Air Combat and Historical Analysis

An Example from the Battle of Britain

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South African Pilot Officer A.G. Lewis of 85 Sqn. Seen here with his Hurricane. Lewis survived the War and was credited with 21 Victories

Symbol of the battle. Eliptical wing plan of the Supermarine Spitfire

Oh, God, that memory might be blotted out; but it was remorseless.

Richard Hillary, The Last Enemy[1]

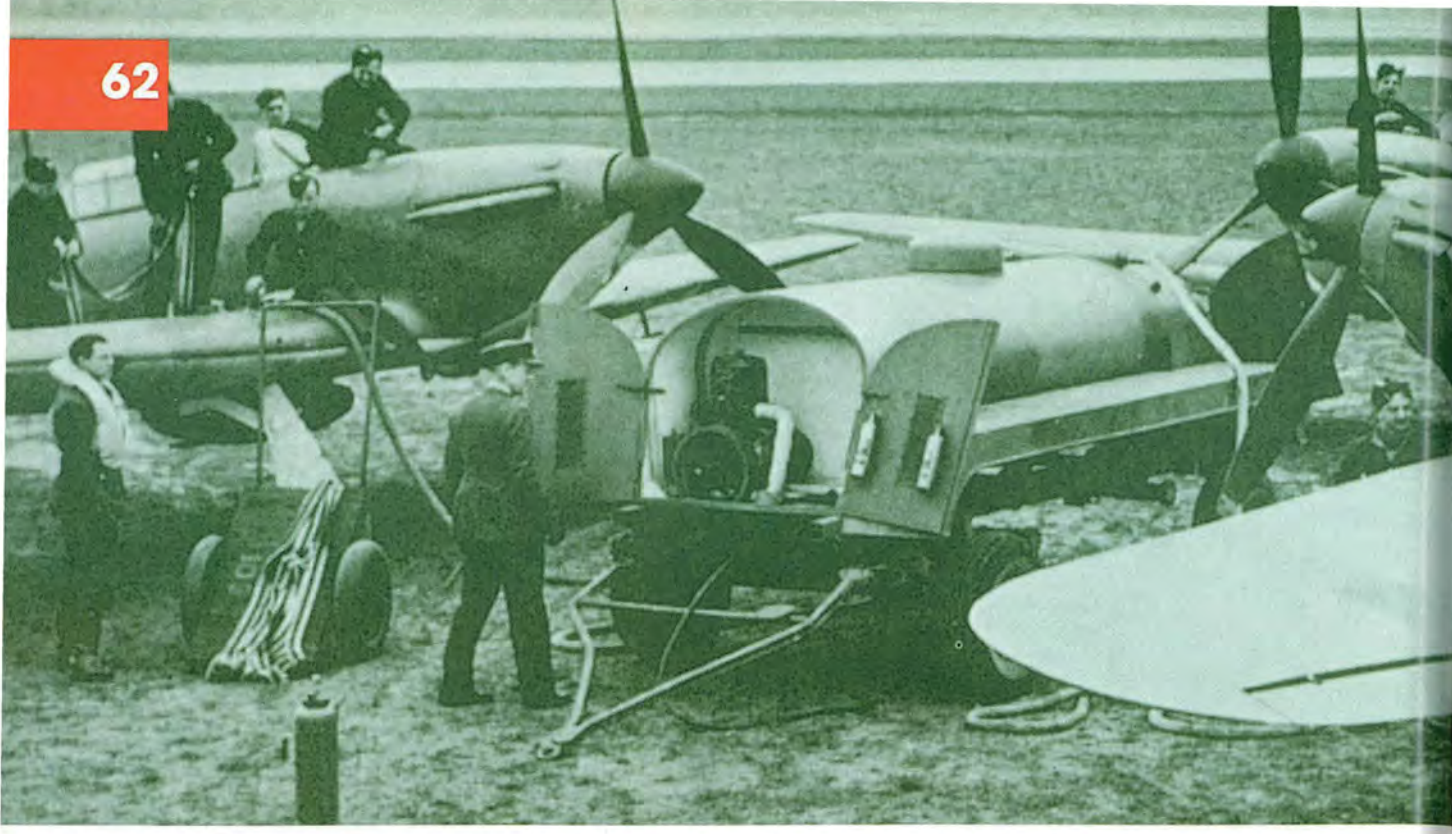
Those individuals frequently exposed to the strain of combat may be left with physical and emotional scars that are a long time healing. But the collective experience gained in war is of potential value, and may have relevance long after weapons and tactics have become obsolete. By offering data for analysis and by helping to establish patterns in combat performance it can provide the memory upon which later generations of strategists and defence planners may draw. This article focuses upon the analysis of data accumulated as a result of a major defensive fighter operation of the Second World War, the Battle of Britain, and reflects the experience of some of the most intensive air combat in history.

Backs to the Wall: The Relevance of Fighter Command's Defensive Air Battle, 1940

Fighter losses in a future Battle of Britain are likely to be very severe, and it is essential, if we are to survive, that we should start the battle with a force of sufficient strength and with adequate reserves of men and material. This is of paramount importance in view of the threat of weapons of mass destruction, because the air defence commander will be forced to engage the enemy with the greatest intensity that his resources permit.

