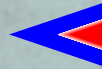


LOGISTICS
and the
BATTLE OF BRITAIN





It is arguable that the Battle of Britain was lost long before the Second World War started. Luftwaffe doctrine, so successful in establishing a powerful synergy between air and land operations, was deeply flawed in its understanding of the fundamentals of air power. The causes were various but the result was that inadequate provision was made for the industrial investment and resources necessary to sustain operations in the face of the high wastage rates that war would bring. By contrast, the Royal Air Force was well placed to defend Great Britain, notwithstanding its perceived doctrinal emphasis on strategic bombing. As Richard Overy has recently pointed out, the contest that the country faced after Dunkirk had been anticipated and prepared for in the 1930s.¹ The Air Ministry, planning the rapid expansion of the frontline, had clearly understood the lessons of the First World War and, in particular, the high cost – in human and materiel terms – of sustaining air operations.² By providing the proper economic and logistic basis for realizing these plans, the air staffs had also established the foundation for increasing Allied air superiority as the war progressed. This is not to say that their pre-war planning was without flaws. Indeed, at a tactical and operational level the Luftwaffe enjoyed self-evident advantages. However, by getting the fundamentals right and being prepared to learn from painful early reverses, the Royal Air Force placed itself in a significantly stronger position to fight the Battle of Britain than the Luftwaffe.

None of this is to deny the huge importance of technology, of tactics, of leadership and the courage of individual pilots in determining the final outcome. No doubt these issues will continue to dominate the debate on the conduct of the Battle of Britain for the foreseeable future – much as they have for the last 60 years. But the possibility of a Luftwaffe victory was effectively compromised by plans laid down in the pre-war period that provided Fighter Command with a quantitative advantage, and the means to sustain this advantage, denied to their opponents.

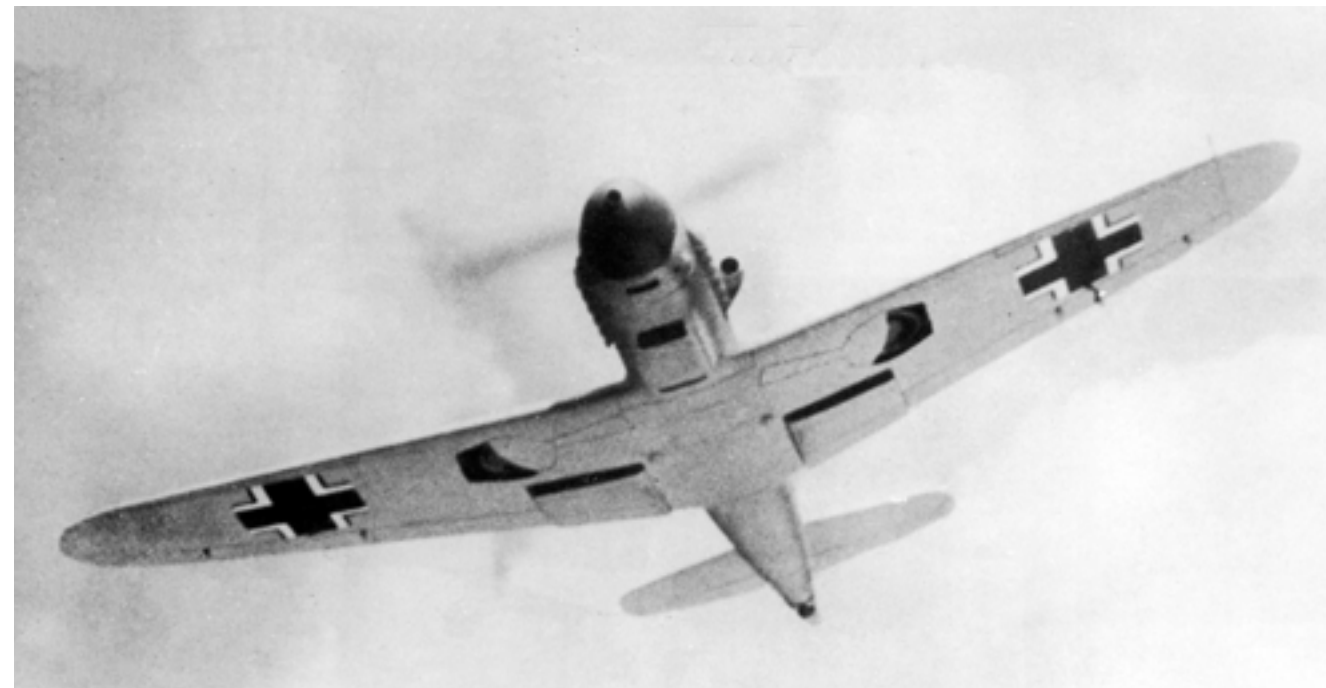
16 *...single seat fighters would need to prevail if the Luftwaffe was to achieve air superiority over Southern England and, in so doing, defeat the Royal Air Force*

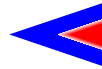
This article seeks to clarify the part played by logistics in the Battle of Britain and how it shaped the outcome. For brevity, the analysis focuses primarily on the single seat fighters deployed by the respective air forces. It was in this arena that the Luftwaffe would need to prevail if it was to achieve air superiority over Southern England and, in so doing, defeat the Royal Air Force.

WASTAGE

As the prospect of war grew ever stronger, the Royal Air Force turned to the First World War for some indication of what to prepare for. While it was recognised that technology had moved on considerably since 1918, it was expected that the problems to be overcome in prosecuting a modern war would be familiar, albeit more acute. In a paper delivered to the Royal United Services Institute in 1934, the difficulties facing a technical service preparing for the next war were explored in some detail, particularly the question of how to make good wastage.³ Chairing the meeting was Sir Robert Brooke-Popham, who had been largely responsible for the development of the highly efficient logistic system that supported the Royal Flying Corps and the Royal Air Force on the Western Front.⁴ In a review of the key issues, it was stated that the average life of an aircraft in war was 2 months, a view shared by Sir Robert, who referred to the 45% monthly attrition suffered by the Royal Air Force between March and October 1918.⁵ Wastage could only be made good from 3 sources: manufacture; reserves; and repair. As matters stood, it was unlikely that either industry or the Service depots could satisfy the demand. Accordingly, for the Royal Air Force to prosecute the next war it would need a greatly expanded peacetime establishment, high production rates, larger repair depots, additional skilled technical personnel, an emphasis on quantity over quality (in the sense of balancing production against continuous progress), long preparation and careful planning.

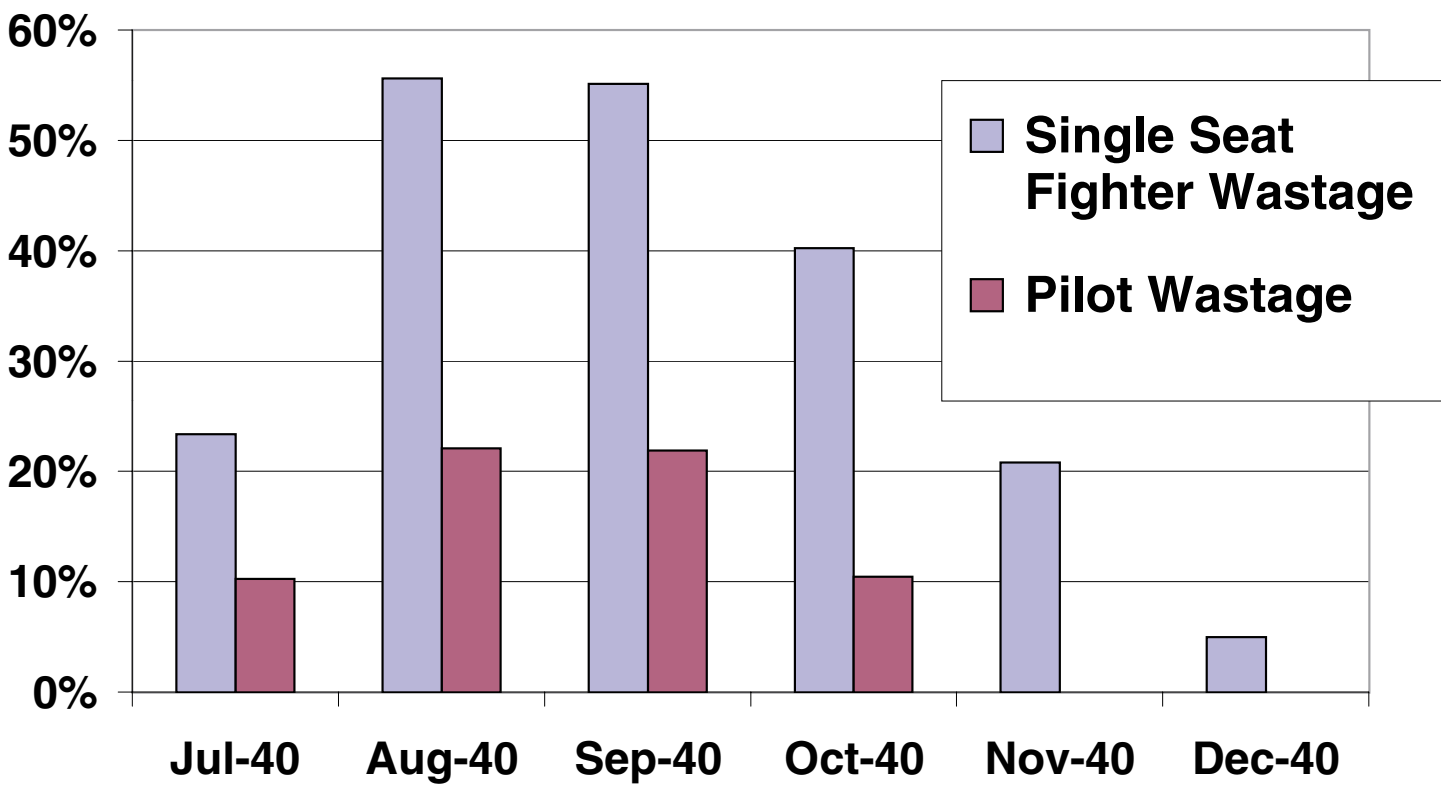
Such public pronouncements were matched by the Air Staff's own calculations in Memorandum No 50 (Secret Document 78), first issued in 1933, that provided data for the calculation of consumption and wastage in war.⁶ The monthly wastage rate for single seat fighters engaged in Home Defence was assessed to be 100% and that for single seat pilots 30%. Thus, it was





anticipated that a fighter force of 50 squadrons would suffer wastage of 1,000 aircraft a month when engaged on active operations. Assuming that the depots could repair 50% of these machines,⁷ industry would need to produce 500 new aircraft a month just to maintain frontline strength. In order to cope with peaks in attrition, and the inevitable delay in mobilizing industrial production, reserves equal to at least 6 weeks' wastage would also be required (some 1,500 aircraft). Finally, approximately 300 new fighter pilots would be needed each month, although it was recognised that dilution would be a major factor in determining whether operational effectiveness could be sustained.⁸ Interestingly, given the received wisdom that pre-war Royal Air Force planners were only interested in strategic bombing, it was further stated that *“Home Defence was the most important commitment that the Service had to prepare for”*.⁹

Figure 1 : Fighter Command Monthly Wastage July - December 1940



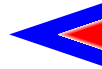
In the event, these calculations would not prove to be grossly unrealistic, as **Figure 1** indicates.¹⁰ More importantly, in recognising the attritional nature of any future war,¹¹ the Air Staff had laid the foundations of an expansion plan that would provide the Royal Air Force with the resources to defeat the Luftwaffe both in terms of availability and sustainability. This is not to say that the Luftwaffe had failed to recognise the importance of wastage. Plans prepared in 1938 envisaged a monthly attrition of 50% in bombers and fighters, but the necessary resources and organizational arrangements to make good such losses were not put in place prior to the outbreak of war. Richard Overy has previously commented that pre-war air theory had largely avoided the difficult question of the appropriate level of supply to sustain air power, noting that *“This was not a question of sheer numbers alone, but also of aircraft quality, and of repair and maintenance as well”*.¹² As we will see, it would be difficult to accuse the Royal Air Force staffs of this failing, whatever their faults in other areas of pre-war planning.



