The Evolution of British Airborne Warfare: A Technological Perspective

By Timothy Neil Jenkins

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Abstract

The evolution of British airborne warfare cannot be fully appreciated without reference to the technological development required to convert the detail contained in the doctrine and concept into operational reality. My original contribution to knowledge is the detailed investigation of the British technological investment in an airborne capability in order to determine whether the development of new technology was justifiable, or indeed, entirely achievable.

The thesis combines the detail contained in the original policy for airborne warfare and the subsequent technological investigations to determine whether sufficient strategic requirement had been demonstrated and how policy impacted upon the research programme. Without clear research parameters technological investment could not achieve maximum efficiency and consequent military effectiveness. The allocation of resources was a crucial factor in the technological development and the fact that aircraft suitability and availability remained unresolved throughout the duration of the war would suggest that the development of airborne forces was much less of a strategic priority for the British than has previously been suggested.

Ultimately, despite the creation of a dedicated research institution in 1942 (Airborne Forces Experimental Establishment), and the development of specialist hardware such as the assault glider, the British did not possess the material resources required for the large-scale deployment of airborne troops. Analysis of the technology has revealed that the development of airborne warfare was as much for the purpose of psychological warfare and British morale as it was for offensive operations.

Contents

Glossary

A & A.E.E.	Aeroplane & Armament Experimental Establishment
A.C.	Air Council
A.C.H.	Aircraft Hand
A.D.R.D.L.	Assistant Director Research & Development Liaison
A.D.R.D.T.	Assistant Director Research & Development (Technical)
A.F.E.E.	Airborne Forces Experimental Establishment
A.I.	Air Inception
A.M.D.P.	Air Member Development and Production
A.M.O.	Air Ministry Order
A.S.C.	Administration Service Clerk
A.S.U.	Aircraft Storage Unit
A.T.O.	Assistant Technical Officer
C.F.O.	Chief Flying Officer
C.L.E.	Central Landing Establishment
C.L.S.	Central Landing School
C.N.E.	Committee on National Expenditure
C.O.	Commanding Officer
C.R.D.	Controller of Research & Development
C.T.O.	Chief Technical Officer
D.C.O.	Director Combined Operations
D.D.C.O.	Deputy Director Combined Operations
D.D.R.D.T.	Deputy Director Research & Development Technical
D.D.S.R.	Deputy Director Scientific Research
D.D.T.D.	Deputy Director Technical Development
D.F.S.	*Deutsche Forschungsanstalt fur Segelflug*

D.G.P.	Deputy General of Production
D.G.R.D.	Director-General Research and Development
D.M.C.	Defence Ministers Committee
D.O.R.	Director of Operational Requirements
D.T.D.	Director of Technical Development
G.A.L.	General Aircraft Limited
G.D.	General Duties
M.A.E.E.	Marine Aircraft Experimental Establishment
M.A.P.	Ministry of Aircraft Production
M.U.	Maintenance Unit
O.C.	Officer Commanding
O.R.	Operational Research
O.R.B.	Operations Record Book
P.T.O.	Principal Technical Officer
R.Ae.S.	Royal Aeronautical Society
R.A.E.	Royal Aeronautical Establishment
R.A.F.	Royal Air Force
R.A.S.C.	Royal Army Service Corps
R.D.L.	Research & Development Liaison
R.D.T.	Research & Development (Technical)
S.A.S.O.	Senior Air Staff Officer
S.T.O.	Senior Technical Officer
T.A.	Technical Assistant
T.D.S.	Technical Development Section
T.I.	Test Installations
T.O.	Technical Officer
W/T	Wireless Transmitter

Introduction

One could be forgiven for considering the development of an airborne capability to be an outstanding example of British wartime determination and technological creativity. Certainly those men who volunteered for airborne forces were of the highest calibre and their bravery and courage could never be questioned. However, despite the creation of two entire airborne divisions examination of the technology suggests that the airborne method of deployment lacked both the strategic direction and dedicated materiel resources required to achieve military effectiveness and, ultimately, operational success. Such deficiencies only become evident through detailed analysis of the technological investment.

Unfortunately, the origins and subsequent technological development of British airborne forces have remained largely neglected by contemporary military historians. Consequently, the failure to engage with the technological and scientific investment has resulted in over optimistic conclusions with regard to the military and strategic effectiveness of the airborne technique. John Greenacre argues that:

> The establishment of the British airborne force rates a few pages at best and a few lines at worst, even in the official and semi-official histories. This is understandable, for battlefield history appears to offer more dramatic reading than the minutiae of establishments and background developments. [1]

[1] J. Greenacre, *Churchill's Spearhead: The Development of Britain's Airborne Forces during World War II* (Barnsley, 2010), p. 8.

Three noticeable research exceptions have been conducted by Terrance Otway, [2] William Buckingham [3] and John Greenacre [4] but their investigations fail to determine the extent to which airborne forces were dependent upon redundant technology and thus restricted by lack of suitable materiel resource. For example, Buckingham established a chronology of events culminating with the formation of the 1st Parachute Brigade in September 1941 and challenged the received wisdom that the formation of an airborne force was first considered in 1940 on the orders of Churchill. However, he has failed to extend his argument further and recognise that Churchill exercised considerable political influence in the creation of an airborne force despite the fact that it could not be technologically satisfied. Consequently, it was the substantial technological development required to turn the vision into reality that holds the key to understanding the limitations upon which the airborne capability was originally constructed.

Barton Hacker believed that ‘technological innovation of almost every kind has historically answered more too military purposes than commonly allowed’ and consequently the contribution of military technology in the development of British post-war aviation will also be briefly examined, particularly in relation to rotary wing aircraft. [5] Without such a thorough understanding of the technological investment, the British airborne experience cannot be truly appreciated and analysis will remain restricted to the study of individual operations that fail to contextualise the development and subsequent application of new technology.

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[2] T.B.H. Otway, *Airborne Forces* (Imperial War Museum, 1990).

[3] W. Buckingham, *PARAS: The Birth of British Airborne Forces from Churchill's Raiders to 1st Parachute Brigade* (Stroud, 2005).

[4] J. Greenacre, *Churchill's Spearhead: The Development of Britain's Airborne Forces during World War II*.

[5] B. Hacker, ‘Military Technology and World History: A Reconnaissance’, *The History Teacher*, Vol.30, No.4, 1997,pp. 461-487, p. 461.

The thesis will challenge the established hypothesis and extend the argument further by demonstrating that, although the concept of airborne transportation had been previously explored by the British, significant technological development was nonetheless required in order to put the principle into practice. This will be explored through an analysis of the dedicated scientific and technological resources responsible for realising the operational requirements of the airborne force and demonstrate that its creation was far from technologically inevitable or achievable.

In order to fully understand the level and capability of the technology then available the thesis will focus upon the technological realisation of the airborne concept in relation to the effectiveness of the strategic doctrine. This will form a framework within which the decision to invest in such technology can be comprehensively analysed. Greenacre defined 'concept' in the following terms:

> A concept is a description of the way in which a military capability will be employed within a given environment. It describes the function or purpose of that capability in a manner that allows its development to be framed, and parameters set, for the procurement of equipment and training of personnel. [6]

Ultimately the level of detail contained in the concept became the cornerstone for all aspects of technological development. The doctrine was subsequently defined from the concept, summarised in the British Defence Doctrine as 'the bedrock on which such decisions can be based', [7] and provided adequate guidance for commanders to use in operational planning whilst not being too prescriptive as to become restrictive. Greenacre succinctly summarised the inter-relationship:

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[6] Greenacre, *Churchill's Spearhead*, p. 172.

[7] Ministry of Defence, *Joint Doctrine Publication 0-01: British Defence Doctrine*, (M.O.D., 2008), p.iii.

> A concept informs developers while doctrine guides practitioners. A concept prescribes where and when a capability will fight while doctrine advises how it should fight. The two together therefore are the catalyst through which physical resources under command are translated into military effectiveness. [8]

Clarity of both doctrine and concept were thus crucial in order to ensure that the technological and financial investments yielded maximum returns, particularly when such development was initiated within the limited resources of a wartime economy. Millett and Murray have argued that military activity consists of both vertical and horizontal dimensions and that without an appreciation of all of these factors the 'military effectiveness' of any particular nation, military organization or specific technological development cannot be thoroughly analysed. [9] In essence the military effectiveness of an organisation requires an analysis of political, strategic, operational and tactical influences. All of these factors will be examined in order to provide, for the first time, a comprehensive formula through which the technological investment in airborne warfare can be contextualised.