Research Branch, Fighter Command, 1952[2]

With the perceived threat of Soviet aggression in the years following the end of the Second World War and its implications for the defence of Britain, the Royal Air Force faced the possibility of again having to fight an intensive air defence battle to defend UK airspace. In order to identify the factors likely to shape such a battle and to influence its outcome the RAF drew upon its most pertinent bank of available experience, that of 1940. Between the beginning of July and the end of October that year RAF Fighter Command under the command of Air Chief Marshal Sir Hugh Dowding had engaged the German Luftwaffe in a series of extensive air battles over southern England: the 'Battle



of Britain'. This had been a prolonged defensive air campaign, ultimately successful in both denying the Germans the air superiority necessary for them to attempt a cross-Channel invasion, and in preventing German strike aircraft from inflicting crippling damage to Britain's warmaking capability and potential; its social, economic and military infrastructure. The battle therefore offered several important aspects for analysis.

Aircraft Serviceability & Fighter Rates of Effort

> *We all agreed that this squadron and probably every other one as well would be grounded for lack of machines after the first hour of an invasion. One has only to see what difficulty we have in putting up about nine machines after one good scrap. And sometimes we have difficulty just through the machines going unserviceable with oil leaks, etc.*

Diary entry, Flying Officer R.G.A. Barclay, 249 Squadron, October 4th 1940[3]

Two of the most critical factors for Fighter Command in 1940 had been the extent to which the serviceability of fighter aircraft could be maintained under combat conditions and, linked to this, the operational flying effort that could be achieved by the defending fighters.

Fighter Command's crucial assets in 1940 had been the single-engine eight-gun Spitfire and Hurricane fighters, the only types capable of engaging German aircraft with a reasonable probability of success and survival.[4]

By July 20th 1940 they faced about 980 German fighters, including some 760 of the formidable single-engine Messerschmitt Bf.109s, and some 1,480 bomber and dive-bomber strike aircraft which the Luftwaffe had deployed for its offensive across the English Channel.[5] The following table shows the total number of Spitfires and Hurricanes in squadron hands during the battle between July and September 1940 and, of those, the number reported at the time as either combat ready or unserviceable.[6]

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Hurricanes refuel and re-arm between sorties

RAF Fighter Command: Spitfire and Hurricane Strength in Squadrons, 1940

		Spitfires	Hurricanes	Totals
July 1st 1940				
	Combat Ready	199	347	546
	Unserviceable	93	115	208
August 1st 1940				
	Combat Ready	208	350	558
	Unserviceable	87	116	203
September 1st 1940				
	Combat Ready	209	349	558
	Unserviceable	76	125	201

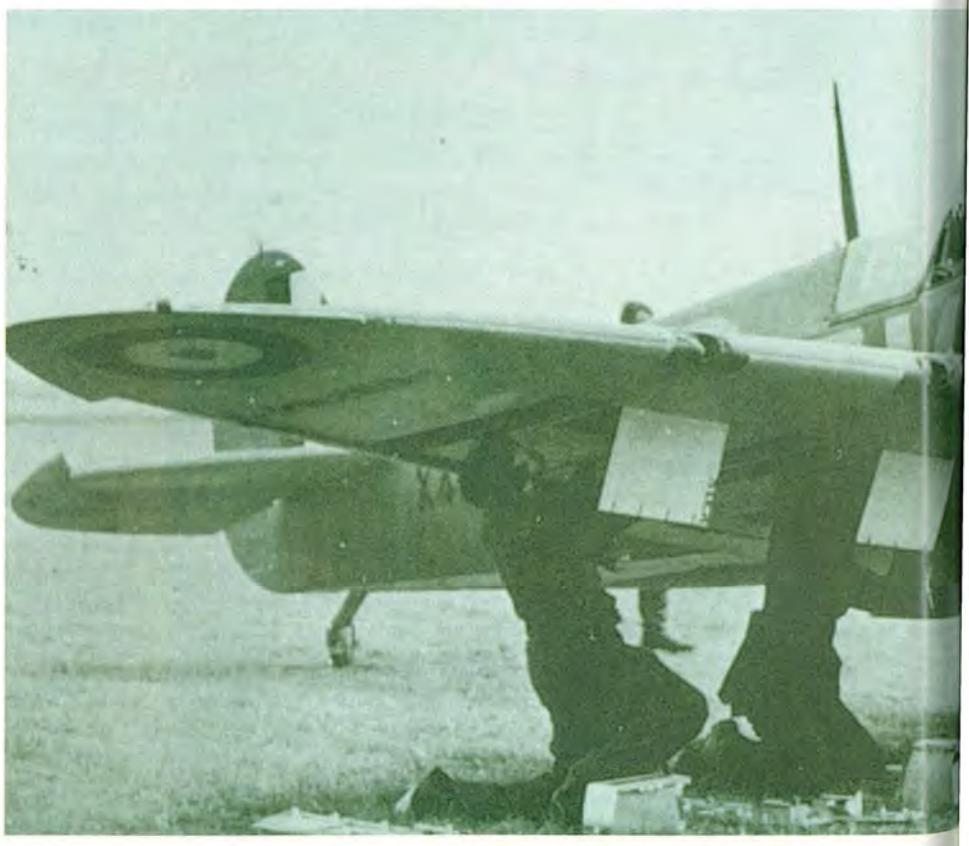
While indicating that the number of combat ready aircraft remained remarkably constant, these figures actually mask a crisis in that as the fighting intensified the number of damaged aircraft increased very rapidly. In June 1940, before the battle, some eight Hurricanes had been reported daily as unserviceable, by July this figure had risen to twelve but in August peaked at fifty-five, and reached forty-eight in September and forty-nine in October. Similar numbers were reported for Spitfires, exceeding fifty on two occasions during September.[7] The squadron ground crews had worked under increasing pressure in order to keep aircraft flying, but despite their efforts the number of aircraft too seriously damaged to be repaired on the squadrons and needing work of more than twelve hours duration had accumulated rapidly. The number of Hurricanes in this state on June 14th was thirty-five, but this had risen to seventy-seven by the end of July, and peaked again at this figure in September. The number of Spitfires peaked at seventy-one on July 21st.[8] These aircraft and those lost in combat or damaged beyond repair had to be replaced by those

held at the Maintenance and Storage Units. On August 10th they had 292 Hurricanes and Spitfires of Category 1, available for immediate issue to the squadrons, but by September 7th they were down to 127. Fortunately aircraft production and the return to service of repaired machines had been able to fill this breach in 1940, and the crucial requirement of maintaining squadrons of sufficient combat power at the forefront of the battle was achieved.[9]

