Aircraft & Armament Experimental Establishment
ACHGD	Aircrafthand, General Duties
AIB	Accidents Investigation Branch
AID	Aeronautical Inspection Department
AMT	Air Member for Training
AMWO	Air Ministry (Weekly) Order
BABS	Blind Approach Beacon System
CAA	Civil Aviation Authority
CFS	Central Flying School
CGCA	Controller General of Civil Aviation
CI(A)	Chief Inspector (Accidents)
DASC	Defence Aviation Safety Centre
DFS	Director(ate) of Flight Safety
DGMA	Director General of Military Aviation
ECFS	Empire Central Flying School
EFS	Empire Flying School
EFTS	Elementary Flying Training School
GAPAN	Guild of Air Pilots and Navigators
GIGFY	Guinness Is Good For You
GTIO	Group Training Inspecting Officer
HUD	Head Up Display
IFS	Inspector(ate) of Flight Safety
ILS	Instrument Landing System
MHDOIF	Most Highly Derogatory Order of the Irremovable Finger
NATS	National Air Traffic Services
OCU	Operational Conversion Unit
OTU	Operational Training Unit
PSAIC	Public Safety and Accidents Investigation Committee
PTC	Personnel and Training Command
QFI	Qualified Flying Instructor
RAeC	Royal Aero Club
RAFFC	RAF Flying College
RS	Reserve Squadron
SBA	Standard Beam Approach
SFTS	Service Flying Training School
SOP	Standard Operating Procedure
TDS	Training Depot Station
TTAAA	Train, Test, Audit, Advise and Aerobat
USofS(C)	Parliamentary Under-Secretary of State (Commons)
VDU	Visual Display Unit

FLIGHT SAFETY
RAF MUSEUM, HENDON, 15 OCTOBER 2005.

WELCOME ADDRESS BY THE SOCIETY'S CHAIRMAN

Air Vice-Marshal Nigel Baldwin CB CBE FRAeS

Ladies and gentlemen – good morning. It is a pleasure to welcome you to what should turn out to be another fascinating day. Most of us, one way or another, have had something to do with our subject. Fortunately, we are the survivors. Many here will have friends who are no longer with us because of some aspect of today's subject.

Before I introduce our Chairman for the day, let me give my usual thanks to Dr Michael Fopp, the Director of the RAF Museums, and his staff for the use of their splendid facilities and their usual warm welcome and help. We would be lost without you.

Our Chairman today, Air Cdre Richie Profit, spent thirty years in the Royal Air Force, flying most of the time, mainly Hunters, Harriers and Jaguars. He was the RAF Inspector of Flight Safety when the Cold War unexpectedly ended so he applied for 'demob' to make his fortune in the world of civil aviation safety. This was a specialisation in which he had first hand experience, having lost three Harriers as a Squadron Commander, five Jaguars as a Station Commander and an average of nineteen aircraft a year as IFS.

He joined National Air Traffic Services Ltd in 1990 as Director Safety, Security and Quality Assurance. He left NATS in 1997 to join the Civil Aviation Authority's Safety Regulation Group at Gatwick, initially as Head of the Aerodrome and Air Traffic Standards Division but he became a member of the CAA Board later in the year as Group Director Safety Regulation. The next six years were unusually eventful for the CAA, not least because of the Air France Concorde accident and the need for the CAA to restore British Airways' Concorde fleet's Certificates of Airworthiness before it became uneconomical to keep it flying. He retired from the CAA at the end of 2003 and is currently one of the four independent non-executive directors on the Rail Safety and Standards Board.

Richie: you have control

INTRODUCTION BY SEMINAR CHAIRMAN

Air Cdre Richie Profit

The original aim of this seminar was to explore the history of the evolution of flight safety in the lifetime of the Royal Air Force. During the planning phase, however, it soon became apparent that there was little recorded evidence of a coherent policy, strategy or even a theme for the development of flight safety in the UK Armed Services. This is not the case in civil aviation. However, apart from a changing flying accident rate, there is ample evidence of major technological developments, changing attitudes, changing cultures and changing approaches to dealing with accidents that have all affected flight safety performance over the years. The society has assembled a team of distinguished and authoritative speakers who will cover these topics today.

Jock Lowe, the Chief Pilot and Operations Director on the British Airways Concorde fleet for many years, once said that the biggest problem converting ex-military pilots to airline flying is to convince them that aircraft are not expendable. This is not surprising. With a history of two world wars, and a wide variety of smaller conflicts, in which the RAF has played a major part, aircraft were certainly expendable in all of them. By way of a simple example, in the period between the Battle of France in May 1940 and the end of the Battle of Britain in September the RAF lost 1,300 aircraft; by the end of that year the total had risen to well in excess of 2,000. While flight safety was always important, operational effectiveness had to take priority. However, unless a balance is struck, operational effectiveness starts to become restricted by the flying accident rate. During today's seminar, you will hear of the many developments, innovations and changes in attitude that have contributed to establishing that balance.

ACCIDENTS – INVESTIGATION, INSTITUTIONS AND ATTITUDES 1910-1918

Wg Cdr Jeff Jefford

'Jeff' joined the RAF in 1959 as a pilot but (was) soon remustered as a navigator. His flying experience included tours with Nos 45, 83 and 50 Sqns and instructing at No 6 FTS. Administrative and staff appointments involved sundry jobs at Manby, Gatow, Brampton and a total of eight years at HQ Strike Command. He took early retirement in 1991 to read history at London University. He has three books to his credit and has been a member of the Society's Executive Committee since 1998; he is currently editor of its Journal.

In the beginning there was the Aero Club. There was the Aeronautical Society, of course (not Royal until late-1918), and there was the Air Battalion of the Royal Engineers, but the institution that was most influential in promoting the development of practical aviation was the Aero Club. Formed in 1901, it became the Royal Aero Club (RAeC) in 1910, by which time powered flight had become a reality in this country and, as an inevitable consequence, so had flying accidents.

The first British aviator to lose his life was Charles Rolls, of Rolls-Royce, in 1910. Rolls had added a supplementary, French-designed, tailplane to his, Short-built, Wright Flyer. While competing in a spot landing competition at Bournemouth he was obliged to impose a pitch demand which overstressed the lengthened tailbooms; one of them broke and the whole contraption collapsed. And so we have Flight Safety lesson Number One – don't do things to your aeroplane without the sanction of the Design Authority.

Seven men died during 1911 making a grand total of nine fatalities from the 110 pilots who had qualified for Aero Club certificates by the end of that year. That represented an 8% casualty rate, compared to 5% in France, where some 500 pilots had qualified, and an appalling 34% in the USA – twelve pilots out of only 35.

This prompted the Royal Aero Club to take action which it did by

setting up its Public Safety and Accidents Investigation Committee. Its aims were to seek the co-operation of aviators in preventing dangerous flying and to arrange for the preparation of reports on the causes of accidents – military as well as civilian.

The Committee's first report (of twenty-six published before war was declared)[1] covered the loss of a Flanders F.3 monoplane, which resulted in the death of both occupants. The Committee sat on three days and heard evidence from, among others, two eye-witnesses, both of them qualified pilots, and from the designers of both the airframe and the engine. Its conclusion was that, at about 500 feet, the pilot had begun a turn to the left in a tail-down attitude; a side-slip had developed which turned into a steepening dive and the aircraft hit the ground nose-first almost vertically. Now that may sound like a stall and spin but the term 'spin' had yet to be coined in 1912, although, with hindsight, there can be little doubt that a number of accidents that were classified as 'side-slips' at the time were actually spins.

In this instance, the pilot had obviously lost control and it was surmised that, because he had not been strapped in, as the nose-down attitude had increased he had been thrown forward onto the controls thus pushing the nose down even further, catapulting him out to hit the ground some 60 feet from the wreckage. It was suggested that, had he been securely strapped in he just might have been able to recover the situation.

Thus began the process of analysing accidents and learning from our mistakes that continues to this day – and you may consider that 'learning from our mistakes' – is as good a working description of the flight safety game as any. In this case the lesson learned, or at least taught, was 'clunk, click – you know it makes sense'. And I would stress the point that much of the 'best practice' that we take for granted today was an innovation when it was first introduced. For us it is second nature to strap in. But in 1912 that simply hadn't occurred to anyone. After all, one didn't strap-in on one's horse, or in one's motor car; so why do it in one's aeroplane? Well, obviously, because it's a long way to fall! But people were still falling out of their aeroplanes two years later.

There were two other incidents worthy of our attention in 1912. The first was in August when Frank McClean flew his Short seaplane between the spans of Tower Bridge. He said that he hadn't meant to

but his aeroplane wouldn't go any higher and, quite coincidentally, there just happened to be a photographer on hand, complete with tripod, bellows camera, etc so the incident was recorded for posterity. This had clearly been a case of an accident looking for somewhere to happen, but it was not actually an infringement of flying discipline because, as yet, there wasn't a rule against it – but there probably was by tea time.

The second notable event occurred during the Army's autumn manoeuvres when four RFC officers died in two separate crashes, the first involving a Deperdussin monoplane, the second a Bristol-Coanda. The Secretary of State for War, Col Seely, set up a Departmental Committee to investigate the circumstances and its report was published in early 1913.[2] Leaving aside the contentious question of the 'monoplane ban',[3] the most significant recommendation made by the Committee in the context of today's seminar was that:

> 'No machine should be taken into use until after examination and approved test, and all machines should be regularly inspected, especially after any serious damage or repair.'

A few months later Lt Desmond Arthur died when he crashed in a BE2. This accident was the subject of the Public Safety Committee's twelfth report,[4] which noted that witnesses had reported that the starboard upper wing structure had failed. Examination of the wreckage revealed that the spar and wingtip had been damaged at some time in the past and that the repair had been made 'in a most improper and unsafe manner.' The report's chief conclusion pretty much echoed that of the Monoplane Committee, in that it recommended that all repairs should be scrutinised by a competent inspector and that all work carried out be documented and retained to create a history of each individual airframe. Incidentally, Lt Arthur had been thrown out of the aeroplane and had landed 170 yards from the wreckage. He had been strapped in, but his seat belt had broken. So, the report also concluded that we needed stronger straps and more secure anchorages. Another lesson learned.

As yet the War Office had still to implement the Monoplane Committee's recommendation but it finally got around to it at the end of 1913 when it established the Inspection Department of Military

George Cockburn, pioneer aviator and founder member of the AID, who would become an acknowledged expert in accident investigation.

Aeronautical Material. Maj John Fulton was appointed as Chief Inspector and his staff included an Inspector of Aeroplanes, Geoffrey De Havilland, an Inspector of Engines, Capt R K Bagnall-Wild plus three Assistant Inspectors and eighteen examiners, viewers and clerks. Only three months after Fulton's empire had been set up it was renamed to become the more familiar-sounding Aeronautical Inspection Department – the AID.

When WW I ended, just five years later, this organisation would have an establishment of more than 10,000 and Bagnall-Wild, by now a brigadier, would be running it in succession to Fulton who had died of pneumonia in 1915.

In July 1914 De Havilland moved elsewhere and his place as Inspector of Aeroplanes was taken by George Cockburn, one of the three Assistant Inspectors. Cockburn was a real pioneer aviator, the holder of Aero Club Certificate No 5, and he was to become a prominent figure in the field of accident investigation.[5]

Meanwhile, in March, the War Office had published the AID's Terms of Reference.[6] This document ran to seven pages but, so far as the RFC was concerned, we can condense it to just four key items:

a. Every aeroplane was to be inspected by the AID after 100 hours or 12 months, whichever came first.

b. Any aeroplane was to be inspected when so requested by Commandant CFS.

c. The AID was to advise on appropriate repairs and then inspect and certify all work carried out.

d. The AID was to examine wreckage and prepare reports on accidents:

i. whenever fatalities had occurred and

ii. on other occasions when specifically asked to do so.

In addition to this relatively parochial in-Service activity, the AID

had a far-ranging remit within the aircraft industry where it was to inspect the manufacture of all components and spares and the erection and assembly of new airframes and engines being built for the War Office – but not the Admiralty.[7] This process led to a good deal of very useful standardisation of the specification and design of common-user items like turnbuckles, nuts, bolts, washers, rigging wires and all manner of grommets, widgets and gizmos.

In April 1914, while completing the second half of the qualifying test for his RAeC certificate, the RFC's Sgt Deane climbed to about 1,000 feet in a Bristol Boxkite and then entered a steep spiral dive. At about 400 feet he fell out. Once again, the Public Safety Committee was obliged to recommend that all aeroplanes should be fitted with seat belts.[8] We learn only slowly.

In June 1914 the RFC held its so-called Concentration Camp on Salisbury Plain and No 2 Sqn was ordered down from Montrose to take part. By the fourth day the ten BEs had reached West Hartlepool. On the next leg one aeroplane was obliged to turn back and attempt a landing in sand dunes which resulted in significant damage to the airframe. The other nine ran into fog shortly afterwards which precipitated a series of forced landings in the course of which three more aircraft were wrecked with the loss of one pilot and his air mechanic passenger. The moral of this one was that it is a good idea to check the Met forecast – and even in those days it would have been possible to telephone down the route to get 'an actual'.

A few weeks later war was declared. Of the 863 certificates issued by the RAeC up to 4 August 1914, 492 had gone to military pilots, 25 of whom had subsequently been killed in accidents. This represented something like a 5% loss rate over a five year period, but in reality it was closer to 10% because not all of the 492 had maintained their currency or had their qualification endorsed by the RFC by attending a course at the CFS. In practical terms there were fewer than 250 pilots actually available to the RFC/RNAS in August 1914.

With the outbreak of war all civilian cross-country flying was suspended under the terms of the Air Navigation Acts of 1911 and 1913. Thereafter, apart from flying training being conducted in the immediate vicinity of civilian schools, now operating largely under contract to the RFC or the RNAS, practically all aviation, and along with it the incidence of accidents, became a military affair.

A DH 4 that spun in at Scampton in 1918.

The relatively light construction of contemporary airframes, and the sometimes temperamental behaviour of their engines, both represented flight safety hazards in their own right in 1914-15. Crashes were far from unusual and in the majority of cases the cause would have been obvious. Apart from engine failure, most will have been due to some combination of inexperience and/or incompetence as a direct consequence of the brevity and inadequacy of the flying training that was on offer. Indeed. as late as the spring of 1917, it was still quite common for newly qualified pilots arriving in France to bend an aeroplane or two before they got the hang of it.

Because so many military aviators died as a result of them, one specific hazard that we do need to consider is ‘the spin’. In the early days, the spin was regarded with considerable trepidation, perhaps something like the ‘sound barrier’ of the 1940s. That is to say that it was a recognised problem to which there was no convenient solution.

It is generally accepted that the first pilot to have recovered from a spin was Frederick Raynham who did it in 1911, but by accident rather than design. He was followed by an RNAS officer, Lt Wilfred Parke, who inadvertently spun an Avro cabin biplane in front of competent witnesses. Having tried everything else, he applied opposite rudder. Much to his, and everyone else’s, surprise, the aeroplane began to behave itself and he landed safely. The logic of this was not understood in 1912 and, at the time both Farnborough and

the National Physical Laboratory were preoccupied with trying to achieve longitudinal, rather than directional, stability. For the time-being, therefore, the so-called 'Parke Dive' was something to talk about, not emulate; the answer to the spin was not to get into one and that more or less remained the case for another five years.

When Lanoe Hawker took No 24 Sqn and its new DH 2s to France in February 1916 he soon realised that his pilots had no idea how to recover from a spin. Hawker did, as he demonstrated by climbing up to 8,000 feet over the aerodrome and deliberately inducing a series of spins, both to the left and to the right, power on and power off, recovering with no difficulty in every case. While this was a great confidence booster for No 24 Sqn's pilots, however, the word was still slow to spread and as late as August 1916, Major Frank Goodden, the chief test pilot at Farnborough, was tasked with establishing that, contrary to damaging rumours, the FE8 was not particularly prone to spinning and that it was possible to recover if it was spun – intentionally or otherwise. This was critical stuff, of course, because in air combat it was all too easy to induce a spin inadvertently and, for those who had the confidence to do it on purpose, a spin was as good a way as any of breaking off an engagement. But either way, one needed to be able regain control at will.

Goodden's trials exonerated the FE8 but his report was not widely publicised so advice on spin recovery was still slow to percolate down through the system. It was not until Smith-Barry began to get a grip on flying training that the spin finally began to lose its mystique, to the extant that it had become a standard practical training exercise by the summer of 1917.

Even so, a survey of training accidents, involving only Camels, RE8s, SE5as and DH 4s – just four types – and occurring in May 1918 alone, showed that in the course of that one month no fewer than forty-one aircraft had been lost to spins, half of them Camels.[9] Interestingly, the recommended method of recovery at the time was to centralise the controls with the stick forward; it was not until the early-1930s that the refinement of applying opposite rudder was introduced. It is also worth recording that, while the Camel undoubtedly deserved its reputation as a fighting machine, it could be very unforgiving. Of the 831 pilots who lost their lives flying Camels,

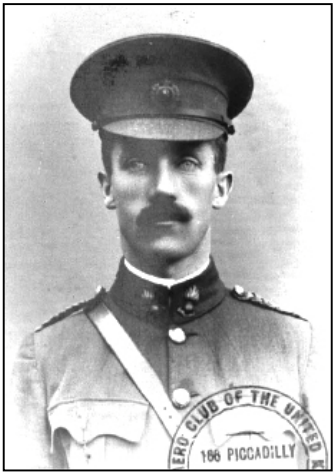
almost half (49%) died in flying accidents rather than in combat.

It is worth taking a slight detour here to make the point that we write history by interpreting the evidence that remains. A copy of last month's accident stats (or last month's anything) is wastepaper that tends to be turned over, used as a scribbling pad and then thrown away. That same piece of paper a hundred years later is no longer rubbish; it is now an invaluable primary source. But relatively few documents survive the wastepaper stage to mature into historical artefacts. So – never throw anything away. This point is raised because, although the RFC will have held Courts of Inquiry into most accidents, certainly those occurring in this country, and there will have been Coroner's Inquests in many cases, there seems to have been little attempt to collate accident data. I doubt that that was really the case but, if the information was recorded, it appears not to have been preserved or, if it was, it has been very well hidden, although it may still be lurking in some dark corner of the archives. From January 1917 onwards, however, there is a good deal of contemporary statistical information.

In the spring of 1917, the War Office and Admiralty were relieved of their responsibilities for industrial inspection which were now to be centralised and standardised under the Ministry of Munitions, which thus took over the AID. So far as accident investigation was concerned, the new Cowdray Air Board decided to adopt a more sharply focused and analytical approach and in May 1917 it asked the Advisory Committee for Aeronautics to assume responsibility for this task. This it did by setting up an Accidents Investigation Committee under the Chairmanship of Col Mervyn O'Gorman, the Consulting Engineer to the DGMA.[10]

The Committee's brief was to investigate any accident, the cause of which was 'obscure, unexplained or presents some special feature', but not accidents which were due to obvious causes. The Committee had only five permanent members,[11] although it had the power to summon anyone it wanted. One of the permanent members was George Cockburn who, as a result of his experience as the AID's Chief Aeroplane Inspector had become something of an expert in the field of accident investigation.

The Committee's remit was not confined to accidents involving fatalities but they were clearly not short of material to work on since,



A founder member of the Air Battalion in 1911, Lt-Col Alan Carden, commanded the Air Park when the RFC first crossed the Channel in 1914 and in 1917 he became Director of the newly created Accidents Department.

leaving aside those from which the occupants had walked away, 1917 had seen 380 fatal accidents to UK-based aircraft. These had involved 481 people of whom 430 had lost their lives.

By the time that the Committee submitted its final report in November 1917[12] it had investigated more than 100 incidents. The report concluded that there was much to be gained by such a painstaking approach and noted that it had been possible, for instance, to identify common factors relating to individual types of aircraft and thus to recommend specific modifications or further investigation into particular phenomena. The Committee considered that its work had been well worthwhile and endorsed an Air Board proposal that the task should be taken over by the military.

This proposal was put into effect by the recently established Air Ministry which promptly set up an Accidents Department under Lt-Col Alan Carden. A founder member of the Air Battalion, Carden had gained his RAeC 'ticket' in 1912, and he had done it single-handed – because he had only one hand. An engineer, rather than a pilot, when the RFC first crossed the Channel in August 1914 Carden had been in command of the Aircraft Park. Having borrowed Cockburn from the Ministry of Munitions, a loan that was made permanent in the following May, the new Department was in business before the end of December 1917.

In essence the Accidents Department worked to much the same brief as the previous Committee in that it investigated only those incidents from which something might be learned. In such cases a full report was produced. Some were signed by Carden but most of the paperwork that emanated from the Branch was signed off by Cockburn. Many, perhaps most, of these reports have survived and

may be examined at Kew.

Taking an early example at random,[13] it concerns a Curtis JN3, A1259, flying from Stamford on 19 December 1917. It had fallen off the top of a loop and suffered a structural failure in the ensuing dive – one wing broke away, and the aircraft spun in killing the student pilot who had a total of 18 hours flying time, 10 of them solo on type. An interesting feature of the report is that it included the following summary of the aeroplane's career to date, thus indicating that the RFC was now routinely complying with the recommendations made by the pre-war Public Safety Committee:

> 'It was erected by the 18th Wing Repair Section, Northolt, and handed over to No 11 RS on 11.8.16. Its previous (*ie Canadian – see below*) history is unknown. It was first flown on 31.8.16 and had a total of 224 hours. A précis of repairs is appended.'

The report noted that two of the drift wires had broken and that subsequent testing had indicated that one of them had been below the specified strength. This was not cited as being the primary cause of the accident, however, this simply being put down to the fact that it was 'extremely doubtful' that a Curtiss Jenny had 'sufficient margin of strength to safely withstand' the stresses likely to be imposed by a tyro pilot attempting an extreme manoeuvre. But it was a particularly significant observation in the light of another remark contained in the report to the effect that 'the aeroplane had not been built under AID inspection.'

So how had it managed to avoid the scrutiny of the eagle-eyed men of the War Office's AID? Because it had been built in Canada, to an RNAS order, and then imported. At the request of the War Office, some of these aeroplanes had subsequently been diverted to the RFC, and it was not until then that they were subjected to an adequate degree of professional scrutiny, as Lt-Col Fulton was to discover when he personally inspected one of the first to be erected. What he found moved him to write to the War Office as follows:[14]

> 'I think it necessary to place on record that constructionally this machine leaves a great deal to be desired. The workmanship and material throughout are of cheap and typically American kind …. It is impossible to effect any improvement in the

> machines without practically scrapping all the existing fittings and making new ones …. The use of these machines is only justified by war necessity.'

Which explains the Accidents Department's easy conclusion with regard to the loss of A1259. The final remark in Fulton's report, to the effect that flight safety takes second place to wartime pragmatism, is particularly notable.

In the course of 1918 the Accidents Department would record a total of 2,681 serious accidents to UK-based aeroplanes, 'serious' being defined as those involving a fatality or an injury resulting in absence from duty of more than seven days.[15] Of these it investigated 231, about 9%, which was sufficient to permit the identification of specific areas of concern, of which the classic example is the DH 6 trainer. Several, instances of loss of control were diagnosed as having been caused by aerodynamic problems which were cured by reducing the excessive camber on the leading edges of the high-lift wing sections, reducing the angle of incidence of the tailplane, narrowing the chord of both rudder and elevators and re-rigging the wings to introduce a substantial degree of back-stagger.

An indication of the interest being taken in analysing the causes of accidents, if not actually trying to prevent them, was the publication in August 1918 of an Order concerning Courts of Inquiry into Flying Accidents which refined and amplified previous advice on what was to be done and explained why.[16]

By this time Cockburn was producing monthly accident summaries. The graph at Figure 1 is based on his figures[17] and shows the numbers of UK-based fatalities, in training, during the last year of the war and it is apparent that a corner was turned in the summer of 1918. That will have been the result of the RAF's restructuring of flying training which involved the wholesale conversion of existing units into Training Depot Stations (TDS), a concept that had first been introduced on a trial basis a year earlier and which implied, among other things, a total commitment to Smith-Barry's philosophy. And, if nothing else, it certainly seems to have reduced the number of flying accidents.

But flight safety is not really about numbers of accidents, because you can reduce the numbers by flying less – to zero if you stop flying

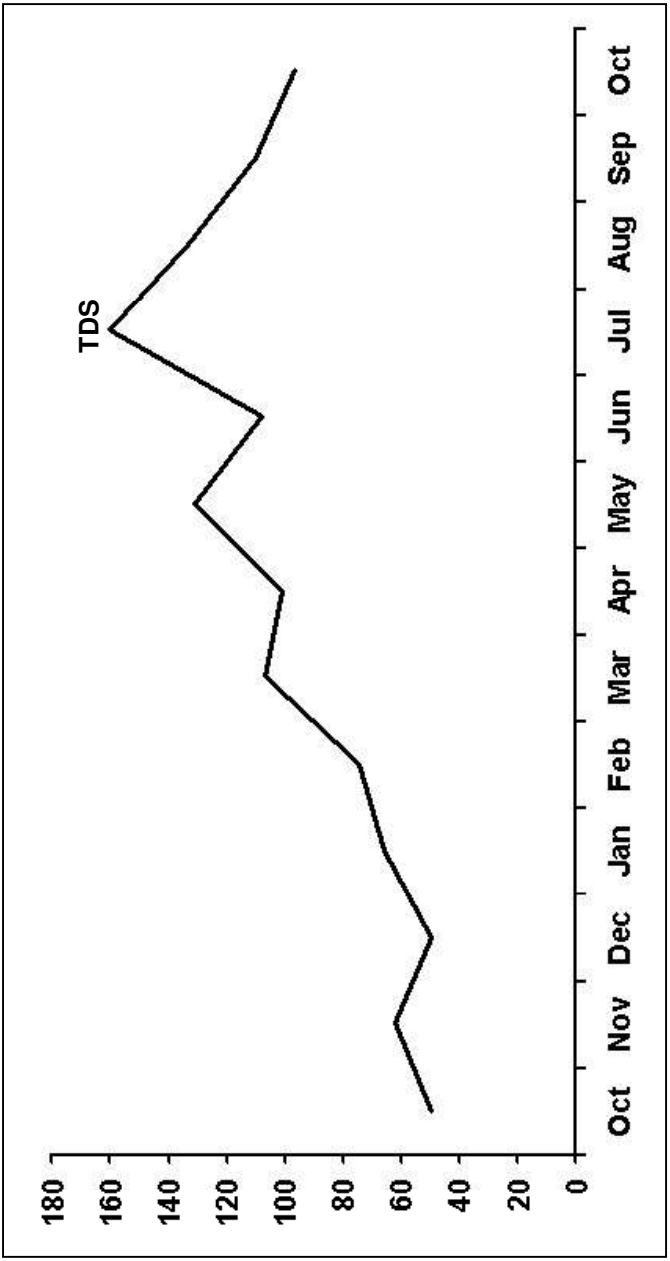


Fig 1. Accidents per month to UK-based aircraft between October 1917 and October 1918.

altogether. The real test is the accident *rate* and Figure 2 uses the same information as Figure 1 but relates it to the numbers of hours being flown. The raw graph looks a bit random, but the superimposed line shows that the underlying trend, upward to begin with, had definitely adopted a downward gradient by the autumn. Incidentally, the RAF's current major accident rate is of the order of 0.25 per 10,000 hours which would barely register on the chart. And this is not even a fair comparison because the graph reflects fatalities whereas the recent figure is for aircraft lost – today, in most cases, the crew will have a better than even chance of surviving.

Cockburn was not simply compiling statistics for their own sake, of course. By breaking down the figures by cause and/or aircraft type a number of flaws were revealed, permitting appropriate remedial action to be taken. For instance, a spate of fatal accidents in which the wing structure of DH 4s and '9s had mysteriously collapsed was eventually shown to have been due to the initial failure of the tailplane. An interim solution was provided by additional bracing struts pending the introduction of a completely redesigned and restressed tailplane. Then again, accidents involving Camels, and to a lesser extent, RE8s and BE2es were traced to defective, or barely acceptable, 'spiral grain' timber being used in the construction of wing spars. This was clearly a 'quality control' issue and, once the AID inspectors had been alerted to the problem, it was virtually eliminated. Similarly, nine failures of the wing leading edges of SE5as during the first six months of 1918 led to a modification programme and there was only one such incident during the next six months.

Most of what I have said up to now relates to the RFC and RAF in the UK, essentially training units. What about the bits that were doing the fighting? Needless to say, a far more robust attitude prevailed on the other side of the Channel. By the summer of 1918 new pilots arrived in France with more than twice as much flying experience as they had done in the old days – more like 80+ as opposed to fewer than 40 *and* they had been through a far better structured sequence *and* been taught in accordance with the gospel as preached by Smith-Barry. At least that was the theory, although there is plenty of evidence to suggest that the system was still working at rather less than 100% efficiency even when the war ended.

Even so, it was a vast improvement on 1917 and the incidence of

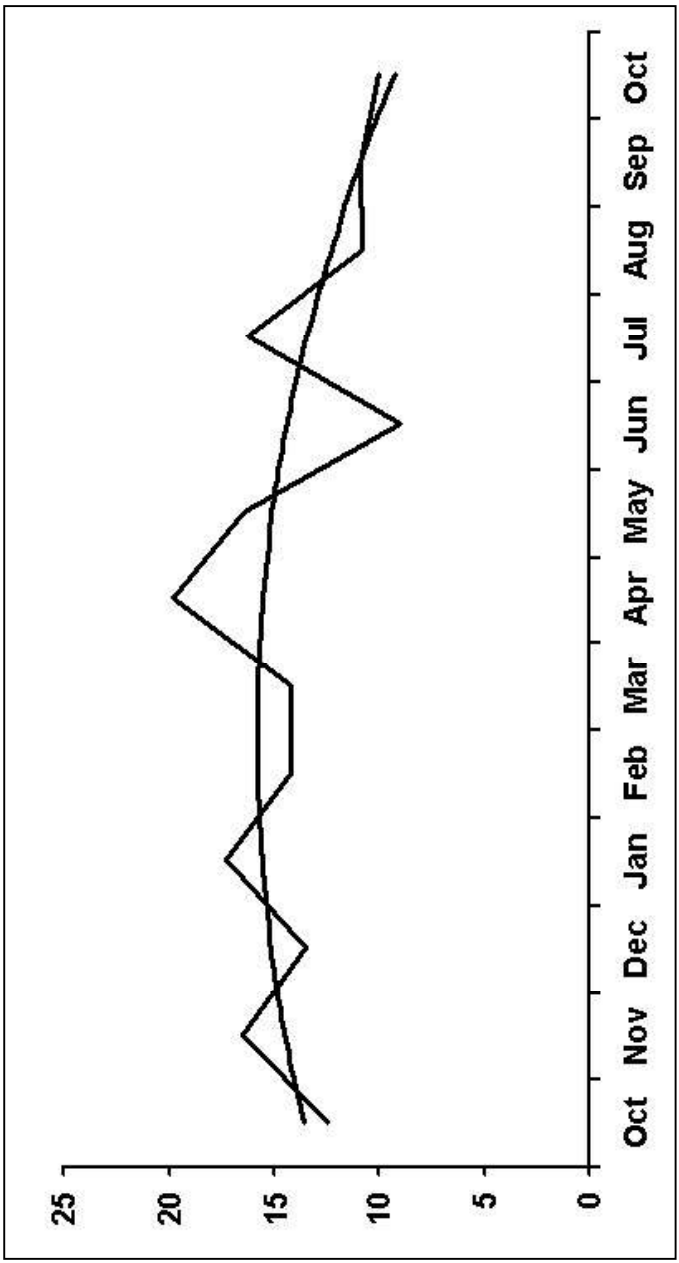


Fig 2. Accidents per month per 10,000 flying hours to UK-based aircraft between October 1917 and October 1918.

new boys bending their aeroplanes was much reduced. Thereafter, once a CO had accepted that a pilot was competent, if he was able to walk away from a subsequent crash, that was probably the end of the matter. That is not to say that accidents in the field were simply being swept under the carpet, of course. Even if no one had been hurt, it was still necessary to account for the loss of an aeroplane so a Casualty Report, an Army Form W3347, was always raised.

Again, there are scores of these at Kew. Taking one at random, it concerns a Sopwith Camel, F3949, of No 203 Sqn which was involved in an accident on 28 October 1918.[18] As with the example of the Curtis JN3 in 1917, the Camel's paperwork provides evidence of meticulous record keeping, telling us that the airframe had flown 24 hours and its engine (a Bentley BR1, serialled V.2551) had run for 26 hrs and 40 mins. The aeroplane had struck a mound of earth on take off and clipped the tips of its propeller blades. It managed to get airborne but with its cropped prop it was short on power and the pilot was unable to avoid some telegraph wires while attempting to land and the aeroplane was substantially wrecked and thus written off. The explanation for the loss was self-evident, so there was no mystery to solve. It had been no one's 'fault' and the pilot was unhurt. So that was that. There was no need to make a fuss. The squadron's Recording Officer will simply have completed the W3347, in collaboration with the pilot and any other interested parties, dropped it in the CO's In Tray, along with the piles of routine returns requiring his autograph, and, having recovered it from the Out Tray, despatched it via Wing and Brigade to HQ RAF. Another form would have been completed to indent for a replacement aeroplane which would probably have been delivered the next day and life would have carried on as before.

That is not to say, of course, that HQ RAF would not have reacted if a trend had become apparent but in France the focus was on combat and tactics rather than accident analysis. That said, with the Accidents Department identifying design faults and manufacturing defects by analysing the many incidents that were occurring in training, trends of that nature were already being dealt with. The problem in France would have been more to do with flying discipline and trying to maintain that elusive balance between 'press on spirit' and foolhardiness.

Notes (document annotated 'AIR' may be viewed at the National Archives at Kew):

[1] AIR1/733/199/7.

[2] AIR1/2100/207/28/11. The Committee comprised: Chair – Dr R T Glazebrook (Director of the National Physical Laboratory); Brig David Henderson (DGMA); Maj Frederick Sykes (Commandant Military Wing, RFC); Maj Robert Brooke-Popham (OC 3 Sqn); Mervyn O'Gormam (Superintendent Royal Aircraft Factory); Lt Spenser Grey (Naval Wing, RFC); F W Lanchester (noted physicist).

[3] Of the total of sixteen aeroplanes that had been involved in fatalities thus far, eleven had been monoplanes. Without waiting for the outcome of the investigation, Seely had promptly banned his pilots from flying monoplanes. But, since the First Lord of the Admiralty, Winston Churchill, had declined to follow suit, this edict had applied only to the Military Wing of the RFC so that pilots of the Naval Wing could still fly any aeroplanes that took their fancy.

[4] AIR1/733/199/7.

[5] When the Admiralty was offered the use of the RAeC's aerodrome at Eastchurch and free tuition in two of Frank McClean's aeroplanes – this was in 1911, before the creation of the RFC – it was Cockburn who taught the first four naval pilots to fly: Longmore; Samson; Gerrard and Gregory.

[6] AIR1/783/204/4/534.

[7] Prior to January 1917, when it established a Fifth Sea Lord to look after naval aviation, issues relating to the design and construction of aeroplanes and to the provision of aeronautical stores had simply been regarded as additional functions to be discharged by the Third and Fourth Sea Lords, along with those traditionally associated with more conventional naval business. Although this would have included 'quality control', the RN did not set up a dedicated organisation equivalent to the Army's AID. Nevertheless, it will have benefited from the work of the AID, since the latter was effectively establishing what came to be regarded as 'the industry standard'.

[8] AIR1/733/199/7.

[9] AIR1/680/21/13/2207. Report G.9 'on accidents to Sopwith Camels with special reference to spinning', prepared by the Accidents Committee of the Advisory Committee for Aeronautics.

[10] AIR1/515/16/3/82.

[11] The permanent members, in addition to O'Gorman, were: Prof J E Petavel (Manchester University and a member of the Advisory Committee for Aeronautics); G B Cockburn (representing the Controller of Aeronautical Supplies); Capt S R Stammers (No 39 Sqn, representing the DGMA); and A Ellerton (Secretary).

[12] AIR1/28/15/1/139.

[13] AIR1/515/16/3/82.

[14] Quoted in J M Bruce's *The Aeroplanes of the Royal Flying Corps (Military Wing)*, p202. (London: Putnam, 1982).

[15] AIR1/984/204/5/1172 and 1174.

[16] AMWO 910 of 29 August 1918.

[17] AIR1/680/21/13/2207.

[18] AIR1/860/204/5/423.