Lieutenant-Colonel Terrance Otway [10] believed that the strategic necessity for the development of the British airborne capability was to produce a force which could 'take advantage of the open flank to place themselves in such a position that they can strike a mortal blow in the most economical manner.' [11] However, further analysis is required in order to ascertain if technological development was alone capable of satisfying the political

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[8] Ibid.

[9] A. Millet, W. Murray & K. Watman, 'The Effectiveness of Military Organizations', in A. Millett & W. Murray (eds.), *Military Effectiveness: Volume One, The First World* War (Cambridge, 2010), pp. 1-2.

[10] Otway commanded the 9th Battalion Parachute Regiment and then served with the 15th Parachute Battalion in Malaya.

[11] Otway, *Airborne Forces*, p. 2.

aspiration and subsequent strategic policy. This will ultimately determine if such technology was worth the investment in the first place.

Methodology & Synopsis

The argument will be presented through an examination of the following research questions. Firstly, the decision to develop such a capability will be placed into the context of the British war-time economy and tested against the War Office policy that procurement was driven by strategic necessity. Consequently, the events leading up to the creation of a dedicated research institution, the Airborne Forces Experimental Establishment (A.F.E.E.), in February 1942 will be explored in order to determine if a strategic necessity had been reasonably demonstrated.

Secondly, the technological developments of the A.F.E.E., and its predecessors, are examined to deduce whether the decision of the war-time government to invest in airborne warfare was both justified and technologically viable. [12] William Hancock, in the Official History of the British War Economy, argued that the British war-time economy of 1940 was not capable of withstanding the financial pressures of technological extravagance:

> Ever since the fall of France the British had been struggling desperately not to lose the war. But how did they propose to win it? The certainly could not win it by procuring new, astronomical programmes for the armed forces. [13]

However, it would appear that the development of airborne forces was conducted contrary to Hancock's statement. This will be examined within the limitations of the available technology,

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[12] P. Howlett, 'The Wartime Economy 1939-1945.' In R. Floud & P. Johnson (ed.) *The Cambridge Economic History of Modern Britain* (Cambridge, 2004), pp. 1-26, p. 1.

[13] W. Hancock & M. Gowing, *British War Economy*, (H.M.S.O., 1949), p. 213.

contemporary scientific opinion, and the personalities contained within the war-time administration and culminate with an analysis of whether the research undertaken by the A.F.E.E. was capable of satisfying the strategic requirement.

The thesis utilises the Millett and Murray devised methodology for examination of military effectiveness across the vertical and horizontal dimensions of military activity. The vertical dimension consists of the ‘preparation for and conduct of war at the political, strategic, operational and tactical levels.’ [14] Ultimately, these factors form the backbone of the process by which a political decision is translated into a means of execution on the battlefield. Paradoxically the horizontal dimension contains the multitude of activities that must be conducted and executed at each hierarchical level in order to ensure both efficiency and effectiveness. These include planning, technological development, procurement, training, and finally, combat. Millett and Murray argue that ‘an adequate definition of military effectiveness must include all these aspects of military activity. Similarly, the deterioration of overall military effectiveness requires assessments across the horizontal and vertical range of military activity.’ [15]

Consequently, the technological development of British airborne warfare requires a broad examination of all these factors in order to determine if the decision to invest in the technology was justified. Military activity consists of interdependent political, strategic, operational and tactical elements that must be explored in order to contextualise technological development.

The introduction contains a brief summary of British experimentation with the airborne technique prior to the outbreak of World War Two and provides the background to Churchill’s

[14] Millet, Murray & Watman, ‘The Effectiveness of Military Organizations’, in *Military Effectiveness: Volume One*, p. 2.
[15] Ibid.

minute of 22 June 1940 which requested further development. [16] The summary proves that the British association with airborne warfare was established in the inter-war period, although divergence of opinion over future policy remained unresolved. [17]

Chapter one examines the influence of science and technology upon political and military thinking during the period immediately before the outbreak of the second world war and introduces the key personalities who influenced the development of the British airborne capability. The mechanics of the war-time economy are also established so that analyses can be conducted of the procurement and contractual frameworks that governed technological development.

The foundation of the Central Landing Establishment and its successors are studied in chapter two and the extent of technological investigations are presented prior to the first British parachute assault, Operation Colossus. The policies associated with the development of airborne forces are also examined to determine their strategic effectiveness and influence on future technological development; particularly the decision to concentrate upon the development of the assault glider in preference to parachute forces which became central to the development programme. [18]

Prior to April 1942 technological development and experimentation lacked both direction and central administration. The Air Ministry recognised that the roles and responsibilities for future investigation required clarification as demonstrated throughout the Operation Records Book (O.R.B.). [19] Between the professionalization of the research and the formation of the A.F.E.E. in February 1942, a system of monthly technical reports had been

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[16] T.N.A., CAB 120/262, Airborne Forces: Minute to War Cabinet, by Winston Churchill, 22 June 1940.

[17] Buckingham, *PARAS*, pp. 11-14.

[18] Greenacre, *Churchill's Spearhead*, pp. 24-25.

[19] T.N.A., AIR 29/512, Operation Records Book, Central Landing Establishment, 1940-1944.

devised so that all stakeholders could be regularly informed of developments and ensure that experimentation could be co-ordinated with War Office requirements. Chapter three will focus on the nature of the research and development programme and ascertain whether the allocation of resources was sufficient for developmental purposes and that the overall strategic policy was adequately defined.

In the final chapter the formation of the A.F.E.E. is examined to determine the contribution the research institution had upon the technological development of airborne forces. [20] Despite the creation of such an Establishment resource allocation, particularly in terms of aircraft, remained problematical and criticism concerning the effectiveness of the organisation will be explored to determine the cause. The procurement of resources and the technological innovation of the glider programme will be examined in detail to deduce the scale of resources required for the delivery of the airborne capability. The post-war work of the Establishment [21] is also scrutinised to determine whether continued experimentation with the airborne technique was ultimately justified following the development of the helicopter and its potential application for airborne deployment.

Historiography & Sources

A key factor in the failure to recognise the technological investment in the development of airborne forces has been that post-war historians have tended to focus specifically upon individual operations in reaction to the broad historiographical formulae employed in official British military histories. J.R.M. Butler summarised the single history approach in 1958 by stating:

[20] Air Ministry, *The Second World War 1939-1945, Royal Air Force, Airborne Forces* (Air Ministry Official Monograph, 1951), pp. 54-55.

[21] T.N.A., AVIA 15/2253: A.F.E.E. Future Technical Policy, by AD/RD Airborne, 22 September 1945.

> British historians are not writing separate accounts of the parts played by the Navy, the Army, and the Royal Air Force, but are compiling a single integrated history of the war as a whole. To do so was part of their official instructions. [22]

Although Butler generally concluded that the practice was well received there can be no doubt that more detailed examination was required.

Maury Feld considered the broad approach too constricted and argued that it failed to deliver a 'historical and analytical treatment of the principles and the criteria of the organizations which directed these men, and of the tools which allowed or prevented them from attaining their goals'. [23] Consequently, the transition from broad historiography to detailed enquiry has resulted in the mechanics of the development of the British airborne capability being largely disregarded in favour of specific operations.

David Edgerton has argued that academic studies of technology 'succeed through substantive content' [24] as much as methodology and the thesis will address this imbalance through a detailed analysis of the technological and scientific investment. Alex Roland succinctly clarified the situation concerning technological contributions to military development:

> The bad news is that military history has been studied often but not well; the history of science has been studied well but not often. Military histories are as old as the Iliad and the Old Testament, but as a genre they are

[22] J.R.M. Butler, 'The British Official Military History of the Second World', *Military Affairs*, Vol. 22, No. 3, 1958, pp.149-151, p. 150.

[23] M. Feld, 'The Writing of Military History', *Military Affairs*, Vol. 22, No. 1, 1958, pp. 38-39, p. 38.

[24] D. Edgerton, 'Innovation, Technology, or History: What is the Historiography of Technology About?, *Technology and Culture*, Vol.51, No.3, 2010, pp. 680-697, p. 680.