Fighter Command's squadrons in 1940 were established with sixteen aircraft to operate twelve, but in July it had been decided to increase Hurricane squadrons to twenty aircraft. For its post-war analysis, the RAF examined the records kept by Hurricane and Spitfire squadrons between July and October 1940. It was discovered that the average number of serviceable aircraft per squadron in Air Vice-Marshal Park's 11 Group in southeast England, the Group most heavily engaged, was 15.2 aircraft. In 13 Group, effectively out of the battle in the north of England and with fewer Hurricane and Spitfire squadrons on strength, the figure was 15.4 aircraft. That 11 Group had maintained such an impressive overall level of serviceability during the battle initially surprised the RAF's own analysts; it indicates the extent upon which aircraft reserves were drawn.[10]

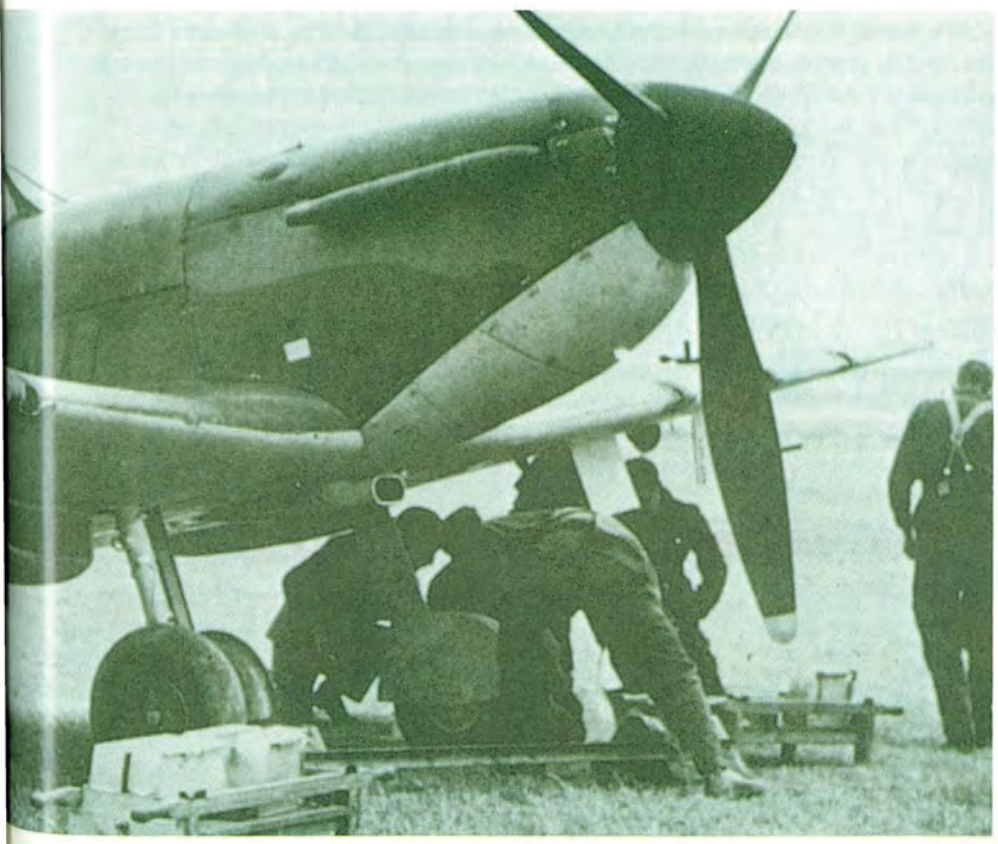
Where the difference between the two Groups had been most apparent was in the extent of operational flying. An examination of records for the period July 1st to October 27th 1940 revealed that the Spitfire and Hurricane squadrons of 11 Group had averaged 8.9 operational and 2.8 non-operational sorties per serviceable aircraft per week. The corresponding figures for those of 13 Group had been 2.4 operational and 7.3 non-operational sorties. Some squadrons had served for a period in both Groups, and a sample of their experience is given below, based on data compiled for the RAF's post-war analysis.[11]

Maintenance on II Group Spitfire while being rearmed to rejoin the Battle



Fighter Squadron Rates of Effort, 1940

Squadron	No. of Weeks in Group	Average No. of Sorties per Week per Serviceable Aircraft while in Group	
		Operational Sorties	Total Sorties
249 Sqn (Hurricane)	4 (11 Group)	10.7	11.3
	6 (13 Group)	3.5	8.6
64 Sqn (Spitfire)	7 (11 Group)	11.4	14.0
	10 (13 Group)	2.3	9.3
41 Sqn (Spitfire)	5 (11 Group)	8.2	15.0
	10 (13 Group)	6.9	18.9
85 Sqn (Hurricane)	7 (11 Group)	13.6	22.0
	5 (13 Group)	0.2	9.0