THE EVOLUTION OF PARACHUTES FOR AIRCREW

AVM Alan Johnson

Alan Johnson was commissioned in 1957 as a National Service Medical Officer. After qualifying as a parachutist, he served with a Parachute Rescue Team in Cyprus and became a founder member of the RAF Sports Parachute Association. Later he was a member of the Joint Services High Altitude Parachute Trials Team, became Chairman of the British Parachute Association Safety and Training Committee and led the British Team at the World Parachuting Championships in Yugoslavia (1970), the USA (1972) and Hungary (1974). Along the way, he obtained the first Diploma in Aviation Medicine and was Head of Training at the Institute of Aviation Medicine.

Introduction

In 1910 the Honourable Charles Rolls (of Rolls-Royce fame) was piloting a Wright biplane in a competition at Bournemouth when his rudder control failed and he crashed to his death from some 300 ft. He had the distinction of being the first Englishman to be killed in a flying accident. His death greatly affected his friend Everard Calthrop, a one time Indian Railway engineer who decided to devote his life to the development of an effective life saver – the parachute.

Parachutes were not new. Their history goes back into the realms of antiquity. This paper will cover the historical development of parachute design, their use as a means of unassisted escape and safe descent from balloons and aircraft in particular by the Royal Air Force.

Early days

There are stories, mostly unsubstantiated, of the Chinese using umbrella-like devices to jump from the Great Wall but the first authenticated design appears in Leonardo da Vinci's *Codex Atlanticus* (1485). The shape and dimensions are familiar and, constructed of the right lightweight materials (not available at the time), would undoubtedly have ensured a safe rate of descent by the user. A century later Fausto Veranzio sketched a similar design *Homo Volens.* A

French physician Dr le Normand contemplated the use of such a device for escape from burning buildings but the real impetus awaited the development of flight. Le Normand is credited with the introduction of the word 'parachute', a French/Greek word meaning 'Against-Fall'. The 18th Century saw the introduction of the balloon and in 1784 Pierre Blanchard launched several animals from his balloons using fabric cone-shaped parachutes. The first man to make a parachute descent was another Frenchman Andre-Jaques Garnerin who on 22 October 1797 jumped from a balloon at 3,000 ft over Parc Monceau in Paris. Despite violent oscillations he landed safely in a basket beneath his 23-foot (flying diameter) parachute. Both he and his wife made several descents over succeeding years. His fifth descent was made in England in 1802, his balloon ascended from the site of where Selfridges is today in Oxford Street and from a height of 8,000 ft he landed in a field behind St Pancras Church.

Throughout the rest of the 19th Century many parachute descents were made by adventurers and showmen at various meetings and exhibitions, the intention being to thrill the crowd. Only one incident is of note in this period, the first fatality recorded in England.

After having witnessed Garnerin's descent in 1802, a Mr Robert Cocking, a somewhat unsuccessful artist, had nurtured the idea of making a parachute in the shape of an inverted cone, similar to the airborne dandelion seed. This he believed would be far more stable. He had to wait thirty-five years till he was able to put his theory into practice. He constructed his parachute from Irish linen, the periphery being held open by a metal loop some 107 feet in circumference. The contraption weighed some 400 lb (including his weight of 170 lb). The only balloon capable of lifting such a weight was the *Nassau* piloted by the most famous balloonist of the day Charles Green. At 7.30 pm on 24 July 1837 the balloon ascended from Vauxhall Gardens. At 5,000 ft the balloon could not rise any further and after the exchange of a few pleasantries, Mr Cocking said, 'Well now I think I shall leave you,' to which Mr Green replied, 'I wish you a very good night and a safe descent.' With a final 'Good night Green,' Robert Cocking cut the release mechanism. Relieved of the suspended weight the balloon shot skywards and Cocking began his descent. Within seconds the fabric and metal, unable to stand the strain, collapsed and Cocking plunged to his death.

Parachute development continued throughout the century but the principle stimulus was to provide better spectacles for the thrill seeking public at balloon displays. The next significant step awaited the invention of the aeroplane.

In the years succeeding 1903 concern was expressed over the increasing numbers of fatalities associated with flying., twenty-nine in 1910, seventy-nine in 1911, 104 in 1912. The case for parachutes was raised repeatedly but the counter arguments continued. Most fatal accidents occurred near to the ground and the successful deployment of the parachute attached to the aircraft would be compromised by the gyrations of the crippled machine. In 1913 an article in *Flight* magazine stated,

> 'Frankly, we see very little future for the parachute as a life saving apparatus in emergency on aeroplanes ….. Nevertheless we are far from dissuading the ingenious inventor from persevering with his attempts to devise a really satisfactory folding parachute that can be applied to the body.'

Whilst not fulfilling the criteria completely, successful parachute descents had been made from aircraft, the first in England was by William Newell in May 1914.

World War One

Despite the increasing loss of valuable aircrew, the possible use of the parachute as a means of escape was ignored by staff officers except in one area – the observation balloon. Used as a platform for artillery spotting, the hydrogen filled captive balloon was vulnerable to the incendiary bullet. A Spencer parachute was attached to the basket and the observer made his escape by attaching the crude harness he wore to the parachute before leaping over the side. The silk parachute was extremely reliable and some 800 observers saved their live using the Spencer. The first military parachuting fatality occurred on 30 August 1916 when Captain Basil Hallam Radford jumped from his balloon over Beaumont Hamel, the balloon having become detached from its cable. Radford was a well-known musical comedy star who had entertained West End audiences and Royalty as 'Gilbert the Filbert, the King of the (K)Nuts', his signature tune. Also known for his parody of a George Robey song which he sang as 'They

Preparing to test, on the left, the Calthrop A.1 'Guardian Angel' and, attached to the basket in its conical container, the Spencer. The Spencer was the standard fit for balloons since the former's rapid deployment entailed a risk of the 'chute becoming entangled with the falling, and burning, balloon.

Wouldn't Relieve Me'. Accounts vary as to the cause, but the general opinion was that he had failed to secure his crude harness before jumping.

Despite the comparative success of the Spencer parachute in the world of ballooning, progress as a means of escape from aircraft was practically non-existent. We now return to Everard Calthrop who campaigned vigorously for the adoption of his 'Guardian Angel parachute by aircrew.

Of similar design to the Spencer, its reliability had been proven to the Admiralty Air Department as far back as January 1915 and by 1916 it had been tested successfully with drops from a BE2c. The inventor claimed that it could be used to drop agents behind enemy lines under cover of darkness using black canopies and rigging lines – the 'Destroying Angel'. Some thirty agents were dropped in this fashion in France and subsequently on the Italian-Austrian front. On one such mission an Italian dropped through a trapdoor in the floor of the aircraft, an SP 4 biplane piloted by Maj William Barker VC.

Officialdom still obstructed their use as escape devices. In the 1916 edition of the *Aviation Pocket Book* the idea was dismissed on the grounds that,

> '….in the case of engine stoppage, or the like, the aeroplane itself acts as efficiently as a parachute and has the additional

Maj Thomas Orde-Lees.

advantage of allowing the landing ground to be chosen.'

This completely ignored the horrors of fire in the air. Objections on the grounds of unreliability (disproven by Calthrop and others), reduced aircraft performance (the additional drag produced by a parachute container attached to an aircraft resulted on a 3-4 mph loss) and the more sinister argument that the presence of a means to escape would result in failure to press home an attack prevailed.

Front line pilots, aware of Calthrop's work, had made enquiries about the private purchase of parachutes but approval to supply them was refused by the Air Board. It was not solely in combat that the need to provide a means of escape was so blatantly apparent. In 1917 some 800 fatal accidents had occurred to pilots under training.

One advocate stood out, a Maj Thomas Orde-Lees (later Secretary of the Air Board Parachute Committee). Orde-Lees was well known as a member of the ill fated Shackleton Trans-Antarctic Expedition of 1914. He remained on Elephant Island when Shackleton made his epic voyage to South Georgia. Faced with starvation, the stranded explorers had considered cannibalism and Orde-Lees was first on the list to be sacrificed. Fortunately for him, and for the story of the parachute, they were rescued in time. In an extraordinary demonstration to prove the reliability of the Guardian Angel, Orde-Lees and Lt (the Hon) A E Bowen jumped from the parapet of Tower Bridge into the Thames some 150 feet below!

In 1918 an MP, appalled by the number of fatalities, again tried to persuade the newly formed Air Ministry to provide trainee pilots with parachutes but to no avail. Major Baird, the parliamentary member of the Air Board replied, '…the great majority of accidents occurred under circumstances which precluded the hope that a parachute would be of any value.'

An experimental installation of a 'Guardian Angel' in a Snipe.

Two fatalities in mid-1918 did focus attention. The death in a flying accident of Maj McCudden VC, one of Britain's leading aces and a strong advocate of parachutes, and Maj Raoul Lufbery, an American ace who jumped to his death after his Nieuport caught fire at 2,500 ft. Also at that time reports had been received of German airmen using parachutes to escape from their crippled aircraft. No less a pilot than Ernst Udet bailed out of his Fokker DVII in June 1918 using a Heinicke parachute attached to the fuselage.

Such events finally stimulated a plethora of research into ways of fitting parachutes to existing aircraft and at Farnborough successful trials were carried out on the SE5, the Snipe, the Bristol Fighter and the DH 9; the ubiquitous Sopwith Camel, however, defied all attempts to provide a satisfactory installation.

In October 1918 Sir William Bull, Conservative MP for Hammersmith, finally drew an admission from the Government that parachutes were an effective aircraft safety device. Shortly afterwards the parachute section of the Air Force Technical Department published a notice advising that parachutes should be of 28 ft

diameter, weigh less than 40 lb, including harness, and be capable of rapid production. Those last words are particularly ironic, since the war ended in the following month. Inevitably, with the coming of peace, the impetus went out of development although it did continue slowly as a result of continuing fatalities in flying training. Orde-Lees was particularly moved by the death of a young flying instructor at Northolt in 1919, a pilot who had made a successful trial descent from an aircraft during this development phase.

Perhaps the last words on this tragic period should be those of a famous airman, probably known to several in the audience, MRAF Lord Douglas of Kirtleside writing in his 1963 book *Years of Combat*. Recounting his days as a scout pilot in 1917, he witnessed a squadron colleague's two-seater aircraft catching fire at altitude and the last moments of his burning friends.

> 'I recalled how many men had died in such agony – all because somebody had thought so little of us that they believed that providing us with parachutes would encourage us to abandon our aircraft – my anger was aroused in a way that is unusual for me.'

Six thousand airmen died in WW I, how many could have been saved?

Between the Wars

As interest faded in Britain the US Army sought a solution by allocating funds to parachute development. Under the leadership of Maj E L Hoffman a team was assembled at McCook Field, Dayton, Ohio to examine all existing parachutes. They came to the incontrovertible decision that a parachute attached to the aircraft was not the answer. They drew up criteria for the ideal emergency parachute which included the following requirements:

- The parachute should permit the airman to leave the aircraft regardless of its position.
- The operating means should not depend on the airman falling from the aircraft.
- The parachute should be fastened to the airman at all times.
- The parachute should be of a size to give maximum comfort to

the airman and not hinder his escape.

- It must open promptly and be capable of withstanding the shock of a 200 lb load falling at 400 mph! (my exclamation mark).
- The harness must prevent the airman falling out on deployment and be capable of speedy removal when landing into water or at high speed.
- The parachute should be of simple construction and easily packed with little time and labour.

These specifications were sound and are equally applicable today.

During their investigations they evaluated many of the parachutes already in existence, including the Guardian Angel. A Lt Caldwell from Britain, keen to demonstrate the claim of the static line chute, jumped over McCook Field from 900 ft. The static line between him and the parachute container snagged on the elevator rocker arm protruding from the fuselage. The line snapped and Caldwell fell to his death, his parachute remaining attached to the aircraft. This effectively spelled the end of the fuselage-attached parachute.

Eventually the work at McCook Field resulted in the creation of the 'A' Type free-fall pack parachute. It had a 28 ft (flat circular) diameter silk canopy, silk rigging lines, a 3 ft apex vent to reduce oscillation, and a small pilot chute to aid rapid deployment, all contained in a back pack which was held closed by a cable passing through cones and released by pulling a D Ring – the Ripcord.

After many dummy drops the parachute was considered ready for its first live test. One member of the team was a man in his mid-twenties; a man who was an experienced parachutist having performed frequently from balloons. On the 19 April 1919 this man jumped from a DH 4 over McCook Field from a height of 1,500 ft. The ripcord was pulled and the parachute was fully developed by 1,000 ft. Despite his experience the jumper sustained a broken ankle on landing. His name? – Leslie Irvin. This successful demonstration, and subsequent ones, resulted in orders being placed by the US Army and the wearing of parachutes was made compulsory in 1921. The following year, on 20 October 1922, a Lt Harris lost control of his aircraft while indulging in mock combat and so he dived over the side to be the first airman to save his life with an Irvin parachute. This and subsequent emergency

escapes inspired Leslie Irvin to found the ‘Caterpillar Club’.

In England development continued slowly. Despite the proven efficiency of the Irvin ‘A’ Type, work continued on alternative designs, notably a plethora of intriguing ideas from Col H E S Holt, who was vocal in his criticism of the RAF for being obsessed with its attempts to find a system which would work when used from an aircraft flying under control. ‘Who wants to escape from a machine flying normally?’ he asked.

In 1921 it was revealed in a Parliamentary Question that the RAF had 1,942 parachutes but that their use had been delayed because of difficulties with harness design. In 1921 one of their most devoted advocates Air Cdre E M Maitland (former President of the Parachute Committee), died in the R38 airship disaster when forty-four of the forty-nine souls on board were killed. Five had escaped by parachute but the suddenness of the disaster had prevented the others using theirs. The Government was also obliged to admit that the parachute research section had been closed down in the interests of economy.

At last, in March 1925, Sir Samuel Hoare, the Secretary of State for Air, told Parliament that it was impractical to await the development of a British design and that the RAF would be equipped with Irvin parachutes; two thirds of the original order was to be imported from the United States and the remainder would be made in Britain. Leslie Irvin came over and in the space of a few months founded his factory in Letchworth where he remained for the next twenty-five years. Many wonder why the company is called the Irving Air Chute company. The ‘g’ was simply a typographical error made by the girl typing the original articles of the company and it has never been corrected. Whether it was to demonstrate confidence in this emergency system or not, Air Mshl Sir John Salmond made a premeditated jump from 2,000 ft over Northolt in July 1926. His confidence boosting demonstration had been forestalled the previous month, however, when Plt Off Eric Pentland, a student pilot at No 5 FTS, Shotwick, contrived to put his Avro 504 into an inverted spin. He bailed out; his parachute opened at 500 ft and he landed safely – the first British Caterpillar.

As for poor Calthrop, he lived to see the Service introduce a safety parachute, but not of his design; he died in 1927.

Figure 1 reflects the increasing use of the parachute as an escape

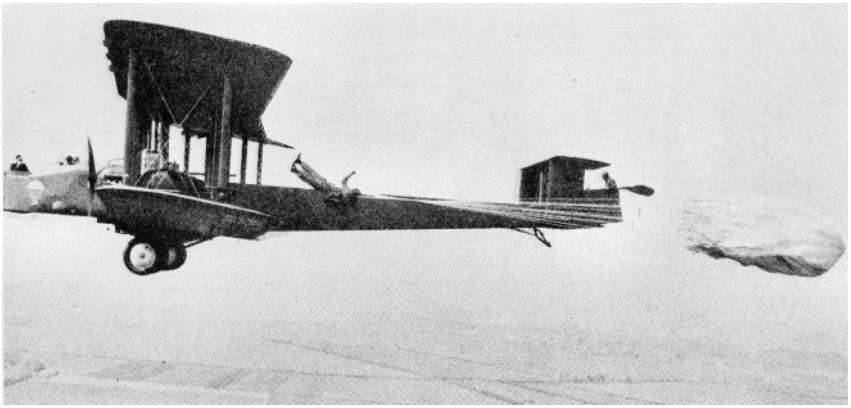
Year	No of Lives Saved
1927	3
1928	6
1929	18
1930	22
1931	30
1932	17
1933	8
1934	19
1935	8
1936	17
1937	24
1938	62

Figure 1.

system by the RAF during the inter-war years. The dramatic increase in the two years after 1936 was due to the expansion of the Service prior to WW II.

During that conflict, the parachute as a means of escape from a crippled aircraft was finally vindicated. By VE Day in 1945, there were 20,538 members of the Caterpillar Club. Strangely, the present administrator of the Club was not able to give a detailed breakdown of the members by country, service, wartime/peacetime but there are now over 100,000 members worldwide with 32,000 on the European register. Surely this is the finest testimony to the dedication of pioneers like Calthrop and Irvin.

Replacing the original Vimys, practical parachute training in the 1930s involved a pull off from a Virginia. The victims took off in the tail gunner's station or standing on platforms mounted on the lower wings where they clung to the outer struts until signalled to pull the D-ring.



There are many accounts of dramatic escapes from crippled aircraft, at high and low level – as many here could probably testify. Perhaps the most dramatic of all was the experience of Flt Sgt Nicholas Alkemade, the rear gunner of a Lancaster, who, prevented from reaching his chest-type parachute by flames, elected to leave the burning aircraft parachuteless rather than burn to death. Incredibly, he survived a free fall from 18,000 ft during which he must have achieved a terminal velocity of 120 mph. His landing impact was attenuated by falling through pine trees into deep snow. He suffered comparatively minor injuries.

While not citing that incident as a precedent, it is a curious fact that making a parachute descent for the first time, unpremeditated, with minimal training in landing techniques, onto landing sites that could present the most fearful hazards, caused surprisingly few landing injuries. Perhaps ignorance is bliss, because the injury rate increases the second time of asking. It has often been argued that all aircrew should be required to make a parachute descent after training to prepare themselves for such an eventuality. Such proposals have never been welcomed by aircrew, the classic response being: 'You are never going to get me to jump out of a serviceable aircraft!'

Nevertheless, there will always be the possibility of having to 'hit the silk' – actually nylon these days. Even the final phase of an assisted escape using an ejection seat involves a descent under a parachute canopy but the uneasy relationship between aircrew and the parachute remains.

Perhaps the final words should be left to two people who were profoundly grateful to the parachute, and to Leslie Irvin in particular, when they wrote to him saying:

> 'Airplane failed; 'chute worked' – *Jimmy Doolittle, after his third bail out.*
>
> 'May I thank you on behalf of my future, and yet unknown, wife and children' – *RAF sergeant pilot, WW II.*

ACCIDENTS – INVESTIGATION, INSTITUTIONS AND ATTITUDES 1919-1945

Wg Cdr Jeff Jefford

In the wake of the Armistice, demobilisation began in the spring of 1919 and the Air Ministry and the Service both began to shrink and morph into their peacetime size and shape. Because it was thought that commercial flying might be about to take off in a big way, and that passenger safety would have to be afforded a high priority, the wartime Accidents Department, which had reported to the Comptroller General of Equipment, became the peacetime Accidents Branch which was to operate under the aegis of the Controller General of Civil Aviation (CGCA) – then a part of the Air Ministry.

Naturally enough, the first man to be appointed as, what amounted to, the Inspector of Accidents,[1] was the very experienced George Cockburn but he resigned at the end of 1921 to be replaced by his deputy, Maj James Cooper.

By this time peacetime arrangements were being more formally defined under the umbrella of the Air Navigation Act of 1920. It should be stressed, again, that all of this was in the context of *civil* aviation but in 1921, while the precise wording of the legislation was still being finalised, CAS had sent Cockburn a memo which read:

> 'In reference to the letter defining your duties with regard to the inspection of accidents, it will also be your duty, independently of the Regulations, to investigate accidents in which Royal Air Force aircraft are concerned, and which are considered to require investigation; and to submit reports through the usual channels to the Secretary of State.'

The gist of this statement was incorporated into Cooper's terms of reference when he was formally appointed as the Inspector of Accidents in 1923.[2] In practical terms, while any accident involving a civil registered aircraft was liable to be investigated by the Accidents Branch, it was only to concern itself with the RAF's aeroplanes if a Court of Inquiry had been unable to establish the cause of an accident.

The original CGCA, Sir Frederick Sykes, had soon become disenchanted with his appointment and, believing that he could do more to promote aviation from the floor of the House of Commons, he had

Cause	Number
Engine failure	90
Error of Judgement	254
Engine failure compounded by Error of Judgement	40
Structural defect	4
Design defect	12
Other causes	73
Total	473

Fig 1. Categorisation of accidents occurring between January 1920 and March 1924.

resigned to become an MP. In that capacity, *Hansard* tells us that, in April 1924, he asked for some data relating to Service flying accidents (evidently of all kinds, certainly not confined to those involving fatalities and/or injuries) that had occurred since January 1920. The response is summarised at Figure 1.[3] It would seem that the majority of accidents, roughly two thirds, were routinely being put down to pilot error. Relatively few were being attributed to airframe problems, although engine reliability still left a lot to be desired and, in many cases, it would seem that pilots were not thought to have handled engine failures as well as they might have done.

From this response, it is evident that the Air Ministry was routinely collating information on accidents, flying hours and the like. In fact it had reinstated a practice established during 1918 and was again publishing periodic statistical summaries, albeit only for internal consumption. Indeed the whole question of accidents tended to be treated with some sensitivity. Although a desire to avoid adverse publicity (for the RAF, but even more importantly for commercial operators) was certainly a factor, there were more substantial rationales underpinning this attitude. First, there was the belief that confidentiality would foster the degree of frankness which was essential if all of the facts relating to an incident were to be established. Secondly, while the investigators could often draw conclusions as to the causes of an accident with a considerable degree of confidence, they were not always able to prove them beyond a doubt and publishing accident reports of that nature could have given rise to all manner of legal and insurance complications. There was no

overt attempt to obscure the truth, hardly possible in some respects, since the findings of a Coroner's Court, for example, are a matter of public record and, as the example noted above indicates, the Ministry would have found it difficult to avoid answering a Parliamentary Question. The policy could be summarised as not volunteering information unnecessarily, and although the question was revisited from time to time, that remained the case for many years.[4]

While they may not have been released to the public at the time, the inter-war accident statistics are a matter of record.[5] They tended to focus on 'serious' accidents which were now defined as those resulting in a fatality or incapacitation for more than 48 hours, as against a week during the recent war. The figures reveal that the annual total of 50,500 hours flown in 1921 had grown to 339,400 by 1930. The numbers of fatal accidents per year fluctuated somewhat, the worst year being 1926 when 54 aircraft were lost. It is worth repeating that this figure reflected *only* fatal accidents; there were another 75 in which people were injured and an undetermined number in which the occupants escaped unscathed.

Furthermore, because many aeroplanes were two-seaters, there were invariably more deaths than accidents, the worst year of the decade being 1928 when 76 men died in 50 crashes – see Figure 2. To put this in perspective, in the air force of the mid-1920s – which, in terms of squadrons, was pretty much the same size as today's RAF – we were quite accustomed to having to bury well in excess of 50 people every year as a result of accidents, which could reasonably be described as living dangerously.

Nevertheless, the picture was not all bad. In fact, while the numbers of fatal accidents had risen initially, they had begun to fall again during the latter half of the decade and, when you bear in mind that the amount of flying being done had increased almost seven fold, the accident *rate* had been in steady decline, from a peak of 5.6 fatal accidents per 10,000 hours in 1922 to just 0.9 in 1929.

So we can move on into the 1930s, with accidents still being relatively frequent and, with bigger aeroplanes, potentially more expensive in terms of lives lost. The RAF's worst single accident between the wars occurred on 4 February 1931 when a Blackburn Iris of No 209 Sqn, crashed while alighting at Mount Batten, killing all but three of the twelve souls on board. It is also worth noting that the RAF

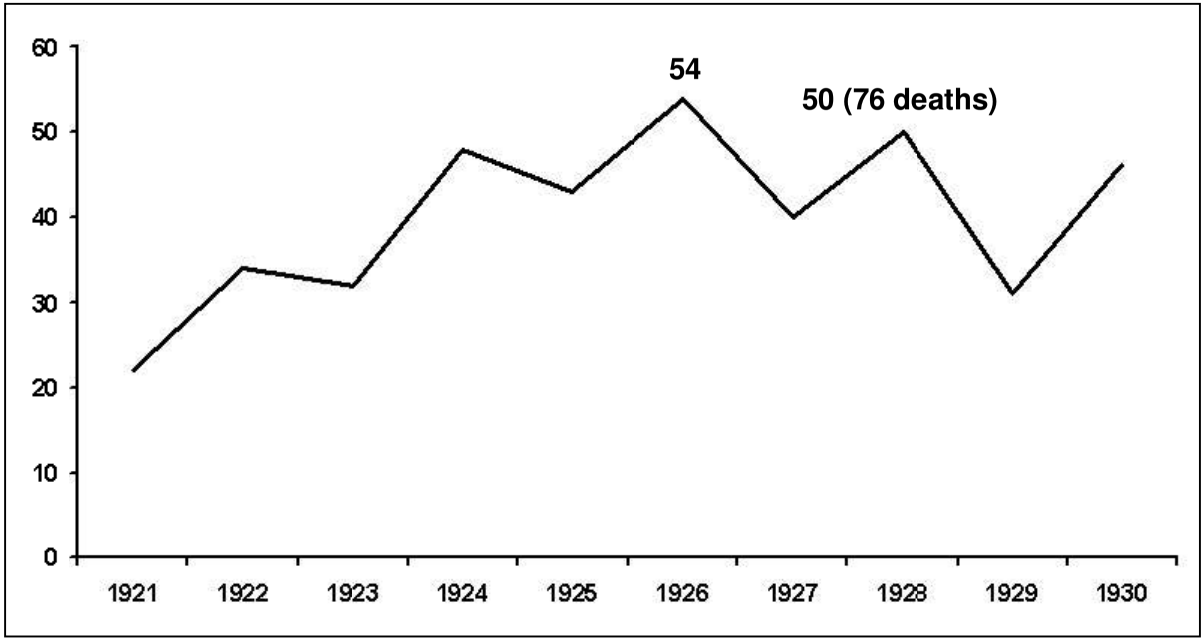
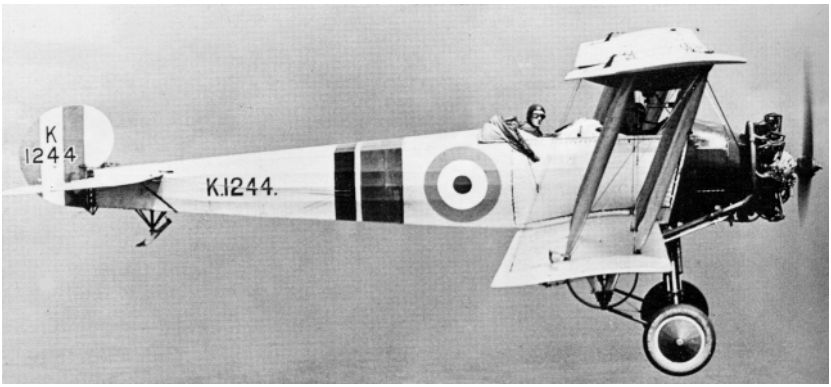


Fig 2. Fatal Accidents, 1921-30.

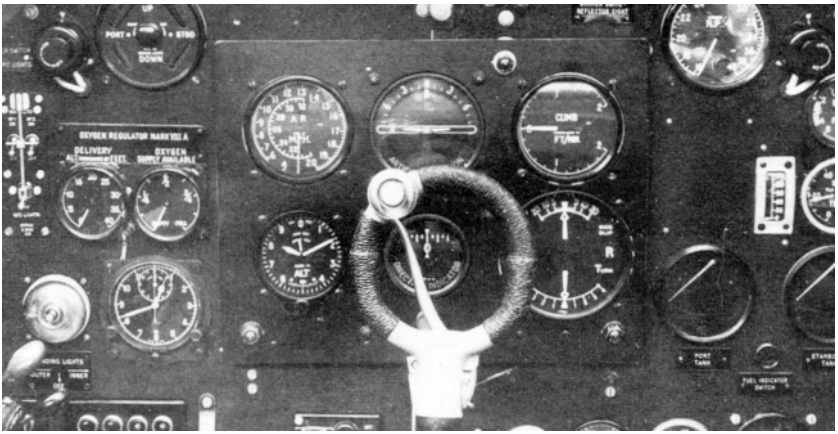


The Avro 504N which the CFS fitted with a hood in order to start introducing the art of cloud flying into the RAF, with consequent beneficial effects on the accident statistics.

still had oversight of the Fleet Air Arm until 1939 and, with the hazards peculiar to carrierborne operations, there was lots of scope for dropping aeroplanes over the side of HM ships.

In the course of the 1930s aviation began to mature, bringing a number of innovations which tended to moderate the accident rate, an early example being improvements in blind flying techniques. The weather had always been a problem to aviators, indeed it still is, but until the end of the 1920s flying in cloud was regarded as something of a black art. Rather like the old pre-1917 'spinning' bugbear, cloud flying was theoretically possible but one was probably ill-advised actually to try it.

The CFS eventually decided to bite this particular bullet in 1930 when it rigged one of its Lynx-Avros with a hood over the rear cockpit. Several dozen pilots, selected at random, were taken up for a trip in this aeroplane and invited to fly straight and level on the available instruments. It transpired that very few could manage more than eight minutes after which they completely lost it and almost invariably finished up in a spin. With appropriate tuition, however, it was shown that it was possible to improve substantially on this, even with limited panel, and the CFS began offering formal instrument flying courses from October 1930 onwards, at a rate of about 100 students per year.



The 'basic six' blind flying panel as fitted to practically all home grown RAF aircraft from 1937 until the 1960s when it began to be superseded by more advanced displays, culminating in today's VDUs and HUDs. Clockwise from top left: airspeed indicator; artificial horizon; vertical speed indicator; turn and bank indicator, directional gyro (sometimes replaced by a compass repeater); and altimeter. This example is a Master I; note that the ASI is calibrated in miles per hour – the RAF did not standardise on knots until 1945.

As part of this programme, in 1932 the CFS was given a Victoria which could be flown from two sets of controls installed within the cabin, which precluded any visual reference to the outside world. One set was installed facing 'backwards', and not re-rigged, so that using it was a little like riding a bicycle with one's hands crossed on the handlebars. The object of the exercise was to demonstrate to pilots the pitfalls inherent in the seat-of-the-pants thinking which had underpinned flying training for the previous twenty years, because your arse (more like your ears really) will lie to you.

The new gospel required pilots to put their faith in their instruments. What was needed to make this a really practical proposition. was an efficient artificial horizon and Elmer Sperry had exactly what was required. The RAF eventually adopted it, enabling it to introduce its 'basic six' instrument panel in 1937, a layout that was to characterise British cockpits for the next twenty years or so.

Another sign of the blind-flying times was that when the RAF

completely overhauled its system of pilot training in 1935 the new syllabus stipulated that the award of a flying badge would now be conditional upon, among other things, a pilot's being able to demonstrate that he could fly solely on instruments, including the ability to recover from unusual positions.

While these developments were all very positive, they did not solve the problem entirely and the weather continued to represent a major flight safety hazard. Perhaps the most obvious example of this was the well known incident in which seven Heyfords of No 102 Sqn encountered freezing fog while flying from Aldergrove to Finningley in 1936. Only one got through; the other six made forced landings in which four aircraft were written off with the loss of three lives. This may sound like a disaster, which it clearly was, but, had it not been for the ability to fly on instruments, it could have been so much worse. If this incident had occurred in the 1920s it is more than likely that all seven pilots would have lost control of their aeroplanes and spun in, resulting in something like thirty casualties. As it was most (all?) of the aeroplanes stayed the right way up, the damage being incurred in the course of forced landings which were made under some degree of control, at least until the nature of the terrain dictated otherwise.

In statistical terms, the progressive increase in annual flying hours noted in the 1920s continued until 1934 in which year the RAF flew 390,500 hours. Despite this increase in activity, the numbers of fatal accidents had continued to decline to reach an inter-war low of only 20 in that year. There were a number of factors contributing to the steadily improving figures, prominent among these being: the introduction of more robust airframes and more reliable engines; the gradually increasing competence in instrument flying; and the availability of parachutes which were now beginning to save lives annually in double figures.

Thereafter things began to change as the implications of the successive Expansion Schemes began to take effect. Since 1934 flying hours had more than doubled to 1,057,400 by 1938 but, over the same period, the number of fatal accidents had increased by a factor of more than five, to 114.

Even so, while the raw figures were not good, when the numbers of occurrences are compared to the increase in flying hours, the fatal accident *rate* was not too bad, as indicated by the graph at Figure 3.

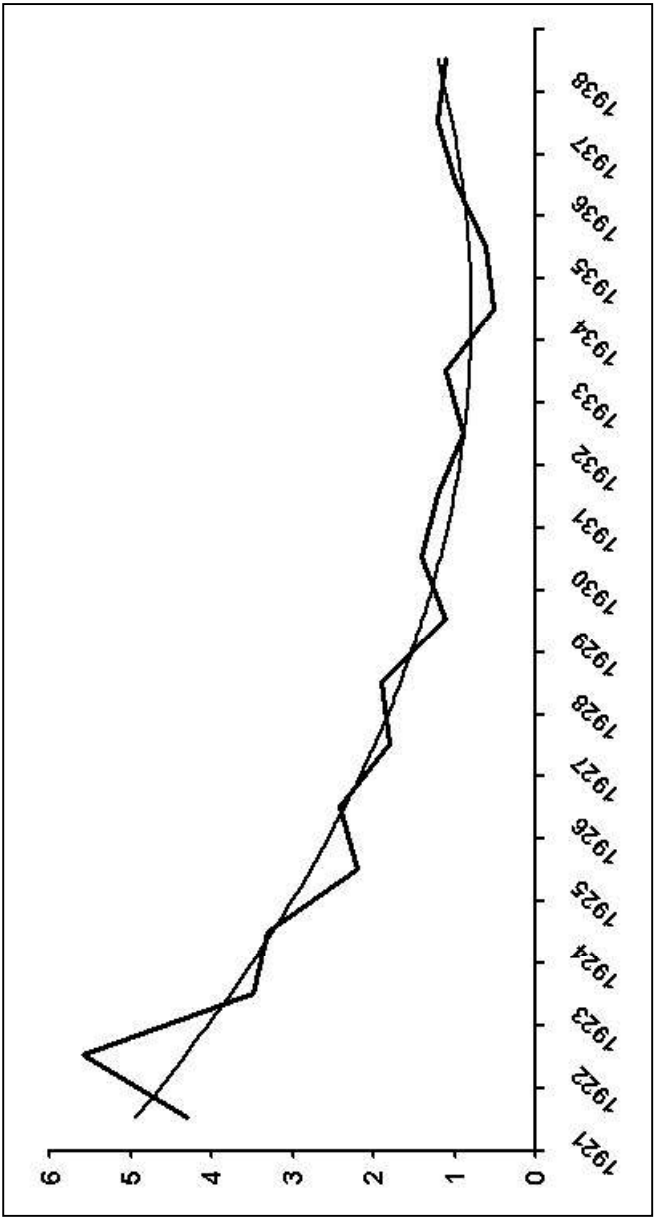


Fig 3. Fatal accident rate per 10,000 flying hours, 1921-38.

Nevertheless, as the superimposed trend line indicates, the long term steady decline had finally bottomed out and had begun to drift upwards again since 1935.

The steady increase in the level of carnage was beginning to cause some public concern and, although the Air Ministry still declined to release official accident statistics, it was possible for a journalist with his ear to the ground to have a fair idea of what was going on. The *Daily Telegraph's* man made it 187 deaths by late October 1938, which was just about spot on.[6] The actual figure, for the whole year would eventually be 218 – and it would have been 280 had it not been for the 62 lives that had been saved by parachute. During the first seven months of 1939, possibly the last peacetime statistics recorded as such, the RAF would rack up a further 99 fatal accidents involving the loss of 169 more lives.[7]

It was inevitable, of course, that the increasing *size* of the air force would be accompanied by an increase in the *number* of accidents, but what was worrying was that the accident *rate* had also begun to increase – so why?

The root of the problem was the rapidly increasing numbers of inexperienced pilots. Until 1935 the RAF had always been expanding, but very gradually, and each year's intake of new pilots had been more or less in proportion to the rate at which the older hands had been increasing in age and acquiring gravitas. This resulted in a pyramid-like structure that was getting bigger all the time but maintaining its proportions. From 1935 onwards, however, the numbers at the bottom of the heap simply exploded.

The problem here is that, 'Green Shield Stamp' schemes notwithstanding, you cannot really create 'instant' flight lieutenants – at least not useful ones. In a proper air force a flight lieutenancy implied fitness to be a Flight Commander and, in round terms, that meant something like five year's practical experience and a 1,000 hours of flying time and to accumulate five year's experience and 1,000 hours takes, very roughly, five years and 1,000 hours.