“Battle of Britain 1940 – Repairs underway by squadron engineering personnel to a Hurricane.” – One of the subsequent lessons drawn by Fighter Command was that the semi-autonomous maintenance system, introduced during the pre-war expansion of the RAF, was not that well matched, in size and flexibility, to the mobility demanded of the flying squadrons.

REARMAMENT

Between 1934 and 1938 there were 8 separate expansion schemes designed to close the air gap with Germany. They were, as John Terraine has observed *“All, in the strictest sense, failures”*, nevertheless adding that they *“did provide Britain with an air force which was fit (just) to go to war in 1939 and fit (by a narrow margin) to win a decisive victory in 1940”*.¹³ Understandably, for the purposes of deterrence, there was a strong element of show compared to substance in all of these schemes, however, they did ultimately provide for a considerably expanded and modern frontline with significant reserves and the necessary industrial capacity, including shadow factories, to sustain operations. For Fighter Command, the intention had been to provide 50 squadrons of Hurricanes and Spitfires by March 1942, the number deemed necessary to defend against a possible attack by 2,000 German bombers. In the event, this would be achieved (just) by July 1940.



Unfortunately, none of the expansion schemes had tackled the question of repair and overhaul. In fact, the air staffs were divided on the advisability of building up a large-scale repair and maintenance organization in preparation for war. There was little prospect of any significant investment while Sir Edward Ellington remained Chief of the Air Staff (CAS). He had famously expressed his own views with the statement that *“There will be no repair in war”*.¹⁴ When Sir Cyril Newall replaced him in September 1937, the Air Member for Supply and Organisation, Air Vice-Marshal Welsh, was moved to comment that *“we had been building up a frontline Air Force, which was nothing but a facade. We had nothing by way of reserves or organisation behind the frontline with which to maintain it”*.¹⁵ To meet these needs, it was agreed to construct 3 large Service depots (Sealand, St Athan and Henlow) and 3 civilian-manned depots under Service control (Stoke, Abbotsinch and Burtonwood). The former would undertake 25% of the repair arisings, the civilian-manned depots the remainder. This presaged a huge expansion in the repair, supply and storage organization as the war progressed. But, while this would ultimately comprise a network of over 300 maintenance units at home and overseas, the outbreak of war arrived before any of the large general repair depots could be completed.



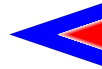
“Battle of Britain 1940 – A Spitfire is serviced and rearmed by squadron engineering personnel.” – At this stage of the war, maintenance was carried out on a semi-autonomous basis, but by 1942 a more efficient, and more mobile centralized system had been introduced.



PRODUCTION

The expansion of the British aircraft industry in support of re-armament was an immense achievement in which huge obstacles had to be overcome. Perhaps the most significant development in pre-war planning was the introduction in 1938 of the War Potential programme that sought to give Britain the capability of producing 2,000 aircraft a month by the end of 1941. As Sebastian Ritchie has pointed out, this provided the basis for planning aircraft production in much greater depth and for developing a comprehensive state production organisation.¹⁶ Although an output of 2,000 aircraft a month would not be achieved until the end of 1942, actual production soon exceeded planned targets. By comparison, German aircraft production languished in the early part of the war. Thus, while Britain produced 4,283 Hurricanes and Spitfires in 1940 against a planned total of 3,602, Germany produced 1,870 Bf 109s against a planned total of 2,412.¹⁷ Incredibly, Germany did not mobilize its aircraft industry on the outbreak of war neither did it seek to expand the Luftwaffe's repair capability to make good this deficiency. In September 1940, when attrition was at its highest, Britain produced 467 Hurricanes and Spitfires while Germany only produced 218 Bf 109s.¹⁸ As we will see, the relative performance of the British and German aircraft industries was critical to both the size and sustainability of the frontline.

Single Seat Fighter Production¹⁹		
	Germany	Great Britain
1939	1,541	1,324
1940	1,870	4,283
1941	2,852	7,064
1942	4,542	9,849
1943	9,626	10,727

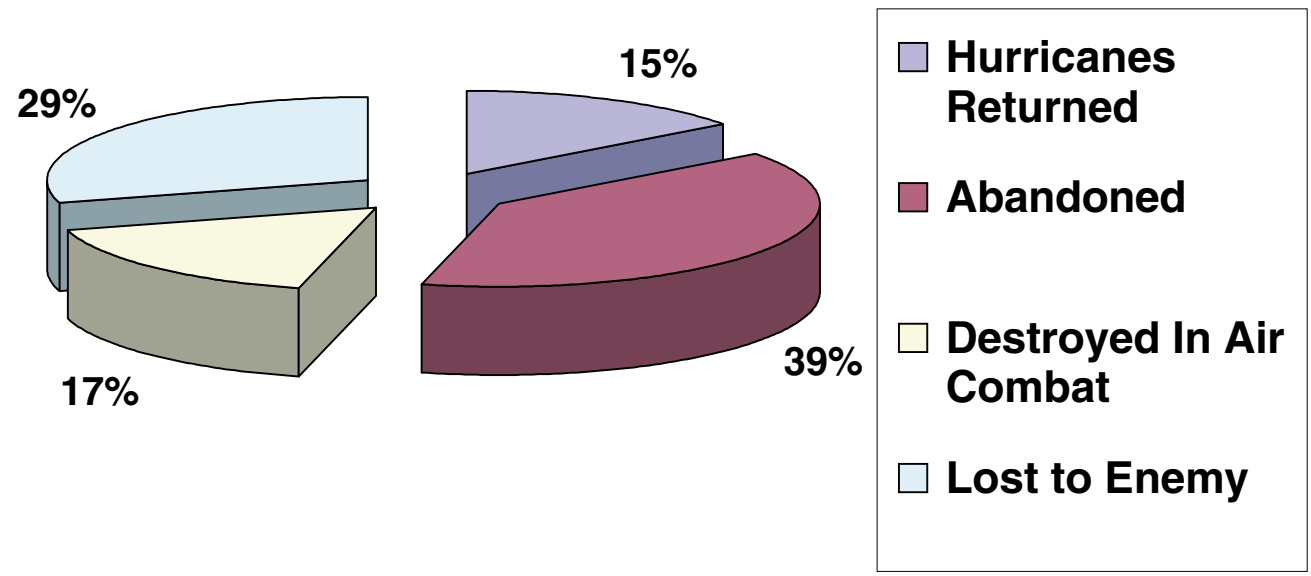


THE BATTLE OF FRANCE

Just how high actual operational wastage would prove was demonstrated in the Battle of France. Of the total of 452 Hurricanes sent to France (equivalent to some 2 months' production) only 66 returned (**Figure 2**). No fewer than 178 of those lost had been abandoned or destroyed through lack of repairs.²⁰ Only a relatively small number were lost in air combat.

These losses could be ill afforded. They were also, to some extent, avoidable. The arrangements for the maintenance of the Royal Air Force units deployed in France were unsatisfactory in many respects. In 1934 it had been decided by Sir Edward Ellington to make deployed squadrons self-sufficient in the event of war rather than to establish a supporting organisation of mobile air parks and depots (based on First World War experience) as had been originally proposed. The course of the war would demonstrate the soundness of the latter scheme; indeed, it would form the basis of the highly effective support arrangements for the Tactical Air Forces.²¹ In the meantime, those squadrons deployed to France found themselves desperately short of reserves, vehicles, spares, and repair and salvage capabilities. Wastage rates were also higher than they had prepared for. As a result, in-theatre repair amounted initially to a mere 2 Hurricanes a week and had risen to only 8 a week by June (and this after considerable effort). Almost no engine repairs had been completed owing to a shortage of tools.²²

Figure 2 : Hurricane Wastage During The Battle of France



No fewer than 178 of those lost had been abandoned or destroyed through lack of repairs



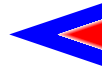
Such experiences were not unique to the Royal Air Force. Anecdotal evidence indicates that the Luftwaffe suffered no less seriously from high operational attrition. Feldwebel Eric Bartel, who served as a Jagdgeschwader mechanic for much of the war, recalled that after just 17 days action his staffel of 12 Bf 109E's from JG 77 had been reduced to just 5 or 6 machines – including spares – but mainly through mechanical failures and “*normal wear and tear*” rather than enemy action.²³

THE ROYAL AIR FORCE MAINTENANCE ORGANIZATION

With the expansion of the Royal Air Force from 1936 onwards came the need to change the policy on aircraft servicing. Prior to this period, each flight within a squadron was a self-contained unit for repair and maintenance, up to ‘write-offs’. This was altered to a 3-flight arrangement under which 2 flights undertook day-to-day maintenance and the third flight all major inspections and repair. This system remained in force during the first year of the war but experience in the Battle of Britain exposed significant weaknesses. As the tempo of operations increased so squadrons were moved at more frequent intervals. The result was that squadrons became increasingly detached from their support staff; in some cases they found themselves distributed across 3 different stations. In December 1940 it was decided to transfer the bulk of the squadron’s servicing personnel to a station maintenance unit, so significantly increasing the mobility of the Fighter Command squadrons.²⁴ These arrangements, with some refinements, would remain in place until the end of the war.