These figures reflect a crucial advantage favouring Fighter Command in 1940, which was unlikely to be repeated in a future similar air defence battle. The Luftwaffe had been unable to bring the RAF under attack throughout the whole of the UK. In the early summer of 1940 the Luftwaffe had learnt two unpalatable lessons from the experience of daylight operations over England. First, bomber formations needed sizeable fighter escort if they were not to suffer prohibitive losses; second, the Messerschmitt Bf.110 twin-engined long-range escort fighters also needed single-engine fighter protection because they were no match in combat for the Spitfires and Hurricanes. Just as for the RAF the outcome of the battle depended upon the Spitfire and Hurricane, for the Luftwaffe it came to depend upon the Bf.109. Battle experience indicated that each bomber, dive-bomber and escort fighter unit needed single-engine fighter protection of three times its own strength, a task quite beyond the Luftwaffe's available force of at most 700 Bf.109s, comparable to the number of Spitfires and Hurricanes available to Fighter Command.[12] Consequently the Luftwaffe's strike force was restricted to a maximum daily average of 300 bombers which could be adequately escorted, and as the combat radius of the Bf.109 was only 300km and its endurance 90 minutes, daylight offensive operations were restricted to south of the Thames. This restriction in the scope of the air battle for air superiority created a sanctuary that the Luftwaffe could not effectively penetrate. It initially enabled Fighter Command to employ a system of rotation whereby battle-weary units could be pulled out of the battle for rest and re-equipment, while inexperienced pilots could receive a measure of combat training in comparative safety.[13]

Pilots

> *We were allowed one week to master the art of aerial fighting in operational service machines with a minimum of twenty-five hours in which do so. After this we were to be posted to fighter squadrons now fully engaged in the south of England, as combatant pilots.*

Roger Hall, Clouds of Fear[14]

Just as for the RAF the outcome of the battle depended upon the Spitfire and Hurricane, for the Luftwaffe it came to depend upon the Bf.109

Picture left shows the later Bf.109-E that entered service in mid-1940

But Fighter Command had been compelled to abandon this system of rotation when the fighting intensified in September, because 11 Group's squadrons were taking such punishment that they needed to be replaced at a rate faster than the units resting and re-forming could be readied for combat. Instead, a system was introduced whereby all squadrons were categorised according to their operational status. Class 'A' squadrons were those within 11 Group or immediately adjacent and which were regularly in action. Class 'B' squadrons, of which there were four, were kept at full operational readiness outside of this area to form a small reserve from which the Class 'A' squadrons could be reinforced or relieved if necessary. Two of them were in fact committed to battle. The remainder, Class 'C' squadrons, were stripped of nearly all their operationally-ready and experienced pilots as replacements for the Class 'A' squadrons.[15] This was a desperate response to Fighter Command's critical weakness as the battle progressed: shortage of pilots adequately trained for air combat.

There had been some 1,200 pilots in Fighter Command at the beginning of the battle and, as with aircraft numbers, the number of pilots serving in the Spitfire and Hurricane squadrons appears constant, 916 on July 1st, 924 on August 1st and 946 on September 1st. Losses in this period totalled 911, of which 332 were killed and 248 wounded in combat.[16] But by September 7th Fighter Command had been 200 pilots below authorised strength and squadrons had on average only 17 or 18 pilots instead of the establishment of 26. Many of these had received only limited operational training before joining their squadrons, as the courses at the three fighter Operational Training Units had been cut from four to two weeks.[17] So while numbers remained constant, there was a risk that the combat effectiveness of squadrons would decline as the best-trained and experienced pilots became casualties and were replaced by those who, until they gained experience, would be extremely vulnerable and of little use in the air.

By early September 1940, of the original 1,000 pilots with which Fighter Command had entered the war, only some 250 were left,[18] a problem which the transfer of pilots with no fighter experience from Army Co-operation, Coastal, and Bomber Commands could not solve. In fact Fighter Command's most significant accretion in fighting power during the battle was the commitment of Hurricane squadrons manned by Polish and Czech pilots, many of whom were combat-experienced having already fought the Luftwaffe in Poland and France.[19] Apart from that, the only possible short-term solution was to 'milk' squadrons of their most proficient pilots for feeding into the battle. This placed a very heavy burden upon the 23 Class 'A' squadrons, some of which were called upon to fly up to 60 hours daily on operations. Their pilots were paying for the deficiencies in the RAF's pre-war training organisation, and in particular for the failure to accurately assess the requirements of a fighter force in sustained combat.[20]

Combat Frequency & Losses

Twenty-four of us flew south that tenth day of August 1940: of those twenty-four, eight were to fly back.

Richard Hillary, The Last Enemy [21]

During August 1940 Pilot Officer Richard Hillary and his fellow Spitfire pilots of 603 Squadron joined 11 Group from 13 Group, relieving the exhausted survivors of 65 Squadron at Hornchurch. By the end of October, of 603's original pilots, and those posted in to replace them, twelve were dead, fourteen had suffered wounds of varying severity, and one had force-landed his damaged Spitfire in France to become a prisoner of war. Twenty-eight Spitfires had been destroyed or written-off while operated by the squadron, while fifteen had sustained varying degrees of combat damage.[22] Squadrons were often exposed to this attrition immediately on arrival from quieter sectors, with their pilots and ground crews having little or no time in which to become acclimatized to the intensity of the battle being fought in the south.