Thus, it was going to be 1940 or so before any of the expansion intake could *realistically* start to take the strain. In the meantime the, more or less, fixed numbers of old-style Flight and Squadron Commanders were presented with an almost impossible task as they endeavoured to supervise the activities of the hordes of fledging pilots

who were frolicking on the nursery slopes.[8]

By the end of 1938, against an establishment which called for 350 experienced flight lieutenants at squadron level, there was a shortfall of some 200, so proper supervision was clearly a problem. The result was that, while pilots were being trained better than ever before, their skills were not being properly consolidated during their early productive service.

This problem was exacerbated by a shortage of flying hours, because the new aircraft that were coming into service were more complicated, which meant that maintenance was more extensive and prolonged, which reduced availability on the flight line. As a result there was a serious lack of continuity in such essential skills as night and instrument flying. Arthur Harris, as AOC 4 Gp, drew Bomber Command's attention to this by citing the case of his No 10 Sqn whose pilots had averaged just 5 hours per month on their new Whitleys during 1937.[9]

On top of all that there was a sudden leap in technology and young pilots who had been trained on single-engined biplanes with fixed undercarriages before joining a squadron to fly, typically, a Hind were having to adapt to things like Battles with new-fangled devices like flaps, pneumatic brakes, wheels that went up and down and variable pitch propellers, and the Blenheim had all of those plus a second engine, with all of the asymmetric complications that that implied.

Furthermore, there was no OTU organisation so type conversion was carried out locally, which might involve, taking No 45 Sqn as a typical example, a transition from Vincents through Wellesleys to Blenheims – three very different types in less than two years – and without Pilots Notes – not easy for a nineteen-year old starting out with perhaps 150 hours under his belt.

While we have all read spirited, even amusing, accounts of what great fun all this was, we should bear in mind that these were written by the guys who got away with it – which certainly excludes the more than 200 who had died in 1938 alone.

The Air Staff was not oblivious to all of this, not least because the Inspector General, Sir Edward Ellington, had submitted an eight-page report on the overall situation to CAS in November 1938.[10] This had identified the prime cause of accidents as a generally 'low standard of airmanship' arising from a number of factors upon which he elaborated

In just two years, No 45 Sqn's pilots, almost all of them young first tourists, were obliged to cope with three very different types, converting from the Vincent biplane of 1937 to the twin-engined Blenheim of 1939 via the Wellesley of 1938 – this was not achieved without incident. No 45 Sqn's experience was far from unique, of course, many other squadrons being similarly affected by the demands of the re-equipment programmes of the late 1930s.

at some length. In the main, these were those which have been discussed above, including: the shortage of flying hours; a lack of instrument flying; poor supervision due to the scarcity of experienced officers; and the inadequacy of the available advice on the flying characteristics of new aeroplanes.

Ellington's letter had been provoked by the Air Council which was minded to set up an Accidents Committee. Since Ellington was content that the accident problem was already well understood, he was 'not very hopeful' that such a committee would be able to achieve very much. Nevertheless, in January 1939 the committee was duly established, with Ellington in the chair.[11] If the apparent absence of a paper trail is anything to go by, Ellington's evident lack of enthusiasm was reflected in the subsequent deliberations of his team. It seems likely that the committee will have been one of the customers which kept the statisticians busy by periodically demanding specific figures collated in a variety of different ways, concerning particular aircraft types, contrasting day incidents with night, relating the incidence of incidents compared to the number of flying hours on type and so on, but it is not clear what productive use was ever made of these figures.

What seems to have happened, in effect, is that *de facto* responsibility for accidents seems to have come to rest on the shoulders of one particular member of the committee, the Director of Training, at the time Air Cdre W A McClaughry.

A more tangible consequence of the Inspector General's report was the action taken to address the problem of the lack of guidance on new aircraft types. Ellington had not been alone in highlighting this deficiency, incidentally; Ludlow-Hewitt at Bomber Command had been beating the same drum and had proposed the introduction of what he called 'Users Manuals'. The outcome was the establishment of a Handling Flight (later Squadron) within the CFS. This unit was tasked with assessing the characteristics of new types as they entered service and producing written advice on the best way to fly them and pointing out the likely pitfalls.[12] By late 1939 the first editions of Pilots Notes had begun to appear; initially contained within orange covers with a bootlace binding, they later became stapled blue booklets.[13]

By this time, starting in early 1938, the RAF had also begun to introduce the Link Trainer – hardly a flight simulator, but great value

Seen here as a major in 1917, when he had been a test pilot at the Experimental Station at Orfordness, Wg Cdr Vernon Brown took charge of the AIB at the end of 1937.

for teaching instrument flying procedures. And, in the context of such procedures, we also began to introduce SBA as an airfield approach aid, to be progressively superseded during the war by BABS and, much later, by ILS, all of which had a moderating influence on the accident rate.

Meanwhile, however, all was not well within the Accidents Branch, which was still being run by Maj Cooper. It would seem that there had been a clash of personalities between the Head (who also appears to have had some problems with delegation) and one of his staff. The upshot of all this saw the retirement of Maj Cooper at the end of 1937, his place being taken by Wg Cdr Vernon Brown who resigned his commission in order to take up the new post of Chief Inspector (Accidents) [CI(A)] in a reorganised Accidents Investigation Branch – the AIB.[14]

Brown continued to head the AIB until 1952, by which time he was Air Cdre Sir Vernon. Interestingly, between 1913 and 1952 there had been, in effect, only three Chief Inspectors – Cockburn, Cooper and Brown – so continuity had never been a problem.

Which brings us to WW II. Taking the Hampden as an example, we know that of the 1,433 built as such only 261 made it to pensionable age. About half of the production run was lost on operations but a remarkable 458 aeroplanes were written off on *non*-operational flights.[15]

So why were so many aeroplanes being lost in accidents? Just as in 1917, the RAF was soon having to deal with a shortage of aircrew and, as is always the case when there is a question of quality versus quantity – quantity wins. In order to sustain the output of pilots, the

Unit	Representative Type	Aircraft Lost
Op Sqn	Wellington	10 to 20*
OTU	Wellington	10 to 15*
SFTS	Harvard	5
EFTS	Magister	2.5

***** ***Seasonal – fewer in summer months.***

Fig 4. Aircraft written off per 10,000 flying hours, Jan-Aug 1941

duration of flying training was both truncated and hurried – graduation after 120 hours in a mere sixteen weeks in December 1940, compared to the pre-war 150 hours in a far more leisurely thirty-seven weeks.

One obvious, even inevitable, consequence of this was to increase the gradient of the accident rate graph, which had already begun to climb during the later 1930s. As previously noted, an inter-war low of only 20 fatal accidents had occurred in 1934. Taking all major accidents into account (not just fatals) the rate for that year had been 11 per 10,000 hours. It was up to 16 by 1938 but it had more than doubled to 34 by 1941.

One of the first shots, in a campaign aimed at reversing this trend, was fired by Air Mshl Garrod, the Air Member for Training,[16] who began publishing his Training Memoranda – *Tee Emm* – in 1941 to enhance awareness of flight safety.

Having studied the problem, Garrod had concluded that, as in 1917, and again during the expansion of the late 1930s, the underlying cause of the high accident rate in 1940-41 was inexperience. The solution was obvious – improve pilot training. What they were getting was good; there just wasn't enough of it. They needed *more* flying hours.

In order to make his case, Garrod provided the Air Council with some irresistibly persuasive evidence drawn from the first eight months of 1941.[17] As illustrated by Figure 4, he was able to demonstrate that operational aircraft were being written off at up to four times the rate at which aeroplanes were being lost in advanced training which was, in turn, twice the rate at the elementary phase.

It was quite plain from this pattern of losses that pupils were being

Command	A/c Lost	Equivalent No of Squadrons
Bomber	67	4
Fighter	78	5
Coastal	25	1½
Total	**170**	**10½**

Fig 5. Average monthly accidental losses of UK-based operational aircraft Jan-Aug 1941

pushed through the system faster than they were acquiring the necessary skills and many of them were simply unable to cope with the progressively increasing complexity of the aeroplanes with which they were being confronted. And if its pilots could not manage a Wellington – how was the Service going to deal with the Stirling and Halifax?

To drive his point home, Garrod offered some even more devastating statistics (Figure 5) that showed that monthly losses to *operational* aircraft due solely to accidents, *not* combat, and relating *only* to the metropolitan air force, were running at 170 aircraft per month. That was the equivalent of 10½ squadrons or, to put it another way, every fifth combat aircraft rolling off the production lines.[18]

Garrod had calculated that a pilot earmarked for heavy bombers needed to have logged at least 350 hours before reaching his first squadron. The system in place in 1941 provided only 207.

It was still necessary to turn out the numbers of pilots required to satisfy the demands of the ever-expanding front line and the need to replace losses, but by this time the output from the Empire Air Training Scheme was beginning to bring the quantity side of the equation into surplus, finally permitting something to be done about quality. So, while accepting Garrod's 350 hours as a long-term aim, the Air Council authorised an immediate increase to 260 for 1942 and by late 1944 the 350 hour target had actually been exceeded.

By this time, late 1941, the procedure for reporting and investigating accidents had already been overhauled.[19] An officer, to be provided with specialist training by Chief Inspector (Accidents), was to be appointed at each Command HQ to act as the permanent

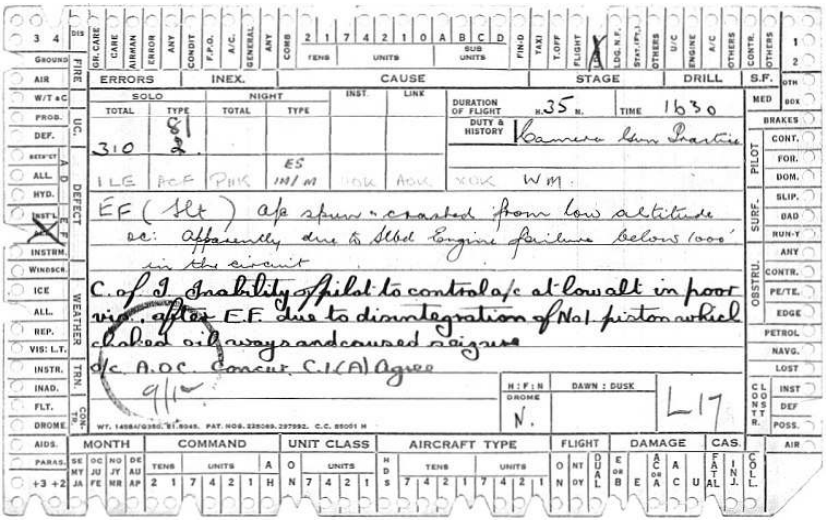
President of Courts of Inquiry. It was made very clear, however, that responsibility in the field of accidents lay primarily with AOCs, that is to say at Group level, where, taking a leaf out of current Bomber Command practice, a Group Training Inspecting Officer (GTIO) was to be established.

The GTIO was to advise on, and supervise all aspects of, accident investigation, summaries of evidence, the convening of Courts of Inquiry and so on, and make recommendations to his AOC on, for instance, the necessity for requesting the assistance of the Accidents Investigation Branch – although the AIB retained the right to investigate any incident that took its fancy.

Vernon Brown's men were still hard at it and they had produced a handy little booklet for the guidance of investigating officers. It included a three-page list of useful King's Regulations, Air Council Instructions and Air Ministry Orders to assist in nailing a pilot's hide – perhaps not, but it must sometimes have felt like that. But, despite the Branch's staff having quadrupled to forty since Brown had taken over at the end of 1937, they could still investigate only about 2% of crashes, which really only nibbled at the edges of the problem.

In brief, the standard procedure in use during WW II in the context of a 'flying accident or forced landing not attributable to enemy action' involved the unit's raising a four-page RAF Form 765(C), in quintuplicate. This provided for the recording of all relevant information, including comment by the pilot, other crew members, and the unit and Station Commanders. In London the details, eventually to include the views expressed by more senior commanders, were summarised on an Air Ministry Form 1180. This information was then used to generate a mass of statistics – ten- or twelve-page documents comprising column after column of densely packed figures which were published on a monthly basis. It was all good stuff, of course, but who had the time to read and digest it all? Indeed, just who was it that was actually supposed to do this? Were there answers buried among these figures? Were a lot of tricks being missed?

In mid-1943 the Inspector General, by now Ludlow-Hewitt, suggested that our whole approach was too *re*active; we were quite good at determining *why* an aeroplane had crashed, but that was hardly enough. What we should have been doing was trying to prevent



A typical AM Form 1180. This one relates to a Beaufighter VI, X7933, of No 125 Sqn which crashed on 10 October 1942, killing both occupants. The notes show that the CO's initial report indicated that the aeroplane had spun in, 'apparently' following failure of the starboard engine while in the circuit. The subsequent Court of Inquiry established that the engine had indeed seized, due to a piston that had disintegrated, and concluded that, in poor visibility and with little height in hand, the pilot had been unable to regain control. The AOC concurred with these findings and CI(A) agreed.

its crashing in the first place. It was also suspected that there was a tendency to focus on pilot errors and airframe and engine malfunctions at the expense of more subtle causal factors arising from inadequate flying (that is to say, air traffic) control, poor signals procedures, misuse of navigation aids and so on.[20]

By this time the accident problem was also worrying the new AMT, Sir Peter Drummond. As previously noted, it had come to be generally recognised that 'accidents' was the business of 'the trainers' but, as Drummond had pointed out in a letter to USofS(C), Capt H H Balfour, his responsibilities in connection with accidents were actually 'undefined'. In short, while the wartime RAF was certainly concerned about the accident rate, and there were periodic bursts of activity in

this connection, it had still neglected to make anyone specifically responsible for any associated policy issues. Balfour finally grasped this nettle by recommending that AMT's previously *de facto* responsibilities should be formally recognised and that these should be discharged via a dedicated staff in a newly created directorate.[21]

These proposals were accepted by the Air Council and implemented at the end of December with the establishment of the Directorate of Accident Prevention – somewhat contrarily abbreviated to the DPA – which was to be run by Air Cdre Henry O'Neill. The core functions of the DPA were:

- to identify problems and devise solutions to them;
- to spread the good word on safe practice;
- to oversee accident reporting procedures;
- to take over the collation of data and the maintenance of record cards from the statisticians, and
- to offer advice to anyone who needed it, specifically including the Americans.

To avoid any clash of interests with Vernon Brown's team, it was made absolutely clear that the DPA did not *investigate* accidents. While the ultimate arbiters remained the AIB, primary responsibility for investigation remained at Group level and continued to be exercised via the Court of Inquiry machinery with the GTIOs ensuring that everything was done promptly and according to Hoyle.

So, did it work? In short – yes.

The graph at Figure 6 provides some impression of the major accident rate – *not* just those involving fatalities – over the period 1927 to 1953.[22] The qualification 'some impression' is necessary because the definition of what constituted a 'major' accident was changed from time to time, so the playing field is not exactly level. Furthermore, the WW II figures are for the metropolitan air force only whereas the pre- and post-war figures are global, and the inclusion of overseas accidents tended to increase the overall rate (on average by 11% per year for the period 1946-53), so the wartime peak should probably be rather taller. Nevertheless, the graph does present a reasonable reflection of the way in which the pattern fluctuated.

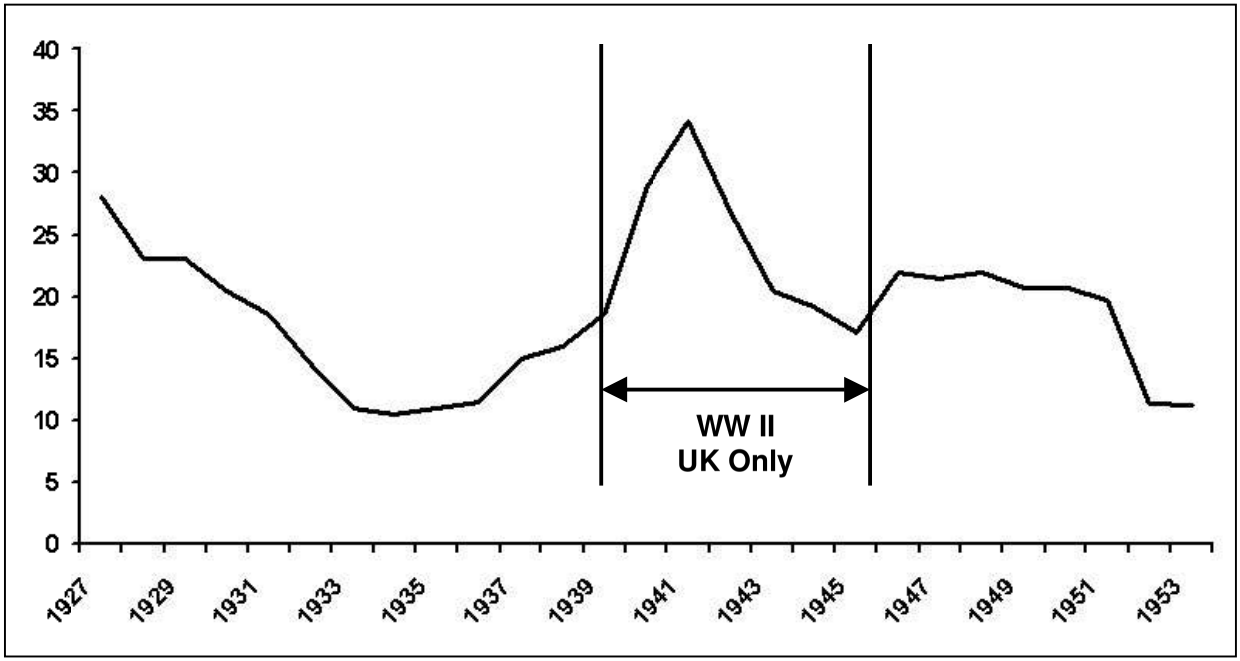


Fig 6. Major Accidents per 10,000 flying hours, 1927-53.

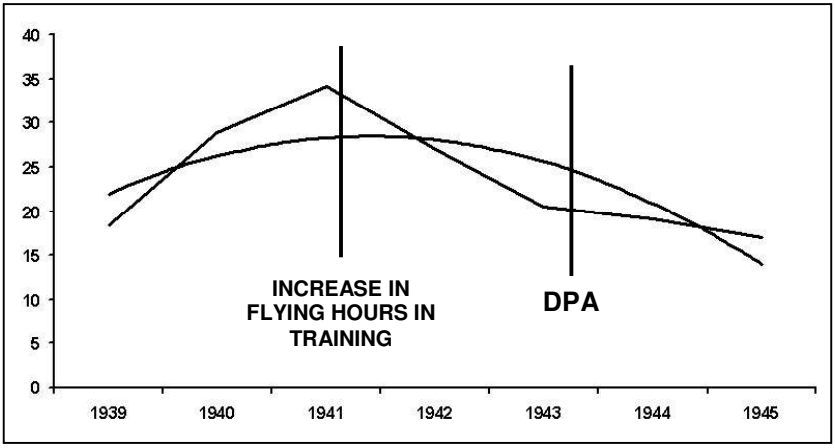


Fig 7. Major accident rate per 10,000 flying hours, 1939-45 (UK only).

Figure 7 expands the WW II period with the lumps and bumps smoothed out by a superimposed trend line which shows the very positive impact made by the two key wartime initiatives – the progressive extension of flying training from early 1942 onwards and the creation of the Directorate of Accident Prevention in early 1944.

Notes (AIR and ZHC references are to pieces held by The National Archives at Kew):

[1] Strictly speaking, Cockburn's post was that of AL2, reporting to the Controller of Aerodromes and Licensing.

[2] Cooper's appointment as Inspector of Accidents was announced in Air Ministry Office Memorandum No 272 of 8 June 1923, which also spelled out his responsibilities.

[3] ZHC2/681, but a copy of the relevant cutting is conveniently filed in AIR5/347.

[4] For instance, as late as 1968, the Air Force Board considered a paper [AFB(68)36] which examined the desirability of releasing additional data on flying accident rates (AIR6/172). At a meeting held on 18 November, after discussing the pros and cons, the Board 'took note' of the paper and 'agreed to reconsider the matter at a later date' (AIR6/160). No change there then.

[5] A considerable amount of statistical data on accidents during the inter-war years my be found at Kew but the SD96 for 1937 (which may be found in AIR10/1585) provides a convenient single source, as it includes a summary covering the years 1921-37. See also Note 7 below.

[6] *Daily Telegraph*, 20 October 1938.

[7] AIR8/253 contains basic accident statistics for the period January 1938 to July 1939.

[8] Interestingly, this was, arguably, pretty much the reason for the *Luftwaffe*'s initially appalling accident rate with its F-104s in the 1960s – a disproportionate number of relatively green pilots.

[9] AIR14/53. Harris to HQ Bomber Command, 12/Air dated 12 January 1938.

[10] AIR2/3467. Ellington to Newall, 18 November 1938.

[11] AIR2/3467. This file notes the establishment of the Accidents Committee in January 1939, and identifies its members, but there are few substantial references to any work that it subsequently did; notably absent is any record of the minutes of the meetings that would presumably have been held from time to time.

[12] CFS and its successors (the ECFS, the EFS and the RAFFC at, successively, Upavon, Hullavington and Manby) retained this responsibility until 1954 when it passed to the A&AEE at Boscombe Down.

[13] The introduction of specific-to-type Pilots Notes, to replace the existing *Handling of New Type Monoplanes* was announced by AMO A.124/1939 of 6 April.

[14] For the benefit of readers who are concerned to get things right/are obsessed with trivia, it should be noted that the Accidents Branch had long since been redesignated as the AIB, this change of name having been promulgated by Air Ministry Office Memorandum No 136 of 19 November 1919. This new title never really caught on, however, and, although it does crop up from time to time in official correspondence, it was not widely acknowledged until as late as December 1942 when the Air Ministry's Distribution of Duties document was finally amended to acknowledge the proper nomenclature. Only then, 23 years late and about 270 monthly editions in arrears, does the Air Force List finally catch up with itself and start to apply the correct label. Not a lot of people know that.

[15] Harry Moyle, *The Hampden File* (Tonbridge: Air Britain,1989).

[16] An Air Member for Training had been admitted to the Air Council in July 1940, this appointment evidently bringing with it the legacy of the rather ill-defined, but apparently generally understood, 'responsibility for accidents' that had been acquired by McClaughry in 1939.

[17] Air Council Memorandum AC70(41), submitted by AMT on 6 December 1941 (AIR6/61).

[18] *Ibid*.

[19] Air Council Memorandum AC46(41), submitted by AMT 29 August 1941, was refined and amplified by AC51(41), submitted by USofS(C) on 17 September (AIR6/61); these proposals were adopted by the Air Council at a special meeting, AC18(41) held two days later (AIR6/72).

[20] AIR20/3148 includes an extract from Inspector General's Report IG/2000/12 of June 1943, containing the key elements relevant to accident investigation.

[21] Air Council Memorandum AC67(43) submitted by USofS(C) on 8 October (AIR6/613); these proposals were adopted by the Air Council at its meeting AC15(43) held on 12 October (AIR6/74).

[22] The figures for 1927-47 are derived from AIR10/5266, validated for 1927-37 by data contained in AIR10/1585, for 1938 by AIR 8/253 and for 1940-47 by AIR2/12650, the latter also being the source for the period 1947-53.

A BRIEF HISTORY OF FLIGHT SAFETY LITERATURE

Stuart Hadaway

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Today flight safety is a cornerstone of the Royal Air Force. The high levels of professionalism and awareness that characterise the modern RAF are maintained in no small part by continuous reinforcement of the flight safety message via the ubiquitous and colourful posters that adorn many of the walls on any RAF station and the wide range of Service, Command and Group magazines spreading the message in the messes and crewrooms. Almost all flight safety literature follows a common style – simple messages communicated in a humorous or light hearted way, frequently through cartoons, with a strong supporting element of personal experiences and true stories. This winning formula initially appeared, virtually out of the blue, with the first edition of *Tee Emm* in April 1941.

In itself flight safety literature is no new thing; it has been around ever since some long forgotten Greek first penned the story of Icarus. But it is a history with a very long gap in the middle. True, manned flight was not a reliable proposition before 1783, and powered flight until 1903, but it would be 1912 until anything approaching a systematic, scientific and public study of flight safety came into being. In that year the Royal Aero Club established a Public Safety and Accidents Investigation Committee (RAeC PSAIC) with the aims of:

1. Soliciting co-operation of aviators in preventing dangerous flying.
2. Arranging for systematic reports by experts on all accidents.[1]

The Committee was even far-sighted enough to have allowed for a

fully confidential reporting system, a practice that would prove to be of great value to the RAF over half a century later.

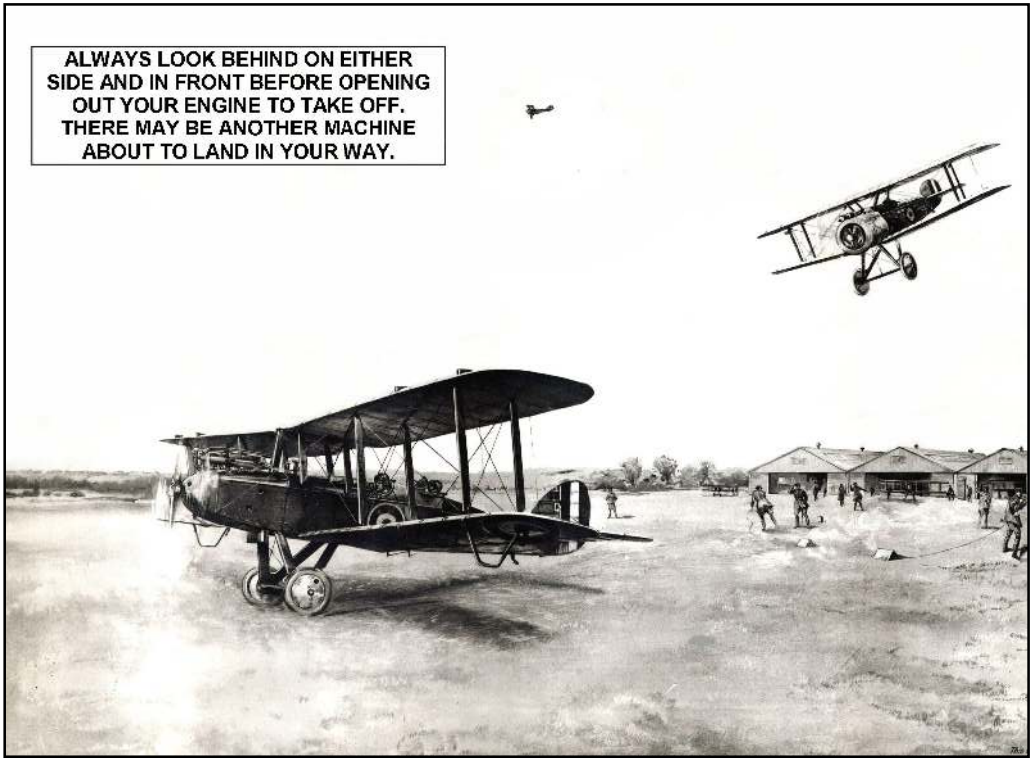
Reports were produced by the Committee on most accidents in Britain from May 1912. Using local panels of experienced aviators, the Committee would examine wreckage, interview survivors and eyewitnesses, and then draw up a detailed sequence of the events leading to each incident with a list of probable causes. Each report was rounded off with recommendations to manufacturers and aviators on structural or procedural issues.[2] These reports were widely publicised, being reproduced in both *Flight* and *The Aeroplane*. This practice lasted until it was brought to an abrupt halt by the outbreak of the First World War, although the RAeC PSAIC continued in existence until 1918. Presumably their importance decreased with the restrictions imposed on civilian flying and the possibility of reports passing useful information to the enemy.[3]

Throughout the war little attention was paid to flight safety as we would recognise it. Aeroplanes were still an emerging technology and accidents were to be expected with such rudimentary machines. While aeroplanes may have been easy to break, they were also relatively easy to mend; a pilot landing a BE2 too heavily and damaging its undercarriage would cause far less, and far more easily repaired, damage than would a Lancaster pilot doing the same thing a generation later. What little thought was paid to flight safety by the RFC tended to come through unit or station Standing Orders, which sometimes carried general and local advice on accident avoidance and standard procedures for emergencies.[4] There was little central direction for these, and the RFC's Standing Orders in the Field offered no advice at all.[5]

From 1918 the Air Ministry took over responsibility for Britain's military and civil aviation. In 1920 this led to the establishment of the Inspectorate of Accidents within the Directorate of Civil Aviation, although it was in fact responsible for the investigation of RAF accidents as well. However, there was very little public output from them on safety issues. One reason that has been given for this is that the Air Ministry's fear that blaming accidents on technical faults or weaknesses could lead to litigation from manufacturers, although there is no firm evidence to prove this theory.[6] On the RAF side there were regular Air Ministry Weekly Orders (AMWO) which covered all

aspects of Service procedure and organisation under various headed sections. Flight safety certainly figured in these, the first mention being in the fourth issue when the dangers of flying aeroplanes near airships were highlighted.[7] However, the issue was not approached in any systematic way. Three consecutive Orders published in October/November 1918 addressed flight safety issues under four separate sections: the dangers associated with carrying matches in the air under 'Discipline';[8] the use of ballast during solo flights in two-seater aircraft under 'Armament and Equipment';[9] the need for regular practices of forced landing procedures under 'Operational and Flying Orders';[10] and the proper channels and procedure for handling Courts of Enquiry into flying accidents under 'Books, Forms, Returns, Correspondence, &c'.[11]

Flight safety was also instilled within the RAF through other means. A similar source to AMWOs (later AMOs) was The King's Regulations and Orders for the Royal Air Force.[12] By 1939 Chapter XII ('Regulations Relating To Flying') ran to over 50 pages with 125 paragraphs of rules. A more visual and accessible source was Air Diagrams. This idea, essentially using large posters in prominent places to transmit simple messages, had already briefly existed in 1918. A series of posters produced by the Air Technical Services[13] staff had offered advice on numerous flying scenarios, mainly based around combat situations and tactics. Several had also focused on safety, primarily landing and take off procedures, such as how to cope with engine failure on take off,[14] make emergency landings[15] or land in difficult wind conditions.[16] After 1918 Air Diagrams moved on to more technical subjects, such as rigging and armaments, but in 1932 the RAF returned to the idea of using them for aircrew safety related matters. At least one new Air Diagram was issued on the subject, illustrating the correct way to exit a generic Hawker biplane by parachute.[17] In January 1936 a further set of three was issued, their stated purpose being 'to draw particular attention to those customs or regulations which affect the safety of aircraft crews generally and to avoid minor accidents.'[18] These were to be displayed in hangers and rotated regularly to keep the messages fresh. Meanwhile, a constant stream of large schematics and diagrams continued to be produced for use by ground crews. Laying out hydraulic and electrical systems, or showing cutaway views of weapons and ordnance, they tackled flight



Although it has been slightly doctored (to clarify the image for small-scale reproduction) the message conveyed by the caption to Air Diagram OT5 1584 of 6 July 1918 remains as valid today as it was when it first appeared.

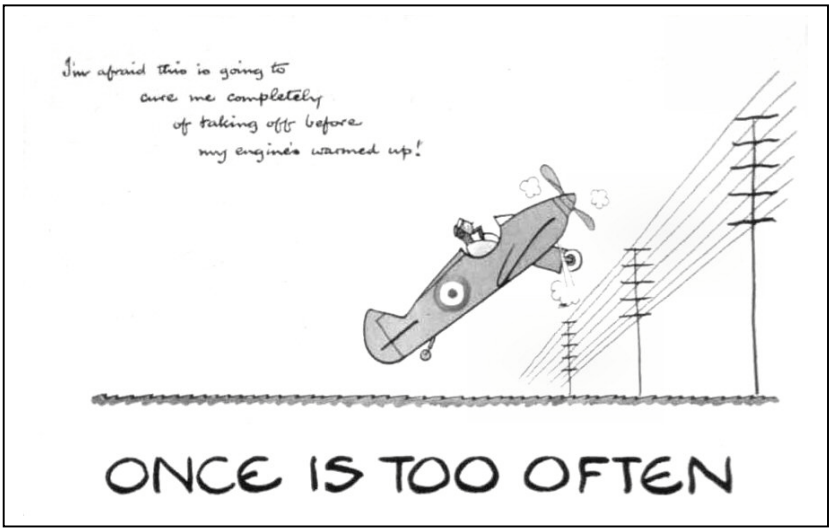
safety from the ground up, striving to keep aircraft and equipment maintenance standards at the highest possible level.

From 1936, and even more so 1939, the RAF expanded, leading to a correspondingly higher accident rate. The existing methods for promoting flight safety awareness proved to be inadequate and when, in the autumn of 1940, an Air Member for Training was appointed a range of options was considered.

One of these was the issuing of regular 'Training Memoranda' to all units to maintain awareness outside the controlled environment of training establishments. The main question was how to make these publications accessible, appealing to read and memorable. The answers to this question were already to some extent in place. Before the war some of the most successful civilian flying manuals had been those written in America by Assen Jordanoff. Jordanoff was a journalist with wide experience in aviation, beginning with service in the Bulgarian Air Force during the First World War. His books[19] proved popular, mainly due to his style and presentation. Written in layman's terms and well illustrated, they also made frequent use of a cartoon character to emphasise essential points. Know as 'Cloudy Joe',[20] he was slap-dash and accident prone and frequently seemed lost in the world of aviation. Since 1939 hundreds of thousands of Jordanoff's books had been bought by the RAF and RCAF for use in their training programmes.

Closer to home was the well-known artwork of Cyril Kenneth Bird, known as 'Fougasse'. In the summer of 1940 new ranges of Air Diagrams had been launched. In May a series of posters very much in the tradition and style of the 1918 Diagrams was issued.[21]. Printed in monochrome, they were pieces of fine art in themselves and depicted various scenarios. Like the 1918 set, the majority were concerned with aerial combat, but others broached other common dangers. The importance of oxygen flow,[22] of remembering to lower the undercarriage,[23] and of checking the hydraulic systems[24] all provided advice aimed at countering some of the more prevalent causes of aircraft and aircrew wastage.

However, while helpful, these were not particularly eye catching and they tended to include large amounts of text. In July 1940 a further set was published. All using the punch-line 'Once is too often', and illustrated by Fougasse, these took the form of colourful and



A typical example of the cheery little (coloured) cartoons drawn by 'Fougasse' (Cyril Kenneth Bird) in the interests of promoting flight safety during WW II.

exaggerated cartoons with an instant visual impact to get a simple message across. This style could be readily transferred to a magazine or booklet, as they had been in No 13 Gp. AOC 13 Gp, AVM R E Saul, and OC 54 Sqn, Sqn Ldr R F Boyd, had had the idea of a booklet full of simple hints and tips on aerial combat which also touched on some salient flight safety issues. The messages were emphasised by the use of cartoons drawn by AC William Hooper, RAFVR ('Raff'), who used a very basic but exaggerated and humorous technique, and the booklet was published as *Forget-Me-Nots For Fighters*.

It was against this backdrop that the format of the new Training Memoranda was agreed. It would be a monthly magazine, mildly humorous and illustrated to encourage readership and hopefully improve the retention of the information provided.[25] An experienced editor was needed and so Maj Anthony Armstrong Willis MC, RE (Retd), a well known humorist and author, was recruited. Commissioned into the RAFVR as a pilot officer on 16 December 1940, Willis was to produce a draft for approval within a month.

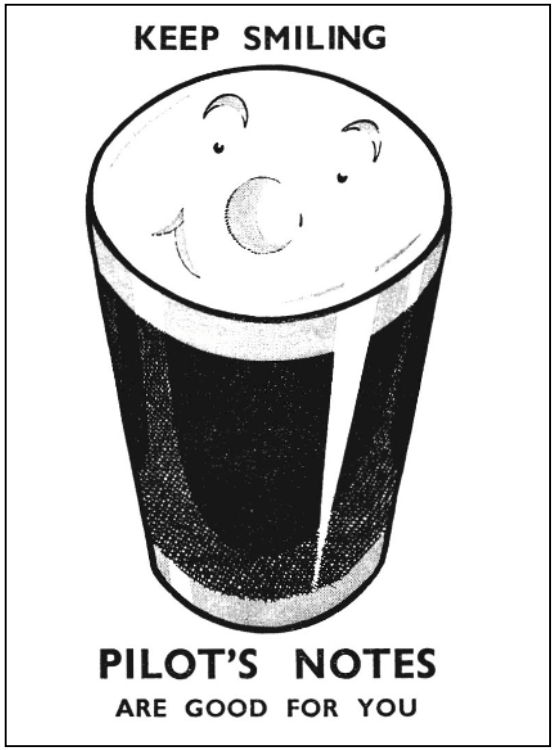
Plt Off Prune swinging a compass.