> dominated by operational accounts of campaigns and battles and hagiography of the great captains. The history of science and technology tends to be more scholarly and critical, but hardly any was written before this century; most of the best work has been done since World War II. [25]

However, there are also other significant gaps in the broader historiography of the Second World War in relation to the development of British airborne forces.

For example, in his seminal work *Raising Churchill's Army*; [26] David French failed to examine the development of airborne forces at all. Nevertheless, French is not the only contemporary historian who has failed to recognise the existence of the airborne soldier in the British army structure. Timothy Harrison Place, in *Military Training in the British Army, 1940-1944*, also neglected the contribution of airborne forces despite stating in the introduction that 'the backdrop to this work is the highly successful campaign waged by British troops against Germany in North-West Europe.' [27]

Such inconsistency in the historiography requires careful consideration as continued exclusion of the technological development in airborne forces from research into the wider history of the British army will ensure that airborne operations remain misunderstood. Although one appreciates the development of airborne forces was a particularly specialised aspect of the British military establishment the technological investment and training required were not inconsiderable and are worthy of further investigation in the context of the wartime economy.

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[25] A. Roland, 'Science and War', *Osiris: Historical Writing on American Science*, 2nd Series, Vol. 1, 1985, pp. 247-272, p. 247.

[26] D. French, *Raising Churchill's Army* (Oxford, 2001).

[27] T. Harrison-Place, *Military Training in the British Army*, 1940-1944 (London, 2000), p. 1.

The research utilises extensive primary sources from The National Archives, particularly in relation to technological development. Primary material pertaining to the research and development of airborne technology has been sourced from former Ministry of Aircraft Production files, which assumed responsibility for aircraft production and development from the Air Ministry in 1940.

In particular, documents classified AVIA 21 have been examined as they contain technological reports of the A.F.E.E. and its predecessors. The reports contained in this series are essentially scientific but have been summarised accordingly in order to determine the extent of technological investigation undertaken. Although some copies of these reports are available at the Royal Air Force Museum [28] and the Museum of Army Flying [29] The National Archives documents have been used for consistency.

The *Air Ministry Official Monograph on Airborne Forces* from the Royal Air Force Museum Collection and Otway's official history of *Airborne Forces*, reprinted in 1990 from the original 1952 restricted War Office publication by the Imperial War Museum, have been utilised to contextualise the development. [30] Files from AVIA 15 series have also been examined to determine the strategic policy for airborne development immediately prior to when the Ministry of Aircraft Production (M.A.P.) assumed responsibility so that the impact of the restructure can be measured.

Further research has also been conducted from Air Ministry documentation contained at The National Archives. The Operations Record Book contained in the AIR 29 series has been examined to provide chronology for the activities of various establishments involved in

[28] Royal Air Force Museum: Department of Research & Information Services (Hendon).

[29] Museum of Army Flying: Library & Archive (Middle Wallop).

[30] Air Ministry, *The Second World War 1939-1945, Royal Air Force, Airborne Forces* (Air Ministry Official Monograph, 1951)

the development programme including those of R.A.F. Maintenance Units. Series AIR 2 provided details of correspondence between the key stakeholders in order to better understand decisions of policy and their effect on the research programme.

Cabinet records have been consulted to contextualise the war situation and the timing of decisions governing the development of the airborne capability. Similarly, the small amount of detail contained in Treasury files has been examined in order to ascertain the level of specialist technical expertise required for airborne development and understand the processes by which professional staff was procured. Archive material held at the Assault Glider Trust has been consulted, particularly in relation to the construction techniques employed in glider manufacture, to ensure that the technical information contained in the research is both accurate and presented in the most accessible format.

Detailed records pertaining to the employment of specialist sub-contractors have been sought but few references to aviation contracts are contained in the archive material. Key war-time sub-contractors such as Austin Motors [31] and Harris Lebus [32] do not appear to have kept any detailed record of activity. Consequently, information regarding contractors has been researched from contemporary aviation journals. However, certain archive photographic material has been located relating to the Austin Motor Company and this has been incorporated to explain the manufacturing techniques and principles employed in glider production. [33]

The thesis utilises the official History of the Second World War Civil & Military Series (See Appendix 1) published from 1949 onwards. These sources provide details of the

[31] University of Warwick, Modern Records Centre: MSS.226/AU/1/1/2-3, Austin Motor Company Board Minutes, 1943-1948.

[32] London Metropolitan Archives: City of London Corporation.

[33] British Motor Industry Heritage Trust: Heritage Motor Centre Archive (Gaydon).

mechanics of the war-time economy and its administration and also provide a framework within which technological investment can be examined. The production of these Official Histories was administered by the War Cabinet through a Historical Section, a system that had been instigated for the publication of official material following the Great War.

Official Histories were not simply confined to the analysis of military operations and all government departments were requested to keep diaries for the purpose of historical research, similar to those retained by fighting units. Professor William Hancock, of Birmingham University, was appointed supervisor for civil histories and an Advisory Committee of university historians was established in order to ensure that all departments of the civil war-time administration were represented. On 26 November 1941 R.A. Butler, President of the Board of Education and Chairman of the Committee for the Control of the Official Histories, presented a paper to the War Cabinet which requested approval for historians to be given access to primary material for the purpose of research. [34] The suggestions were approved and the compilation of source material was instigated with professional historical support.

The first of the Civil Series, published in 1949, was written by Hancock with the assistance of Mrs Gowing, who had served in the Board of Trade during the war. The volume was entitled *British War Economy* and provided a synoptic account of the mechanism by which the war-time economy was administered. Recognition of the economic and governmental systems are important; particularly when applied to the development of airborne forces, where the examination of the subject has been primarily focused upon the operational detail at the expense of those scientific and research staff who made the concept technologically possible. Mary Murphy argued that economic events needed to be linked with strategic events and that a ‘controlled economy cannot be understood without an over-

[34] T.N.A., CAB 67/9/140, The Official Histories of the Present War, by R.A. Butler, 26 November 1941.

all view of the controlling institutions, and that it would be insular and unrealistic to ignore the international environment which so powerfully governs a nation's economic effort.' [35] Consequently, an analysis based solely upon the military application of any particular technology cannot be adequately contextualised without appreciation of the economic climate and wider influence of international affairs.

However, although the works of the civil series provide a foundation for analysis of the influence that war-time controlling institutions possessed upon the technological development, imperfections are evident. For example, the fourth book of the series entitled *British War Production* by Professor M.M. Postan was unable to go into the specific and technological detail originally intended regarding the industrial experiences of 'individual firms and the development of weapons as viewed from the factory floor.' [36] The restriction was due to the fact that by the time the work was ready for publication in 1952 many of the firms employed on specific military programmes were once again developing and refining earlier designs to meet the changing strategic demands of the Cold War era. The technological experiences of the British aviation industry in particular were unfortunately disregarded.

There was also one consistent failure throughout the entire Civil and Military series: documentation. The final volume of the Civil Affairs and Military Government sub-section of the Military series, entitled *Central Organization and Planning*, published in 1966, continued the disappointing trend of containing no references. The omission of these details, however, was probably due to classification clauses contained in British Government's Public Records Act of 1958 which stated that documents transferred to the Public Record Office would 'not

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[35] M. Murphy, 'British War Economy', *Annals of the American Academy of Political and Social Sciences, Vol.266, Government Finance in a Stable and Growing Economy*, Nov. 1949, pp. 199-200, p. 199.

[36] R.G.D. Allen, 'British War Production', *The Economic History Review*, Vol.6, No.1, 1953, pp.81-91, p.89.

be available for public inspection until they have been in existence for fifty years.' [37] The timescale was relaxed in an amendment to the Act on 14 July 1967 to thirty years 'beginning with the first day in the next after that in which they were created' [38] but by this time the Civil Series had already been published.

The thesis also references a semi-official history entitled *Science at War* which was jointly devised by J.G. Crowther and R. Whiddington and published by H.M.S.O. in 1947 following pressure from Clement Attlee. [39] The work references the development of airborne warfare and includes an analysis of Operational Research that can be applied directly to the technological development of the British airborne capability.

References are made throughout the research to memoirs published by the key personalities involved in either the development of airborne forces or the direction of policy, such as Churchill [40] and Lord Ismay. [41] The accounts of personnel who had actual experience of the technology, such as Lieutenant-Colonel Anthony Deane-Drummond, [42] have also been consulted to allow technological development to be examined from the perspective of the end-user and contextualise the technological investment.