Repair was a more difficult issue to resolve. It became rapidly apparent, even before the outbreak of war, that the Royal Air Force would not have the capacity to meet anticipated arisings. As a result it was agreed in October 1939 that a Civilian Repair Organization (CRO), based around the ‘fringe firms’,²⁵ would be set up under Lord Nuffield who would also control the Service repair organisation; including the Service-manned depots. At the time, this was a difficult decision taken in the face of some understandable hostility. The CRO came into being in January 1940, yet by the end of the year it had repaired a total of 4,955 airframes, about 33% of the total airframe output going to the Metropolitan Air Force. By 1941, the total was slightly over 50%.²⁶ Similar arrangements, organized around the original equipment manufacturer, were put in place for engine and propeller repair.

Prior to the expansion scheme such reserves as existed were stored on the stations where they were to be used. The significant increase in the size of the reserve demanded dedicated storage facilities. It was planned to establish 24 Aircraft Storage Units (ASUs) equipped to store 400 aircraft each and located at existing airfields (but as far away from continental Europe as practicable). On the outbreak of war, the Royal Air Force had some 2,200 aircraft in storage at 12 ASUs. Early in 1940 it was decided that large hangars storing considerable numbers of aircraft presented too high a risk and, accordingly, aircraft were dispersed more widely to reduce the maximum holdings in each ASU from 400 to 200 aircraft.²⁷ ASUs not only provided a strategic reserve of aircraft but also formed an important buffer between the factory and the frontline to cope with inevitable surges in wastage and also to complete modification and installation work prior to final delivery. For example, in



August 1940, No 19 Maintenance Unit at St Athan issued 58 Hurricanes and received 55, leaving 23 in stock out of a total of 237 stored aircraft of 19 different types. By the last quarter of 1939 total ASU holdings had risen to 3,600 aircraft and had grown to over 5,000 by the end of 1940.

THE LUFTWAFFE REPAIR ORGANIZATION

Much of June and July 1940 was used by the Luftwaffe to make good the significant losses it had suffered²⁸ and, in particular, to put in place the logistic arrangements needed to support operations from their new airfields across northern France. The repair organisation was less easy to improvise. Day to day maintenance was the responsibility of mechanics attached to each staffel.²⁹ When in the field, major repairs and overhauls (such as routine replacement of the Bf 109's Daimler-Benz 601 engine after just 100hrs flying time) fell to the workshop section attached to the Group Headquarters Company. Work that was expected to take longer than 2 days was transferred where possible to regional workshops based at major airfields, established to undertake major repairs or modifications. At this stage of the war, however, these workshops were all located in Germany and thus many damaged aircraft had to be transported considerable distances by road and rail just to be repaired. There was no equivalent of the CRO, although there had been a violent debate early in 1938 between Udet (Head of Supply and Research) and Milch (Goring's deputy and State Secretary for the Air Force) about the provision of more extensive repair capabilities to support the Luftwaffe. The latter's view – that campaigns would be short and aircraft could be repaired and salvaged at home after victory was achieved – prevailed against Udet's proposals for significant investment in spares, tools and repair facilities.³⁰ It is tempting to compare this outcome with the decision reached by Royal Air Force staffs on the very same issue at much the same time.

Much of June and July 1940 was used by the Luftwaffe to make good the significant losses it had suffered



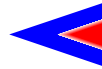
Field maintenance on a BF 109E of JG 26 based at Caffiers, near Calais. The DB 601 engine required replacement every 100 flying hours

In quality and general professionalism it would be hard to fault the Luftwaffe maintenance organisation – it was certainly a match for the Royal Air Force. However, it was not organized for an attritional war and had made little provision for timely repair and salvage. It is also arguable that it was less flexible and found it more difficult to respond to changing circumstances. For example, as the war progressed, it became increasingly evident that maintenance personnel were finding it difficult to keep up with their parent units, much as Fighter Command would discover in 1940. Nevertheless, it would not be until late 1944 that the Luftwaffe introduced independent maintenance companies subordinate to the airfield rather than a particular flying formation to resolve this particular problem.³¹

THE BATTLE

Over the course of June and July 1940, it became obvious that Britain was not about to sue for peace. The Germans recognised that the destruction of the Royal Air Force had now become essential to the achievement of their strategic aims. On 1 August 1940, Hitler issued his Fundamental Directive No 17 for the “Conduct of the Air and Sea War Against England”. The Luftwaffe was to use all means to overpower the Royal Air Force in the shortest time possible. Attacks were to be directed primarily at flying units, their ground installations and their supply organization as well as the aircraft industry in order to “*establish the necessary conditions for the final conquest of England*”.³² To achieve this aim, the Luftwaffe could muster 3,358 aircraft, as follows:

Luftwaffe Order of Battle – 10 August 1940 ³³			
	Establishment	Strength	Serviceability
Bombers	1569	1481	998
Dive-Bombers	348	327	261
Single Engine Fighters	1011	934	805
Twin Engine Fighters	301	289	224
Reconnaissance	246	195	151
Ground Attack	40	39	31
Coastal	94	93	80
Total	3,609	3,358	2,550



Other sources give slightly different figures but most agree that the Luftwaffe deployed an effective strength of a little over 900 Bf 109 fighters out of an establishment of some 1,000 aircraft. This comprised the bulk of their single seat fighter force – approximately 150 aircraft remained in other theatres, including Germany, to defend against possible Bomber Command attacks.³⁴ By comparison, Fighter Command could field 52 squadrons of Hurricanes and Spitfires – some 1,100 aircraft in total. Thus, in terms of single seat fighters, the opposing air forces were fairly evenly matched, albeit that Fighter Command was outnumbered more than 3:1 in overall terms.

Fighter Command Order of Battle – 11 August 1940³⁵			
	Establishment	Strength	Serviceability
Hurricanes	723	721	656
Spitfires	366	374	334
Total	1,089	1,095	990

...in terms of single seat fighters, the opposing air forces were fairly evenly matched, albeit that Fighter Command was outnumbered more than 3:1 in overall terms



Of course, these figures only provide an opening balance. Not unexpectedly, the strength of the respective air forces altered over the course of the summer and autumn as attrition took its toll. However, when we look at the overall picture, **Figure 3**, it is evident that Fighter Command steadily fielded more single seat fighters as the Battle progressed. In fact, as the Royal Air Force grew stronger so the Luftwaffe grew weaker.³⁶

**Figure 3 : Single Seat Fighter Strength
July - December 1940**

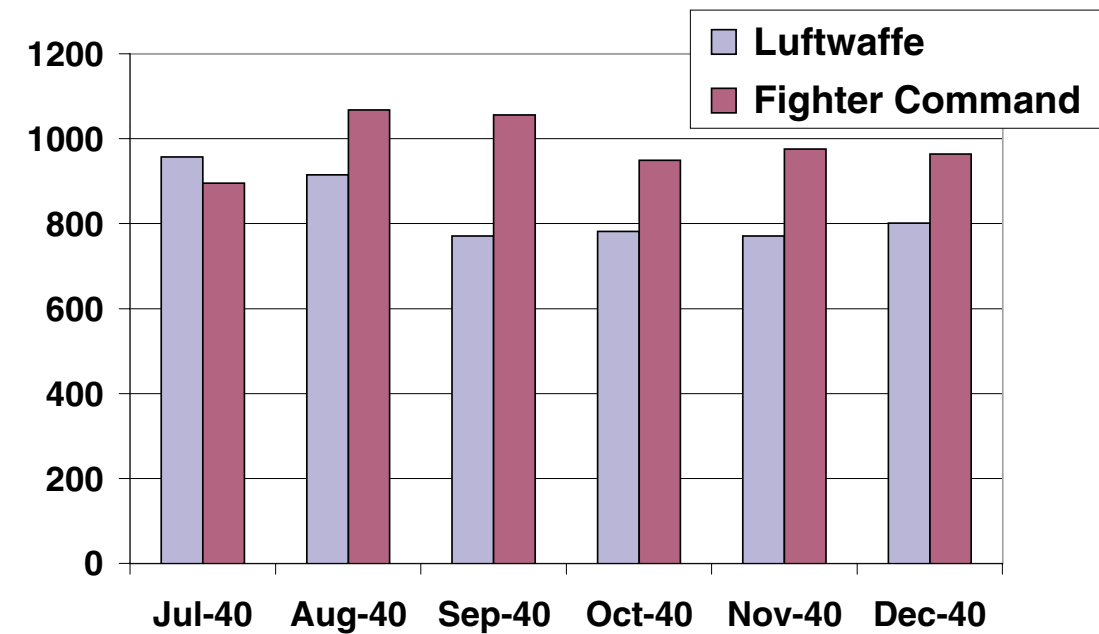
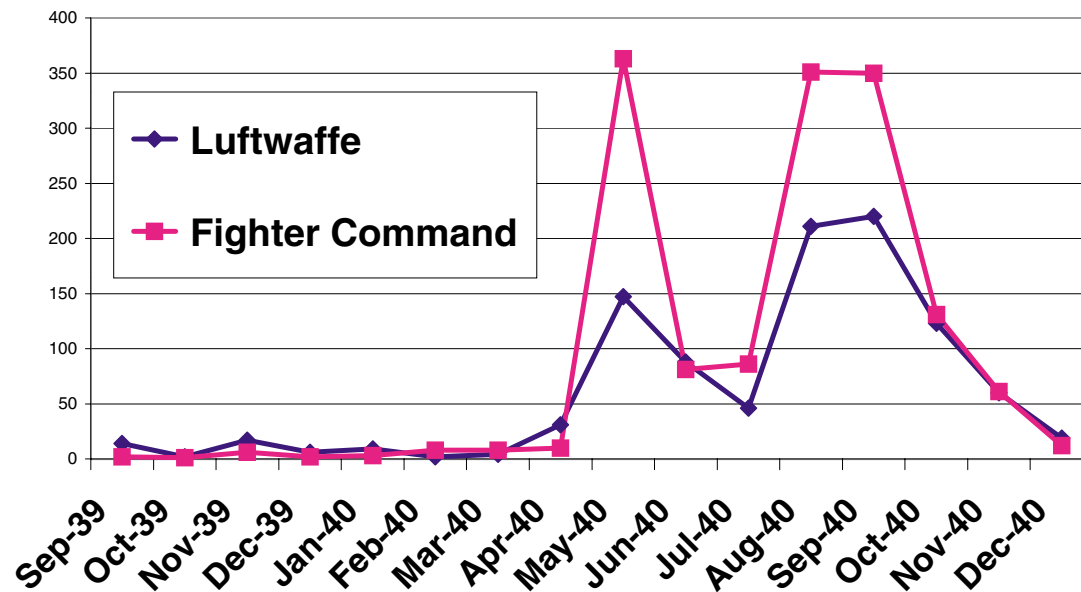
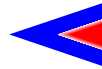


Figure 4 : Single Seat Fighters - Operational Losses 1939 - 1940



What makes this all the more surprising is that Fighter Command's operational losses were significantly higher than those suffered by the Luftwaffe's fighter force. This was equally true for the Battle of France as it was for the Battle of Britain (**Figure 4**). Thus, for the 4 months, July-October 1940, Fighter Command lost over 900 Hurricanes and Spitfires destroyed on operations³⁷ compared to 600 Bf 109s recorded by the Luftwaffe Quartermaster returns.³⁸



Of course, operational losses do not tell the whole picture since they exclude accidents and other wastage.