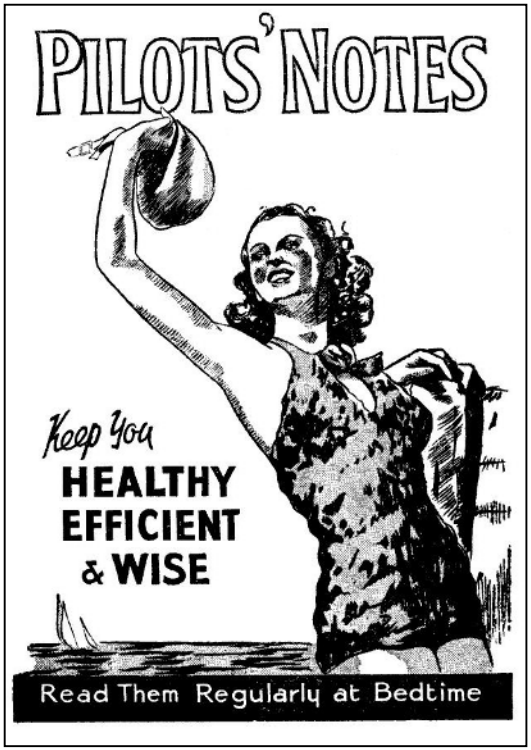
Willis in turn recruited Hooper to provide some of the illustrations, and put a personal slant on the issues. The result would be Pilot Officer Prune.

This ambitious target was met, and on 1 April 1941 perhaps the best known of all flight safety publications, and the best known of all flight safety instructors, was launched.[26] Their approach was to take what the Air Ministry called a 'popular style',[27] and their purpose, as Willis saw it, was to: 'put the stuff across in a light-hearted manner without too much 'Whitehallese'. The general idea being to make it readable and get it read.'[28] This he accomplished, and *Tee Emm* and Pilot Officer Prune were an instant success. Over the next five years their circulation and reputation became global. The style was indeed popular, in both senses of the word, breaking down complicated issues into simple concepts and using personal examples to emphasise points.

Prune became more and more the human face of flight safety, and appealing on this personal level had a dramatic effect. As time passed other ways to exploit this first-person approach were found. The 'Learn From The Other Fellow's Mistakes' column started in October 1941 to be followed by the, near-legendary, 'Most Highly Derogatory Order of the Irremovable Finger' (MHDOIF) from March 1942, participation being encouraged by the anonymity afforded to contributors.

Not that *Tee Emm* was the only approach the RAF took. AMOs continued to contain safety warnings and directives; Air Ministry Pamphlets[29] were issued, and Air Diagrams on maintenance, emergency procedures and the use of emergency equipment multiplied exponentially. Training films also gathered pace and were widely used, often using the first-person approach pioneered by *Tee Emm* in





Selling the message by appealing to the more basic appetites of the average youthful aviator – adaptations of the contemporary 'GIGFY' advertising campaign and a reference to what passed for a 'top shelf' magazine in days of yore.

what we would now call 'docudrama' formats.

By mid-1945 the volume of flight safety literature available was staggering, although, like the rest of the RAF, peace brought a sharp decline in numbers. With contraction of the RAF it was felt that flight safety could be improved by returning to the pre-war principle of a small, highly trained service. In March 1946 *Tee Emm* was discontinued.

This proved to have been too hasty a move, however, as accident rates increased again. *Happy Landings* was established in January 1946, and then, almost on the heels of *Tee Emm's* demise, came the publication of *Air Clues* in May of that year. From then on the production of magazines, films and posters was prolific. Most UK-based Commands[30] and RAF Germany[31] had their own flight safety organisation and specialised publications dealing with the specific equipment and conditions of those units. The practice has even crossed over from the RAF into the Royal Navy[32] and, more recently, to the combined Defence Aviation Safety Centre.[33] Many of the more successful characteristics of *Tee Emm* and, of the old RAeC PSAIC, have lived on: anonymity for those willing to come forward and tell of their mistakes; in-depth analysis of accidents, tempered with humour and accessibility; use of cartoons to reinforce points; and first-person accounts.

In other areas the general style has been developed. *Tee Emm* briefly used the idea of holding up examples of how it should be done, either in its 'Learn From The Other Fellow's Successes' columns[34] or, later, in the regular antidote to the MHDOIF, the 'Most Highly Desirable Order of the Vacated Orifice' (MHDOVO). This proved to be fairly short lived[35] and not as popular as the MHDOIF, going as it did against the self-deprecating tone of *Tee Emm*. However, subsequent publications have tended to highlight good examples, and competitions for the collection of 'FOD' (waste likely to cause Foreign Object Damage), certificates for exceptional performances and other forms of recognition have all become the norm.

Notes:

1 RAeC PSAIC Report No 1, 1912. RAeC Archives Box 479, held at RAF Museum.
2 RAFM AC75/21/479.
3 *The Aeroplane*, Vol. VII, No 6, 5 August 1914, p132.

[4] For example: 'Standing Orders for RFC Norwich: Flying Orders and Aerodrome Rules', February 1917; RAFM R024738.
[5] 'Standing Orders of the Royal Flying Corps in the Field', 1915; RAFM 000601.
[6] Grey, C G: *A History of the Air Ministry*, pp 127-128 (London, 1940).
[7] AMWO 35, 10 April 1918.
[8] AMWO 1384, 7 November 1918.
[9] AMWO 1316, 24 October 1918.
[10] AMWO 1288, 24 October 1918.
[11] AMWO 1428, 7 November 1918.
[12] Later The King's Regulations and Air Council Instructions for the Royal Air Force.
[13] Later RAF Technical Services.
[14] OT5 1671, 20 June 1918.
[15] OT5 1580, 9 April 1918.
[16] OT5 1581, 21 April 1918, and OT5 1582, 11 June 1918.
[17] AD 1093 'Method of leaving aeroplane for emergency descent by parachute', RAFM X001-4108.
[18] AMO A.20/36, 30 January 1936.
[19] *Your Wings*, *Through the Overcast*, and *Safety in Flight*.
[20] Drawn by Fred L Meager.
[21] AMO N.327/40.
[22] AD 1299, 'Sheer carelessness', RAFM X001-4253.
[23] AD 1300, 'Remember your undercarriage', RAFM X001-4254.
[24] AD 1298, 'Hydraulics safety first', RAFM X001-4252.
[25] AC 4(41), 18 January 1941. NA AIR6/61.
[26] AMO N.288/41.
[27] *Ibid*.
[28] *Tee Emm* Vol 2, No 1, April 1942, p2.
[29] For example: AMP 104 'Prevention of aircraft accidents', July 1940.
[30] For example: Bomber Command, Training Command and Support Command all had *Flight Safety Reviews*.
[31] *Flight Comment*.
[32] *Cockpit*.
[33] *Aviate*.
[34] For example: Vol 5, No 3, June 1945.
[35] July 1945-February 1946, and changed to the 'Good Show Medal' in August 1945.

MORNING DISCUSSION PERIOD

Mike Meech. The point was made that flight safety deteriorated prior to WW II due to problems associated with pilot training as a consequence of the expansion schemes. The expansion involved groundcrew as well. Did that not also produce problems? And how were they solved?

Wg Cdr Jeff Jefford. Good point. The problems were very similar. To cope with the expansion, the air force obviously needed to recruit large numbers of tradesmen. (*The Air Estimates for 1935 authorised a strength of 19,096 airmen; for 1938 it was 51,696 – a 270% increase in just four years.* ***Ed***) As with pilots, there was an imbalance between this influx of 'green' aircraftmen and the relatively small numbers of seasoned SNCOs who had to supervise their activities. At the same time the Service was having to cope with the technical revolution, which involved switching from patching fabric on biplanes to tin-bashing on stressed-skin monoplanes, not to mention the introduction of far more demanding hydraulic, pneumatic and electrical systems and devices. Thus, as I said, aeroplanes were more difficult, and took longer, to maintain which lead to scarcity on the flight line and reduced flying hours. The ultimate solution, as always, lay in training and, in the case of groundcrew, this was accompanied, certainly during the war years, by increased specialisation. The pre-war aim had been to produce Fitter Is, multi-skilled tradesmen who could, single-handedly, do just about everything necessary to keep a Hind and its Kestrel airborne. This level of expertise would take far too long to achieve in wartime so, to cut down on training time, we introduced more sharply focused trades, so that a recruit could be quickly taught to become productive in a relatively narrow specialisation to which those who were so inclined could add further qualifications in service. That is something of an oversimplification but it is a fact that the RAF went to war with about fifty trades; by VJ-Day it had 235 and that was, at least in part, a response to the problems that had originated with the expansion.

Air Cdre Richie Profit. When I was in Singapore in the 1960s, fast jet pilots were encouraged to do a parachute jump into the sea at

Changi. Was that an *ad hoc* arrangement or was it a common practice elsewhere?

AVM Alan Johnson. It was 'an optional extra' that was on offer in England, by the Parachute School, as well as in Singapore. It was a nice easy way to experience a parachute descent because the hard part is the landing, which is obviously a lot softer in water than it is on the ground. Quite a lot of people did take the opportunity, including some very senior officers. I had the pleasure of instructing Sir Andrew Humphrey, although I thought my promising early career might be about to come to a premature end because, during a practice session, I said, 'Do not jump off the platform,' because the harness initially will go very slack and when it then takes the strain it can cause problems with the family jewels. Unfortunately, Sir Andrew did jump off, into the air, but, even though his face turned a shade of green after landing, fine officer that he was, he gritted his teeth and carried on, eventually to make a very good water descent!

Sir Freddie Sowrey. When I did it my instructor confided, 'We won't tell anybody that we pushed you, Sir!'

My question is for Stuart. Is there any evidence to show that Plt Off Prune and Anthony Armstrong actually had any identifiable impact on the accident rate? *Tee Emm* was certainly great fun to read, but do we know whether it actually had any effect?

Stuart Hadaway. I am afraid that that would be very hard to quantify. Apart from anything else, there were always other initiatives being implemented, lectures, films, posters and so on, so it would be difficult to isolate the impact of any particular initiative. All that we can say is that *Tee Emm,* and Prune, were very popular. Since tens of thousands of copies were being distributed all around the world, it would be reasonable to assume that lots of people were reading it and that some of the messages will have sunk in. There is certainly some evidence to support a wide readership base in the large numbers of 'citations' that were submitted in pursuit of the award of one of the spurious medals.

Jefford. While not disputing that applications for the MHDOIF provide evidence of an enthusiastic readership, it has been argued that the mock medals eventually tended to become counter-productive.

One of the factors that tends to undermine flight safety is that any form of flying entails a degree of risk and the excitement that this engenders can be heightened by pushing the boundaries. Breaking the rules is fun, until it all ends in tears. The classic examples are usually associated with unauthorised low flying but the exercise illustrated in this picture was not actually in the syllabus either – Avro 504K of No 4 FTS at Abu Sueir in the mid-1920s. (MAP)

The Order was associated with a black ribbon and towards the end of the war there are said to have been instances of pilots having to be told to desist from wearing a black medal ribbon. The MHDOIF had become a badge of infamy so desirable that there was a risk of people actually competing to be awarded one! Since that encouraged people to do stupid things, it could hardly have been good for flight safety.

In the general context of people doing stupid things, in the first Journal that I handled as editor, I reproduced a short article from the June 1941 edition of *Tee Emm*, a piece that CAS had personally directed should be published. It provided an account of two incidents in which a Hampden and a Havoc had been lost, with only one survivor from the two crews. Both accidents had been caused by pilots 'beating up' their girl friend's homes. The sting in the tail was that these were merely examples; in the first six months of 1941 no fewer than eighty-one men had died in incidents of this kind. What a waste! Eighty-one men dead through pilots showing off.

Capt Jock Heron. Most of this audience will have been familiar with *Air Clues*, with its content nicely balanced between flight safety and other aspects of airmanship in the round. *Air Clues* has disappeared to be replaced, in part, by *Air Power*, but this does not address flight safety so how is the word being spread today?

Hadaway. The current flight safety publication is the tri-Service *Aviate* magazine.

Desmond Goch. I can add a small footnote to AVM Johnson's history of the parachute. I was with the Irving Parachute Company in the 1950s when we were developing, for the Ministry of Supply, a barometrically operated parachute release mechanism to cater for the increasing heights at which aircraft were operating. It allowed crews to free fall until they reached a denser atmosphere. The device worked very successfully and was produced in some numbers. I recall a special version for back-type parachutes that were supplied for use by RAE personnel who were investigating the causes of the Comet disasters. It was a fully developed device but I don't doubt that it has been superseded by further advances in technology.

Johnson. I am familiar with the Irving release mechanism; we used it for early Special Forces high altitude drops. As you say, technology has moved on; what used to be about the size of a cigar box is now smaller than a match box but it is still very reliable – and it has saved lives.

Anon. Stuart Hadaway discussed the way that graphics were used to get the flight safety message across. It may be of interest to consider the way in which similar techniques could have been used in other circumstances, basic handling manuals, for instance. The RAF's Lancaster manual consists of fairly tedious lists and diagrams whereas the equivalent American version for the B-17 contains more 'cartoony' graphics which may have helped the reader to get a feel for operating a B-17 more quickly. Did we put much effort into making training manuals more accessible, in the way that we did in promoting the safety message?

Hadaway. I don't think so. I referred to the Bulgarian-American Assen Jordanoff and the 'Cloudy Joe' character that he used to brighten up his series of pre-war civilian flying manuals, substantial

numbers of which found their way onto wartime training stations, particularly in Canada. Generally speaking, however, the RAF preferred formality in its technical publications, including Pilot's Notes, and I think that they were probably right.

Profit. I think that the old-style Pilot's Notes, with which many of you will be familiar, were absolutely excellent and that they achieved exactly what they were supposed to do. They told you how to fly a particular aircraft type. They didn't tell you what it would 'feel' like, of course, but they did tell you how to get it going, how to fly it, how to land it and provided warnings of handling idiosyncrasies and spelled out any critical limitations. That changed around about the late 1960s when we introduced specific-to-type Aircrew Manuals which were almost Release To Service documents, as well as handling manuals. Personally, I was never convinced that that had been a move in the right direction.

During WW II, incidentally, the Air Transport Auxiliary produced a combined set of abbreviated pilot's notes that covered something like sixty types of aircraft, everything from a Spitfire to a Lancaster via the Typhoon and Mosquito. They didn't tell you how to 'operate' the aircraft, of course, but they did provide the basic information needed to start it up and fly it safely from A to B. A remarkable achievement, I think.

Jefford. To amplify that a little, something that I didn't mention in my presentation was the introduction of mnemonics, which was yet another pre-war innovation that the CFS can take credit for. For instance, there was BUMPF – Brakes, Undercarriage, Mixture, Pitch, Flaps – which would take care of most of the things that had the potential to cause expensive noises if they were overlooked prior to landing. There were variations on this theme, of course, as it was often necessary to adapt the mantra to deal with a specific foible associated with a particular aircraft type – which is where Pilot's Notes came in, because it spelled out the various checks required at each stage of a flight.

Nigel Baldwin. I don't have a question, but would like to offer an observation. Listening to Alan Johnson talking about official attitudes towards the provision of parachutes during WW I, I was reminded of

Freeman Dyson's autobiography, *Disturbing the Universe*, in which he recalls that, while working at Bomber Command as a young scientist in WW II, a colleague investigating the survival rates of aircrew, had noted that, because its escape hatch was a couple of inches narrower than the others, the chances of escaping from a Lancaster were significantly less than from a Halifax or Stirling. His figures indicated that only 15% of Lancaster men survived, compared to 25% from Halifaxes and as many as 50% from American B-17 crews, although the fact that they were doing it in daylight, rather than in the dark, probably accounted for some of the difference. My point is that, if the losses per crew are multiplied by the number of Lancasters lost, it amounts to several hundreds, perhaps even thousands, of men who might have survived if the hatches had been made just that little bit wider. But they never were. Which leads me on to a related topic, one that will no doubt be addressed by Brian Miller this afternoon – the failure to provide ejection seats for the rear crew members of the V-bombers. Both are examples of official reluctance to provide appropriate facilities.

Air Cdre David Strong. A personal comment on the situation in Bomber Command at the beginning of the war. In 1939 I was a flying officer on a Whitley squadron in Yorkshire. We were notionally intended for operations, of course, but we were almost immediately moved down to Abingdon where we became the conversion unit for Whitleys. Reflecting what was said earlier about training in those days – as a still very junior officer I suddenly found myself cast in the role of instructor. I knew little of instructional techniques; I was certainly not a QFI. We just got on with it and did the best we could, trying to teach people how to fly the aeroplane. We were simply unaware of 'flight safety', as such. Things did improve later with the introduction of more formal training programmes, which recognised that it was also necessary to address the needs of other crew members, and in the spring of 1940 these early training squadrons were eventually redesignated as OTUs.

Wg Cdr Clive Rustin. A comment on Richie's observations on Pilot's Notes v Aircrew Manuals, when I was OC Handling Squadron at Boscombe a senior wheel came to visit me one day and I asked him whether he thought we were doing it right. On the left hand side of my

desk was the slim volume that constituted Pilot's Notes for the Mosquito. On the right I had a two-foot high pile of Tornado documents. I don't know whether we were, or still are, doing it right – but perhaps it's just not possible to go back to the good old days.

A question. A crude calculation, based on the 1941 figures that were presented, suggests that we might have lost as many as 10,000 aircraft through our own efforts during WW II. I seem to remember reading in an RAF diary many years ago that we actually lost over 20,000 aircraft without the assistance of the enemy. Is that a reasonable figure?

Jefford. Using Garrod's 170 per month for home-based aircraft, 10,000 would appear to be about right, possibly even on the low side because the air force was still expanding in 1941 and Garrod's figures had excluded trainers. So, apart from allowing for a bigger air force, and including lots of Tiger Moths, Harvards and Oxfords, one would also have to allow for the fact that a substantial proportion of the RAF was stationed overseas. Since it was crashing aeroplanes with gay abandon in the Middle East, Italy, India, sub-Saharan Africa and sundry other places, I could certainly go along with 20,000 as an informed guess.

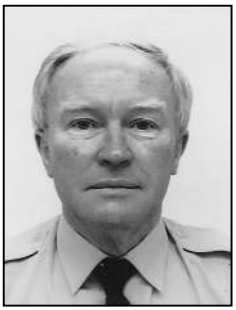
Picking up on what you said about the size of the pile of Tornado documents, my own observation, based on drifting in and out of crew rooms over the years, is that when the RAF introduces a new aeroplane into squadron service it is accompanied by a document called, depending upon the operating authority, something like Group Air Staff Orders (GASO) which all aircrew are required to read periodically and sign as having read. On Day One, this document contains one page which says, more or less, 'Do not break this aeroplane.' A week later someone lands with his brakes on, bursts a tyre or two and takes to the grass. There is an inquiry which, among other things, recommends publication of GASO No 2 that says, 'Do not land this aeroplane with the brakes on.' By the time that the aeroplane is withdrawn from service thirty years later, GASOs are three inches thick with each page saying, in effect, 'Don't do what the last chap did!' It's just the way we do things. Ostensibly, the aim is to improve flight safety by preventing repetition of accidents – although a cynic might see it as the umbrella syndrome.

Footnote: Subsequent to the meeting, **Air Cdre Henry Probert** offered the following**:**

During the discussion about *Tee Emm* I was reminded of the occasion in 1943 when Donald Bennett drew Harris's attention to an anonymous item stating that the bomber pilot's answer to predicted *Flak* was to make a 90 degree turn every 30 seconds or so. Harris promptly told Garrod, Air Member for Training, that he could think of no better way of ensuring that no bomb ever hit its objective; Garrod thereupon rose to the defence of *Tee Emm*'s staff and offered to print an article from Bennett with a view to opening up what might prove to be a valuable discussion. There followed further discussion in *Tee Emm* and an increasingly acid dialogue which culminated in Harris ordering a ban on *Tee Emm* on every Bomber Command station. It took Garrod's successor, Peter Drummond, to calm the situation. The full story is on page 235 of my book on Harris.

POST-WAR FLIGHT SAFETY

Wg Cdr Colin Cummings



Colin Cummings served in the Supply Branch for 31 years. After a series of station tours, mostly in the Far East, he spent a significant element of his service involved with IT systems both within the Supply Branch and in other areas, such as the Directorate of Flight Safety. He was the first Supply officer to manage an aircraft Support Authority (the Jaguar). He is a member of the RAFHS committee and, not satisfied with one Queen's Commission, he currently he holds two; one in the RAFVR(T) and the other in the RAFR.

If the Royal Air Force believed that the advent of peace in Europe would bring with it an immediate and dramatic reduction in the aircraft accident rate, it was to be sadly disappointed. With aircraft being written off in accidents at the rate of a dozen per day, within 48 hours of VE-Day there were four major losses to aircraft engaged on transport duties, claiming eighty lives. One of these involved a Stirling of No 190 Sqn which disappeared while carrying airborne troops to garrison Norway. The circumstances of its loss mirror those surrounding an accident in the previous November which had resulted in the death of Air Chf Mshl Sir Trafford Leigh-Mallory and nine others, including Lady Dorothy Leigh-Mallory. The Stirling had been operating in appalling weather; it was off course, below safety height and out of radio contact. Furthermore, it too was carrying a very senior officer, in this case AVM James Scarlett-Streatfield, AOC 38 Group, which inevitably raised questions as to whether his presence on board had had any influence on the captain's decision-making process. By a rather eerie coincidence, Scarlett-Streatfield had presided over the Board of Inquiry that had investigated Leigh-Mallory's loss.

This presentation will explore the post-war accident scene by: considering the size and shape of the air force in the immediate aftermath of WW II and the statistical pattern of subsequent losses; reviewing some of the main causes of accidents; outlining the

Commands	Groups/ AHQs	Main Units	Sqns	Flying Units
Bomber	10	85	85	40
2nd TAF	5	37	81	4
Fighter	7	49	59	15
Coastal	8	33	41	21
Flying Training	8	57	-	65
Tech Training	4	?	-	-
Maintenance	4	59	-	9
Transport	7	69	46	35
Mediterranean AAF	8	46	59	12
Middle East Command	10	68	30	42
ACSEA	16	89	75	52
Total	**87**	**592**	**476**	**295**

Fig 1. RAF Organisational Structure in mid-1945.

evolution of the flight safety organisation; and conclude with a brief examination of the RAF's engineering organisation and its contribution to reducing the accident rate.

THE SIZE AND SHAPE OF THE POST-WAR RAF

When the European war ended, the Service had a total strength of a little over one million men and there were, in addition, substantial numbers of Commonwealth personnel still available along with significant Polish and Czech contingents.

Surprisingly, we do not really know how many aircraft the RAF had to the degree of accuracy that one might have expected and the generally accepted figures of 8,800 operational and 18,000 training and second level aircraft should be regarded as an informed estimate rather than a precise ORBAT. In fact, such was the chaotic state of affairs after six years of war, that the RAF was eventually obliged to carry out a census of its aircraft holdings, which revealed that, apart from the informal use that was being made of captured enemy aircraft, there were other instances of 'private enterprise' with aircraft being unofficially retained after they had supposedly been struck off charge.

Figure 1 illustrates the basic organisation and distribution of the RAF and its assets in mid-1945. Compared to today's air force, the

RAF of sixty years ago was a massive operation – eighty-seven organisations of group status and almost 600 other units of consequence. In terms of flying units there were some 750 squadrons, schools and training units of various kinds plus communications flights and a variety of specialist flying units. To this total one could also add the ubiquitous station flights.

At four years or less, the average age of the aircraft in the fleet was very young by today's standards. This was due to a combination of attrition and the rapid onset of obsolescence, the latter arising from the rate at which technology had developed under the impetus of war. In later years, of course, aeroplanes tended increasingly to be repeatedly refurbished and refitted, rather than simply being replaced as had been the practice in the past.

From its peak in 1945, the RAF's strength, in both manpower and numbers of squadrons, has been in almost constant decline, the only significant deviations from this pattern being the Korean War period and (in terms of numberplates only) the era of Thor and Bloodhound.

STATISTICS RELATING TO AIRCRAFT LOST THROUGH ACCIDENTS

Before considering post-war accident rates, it would be as well to clarify some of the terms used. First, the RAF has always used a, basically, five-element system to categorise the damage sustained by its aeroplanes, although the symbols allocated to each element have changed from time to time. At present the categories are numbered from 1 to 5 – with 'Cat 1' being something which can be dealt with at unit level while a 'Cat 5' amounts to a total loss.

Secondly, the definitions of what constitutes an 'accident' and, the less serious, 'incident', have been changed several times.

Finally, the categorisation of an aircraft in the immediate aftermath of an accident might not reflect the eventual outcome. If there were significant holdings of the type in question, a damaged aircraft might well be scrapped, even after a relatively superficial, and certainly repairable, occurrence. This frequently occurred in the early post-war years, particularly with smaller aircraft or with those approaching the end of their fleet lives. Furthermore, a post-dated decision to dispose of a lightly damaged, but obsolescent, aircraft, was not always linked back to the original accident. It thus becomes debatable, whether the

The rather inadequate details recorded in connection with the demise of this Wellington, LP914, indicate that it was damaged in an unspecified incident at Swinderby on 12 June 1948. In fact it was being flown by (Society member) Gp Capt Hans Neubroch, then a youthful flight lieutenant, on his first night cross-country with No 201 AFS. Having taken off from Swinderby, the aircraft was diverted to Shawbury where, in poor visibility, it landed fast, overran the runway and tipped up on its nose (hence the visible buckling) before slamming back down onto its tailwheel.. Reflecting the relatively relaxed attitude prevailing at the time, Hans notes: 'Having heard nothing for two days, I thought it only polite to go and see my Flight Commander and explain myself. He listened and then commented, "Don't worry, old boy - could have happened to anyone!" I heard no more.' The aeroplane was eventually struck off charge, presumably still unrepaired and still at Shawbury, on 1 November 1948, illustrating the way in which an airframe may be written off by delayed administrative action, rather than as the immediate result of an engineering decision, thus distorting the 'accident' statistics.

aircraft should actually be recorded as having been written off as a consequence of the accident, or whether it should be more appropriately reflected as a mere 'stock-management' decision. Inconsistencies such as these tend to distort the overall accident statistics and go some way towards explaining the numerical discrepancies

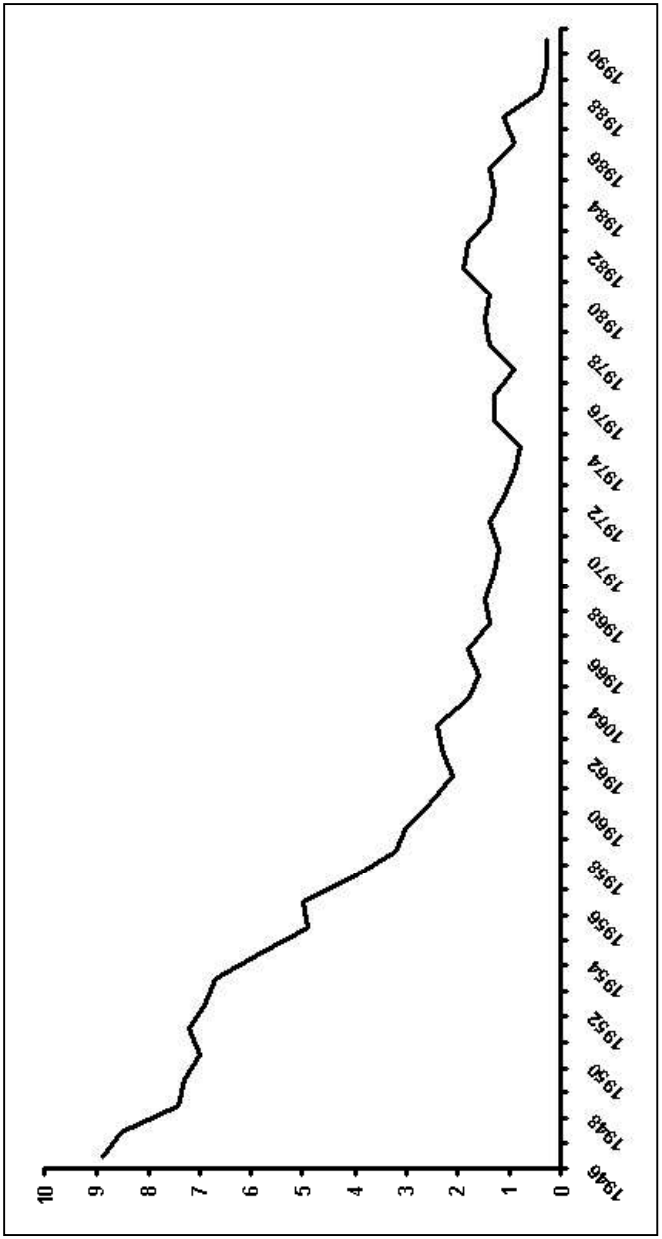


Fig 2. Loss rate (Cat 5) per 10,000 flying hours, 1946-1990.

evident in figures relating to aircraft losses compiled by different authorities and/or researchers.

This paper will consider only Category 5 accidents – those in which the aircraft was destroyed in, or subsequently disposed of following, an accident. The basic measure of accidents is the loss rate per 10,000 flying hours and Figure 2 illustrates the rates for Cat 5 losses (or earlier equivalents) between 1946 and 1990. The rate for the last eight months of 1945 was significantly higher.

It is apparent that the overall loss rate has fallen steadily with the passage of time, but the relationships between the dominant causes of accidents have also changed. It is important to understand, however, that because they tend to be related to each other, rather than to a common baseline, comparative statistics can be misleading. That is to say that, if there is a decrease in accidents due to cause 'A', then, while there may not have been any change in the number of occurrences actually arising from cause 'B', the *proportion* of the total attributable to the latter will inevitably have increased, thus creating a superficial impression of a worsening cause 'B' situation.

There have been occasional fluctuations in the downward gradient, some of which could be characterised as 'rogue' years. Those who. remember such events, may recall that the top brass could sometimes be pretty unforgiving with more than one Squadron Commander, and even the occasional Station Commander, being relieved of their posts and moved sideways into relative obscurity.

Translating the accident rates at Figure 2 into numbers of aircraft actually lost and, more importantly into the numbers of casualties sustained, presents a sobering picture.

In the eight months between VE-Day and the end of 1945, there were some 2,500 aircraft accidents resulting in the deaths of about 2,000 crew, passengers and persons outside the aircraft. Although these figures include the odd anomaly (such as twenty-three people being murdered by Indonesian nationalists after they had safely evacuated a Dakota which had been forced to land on a beach) a routine loss rate of a dozen aircraft *per day* does seem to be a remarkable state of affairs when viewed from today's vantage point.

Figure 3 tabulates those aircraft written-off, ie 'Cat 5s', and the associated numbers of annual fatalities between 1946 and 1998. If the VE-Day-to-end-of-1945 figures noted above are included, the post-

Year	Cat 5s	Deaths
1946	1014	677
1947	420	176
1948	424	205
1949	438	224
1950	380	238
1951	490	280
1952	507	318
1953	483	333
1954	452	283
1955	305	182
1956	270	150
1957	233	139
1958	128	87
1959	102	59
1960	80	46
1961	74	55
1962	68	50
1963	60	41
1964	62	33
1965	46	71
1966	62	33
1967	60	60
1968	51	43
1969	31	22
1970	36	25
1971	40	72
1972	28	22
1973	30	21
1974	16	5
1975	21	17
1976	33	20
1977	14	7
1978	25	27
1979	27	13
1980	24	13
1981	26	7
1982	35	10
1983	26	19
1984	23	4
1985	19	9
1986	19	10
1987	20	17
1988	19	18
1989	17	9
1990	18	19
1991	22	15
1992	10	8
1993	11	13
1994	9	34
1995	10	9
1996	14	2
1997	11	3
1998	7	3

Fig 3. Accident Statistics 1946-98 – source Air Britain (Historians).

war total amounts to some 9,330 RAF aircraft accidentally destroyed or damaged beyond repair, resulting in the loss of more than 6,200 lives.

The numbers of lives lost would have been significantly higher had it not been for the introduction of ejection seats, principally, although not exclusively, those built by Martin-Baker, along with a modest, and steadily reducing number of aircrew who survived by taking to their parachutes in a less dramatic fashion. In the period from July 1951 –

when Sgt Bill Tollit abandoned a Meteor of No 65 Sqn to become the first RAF pilot to escape using an ejection seat – to the end of 1996, there have been more than 700 successful abandonments, including several made outside the design parameters of the seat.

In the context of ejection seats one cannot avoid registering one of the more emotive flight safety debates of the 1950s and '60s – whether or not to provide such a means of escape for all members of a V-bomber crew, not just the pilots. Despite the development of a potentially suitable system and successful trial firings, including a live ejection in 1960, such seats were never provided. The story of why that was never accomplished is told in Chapter 12 of Sarah Sharman's *Sir James Martin: The Authorised Biography of the Martin-Baker Ejection Seat Pioneer* (Patrick Stephens Ltd; 1996)

It will be apparent from the table at Figure 3 that there is no direct correlation between numbers of accidents and the numbers of casualties incurred. This arises from the types of aircraft involved and the roles in which they were being employed. For example, in 1946 the RAF lost fifty-nine Dakotas, nine Liberators and twelve Yorks engaged in a variety of transport tasks, resulting in the loss of no fewer than 266 lives. By comparison, the 157 Mosquitos that were written off that year involved 'only' seventy-two fatalities. While losses of relatively large aircraft have declined steadily over the years, they still represented a significant factor in the accident statistics until well into the 1950s which saw the loss of several Shackletons, plus a mid-air collision between a Lancaster and a Valetta in which twenty-six men died.

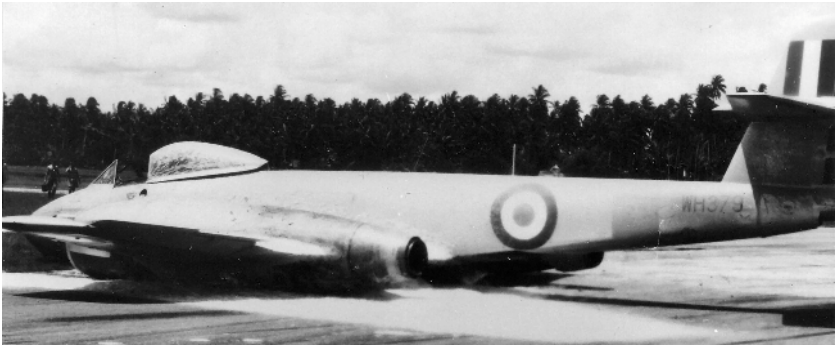
Supply dropping in Malaya during Operation FIREDOG was particularly dangerous, since the Valettas used in this role often had to descend into deep valleys, flying close to their single-engined safety speed, in turbulence. On several occasions, engine failure in those circumstances cost the lives of seven or eight crew, of whom four were usually Royal Army Service Corps air despatchers.

The significant increases in fatalities in 1965, '67 and '71 were all attributable to the disproportionate impact on the statistics caused by the, increasingly unusual, losses of large aeroplanes with the associated tendency for them to have relatively large numbers of souls on board. The first was a consequence of a Hastings crash at Abingdon which claimed forty-one lives. The second arose from the

Specific details are lacking, but this Hastings is No 24 Sqn's WD491, which is known to have been in involved in some kind of non-fatal incident on 9 June 1967 and this would seem to fit the bill. One can see, however, how the total loss of just one fully loaded aircraft of this size would result in a significant 'blip' in the annual fatality statistics.

loss of three Shackletons. Finally, six crew and forty-six Italian Army parachutists died in a Hercules which crashed off Pisa in November 1971. In addition to these, a 'blip' in 1990 reflects the loss of a Shackleton on the Isle of Harris and, whilst there were only four fatal accidents in 1994, the Chinook on the Mull of Kintyre accounted for all but six of the lives lost that year.

Before leaving statistics it should be pointed out that they tend to reflect contemporary attitudes. That is to say that, while the figures for the late 1940s and early '50s may seem appalling to us today, they were not considered to be particularly remarkable at the time. When the Prime Minister learned that, in 1952 alone, the RAF had lost no fewer than 232 fighter aircraft and 141 pilots (ninety four of whom had died in Meteors, forty in Vampires and seven in Hornets), which represented a one-in-sixteen chance of a pilot's being killed within an eighteen-month period, he wanted to know what was being done about it. Having studied the problem, the Air Minister advised Mr Churchill that these figures 'are not abnormal and there is no cause for alarm.'



Following the sudden grounding of No 45 Sqn's Butterworth-based Hornets in 1955, HQ FEAF adopted a typically pragmatic '1950s' approach and, pending delivery of Venoms, it cobbled together a motley collection of Meteors and Vampires with which to run an ad hoc on-site OCU-cum-jet conversion course in order to keep the pilots flying. Perhaps surprisingly, the only significant incident occurred on 8 August when the pilot of this F.8, WH379, was caught out by the unaccustomed lack of responsiveness of the Derwents, compared to the familiar Merlins (a not unusual occurrence in the early jet era) and undershot the runway.