> *The CO addressed the pilots on tactics with particular reference to the experiences of the 3 dog fights in which the Squadron has been engaged since its arrival here on the day before yesterday.*

No.73 Squadron Operations Record Book, entry for September 7th 1940 [23]

Such was the experience of 73 Squadron's pilots. They flew south from Yorkshire with fifteen Hurricanes to operate from Castle Camps, a satellite of Debden, on September 5th and went into action the same day over Burnham in Essex, losing one killed and one wounded while another baled out unhurt and three others landed with damaged machines. Two days later, by the end of September 7th, another pilot had been killed and two others wounded, with a further two Hurricanes destroyed and one severely damaged.[24]

> *Squadron ordered to MAIDSTONE in time to intercept a raid of thirty He.IIIs with the usual escort of fighters above and at the sides. A quick flank attack was made on the bomber formation, but there was no time to observe the effect of the fire before breaking away. The Squadron was then attacked by Me.109s and a dog fight followed. Six serviceable aircraft returned to base and were ordered off again within a quarter of an hour. As these six took off, a large enemy force passed over the aerodrome but did not bomb until they reached N.E. London at 15,000 feet. The six aircraft of the Squadron then attacked an enemy force of approximately 100 aircraft, as the result of which 1 Do.17 was destroyed and several damaged. Our casualties in the first engagement were 74672 PILOT OFFICER ROBERT DAVID SPITTALL FLEMING killed, Sergeant KILLINGBACK baled out wounded, Sergeant SMITHSON crashed at EASTCHURCH, wounded, F/O WELLS missing. Result of second action – Sergeant BEARD had to bale out owing to being hit by AA P/O BARCLAY was shot down but was unhurt. By far the heaviest day's fighting the Squadron has yet had.*

No.249 Squadron Operations Record Book, entry for September 7th 1940 [25]

> *While combat could result in sudden and heavy losses, a closer examination of squadron experience indicates that even within 11 Group considerable operational effort could be expended without resulting in action. No.249 Squadron, equipped with Hurricanes, relieved 56 Squadron at North Weald at the beginning of September 1940. The following table shows that during that month the squadron flew over 640 operational sorties, of which some 160 engaged the enemy. Four pilots were killed and 7 wounded, while 13 Hurricanes were destroyed and 7 damaged. Thirteen pilots were posted to the squadron during the month, one of whom was returned as non-operationally trained.*[26]

No.249 Squadron September 1940

Date	Number of Opnl Sorties	Number of Opnl Sorties Engaging Enemy	Pilot casualties	Aircraft Losses
2/9/40	34	19	1 wounded	1 destroyed, 2 damaged
3/9/40	36	none	1 slightly concussed	1 damaged (friendly AA fire)
4/9/40	27	none	none	none
5/9/40	27	12	none	1 destroyed
6/9/40	33	12	1 wounded	1 destroyed
7/9/40	45	19	1 killed, 3 wounded	4 destroyed 2 damaged
8/9/40	7	none	none	none
9/9/40	10	none	none	1 damaged (forced-landed)
10/9/40	3	none	none	none
11/9/40	24	11	1 wounded	1 destroyed
12/9/40	12	none	none	none
13/9/40	18	none	none	none
14/9/40	26	none	none	none
15/9/40	39	25	none	1 destroyed
16/9/40	15	none	none	none
17/9/40	13	none	none	none
18/9/40	51	13	1 killed	1 destroyed
19/9/40	11	2	none	none
20/9/40	12	none	none	none
21/9/40	14	none	none	none
22/9/40	5	none	none	none
23/9/40	13	none	none	none
24/9/40	25	none	none	none
25/9/40	21	none	none	none
26/9/40	11	3	none	none
27/9/40	36	34	2 killed	2 destroyed 3 damaged
28/9/40	23	11	1 wounded	1 destroyed
29/9/40	14	none	none	none
30/9/40	36	none	none	none

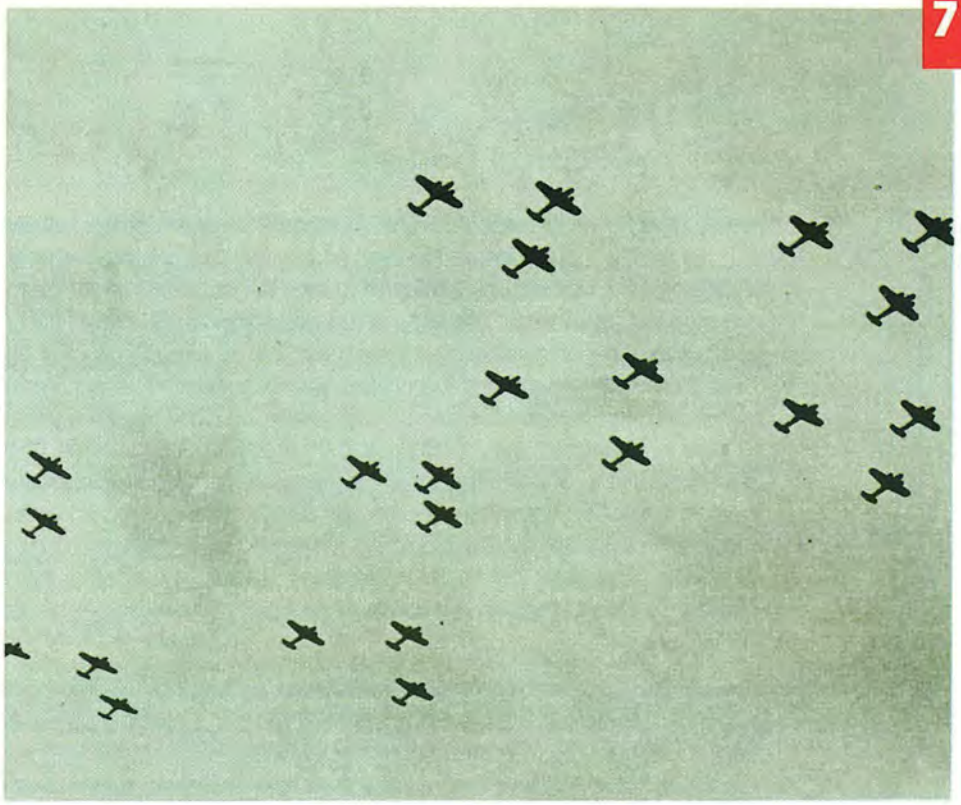
The post-war analysis of the battle by the RAF focused on the overall loss rates sustained by Fighter Command's squadrons in the 54 days from August 8th to September 30th 1940. In this period Fighter Command's strength averaged 50 squadrons with a total force of some 1,000 fighters. They flew 34,967 operational sorties, 69 per cent of which were 'scrambled' with orders to intercept German raiders, 21 per cent were sector patrols, and 10 per cent were for such duties as convoy and shipping protection. A maximum effort of 1,320 sorties was achieved on one day, and over 1,000 sorties per day achieved on four separate occasions, but the daily average over the 54 days was just under 650 sorties.[27]