Determining the actual attrition (total destroyed and damaged) in single seat fighters during the Battle is not entirely straightforward. Definitions vary between the air forces and some interpretation is required. **Figure 5** indicates the total attrition in fighters over the period July to December 1940.³⁹ At the height of the Battle, Fighter Command's total wastage in Hurricanes and Spitfires was over 180% of its operational losses, compared to 140% for the Luftwaffe's Bf 109s. Given Fighter Command's greater combat losses it is hardly surprising to find this

Figure 5 : Single Seat Fighter Attrition July - December 1940

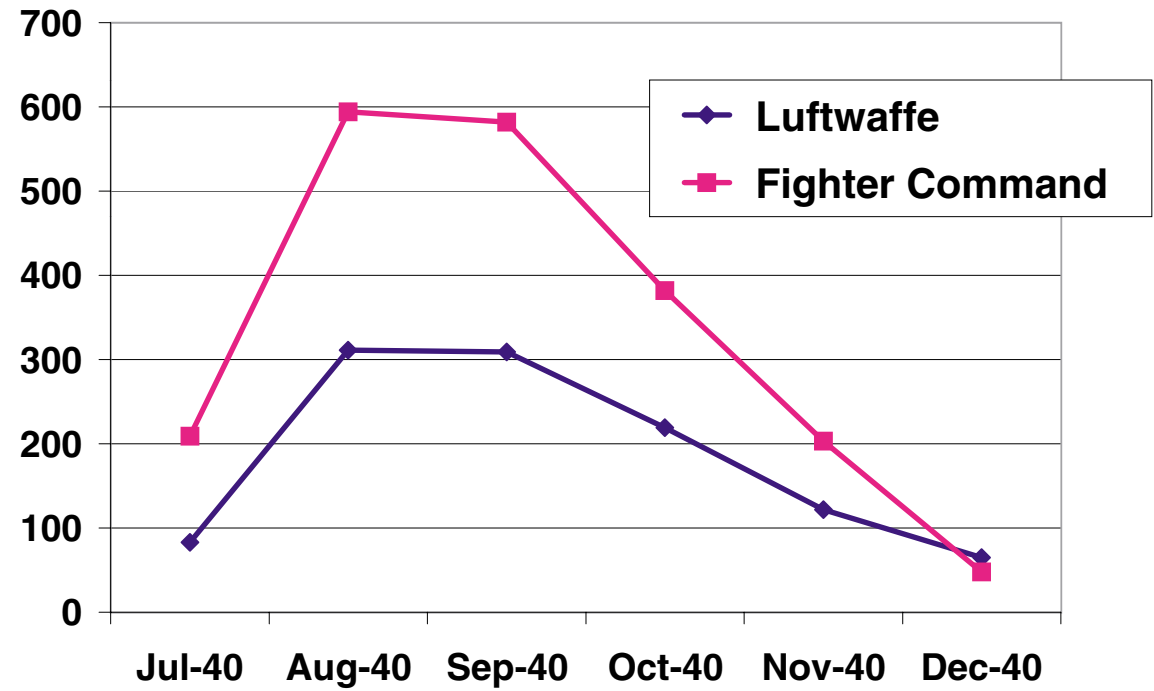
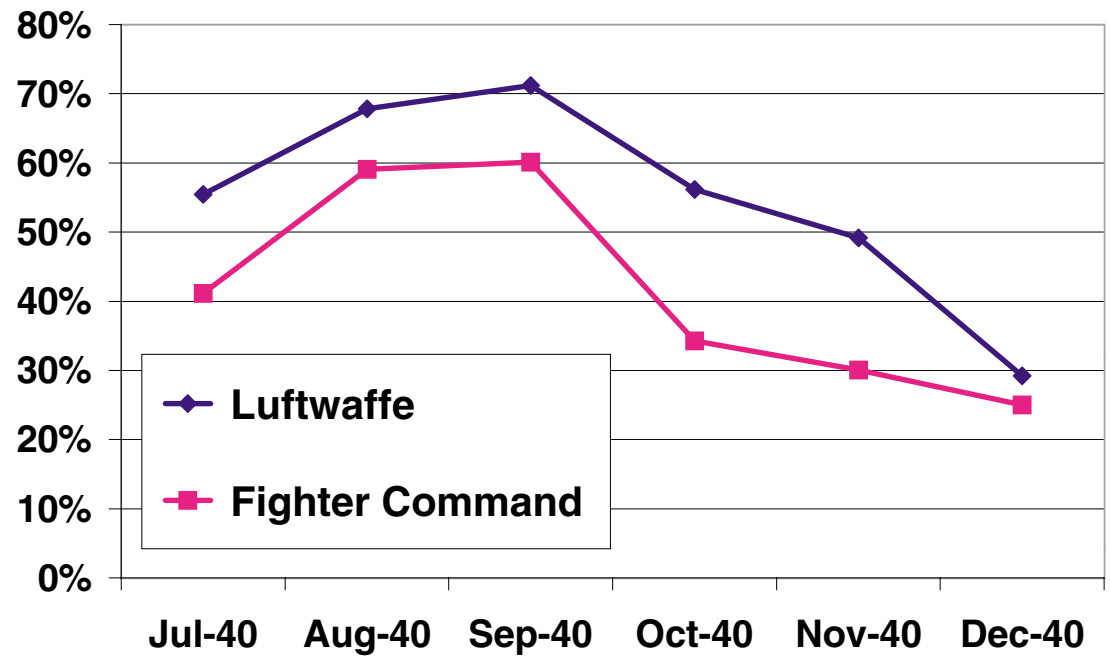


Figure 6 : Single Seat Fighter Operational Losses Against Overall Wastage

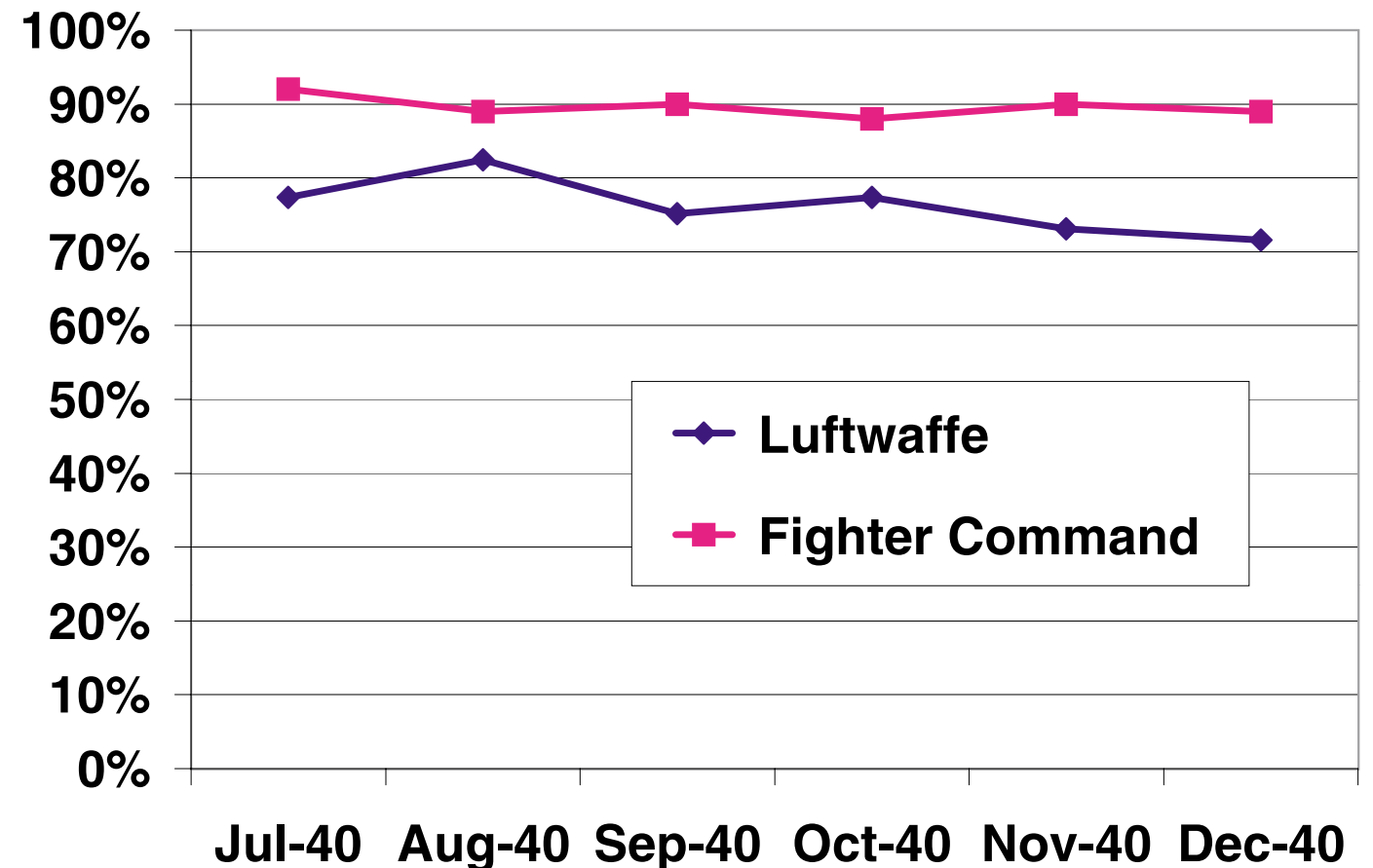


matched by a higher overall attrition. However, the Luftwaffe's figures seem lower than might be expected, even allowing for the fact that damaged Bf 109s were less likely to make it back to their home airfields. When one compares operational losses, as a proportion of the overall wastage recorded, this disparity becomes clearer (**Figure 6**). While distance and the hazards of a Channel crossing could explain some of the difference, it seems likely that the attrition suffered by the Luftwaffe was actually higher (perhaps by as much as 20-25%) than the Quartermaster returns would indicate.