FACTORS CONTRIBUTING TO ACCIDENTS

Factors contributing to accidents may be conveniently considered under five headings: the extraneous pressures on aircrew and others; the idiosyncrasies of particular aircraft types; human factors; technical issues; and the environment.

Extraneous Pressures

The most obvious example of post-war 'pressure' was the advent of the jet age and its subsequent development. Until the late 1950s all flying training was conducted on piston engined aircraft and many pilots were still able to go on to fly similarly powered aeroplanes in productive service. For those obliged to switch to jets early in their careers, however, it was mid-1949 before the availability of the Meteor T.7 permitted formal conversion courses to be organised using a dual-control jet trainer and it was 1954 before a dual-controlled Canberra emerged. Pilots were not the only people affected by the introduction of jets, of course; Air Traffic Controllers were also

obliged to adjust their working practices in order to take account of the greater speeds and heights at which events occurred.

While the first-generation jets flew faster and higher than their predecessors, their performance was limited in other ways, notably endurance. They also displayed a number of other deficiencies due to associated technologies' failing to keep pace with the advances made possible by the gas turbine. Instrumentation, for instance, left something to be desired; oxygen systems lacked the necessary degree of reliability and the heating, pressurisation and ventilation systems fitted to the early jets tended to lag behind the demands of the environments in which they operated. All of these factors had significant flight safety implications.

Many pilots came to jets after lengthy spells on the ground and they sometimes found the transition quite difficult. Directives from on high were not always entirely helpful and, during Dermot Boyle's tenure as CAS, for example, Station Commanders were required to be capable of flying the jet aircraft operated by their units. Since failure to command a station would clearly represent an impediment to further promotion, some senior officers pressed on with jets when the edge of their skills and mental agility had perhaps been dulled by the passage of the years and exacerbated by a lack of currency. Several two-star officers, at least one of whom had his third 'in the bag', were lost in jets that they were not really up to flying in the prevailing conditions. One, for example, disappeared into the Mediterranean, officially because he is thought to have suffered from anoxia, but quite possibly because his vanity had precluded his wearing his spectacles.

Another extraneous pressure was economic. Flying pay was introduced, initially for very junior officers only, in 1946 but it was extended to all GD officers up to and including group captain in 1950. Six years later the rate was substantially increased to the extent that it now represented a significant element of a junior officer's pay. This supplementary income could be drawn, however, only if the recipient remained in current flying practice. This inevitably contributed to a number of accidents as a result of pilots on ground tours endeavouring to keep their hands in by flying aeroplanes on which they were no longer current or, worse still, with which they were unfamiliar.

Perhaps associated with this syndrome, there were several accidents which involved senior officers flying off to meetings, often

in an Anson with a clutch of staff officers as passengers, but getting things badly wrong with disastrous consequences. In this context it is interesting to observe that many of the Command and Group Communications Flights of the 1950s tended to harbour the odd Spitfire, Tempest or Meteor and one wonders what the function of such hot rods really was – were they there largely to satisfy the urges of desk-bound, middle-aged boy racers?

Since it was probably cheaper to dole out flying to pay to aircrew, even those not currently holding flying appointments, than to have to replace the aeroplanes that they occasionally bent, not to mention the lives that were being unnecessarily lost, the must-fly-for-your-money policy was abandoned in the mid-1960s.

Aircraft Idiosyncracies

The wartime Oxford trainer soldiered on until 1955 as a communications aircraft. One might have thought that an aircraft intended to introduced pilots to the rigours of multi-engined flying would have had benign handling characteristics but it was exceptionally difficult to recover from a spin. Similarly, the Harvard basic trainer could easily be induced to depart from controlled flight if handled roughly.

As an example of the early jets, Pilot's Notes for the Vampire contains dire warnings about ditching, difficulties with restarting the Goblin engine and, in the absence of an ejection seat, the perils of abandoning the aircraft, other than by turning it upside down and falling out. Underpowered, it also had a tendency to flick in tight turns or sharp pullouts and would porpoise at high speeds. On landing, it adopted a sharp nose up attitude when the flaps were lowered and this needed to be immediately corrected for obvious reasons. Somewhat incongruously, the aircraft is described elsewhere as being 'a delight to fly.' The cockpit layout of the single-seat version was an ergonomic nightmare and the T.11 two-seat trainer, no better.

Problems with cockpit layouts were far from unusual, not least because of partial implementation of rolling modification programmes. A survey of the Hunters of the Khormaksar Wing, conducted in about 1964, for instance, revealed a dozen variations of cockpit layout; a configuration management nightmare and not conducive to the swift and correct application of remedial measures *in*

extremis.

The Meteor had its share of vices and those who flew it will recall the difficulties with asymmetric flying at circuit speeds with a rudder without power assistance or electrical trim. A recent account of training on the Meteor describes a single-engined overshoot as a 'white knuckle ride' with the foot loads enough to push the pilot out of his seat if he had not lowered it, braced his leg and tightened the straps. A further exciting addition was that the hydraulic pump was driven from only one engine so, if the dead engine was the one which drove the pump and if the hydraulic reservoir was already exhausted, the undercarriage had to be pumped up by hand. If a ventral tank was fitted, aerobatics were not permitted, nor were overshoots allowed until the tank had been drained.

The Meteor had a particular vice, to which the T.7 was more susceptible than a single-seater. The undercarriage legs came down in sequence causing the aircraft to snake. If the airbrakes were still extended the yaw resulted in the inner wing stalling and the aircraft rolled and dropped its nose. The solution required the brakes to be snapped shut pretty swiftly but at circuit height and speed, there was but a narrow margin between a successful recovery and, what was known as, 'the phantom dive'. It was this phenomenon that led, on 30 May 1988 at Coventry Airport, to the loss of the last RAF Meteor.

It is also worth noting that, although some elements of the RAF had been working in nautical miles and knots for many years, it did not standardise on these until as late as 1945. As a result, until all aircraft had been refitted it was quite possible to find examples of the same type of aeroplane with ASIs calibrated in knots while others were still in mph. The implications of this in terms of dredging up the appropriate set of recommended manoeuvring and limiting speeds from one's memory bank are obvious.

The Meteor was not alone in suffering from a lack of duplication when it came to ancillary systems. On larger aircraft, the Lancaster, for instance, the hydraulic, pneumatic and electrical systems derived power from pumps and generators fitted to different engines and these were not always duplicated. It follows that a relatively straightforward engine failure could imply additional difficulties. Then again, fuel systems, which could be quite complicated, even on relatively small aeroplanes, represented another potential pitfall for the unwary and

many accidents were caused by fuel mismanagement.

Helicopters were another post-war innovation and members of this Society will recall Gp Capt Price describing the problems associated with operating the early underpowered machines, leading him, in Cyprus in the late-1950s, to carry a set of bathroom scales with which to weigh every soldier individually in an attempt to squeeze the last ounce of payload into the aircraft (*Journal 25*, p32). Power, or the lack of it, would prove to be a major limiting factor in the exploitation of the helicopter's potential for most of the first forty years of its service. This limitation could be partially overcome by employing the 'running take-off' technique, gaining forward speed over the ground before converting this into additional lift, although this required a fine degree of judgement. There were other risks involved in hovering when still relatively heavy.

Helicopters had a number of other peculiarities. First, they could be stalled by being flown too fast, when the airflow over the rotor blade that was going backwards resulted in a net airflow component that was insufficient to sustain lift. The consequent 'retreating blade stall' caused the aircraft to fall off in the direction of the retreating blade. Secondly, it was possible in certain conditions to generate an airflow circulating around the main rotor blades, creating a 'vortex ring', which effectively destroyed the lift. Another syndrome was a loss of cyclic control authority which could occur in certain wind conditions and this was, in part, the cause of the last two Sycamore accidents at Ternhill in the spring of 1966. A fourth, and remarkably unpleasant, problem was ground resonance. This involved an uncontrollable vibration which, in extreme cases, could result in the machine literally shaking itself to bits! Ground resonance could often be cancelled by taking off again but, since it sometimes started during shut down, this was not always an option.

An engine failure in a helicopter was not of itself a disaster, because it was possible to auto-rotate and, assuming the availability of sufficient time, height and a reasonable surface beneath, the aircraft could be forced landed. This is rather easier to say than it is to do, of course, and getting it wrong could still result in a very heavy landing. Similarly, while serious, it was also possible to deal with a tail rotor failure, although this dictated a landing with forward speed and precluded hovering or a vertical descent.

Human Factors

'Human factors' covers a multitude of sins ranging from poor crew co-operation, through errors in navigation and the misreading of instruments to simply failing to pay sufficient attention. The latter could arise from boredom or through genuine fatigue and there is evidence to suggest that fatigue did play a significant part in many accidents. One may view with a degree of cynicism the requirements of transport crews who always expect to be provided with air-conditioned accommodation, while the walking freight has to make do with whatever else is available, but this practice was introduced as a result of bitter experience. Fatigue can kill and it can do it in large numbers if it involves a transport aircraft.

Perhaps surprisingly, alcohol played an important part in several accidents, one of which involved a ground staff officer attempting to operate an aircraft whilst under the influence. In another case a pilot lost control beating up a mess, having taken an aircraft when drunk at the end of a guest night. A pilot, who had been suspended from flying for psychological reasons, took a Meteor in the early hours of the morning and was never seen again – and then there was the airman who flew a Varsity to France, presumably because he was homesick.

Disorientation, which could be aggravated by the effects of colds or flu, was a feature of a number of losses. The recommended response to disorientation is to concentrate on the instruments but, conversely, it is while actually flying on instruments that the problem may arise. One notably high risk stage of a flight was turning inbound, having completed the first, outbound, stage of a QGH (a procedural let down in cloud). This involved a particularly high workload, with changes to speed, height and heading while deprived of normal visual cues and, in the worst case, while groping for the centreline steady tone of the SBA.

Pilot error, a perennial cause of accidents, can take many forms. An error of judgement may be the result of a failure to observe an aircraft's performance parameters or it may be due to the lack of a particular skill, which may have been inadequately taught or arisen through a lack of currency, or perhaps through an undetected 'blind spot' in an individual's capabilities. On the other hand poor judgement may manifest itself through deliberate disregard of the rules – allowing a passenger to fly one's aircraft, for instance, or, and all too

frequently, through low-flying. The latter could be the result of sheer high spirits but, as often as not, it would be associated with an attempt to impress a lady friend. By way of example, the leading police witness at a civil court hearing in the early 1960s, stated that: 'Mr Poole flew the aircraft past his girlfriend's bedroom window – she lives in a bungalow'! The Magistrate was even more caustic: 'Poole's low flying was tantamount to dangerous driving.'

As an aside, it is worth pointing out that, beginning in 1955, the RAF underwrites 75% of the excess life insurance premium arising from the addition of flying risks. Interestingly, in 1975 I was asked to comment on a forthcoming publicity initiative aimed at encouraging more aircrew to take up this option. This interest had been stimulated by the recent loss of an aeroplane and its five-man crew, all of them married with at least two children. None of them had been insured against flying risks.

Technical Issues

Servicing errors were a frequent cause of aircraft accidents and were sometimes caused by fatigue amongst groundcrews attempting to keep aircraft serviceable whilst working under difficult conditions, perhaps in the cold and wet or with inadequate lighting. Servicing manuals were not always well written or laid-out and the configuration management problems that have already been mentioned represented potential hazards for technicians as well as aviators, because it is just as important for groundcrew to check the positions of cockpit switches as it is for pilots. For instance, failing to check that the arming switches are set to 'Safe' can result in the inadvertent release of a weapon when the armourers connect the firing circuits, with potentially fatal consequences. A more common problem was tools that had been left in aircraft causing control restrictions, although these tended to result in incidents rather than major accidents. The introduction of 'shadow boards' which showed at a glance if any tools were missing, rigorous management of tools within the workplace and zonal checks all contributed towards reducing this particular hazard.

Environmental Issues

In March 1966, a BOAC Boeing 707, departing Tokyo, broke up in mid-air in the vicinity of Mount Fuji. The aircraft had been the victim

of clear air turbulence – at that time a little known phenomenon but one that would become more familiar with the rapid expansion of high speed, high altitude air travel.

On the other hand, turbulence associated with clouds, particularly big cu-nims, along with damage from hail and lightning strikes, was relatively well understood. Unfortunately, the limitations imposed by aircraft performance may limit a crew's options and, despite the known hazards, a cloud penetration may sometimes be unavoidable. In the case of a fully developed tropical thundercloud, such an excursion may not be survivable. Perhaps the most tragic of post-war accidents, the loss of a Dakota repatriating thirty-six former prisoners of the Japanese, occurred under just such circumstances.

Icing is another danger that needs little amplification. Ice accretion on the wings destroys lift, in engine nacelles and carburettors it blocks airflow, causing engine performance problems, whilst on the control surfaces it inhibits manoeuvrability. Similarly, it soon proved necessary to add icing inhibitors to early jet fuel (kerosene) to cope with the low temperatures encountered during prolonged high altitude flights; this was eventually catered for by appropriate blending at the production stage and the marketing of fuels of different grades.

Another environmental hurdle that we more or less take for granted is the need to be able to fly in poor visibility. In view of the thousands of wartime sorties flown at night and in poor weather, it is perhaps a little surprising to find that there was no formal instrument rating system at the time. The introduction of the original version of the scheme with which we are familiar today was not announced until as late as December 1945. The task of implementing the system fell to the CFS which certified the first batches of examiners during 1946-47, permitting the bulk of the air force's pilots to be rated for the first time by the end of 1948.

Fighter Command handled the initial heavy demand by dedicating two units (Nos 1 and 41 Sqns) to the task for a year and funnelling all of its pilots through one or other of these. Bomber Command relabelled its Instructors School as its Instrument Rating and Examining Flight which then visited stations to test units on their home ground. Transport Command did much the same with its Examining Unit while Flying Training Command's QFIs were examined by the CFS 'trappers'.

There were some early teething problems and in 1950 some changes were made to the format of the practical exercise that was to be flown by all pilots; at the same time the Master Green rating was added to the previous White and Green Cards. Thereafter the system evolved to cater for the demands imposed by different roles and aircraft characteristics but the three-card ratings are still with us sixty years on.

THE FLIGHT SAFETY ORGANISATION

On the recommendation of the then Inspector General, the RAF had set up the Directorate of Accident Prevention, its first dedicated flight safety organisation, at the turn of 1943/44. This was, in part, an attempt to overcome defects in previous practice which had been characterised by inadequately-defined areas of responsibility and haphazard procedures which could result in, for instance, a failure to implement recommendations. With the post-war contraction of the Service the status of the organisation was reduced to that of a Deputy Directorate in 1947 and in 1950 it was further downgraded to become an Assistant Directorate. That is to say that it was now headed by a mere wing commander and one can imagine the problems that he might have encountered in telling a fire-eating Commander-in-Chief that his approach to flight safety left something to be desired.

The significant increase in the accident rate during the Korean war expansion led to a review of the situation and the Inspector-General concluded that, if it was to exert the necessary influence, the accident prevention organisation would have to be expanded and restored to its previous prominence. The Air Council concurred and the Directorate of Flight Safety (DFS) came into being with effect from 1 January 1956.

Meanwhile, although the Royal Navy had gone its own way since 1946, the RAF had continued to have responsibility for the Army because the War Office had little in the way of an air staff of its own. Even after the establishment of the Army Air Corps in 1957, it still made sense to tap into the RAF's expertise and one DFS post had specific responsibilities for army aviation until 1980 when the Army set up its own flight safety centre at Middle Wallop.

In August 1977 the Directorate of Flight Safety became an Inspectorate (IFS). This was no mere re-branding exercise, however,

as it signified a more proactive, hands-on approach. The head of the organisation, the Inspector, was now required to fly in many, if not all, of the types in service and to maintain a rated currency on at least one of them. He also personally handled the confidential (and virtually anonymous) mechanism for reporting (confessing to) incidents which one would rather not declare via more formal channels – the so-called CONDOR system. Furthermore, he briefed the Air Secretary on personnel issues and had direct access to CAS, all of which is symptomatic of the degree of prominence afforded to flight safety in an RAF which could no longer tolerate the accident rates of yesteryear.

In the interests of 'jointery' and economy, the most recent link in this evolutionary chain has seen the demise of the RAF's IFS in favour of the tri-Service Defence Aviation Safety Centre (DASC) in April 2002. The functions of the current organisation are described in appropriate management-speak but it is reassuring to note that it is still headed by a one-star officer so it retains the essential 'clout' of its predecessor.

ENGINEERING

The slogan 'Flight Safety Is Everyone's Concern' remains as true today as it did when it was first coined and the RAF's engineers are as deeply involved in flight safety as anyone.

Having, in 1939, finally come to terms with the fact that it would be impractical for the RAF to rely on pilots to handle engineering issues in a wartime air force, the RAF eventually set up a dedicated Technical (not Engineer until 1966) Branch in the spring of 1940. Thereafter a great deal of effort was expended in devising systems for the planned servicing of different aircraft types operating in different roles, in a variety of climates while attempting to satisfy a number of different imperatives. Suffice to say here that the principal driver during the war was the generation of sufficient serviceable aircraft to satisfy the operational requirement. The main problems that had to faced were: the provision of the necessary technical personnel to do the work; the impact of attrition, which tended to confound attempts to impose planned servicing; and the fact that second-line units were often equipped with tired 'hand me down' aeroplanes which could be difficult to keep serviceable. There were flight safety implications

embedded within all of this, but, in the absence of a significant wartime ‘flight safety culture’ the only substantial goal was ‘serviceability’

After due deliberation, it was decided to retain a professional Technical Branch in the post-war air force and to support it in its endeavours the RAF established a centre of excellence to solve technical problems and to develop engineering strategies to cater for the maintenance of high performance aircraft of constantly increasing sophistication. Originally set up at Wattisham in March 1947, as the Air Ministry Servicing Development Unit, it subsequently moved several times before, having become the Central Servicing Development Unit (CSDU) in the interim, it eventually settled at Swanton Morley in 1958. Known today as the Central Servicing Development Establishment (CSDE), it has been at Wyton since 1995.

While the CSDU/CSDE was not there solely to deal with flight safety, this was an inevitable spin off from its efforts to overcome design flaws, eradicate servicing errors, promote configuration control and so on, all of which helped to minimise the risk of accidents. In addition, Field Teams were deployed with major contractors and this ensured that a close liaison was maintained through which issues relating to safety could be addressed.

A major philosophical change took place within the engineering community when the term ‘servicing’ was replaced by ‘maintenance’. The implication was that it was no longer sufficient merely to ensure that an aircraft was serviceable; the aim was now to arrange for it always to be maintained to a required standard, with a consequent improvement in serviceability which would, in turn, reduce the incidence of accidents. Furthermore, the application of the Maintenance Steering Group’s maintenance logic principles, means that aircraft maintenance arrangements are now derived from the outset with safety as a major consideration.

Aviation has always tended to operate at the cutting edge of technology, and, as a result it has encountered phenomena which were little understood to begin with. As a result, aside from solving engineering ‘management’ problems, the CSDU/CSDE has been involved in a great deal of mould-breaking technical work. A classic example is metal fatigue. The layman was first made aware of the accident potential inherent in metal fatigue by the aircraft designer

Neville Shute in his 1948 novel *No Highway* which, arguably, foreshadowed the Comet disasters of the 1950s. The increased awareness of this hazard resulted in the RAF's developing and employing Non-Destructive Testing (NDT) using X-rays and other means to examine the integrity of components while industry used fatigue rigs within which a test airframe was artificially subjected to stresses which were calculated to exceed those being experienced by the most hard-worked aircraft in squadron service. There were practical limitations to what could be achieved, however, as catastrophic failures due to metal fatigue would eventually lead to the demise of the Valiant and a temporary, but lengthy, grounding of the Buccaneer fleet.

Within the DFS, engineering aspects had been handled by a small staff headed by a wing commander but, to reflect the change of emphasis introduced in 1977, the rank of the senior IFS engineer was raised to group captain who, in line with the more interventionist approach, was restyled the Engineering Inspector.

CONCLUSION

To conclude on a lighter note, the following is extracted from one of the Accident Cards held by the Air Historical Branch:

> Description of Incident: 'The engine stopped when the pilot selected the 'overload' fuel tank'.
> CO's Comment; 'This was a stupid thing to do as the aircraft was not fitted with an overload tank'.
> AOC's Comment: 'When the pilot realised he would undershoot the landing area, he should have opened the throttle and gone round again'.
> Anon: 'The Horsa is a glider'.

Finally, a word of wisdom culled from a recent DASC presentation: 'There are rarely new accidents, just old accidents waiting for new people to have them.'

Acknowledgements: I should acknowledge the assistance I received, while preparing this presentation, from AVM Peter Dye, Wg Cdr Jeff Jefford, Sqn Ldr Tony Fairbairn and Wg Cdr Ian Woodhouse, an engineer officer serving (at the time of writing) with the DASC.

AIRCREW SAFETY – MARTIN-BAKER AND THE RAF

Brian Miller

Brian Miller joined Martin-Baker in 1961. He spent four years at Norfolk, VA as Technical Representative to the US Navy, before becoming Reliability and Maintainability Engineer, Manager Advanced Projects, Head of Marketing and, from 1999 to 2004, Executive Vice President in the USA. Career milestones included being Project Engineer for the Mk 10 seat, persuading Embraer to install ejection seats in the Tucano, thus establishing a new lightweight seat market, and managing studies of the crashworthy seats for helicopters, which have since become another major product line.

Today the name Martin-Baker is synonymous with aircrew safety in the Royal Air Force and the story of how the Company designed and developed increasingly capable ejection seats is well documented. What is perhaps less well known is the effort and innovation that went into this unceasing quest for greater safety. This paper describes some of this work and other escape system developments that promised much but which never reached production.

A Novel Start

For various reasons the British services always seemed to lag behind Germany, and other nations, in the matter of aircrew safety. In the Great War RFC and RNAS crews were without parachutes while their German counterparts were able to parachute to safety if the need arose. WW II saw a repeat situation where the Germans (and Swedes) developed ejection seats and had them in service to save some 60 aircrew lives during the hostilities. In contrast, Allied aircrew were obliged to rely on over-the-side bale out from increasingly faster aircraft – and died in increasing numbers as a result. By 1943 something had to be done!

Engineer James Martin, who, in 1934, had founded Martin-Baker Aircraft Co Ltd, in partnership with test pilot Valentine Baker, had demonstrated a flair for innovation during the design and construction of several novel prototype aircraft. He had also designed a range of

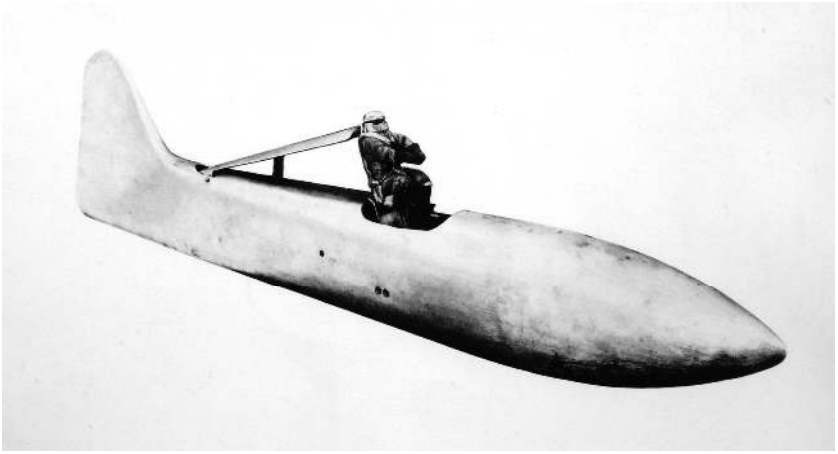
devices such as a Barrage Balloon Cable Cutter, 250,000 of which had been fitted in the leading edges of bomber aircraft, and had produced a cockpit canopy emergency release mechanism that was now fitted as standard to Spitfires. This gave him some credibility in the fields of both explosively operated devices and aircrew safety.

This track record of engineering innovation identified Martin-Baker as a candidate to design, develop and introduce 'some form of assisted escape' system for fighter aircraft. ML Aviation was also approached but fell by the wayside – the RAF standardising on the Martin-Baker seat in 1947.

In the dark days of 1943 the RAF were desperate for 'something' to help pilots escape from high speed aircraft. The aircraft of the day such as the Typhoon, the new Tempest, and especially the Spitfire, had cockpits just about big enough for the pilot and little else, plus they would have to be modified quickly and easily so as to remain operational at all costs. Faced with a seemingly impossible task Martin came up with a very novel design that has often been dismissed as 'Heath Robinson' by those who did not appreciate the constraints under which he was working.

Martin designed an 'external escape system' that would extract the pilot from the cockpit and throw him clear of the fin. The device consisted of a very light aluminium arm of an inverted 'U' section, hinged at the base of the fin leading edge and conforming to the shape of the fuselage spine aft of the canopy. The front of this arm terminated in twin hooks that engaged in rings on the pilot's parachute harness shoulder straps and was locked down by a simple latching mechanism, compressing a powerful spring beneath the arm. Installing the device would have been very straightforward and could have been done quickly in the field with minimal tools. When painted it would have appeared to be an extra panel along the top of the fuselage that would have added little weight and had negligible effect on performance.

In an emergency the pilot would jettison the canopy separately and then operate a lever to release the arm and his harness from the seat. The spring would have lifted the arm into the airflow and the aerodynamics would have taken over to extract the pilot and toss him back over the fin. Importantly, the pilot would be lifted out of the cockpit in a standing position so that his knees would clear the



Wind tunnel model of Martin-Baker's original concept of a 'swinging arm' escape system.

instrument panel and windscreen. The system used no explosives and had an elegant simplicity that becomes increasingly apparent with closer scrutiny. Martin conducted wind tunnel tests with a model (which still exists) but it had already been decided that, with the tide of the war turning in the allies' favour, existing aircraft would not be modified retrospectively.

The Quest for Knowledge

The mainstream story of the development of the ejection seat is well documented and shows how Martin brought his very considerable engineering ingenuity to bear with the full force that was typical of this remarkable man. He was probably one of the first people to study human physiology, and especially the spine, from an engineering view point so that he could develop an ejection gun that would minimise the risk of injury in the process of saving life. He became driven in his quest to save lives and he genuinely regarded aircrew as 'the salt of the earth'. His thirst for feedback on his products was legendary and he conducted far more tests than his contemporaries. He also conducted an extraordinary number of tests with live subjects, the first being Benny Lynch, one of his fitters, who volunteered to ride the seat so that the effect on the human body could be determined. From the first emergency ejection in 1949, by

Armstrong Whitworth test pilot J O Lancaster, Martin wanted to hear at first hand how the seat had performed. Every ejectee had an open invitation to visit the Company where they were quizzed on every aspect of their escape and were his personal guests for the day.

Martin's business philosophy was simple; he would build the best seat possible, which would save lives, see off the Competition – and make the Company successful in the process. He needed a reasonable profit, not to get rich, but to plough back into making an ever better seat. Every employee understood this mission, enabling us to focus on the saving of lives. Another of Martin's strengths was to recognise talent and so gather round him an exceptionally skilled and dedicated work force who could translate his concepts into working designs. The result was a very happy team who gave freely of their time and effort, sometimes working through the night if needed.

By 1947 Martin had decided that ejection seat design was to be the Company's principal business. He already had an automatically operating seat in development before the first emergency ejection and within 7 years had a revolutionary lightweight seat, the Mk 4, capable of safe ejection at ground level, as long as the aircraft was travelling at 90 knots or more.

Rocket Powered Ejection

From the outset the seat had been propelled by a telescopic ejection gun powered by one, then two and finally five cartridges that fired progressively as the seat was ejected. The most powerful gun was needed to propel the heaviest pilot over the high Victor tailplane when travelling at 600 knots. By the late 1950s it was clear that the ejection gun could provide no more power without incurring an unacceptable risk of back injury and Martin decided to use a rocket to augment the thrust of the gun.

Pulling the seat was obviously going to be much easier than pushing it, so the first approach was to use two 2-inch air-to-ground rocket motors to tow the seat into the air. The proof-of-concept tests were done from the back of the factory car park in Denham, Bucks, and were less than successful. When the rockets fired they sped away from the seat, rapidly extending their pendant lines. Instead of hauling the ejecting seat away, the lines snapped and the rockets soared away across the fields towards Gerrards Cross! We waited for the calls of

protest but none ever came and those motors must still be out there somewhere. It was quickly decided that we would, after all, have to push rather than pull the seat!

Initially we mounted the same motors vertically down either side of the seat using an angled manifold at the base of each rocket to correctly position the thrust line. Tests at the Company airfield at Chalgrove, near RAF Benson, proved the viability of the system and development of the concept continued apace, resulting in a rocket motor pack that fitted under the seat pan. Ministry boffins had predicted disaster for such a motor but the 'experts' were confounded when a highly efficient and adaptable motor was produced.

The introduction of the rocket transformed the science of pilot ejection. No longer did the seat have to attain all of its velocity during the six-foot gun stroke as the rocket could now effectively extend the acceleration phase to 120 feet. As a result the thrust provided by the gun could be reduced dramatically, thus greatly reducing the risk of injury due to the ejection forces. Aircrew who later ejected with both ballistic and rocket seats described the rocket seat experience as a sustained push rather than the kick that they had experienced with the earlier seats.

VTOL Flight

As the Company grappled with the problems of rocket ejection, and initially there were many, Hawker's and others began the development of VTOL flight. I can still see the immaculate blue and silver, chauffeur-driven, Armstrong Siddeley Sapphire in which Sir Sidney Camm used to visit Denham. The P1127 was under construction but, as yet, Martin-Baker did not have a practical rocket seat that Camm felt would be a prerequisite for test pilot Bill Bedford's safety. Camm was clearly worried and no amount of reassurance by Martin, that the seat would be ready, could allay his concerns.

As insurance, Martin-Baker produced two special Mk 4 seats, one the Mk VHK4, with a mortar deployed parachute for ejection when hovering or at very low speed, and another, more conventional, seat for ejection in normal flight. This insurance paid off as these seats were installed for the P1127 flight trials, the Mk 6HA, the first rocket seat, being installed in the later Kestrel.

The V-bomber Saga

Martin had long been concerned about the lack of ejection seats for the rearward-facing rear crew members in all three V bombers. He had developed a rearward-facing ejection seat for the Valiant, demonstrating its practicability when, in 1960, ex-RAF parachute instructor, W T 'Doddy' Hay, made a rearward facing ejection from the back of a Valiant over Chalgrove.

In the other two V-bombers, ejection seats had been installed for the test pilots only because it was intended that production aircraft would have jettisonable crew cabins that would be recovered by parachute. When it became apparent that these crew capsules had been abandoned, Martin lobbied hard to have ejection seats installed for the entire crew. When a Vulcan crashed on approach to Heathrow on returning from a flight to Australia, and only the pilots survived, Martin became incandescent.

The RAF was fully supportive of his efforts on their behalf and the nose section of a scrapped Vulcan was delivered to Denham for the development of rear seat ejection – as a private venture. The pressurised cabin structure precluded the provision of separate hatches for each seat, which would have been the ideal, and instead Martin had to devise a way to eject all three crew members through a single, central, hatch. In typical style, Martin turned the challenge into an advantage by incorporating a command ejection system that would automatically sequence the ejections so that the rear crew could be ejected in the shortest time without risk of collision.

A special rig was constructed to demonstrate the concept. When ejection was initiated, the rear seat shoulder harnesses were tightened automatically to position the rear crew members for ejection. As they were brought back in their seats the chart table, which extended across the width of the cabin, was folded upward by cartridge-powered pistons, to provide leg clearance, and the central hatch was blown. The centre seat and occupant then ejected, allowing, the other rear crew members to cant sideways and eject in turn through the same hatchway. Having proved the concept, the system was installed in the Vulcan crew compartment and was demonstrated very successfully to high level RAF and Ministry officials.

Incredibly the men from the Ministry decreed that ejection seats would not be provided for the rear crew of any of the V-bombers

The rig built to demonstrate the feasibility of installing three rearward facing seats in a V-bomber.

The Mk 16E seat for the F-35 Joint Strike Fighter.

despite the availability of a very practical system. It is a matter of record how many rear crew members were condemned by this decision but what is not so clearly appreciated is the number of pilots who gave their lives by remaining too long with their aircraft while trying to give their crew a chance to live.

Martin-Baker has striven continuously to provide the Royal Air Force with the very best in crew escape. That 791 RAF aircrew have been saved is a measure of their success. As in other fields, much of the progress was achieved by private venture projects which often contradicted officially sponsored requirements. Jimmy Martin was always a thorn in officialdom's side because he believed fervently that he could contribute more to aircrew safety if only they would let him. The very advanced Mk 8 seats with leg, torso, arm and head restraint and able to eject safely at 800 knots, as developed for the cancelled TSR2, give some insight into what might have been achieved at a much earlier stage than was actually the case.

In the mainstream of escape system development for the RAF, the Company's Mk 1, Mk 2, Mk 3, Mk 4, Mk 6, Mk 8, Mk 9, Mk 10, Mk 12 and now Mk 16 ejection seats have each establish new and ever higher benchmarks for crew escape. (The missing Marks denote seats for other customers). With over 70,000 seats produced for 93 air forces and 7,130 aircrew lives saved world-wide (as at 30 December 2005), one can only wonder how much more might have been achieved had officialdom been more supportive of Martin-Baker's unceasing efforts to provide the Royal Air Force with the very best in crew escape.

THE POST-WAR CENTRAL FLYING SCHOOL AND FLIGHT SAFETY

AVM Paul Robinson

Paul Robinson graduated from Cranwell in 1970 to fly Harriers in Germany and later as OC 233 OCU. Staff tours at MOD and HQs 1 and 2 Gps were interspersed with operational appointments in Bosnia, Saudi Arabia and Cyprus and as Station Commander at Cranwell. Commandant CFS in 2000-01, his final tour was at Northwood. A QFI with experience on a wide variety of types, he continues to fly Tutors, teaching basic navigation to RAF Weapon System Officers.

INTRODUCTION

Chairman, ladies and gentlemen; good afternoon. I am very conscious that I am in the post-prandial slot, and how much we've enjoyed our lunch. I'm also very aware of the impressive level of knowledge that members of the RAF Historical Society possess on all aspects of aviation, and that several of my ex-bosses are in the audience. So, if nothing else, I hope I shall be able to keep you awake for the next half-hour, but my visual aids are not essential, so you're authorised to listen with your eyes shut. Jock Heron gave me free rein on how to cover the post-war CFS and flight safety, and rather than dwell on too many historical statistics, I have chosen to cover the subject rather more intuitively, and through my own and colleagues' personal experience. Specifically, I will examine the contribution CFS has made, and continues to make, to flight safety; and touch on areas where I feel its impact could have been greater. I stress that these are my personal views, gleaned from flying tours in every rank up to AVM (if you include my current job), and having instructed right across the training continuum, from gliders to front-line squadron QFI.

You all realise that an air force, from time to time, needs to get in harm's way, and preparing for this is of necessity challenging and occasionally risky. In the 1970s, someone coined the expression

'Flight Safety equals Fight Safely', and that pretty well sums up my own philosophy. Some training organisations, like the USAF, teach sticking rigidly to scripted flight profiles, speeds and so forth, and assess their students on their ability to fly by numbers. This approach stifles the flexible, intuitive flying skills required in air fighting. On the other hand, accuracy and discipline are essential building blocks to safe flying. And here's the dilemma: military aviation is a blend of pure and applied pilotage. CFS, as the champion of pure flying skills, and the front-line operational evaluation units and Standardisation/Evaluation teams, as champions of tactics and weaponry, must see themselves as two sides of the same coin and not – as has happened in the past – alternative world views.

CONTENT

More of this later, but I will start my presentation with an analysis of what CFS has been doing over the last fifty years. Flowing from that, I should be able to convince you that CFS has made, and continues to make, a significant contribution to flight safety. We will follow that up with a look at some case histories.

COMMANDANT CFS'/INSPECTOR OF FLYING TRAINING'S DIRECTIVE

Let us first consider Commandant CFS' Directive. This statement, which has not changed in substance for many years, gives the Commandant's overall mission, which is:

> '… to develop and maintain the highest possible standards of pure flying and flying instruction … throughout the RAF.'

Interestingly, in these days of 'jointery', his remit only runs for the RAF. You will also note that, since the demise of the Directorate of Flying Training, the Commandant is double-hatted as the 'Inspector of Flying Training'. You will also see that, post-war, he lost his non-core responsibilities for issues like Pilots' Notes to organisations such as Handling Squadron.

WHAT CFS DOES: TTAAA

From this directive falls a series of tasks, which I remember through the traditional CFS technique of a mnemonic – TTAAA:

Train, Test, Audit, Advise and, last but not least, Aerobat. This section is a little 'Mother and apple pie', but it is important to understand the mechanisms that have evolved since WW II, through which CFS has controlled and influenced UK military flying standards.