The principal secondary sources are those published by William Buckingham and John Greenacre who have successfully developed a chronological narrative of airborne forces development. These texts are examined throughout the thesis, in conjunction with primary source material, to explain the political and military environment that governed

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[37] H.M.S.O., Public Records Act 1957, Section 5 (1), p.4.

[38] H.M.S.O., Public Records Act 1967, Chapter 44, Section 5 (1) Revision.

[39] T.N.A., CAB 66/60/32, Popular Account of British Scientific War Work, by Clement Attlee, 8 January 1945.

[40] W.S. Churchill, *Their Finest Hour*, (London, 1951).

[41] Lord Ismay, *The Memoirs of Lord Ismay* (London, 1960).

[42] A. Deane-Drummond, *Return Ticket* (London, 1953).

technological investment. A variety of secondary academic sources have been consulted that provide details of the scientific and engineering personalities involved. The *Biographical Memoirs of the Royal Society* provide a wealth of information concerning individual scientists whilst the research of Professor David Edgerton provides background to the mechanism of the British war-time administration and its relationship with both technological and scientific innovation. [43] Finally, the three volume series by edited by Allan Millett and Williamson Murray entitled 'Military Effectiveness' provides a framework within which the multitude of spheres and influences involved in the creation of new technology can appropriately examined.

The Origins of British Airborne Warfare

British experimentation with the air transportation of military equipment and supplies was first conducted in 1916 during the relief of the Kut-al-Alamara garrison in Mesopotamia. David French argues that between 1916 and 1918 the British 'developed a combined arms practice' [44] which was dependent upon the close tactical collaboration of aircraft, artillery and infantry. Indeed, Buckingham believes that through close cooperation between the Army and R.A.F. the British established a world lead in the technique of air transportation and utilised the technique throughout the Empire. [45]

However, far more dedicated research was undertaken during the inter-war period than Buckingham identifies. On 19 February 1921 a report was issued to Cabinet by the Secretary of State for Air [46] which detailed the work of the R.A.F. in Mesopotamia and

[43] D. Edgerton, *Britain's War Machine* (London, 2012).

[44] D. French, 'Doctrine and Organization in the British Army, 1919-1932', *The Historical Journal*, Vol.44, No.2, 2001, pp. 497-515, p. 505.

[45] W. Buckingham, *PARAS*, p. 9.

[46] A position then held by Winston Churchill

included examples of experimentation with air transportation. [47] Although this report was by no means a unique reference to instances of air transportation during the inter-war period it is worthy of examination for two reasons.

Firstly, the opinions expressed in the report are an early encapsulation of both inter-service co-operation and fundamental strategic disagreements that continued throughout the subsequent development of British airborne forces. Secondly, the report is evidence that Churchill, who was later instrumental in the development of the British airborne capability, witnessed the use of aircraft for the transportation of troops by air as early as 1920. [48] The main body of the report was compiled by the General Officer Commanding-in-Chief, Sir A. Haldane, and analysed operations in Mesopotamia conducted in response to numerous insurrections. The report concluded with notes from both representatives of the Imperial General Staff, Lieutenant-General P.W. Chetwode, Deputy Chief of the Imperial General Staff, and the Air Staff, Air Marshal H. Trenchard, Chief of the Air Staff.

Haldane listed numerous instances of aircraft used in collaboration with ground forces to achieve both tactical and operational success. The main functions the R.A.F. performed were reconnaissance, tactical co-operation with troops, and distant attacks. Haldane reported that at Samawah and Kufah ‘aeroplanes were of great use in conveying either food, supplies, spare parts of machine guns, wireless apparatus, and even on one occasion, the breech block of a 13-pounder gun.’ [49] In addition to the transportation of

[47] T.N.A., CAB/24/120/52, The Work of the Royal Air Force in Mesopotamia, by Winston Churchill, 19 February 1921.

[48] D. Killingray, ‘A Swift Agent of Government: Air Power in British Colonial Africa, 1916-1939’, *The Journal of African History*, Vol.25, No.4, 1984, pp. 439-444, pp. 434-435.

[49] T.N.A., CAB/24/120/52, The Work of the Royal Air Force in Mesopotamia, by Winston Churchill, 19 February 1921.

supplies aircraft were also used to ferry officers and others, ‘carrying commanders rapidly to various parts of the areas under their control.’ [50]

However, Haldane was sceptical about the accuracy of re-supply when stores were dropped from aircraft. Naturally, Trenchard responded that the R.A.F. was entirely capable of re-supply and that it must be recognised that the aircraft in Mesopotamia were not of weight-carrying type:

> There are in existence in the Air Force aeroplanes of such capacity that a mountain gun complete with crew and ammunition can be carried by two of them to reinforce a post, whilst a single machine can transport 2,000 lb. of food or ammunition to a distance of 200 miles and return without landing. [51]

Trenchard had effectively summarised the strategic blueprint upon which the glider-borne aspect of the British airborne capability was eventually created. But despite the apparent harmony between Army requirement and the capability of the R.A.F. to deliver there remained fundamental disagreement between senior strategists.

The Army believed that its experience in Mesopotamia had proved that the aeroplane was a valuable auxiliary to orthodox troops whilst the Air Staff argued that a sufficient number of aeroplanes could effectively undertake a large proportion of Army functions. Trenchard concluded that:

> The Royal Air Force have shown in Mesopotamia that they are in a position without assistance from other arms to lend adequate support to local levies in the maintenance of order, and that a sufficient force of the Royal Air

[50] Ibid.

[51] Ibid.

> Force, supported by a small first-class number of military units, primarily for garrison duties, would afford effective protection at less expense than any alternative scheme of defence. [52]

The opportunity for further co-operation was ultimately over shadowed by inter-service rivalry and the desire to maintain autonomy. [53] However, Trenchard later developed his argument further and advocated that aircraft, namely bombers, could provide offensive military success far more effectively than other forces.

The British first experienced airborne forces *en masse* during Soviet tactical exercises in September 1936 but initially decided not to pursue such technology despite political pressure to examine future potential. [54] Interest in airborne forces was expressed on 17 November 1936 by Lord Strabolgi [55] during a debate on government policy and defence services in the House of Lords. Strabolgi enquired whether the government was 'developing the system of carrying military detachments by air and landing them by parachute?' [56] before presenting an informed summary of airborne developments in the Soviet Union, Germany and France:

> I understand that it is being developed by other Armies—the Russian, the German and the French. I saw a film recently of the great Russian military manoeuvres round Kiev, and to my lay mind the carrying of a whole

[52] Ibid.

[53] Killingray, 'A Swift Agent of Government: Air Power in British Colonial Africa, 1916-1939', p. 435.

[54] J. Bassett, Past Airborne Employment, *Military Affairs*, Vol.12, No.4, 1948, pp. 206-216, pp. 207-208.

[55] Lieutenant Commander Joseph Kenworthy, 10th Baron Strabolgi, had served in the Royal Navy between 1901 and 1919 and his obituary in *The Times* described him as being in possession of a 'questioning mind and almost too wide interests' (Obituaries: Lord Strabolgi Naval Officer & Politician, *The Times*, 9 October 1953, p.11.).

[56] Hansard Parliamentary Debates, House of Lords, Vol. 103, cc, 140-196, 17 November 1936.

> division by air was most impressive. The advance guard of soldiers was dropped by parachute—the whole brigade were landed in that way—and then tanks and medium artillery were carried by air and landed by parachute on the ground held by the advanced brigade. This impressed me very seriously indeed. The fact that this system is being copied in the German and French Armies makes it worthy of attention by those responsible for the efficiency of His Majesty's Army. [57]

In 1938 Thomas Inskip, Minister for Co-ordination of Defence, referenced the Russian airborne capability in a Cabinet report that compared the relative strength of Britain to other nations. [58] Yet little action seems to have been taken in government circles.

Although air transportation had previously been well practiced it was not until 1939 that serious investigation into the deployment of parachutists was undertaken at the Inter-Services Training and Development Centre. [59] The analysis concluded that the technique was feasible but doubted whether further investment in development could be justified as there was then no indication that such a weapon would ever be used. [60] However, following the successful German demonstration of the airborne technique during the invasion of Scandinavia and the Low Countries in 1940 the government were forced to seriously consider such a weapon in the face of mounting political criticism.