The 54-day period was selected because it coincided with an intensification of the air fighting. In the first five weeks of the battle, from the beginning of July to August 11th, the Luftwaffe had flown some 1,725 daylight bomber and dive-bomber sorties and some 5,300 fighter sorties. About 70 per cent of this effort had been directed against coastal targets; shipping, port facilities and naval bases, an important objective being to remove the threat posed to an invasion force by the Royal Navy.[28] But thereafter the emphasis of the attacks by German bomber formations and their fighter escort progressively shifted to inland targets, offering more opportunity for interception and combat. Fighter Command, its airfields, and its supporting air defence system within striking range had been heavily targeted between August 24th and September 6th and 11 Group came dangerously close to being overwhelmed. But the Luftwaffe's effort was instead diverted against London, and the period examined had culminated in major daylight raids against the capital.[29]

Fighter Command's aircraft battle casualties in the period were 1,206 fighters, of which 746, or 62 per cent, were destroyed, missing, or damaged beyond repair.[30] This represented, over the 54 days, battle wastage of one fighter casualty per 30 operational sorties. But this was hardly a true picture, because closer examination discovered that an average of only 23 per cent of total operational sorties had actually engaged the enemy. When operational sorties not necessarily expected to result in action, such as those for shipping protection, were removed from the equation and only those sorties ordered to intercept considered, the average number of operational sorties engaging the enemy during the 54-day period still amounted only to 31 per cent. This had been largely due to the rudimentary nature of the early warning and fighter control system available in 1940. Even with the advantage of radar the warning time from the detection of an incoming raid to the actual bombing of the target had been very short, and German bombers flying at 190 mph from the Pas de Calais had been able to reach London in less than 30 minutes. The defence had only a critically small margin of time for information to be assimilated, for 11 Group's squadrons to be 'scrambled', and for the Hurricanes and Spitfires, once airborne, to gain altitude – they had needed at least 10 minutes to reach 20,000 feet.[31] Consequently there was no time for 11 Group to concentrate units for interception, and squadrons had to be committed singly. Considerable effort had also been expended in the provision of standing patrols.

As the Luftwaffe conducted deeper penetrations against London towards the end of September, the proportion of RAF fighters engaging had risen to nearer 40 per cent and on one occasion had reached 78 per cent. The depth and duration of these heavy German raids allowed the employment of two-squadron formations by 11 Group, and the intervention in the fighting by larger wing formations from the adjacent 12 Group covering East Anglia and the Midlands. However, over the whole 54 days, on average Fighter Command had taken one fighter casualty per 6.5 combat sorties. Fighter Command's aircrew casualties in the period totalled 569, of which 304 were killed or reported missing. A rate of one aircrew casualty for just over two aircraft casualties can be considered favourable, a key factor being that as the battle was fought over the UK and its coastal waters, pilots who baled out unhurt were not lost to their units.[32]

In the first five weeks of the battle, from the beginning of July to August 11th, the Luftwaffe had flown some 1,725 daylight bomber and dive-bomber sorties



Dornier Do 17s. This type was employed in massive numbers over England in the summer of 1940

It was estimated that the Luftwaffe had made 21,000 sorties over the UK and its approaches in the period, and had sustained a total of 1,619 aircraft casualties of which 1,216 or 75 per cent were destroyed. As 60 per cent of total German losses were fighters, the RAF analysts concluded that 'we were losing roughly one RAF fighter for every GAF (German Air Force) fighter destroyed and that we can regard the German bombers shot down as a bonus on this.'[33] Fighter Command's aircraft battle casualties are tabulated below, based upon data accumulated for the RAF's analysis:[34]

Fighter Command Battle Casualties, August 8th-September 30th 1940

Period	Total Opnl. Sorties	Number of Sorties Engaging Enemy	Total a/c Casualties	Number of Opnl Sorties per a/c Casualty	Number of Sorties Engaging Enemy per a/c Casualty
Aug 8-17	6,984	1,478	250	28	5.9
Aug 18-24	4,438	712	131	34	5.4
Aug 25-31	4,971	1,193	214	23	5.6
Sept 1-7	5,267	1,283	236	22	5.2
Sept 8-14	2,969	742	104	28	7.1
Sept 15-21	4,182	951	96	44	9.9
Sept 22-30	6,156	1,457	175	35	8.3