It could be argued that a better test of relative strength is serviceability. The comparative rates for Fighter Command and the Luftwaffe are shown at **Figure 7**. The Fighter Command data has been extracted from an analysis produced in 1945 on production and wastage during the Battle of Britain.⁴⁰ The levels appear to be higher than those quoted in other sources, notably Dempster and Wood.⁴¹ Another source states that Fighter Command serviceability rose from 70% on the outbreak of war, to 80% by November 1939, but, having fallen to 76% in July 1940 had recovered to 80% by September where it stayed for the remainder of the year.⁴² All in all, it seems safe to conclude that serviceability remained fairly constant in Fighter Command throughout the Battle, at somewhere between 80 and 90%.⁴³

The Luftwaffe figures, drawn from the Quartermaster returns, indicate that the serviceability of the single engine fighter force fell from a little over 80% at the start of the Battle to close to 70% by the autumn. These are also somewhat higher than other sources might indicate. Indeed, Richard Overy has suggested that the number of serviceable Bf 109s could have fallen as low as 40% of total strength in October 1940.⁴⁴ If, as discussed previously, operational wastage was actually higher than recorded, then availability may well have fallen to these levels. What is not in doubt is that Fighter Command, unlike the Luftwaffe, was largely able to sustain the serviceability of its fighter force.

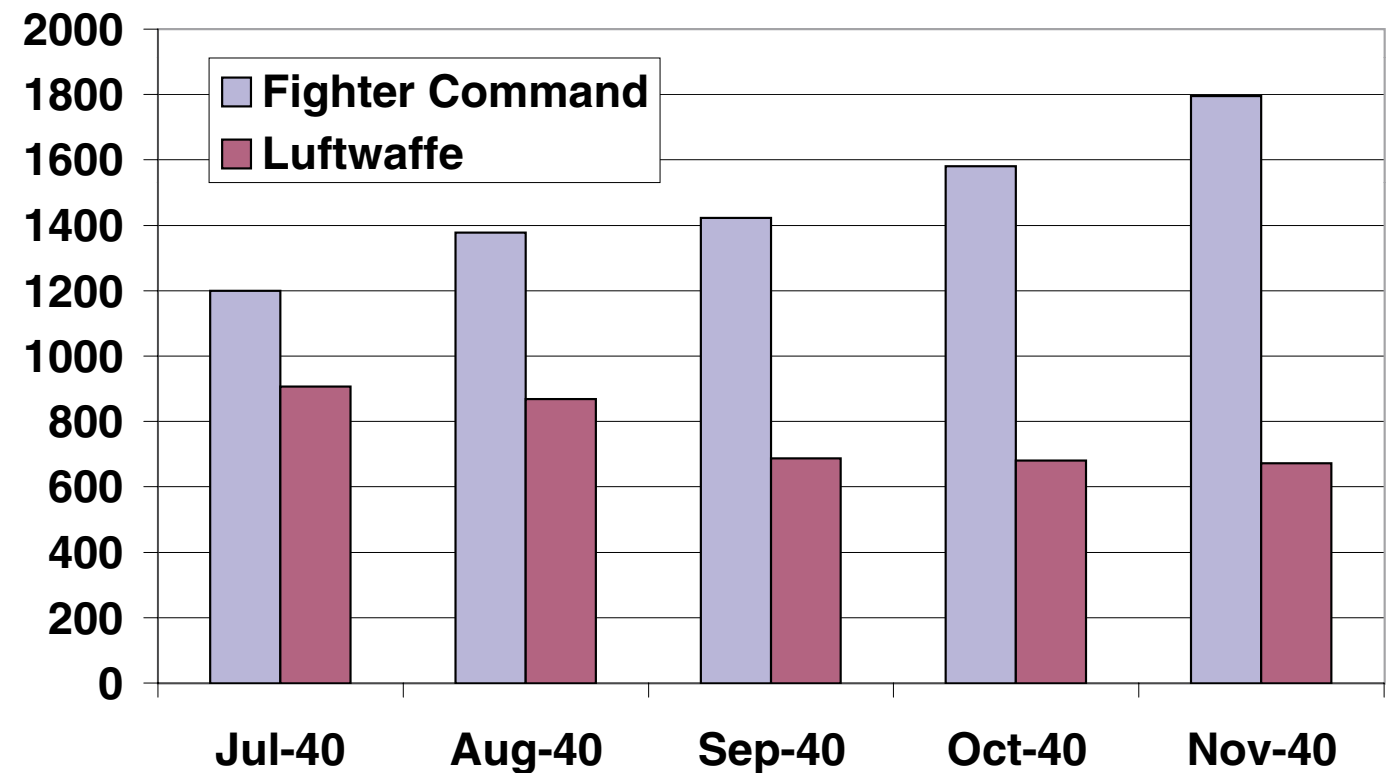
**Figure 7: Serviceability Rates
July - December 1940**



OPERATIONAL IMPLICATIONS

The operational implication for the Luftwaffe in the steady decline in the number of serviceable Bf 109s was significant, if not crucial. Experience rapidly demonstrated that only the Bf 109 could provide adequate protection to the bomber formations. In general, attacks on mainland targets required a 2:1 fighter: bomber ratio and sometimes as high as 3:1. With only 600-700 Bf 109s available daily for offensive operations, the attacking force was limited to no more than 250-300 bombers out of a total strength of 1,800.⁴⁵ Quite simply, the number of Bf 109s available for escort duties determined the Luftwaffe's day offensive capability. Although great emphasis has been placed in the past on the shortage of pilots faced by Fighter Command, the Luftwaffe suffered even more from the impact of wastage. Fighter Command's pilot casualties reached a little over 20% in August and September, but with some 260 pilots (albeit inexperienced) being produced each month from the Operational Training Units, the situation was unlikely to become desperate. In fact, as **Figure 8** indicates, Fighter Command started with a distinct advantage in pilot numbers that only increased as the Battle progressed.⁴⁶ Robin Higham argues that Fighter Command's effective strength was lower, at between 900 and 950 operational pilots.⁴⁷ But, even on this basis, Fighter Command was able to field 250 more single seat pilots than the Luftwaffe in September 1940. The cause was the Luftwaffe's systematic neglect of training; a chronic weakness that only worsened as the war progressed.

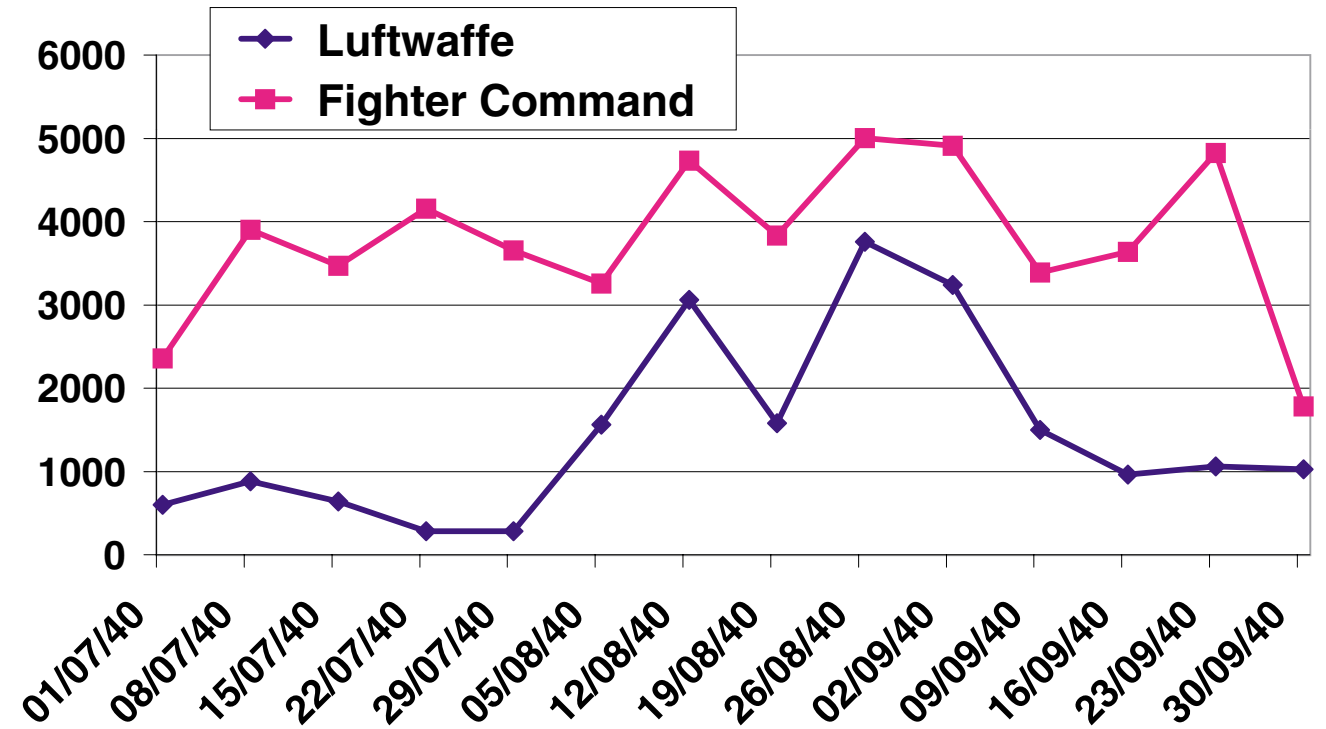
**Figure 8 : Single Seat Pilot Strengths
July - November 1940**





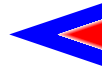
...at the peak of the Battle, Fighter Command's Spitfires and Hurricanes flew 1,000 sorties per week more than the Luftwaffe's Bf 109s

Figure 9 : Comparative Weekly Fighter Sorties



In operational terms, Fighter Command significantly outperformed the Luftwaffe. A comparison of day fighter sorties between the respective air forces indicates **(Figure 9)** that it was able to generate up to as many as 4 times the weekly sortie rate as the Luftwaffe. Even at the peak of the Battle, Fighter Command's Spitfires and Hurricanes flew 1,000 sorties per week more than the Luftwaffe's Bf 109s.⁴⁸

Fighter Command clearly possessed an increasing advantage in single seat fighters as the Battle continued, notwithstanding higher aircraft and pilot attrition. How then, was this achieved?