Let us look at **Training** first. The Commandant is responsible for the selection and training of all RAF 'Q-annotated' flying instructors: Qualified Flying Instructors, Qualified Helicopter Instructors, Qualified Pilot Navigation Instructors, Qualified Navigator Instructors, Qualified Helicopter Navigator Instructors and Qualified Helicopter Crewman Instructors. You will note that the Hawk Qualified Weapons Instructors of Personnel and Training Command fall into this category, but not front-line QWIs. The latter, however, join their 'pure flying' colleagues on the CFS Aircrew Instructor course prior to airborne training, where they are given the theory and practice of teaching on the ground. CFS also trains QFIs and QHIs for the Royal Navy and Army, and other foreign and commonwealth armed forces as required. All instructors attend common groundschool modules conducted by HQ CFS at Cranwell before starting the flying syllabuses. You may know that CFS training flights are embedded on the main user station of that aircraft type, rather than one CFS station operating many types as in the past at Little Rissington and Scampton. The Hawk CFS Flight is, therefore, at Valley, the Tucano Flight at Linton, and so forth. This federated approach brings dividends in terms of engineering and personnel stability, but standardisation and the cross-fertilisation of ideas across the instructor cadre are more difficult.

Testing next, and by this I mean the periodic categorisation and upgrading of individual instructors. As well as those within Personnel and Training Command, CFS tests all front-line flying and simulator instructors. Testing is either conducted by CFS examiners, or by a front-line CFS 'Agent', a type-experienced qualified instructor accredited to CFS who holds the right of direct access to the Commandant.

The Agency scheme is fundamental to achieving the Commandant's mission across Command boundaries. Weak agents unsupported by HQ CFS have led to that critical balance of pure and applied front-line flying skills being upset: operational efficiency may go up, but so may the pure-flying accident rate. An example: in the

early 1990s, a breakdown in relationships between CFS and three OCUs, together with a shortage of type-rated QFIs and an enthusiasm in some quarters for the US-style 'Instructor Pilot', led these units to certify their own conversion-to-type flying instructors. This concept had some merit, but risked instructional standards and put the individuals at a career disadvantage as their qualification was not officially recognised. I am pleased to say that CFS and the OCUs have developed a scheme whereby their CFS Agents can 'fast track' experienced individuals through to a type-specific formal CFS categorisation.

To summarise so far, the Commandant, having selected, trained and categorised his instructors, has been able to control the quality of UK-service pure flying instruction.

Now let us look at the **Audit** function, which sits squarely under the 'Inspector of Flying Training' aegis. The Inspector achieves this through a continuous and comprehensive survey of all aspects of flying training. First, he checks coherence across the flying training continuum. There are clear risks to flight safety as well as training standards if a student is taught different techniques and SOPs at each training stage, for no good reason. For example, common formation SOPs and R/T phraseology should originate in the front line and be reflected downwards through the flying training schools. This is more efficient (aircrew learn them only once) and safer (aircrew should not, in time of stress, revert to an earlier embedded motor skill). Continuity is another important aspect of coherence: if students cannot progress from one stage to the next in a timely manner, they should at least be given adequate refresher training.

Next, the Inspector is responsible for the standard of pure flying within the training organisation. He already tests the instructors; by flying with a cross-section of students, he can audit the schools' output standards. This checks the progressive development of skill and experience as students move through the system (there should be no overlap or negative teaching) as well as certifying that the OCU entry standards are being achieved. Units are subjected to a rolling external quality audit by CFS examiners, with each unit assessed about once a year and each instructor 'trapped' at least every eighteen months.

These mandates apply within PTC. The same audits can be

provided, on request, to other commands, services and nations. Front-line STANEVAL visits will invariably include the Force CFS Agent. Tasks to audit foreign air arms are undertaken at least once a year, sometimes to a single unit, but occasionally the invitation will be for a multi-disciplinary assessment of an entire force. An example of this has been a regular, wide-ranging audit of the Royal Jordanian Air Force, conducted by a CFS-led team comprising individual air and ground branch specialists.

The Commandant's penultimate mandate is to provide **Advice** on all aspects of flying training. His auditing programmes make him well-placed to do this. Also, he is tasked to liaise closely with other aviation organisations such as the CAA, GAPAN and the Royal Aeronautical Society, and academic institutions such as Cranfield. Visits to foreign air arms, such as my 2001 visit to the USN flying training system where I flew the T-45C glass-cockpit Hawk and the F-18F Super-Hornet, are most valuable. All in all, CFS possesses a unique and comprehensive insight into training platforms, equipment, organisation, syllabuses and instructional techniques.

The introduction of the UK Military Flying Training System (UKMFTS), which looks to contract out much of the organisation and equipment provision of the flying training schools to a civil consortium, is included within this wide-ranging remit, and the Commandant acts as a focal point on studies with the Defence Procurement Agency and the Defence Logistics Organisation. HQ CFS has absorbed the Flying Training Development Wing at RAF Halton to help with the development of instructional techniques and training needs analysis, and retains its long-standing responsibility for the development of instrument flying and testing.

Lastly, **Aerobatics**. CFS has a long history of providing RAF aerobatics teams, from the Pelicans, Skylarks and Yellowjacks to the current Red Arrows. Furthermore, the well-established Wright-Jubilee Trophy competition for individual aerobatics, managed annually by HQ CFS, is used in the approvals and authorisation process for PTC display aircraft. CFS' hard-won expertise in the selection, management and execution of display flying is invaluable. This totally professional approach to a high-skill, high-risk enterprise is a notable example of the pursuit of excellence that CFS strives to attain, and to

inculcate within the RAF at large.

HOW CFS HELPS WITH FLIGHT SAFETY

So, how can CFS help with flight safety? It does so both formally and indirectly. Firstly, the Commandant is formally tasked to advise Air Officer Training on standards of flight safety within PTC. Thus, each unit audit is charged to report on flight safety and to propose remedial action when necessary. *In extremis*, the Commandant can direct that action takes place if time is of the essence. Naturally, CFS examiners ensure that remedial action has been successful during the next unit visit. The Commandant has formal responsibility for the safe operation of the RAF Aerobatic Team (RAFAT – the Red Arrows); and he ensures that pilots achieve a suitably high standard of instrument flying through the Instrument Rating Scheme.

As an aside, this may be the right place to mention flight crew licensing. Some of you will know that the RAF is one of the few remaining air arms that licenses its own pilots. I believe that we should join the US, the Germans and most other air forces by licensing and rating our pilots through a joint scheme with the CAA, so military pilots would hold civil licences. To me, this seems essential to safe and efficient operations in an era where we share the same airspace, and I opened preliminary discussions on the subject with the CAA when I was Commandant.

At the same time, the Commandant holds many other indirect levers with which to positively influence flight safety. Instructors are selected, trained and categorised with responsibility and safety consciousness in mind. Student syllabuses are coherent and relevant, and conducted in an open environment where honesty and shared experience is encouraged. Importantly, the Commandant's liaison and audit programmes inform him of standards of flight safety across the UK and the world, and give him the opportunity to spread best practice. And he will continue to hold all these levers of influence under UKMFTS.

CASE HISTORIES

The post-war history of CFS contains numerous examples of how CFS has contributed to flight safety, and also several where it could have done better. Much has depended upon the authority and

reputation of the Commandant and his staff, and the strength of the CFS Agency scheme. I am pleased to report that, after a period during the late 1990s when it seemed possible that CFS would be disbanded completely, the organisation is once again flourishing, and indeed has assumed greater responsibilities. Let us first look at an instance where the system worked as advertised.

During the heyday of the Buccaneer, its CFS Agent became uneasy over the teaching and practice of asymmetric handling within the force. He reported his misgivings to Wg Cdr Exam Wing in HQ CFS, who was himself ex-Buccaneers. The Commandant spoke to the Station Commander at Lossiemouth, who invited CFS to visit and make recommendations. The visit was quickly completed and appropriate amendments made to the SOPs by the Buccaneer STANEVAL staff. Job done. Why did it work so well? The Agent was experienced, respected and confident in his links to CFS. Wg Cdr Exam Wing's reputation was also very positive, and the Commandant enjoyed strong links with his front-line colleagues. As a result, CFS' force for good was utilised quickly and effectively to pre-empt a potentially unsafe situation.

Recently, the teaching of stalling during flying training was also changed quickly and for the better. This time the stimulus was two-fold: experience from general aviation, and the replacement of the Bulldog with the stall-warner equipped Grob 115E Tutor. Interestingly, the Bulldog had a stall warner, but we wired it off to avoid confusion. Our contacts at GAPAN and Cranfield had pointed out a number of civil accidents in which the pilot had carried out the standard stall recovery ('full power, stick centrally forward to eliminate buffet, etc') when the stall warner sounded on short finals or in the flare; in other words, they confused the warning of an approaching stall with the stall itself. We realised this could occur on the Tutor, and changed the stalling sequence accordingly to differentiate between a stall warning:

stall warner or onset of light buffet = increase speed;

and a stall:

heavy buffet = standard stall recovery.

This also tied in well with 'manoeuvre stalling': aerobatics, like

Was this exercise really necessary? An RN, as distinct from an RAF, Bulldog written off in the course of a PFL on 29 September 1986.

combat, are flown at or near $C_L(max)$, so the stall warner is continuously sounding but there is no need to worry.

But before we congratulate ourselves, there is a sting in the tail. Several V-bomber landing accidents occurred because pilots reacted to slow approach speeds by lowering the nose rather than simply applying power. They had been taught the proper Vulcan technique at the OCU, so why did they make such a basic error? The Jet Provost (JP) Mk 3 was the last (and one of the few post-war) aircraft in the RAF's inventory that could not power away from the light buffet, and this defined the standard stall recovery technique for many years. The Vulcan pilots' instinctive reversion to a motor skill learned early in training on the JP3 might have contributed to their downfall. Perhaps this change in teaching the stall to ab-initios should have been introduced when the JP3 went out of service in the mid-1970s, not in the late 1990s.

A more meaty and drawn-out debate has occurred over the subject of practised forced landings (PFL) and, in particular, turnbacks. It was clearly important to learn, and practise, how to land without power in the days when a fair proportion of the front line consisted of single-engined aircraft that could be forced landed safely. However, since the 1970s our operational aircraft have all been at least twin-engined except the Harrier, whose role and handling characteristics precluded forced landing as a normal squadron option. Moreover, the reliability of our single-engined training aircraft (the Bulldog, Tutor, JP, Tucano, Gnat and Hawk) was such that the risk of a solo student suffering

engine failure was statistically very small. Hence, one could argue that there was no pressing need for students to learn and conduct PFLs, and their time would be better spent on transferable operational skills such as night flying. Rather, a student should be taught to cope with engine failure through correct restart drills, and abandonment at a time and location that saved the crew and avoided casualties on the ground. Some argued that, for the light aircraft trainer, forced landing was safer than abandonment, particularly in a strong wind; or that the PFL provided a valuable test of airmanship and handling skill. Others countered that high-angle dive-bombing also tested airmanship and handling skill, but at least it was applicable to the front line.

The arguments become clouded further over the subject of the 'turnback'. The chance of a turnback in itself saving an aircraft or pilot whilst avoiding civilian casualties is statistically remote: indeed, I have been unable to find an example. Yet to my knowledge we have lost a handful of Bulldogs, JPs and Hawks during practice, and had many narrow squeaks. As a Hawk QFI I recall musing over the sense of attempting a turn back to a short runway with a 25-knot tailwind between married patches and the domestic site when practising or monitoring turnbacks at Valley. How much safer to point the aircraft out to sea and eject?

The issue reached a head for CFS in the early 1980s, when a CFS JP with an A1 QFI captain and an A2 candidate handling pilot, stalled and crashed during a practice turnback. CFS' first action was to define how to fly a turnback safely, followed by an analysis of where and when turnbacks should be flown, as opposed to landing ahead or abandoning. The loss of a Tactical Weapons Unit Hawk during a practice turnback at Chivenor in 1992, closely followed by one at Brawdy and yet another at TWU Valley – all involving QWIs checking out other QWIs – focused attention on the Strike Command Hawk community. Policy was still evolving at the turn of the century, and I recall making recommendations on Hawk turnback safety after CFS' visit to Valley in 2001.

It took too long to evolve, but the current PFL/turnback policy is now well found. Light aircraft and Tucano students do PFLs but not turnbacks. Hawks do PFLs, but there is less emphasis on them than previously; with an engine failure after take-off, staff may position for another runway if they can safely do so. But the priorities are clear:

safeguard the public; save yourself and then, only if the situation looks favourable, try to save the aircraft. CFS has played its part in this evolution: but should it have been more positive? Should there have been a better tie-in between CFS and Strike Command over the Hawk? In 2002 a Valley Hawk took a bird after take-off and lost its engine; after attempting a relight, the pilot resisted the temptation to turn back and ejected safely, and the aircraft crashed in open countryside. We've got there in the end, but what a cost.

Lastly, let me touch on displays. It's true to say that the post-war RAF has had a chequered relationship with display flying. Some commanders felt it an important part of public relations; others felt it an unnecessary distraction. At times, front-line squadrons were dedicated to formation aerobatics; at others, it was considered a minor, low-priority secondary duty. There have been several significant milestones on the road to our current policy which, I believe, provides a reasonable solution.

The first milestone was the decision, in the 1960s, that CFS would provide the RAF's formation aerobatics display team. This focus has permitted continuity in the evolution of team selection, organisation, training and the sequence itself. I am certain that the Red Arrows have become today's safe, successful and utterly professional team because of their continuity in role, and because of the support, supervision and top-cover they have received from successive Commandants.

The second issue is that of display pilot selection. In the past, display pilots have too often been incompetent, undisciplined or unenthusiastic, often undertaking the role as a secondary duty tied to their primary appointment. The late 1970s and early '80s witnessed a spate of display accidents: the CFS Vintage Pair mid-air, the Lightning lost off Cromer during an impromptu display, a Victor that stalled on finals in Canada due to a breakdown of crew co-operation, the Chicago Vulcan and the Abingdon F-4 to name but a few. The subsequent boards of inquiry identified several common threads. The first was crew selection, and henceforth display crews drawn from volunteers possessing a proper degree of flying skill, professionalism and self-discipline.

Equally important was work-up training and supervision: most RAF display pilots were new to the game and their time on the display circuit lasted only one or two seasons, so the training burden was

Victor K2, XL191, which undershot on approach at Hamilton, Canada, on 19 June 1986.

considerable and experience hard to retain. For example, two CFS Jet Provosts were lost during pre-season training due, in no small part, to inexperienced coaching, poor supervision, over-ambitious sequences and inadequate work-up syllabuses. Since then, our retained level of display expertise has greatly improved, not least due to the regular pre-season symposia and post-season wash-ups, where the experiences of teams, supervisors and display organisers are shared and recorded for their successors. Overall, the RAF's record in display safety is now second to none, but it has been a hard and painful road.

CONCLUSION

So, what do I conclude from all this? Firstly, the post-war CFS has played a significant part in the attainment of the very low accident rates that the UK services and many overseas air arms now enjoy. It has done this directly, through mandated responsibilities to monitor and improve flight safety within the RAF's training organisation, and indirectly, through its training and supervision of flying instructors and its auditing programmes at home and across the world. It has been at its most effective when strong, authoritative and respected; less so when the CFS Agency arrangements have been weak, and pure flying standards within the front line have been given less emphasis. In this regard, the recent reduction in the rank of Commandant CFS from air commodore to group captain strikes a cautionary note; on the other hand, the ever-closer integration and probable amalgamation of PTC and Strike Command promises greater integration. The challenge of UKMFTS lies ahead. But the issue that keeps me awake at night? What role for CFS in the era of the UAV – the unmanned air vehicle?

ATTITUDES TOWARDS SAFETY 1950-1980 - A PERSONAL PERSPECTIVE

AVM George Black

George Black joined the RAF as a National Serviceman in 1950. Trained in Canada, he flew Vampires, Meteors and FAA Sea Hawks. A QFI, he later flew Lightnings with No 74 Sqn, as the CFI of No 226 OCU and as OC 111 and 5 Sqns. Command of RAF Wildenrath followed, along with staff jobs at MOD and HQs 38 and 11 Gps. More senior appointments included command of a Sector in 2ATAF, Commandant ROC and a post at HQ AAFCE. On retirement in 1987 he joined Ferranti and he is currently a Defence Consultant with BAE SYSTEMS.

Chairman, Ladies and Gentlemen, thank you for your kind remarks and for giving me the opportunity to share some of my personal recollections concerning the important aspects of flight safety through the immediate post-war decades of front line fighter operations. Let may say that my views and opinions are as I remember them from experiences at the time. But, since I cannot recall seeing or reading much on the policy side of flight safety, especially in the early post-war years, it was abundantly clear that operational priorities took precedence over safety issues. It was certainly the case during the 1950s, as evidenced by the high number of training accidents. This seemed to be accepted as the price that had to paid in order to satisfy the task, but, more importantly, it also ensured that pilots flew with the dash and spirit that had characterised operational activities in WW II. How many times in these early days did I come across the expression that 'flight safety is something that stops us getting on with the job'?!

But, before looking at this in more detail, let me tell you about when I first achieved some notoriety in the monthly Fighter Command accident summary dated October 1953. It was the Station Battle of Britain Open Day in September of that year and Item 5 in the document reads as follows:

AVM Black joined his first operational unit, the Meteor-equipped No 263 Sqn, in 1952, a year in which the RAF wrote off more than 500 aircraft, 150 of them being Meteors. This is one of No 263 Sqn's F.8s photographed circa 1954. (MAP)

> 'Tiger Moth accident – Fg Off. Black. The pilot was taking part in a display which included an instructor:pupil demonstration (*I was detailed as the student*). Whilst making a second attempt at a loop the engine cut out in the vertical and the aircraft stalled. A restart was unsuccessful. Height was now about 500 ft so a force landing was made on the airfield. In an effort to avoid the public enclosure the pilot had to make a steep turn close to the ground'

You can guess the rest. The aircraft landed rather heavily – not Cat 5; only 4! However, The Command Flight Safety Officer commented that the prevailing wind conditions made the subsequent forced landing none too easy! I heard no more about the error of my ways, or indeed being apportioned blame for the accident, but, of course, I took the inevitable ribbing in the bar afterwards. However, I must also mention that the CinC, who was standing on the tower roof with the Station Commander at the time, said, 'What is the name of that pilot?' 'Black,' came the answer. To which the CinC replied, 'How appropriate!' I thought it worth recalling this incident because it did, to a certain extent, reflect the attitude to accidents at the time – that aircraft safety was not an over-riding issue. In this instance nothing more was ever said about the accident. Again, to emphasis the point about attitudes, the morning I arrived on my first squadron I was

greeted by my new Squadron Commander who said, 'Flying Officer X has just crashed after take-off and been killed – your arrival is timely; you can take his place on A Flight!'

And so it was for the next few years with training accidents and incidents on the Wing occurring at frequent intervals and being accepted as part of life on front line units. Interestingly, I must make mention here about the situation at the AFSs, the Advanced Flying Schools for jet conversion, where the accident rate was significantly higher than that of the front line. At Driffield, for example, during my four-month course the rate averaged about one fatality per week; I lost three killed on my course alone. Whilst at the time I put this high loss rate down in part to the exciting privilege of training to be a fighter pilot, I have often reflected on the possible reasons why the accident rate was so high. Perhaps the following sheds some light on the issue.

My first observation concerns the scant attention that was being given to ensuring safety during a sortie – the priority always stressed the key operational issues of achieving success in every part of the exercise that had been authorised. Dare I suggest to this audience that at this time we were perhaps not as professional in our flying as we gave ourselves credit for, certainly when considered by today's high standards. At the AFSs the level of instruction varied greatly, yet students were expected, with a minimum of dual flying, to undertake solo exercises involving engine-out asymmetric flying, including circuits and landings. Aerobatic sorties were authorised above total cloud cover, necessitating IMC recoveries on limited panel, because of the toppling of suction driven instruments. Recoveries often had to be carried out in marginal weather conditions into very busy traffic patterns, with only basic D/F as a means of homing. Following an accident on the unit I always assumed that a form of investigation had been carried out, but I cannot ever recall being briefed on the findings. Standard briefings for solo exercises used to include such remarks as, 'When in doubt, get on to instruments; remember the inherent errors and believe what they are telling you and stay with it until you have good visual reference with the ground.'

There is, however, another important aspect which affected both the training and the frontline in the 1950s. The majority of instructors, executives and the rest of the hierarchy were, almost without exception, those with wartime experience, who held strong

convictions that operational effectiveness had to remain paramount. If this involved taking an element of risk then it was clearly considered to be an acceptable part of the routine training programme. But looking back on it now we paid a high cost in both aircraft and lives for adopting such attitudes. Although I have referred largely to the AFSs, much of what I have said could apply equally to prevailing attitudes on the front line squadrons.

Talking of cost provides an ideal point at which to move on a few years to the late '50s and the 1960s when I recall some notable and significant changes in attitude towards flight safety were beginning to emerge. For example, I remember seeing a Manual of Flight Safety appearing in the crew room, although I confess that my awareness of this might have been more to do with my promotion exams than as essential reading for all aircrew. So why the shift towards safer operations? In my opinion we were still experiencing far too many training accidents, even if they were fewer than in the past. First, I believe that Sandys' 1957 Defence White Paper, which resulted in significant reductions in overall front line strength, made any accident and aircraft loss far more noticeable than at any time previously. Secondly, a new generation of more complex aircraft and systems was starting to enter squadron service, albeit in considerably smaller numbers than in the past – I am thinking here of the Javelin and Lightning. Furthermore, compared to former standards, the level of professionalism had also risen. Training standards on the new aircraft had improved; simulation had begun to enter service and I recall that the level of pre- and post-flight briefings was far more thorough in covering the safety aspects of a flight.

There was now a definite shift in attitude which was promoting a keener interest in driving home safety issues whilst also recognising that, up to a point, the press-on spirit was still an essential part of training. It was gradually becoming acceptable to abort any part of a sortie if safety was threatened. A much improved system of reporting all incidents and accidents, however minor in nature, was now mandatory. A clear policy instruction had emerged for recording all the detail associated with improving overall awareness, and achieving higher standards, of safety, at all levels. This, together with the means to circulate and disseminate all the relevant information for the benefit of other users, was a major step forward.

AVM Black was in on the ground floor with the Lightning, joining the first operational unit, No 74 Sqn. These are F.1s of No 74 Sqn wearing the black spine and fin adopted in the summer of 1962. The aeroplane nearest the camera, XM142, was an early casualty as it was abandoned by its pilot following an hydraulic failure in April 1963. (MAP)

Clearly, implementation of these procedures often necessitated drawing a fine line between making a balanced judgement of fulfilling the demanding operational requirement, or aborting a sortie in the interests of safety. This is not to say that the keen press-on overzealous pilot – the type we all recognise so well – had been excluded from the front line. But, importantly, increased levels of closer supervision had been introduced, which resulted in a greater awareness of the ongoing need to minimise the avoidable type of accident which, to a certain extent, had characterised most of our flying activities in the past. Whilst attitudes had clearly shifted and the focus of attention was very much more towards safer operations, the inevitable pressures continued to impact unabated on front line units to meet their many, and often diverse, commitments. Achieving a delicate balance with safety did not always mean that the element of risk was eliminated entirely and, as most here will know, occasionally risks did have to be taken. Meeting the tasks with the available resources, sustaining aircrew currency and combat proficiency, often in the face of difficult manpower shortages, and the timely delivery of critical spares continued to confront the front line and impose severe stretch on the system. Nevertheless, there existed at this time a basically sound understanding of the situation and of the pressures that

units were operating under. Moreover, I believe that when disciplinary action was necessary it was apportioned fairly and at the appropriate level – in most cases.

This is perhaps a convenient point to take a closer look at the Lightning with regard to certain of the above factors, especially as our Chairman has specifically requested that I include my views on its role and highlight some of the key safety issues associated with day-to-day operations. It is generally accepted that, whilst the Lightning was very much the pilot's aeroplane, the engineering effort it demanded, throughout its Service life proved to be enormous – indeed many hours of maintenance were required for every hour spent in the air. Certain critical technical aspects tested the system severely, leading to practices which increased the risk-factor. For example, the robbing of spare parts from other aircraft. 'Robbing', which effectively doubled the manpower effort required, often with poor technical recording in the process, was something to be avoided; yet I confess to being as guilty as many others on the front line of condoning it! That said, I believe that there continued to exist a good understanding of the pressures on the front line in the early to mid-1960s. I recall that the means for taking disciplinary action gave adequate consideration to all the known facts and that careful consideration was given before corrective action was taken.

Our Chairman has told me that, when he was ADC to AOC 11 Group, there was growing concern that we were leaving too many Lightnings in the North Sea. It is true that the loss rate in the late '60s and 1970s had risen dramatically from the earlier years of service. Of the 340 aircraft built (286 RAF and 54 for export) some eighty aircraft were lost due to accidents. Although a large number involved technical malfunctions there was, nevertheless, a worrying trend about the number which continued to be classified in the 'avoidable' category. I put it to you that this percentage loss rate is on a par with that of the notorious *Luftwaffe* Starfighter fleet, indeed it may even be slightly worse. One can therefore understand, but perhaps not condone, the level of concern being expressed up the chain of command and the pressure being exerted to instigate speedy remedial measures once the likely causes for the upsurge in accident rate had been clearly identified – difficult as this often is to pin down with any degree of certainty. Alas, the need to be seen to be taking swift action

A Lightning F.6 of No 5 Sqn circa 1970. (MAP)

often overtook the normal and more lengthy process of well-reasoned judgement with all the facts to hand. There followed a series of unwelcome edicts from CinCs downwards ordering the sacking of Squadron Commanders, Station Commanders and any others in the command chain. As I recall, retribution was swift and frequently implemented with indecent haste. The pendulum had clearly swung too far as far as safety was concerned. Attitudes had clearly hardened and the instigation of a speedy means of removing senior executives from the front line could occur within days, sometimes in hours, following an aircraft accident. I could expand on this but for the moment, I will simply observe that this sort of retribution did not prevent, or even check the trend quickly, but it certainly impacted badly on the morale at the front line!

At about this time I was summoned to see AOCinC Strike Command. Not for a ceremonial sacking in this instance, but to be directed to hand over my CFI post at the Lightning OCU at Coltishall and take command of No 5 Sqn at Binbrook – in three day's time! I was to replace the Squadron Commander who had been removed from post for some of the reasons I have previously discussed, but primarily because of the unacceptably poor performance of the squadron. Soon afterwards the Station Commander also left. Time does not permit me to go into the fine detail, but I can summarise the main issues as a lack of leadership throughout the squadron, where the groundcrew seemed

to decide what was to be done, and a noticeable lack of firm and decisive supervision, of both air and ground crews. This unsatisfactory state of affairs had contributed to at least one recent aircraft loss and a number of other minor incidents. Moreover, the monthly flying task showed repeated shortfalls in flying hours of almost 50% caused by poor aircraft availability. This, on a squadron with its full complement of aircraft, better than average levels of experienced groundcrew and with adequate resources for the task, given, of course, that it was properly managed.

With a Far East deployment only a matter of weeks away, few pilots were current in air-to-air refuelling procedures, and there were other currency issues caused by the shortfalls in flying hours. On the day that I assumed command I assembled all pilots and groundcrew in the hangar, locked all the exit doors, and then issued an ultimatum to the effect that no one was to leave until at least eight serviceable aircraft were available for the following morning. This may have had something to do with the remarkable shift in attitude that occurred. Daily aircraft availability improved steadily; the long range deployment was successfully achieved and three months after its return to the UK the squadron won the much coveted NATO AFCENT Air Defence Trophy.

Yes, it is true that several heads rolled in the process of putting things back in shape, including that of an exchange pilot – and sacking one of those is not an easy decision to take. But I was always mindful of the CinC's last words to me, 'Black, go and sort it out.' I can't remember exactly what else he said, but the message had been abundantly clear and I was left in little doubt about my own career prospects had things not been sorted out and the squadron's performance markedly improved. I acknowledge that my tale has not been wholly concerned with flight safety issues but, as this audience will appreciate, it does feature many of the factors which have, over the years, given rise to the adverse findings of many a Board of Inquiry. However, in conclusion, let me say that I am now firmly of the opinion that an acceptable and appropriate balance has finally been reached between getting the operational job done whilst maintaining a close watch on all aspects of flight safety. Mercifully, gone for good is the adage from former times that it is 'safety which prevents us from getting the job done.'

RAF BOARDS OF INQUIRY – A CASE HISTORY

Wg Cdr Andrew Brookes

Having gained a degree from Leeds University, Andrew Brookes completed his flying training in 1968, subsequent tours providing experience on Victors, Canberras and Vulcans. He held appointments in Hong Kong, at HQ Strike Command, at the Greenham Common cruise missile base and with the IFS before joining the DS at Bracknell. He is currently the Aerospace Analyst at the International Institute for Strategic Studies. He has written a dozen aviation books, four of which deal with flight safety issues.

Since 1918 the official means of investigating accidents to RAF aircraft has been first the Court, and then the Board, of Inquiry. Board rules and procedure have changed little since 1924 and are currently based on the Air Force Act of 1955. Generally a Board is convened if there has been a fatality, if the cause has not been established beyond reasonable doubt, or where negligence or default is suspected.

The Board acts as a fact-finding tribunal but it does more than simply determine accident causes. In a disciplined service, the performance and actions of individuals must also be judged in a firm but fair fashion. The Board of Inquiry (BOI) therefore serves as a convenient, all-round tool from whose findings a commander should be able to judge all operational, administrative, technical and disciplinary facets of an accident.

A BOI is set up by the convening authority, which means the military chain of command. So, if a Lightning belonging to No 11 Group was lost, Air Officer Commanding (AOC) 11 Group would authorise a BOI. The president normally has a current aircrew background, and will be at least a wing commander in the case of a fatal accident. He or she will be assisted on the Board by two or more officer members junior to him – one will usually be aircrew and the other an engineer. They should all have recent experience of the aircraft type or role under investigation, and ideally they should

come from another station so that their judgement is not clouded by personal factors. As an aside, the president should not be junior in rank or seniority to any officer whose conduct, character or professional reputation may be called into question. Thus, when Air Mshl Sir Harry Broadhurst was on the flight deck of the Vulcan lost at Heathrow in 1956, Air Chf Mshl Sir Donald Hardman was president assisted by AOCinC Fighter Command and the Commandant of the RAF College at Manby.

No two Boards are ever the same, but in general terms an RAF accident is investigated along the following lines. Once assembled, the Board begins what can best be termed as a gathering of facts and clearing of thoughts phase. This culminates in the dispatch of an Interim Report by signal within 96 hr (or 48 hr if possible) to give a preliminary assessment of the cause if known, comment on the integrity of the aircraft and its systems, and on the validity of operating procedures. Occasionally a major structural defect can come to light – as when metal fatigue caused the starboard wing to fall off a Buccaneer while it was flying over Nevada in February 1980. The Interim Report can alert higher authority to the possibility of having to ground the entire fleet of the aircraft type concerned until the full facts are known.

As early as possible after assembly the Board considers the need for detailed examination of both the crash scene and the wreckage. In this, as in many other endeavours, it is greatly assisted by outside specialists such as those from the Air Accidents Investigation Branch at Farnborough. Nowadays, requests for assistance from the Institute of Aviation Medicine's Pathologist or Behavioural Scientist are compulsory when an accident involves fatalities or suspected human error, respectively. In short, the Board is never on its own.

The next stage is to take evidence from witnesses. Evidence is given under oath but a Board of Inquiry, not being a court of law, may receive any evidence it considers relevant so long as it is the 'best' evidence available. An important point to be made is that a BOI operates under different rules from a court of law. The rules of evidence are looser and very different for the very good reason that the aim is to find the cause of an accident, not to administer punishment. Lawyers are deliberately excluded and the BOI may

listen to 'hearsay' because legal niceties should not be allowed to stand in the way of flight safety. For this reason, until the 1990s BOI proceedings were privileged. They could only be released to a coroner for the very good reason that if witnesses knew that their statements would end up in the public domain, they might not tell the whole truth and the admirable aim of preventing a repeat flying accident would be lost. Consequently, although BOI evidence was taken under oath, judicial action could not be based on it. If a BOI unearthed an illegal act, the convening authority would have to authorise a separate summary of evidence.

Having sifted all the evidence, the Board is ready to record its findings in a form which aims to provide the reader with a logical outline of what happened together with all supporting evidence. Board proceedings start with a narrative of events followed by a diagnosis of all possible causes. The Board assesses the relative importance of each cause, and accepts or discounts it on the basis of the evidence. For example, a sudden loss of engine power might have resulted from contaminated fuel, so the fuel analysis results must be obtained. This diagnostic process of elimination continues until the Board is in a position to make a statement along the lines of 'the primary cause of the accident was the pilot's failure adequately to maintain airspeed during the later stages of the approach. A contributory cause was the presence of moderate turbulence.'

The Board then considers other factors such as degree of injury, whether Service personnel involved were on duty at the time, compliance with orders and instructions, the effectiveness of aircraft escape facilities, damage to property, and consideration of human failings. Finally, the Board makes its recommendations with the aim of preventing a repetition. The whole package is then progressed through the command chain until the Board is finally signed off by the Air Officer Commanding-in-Chief. Finally, the report will go the Inspector of Flight Safety, an independent arbiter with right of direct access to the Chief of Air Staff. At any stage in this process, the Board can be re-convened if errors or omissions are found which need to be resolved. Although a BOI report will be signed off by a handful of senior officers, it will have been checked and authenticated by hundreds of aviation professionals in the process.

Remember that the role of military flight safety is not to reduce aircraft accidents to zero – it could do that tomorrow by banning flying! It is to reduce accidents to a minimum consistent with maintaining operational effectiveness.

Harking back to my first point, about a BOI not being a court of law, convening authorities could not come up with a verdict like manslaughter. However, they could point the finger of blame by announcing that someone had committed an 'error of judgement', or been guilt of 'negligence'. What is the difference? In general terms, if a pilot is faced with an unusual situation with several courses of action open to him and, with hindsight, it can be shown that he chose the wrong one in good faith, that is an error of judgement. Negligence on the other hand means not taking care when any reasonable person would expect care to be taken.

That said, the Manual of Flight Safety is quite specific in that 'only in cases where there is absolutely no doubt whatsoever should a deceased airman be found guilty of negligence.'

Let me run through a case study to illustrate the scale and the dedication to detail involved in one high profile BOI.

Back in 1959, Britain's most modern strategic jet bomber was the Handley Page Victor Mk 2. It was derived from the Victor Mk 1 by the classic 'stretching' process of bigger engines, more wing area and higher all-up weight, but, as the first contract for Mk 2 Victors excluded provision for a prototype, a Mk 1, XH668, was brought forward on the production line at Radlett to assume the role. Painted overall in anti-nuclear flash white, XH668 made its maiden flight in the hands of the company's Deputy Chief Test Pilot, Johnny Allam, on 20 February 1959.

After manufacturer's proving flying, XH668 was transferred to the experimental and evaluation establishment at Boscombe Down for preview handling trials. The first trials flight, scheduled for Wednesday 20 August, called for a climb to 52,000 ft, an hour's tests, including high speed turns to reach the fringe of wing buffeting and to pass a little beyond it, a rapid descent using airbrakes down to 35,000 ft for a further series of tests before returning to Boscombe after a trip lasting two to three hours.

XH668 got airborne at 1035 hrs local time. A warning of an aircraft passing ahead was acknowledged by XH668 at 1038 hrs, but

XH668 – the prototype Victor B Mk 2.

Boscombe had no further radio contact with the Victor crew. Although Boscombe's Flying Orders stated that prototype aircraft should maintain communications with the ground, XH668 was regarded as a new mark of an existing type so it was not considered to be 'a prototype' under the terms of this Order. Furthermore, because of weather vagaries and the large distances covered at high speed, pre-flight submission of a precise flight plan was not expected and therefore Boscombe had only a rough idea of when and where the crew intended to operate.

Whatever the rights and wrongs of this loose-leash system, no one was officially keeping an eye on XH668. It was only because the Victor captain had asked for his landing run to be photographed that anyone noticed anything amiss as early as they did. At about 1310 hrs the photographer made a telephone call to ATC asking for XH668's estimated time of arrival. After some confusion, because nobody was exactly sure how long the test crew intended to stay airborne, 'overdue' action was taken at 1503 hrs. By then, XH668 had long

since disappeared from the sky.