Mr Garro-Jones, MP for Aberdeen North, opened a debate in the House of Commons on 4 June 1940 with an accusation that the government had failed to realise the potential of

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[57] Ibid.

[58] T.N.A., CAB 24/273/71, Comparison of the Strength of Great Britain with that of Certain Other Nations as at January 1938, by Thomas Inskip, 3 December 1937.

[59] The Inter-Services Training and Development Centre was established in 1938 at Portsmouth. It was tasked with studying the subject of Combined Operations and administered by the Chiefs of Staff.

[60] Air Ministry, *The Second World War 1939-1945, Royal Air Force, Airborne Forces*, pp. 1-2.

airborne warfare which had placed the country at a technological disadvantage and immediate risk of airborne invasion. Garro-Jones questioned whether airborne warfare, ‘which has been experimented upon by foreign armies over the last three years, has been equally studied by the British War Office.’ [61] Anthony Eden, Secretary of State for War, replied that such techniques were ‘now being studied.’ [62]

Consequently, in reaction to political pressure the Prime Minister issued a minute to Major-General Ismay on 22 June 1940 that demanded investigation into the feasibility of developing an airborne force. The minute itself was primarily concerned with offensive action and called for a capability for the deployment of ‘at least 5,000 parachute troops’. [63] The relationship between Churchill and Ismay requires clarification as it is referred to throughout the thesis. The association began in April 1940 when Churchill assumed the Chairmanship of the Military Co-ordination Committee on behalf of Neville Chamberlain. The Military Co-ordination Committee became responsible for giving guidance to the Chiefs of Staff Committee and Ismay was selected as the senior staff officer responsible for coordination and ultimately maintained the role when Churchill assumed office. [64] Ismay’s precise position, by his own admittance, was difficult to define but he did receive all Churchill’s direct instructions and was responsible for ensuring that they were transmitted onwards:

> Perhaps my principal function was to be a two-way channel of communication on military matters between the Prime Minister and everyone in Whitehall who was concerned with military business. On the one hand, I was required to communicate, and if necessary, amplify and

[61] Hansard Parliamentary Debates, House of Commons, Vol. 361, cc, 750-1750, 4 June 1940.
[62] Ibid.
[63] T.N.A., CAB 120/262, Airborne Forces: Minute to War Cabinet, by Winston Churchill, 22 June 1940.
[64] D. Dilks, ‘The Twilight War and the Fall of France’, *Transactions of the Royal Historical Society*, Fifth Series, Vol. 28, 1978, pp. 61-86, pp. 77-78.

> explain his views to those concerned, and on the other, to obtain for him all the manifold information which he needed. [65]

Consequently, he was crucial to the initiation of the development of the British airborne capability through the interpretation and implementation of Churchill's instructions. Anthony King argues that Churchill 'liked to have around him distinguished public men who were old friends, who had no previous connections with politics,' [66] but in the case of Ismay he also found a respected military officer of sufficient rank and status capable of delivering his wishes.

There can be little doubt that Churchill's instruction for parachute forces was ambitious, particularly in light of the fragility of the country's military and economic situation. The War Cabinet Weekly Résumé for the week ending 20 June 1940 confirmed that the evacuation of the British Expeditionary Force had been completed and that 'German air attacks against industry' [67] had been initiated. It was also recorded that '380 fighter sorties were flown over Britain' [68] and that 'Bomber Command carried out extensive attacks on communication and industrial targets in Germany.' [69] The strategic requirement with regard to resource allocation would appear to have been clear.

However, notwithstanding the timing of the request for an offensive capability beyond that of Bomber Command, Greenacre has argued that Churchill's original minute failed to adequately express his vision and 'fell far short of articulating an adequate concept of the

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[65] Ismay, *The Memoirs of Lord Ismay*, p. 168.

[66] A. King, 'The Rise of the Career Politician', *British Journal of Political Science*, Vol. 11, No. 3, 1981, pp. 249-285, p. 272.

[67] T.N.A., CAB 68/8/42, War Cabinet Weekly Résumé (No.42), by Chiefs of Staff Committee, 13-20 June 1940.

[68] Ibid.

[69] Ibid.

purpose that he expected his proposed airborne force to operate within.' [70] Consequently, future technological development was inefficient and lacked clear research parameters, particularly regarding future deployment.

The combination of ambiguity within the initial requirement, military priorities, notwithstanding political and economic pressures, was not the most solid foundation upon which to develop new technology despite the considerable experience gained during the inter-war period. Alan Booth argues that by the end of 1940 'the whole war effort was threatened by shortages and the lack of authoritative allocations machinery' [71] and concludes that the country had far more pressing priorities than the development of new and unproven technology:

> Between May and December I940 the driving force in economic policy had been crisis. The army had been rescued more or less intact from Dunkirk, but it had been forced to leave most of its equipment. It stood alone and unarmed. The threat of airborne invasion was dire, so the need for anti-craft defences and fighter aircraft was equally urgent. [72]

But in June 1940 one can thus easily understand why the diversion of financial and material resources into the development of untested technology may not have been considered a strategic priority. Niall Ferguson believes that 'changes in military technology and government regulation ensured that one could never be certain that the next war would

[70] Greenacre, *Churchill's Spearhead*, p. 173.

[71] A. Booth,' Economic Advice at the Centre of British Government, 1939-1941', *The Historical Journal*, Vol. 29, No. 3, 1986, pp. 655-675, p. 666.

[72] Ibid.

have the same financial impact as the previous war'. [73] The financial implications of the war were difficult enough to predict without further interference.

However, the strategic military situation was known to the government and the implications of technological investment could have been measured against the competing demands of the military situation. The responsibility for the development of airborne forces fell most heavily upon the Royal Air Force, which at the time was the only offensive force capable of conducting offensive operations against the enemy and despite the obvious enthusiasm there was no infrastructure in place for the progression of airborne warfare. The development required significant scientific research and investigation prior to the production of any bespoke equipment or a methodology of application could be defined. [74]

The British had to start from scratch and, although existing supplies and materials were utilised through necessity, the development of an airborne capability that could be deployed in strength was a gradual process that Ferguson believes took years to construct:

> At a time when national resources were strained as never before (in the short period between autumn 1940, and autumn, 1944) there were created a British airborne corps of two complete divisions. [75]

The creation of such a force required considerable technological application in the design and development of equipment, aircraft and technique that culminated in the formation of the A.F.E.E.

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[73] N. Ferguson, 'Earning from History? Financial Markets and the Approach of World Wars', *Brookings Papers on Economic Activity*, Vol. 2008, 2008, pp. 431-477, p. 472.

[74] Otway, *Airborne Forces*, pp. 21-22.

[75] Ibid, p. 4.

The dedicated research Establishment originated in the Central Landing School. The unit was formed at Ringway in the middle of 1940 under Army Co-operation Command to 'implement a high level decision to train a considerable body of parachute troops as quickly as possible.' [76] The scope of technological research at Ringway was soon extended and included the development of assault gliders and the associated technique of glider towing. The Unit was subsequently re-named the Central Landing Establishment and divided into three separate sections with defined areas of development: a Paratroop Training Squadron, a Glider Training Squadron, and a Glider Development Unit. [77]

In early 1942 the Establishment was restructured into the A.F.E.E. and all aspects of routine training were absorbed into normal R.A.F. formations. Consequently, the Establishment was concerned with 'development and experimental work in connection with the transport and delivery of airborne forces and their necessary equipment' [78] and was placed under technical control of the Ministry of Aircraft Production as detailed in an official report:

> The main function of the Establishment was to test and assist in the technical development of the means for transporting and delivering on the ground in serviceable condition airborne forces with their equipment so that they can immediately engage the enemy. [79]

However, the expansion in dedicated materiel resources provoked Trenchard to reiterate the arguments he had formulated in 1916 that bomber aircraft were a much more effective method of offensive action that should not be compromised.

[76] T.N.A., AVIA 21/247, Work of the Airborne Forces Experimental Establishment 1940-1945, by W.G. Jennings, 31 December 1949.

[77] Ibid.

[78] Ibid.

[79] Ibid.