PRODUCTION BALANCE

The simple answer is that losses were never greater than production. Deliveries to the operational squadrons actually exceeded wastage throughout the Battle (**Figure 10**). This disguises, however, the crucial role played by the CRO.⁴⁹ While the sustained efforts of the aircraft industry were vital to maintaining the frontline, repair provided 40% of the total output received by the operational squadrons,

Figure 10 : Fighter Command - Aircraft Issued July - December 1940

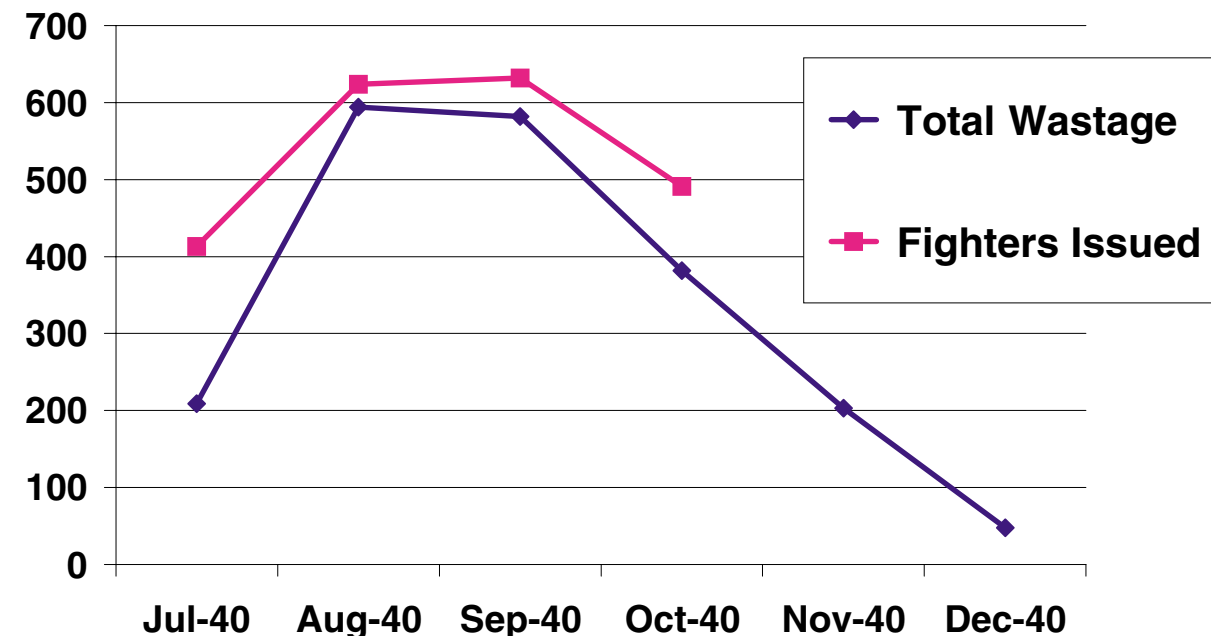
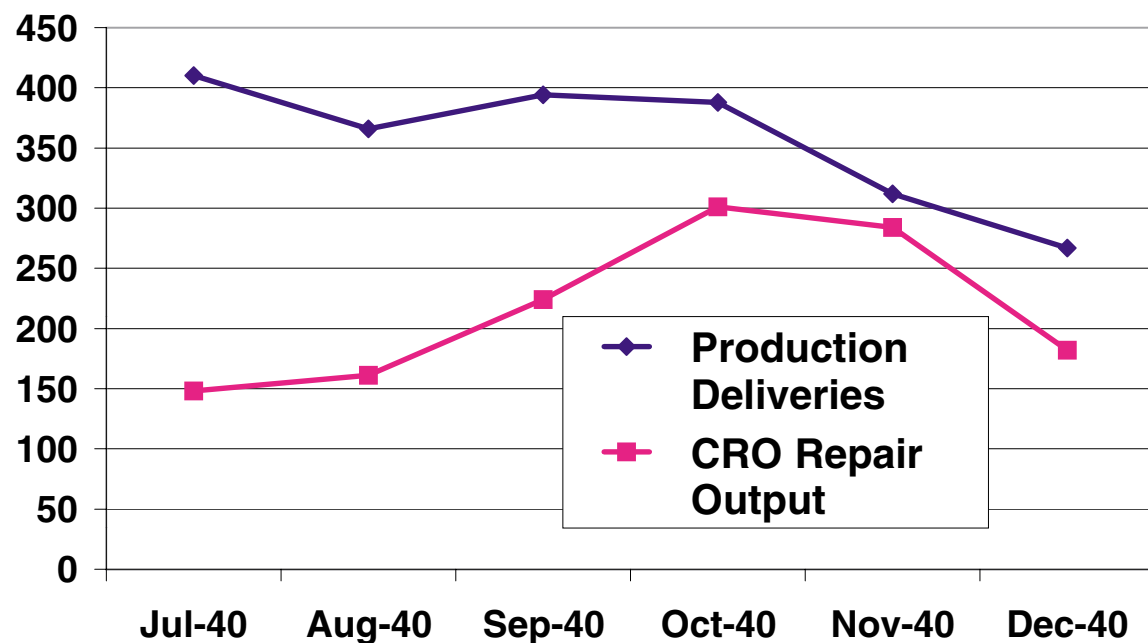


Figure 11 : Hurricane & Spitfire Production vs Repair July - December 1940



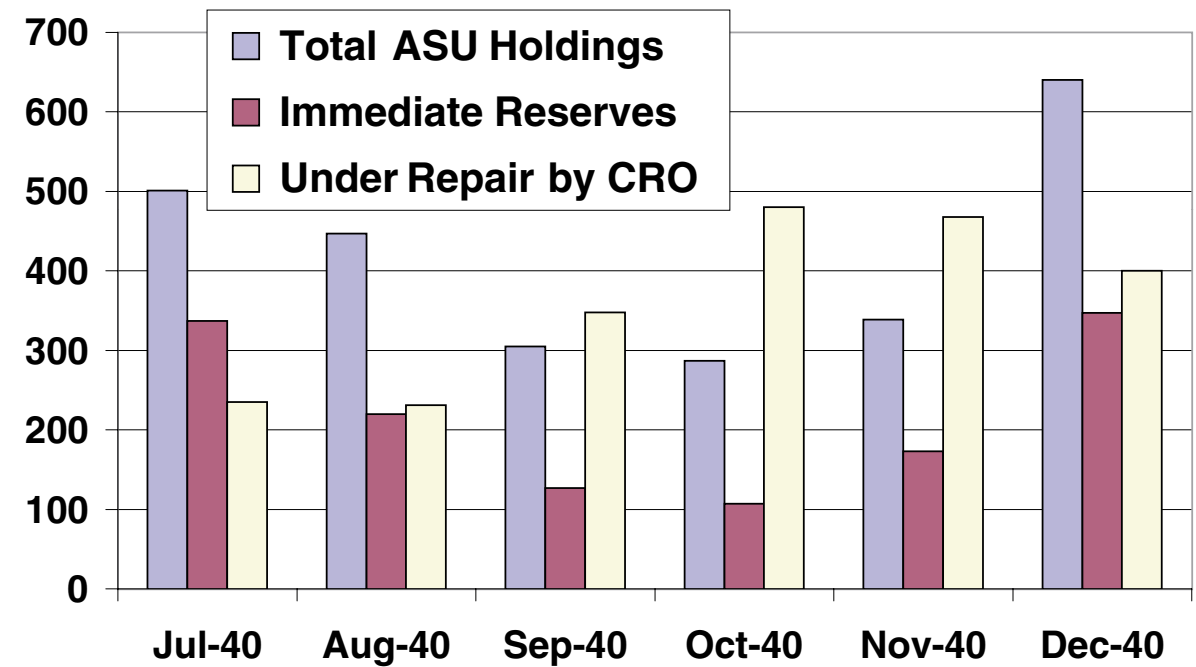
as **Figure 11** illustrates. At the height of the Battle, the CRO was achieving repair turn round times of under 6 weeks for Hurricanes and Spitfires, employing a combination of depot, fly-in and on-site repair. The Luftwaffe had no capability on this scale. In fact, until as late as 1942, repair output was no more than 25% of production.⁵⁰ Germany had entered the war with reserves of 900 aircraft, equivalent to 25% of front line strength, compared to reserves of 2,200 aircraft, some 115% of front line strength, held by the Royal Air Force.

Accordingly, the Luftwaffe's relatively modest reserves were rapidly dissipated through operational attrition.

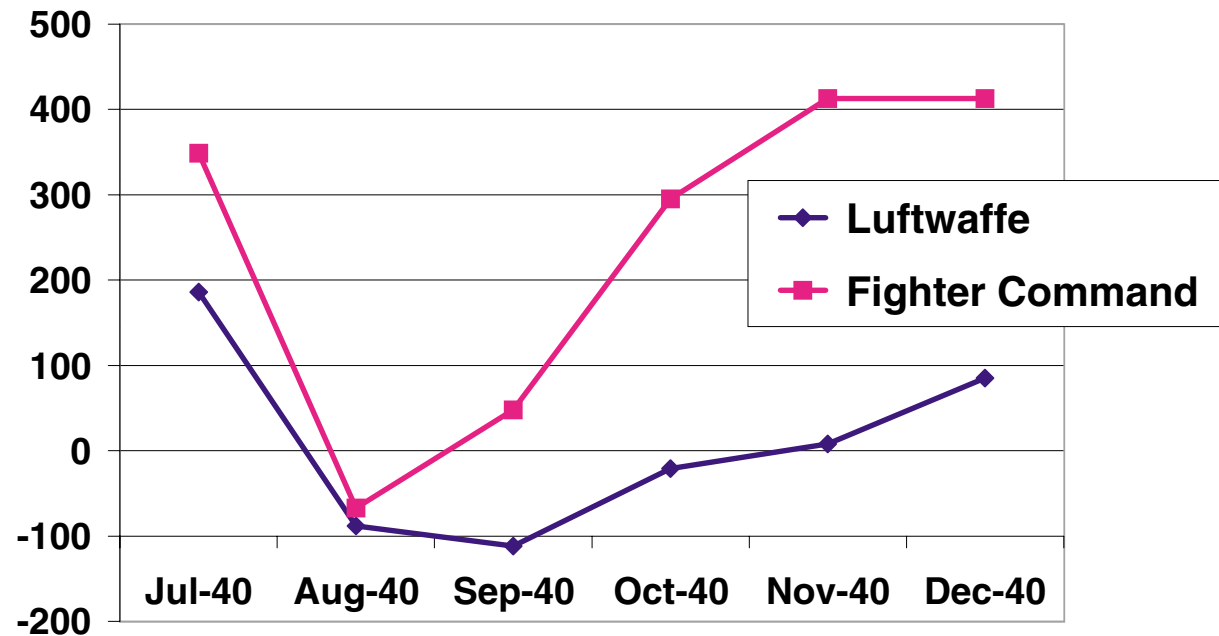
Fighter Command's reserves did shrink after July 1940, but they never totally disappeared and by the end of the year had returned to their previous levels (**Figure 12**).