A Board of Inquiry was convened at Boscombe on 21 August. The disappearance of Britain's latest bomber conjured up all manner of theories, including a hijacking along the lines of James Bond's *Thunderball*. Many people said that they had seen an unfamiliar shape 'flying at a great height and very fast', but most sightings were either too late in the afternoon or in unlikely places such as 'low flying over Kensington'. There were also the usual weird offerings, such as that from the Parisian gentleman who attributed the loss of XH668 to mysterious, but nonetheless damaging, powers unleashed when the moon rose and set.

On a small coaster, *Aquiety*, bound from the Mersey to the Thames on 20 August, the Master had heard a BBC radio broadcast that an aircraft was overdue from Boscombe Down. Earlier that day, when the coaster was off St David's Head, Pembrokeshire, the Master and two of his crew had been on the bridge because there were extensive fog patches about. At around 1140 hrs the vessel ran out of the fog and the seamen observed a large column of water and spray about 50 feet high and some five miles away, followed almost immediately by two sharp reports similar to rifle fire. Fortuitously, radar stations kept films of all responses seen on their screens and GCI Wartling in West Sussex found a radar track that ended abruptly at approximately the same position and time as that reported from the coaster.

The final radar response from the Victor showed it to be in a turn to port and the corrected position of this last response and the position of the splash were found to be only 10 miles apart. The view that, at least a substantial portion of, XH668 had entered the water at the reported position was confirmed on 25 August when the first white fragment of Victor radome was found by a schoolboy on White Sands beach at St David's.

At this stage, there was no evidence as to why the Victor went down when it did. The HP Deputy Chief Test Pilot was completely satisfied with the performance of Sqn Ldrs Morgan and Stockman. While at Boscombe, the aircraft was serviced entirely by Handley Page personnel. There was an adequate supply of oxygen on board and as individual crew members were wearing air ventilated suits, anti-g trousers, partial pressure jerkins and helmets, they should have been protected from the physiological effects of flying high.

Boscombe was a very secure airfield patrolled at night by police with dogs, and to wipe a Victor off the screen at one fell swoop would have required precise knowledge about take-off time, duration of flight and the vulnerable parts of the aircraft's structure. The sabotage hypothesis just did not seem to be credible.

The plotted track of the missing Victor passed close to the missile range at Aberporth which around that period was testing the Bloodhound surface-to-air missile designed specifically to cope with high-flying jet bombers. No novelist would have dared to use the plot but – suppose that a Bloodhound had been test-fired out over the Irish Sea and the Victor was heading in that direction. The Bloodhound suddenly went astray, its controller found that his destruct button would not function, and the latest British air defender collided with the latest British attacker. It must have been with a sigh of relief that the inquiry found that there had been no missile launches from Aberporth on 20 August, nor had there been any simultaneous activity in adjacent danger areas where interceptors may have been firing guns or air-to-air missiles.

Just as there is little chance of securing a murder conviction without a body, the investigation into the loss of XH668 could progress no further in the absence of a substantial amount of wreckage. An extensive air and sea search had been going on which by 1 September had narrowed down to an area 16 miles long by 12 miles wide in a south-southwest direction, centred on the estimated position of the splash noted by *Aquiety* and now marked with a datum buoy. Some 192 square miles might not seem an overly large area, but it approximated to the major part of Greater London from Tottenham to Streatham and from Woolwich to Ealing. XH668 was felt to be somewhere in that area: it might be in six or 600 pieces, but if it was there it had to be found and raised to the surface to re-establish faith in a crucial pillar of British nuclear deterrence.

The trouble was that St George's Channel was nearly 400 feet deep where the splash had been seen. Visibility down there was very limited and the sea bed was scattered with rocks plus more than forty other wrecks. Nothing daunted, the Royal Navy set up an operations room near Milford Haven from where ships carried out a co-ordinated sweep of the sea bed with ASDIC, the submarine detection device. When suitably high intensity echoes were found, wreckage was retrieved by fishing trawlers

specially hired for the purpose. As time went on, the number of trawlers would rise from four to sixteen, supplemented by a special salvage ship, *Twyford*, which carried a diving chamber, underwater television and huge grabs capable of lifting 20 tons.

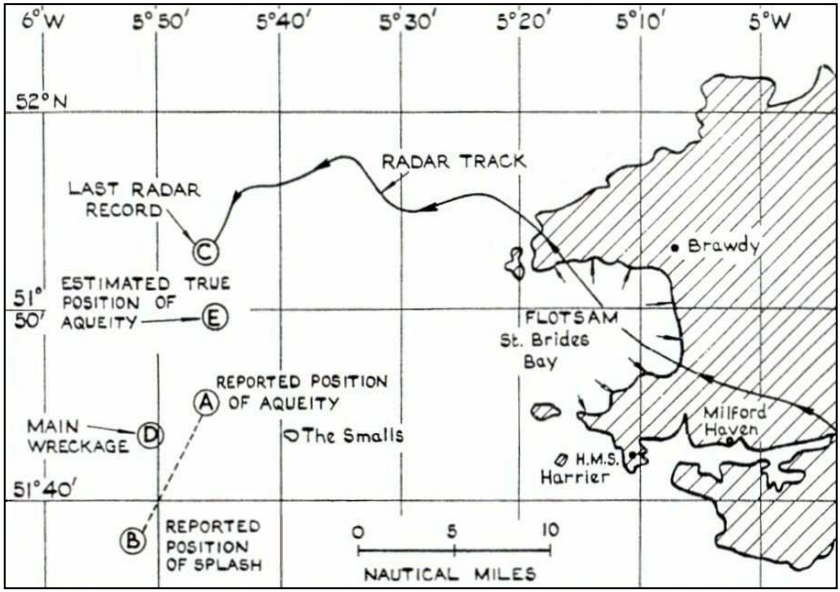
Christmas Day came and went without any success. Then on 5 January 1960, the *Picton Sea Lion*, a trawler fishing out of Milford Haven and independent of the search itself, left her nets down instead of picking them up as she approached the designated search area. When the catch was finally examined, it contained a crumpled piece of shiny corrugated metal bearing only a trace of marine growth. The small piece of metal was hurriedly dispatched to Farnborough where it was identified as a piece of Victor.

But it was not until 13 March that the trawler *Clyne Castle*, searching north of the Smalls, brought up four pieces of bent and twisted metal, seven pieces of fibreglass and three lengths of plastic-covered wire. By noon the next day, all fourteen pieces had been identified as wreckage from XH668. After seven months' effort the trail was getting warmer.

On 23 March the trawler *Forards*, operating further west than usual, recovered a piece of engine and some outer skin of one of the bomb doors. The large and unbuckled piece of bomb door was the first indication that the Victor had begun to break up before hitting the sea.

Dr Percy Walker, Head of the Structures Dept at Farnborough and the man tasked with overall investigation into the accident, authorised the diversion of two trawlers to search the new western area. However, while they concentrated on looking for pieces that must have broken away at altitude before gently falling into the sea, the real search effort swung towards where it looked increasingly likely that the mass of the wreckage had hit the water – the area where *Clyne Castle* had made her initial find. For three days *Twyford's* underwater TV camera tried to pierce the sea bed gloom and guide the grab towards more than mud before the trawlers were brought back in again. Overnight they recovered 42 pieces including more engine parts and a whole ejection seat. By the end of March, 100 pieces – or just over 1% of the Victor by weight – had been recovered.

Every time a piece was lifted from the sea bed, it followed the same route: by sea into Milford Haven, from there by road to the RNAS at Brawdy and thence by air to Farnborough. At Farnborough, a full-size skeleton of the Mk 2 prototype had been erected and was waiting: such

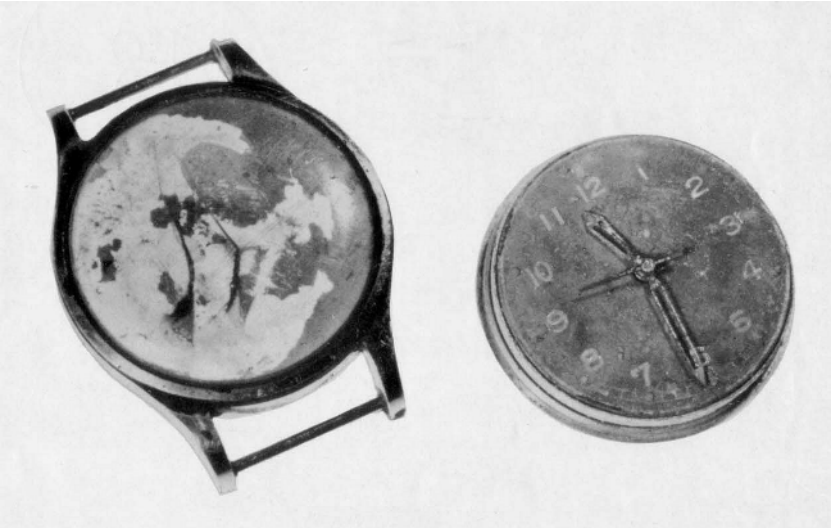


Map of the search area.

was the importance accorded to the whole exercise that the second Victor 1 prototype had been dismantled at Radlett and its major components taken down to Farnborough for comparison. The plan was that XH668 would be more or less rebuilt from its broken remains, and in fitting the jigsaw back together it was hoped to discover why it had broken up in the first place.

By dint of meticulous manual plotting of each recovered piece, it was soon possible to pinpoint by Decca navigation equipment the area in which XH668 was most likely to be found. As the total score reached 275 pieces on 7 April, a marker buoy was dropped on the new Search Datum. It was over five miles north of the original datum and *Aquiety's* estimated position of the splash.

By 21 June, 100 days after *Clyne Castle* had located the first piece of Victor wreckage, 18½ tons had been found. XH668 weighed around 63 tons when it crashed of which 20 tons was fuel. The maximum recoverable weight was optimistically put at 40 tons, which left 21½ tons still to be found but, having recovered half-a-ton a day in June, a definite pattern was emerging. Nearly all the wreckage was concentrated in a relatively small circular area not more than 200



The co-pilots watch, which had stopped at 11.30.46.

yards in diameter, but Farnborough was becoming just as interested in wreckage being recovered from the western outer area. It was there that pieces were recovered showing remarkably little damage, pointing almost certainly to portions of aircraft having broken away before the main mass hit the water. Had they remained attached to the Victor they would have suffered the same impact damage as all the other wreckage recovered from the main area. It therefore became most important to recover more of these relatively undamaged pieces to determine why and in what sequence they had become detached.

Eventually 592,610 pieces of Victor would be retrieved. Individual pieces ranged from a few ounces up to an engine component weighing 570 lb, but no matter what the size every fragment was examined – sometimes microscopically – and its place identified in the Victor skeleton mock-up. One small piece of evidence that contributed more than most was the co-pilot's wrist watch. Given the shattered condition of the co-pilot's ejection seat, his watch must have been in the aircraft when it struck the water. The hands on the watch face had stopped at 11 hr 30 min and 46 sec, and experts concluded that at this time the watch had been stopped by a single violent blow.

Colleagues of the co-pilot were unanimous in stating that he was meticulously precise in setting his watch, but the master of *Aquiety* had seen the splash at 11.40hrs so there was now a discrepancy in time as well as position. *Aquiety's* log was obtained and the reported bearing and estimated distance of the splash were found to have been extremely accurate. It was where the coaster was said to have been at the time of sighting that was wrong. That was her position when the entry was actually written into the log, *not* where she had been when her crew saw the splash. Once the true position of the splash was calculated, it coincided almost exactly with the location of the main wreckage. If only the searchers had known that nine months earlier, it would have saved so much time and effort.

The combined evidence from Wartling radar and the co-pilot's watch indicated a time of descent not exceeding 1.25 min. The condition of the wreckage was also consistent with a rapid descent and Farnborough was able to show that XH668 had struck the sea at around 700 mph whilst diving steeply. Calculations indicated that the prototype would have rapidly gone supersonic at high altitude – the sharp reports heard on *Aquiety* were probably sonic bangs – but the speed would have become subsonic again in the denser atmosphere lower down. Nevertheless, a descent speed around 600 kt would have been sufficient to tear XH668's bomb doors and wingtips away between 8,000 ft and 5,000 ft. Bomb door disruption was not unexpected but it took wind tunnel tests to establish that the wingtips would have fluttered at the appropriate height as the speed passed from supersonic to subsonic. Although the wingtips would have disintegrated with the onset of flutter, the remainder of the wing structure stayed outside the flutter range and reasonably intact.

The aeroplane had remained in a clean configuration with flaps, undercarriage, and airbrakes retracted, but rather surprisingly the nose flaps along the outboard wing leading edges were found to have been extended. All four engines had been running at high power with throttles set forward, and there was no evidence of any fire. An interesting find was one of the voltmeters which, although crushed on impact, showed a faint mark on the dial when viewed through a microscopic lens. The needle itself was still under the sea but the

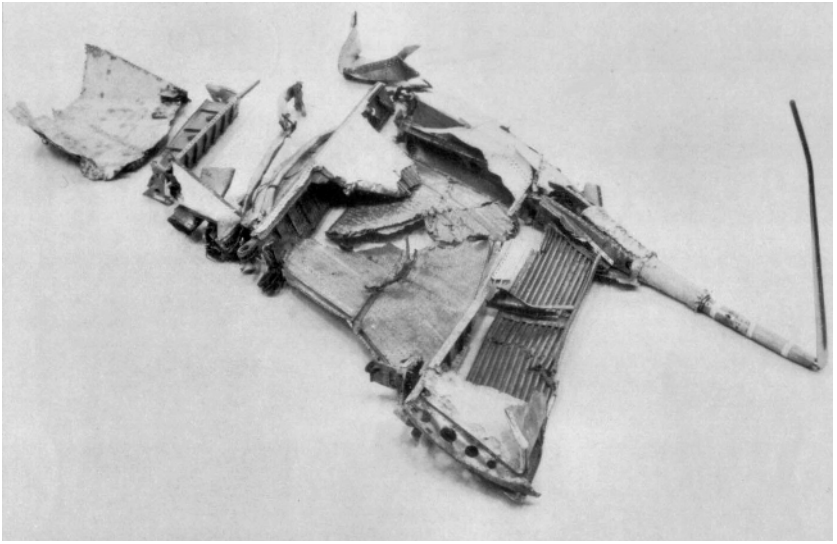
faint mark showed where it had been smashed against the face of the dial as the aircraft hit the water. The meter was registering 200V at the time which showed that the Victor's main electrical system was working right up to the end.

Two weeks after XH668 went down, a Victor 1 flying out of Boscombe had spontaneously lost both pilots' roof hatches due to misalignment of the quick release catches. For a time it was feared that the same might have happened to the Victor 2 prototype, causing the crew to lose consciousness immediately above 50,000 ft, but when XH668's hatches were eventually retrieved they were only slightly damaged and appeared to have been intentionally jettisoned below 10,000 ft. The captain's ejection seat had left the aircraft in the correct manner but although he had separated from his seat, his parachute would have been unable to deploy properly. The co-pilot's seat had not left the aeroplane but the evidence showed it was still occupied and in the process of ejection. The rear crew seats were barely recognisable.

Knowing that the pilots were fully conscious and not injured in any way, and having recovered motors, generators and hydraulic pumps that showed signs of running just before final impact, Dr Walker and his team had to consider loss of control brought about by other factors. Going back to the beginning, XH668 and its crew had been sent to operate up to a speed of Mach 0.97. As the Victor approached the speed of sound, aileron control would have virtually disappeared because the power flying control jacks would have been unable to supply the heavy forces required to operate the down-going aileron. This would not have been critical when flying straight and level, but the crew was briefed to carry out buffeting steep turns and buffeting would have restricted the amount of extra lift the elevators could generate. The combined effects of all these factors meant that a spiral dive could have developed from which recovery became less and less likely as speed increased.

Yet even if this had happened to the Victor, it would have been the result and not the cause of the accident. This issue rested on what had caused the Victor to exceed Mach 0.97 in the first place?

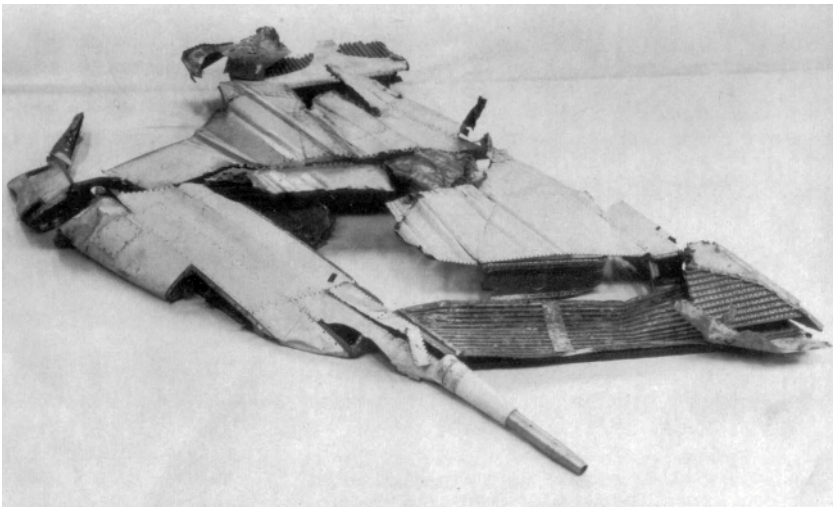
Among the recovered wreckage to be re-assembled and examined were the wingtips which came adrift during the descent. Victor 2 wingtips were more or less self-contained and detachable



The port wingtip of XH668 with its pitot tube bent through more than 90° but still in place.

units, and each carried a long, slender tube, projecting some six feet ahead of the wing leading edge and comprising both static and pitot pressure systems. When the wreckage of the port wingtip was re-assembled it was noted that the pitot tube was bent through more than 90° at the end of the supporting sleeve that constituted part of the mounting. This damage was probably caused by flutter late in the descent but it was significant that, despite the severe strains imposed, the pitot tube base remained firmly held in its mounting.

The re-assembled starboard wingtip told a different story because, although structural damage was similar to that on the port side, the pitot tube was missing in its entirety. A Victor pitot tube was held in position by a form of chuck in which a conical sleeve was tightened against two tapered collets. There was nothing wrong with the design but the starboard pitot tube had come cleanly and neatly out of its mounting without any signs of damage. Furthermore, when the tapered sleeve for the starboard mounting was recovered from the sea with the collets still in position, the inside of the sleeve was found to be covered in protective paint which had clearly been applied too freely. It was surmised that the



The starboard wingtip, which had lost its pitot tube.

sleeve had originally been tightened adequately but only against localised areas of paint. As the paint wore away or became distorted, progressive loosening of the collets' grip upon the pitot tube could reasonably be expected. Nothing similar was found on the port installation.

The main flying instruments were duplicated – the port pitot tube fed the captain's instruments while the starboard fed the co-pilot's and navigator's – and the pitot systems were in many ways identical, but the starboard was unique in serving the 'stall detector' and the Mach trimmer. Wind tunnel tests a decade earlier had predicted that the crescent wing stall would be pretty vicious, so Handley Page developed great accumulators of stored energy which thumped leading edge flaps down within a second on a signal from a pressure ratio switch which calculated lift coefficient from tappings below the wings. While the flaps travelled, warning lights illuminated in front of both pilots. As it turned out, the stall was nothing like as bad as had been feared so the nose flaps would eventually be locked up on the Victor 2, but in 1959 XH668 still had them. In addition to pressure ratio switch signals, the stall detector received pitot and static pressures from the starboard pitot tube.

The Mach trimmer was incorporated to counteract the nose-down trim change caused by air compressibility at high Mach number. As the aircraft accelerated from Mach 0.85 to Mach 0.95, the Mach trimmer raised the elevators through an angle of about 5° without altering the stick position, and irrespective of the pilot's control inputs, in response to pressures conveyed from the starboard pitot tube.

With all this information at their disposal, Dr Walker's team set off by assuming that XH668 was flying buffeting turns around Mach 0.94 at 52,000 ft. Suppose then that the starboard pitot pressure tube started to come adrift slowly under the effect of all the buffeting. A leak would slowly develop causing a fall in indicated airspeed on the co-pilot's side. Assuming this was noticed, the captain's instruments would still be functioning properly and maybe the assumption was made that a bit of water in the starboard system had frozen up.

So far so good, but then the pitot tube dropped clean away. Zero speed would definitely have been recorded before the co-pilot but as the tube fell away the stall detector would have lowered the nose flaps. The first the pilots might have known about this was when the warning lights came on, but what would they have made of them? At Mach 0.94 and 52,000ft, a Victor Mk 1 would have sailed along very comfortably like a knife through butter, but in similar circumstances a Victor 2 buffeted and shuddered around most uncomfortably because of its larger wings and bigger engine air intakes. XH668 would certainly have been bucking and rearing round the stops as its crew explored the steep turn buffet boundary, and in such circumstances the warning lights and lowering nose flaps would only have confused matters because they would have been activated for no reason as far as the crew was concerned.

Faced with stall warning indications, the natural reaction would have been to lower the aircraft's nose. Unfortunately, these distractions would have masked the most sinister 'gotcha'. At Mach 0.95 the Mach trimmer would have been fully out, but on receipt of a spurious low-speed signal it would have steadily lowered the elevators and pushed down the aircraft's nose which was very efficient aerodynamically. Moreover, the elevators would be lowering through almost 5° at a time when the pilot might have been pushing the stick

forward himself. The combined nose down movement – and it might have been increased if the co-pilot had instinctively reacted to an apparent fall in his airspeed indicator before realising what was happening – would have pushed the Victor quickly beyond human recovery. It is most likely that the throttles stayed open and the airbrakes closed because both pilots were concentrating all their hands and efforts on trying to overcome the forces opposing the aileron jacks to level the wings as an essential preliminary to recovering from the dive. It would have been a futile effort and the crew was doomed as the spiral tightened. On deciding that the wings were now at a low incidence, the stall detector should have sent a signal to raise the nose flaps, but the aerodynamic forces experienced in the high-speed dive would have resisted their operating jacks as well. Although the sequence of events in the critical period could never be established precisely, XH668's nose flaps were found to be down and its Mach trimmer actuator virtually fully retracted when it hit the sea. The jigsaw fitted together to provide all the ingredients of a major disaster. To prevent recurrence, the mountings of the pitot tubes of all Victor aircraft were modified such that the collets were locked permanently and therefore could not vibrate loose in future under any circumstances.

Right at the bottom of St George's Channel, a Victor 2 pitot head lies buried in the sand and is ever likely to remain so. And 30% of XH668 was still missing by the time Farnborough called the trawlers off on 19 November 1960, but Dr Walker's men had the answer and the winter storm season was rapidly approaching. The wreckage area has been described as the bleakest and roughest patch of sea anywhere in the vicinity of the British Isles, and in all 1,480 men and forty vessels, or twice the number of ships as were involved in the search for the BOAC Comet that went down off Elba in the Mediterranean six years earlier, took part in the quest for XH668 over fifteen months. After spending £2 million at 1960 prices (the cost of a new Victor 2), Britain restored the bomber's credibility.

The modern answer to pinpointing wreckage expeditiously is the Accident Data Recorder (ADR). Lacking an ADR, the only record of what went on inside XH668 that fateful day was a fragment of the crew's last conversation transmitted in error and picked up purely by chance at Boscombe. It was a very weak and

mangled transmission and by a freak of radio it told the inquiry that the crew had been listening to 'Mrs Dale's Diary' as the aircraft went down.

If the loss of XH668 taught anything, it was that everybody involved in building, operating or maintaining aircraft, no matter how remote from the flight line, must always give their task their utmost care. Quality control and effective supervision are not just high tech preserves: they apply right down to the chap with the paint brush.

Once the loss of XH668 had been rationalised the Victor's credibility was restored, permitting the Mk 2 to take its place in the deterrent force. This, BLUE STEEL-armed example is XL190 of the Wittering Wing. (MAP)

AFTERNOON DISCUSSION

Wg Cdr Jeff Jefford. To ensure that they are reflected in the account of the day's proceedings, I would like to raise two issues. First – the hazard that aeroplanes can represent, even while they are still on the ground. In one of Stuart Hadaway's film clips we saw a foreign object being ingested by a Vampire. This will have done the engine little good, of course, but, although there have been some unfortunate incidents, jets do not, generally speaking, eat people. As a result, the flight line is a far safer place that it used to be in the days of whirling propellers. The first man to be killed by a prop died in 1912 and such accidents became commonplace during WW I. There were, for instance, no fewer than thirty-two propeller-related incidents in the UK in September 1918 alone. They would not all have resulted in fatalities but some certainly did. Indeed propellers caused so many injuries, including amputations, that accidents involving propellers were toted separately in inter-war statistics. There was a steady improvement in the figures between the wars but the position deteriorated again during WW II. I would imagine that a significant

Until the Hucks starter became available in the mid-1920s, the most common means of starting an engine was 'swinging the prop', an inherently dangerous exercise which could result in injury, or worse.

factor would have been an increase in the employment of rapidly trained and inexperienced ground personnel. One can picture a young, unskilled airmen, standing under the wing of a Wellington holding the rope with which he had been told to pull the chock away when the pilot gave the signal. In the dark, with his senses overwhelmed by the thundering engine, his attention would have been entirely focused on the task in hand, and in getting it right – on not fouling up. On seeing the pilot wave the chocks away, he would have heaved on the rope – and walked straight into the propeller. This sort of thing happened, all too often.

Wg Cdr Andy Brookes. I think your point is very valid. Because we are accustomed to talking about *flight* safety, the inference is that we are concerned only with 'flying'. But flying is, of course, only part of the problem. I think that I am right in saying that, after aircrew, armourers were the group most at risk during WW II. And accidents with weapons still occur today. I am thinking, for instance, of the injuries inflicted on a party of soldiers by the inadvertent release of a missile from an aircraft at Port Stanley – as I recall, it was something to do with an armament safety switch, associated with the undercarriage, having been disenabled, perhaps because the aeroplane had been raised up on jacks. I suspect that technical procedural regulations would probably have prevented this happening at home, but this incident occurred under field conditions when pragmatism may dictate deviations from 'the book'.

(Subsequent to the meeting, ***AVM Peter Dodworth,*** *who had presided over the Broad of Inquiry, was approached with a view to clarifying Wg Cdr Brookes' recollection, and providing, in broad terms, a description of what had actually occurred. The Sidewinder arming switch had three positions: vertical for off, forward for live and rear for jettison. The jettison mode fired the missiles with unarmed warheads without the need for any further buttons or triggers. During the shut down checks after the previous sortie (which had been at night), the pilot had inadvertently selected the jettison position. Most, if not all, of the other switches in the Harrier were back for 'off' and forward for 'on', so it was customary on shut down to put all switches to the rear. But provision for Sidewinder had been made only recently, and at very short notice, immediately prior to deployment to the South*

Atlantic, which would explain why it did not conform to the standard arrangement. The same pilot flew the aircraft the next morning and did not move the Sidewinder switch. He therefore took off with 'jettison' pre-selected and, when the 'weight-on-the-wheels' micro-switch completed the circuit, the missiles fired. Both hit a group of soldiers working at the upwind end of the runway where they had been chipping away at the ice so that the runway could be opened for a Hercules to get in and take them home. The sharp-edged fins of the missiles severed the legs of several of these men. One lost both legs and several others each lost one. None of them died because of the prevailing high state of readiness and level of training. They were given very good first aid and transferred by helicopter to the hospital ship where they were on the operating table within about 15 minutes of the accident. There will, of course, have been many other factors surrounding this unfortunate accident but these are the salient points.)

Jefford. The other topic I wanted to raise was the use of simulators, not least in the context of the asymmetric 'problem'. I am pretty sure that, in the past, we probably crashed more multi-engined aeroplanes learning how to cope with an engine-out situation than we lost through actual engine failures. Flight simulators are now so sophisticated that we can rehearse all manner of dangerous conditions. As a result, we become so competent that, when faced with a real problem, we either survive or crash extremely professionally, having practised it many times before! Would the panel care to comment on the impact of simulators?

Wg Cdr Colin Cummings. In the context of civil aviation, I would offer the thought that when the loss of a Trident, at Staines in 1972, was being investigated a flight simulator was used to recreate the condition that resulted if the leading edge flaps were retracted too soon. Seven pilots 'flew' the exercise and none of them were able to cope with the situation. So simulators can certainly be a useful investigative tool – after the event.

AVM Paul Robinson. Simulators are very useful tools, but you do have to use them with great care, because they are not the solution to every problem. In flying training, for instance, while we do try to save as much money as possible by using synthetics, in the final analysis

simulators are no substitute for proper flying hours. They can also engender a dangerous degree of overconfidence. I recall a pilot who, because he was temporarily grounded with some medical problem, had been obliged to spend a great deal of time in the simulator and he had become accustomed to flying it right down to ground level when practising instrument recoveries. Shortly after resuming flying he did exactly the same thing for real and his wheels cut through the heather in the undershoot at Leuchars. So, while they can generate complacency, there is no denying that simulators are of enormous value in the context of instrument flying – you can do a far better instrument rating in a simulator than you can in the aircraft – and for practising emergency procedures – you can present people with situations which you would not dare to try in the air. But – you do have to use them very, very carefully.

AVM George Black. I would endorse all of that. The early simulators, like the 'Lightening bolted to the floor' were very good for getting procedures right, for gaining familiarity with the cockpit layout, and for gaining experience in interpreting the radar. But many of the incidents that we encountered in real life had not been incorporated into the simulator's programme, so there was a constant need for updates in response to feedback from actual emergencies. Much the same was true of the early Harrier simulator. I don't think that many of us really liked it very much. Although it was good for certain things, it was very limited when it came to simulating the operational role. Things have improved tremendously since then and on the civil side, judging by what my son tells me, the airlines place great reliance on modern simulators and they do it with great confidence. But I am not sure that the military will ever be able to substitute synthetic training for flying time to the extent that the airlines do because there is no substitute for getting your backside into a real aeroplane and 'doing it'. The simulator lobby might disagree, of course, but time will tell.

Jefford. It's the adrenaline factor – or the lack of it.

Black. Exactly! Picking up on your point about propellers; I do recall an incident in which somebody was sucked into the intake of a Meteor, so there were accidents with jet aeroplanes. But even today I

still see people wandering around flight lines, evidently quite unaware of the risks represented by propellers. You can, for instance, still get a 'live mag' which will cause a prop to kick back with enough force to do you damage. We tend to forget about old-fashioned problems, but they haven't gone away.

Robinson. The air force has actually changed its policy on propellers. You may recall that it used to be the practice on Air Experience Flights for cadets to climb aboard with the engine running. That is no longer the case; today we shut the engine down while cadets get in and out. So we do learn – slowly.

Peter Hearne. Perhaps I could expand on George Black's point about folk being unaware that the flight line is a dangerous place. I am involved with one of the larger sporting flying organisations which has some 10,000 active pilots. We have recently seen the annual fatality rate rise from 1 per 2,500 active pilots to 1 per 1,000. If you relate this figure to the UK's 3,500 annual road deaths it turns out that you have a 16 times greater chance of being killed flying one of the aircraft types with which I am concerned than of dying in a road accident. Even compared to the highest risk category of road accidents, that is to say motorcyclists, it is still 2½ times safer to ride something like a Honda Fireblade than to fly one of these aircraft.

There is a serious problem here and it is rooted, I believe, in an assumption that flying is inherently safe, that there is more risk involved in driving to the club than in getting airborne – which is clearly not actually the case. I am currently trying to educate my people by publicising some of these figures but it is an uphill struggle because it means overcoming the widespread, but false, perception that flying is not a dangerous activity. Flight safety has to begin with the attitudes of pilots who have to be persuaded to accept that there are risks and that it is their responsibility to acknowledge them and to act accordingly. I wonder whether this question of individual responsibility represents a problem within the Service environment.

Black. I quite agree. I still fly light aircraft, from Halton, and have observed the lackadaisical attitude towards safety. Loose articles, for instance; we have found mobile phones, cameras, spectacles, all manner of things in our Chipmunk – an aeroplane which we use to

teach aerobatics. No matter how hard we try, we don't seem to be able to impress upon people just how potentially dangerous flying can be. It all comes down to discipline in the end; the difference between an essentially civilian and a military community, as I am sure that Commandant CFS and his team find on their visits to check civilian instructors. But we just have to keep driving the message home – despite resentment from some individuals within the civilian club environment..

Robinson. They are always on their best behaviour when the CFS visits, of course, so the problems are perhaps less obvious. But it is, as you say, very different in the Service where attitudes have been completely transformed, even compared to the RAF of thirty years' ago when I was a young pilot. Today's aircrew are totally professional in the way that they go about their business. I wonder whether there is an element of bravado involved; is civilian life so humdrum and boring that some folk actually feel the need, perhaps subconsciously, to take risks?

Black. I think that it is essentially a lack of discipline. At one time the air force tended to 'kick the tyres; light the fires; first one airborne is leader; brief on 121.5.' but those days are long gone. I have the highest admiration for the standards I see in the front line today – and in the airlines. But attitudes still leave much to be desired in the world of private flying and flying clubs where pilots self-authorise and fly off in weather which I would certainly have second thoughts about. Alas, mention the word 'discipline' in flying club circles and you can see and feel the resentment – 'We're not military here!'

Hearne. The fundamental point that we have to get across is that being airborne, in fact being *in* an aeroplane, is a dangerous place to be. Once that has been grasped, there is a logical follow through to the need to observe flight safety procedures. The problem is getting people to recognise that danger in the first place.

Robinson. Perhaps, but you do still need that element of discipline; there has to be some sense of impending retribution. If someone leaves a loose article in the cockpit of a Service aeroplane you can take some positive action, even if it is only taking them to one side and giving them a thorough talking to. Can you do that sort of thing in

a civilian flying club? Or does the financial imperative represented by their membership fees oblige one to turn a blind eye?

Gp Capt Jock Heron. I would like to explore the old chestnuts of practice asymmetric and spinning. In the 1950s CFS was still insisting on doing practice asymmetric, down to 130 knots in a Meteor, and spinning for a prolonged series of turns, rather than simply inducing the onset of a spin and then stopping it. We lost a lot of people doing these very dangerous exercises. Would the panel care to comment?

Robinson. I purposely avoided asymmetric in my presentation because I was quite sure that it would come up in discussion, so I focused on PFLs and turnbacks instead – these being similarly dangerous activities. The question we have to ask is: why do something if it is not necessary, and is quite likely to kill you, especially when there are better ways of doing it? I mean why do an asymmetric *overshoot* for heaven's sake?! The teaching today is to land from your asymmetric approach; you don't practise going round again.

Black. I never understood the arguments of the spinning lobby. Eight or ten turns in a Vampire? Why? For what purpose? I have always been opposed to spinning aeroplanes intentionally, indeed it was actually forbidden in some, the Lightning and the Javelin, for instance. Even in more docile types it is quite sufficient merely to demonstrate that if you take control of the aircraft, certainly a trainer, at the point at which a spin is about to start and then centralise the control column it will avoid the spin developing. This prevents any unnecessary pilot inputs, which invariably aggravate the situation.

Robinson. That is the current policy. We teach people to recognise an incipient spin and then recover.

CHAIRMAN'S CLOSING REMARKS

Air Cdre Richie Profit

We have touched on many issues during this seminar. Flight safety is of vital importance – it impacts directly on operational capability and effectiveness. This has been underlined over the past twenty years when the inventory has shrunk to a small number of extremely expensive aircraft – avoidable accidents have become increasingly unacceptable. However, operational capability must always take precedence and safety should not be put on a pedestal. That said, in my opinion and from what we have heard today, military aviation could benefit by the policy makers' adopting a more systematic approach to the management of flight safety – if they have not already done so.

Within the Service careers of most of us here, the highest accident rates have always been in the air defence and ground attack fighter forces and subsequently in the fast-jet force. These aircraft are demanding to fly and, more so, to operate. In the civil aviation world, all western type-certificated large public transport aircraft are built to an airworthiness design requirement such that no failure of any single safety critical system or component can give a greater probability of a catastrophic accident than one in a billion flying hours per airframe. Furthermore, an airliner is designed to be flown and operated safely by the lowest common denominator amongst the civil licensed pilot community.

There was a change in attitudes towards flight safety and the expendability of aircraft with the introduction of the V-Force in the late 1950s. This was a very expensive set of vital assets and had to be preserved – the excellent flight safety record of the V-Force speaks for itself. In 1969 when it first entered service, the unit cost of a Harrier was of the order of £750,000 and a couple of years or so later, a new Jaguar only cost in the region of £1.5 million – both with high accident rates that were reluctantly tolerated. However, with the introduction of the £20 million Tornado, official tolerance of a high accident rate was significantly lowered. It was around then that many new innovations were introduced – in training, in the airworthiness of design, and in reliability, maintainability and availability. Prior to this, it would seem to me that the approach to flight safety at the policy and

command level had been primarily reactive. When the accident rate was perceived to be unacceptable, initiatives were frequently taken and sometimes decisions made that were badly thought through and with little consideration of the consequences.