On 5 September 1942 the Prime Minister circulated a note by Trenchard amongst the members of the War Cabinet which expressed his opinions upon the effect of diverting aircraft away from the bomber offensive for use in airborne operations. Trenchard reminded members of the War Cabinet of the dangers of interfering with a major strategic plan, such as the allied bomber offensive against Germany, and argued that 'compromise in war plans was invariably fatal'. [80] Unsurprisingly, Trenchard argued that nothing should be allowed to interfere with Bomber Command operations even though during the inter-war years, and in particular during operations in Mesopotamia, he had advocated that there was potential in further exploration of the airborne method:

> Germany is our chief enemy: The only force by which we are able to carry war operations into German territory and directly against the war production and industrial life of the German nation is the aircraft of our Bomber Command. [81]

In hindsight it would appear that Trenchard's concerns were correct.

The A.F.E.E. relocated to Sherburn-in-Elmet in the middle of 1942 but unfortunately local weather conditions proved unsuitable for experimental flying and caused serious disruption to the experimental research programme. [82] A suitable airfield was not available until the end of 1944 and the Establishment was relocated to Beaulieu, Hampshire, in January 1945. Although the improved weather conditions permitted a considerable increase in experimental and technological work relocation was too late to influence the military effectiveness of British airborne capability in the later stages of the Second World War.

[80] T.N.A., CAB 66/30/11, Strength of Bomber Command, by E.E. Bridges, 23 October 1942.
[81] T.N.A., CAB 66/28/29, Note by Lord Trenchard on Our War Policy, by E.E. Bridges, 5 September 1942.
[82] T.N.A., AIR 29/512, A.F.E.E. Shreburn-in-Elmet, 1 July 1942.

The creation of British airborne forces was destined to attract controversy long before strategic plans for its technological development had been formulated. The thesis will examine the technological events chronologically and in detail to provide a considered technological understanding of the British airborne capability.

Chapter One: Science, Technology, Economics, & War

Introduction

The general war situation during the last six months of 1940 remained ominous for the British. Italy declared war on 10 June which exposed British shipping in the Mediterranean to attack by enemy land based aircraft forcing ships carrying vital supplies to make longer journeys. [1] The Italian invasion of Greece in October also forced Britain to dispatch aircraft desperately needed for home defence. [2]

In Britain the *Luftwaffe* was conducting an intensive bombing campaign that required extensive resources to be made available to the R.A.F. whilst preparations were being made for a German invasion both by sea and airborne forces. The responsibility for defence against such threats fell most heavily upon the R.A.F. which consequently became the strategic priority in terms of resource allocation. The only force capable of offensive action was Bomber Command and this was naturally considered one of the highest strategic priorities. Consequently, the resources required for the development of an airborne capability were scarce.

This chapter will explore the mechanisms of the war-time economy and the political and scientific environment in which new technologies were procured. Despite the 'Heath Robinson' nature of the early training programme the embryonic airborne force required substantial resources. Millet and Murray identify political efficiency as a critical element of military effectiveness and argue that resources needed to be procured consistently and efficiently in order to achieve success. Naturally, the first step to achieving such success

[1] T.N.A., CAB 65/7/56, War Cabinet Conclusions WM (40) 161, 11 June 1940.

[2] Air Ministry, *The Second World War 1939-1945, Royal Air Force, Airborne Forces*, pp. 4-5.

required the ‘military to obtain the cooperation of the national political elite.’ [3] However, in terms of British airborne warfare the strategic direction was dictated by the political, rather than the military sphere of influence.

The majority of resources were required from the Royal Air Force and took the form of bomber aircraft, personnel and airfields. The demands were difficult to satisfy, particularly as they would have to be supplied primarily by Bomber Command, subsequently aircraft shortages for the conduct of airborne operations remained a problem throughout the Second World War. [4]

Within this context the proposed development of a British airborne capability attracted two conflicting schools of thought, [5] not too dissimilar to the conclusions drawn in Mesopotamia. [6] The proponents of airborne warfare doubted that the bomber offensive alone could deliver victory and believed that the decisive battles would still be fought by infantry. In order to achieve success an airborne force would be required and, since such a capability would take time to develop, it should take strategic priority over the bomber offensive.

The opponents argued that the bomber policy was clearly defined and results were immediately attainable, whereas the concept of an airborne army was ‘a slightly Wellsian dream of the somewhat distant future.’ [7] Ultimately, the bomber offensive prevailed and the creation of an airborne capability was, certainly for the first two years of its existence, limited

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[3] Millet, Murray & Watman, ‘The Effectiveness of Military Organizations’, in *Military Effectiveness: Volume One*, p. 4.

[4] J.A. Huston, ‘Use of Air Power in World War II: The Army Experience’, *Military Affairs*, Vol. 14, No. 4, 1950, pp. 166-185, p. 181.

[5] Ibid.

[6] T.N.A., CAB 24/120/52, The Work of the Royal Air Force in Mesopotamia, by Winston Churchill, 19 February 1921.

[7] Air Ministry, *The Second World War 1939-1945, Royal Air Force, Airborne Forces*, p. 5.

to the development of technique, specialist equipment, training of personnel and small-scale raids. Until American troop carrying aircraft were available from 1943 onwards the British airborne force had to tolerate whatever equipment and aircraft other R.A.F. Commands could spare. [8]

The impact of the decision to commit technological resources to the development of a British airborne capability cannot be fully appreciated without an appraisal of the war-time economy, the government departments responsible for the procurement of new technology, the personalities contained therein, and contemporary scientific debate. The chapter will contextualise the environment in which the British airborne force was conceived and ultimately developed in order to determine whether a strategic necessity had been sufficiently demonstrated to justify the immediate and future investment.

Mechanics of the War-time Economy

The normal market orientation of the British economy was replaced by a government system of control and economic planning during the Second World War. The primary characteristic of this framework was the controlled allocation of material resources through a process of physical planning determined by strategic necessity as argued by Ely Devons:

> Planning was necessary in war-time, because the Government was acting as the sole consumer of the products of the economic system, and had to weigh up the relative importance of the production of different items in achieving the single objective of winning the war. [9]

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[8] Ibid, pp. 5-7.

[9] E. Devons, *Planning In Practice: Essays In Aircraft Planning In War-Time* (London, 1950), p. 3.

Following Chamberlain's resignation on 10 May 1940, Churchill instigated further adjustments within the institutional framework of the wartime administration and developed a 'system for the central direction of the war economy' [10] in an attempt to maximise productivity. The system for strategic policy making within the British government was relatively simple and provided direct lines of communication between the military and politicians. However, Murray argues that the system required personal drive to ensure operational efficiency and that 'unfortunately in the pre-war period without the drive that Churchill provided, the system allowed for maximum delay by both civilian and military bureaucracies.' [11] The unforeseeable consequence of Churchill's determination, however, was his ability to directly influence and manipulate strategic policy and resource allocation.

Churchill had advocated the principle of governmental management of strategic industry for the purpose of rearmament throughout the 1930s. During a Commons debate on 10 March 1936 he argued that the manufacture of aircraft components should not be restricted within the aviation industry but widely dispersed amongst numerous manufacturers to ensure a continuous flow of parts to satisfy war-time demand. A method of procurement and assembly later adopted in the manufacture of assault glider which Churchill argued was 'the simplest and most primary method by which the freedom of a country can be assured, and it is the very heart of modern national defence.' [12] The logic was theoretically sound and in the same year the Baldwin Government commenced a programme of aircraft production to re-equip the R.A.F. with a new generation of aircraft.

The expansion in the aviation industry resulted in the construction of state financed 'shadow factories' managed by non-aviation specialist companies which manufactured

[10] P. Howlett, 'New Light Through Old Windows: A New Perspective on the British Economy in the Second World War', *Journal of Contemporary History*, Vol. 28, No. 2, April 1993, pp. 361-379, p. 362.
[11] B. Bond & W. Murray, 'The British Armed Forces, 1918-1939', in A. Millett & W. Murray (eds.), *Military Effectiveness: Volume Two, The Interwar Period* (Cambridge, 2010), p. 101.
[12] Hansard Parliamentary Debates, House of Commons, Vol. 309, cc, 1973-2099, 10 March 1936.

designs supplied from established airframe and engine manufacturers. [13] It was believed that the adoption of the mass production technique in aviation would dramatically increase the output of aeroplanes and return efficiencies in the procurement process.