An exchange rate of one RAF fighter for each German fighter destroyed suggests that in air-to-air combat neither fighter force obtained an appreciable or decisive advantage. In retrospect this is surprising. The tactical proficiency of many RAF squadrons had been generally inferior to their more experienced opponents, certainly at the beginning of the battle, and there had been no time for the combat experience gained by a limited number of squadrons over France between May and June 1940 to be fully assimilated throughout the Command. The rigid formation attacks developed pre-war for use against bombers had soon to be abandoned in practice, while the 'vic' of three fighters in arrowhead formation proved far less manoeuvrable and effective in combat than the loose formations of mutually supporting pairs of fighters employed by the Luftwaffe.[35] German pilots, though, had been hampered by the 109's lack of range and endurance and, particularly in the later stages of the battle, by many of them being restricted to close bomber escort. Much of the tactical initiative was thereby lost to the defending RAF fighters, a factor that can be discerned in the increase in the number of RAF sorties engaging the enemy per aircraft casualty shown in the above table.

This would have been of little account however, had not Fighter Command been able to withstand a battle of attrition in 1940. Both Fighter Command and the Luftwaffe discovered how dependent they could become upon the capabilities of certain aircraft types, how precious an asset were pre-war trained and experienced aircrew, and how vital were reserves of both. The most enduring lesson from the 1940 experience must surely be that the outcome of an air defence battle, or of an offensive to gain air superiority, is decided not only in the air, but in the extent to which an air force has been equipped and trained to sustain it.

NOTES

1 Richard Hillary, *The Last Enemy* (London: Pan Books Edition, 1956), p.180. Pilot Officer Richard Hillary of No.603 'City of Edinburgh' Squadron (Royal Auxilliary Air Force) suffered severe burns when his Spitfire was shot down in combat with German Bf.109 fighters on September 3rd 1940. He lost his life while training as a night-fighter pilot in 1943, following a courageous struggle to return to flying. His book *The Last Enemy*, first published in 1942, remains a classic of war literature.

2 Research Branch, RAF Fighter Command, Report No.710 (May 1952). *The Trend of Defensive Day-Fighter Losses in Intensive Air Operations in World War 2*, PRO AIR 16/1218.

3 Quoted in Humphrey Wynn (Ed), *Fighter Pilot: A Self-Portrait by George Barclay* (London: William Kimber, 1976), p.78. No.249 Squadron was equipped with Hurricanes and was based at North Weald in No.11 Group during the Battle of Britain. Squadron Leader R.G.A. Barclay, DFC, was killed in action in North Africa in July 1942 while commanding No.238 (Hurricane) Squadron.

4 Other fighter types on Fighter Command's strength in 1940 included the Boulton Paul defiant turret fighter, the twin-engine Bristol Blenheim IF fighter (a conversion from the Blenheim light bomber), and the Gloster Gladiator bipline fighter. None of these proved adequate for day fighting, and were certainly no match for the German Bf.109E.

5 Francis K. Mason, Battle Over Britain p.96 (Bourne End, Berks: Aston Publications Edition, 1990).

6 Figures are taken from Fighter Command's Order of Battle recorded at 0900 hours on July 1st, August 1st, and September 1st 1940, reproduced in Francis K. Mason, *Battle Over Britain* (Bourne End, Bucks: Aston Publications Edition, 1990), pages 98, 160, and 265.

7 Figures from British Air Ministry reports and RAF daily equipment records, quoted in Robin Higham, *The Royal Air Force and the Battle of Britain* Chapter 3 in Benjamin Franklin Cooling (Ed), *Case Studies in the Achievement of Air Superiority* (Washington, D.C: Center for Air Force History, 1994), p.151.

8 Ibid.

9 Figures are taken from Appendix E, 'Production, Availability and Wastage of British Fighters', in Francis K. Mason, *Battle Over Britain* (Bourne End, Bucks: Aston Publications Edition, 1990), page 503. This source also indicates that in the period week ending August 10th to week ending September 7th fighter production totalled 269 Hurricanes and 185 Spitfires.

10 Research Branch, RAF Fighter Command, Report No.689 (May 1949), *Day Fighter Rates of Effort During the Battle of Britain*, PRO AIR 16/1047.

11 Ibid. It was noted that in 11 Group the number of operational sorties per serviceable aircraft per week reached 14 during one period of very intensive fighting. In 13 Group the number of operational sorties per serviceable aircraft per week rarely exceeded 4.

12 Dr Horst Boog. *The Luftwaffe and the Battle of Britain*, Chapter 5 in Air Commodore Henry Probert and Sebastian Cox (Eds), *The Battle Re-Thought: A Symposium on the Battle of Britain* (Shrewsbury: Airlife, 1991), p.25.

13 See Basil Collier, *The Battle of Britain*, (Fontana Books Edition, 1974), pp 84-85; E.R. Hooton, *Eagle in Flames: The Fall of the Luftwaffe* (London: Arms & Armour Press, 1997), p.21.

14 Roger Hall, *Clouds of Fear* (Folkestone: Bailey Brothers & Swinfen, 1975), p.34. Originally a pilot in Army Co-operation Command, Roger Hall volunteered for Fighter Command in 1940 and served as a Spitfire pilot with 152 Squadron during the Battle of Britain. He was awarded the DFC in 1942.