Perhaps the most telling comparison is the monthly balance between wastage and production (including repair). Fighter Command and the Luftwaffe both experienced a negative balance in single seat fighters during August. Against a total wastage of 594 Hurricanes and Spitfires, new production and repair could only provide 527 aircraft, the difference being found from the immediate reserve stocks.⁵¹ In turn,

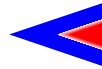
**Figure 12 : Fighter Command Reserves
July - December 1940**



**Figure 13 : Single Seat Fighter Production
Balance July - December 1940**



the Luftwaffe lost over 300 Bf 109s against new production of only 173 aircraft. Repair and reserves made good some of this shortfall but such sources were nowhere near the scale of those available to Fighter Command.⁵² More importantly, while Fighter Command quickly recovered to a positive balance of some 50 aircraft a month by September, it took the Luftwaffe a further 2 months to reach this position (**Figure 13**). In October, after 3 months of steady attrition, Fighter Command's frontline stood at some 98% of its established strength, slightly higher than when the Battle opened. By comparison, the Luftwaffe fighter force had



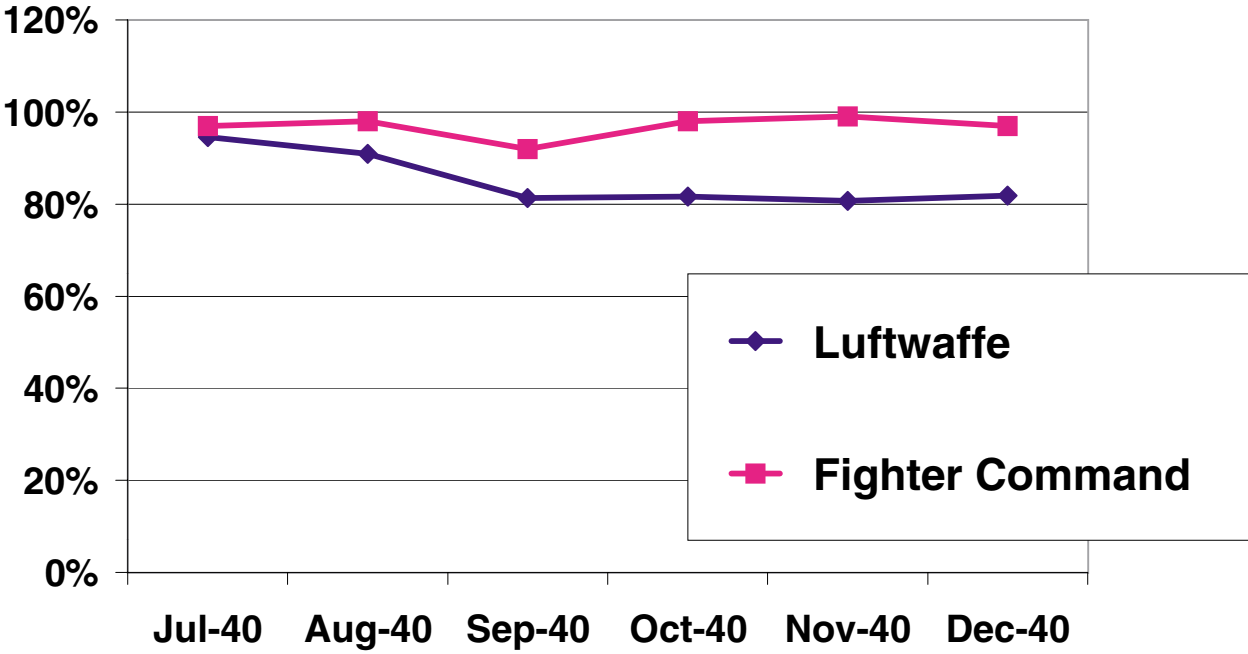
fallen from 95% to 82% of established strength (Figure 14). Reserves aside, the fundamental reason for this outcome was that Britain was out-producing Germany in single seat fighters by a ratio of 2:1 and, including repair, by closer to 3:1.

LOGISTICS AS A TARGET

If the Royal Air Force’s logistic system was the foundation of its operational strength; it raises the question as to why the Luftwaffe did not attack such an important target more vigorously? The answer would seem to lie partly in faulty intelligence that significantly underestimated the strength of Fighter Command and partly in the flawed thinking that had shaped the Luftwaffe’s own logistic arrangements. It might also be added that the rapid destruction of the Polish, Norwegian, Dutch, Belgian and French Air Forces had provided little indication that the Royal Air Force would prove any more difficult to

overcome. Thus, while attacks were made on Fighter Command’s airfields, and some of the depot and storage units, they were never pressed home with the urgency, discrimination and weight that their significance warranted. Continued attacks on the Supermarine’s Southampton factories did eventually stop production of the Spitfire Mk 1, but this was not part of a coordinated plan and had no marked effect on the delivery of new or repaired aircraft to Fighter Command. To be fair, the dispersed nature of such facilities made success problematical. It was the view of some in the Luftwaffe that such attacks would not succeed. *“We have no chance of destroying the English fighters on the ground. We must force their last reserves of Spitfires and Hurricanes into combat in the air”*.⁵³ Failure to understand the complexity and strength of the Royal Air Force’s logistic system, and overly optimistic combat claims, led directly to the fateful decision in early September to cease attacks against Fighter Command’s airfields and concentrate instead on London – in the mistaken belief that only a few enemy fighters were now left to prevent the Luftwaffe’s final victory.

Figure 14 : Comparative Fighter Strengths Against Establishment



The Battle of Britain was essentially an attritional struggle that tested the logistic systems of the opposing air forces as much as it tested individual pilots, technologies and tactics. It was a trial of strength, a relentless and grinding contest far removed from the popular image of 'the few' pitted against 'the many'. Production, storage, repair and salvage may not have been as glamorous in the public eye as the undoubted heroism shown by Fighter Command's pilots, but they were just as important.

Fighter Command's overall logistic position through 1940 is illustrated at **Figure 15**. Although total wastage in Hurricanes and Spitfires approached 3,000, deliveries to the squadrons were in excess of 3,500. The front line strength of Fighter

Figure 16 : Luftwaffe Strength, Production & Losses 1940

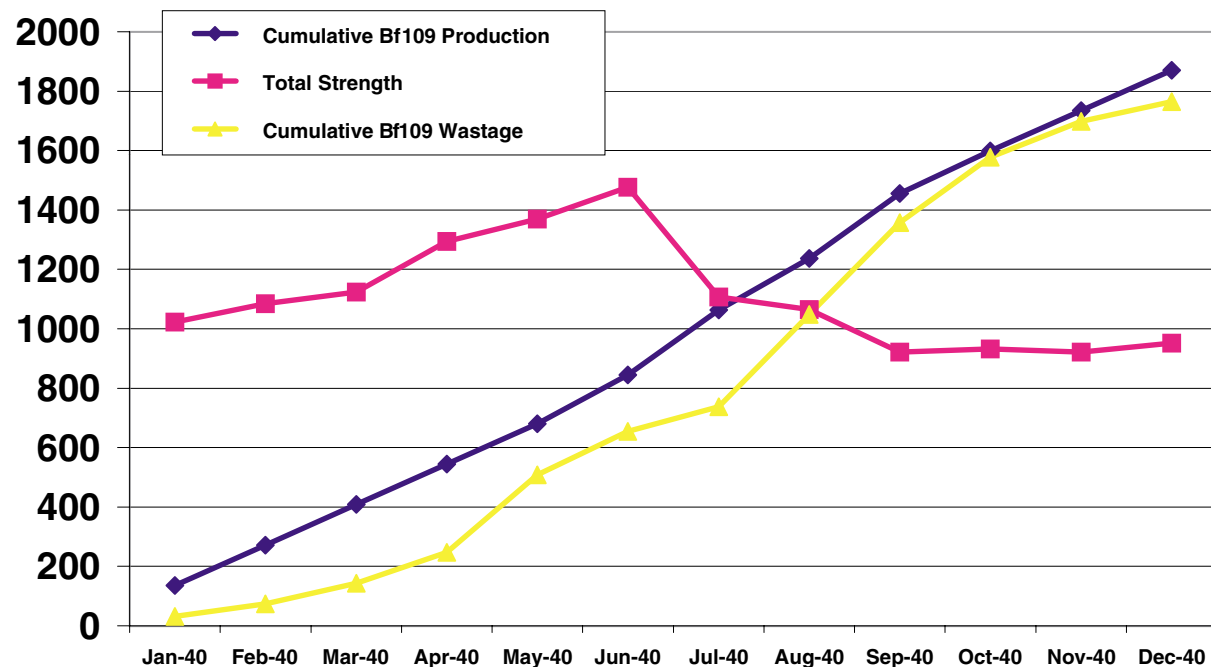
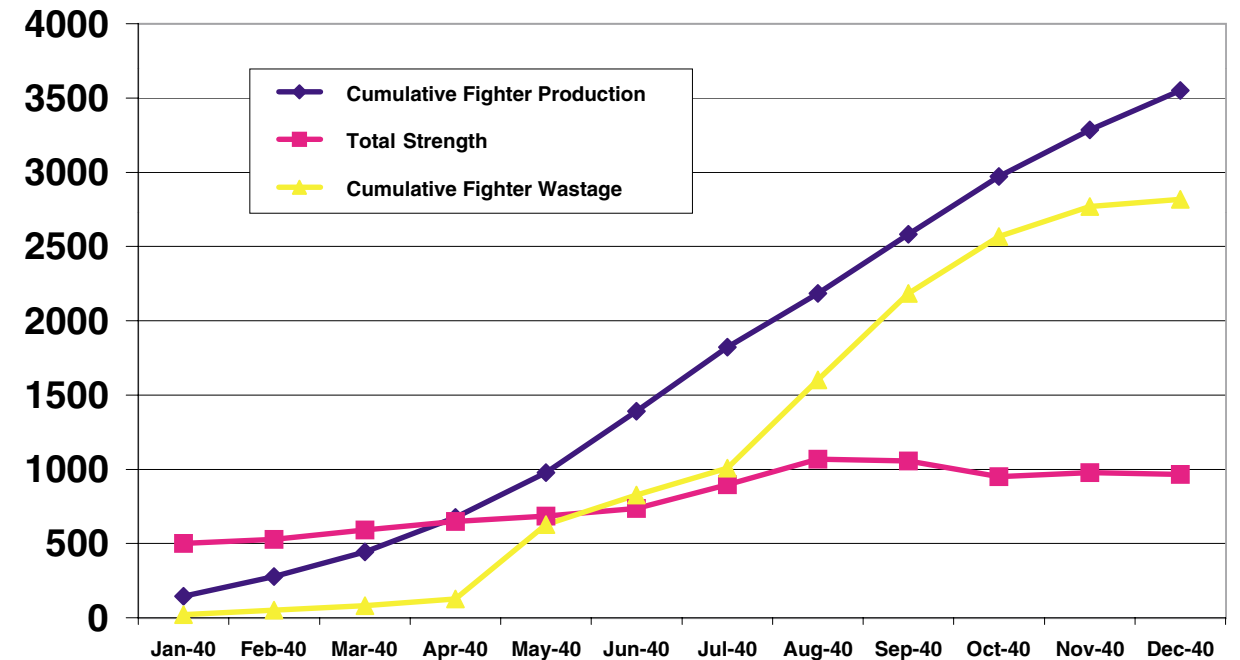
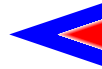