However, not everyone was convinced that the 'shadow factory' technique of manufacture was feasible. The Society of British Aircraft Constructors (S.B.A.C.) opposed the Air Ministry Scheme and believed that manufacturers of standardised products 'lacked the flexibility to accommodate the frequent modifications in design inherent in aircraft production.' [14] However, Jonathan Zeitlin has suggested that many members of the S.B.A.C. were inclined to delay the introduction of new aircraft types in an attempt to obtain 'lucrative continuation orders on well-established models.' [15]

In practice, the scheme was of limited success. Some firms such as Standard Motors (later English Electric) successfully adapted to the challenges and continual modifications demanded by the aviation industry but other large scale manufacturers were less effective. For example, the Austin Motor Company was demoted from the position of sole aero engine assembler outside the aircraft industry and the factory was subsequently transferred from Nuffield (Morris) to Vickers-Armstrong in 1940. However such manufacturers later became involved in the production of gliders for the airborne forces which were produced solely by the sub-contract technique and the difficulties will be discussed later.

Despite the efforts of the re-armament programme in the 1930s, once in power Taylor Downing argues that Churchill established additional departments in 1940 with responsibilities for the production and procurement of all aspects of war materiel:

[13] M. Postan, *British War Production*, (H.M.S.O. 1952), p. 19.

[14] J. Zeitlin, 'Flexibility and Mass Production at War: Aircraft Manufacture in Britain, the United States and Germany 1939-1945', *Technology and Culture*, Vol.36, No.1, January 1995, pp. 46-79, pp. 50-51.

[15] Ibid.

> Churchill immediately started putting together his national government. And he set about restructuring the war effort to streamline the complex and cumbersome decision making system that had been in existence up to this point. [16]

These departments consequently dominated the wartime economy and controlled delivery of commodities that were required by the armed forces. [17] Clement Attlee described the mechanics of the administration in the Commons on 22 May 1940 in accordance with the Emergency Powers (Defence) Bill): [18]

> It is essential in this crisis that we should produce to the full all our essential munitions, and the Minister of Labour has been given the responsibility of supplying the labour required for the programmes of the various Departments. He proposes to set up at once a Production Council consisting of representatives of the chief Government Departments concerned with munitions supplies—the Admiralty, the Ministry of Aircraft Production, the Ministry of Supply, the Ministry of Labour, the Ministry of Agriculture and the Ministry of Mines. [19]

But raw material and personnel were not infinite commodities. Consequently, numerous situations arose which resulted in inter-departmental competition for supplies conducted through a system whereby a business case was presented to a War Cabinet Committee before a decision was taken by the War Cabinet. Robin Higham suggests that such

[16] T. Downing, *Churchill's War Lab* (London, 2010), p. 84.

[17] P. Howlett, 'New Light Through Old Windows', pp. 365-366.

[18] The Emergency Powers (Defence) Act was passed in 1939 to enable the government to make all necessary efficiencies in relation to the conduct of the war.

[19] Hansard Parliamentary Debates, House of Commons, Vol. 361, cc, 154-85, 22 May 1940.

competition was actually detrimental within the war-time economy and could 'complicate the awarding of contracts and frustrate or delay progress.' [20]

Departments not only consisted of professional personnel to deliver specific contracts but were also dependent upon the ability of departmental advocates and strong political representation to present convincing arguments. This was crucial during the development of British airborne forces and not unlike the free-market economy of peacetime. [21] Peter Howlett has suggested that:

> The allocation of resources to a department depended on the relative priority given by the War Cabinet to their production programme and the relative strength of that department compared to other departments, including the ability of each of the service departments (those directly responsible for the army, navy and air force, respectively the War Office, the Admiralty and the Air Ministry) to influence overall military strategy. [22]

Howlett identifies key criteria that a department needed to satisfy before it succeeded in securing any desired resource allocation. The Churchill government effectively split the decision making process into two separate categories of 'production' and 'strategy.' A process whereby 'in the strategic sphere the military decisions which affected production were taken; in the Production Sphere, the production programmes were formulated and implemented so as to meet the military needs.' [23]

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[20] R. Higham, 'Government, Companies and National Defence: British Aeronautical Experience, 1918-1945 as the Basis for a Broad Hypothesis', *The Business History Review*, Vol. 39, No. 3, Autumn 1965, pp. 323-347, p. 326.

[21] Howlett, 'New Light Through Old Windows', p. 362.

[22] Ibid, pp. 362-363.

[23] Ibid, pp. 367-368.

The inter-relationship between strategy and final production followed a staged process, not followed in the development of airborne forces. Requirements were identified by Service Departments and passed to the Chief-of Staffs Committee which met daily to debate the military situation. The Chief-of Staff Committee then passed the strategic plans to the Defence Committee (Operations) where a final decision was made as to whether they would be passed to the War Cabinet for approval. [24] Despite this process, whereby consensus, based upon the military situation and strategic requirements, was theoretically reached before final submission to the War Cabinet it was heavily dependent on the whims of the prime minister.

For example, Churchill was the only official permanent member of the Defence Committee (Operations) and thus had ultimate discretion over strategic objectives. [25] His governance style was such that he could not resist involvement in departmental affairs which Mark Harrison describes as 'a taste for strategy and enthusiasm for interference in operational decisions; [often] dictatorial towards subordinates and intolerant of correction by them.' [26] However, Harrison concedes that such character traits were endemic amongst war leaders and were shared by Stalin, Hitler and Roosevelt. [27] What is important to recognise in relation to airborne forces was that if Churchill believed in a particular military strategy, he had the influence to ensure it went ahead regardless of process.

Howlett argues that Churchill directly influenced strategic objectives through the War Cabinet and edited information presented to the Production Sphere for the physical manufacture of goods or associated scientific research:

[24] Hancock & Gowing, *British War Economy*, pp. 99-100.

[25] Howlett, 'New Light Through Old Windows', pp. 367-368.

[26] M. Harrison, 'Mobilisation for World War II: The U.K., U.S.S.R., and Germany 1938-1945', *The Economic History Review*, Vol. 41, No. 2, May 1988, pp. 171-192, p. 181.

[27] Ibid.

The War Cabinet was responsible for the overall direction of the state. Its members represented the senior ministries of the Crown and as such they reflected the political balance of the Coalition Government. The supply and service ministers were excluded except in the case of Beaverbrook, whose place in the War Cabinet was not due to his ministerial brief but to his role as trusted adviser to Churchill. In most cases the War Cabinet merely rubber-stamped the decisions passed on to it by the co-ordinating committees.' [28]

Consequently, Churchill's aspiration for an airborne force became more important than considered professional military opinion.

The composition and management of the war-time economy naturally attracted political criticism. Churchill himself had to defend the system in the House of Commons on 7 May 1941 in response to criticism from Lloyd George concerning the effectiveness of the administration and a desire to know who was responsible for the conduct of the war:

The War Cabinet consists of eight members, five of whom have no regular Departments, and three of whom represent the main organisms of the State, to wit. Foreign Affairs, Finance and Labour, which in their different ways come into every great question that has to be settled. That is the body which gives its broad sanction to the main policy and conduct of the war. Under their authority, the Chiefs of Staff of the three Services sit each day together, and I, as Prime Minister and Minister of Defence, convene them and preside over them when I think it necessary, inviting, when business requires it, the three Service Ministers. All large issues of military

[28] Howlett, 'New Light Through Old Windows', p. 369.

> policy are brought before the Defence Committee, which has for several months consisted of the three Chiefs of Staff, the three Service Ministers and four members of the War Cabinet, namely, myself, the Lord Privy Seal, who has no Department, the Foreign Secretary and Lord Beaverbrook. This is the body, this is the machine; it works easily and flexibly at the present time, and I do not propose to make any changes in it until further advised. [29]

Despite Churchill's obvious authority within the hierarchy Franklyn Johnson argued that the process of forming the War Cabinet was a necessary 'form of constitutional dictatorship' [30] by which power was effectively transferred from Parliament to executive. The system in times of crisis was both efficient and flexible:

> The Prime Minister, in rejecting efforts to decrease the War Cabinet membership, explained that, under his system, a War Cabinet of both departmental and portfolio-free ministers saved time in the long run. [31]

Essentially this amalgamation meant that Churchill would have no competition from another Minister of Defence for example, but he did have a Defence Committee (Operations) and the Defence Committee (Supply) which regularly considered the larger issues of the war.