Until relatively recently, RAF Boards of Inquiry also determined culpability. 'Pilot or aircrew error' was for many years accepted as the most common cause of flying accidents. 'Pilot error' covered a multitude of sins and encompassed anything from errors of skill, errors of judgement, negligence, gross negligence to recklessness. However, as a general rule, the 'contributory factors' underlying these causes usually hold the key to preventing a recurrence. By 'contributory factors' I mean those factors that made the accident more likely to occur. For example, poor quality of training, poor supervision, flawed design, high-risk practice emergencies, dubious crew resource management, poor leadership at unit level, fear of failure to achieve high operational standards and so on. In my opinion, these contributory factors are systematic failures of safety management and each can and has contributed to numerous accidents – often individually categorised at the time as 'pilot error'. The more enlightened shift in emphasis from a focus on culpability towards the science of Human Factors in the 1980s did much to address the associated contributory factors.

On behalf of us all, I would like to offer thanks to the Royal Air Force Museum for hosting us today and to Nigel Baldwin, Jeff Jefford, Colin Cummings and Jock Heron for all the work they have done in putting the seminar together. Finally, I offer our sincere thanks to all of today's speakers. Regrettably there is no authoritative documented history of the evolution of flight safety in the Royal Air Force, but each of our speakers has shone a light into some extremely interesting and murky areas. Perhaps the publication of the Society's Journal recording this seminar will provide someone of the likes of Andrew Brookes with the inspiration for his next best-selling book.

BOOK REVIEWS

The Influence of Air Power Upon History by Walter Boyne. Pen & Sword; 2005. £25.00.

Colonel (USAF ret.) Walter Boyne was one of the first directors of Washington's Smithsonian National Air and Space Museum. He has a long pedigree in the US as a writer on air power. His intention in this 464-page book is ambitious: to examine the influence of air power beyond war 'or the threat of war' to include 'the direction of national policies, the growth of industries, and perhaps most important, the rapid advance of technology, even in times of peace.'

He writes primarily for American readers from an American perspective. His bibliography is, however, international and his observations on other countries are usually objective. The absence of maps, other illustrations and a very limited acknowledgement of sources detracts from its potential impact. He concedes that his account of air power is necessarily selective but many British readers will agree broadly with his selection, although they may find evidence of the comparative weight of British and US air power from WW II onwards uncomfortable.

He identifies the size and air power share of the military budget, national threat perception, level of aviation technology, national security policy and the impact of individuals as factors which 'mould air power theory and determine its success or failure.' Initially, he defines air power as 'the ability to conduct military, commercial, or humanitarian operations at a chosen place, but not necessarily at all places or at all times.' It may be called 'aerospace power' when it includes intercontinental ballistic missiles, or space-based assets. It includes both military and civil components.

Boyne reflects earlier definitions by General Hap Arnold or MRAF Sir John Slessor, when he writes, 'The civil components include all of the elements of the entire nation, including its leadership, industry, natural resources and general population.' British definitions tend to be more succinct and helpful, concentrating on the projection of military force by or from a platform or missile which actually exploits air and space to achieve specific effects. Later references by Boyne to 'true air power', meaning the combination of aerial dominance and the ability to deliver destructive power, tend to weaken his underlying

definition. Yet in asserting that 'the influence of air power upon history was settled in the first thirty days of World War I', he is referring to the permanent influence of aerial reconnaissance, not to any destructive power. His lament that recce is the first to have influence in war but the first to be sacrificed in peacetime is only too accurate.

He analyses the influence of air power in WW I on the major participants rather than on the war itself. The creation of the RAF merits only one paragraph and he underestimates the impact on British morale, and hence on Trenchard, of the sporadic German bombing of the UK. In repeatedly observing that 'everyone' underestimated the resilience of civilian populations, Boyne, along with many distinguished exponents, is surprisingly unaware of Churchill's clear warning in 1917 that, *inter alia*, strong control by police and military authorities should be sufficient 'to preserve the national fighting power unimpaired' and that civilian 'combative spirit' would be roused, rather than cowed into submission.

His examination of the inter-war years is comprehensive and illuminating, especially the influence of Billy Mitchell, British budgetary constraints and the political impact on France and Britain of *Luftwaffe* propaganda. His criticism of the various bomber exponents, however, tends to underestimate the pre-radar advantages of the bomber over the fighter. His identification of Guernica as the primary influence of air power in the Spanish Civil War on history sits well with his earlier observation of the coincidence of the arrival of air power with that of the popular press. Perhaps if Colonel Boyne had come from a different background he might have speculated on the possibility that the temporarily successful use of British air power in Imperial Policing obscured the potentially debilitating political and financial costs of over-extension of empire.

In WW II he praises the bravery and sacrifice of the aircrew of Bomber Command, for so long ill equipped to carry out their designated roles. He recognises the history defining impact of the Battle of Britain and the Pacific turning point at Midway. He records the establishment of air supremacy which enabled the Normandy invasion and the impact on German industrial capacity and diversion of resources achieved by the Combined Bomber Offensive. In observing that, while some countries under estimated the potential and

others over estimated it, his assertion that 'only the US and the USSR measured it with some skill' may be debatable. The US Navy was encouraged to depend on air power only after it lost its battleships at Pearl Harbour. The USAAF's B-17 offensive was only preserved by the accidental creation and application of the Rolls-Royce-powered P-51 Mustang and even then, 'precision' bombing attacks came to resemble those of the RAF. Except for understating the impact of air power on the Battle of the Atlantic however, his overall analysis of air power in all theatres of WW II draws soundly on substantial authorities. Even now, the statistics of US wartime aircraft production raise British eyebrows.

His analysis of air power post-1945 is inevitably heavily focused on American air power, with only passing references to British contributions, albeit associated with complimentary comments. He identifies the major landmarks of the Cold War, but prefers to place the Berlin Airlift in the context of US-USSR confrontation rather than its transformation of the political destiny of Europe.

His observations on deterrent air power are well founded. He identifies the impact of interdiction in Korea and his analysis of the contribution of reconnaissance and deterrence in the Cuban crisis of 1962 is concise and clear. Indeed, his recognition of the continuous and critical contribution of reconnaissance throughout the Cold War is a salutary reminder to those who equate air power solely with putting weapons on a target. Regrettably, he does not mention the contribution of RAF Canberra and RB-45 over-flights of the USSR to the earlier period of post-war reconnaissance.

Compared to his earlier insights and objectivity, Colonel Boyne's later chapters are disappointing. His examination of Vietnam repeats one sided complaints about political micro-management, constraints on the bomber offensives, and acclaim for the 'success' of Linebacker II. He shows the scars of his generation from the hundreds of personal USAF tragedies incurred in that misguided war. He therefore embraces John Warden's later concepts of striking at the enemy's heart and enthuses over the application of the Colonel's theories in DESERT STORM. He fails to note the absence of political context in Warden's ideas, and coincidentally misses his true importance in restoring the concepts of strategic conventional attack to the air power lexicon. Nor does he impute sufficient weight to the near perfect

circumstances of 1991 in which air power reached its 'apotheosis' (an expression familiar to this reviewer).

Events of the last decade are scarcely mentioned. This is regrettable when for the first time in its history air power has become the instrument of political choice of the West, and when the US has established a world hegemony on a foundation of unassailable air power. He does see the conventional invincibility of US air power and concludes that 'more than a quick and certain victory, it holds the promise of a genuine Pax Americana, one unmarred by terrorist threats or aggressive warfare by one state upon another.' He does not see that air power has indeed finally transformed the conduct of war, but has driven opponents to contribute to that transformation by employing asymmetric strategies and tactics to counter it.

The book is a welcome but uneven addition to studies seeking to survey the broad sweep of a century of air power. It raises the question of whether any one volume can now include sufficient detail to support convincing analysis of all its major evolutionary events. Rather than buying a copy, members of the RAF Historical Society are recommended to borrow it from a library and return it after reaching the chapter on the Cuban Missile Crisis. Air power still awaits its Mahan.

AVM Tony Mason

Spitfires In Japan by Air Vice-Marshal Sir Cecil 'Boy' Bouchier edited by Dorothy Britton. Global Oriental (PO Box 219, Folkestone, CT20 2WP; Tel 01303 226799); 2005. £35 (but see below).

AVM 'Boy' Bouchier died in 1979, a few years after completing his memoir. Too long to be published as it stood, his widow, the second Lady Bouchier, eventually set about condensing it to an acceptable size. As she puts it in her introduction, 'I left out nothing, and did not alter the style. All I did was tighten everything up.' She succeeded admirably but, before saying how much I enjoyed this book, I do need to get the brickbats out of the way.

While I find no fault with the syntax, I do have a few reservations over the content. It is evident that, as befits a memoir, much of the original manuscript was drafted from memory, rather from documentary sources. It might, therefore, have been advisable to have had the text checked by an aviation historian, to weed out some of the

factual errors that one can spot, leaving one wondering how many others there might be. For instance: while the author was, very justifiably, proud of having been the first commander of the fledgling Indian Air Force in 1932, he refers to it throughout as the *Royal* Indian Air Force, which it did not become until 1945; the aeroplane in the photograph of Bouchier as OC 54 Sqn is a Gladiator, not a Gauntlet; the British beaches on D-Day were Juno, Sword and Gold (not Red); Wernher von Braun was not a Count; the Hurricane, having been withdrawn from Fighter Command in March 1944, the several subsequent references to the type should probably have been to the Typhoon; AOCinC 2nd TAF in 1945 was Coningham, not Cunningham, and so on. Then again, considering that the book was being published some thirty years after it had been drafted, it contains some opinions that now seem oddly dated. For example, in reminiscing about his time commanding the Hornchurch Sector during the Battle of Britain Bouchier suggests that the 185 enemy aircraft that the RAF claimed to have destroyed on 15 September was probably more like ninety, whereas we now know that it was only fifty-six. Finally, a more conscientious attempt at proof-reading by the publisher could have weeded out a number of typos/misspellings – I found at least twenty.

So, having issued the necessary health warning, what did I really think of the book? I loved it. Bouchier's story is a classic case of (almost) rags to riches and a demonstration of the fact that, if a war doesn't kill you, it can be the making of you. Having left school at fourteen, he embarked on what would very likely have been a permanently unrewarding life of drudgery as a salesman and/or clerk had WW I not offered him the opportunity to enlist. By the late spring of 1915 he was in the Middle East as the centre driver of a six-horse team drawing a fieldpiece of the Honourable Artillery Company. After two years of active service with the guns his application to train as a pilot was accepted. On gaining his flying badge, and still in Egypt, he was commissioned into the RFC and, with just 24 hours of (pre-Smith-Barry-style) solo flying under his belt, he was promptly 'creamed off' to become an instructor. This frustrated his ambition to see combat over France but in 1919 he flew with the British intervention force in northern Russia where he earned a DFC.

He had a particularly interesting inter-war career including, in the

1920s, a tour with No 41 Sqn and four years as a test pilot at Farnborough where he had the almost unique experience of flying the Brennan helicopter. Following Staff College, plus stints of overseas duty in India and Egypt and as OC 54 Sqn, he was a wing commander at HQ 11 Gp when war broke out again. His wartime appointments included command of Kenley, Deputy Director of Fighter Operations at the Ministry and SASO 11 Gp (and Acting AOC, although for only four months, rather than the nine that he recalls), in the course of which he wrote, and supervised the implementation of, the fighter cover plan for the invasion of Normandy. In June 1945 he was given a second star and posted to Burma as AOC 221 Gp. With the early end to the war he became AOC British Commonwealth Air Forces of Occupation which took him to Japan for three years. Having left the Service in 1949, he was promptly recalled to spend 1950-52 back in Japan as the personal representative of the British Chiefs of Staff to, successively, Generals MacArthur, Ridgway and Clark. This appointment provided him with a uniquely intimate perspective on the conduct of the campaign and permitted him to exert a direct influence on British involvement. Following his second retirement he accepted the considerable challenge of raising the funds required to restore the bombed and burned out ruin that was to become the RAF's own church, St Clement Danes in the Strand. It was thought that this task might take ten to fifteen years; Bouchier did it in three.

It is a fine record and the tale is told in an easy, readable style, full of anecdote and interest. Bouchier was proud of his achievements, sometime bruised by ingratitude, but never bitter, and occasionally a little rueful over some of his decisions – had he, for example, been right to recommend against the award of a potential VC? The tale includes some remarkably frank revelations, in which we learn of his early youthful sexual encounters and the eventual loss of his virginity – to an Egyptian whore – not the sort of information that one normally expects to find in the biography of an air officer but the sort of frankness and honesty that really makes one wish that one had known him. Along the way there are many incidental insights into the personalities of some of the great and good, including, for instance, Roderic Hill, Hugh Saunders, John Whitworth-Jones, Keith Park, Trafford Leigh-Mallory and, not least, MacArthur, and even Churchill. These are, of course, very personal observations on people

for whom Bouchier just happened to have worked or encountered from time to time, but they are often very informative, for instance, in shedding light on the influence wielded by these iconic wartime figures who could make or break a career – or salvage one – with a mere telephone call.

Published at £35, this 358-page hardback is being made available to RAFHS members at £25 (plus £3.95 UK p&p) at the address above. Quote Code GL01; payment by cheque only, made out to Global Oriental Ltd. Not cheap, but, I think, well worth it.

CGJ

A Birds Eye View From The Ground by Frank Authers. Available from the author at 'Fairways', Nutwell, Exmouth, EX8 5AP.

Frank Authers enlisted as a ACHGD in 1938 but, because of his previous qualifications, it was not long before he was remustered as a Cook and Butcher. As such he was posted to Benson which meant that he soon found himself in France with No 74 Wg of the AASF. Having succeeded in extricating himself from the Continent, he spent some time at St Eval before sailing for Egypt in 1941. He served in North Africa, Sicily, Italy and Yugoslavia for the rest of the war, first with No 977 Sqn (balloons) and latterly with No 249 Sqn. He transferred to the RAF Police in 1947, seeing further service in Germany, Malta, Bahrein, Singapore and Gan, plus the usual run of home postings, before retiring in 1968 as a flight sergeant with a BEM to begin a second career in the motor trade.

As the sub-title of this 158-page softback explains, this book presents 'the ramblings' of the author, covering his thirty years of service. You should not expect a literary masterpiece. The style is very relaxed and informal, and you will have to put up with rather more than the average number of typos – but you will be entertained. Many of Authers' tales are quite comical, like his investigation into the theft of waxed paper packages of gelignite from an explosives store in Malta in the late 1950s; it turned out that they had been pinched by a local employee who, not knowing what the substance really was, had used it to putty-in the windows of a house that he was building. Better still are the yarns drawn from the wartime years. Being a Cook and Butcher in the field could mean 'foraging' with all that that could imply in terms of scrounging, trading with locals and, on occasion,

even run to liberating the odd Jeep, or two(!), albeit from allies who were so over-endowed with kit that they probably never missed them anyway. Some of the stories embedded within this account are outrageously 'non-PC' but I have to confess that some of those made me laugh out loud.

Self-published at £9.95, and containing about 100 photographs, the author has offered copies of his memoir to members of this Society at £8.00 (inc P&P), cheque to Frank Authers, from the address above. The book is not great literature, and does not present itself as such; an independent proof reader would have spotted some of the spelling mistakes and there are some rather distracting errors (eg Scampton operated Vulcans, not Valiants) but this book is not about historical accuracy; it is about 'atmosphere'. There are all too few accounts of Service life written by non-commissioned personnel and this one presents us with an impression of life in the ranks that is both informative and amusing and the reader may even find that the lack of polish actually enhances the sense of warts and all authenticity. The writer clearly enjoyed his time in the RAF and I enjoyed reading about it.

CGJ

Red Star Against the Swastika. The story of a Soviet Pilot over the Eastern Front by Vasily B. Emelianenko. Greenhill Books; 2005. £18.99.

The Ilyushin Il-2 *Shturmovik* was a ground attack aircraft, of which, including all variants, more than 36,000 were supplied to the Soviet Air Force during WW II. *Shturmovik* is derived from *Bronirovanni Shturmovik* which means armoured attacker. Hence it is the name of a type and not of a particular aircraft – as in Spitfire – but it became synonymous with the Il-2. Soviet thinking saw the air arm as coupled to the needs of ground forces and a commitment to a designated ground attack aircraft had emerged by 1937. S V Ilyushin came up with a proposal for a heavily armoured and armed machine in January 1938 and the *Shturmovik* began its life on the drawing board. He was not the only Russian aircraft designer to put forward proposals but Vladimir Vershinin, who has written an Introduction to this book, implies that the choice of his design may have owed something to his contacts among the Soviet hierarchy, reaching up as far as time spent

at Stalin's summer residence. Whatever, a mass production order materialised in December 1940 and no subsequent proposals were able to displace the Il-2. Stalin was certainly an enthusiast for the *Shturmovik* but it needs to be said that Soviet practice was to focus production on a limited number of effective aircraft types for particular roles, for example those designed by Yakovlev and Lavochkin where fighters were concerned. This approach facilitated the high volume series production that helped to lead to the total air superiority which Russia eventually achieved.

The Il-2, at first a single-seater but later incorporating an air gunner, entered service in June 1941, going into action three days after the German invasion began on the 22nd of that month. Vershinin describes the aircraft as 'mediocre'. Not highly manoeuvrable, it relied heavily on fighter cover and operational experience suggested that speed and manoeuvrability would have been a better all-round defensive bet than massive armour. To compare the *Shturmovik* with, say the Typhoon, is perhaps to compare a Lada with a Jaguar. Nevertheless, *Shturmoviks*, liked by their pilots, were an undoubted operational success and Vershinin regards that as a tribute to those pilots – a view endorsed by German opinion of the ferocity and effectiveness of Soviet ground attack units.

This book was written in 2005 by a highly decorated, 94-year-old, *Shturmovik* pilot. If you enjoy accounts of actions then it will certainly appeal. From it a picture emerges of what it was like to fight an experienced and well equipped enemy over a fluid battlefield situation. It is rich in detail about the life of the pilots, both on the ground and aloft.

The author learned to fly during the 1930s in an aeroclub, 200 of which were set up to train *Komsomol* (Youth Communist Union) members with the aim of producing 150,000 pilots for the Soviet Air Force. The movement had some similarities to the RAFVR with young men – and women – working in their jobs whilst learning to fly. He became an instructor in such a club and in May 1942, via a series of experiences in military training units, joined the 7th Order of Lenin Guards Ground Attack Regiment equipped with *Shturmoviks*. The 7th had started the war as the 4th Ground Attack Regiment, comprising five squadrons which were in action within days of the German invasion. It took very heavy casualties – a reflection of the lack of

training and experience of the pilots, the inadequate Soviet fighter capability at that time and the air supremacy enjoyed by the *Luftwaffe*. The 4th was awarded the Order of Lenin in recognition of its courage, promoted to the elite Guards status, and reformed as the 7th with two squadrons in September 1941.

Beginners flew as wingmen to experienced pilots, who selected targets and whose actions they would try to follow. As losses mounted and pre-operational training shortened, this sort of hands-on procedure became the norm and was similar to RAF practice when an operational squadron received men fresh from OTUs. However, there were some differences. Men could arrive from training establishments in the hinterland not only partially trained but, according to the author, poorly nourished and needing feeding-up before they were physically fit enough to go into action. Ground-attack aircrew had to adjust rapidly to rapidly changing conditions on the battlefront and evolve tactics accordingly, which was a costly way of learning for many, including the most experienced. In the early stages of the war radio communications were virtually non-existent – either there were no sets at all or, when there were, the pilots were deafened by the static and simply switched off. Throughout the war the *Shturmovik* was never equipped with a decent bomb sight and pilots relied on pins and markers attached to the fuselage (the author compares them to barnacles on the bottom of a ship) to help them calculate their run-in by the seat of the pants in the few seconds available to do so. Generally speaking, living conditions were rough, sometimes harsh, and losses were high in ground attack regiments even after the Soviets began to attain air supremacy.

The author saw a lot of successful combat action, his decorations, which include the award of Hero of the Soviet Union, attesting to that. He became a flying technique inspector, responsible for accompanying and directing squadrons on missions, flying either behind or at the side of the attacking formation. His qualifications for such an appointment included the fact that he was ten years older than the majority of the pilots he controlled. Finally, with the rank of captain, he was sent to the Air Force Academy in Moscow from which he graduated as the war ended. He arrived there wearing a worn American flying jacket, trousers which had been made for him from a captured greatcoat by a female armourer and boots which his

mechanic had made from an old parachute case. Such details illustrate the sort of conditions with which Russian airmen were obliged to cope. Other differences from RAF experience include the presence of women as ground staff, as air gunners in *Shturmoviks* and among the pilots flying their escorting fighters. Weaponry was generally similar in all air forces but the use of phosphorus granules discharged from wing mounted containers was possibly unique? Phosphorus ignites spontaneously on contact with oxygen and sheets of fire streaming behind a *Shturmovik* fell onto men and machines on the ground. The evening issue of 100 gm (about 3 fluid ounces, of which there are 20 in a pint) of vodka for the completion of every sortie flown that day was not, so far as I know, duplicated with whisky by the RAF!

Do I have any gripes? The major defect for me is the total absence of maps. I hope that the publisher will insist on this omission being remedied in any future edition. By contrast, the use of footnotes to explain unfamiliar Russian jargon when it crops up in the text is useful. So, should you buy this book? That depends on how much you already know about the air war on the Eastern Front and the sort of conditions under which Soviet aircrew operated. If, like me, you are not very familiar with those things perhaps you should. Reading it has certainly prompted me to find out more about a major contribution to the defeat of Nazi Germany, for which we all have reason to be grateful.

Dr Tony Mansell

The Flying Years by Richard Boult. Merlin Massara Publications; 2006. £21.95.

Having joined the RAF in 1950, via Cranwell's 57th Entry, Richard Boult (was) retired as a squadron leader when the Service instituted its notorious 'purge' in 1976. In the meantime he had flown Meteors and Hunters with Nos 63 and 26 Sqns, done a stint as an ADC and become a graduate of the ETPS, subsequently spending 1961-63 at the A&AEE flying a variety of types, but especially early Lightnings. Thereafter, following a pretty average showing at Staff College (Boult is well aware of the degrees of success and failure that punctuated his career and makes no bones about them), his later postings were rather more mundane, involving HQ Air Cadets, a year at Gan, and staff appointments at HQ FEAF and Pitreavie Castle. His

enthusiasm was rekindled in 1971-74 by a tour as a Squadron Commander at Henlow's OCTU. After participating in the closing down of Chivenor/opening up of Brawdy, he spent a final year at Lacon House before embarking on a new career as a maths teacher. In the course of gaining his Cert Ed, he realised that teaching teenagers was not really going to be for him. What he could do, however, was to build on the experience he had gained at Henlow, and the insight into the practicalities of 'leadership training' that this had provided, and he spent the next twenty-odd years running courses on leadership for The Industrial Society.

That, in brief, is Richard Boult's story, which he tells in some detail in this 418-page hardback. The prose is immaculate – no split infinitives here. Some may consider the style to be a little laboured – perhaps too *much* detail? – and pilots, in particular, may find some of the passages dealing with flying techniques a little patronising. Whether it was really necessary to provide a 35-page annex expanding on 'Some Flying Technicalities', starting with effects of controls, is, of course, a matter of opinion, but I thought it a bit much.

The author has a remarkable facility for recalling the names of colleagues (far better than mine, and I can give him ten years) and the circumstances of events in which he participated but he can otherwise be a little off the beam. He tells us, for instance, that the Spitfire he flew, realising a long-held ambition, had a Napier engine, and he has the Hastings powered by the Pegasus. He can also be a bit vague about units – No 253 Sqn did not serve in India between the wars; FEAF's Shackletons were operated by No 205 (not 208) Sqn and the Sabre from which Pete Underwood escaped so miraculously belonged to No 234 (not 14) Sqn. Oh yes, and the Scimitar which he recalls running into the sea off the end of Gan's runway in 1967 was a Sea Vixen.

All of that aside, this book represents a very worthwhile addition to the recording of RAF history. It tells us nothing about higher policy or the evolution of tactics and little that we did not already know about flying Meteors and Hunters. What it does do, however, is to provide us with an impression of the day-to-day life of a young pilot in the 1950s. Quite coincidentally, the book I had been reading when a copy of *The Flying Years* arrived in the post had been Claude Keith's *Flying Years*, which describes the day-to-day activities of a young

pilot in the mid-1920s. These two accounts complement each other in that they tell us much about the 'texture' of contemporary Service life. Because I can remember the 1950s, I rather take them for granted, but life was very different in the RAF of half-a-century ago and Boult's book provides us with a vivid time capsule.

His recollections of the 1960s, with their overtones of withdrawal from east of Suez are equally lucid – his descriptions of life on Gan, for instance, and of the imperial splendours of Fairy Point Mess. Along the way he succeeds in conveying some idea of the sheer youthful enjoyment of flying high performance aeroplanes, especially in formation, of the camaraderie of squadron life and of the joys of the extra-curricular activities, sailing and skiing in Boult's case, to which the Service provides relatively easy access. It is not all positive, of course, and the author also describes his occasional frustration in dealing with higher authority, the casual offence that can unthinkingly be given by some senior officers (those who seemed to have lost the common touch) and a growing appreciation of what he perceived to be deficiencies in the way that the air force managed itself, particularly its people. It is all very honest and *The Flying Years* is a valuable contribution to the annals of the RAF, indeed (like Keith's book) I think, because of the insight that it provides into RAF society of a specific era, its value will actually increase as the 1950s and '60s recede further into the past.

Boult writes from the perspective of 'one of the chaps'; his RAF career was that of a young aviator who eventually drifted into middle management. It was thus far more representative of the norm than the biography of one of the Service's movers and shakers – in fact it pretty well mirrors my own experience, which is, perhaps, why I like the book. I think it might have been even better if it had been 100 pages shorter, but perhaps that's just me.

CGJ

Vulcan 607 by Rowland White. Bantam Press 2006; £16.99

This pacey and gripping thriller is actually a well-researched and detailed account of the RAF's initial response to the invasion of the Falkland Islands in 1982. Prime Minister Thatcher, having received some trenchant advice from Adm Sir Henry Leach, then CNS, had agreed to sail a task force towards the Falklands, but this would take

weeks to arrive and there were huge problems in arranging for its logistic support. Meanwhile the Argentinians were steadily reinforcing their presence on the islands and were likely to deploy capable attack aircraft to Stanley airfield. If this were achieved, it would present an almost insurmountable threat to the task force and its Harriers. With this in mind, CAS, Sir Michael Beetham, turned to the question of how to prevent this happening. An air attack on the airfield would not only deter the deployment of Argentinian A-4s or Etendards, it would also send a powerful signal to the Junta that Britain intended business. The target, however, was over 7,000 miles away, and the only possible asset that could be used – the Vulcan – was about to be withdrawn from service.

White sets the scene in some detail, giving a short history of the chequered ownership of the islands and describing briefly the attempts at a diplomatic solution. He also covers the deployment of attack submarines whose role was to deny the Argentinian Navy use of sea transport. The main narrative covers the huge difficulties involved in restoring the Vulcan's flight refuelling capability, its conventional bombing role equipment (some had to be rescued from a scrapyard in Newark) and improving its ECM to cope with expected Argentinian defences. There was also the question of navigation – astro alone would clearly be inadequate for such an operation, and the Vulcan's elderly equipment depended primarily on the H2S Mk 9 radar which would be of no help at all over the sea. Eventually, twin Carousel INS equipments were robbed from stored ex-civil VC10s. The book describes the training of the selected crews and the gradual evolution of the operational plan – a plan that continued to evolve right to the last minute.

The original concept was to mount the operation from Ascension Island, using Victor tankers to support a single Vulcan dropping 21 × 1,000 lb retarded bombs from 300 ft onto the Stanley runway. When it was realised that this would give inadequate penetration of the runway surface, the plan changed to a '2J' pop-up attack to 8,000 ft (later revised en route to 10,000 ft) delivering ballistic 1,000 pounders. The planners calculated that no fewer than thirteen Victors would be needed to provide all the necessary fuel. In the event some seventeen Victor sorties had to be flown, not least because no consumption figures were available for the Vulcan at the considerable overweight

take off condition, nor could account be taken of the need to keep station in formation, with constant throttle movements, or of the requirement to refuel at lower altitudes than optimum cruise levels.

White takes us through all of these problems rather like the unfolding of a detective novel, yet his accuracy and technical detail is almost faultless. As the planning and the operation develop, the book becomes a real page-turner. There are a few quibbles, perhaps inevitably with a book of some 370 pages. One reads Colby instead of Coleby for the village near Waddington, El Adam for El Adem and Konakry for the more usual Conakry. (I don't think WOp/AGs were ever called WAGs either). There are some interesting pictures, some necessarily of poor quality, but their presentation could have been improved by providing larger prints. Some might consider that there are rather too many excursions from the main theme in the earlier chapters, but I found them useful in setting what was a complex scene. Overall, this was a jolly good read and an excellent historical record of what was (certainly then) the longest attack mission ever carried out. Recommended.

Gp Capt Kevan Dearman

2nd Tactical Air Force, Vol 3 – From the Rhine to Victory by Christopher Shores and Chris Thomas. Classic Publications; 2006. £29.99.

I reviewed the first two volumes of this trilogy, very enthusiastically, in Journals 33 and 35 so I will keep this relatively brief, because Vol 3 fully maintains the very high standards set by its predecessors. That is to say that it is a lavishly illustrated A4 hardback in which the narrative is presented in diary form, amplified by tables presenting the salient details of claims and losses on a day-to-day basis, and interspersed with more detailed accounts of particularly notable incidents or operations. It is possible to find the odd slip of the pen, Embrey (for Embry), Sheperd (for Shepherd) and Fassburg (for Fassberg) for instance, but these are few and far between.

Vol 3 differs slightly from Vols 1 and 2 in that it includes appendices providing: explanatory notes on such non-operational units as Air Stores Parks, Air Ammunition Parks, Repair and Salvage Units and the Group Support Units; an essay on the various forms of tactical control employed by agencies on the ground (including radar-directed

bombing through cloud); a brief account of RAF Regiment activities and tabulated summaries recording the movements and commanding officers of the various Group and Airfield/Wing HQs. These notes cover the whole period from April 1943 to VE-Day (not just the months embraced by Vol 3). There is a page of errata and addenda relating to Vols 1 and 2 and the book is rounded off by two indices, one dedicated to units mentioned in Vol 3 alone while the second provides references to personnel occurring in all three volumes and to facilitate the latter the pages of all three books are numbered consecutively in a coherent series.

The whole work runs to 576 pages and, leaving aside the very comprehensive text, by my count these contain 675 photographs, 96 of Chris Thomas' excellent profile paintings and six maps, all reproduced to the highest possible standard on coated paper throughout and not stinting on the use of colour when appropriate. The downside is that one does have to pay for this sort of quality and the whole set will set you back almost £90 but that is still remarkable value for money – less that 16p per page and less than 12p per illustration.

2nd Tactical Air Force is not an 'academic' work. By comparison with *The Strategic Air Offensive Against Germany*, for instance, there is little attempt at analysis and relatively few statistics are provided. That is not a criticism, but it is as well that the prospective purchaser should understand what he is getting. That said, as operational histories go, this one has set the bar higher than ever before and this is the standard to which other writers must now aspire.

CGJ

Did You Survive the War? by C W 'Jerry' Jarrold (with Ken Delve). Raydon Wings Ltd, Woodlands Hall, Raydon, IP7 5QD; 2006. £14.99 plus £1.50 p&p.

The glamour associated with the exploits of prominent fighter pilots tends to distort the overall picture. During WW II some 3,000 of the men who flew with the air forces of Britain and the Commonwealth were credited with two or more victories, about 1,200 of them achieving five-victory 'ace' status. Since these men were drawn from a pool of well in excess of 20,000 fighter pilots, however, it follows that 85% of them claimed one victim or fewer – and in most

cases it was 'fewer'. *Did You Survive the War?* reflects the experiences of one of this statistically preponderant but little publicised group.

Jarrold presents his story in a 118-page, A5 hardback with a photographic insert comprising thirty or more contemporary snapshots and copies of pages from sundry documents. Having enlisted in 1940, he was, mistakenly, rejected as aircrew on medical grounds and it was May 1941 before this problem was resolved. Having gained his 'wings', he was posted, as a sergeant pilot, to the Middle East where, in January 1943, he joined No 80 Sqn, flying Spitfires with them in North Africa, Italy and the UK until August 1944. Following a 'rest' as a staff pilot with No 13 OTU, he converted to Typhoons which he flew with No 181 Sqn between February and October 1945. Thereafter he marked time with No 695 Sqn before being 'demobbed' in the summer of 1946 with some 800 flying hours under his belt.

Jarrold's account draws heavily on his log book, supplemented by the ORBs of the units with which he served but the structure of the book is very uneven. One cannot be sure, of course, but this would appear to be a consequence of co-authorship. The problem is that, while Jarrold's own story unfolds in a reasonably coherent fashion, it is frequently interrupted by biographical details of notable pilots with whom he came into contact from time to time. These have little real relevance to the tale that is actually being told and the inclusion of these notes disrupts the flow of the core account, rarely adding anything of real substance to it – they read like insertions from a different pen, which is, I suspect, exactly what they are. Much of this extraneous detail seems to have been extracted from Shores' and Williams' *Aces High* but, whatever the source, it has not been done with adequate care, eg among the named pilots of No 80 Sqn are: Peter Wykeham (not Wickham), Russell Foskett (which is spelt with two 't's not one) and John Lapsley, who did not (as stated) command the unit. Furthermore, with an experienced aviation writer riding shotgun it is surprising to see other unnecessary errors – for instance, El Adam (for Adem); Frosimone (for Frosinone); Wadi Seidna is not at Khartoum; Heliopolis is hardly 'by the Pyramids' (they are ten miles distant on the other side of Cairo) and so on.

Leaving the diversions aside, Jarrold's own story is worth reading, simply because it tells us about an 'ordinary' fighter pilot – one of the

many, rather than 'the Few'. While he may not have succeeded in shooting down any Messerschmitts, this was largely due to a lack of opportunity and/or the style of operations to which he was committed. It was certainly not for want of trying; after all he flew 127 operational sorties on Spitfires alone, including patrolling over the D-Day landings, but if the *Luftwaffe* failed to put in an appearance, targets were obviously going to be scarce. I did not divine how many sorties the author flew on Typhoons (I would guess about thirty) but, again, the nature of the task – armed recce and ground attack – rarely presented opportunities to engage in combat. That is not to say that such operations were without risk, of course; losses to *Flak* were very heavy and, if nothing else, the author clearly had luck on his side.

Jarrold hints at some interesting aspects of Service life in the course of telling his tale. For example, while he does not explore the problem in any depth, the occasional remark does offer some insight into the problems that could arise from the class-based rank hierarchy. Referring to Sqn Ldr Curry's time as OC 80 Sqn, for instance, he notes that: 'As far as NCO Pilots were concerned, he appeared to have no time whatsoever for any of us, and I can't remember ever talking to him. As for recommending anyone for a commission, I don't think it ever occurred to him.' Jarrold, incidentally, was commissioned just as the war ended.

Not a masterpiece, by any means, but worth a look, especially if you are 'into' fighter pilots, but otherwise I would suggest that you persuade your local library to obtain a copy before deciding whether or not to invest.

CGJ

ROYAL AIR FORCE HISTORICAL SOCIETY

The Royal Air Force has been in existence for over 80 years; the study of its history is deepening, and continues to be the subject of published works of consequence. Fresh attention is being given to the strategic assumptions under which military air power was first created and which largely determined policy and operations in both World Wars, the inter-war period, and in the era of Cold War tension. Material dealing with post-war history is now becoming available under the 30-year rule. These studies are important to academic historians and to the present and future members of the RAF.

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

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

Membership of the Society costs £18 per annum and further details may be obtained from the Membership Secretary, Dr Jack Dunham, Silverhill House, Coombe, Wotton-under-Edge, Gloucestershire. GLI2 7ND. (Tel 01453 843362)

THE TWO AIR FORCES AWARD

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

1996 Sqn Ldr P C Emmett PhD MSc BSc CEng MIEE
1997 Wg Cdr M P Brzezicki MPhil MIL
1998 Wg Cdr P J Daybell MBE MA BA
1999 Sqn Ldr S P Harpum MSc BSc MILT
2000 Sqn Ldr A W Riches MA
2001 Sqn Ldr C H Goss MA
2002 Sqn Ldr S I Richards BSc
2003 Wg Cdr T M Webster MB BS MRCGP MRAeS
2004 Sqn Ldr S Gardner MA MPhil
2005 Wg Cdr S D Ellard MSc BSc CEng MRAeS MBCS

THE AIR LEAGUE GOLD MEDAL

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

Air Marshal Sir Frederick Sowrey KCB CBE AFC
Air Commodore H A Probert MBE MA

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Gp Capt K J Dearman
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