15 See Anthony Robinson, *RAF Fighter Squandrons in the Battle of Britain*, (London: Arms & Armour Press, 1987), pp.19-20 and Francis K. Mason, *Battle Over Britain*, p.285.

16 RAF Fighter Command Report, April 1952, (PRO AIR 16/609) quoted in Robin Higham, *The Royal Air Force and the Battle of Britain* Chapter 3 in Benjamin Franklin Cooling (Ed), *Case Studies in the Achievement of Air Superiority* (Washington, D.C: Center for Air Force History, 1994), p.144.

17 Anthony Robinson, *RAF Fighter Squadrons in the Battle of Britain*, p.17.

18 Robin Higham, *The Royal Air Force and the Battle of Britain*, op.cit, p.135.

19 Two Polish and two Czech squadrons became operational during the battle, Nos.302 and 303 (Polish) Squadrons and Nos. 310 and 312 (Czech) Squadrons, No.303 (Polish) and No.310 (Czech) squadrons were the most heavily committed; No.310 Squadron operated from Duxford in 12 Group and claimed 371/2 victories, while No.303 Squadron, flying from Northolt in 11 Group, became the top-scoring squadron of the battle claiming 1171/2 victories. See John Rawlings *Fighter Squadrons of the R.A.F. and Their Aircraft* (Somerton: Crecy Books, 1993 Edition), p.390 & p.396 and Christopher Shores and Clive Williams, *Aces High* (London: Grub Street, 1994), pp.56-60.

20 This is discussed by Robin Higham in *The Royal Air Force and the Battle of Britain* Chapter 3 in Benjamin Franklin Cooling (Ed), *Case Studies in the Achievement of Air Superiority* (Washington, D.C: Center for Air Force History, 1994), pp.143-147.

21 Richard Hillary, *The Last Enemy*, p.100.

22 Data from Winston G. Ramsey (Ed), *The Battle of Britain Then and Now* (London: After The Battle, Fifth Edition, 1989); see also Leslie Hunt, *Twenty-One Squadrons: The History of the Royal Auxiliary Air Force 1925-1957* (Somerton: Crécy Books, 1992 Edition), pp.102-104.

23 No.73 Squadron Operations Record Book, September 1940, PRO AIR 27/629.

24 Ibid.

25 No.249 Squadron Operations Record Book, September 1940, PRO AIR 27/1498.

26 Details from Forms 540 and 541, No.249 Squadron Operations Record Book, September 1940, PRO AIR 27/1498.

27 Research Branch, RAF Fighter Command, Report No.710 (May 1952), *The Trend of Defensive Day-Fighter Losses in Intensive Air Operations in World War 2*, PRO AIR 16/1218. These figures should be compared with those quoted for RAF Fighter Command during the battle in E.R. Hooton's recent detailed study of the Luftwaffe in the Second World War, based upon the Air Historical Branch Narrative, Fighter Command Air Staff Diary (PRO AIR 24/526), RAF Fighter Command Summary of Sorties (PRO AIR 16/1037), the Operations Record Books of Nos.10 & 13 Groups (PRO AIR 25/182 & PRO AIR 25/232) and various squadron records. These sources indicate that in the eight-week period August 5th-September 29th Fighter Command flew 33,584 defensive day sorties, of which the single-engine fighter of Nos.11 and 12 Groups flew 25,395. See E.R. Hooton, *Eagle in Flames: The Fall of the Luftwaffe* (London: Arms & Armour Press, 1997), p.15.

28 E.R. Hooton, *Eagle in Flames: the Fall of the Luftwaffe* (London: Arms & Armour Press, 1997), p.15.

29 This change in German strategy, following a raid on Berlin by Bomber Command on the night of August 25th, is generally considered to have been the salvation of 11 Group and a key factor in the German failure to obtain air superiority over south-east England.

30 Research Branch, RAF Fighter Command, Report No.710 (May 1952), *The Trend of Defensive Day-Fighter Losses in Intensive Air Operations in World War 2*, PRO AIR 16/1218. Sources consulted by E.R. Hooton indicate that in the eight-week period August 5th-September 29th Fighter Command lost 689 fighters in daylight operations, of which Nos.11 and 12 Groups sustained 608 or 88 per cent. See *Eagle in Flames*, p.15.

31 Robin Higham, *The Royal Air Force and the Battle of Britain* Chapter 3 in Benjamin Franklin Cooling (Ed), *Case Studies in the Achievement of Air Superiority* (Washington, D.C: Center for Air Force History, 1994), p.130.

32 Research Branch, RAF Fighter Command, Report No.710 (May 1952), *The Trend of Defensive Day-Fighter Losses in Intensive Air Operations in World War 2*, PRO AIR 16/1218.

33 Ibid. Figures quoted by E.R. Hooton based on German sources indicate that in the eight-week period August 5th-September 29th 1940 the *Luftwaffe* flew some 7,975 daylight bomber and dive-bomber sorties and some 20,900 fighter sorties, for a total of 28,875 sorties. Some 394 bombers and 589 fighters (983) sustained combat damage of 60 per cent or over, which constituted a loss or write-off in German terms. That fighters represented 60 per cent of these losses accords with the RAF's 1952 analysis. See *Eagle in Flames*, p.14.

34 Research Branch, RAF Fighter Command, Report No.710 (May 1952), *The Trend of Defensive Day-Fighter Losses in Intensive Air Operations in World War 2*, PRO AIR 16/1218.

35 Mike Spick, *Fighter Pilot Tactics: The Techniques of Daylight Air Combat*, (Cambridge: Patrick Stephens, 1983), pp.58-61.