Figure 15 : Fighter Command Strength, Production & Losses 1940



Command was able, therefore, to grow from some 500 Hurricanes and Spitfires in January 1940 to over 1,000 by August. Even so, without a comprehensive repair and salvage organization, attrition (in excess of 50% of front line strength per month) would have rapidly weakened the operational squadrons. That such a decline did not occur was owed to the pre-war Air Staffs, who not only understood the attritional nature of air power, but also put in place the necessary resources and support arrangements to enable Fighter Command to fight effectively when war came. Their achievements are all the more commendable given the Luftwaffe's failure to grasp these principles (**Figure 16**). Over the course of 1940, the Luftwaffe's single seat fighter



strength fell slightly while the once considerable numerical superiority over Fighter Command was rapidly lost. With production, wastage and strength in close balance, it is clear that the Luftwaffe enjoyed few reserves and little repair capability. In turn, this left no ability to cope with surges in attrition, leading to an inevitable decline in operational capability. The Luftwaffe's half-hearted attacks against the aircraft industry, storage units and Fighter Command airfields reflected not only a weakness in intelligence but also the shortcomings in their own approach to the logistics of an attritional war.⁵⁴

The Battle of Britain was a contest that the Luftwaffe had neither prepared for nor envisaged. Created as a strategic instrument, the Luftwaffe had become a superb tactical weapon. However, the expectation of a 'short war' meant that there were neither the industrial resources nor the necessary logistic arrangements in place to sustain operations in the face of a determined enemy. These shortcomings were never properly redressed and, coupled with the huge resources available to the Allied air forces, would ultimately seal the Luftwaffe's fate.

That said, too much can perhaps be made of the Luftwaffe's doctrinal weakness and flawed decision making. It was the creation of a strategic air defence force, in the form of Fighter Command, with the necessary equipment, organization and resources – underpinned by a comprehensive and highly effective logistic system – which defeated the Luftwaffe. Fighter Command's victory was founded on the vision, determination and hard work of the pre-war planning staffs. As Dempster and Wood concluded, in their authoritative study of the Battle of Britain, "*the outcome was the combination of the preparation, good judgement and error, made in the preceding seven years*".⁵⁵

NOTES

- 1 Dr Richard Overy, *The Battle*, page 9, London, 2000.
- 2 Air Commodore Brooke-Popham expanded on these issues in a lecture on the Air Force in the Great War presented to the RUSI on 3 December 1919. One of the significant conclusions was that "...it was of the highest significance that spare machines and spare parts of every sort shall be instantly available. This means large base depots and an efficient channel of supply between depots and squadrons, and on the sound working of this supply system the efficiency of the Royal Air Force in any theatre of war very largely depends."
- 3 Wing Commander GW Williamson, *Some Problems of a Technical Service*, Lecture delivered on 21 March 1934. RUSI Journal No 516, pages 780-800.
- 4 A full description of the Royal Flying Corp's logistic system in France can be found in *Air Power Review*, Vol 1 No 2, pages 42-58.
- 5 Wastage grew steadily through the war. The average number of aircraft dispatched to France to maintain the frontline (additional to any new squadrons) was 33% in 1914, 26% in 1915, 37% in 1916, 47% in 1917 and 52% in 1918 (PRO AIR1/676/21/13/1880). Interestingly, of the 6,500 aircraft struck off charge in France between March and October 1918, 6% were time-expired, 36% were due to enemy action, 24% arose from pilot error and 29% from forced landings as a result of engine failure.
- 6 Air Staff Memorandum No 50, PRO AIR 10/1522.
- 7 This was the planning figure used in France in 1918, however, the actual achievement was probably closer to 25%.
- 8 It was recognised that such figures were only approximate in nature, being based to some extent on conjecture. When setting targets for the 1918 flying training programme, the 'life' of a single seat fighter pilot on the Western Front was estimated, for planning purposes only, to be just 10 weeks (PRO AIR 1/683/21/13/2234).
- 9 The traditional views on the development of Britain's air defence, prior to the establishment of Fighter Command, have been recently challenged by John Ferris, *Fighter Defence Before Fighter Command*, *The Journal of Military History*, pages 845-885, October 1999. He properly identifies the influence of the First World War and argues powerfully that without Bomber Command there could have been no Fighter Command. His article is highly recommended reading.
- 10 The aircraft wastage data is drawn from PRO AIR 20/1835 that provides gross weekly wastage in Spitfires and Hurricanes experienced by the operational squadrons. Pilot wastage has been calculated from the pilot strengths for Fighter Command provided by Richard Overy, *op. cit.*, page 162, and the gross monthly casualties to be found in Appendix 34 of the AHB Narrative. If wastage is calculated on the basis of the squadrons' actual pilot strength, the rate is closer to 42%.

- 11 These wastage figures were to some extent drawn from British and American plans. German experience in the First World War indicated that a monthly attrition of some 30% might be expected. In 1938 it was calculated that a front line of 2,307 would demand a monthly production of some 1,800 aircraft. On the outbreak of war, the Luftwaffe's front line strength was in excess of 3,600 but monthly production was less than 700 aircraft. Edward Homze, *Arming The Luftwaffe*, pages 182-183, Nebraska, 1976.
- 12 Dr Richard Overy, *The Air War 1939-45*, page 45, London, 1980
- 13 John Terraine, *The Right of the Line*, pages 24-36, London, 1985.
- 14 PRO AVIA 46/168, The Repair and Maintenance of Aircraft 1939-1945.
- 15 Official History, *Maintenance*, page 5, AHB, 1954.
- 16 Dr Sebastian Ritchie, *Industry and Air Power*, page 5, London, 1996.
- 17 Dr Richard Overy, *The Battle*, page 54, London, 2000.
- 18 Dr Richard Overy, *The Air War*, page 33, London, 1980.
- 19 This data is drawn from M.M Postan, *British War Production*, pages 484-485 and the BBSU Report on the German Aircraft Industry, Appendix B.
- 20 Norman Franks, *Fighter Command Losses 1919-1941*, pages 18-28, Midland Publishing, 1997.
- 21 Official History, op cit, page 54.
- 22 PRO AIR 16/1023, Report on Operations of British Air Forces France.
- 23 Christian G Sturm, *The Black Men*, pages 44-55, Air Combat, 1986.
- 24 Official History, op cit, pages 179-182.
- 25 The 'fringe firms' were companies with some experience of the aircraft industry and a degree of familiarity with the problems of aircraft production and repair that were able to provide additional production capacity – initially for airframe modification work. By June 1939, 5 companies (Rollason's, Airwork, Brooklands Aviation, Scottish Aviation Prestwick and General Aircraft) had joined the scheme.
- 26 AVIA 46/168.
- 27 PRO AVIA 46/149, The Storage and Distribution of Aircraft.
- 28 The Luftwaffe lost 288 Bf 109s to operational causes over the months of April and May 1940.
- 29 Each fighter staffel comprised some 90 ground personnel.
- 30 Control Commission for Germany, *The Supply Organisation of the German Air Force*, pages 71-74, June 1946. According to Milch, "The movement of squadrons must not be hampered by administrative work. Officers will not be dependent on engineers – such a situation would prejudice the whole morale of the Luftwaffe".
- 31 Ibid, pages 229-231.
- 32 Dr Hans Boog, *The Luftwaffe and The Battle of Britain*, The Battle Re-Thought, RAFHS, 1990. Hugh Trevor-Roper, *Hitler's War Directives*, London, 1964.
- 33 AHB/VII/39, Appendix A, page 7. This total does not include the 190 aircraft of Luftflotte 5 based in Norway.
- 34 Bomber Command had commenced strategic attacks on Germany from the night of 14/15 May 1940.
- 35 PRO AIR 20/2307.
- 36 The figures for Fighter Command are somewhat higher than those quoted in other sources but have been taken directly from PRO AIR 20/2307. Nevertheless, it is the trend that is important rather than precise strength levels.
- 37 Norman Franks, op cit.
- 38 AHB VII/83.
- 39 The Luftwaffe data represents total wastage (destroyed and damaged for the entire fighter force on operational and training sorties). The Fighter Command data is from PRO AIR 20/307 and records gross wastage on the operational squadrons. The wastage rates for November and December 1940 have been estimated from the known operational losses.
- 40 PRO AIR 20/1835.
- 41 Dempster and Wood, *The Narrow Margin*, London, 1961.
- 42 Official History, op cit, pages 185-186.
- 43 An analysis undertaken by the Fighter Command Research Branch in 1949 (PRO AIR 16/1047) indicates that the average number of serviceable aircraft per squadron across 11 and 13 Groups was in excess of 15 for the period July to October 1940.
- 44 Dr Richard Overy, op cit, page 33, London, 1980.
- 45 Hooton, *Eagle In Flames*, page 21, London, 1999.
- 46 Data drawn from the AHB Narrative and Richard Overy, op cit.
- 47 Dr Robin Higham, *The Royal Air Force in the Battle of Britain*, Centre for Air Force History, 1994.
- 48 Taken from Hooton, op cit, pages 14-15. The Luftwaffe figures have been abated by 20% since Bf 110 and fighter-bomber sorties have been included in Hooton's total.
- 49 This is described in some detail by Dempster and Wood, op cit, pages 103-105 and in PRP AVIA 46/168.
- 50 Wing Commander Asher Lee, *The German Air Force*, pages 234-235, London, 1946. Repair turn round times are not known but prior to the war periods in excess of 3 months were average. Edward Homze, op cit, page 156.
- 51 This largely explains why ASU reserves fell so rapidly, notwithstanding the overall positive production position – an apparent anomaly identified by Robin Higham, op cit, page 135.
- 52 Only 400 repaired Bf 109s were accepted by the Luftwaffe in 1940, equivalent to just 21% of new production. Harold Faber, Ed, *Luftwaffe*, page 203, Sidgwick and Jackson, 1979.
- 53 Kesselring, Commander Luftflotte 2.
- 54 Between 15 August and 25 September 1940, the Luftwaffe destroyed or badly damaged on the ground just 44 Hurricanes and Spitfires.
- 55 Dempster and Wood, op cit.



Artist impression of C-17 in Royal Air Force livery. Four are due to enter RAF service during 2001.

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