Despite the bureaucracy of the organizational structure key personalities had the opportunity to manipulate the strategic direction of the British war-time economy, particularly from within the War Cabinet, and by-pass the prerequisite that decisions were taken based upon military necessity and immediate strategic requirements. In order for Churchill to obtain

[29] Hansard Parliamentary Debates, House of Commons, Vol. 371 cc, 867-950, 7 May 1941.
[30] F.A. Johnson, *Defence By Committee: The British Committee of Imperial Defence 1885-1959* (London, 1960), p. 281.
[31] Ibid, p. 282.

an airborne capability he required support from fellow ministers and it is briefly worth examining certain key government appointments and their associated portfolios to determine the influence of personalities upon the procurement of new technologies. [32]

Churchill and Lord Beaverbrook

Beaverbrook's appointment to the War Cabinet could be interpreted as being more for the purposes of supporting Churchill's personal opinions, and reinforcing his prejudices, than to provide professional expertise. [33] He immediately established himself as one of Churchill's intimate advisors upon the latter's appointment as Prime Minister. Described as a 'conservative free-booter' [34] in one contemporary American article, Beaverbrook's career was certainly diverse and included a wealth of experience as a financier, politician, statesman, newspaper proprietor and amateur historian.

Churchill entrusted him to give advice on new appointments and relied on his network of contacts from both a wide political and professional spectrum. The two had been associates for some thirty years and by 1940 Beaverbrook was the Prime Minister's few personal friends in political circles and he came to rely heavily upon both his judgement and support. Brian Farrell argues 'his closest colleague and kindred spirit was Beaverbrook. The ties between them rested on shared experiences, compatible personalities, a view of the war as a crusade and the desire to press it as vigorously as possible.' [35] Beaverbrook's principal career was as a newspaper proprietor and his major expertise was publicity and media but

[32] Howlett, 'New Light Through Old Windows', p. 362.

[33] Ibid, p. 369.

[34] H, Finer, 'The British Cabinet, The House of Commons and the War', *Political Science Quarterly*, Vol. 56, No. 3, September 1941, pp. 321-360, p. 339.

[35] B. Farrell, 'Yes, Prime Minister: Barbarossa, Whipcord, and the Basis of Grand Strategy, Autumn 1941', *The Journal of Military History*, Vol.57, No.4, 1993, pp. 599-625, p. 602.

Churchill charged him with a task that, on paper, he was not ideally suited for and initially hesitated to accept. [36]

The assignment in question was the formation of a government organisation for the production of aircraft. In his memoirs Churchill acknowledged both Beaverbrook's reluctance and capabilities and commented that 'I felt sure however that our life depended upon the flow of new aircraft; I needed his vital and vibrant energy, and I persisted in my view.' [37] Consequently, following pressure from Churchill, Beaverbrook accepted the position of Minister of Aircraft Production on 17 May 1940 in the newly constituted M.A.P. and, combined with his later appointment to the War Cabinet, became an extremely influential figure in the realisation of the strategic military direction of the war. [38] A.J.P. Taylor, admittedly not the most obvious choice of biographer, made the following pertinent observations concerning Beaverbrook's influence and management technique:

> In this new world of government Beaverbrook remained what he had always been. He did not run the ministry as a trained administrator or a politician would have done. He ran it as he ran his private life. He ran it as a drama, working through individuals, not through committees, and ready to fight every level. [39]

Beaverbrook's chief struggle was in his relations with the Air Ministry, which was resentful of its supply branch being removed from its control, and the immediate competition for limited material resources between rival ministries, [40] a task in which Lewis Broad suggests 'the

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[36] A.J.P. Taylor, *Beaverbrook* (London, 1972), pp. 412-413.

[37] Churchill, *Their Finest Hour*, p. 26.

[38] D. Edgerton, *England and The Aeroplane* (London, 2013), pp. 109-110.

[39] Churchill, *Their Finest Hour*, p. 415.

[40] J. Hurstfield, *The Control of Raw Materials* (H.M.S.O. 1953), pp. 96-97.

poacher from Fleet Street was the star performer'. [41] But it was Churchill's experience of the Air Ministry during the later stages of the First World War and the re-armament period that may well explain the appointment of Beaverbrook and the creation of M.A.P. The origins of the relationship are briefly worth examining as both M.A.P. and the Air Ministry were crucial to the development of airborne forces.

Churchill and the Air Ministry

In October 1936 two R.A.F. pilots embarked upon a private visit to Germany in order to determine the technological capabilities of the *Luftwaffe*. During their tour they were warmly hosted by German pilots who even permitted them to fly the latest German bomber designs. Upon returning to England Squadron Leader Rowley produced a report concerning the capabilities of German airpower and suggested that British efforts be concentrated upon medium-bombers and advanced fighters to counter German aviation technology. [42] The report was largely ignored by the Air Ministry but Rowley sent a copy to Wing Commander Charles Anderson who, between 1936 and 1939, secretly supplied Churchill with information pertaining to what he perceived to be weaknesses in R.A.F. aircraft design.

Such intelligence persuaded Churchill that the Air Ministry was negligent and that the country was technologically incapable of defending itself against German air attack. Vincent Orange argues that such information gave Churchill the opportunity to return to government circles:

> Nominally a mere back-bench Member of Parliament, with little prospect of returning to office, Churchill's persistent, widely publicized, and apparently

[41] L. Broad, *Sir Anthony Eden: The Chronicles of a Career* (London, 1955), p. 147.

[42] T.N.A., AIR 40/2086, Report on a Visit to Germany by Squadron Leader H.V. Rowley and Flight Lieutenant R.L. Atcherley: An Assessment of the German Aircraft Potential, October 1936.

> well-informed agitation had persuaded the government to appoint him a member of the important Air Defence Research Sub-Committee of the Committee of Imperial Defence in July 1935. [43]

It also gave him a suspicion of this professional advice when he became prime minister. Higham believes that for a particular project to obtain the necessary resources high-level political support was thus crucial to the outcome and the flow of funds depended upon ministerial-level support. ‘This has often been as much dependent upon political and national economic considerations as upon the technical aspects of the enterprise.’ [44] Ultimately, it was difficult to dissuade the Prime Minister from any strategic direction he might wish to advocate and must be considered in relation to the development of the airborne capability.

However, it would be wrong to assume that Beaverbrook, through association with Churchill, was also a proponent for the development of airborne forces. But he did have indirect influence upon the military effectiveness of the new technology. Beaverbrook was singularly determined to produce fighter aircraft for the purpose of securing strategic victory during the Battle of Britain; a task in which he was undoubtedly successful, but not without wider strategic consequences.

Air Chief Marshal Sir Philip Joubert, a proponent of the strategic bombing offensive, suggested that through this accomplishment the ‘bomber programme was disrupted to allow high-speed production of fighters.’ [45] Consequently, the delay in bomber production had a significant secondary impact upon the airborne forces programme. Greenacre argues that ‘airborne forces relied on bomber aircraft throughout the war but almost exclusively until late

[43] V. Orange, ‘The German Air Force is Already The Most Powerful in Europe: Two Royal Air Force Officers Report on a Visit to Germany: 6-15 October 1936’, *The Journal of Military History*, Vol. 70, No. 4, 2006, pp. 1011-1026, p. 1012.

[44] R. Higham, ‘Government, Companies and National Defence’, p. 341.

[45] P. Joubert, *The Third Service* (London, 1955), p. 136.

1942. During this period operations and some areas of training were often frustrated by a lack of aircraft.' [46] Although high-level support was crucial to the successful outcome of any particular project it would be wrong to assume that every ministerial decision was mutually beneficial.

Ministry of Aircraft Production

Without an understanding of M.A.P's. responsibilities and its relationship with the Air Ministry the technological investment in airborne forces cannot be placed into any meaningful context. M.A.P. was created to take responsibility for the 'supply, inspection and repair of aircraft and all their armament and equipment; for design and development and for storage up to the stage of issue to operational squadrons.' [47] Although these responsibilities themselves do not appear unfamiliar it is important to recognise that these were originally the functions of an Air Ministry department under the Air Member for Development and Production (A.M.D.P.). [48] In the early months of its existence M.A.P. simply became a new name for the A.M.D.P. but under Beaverbrook the organisation significantly altered and the new ministry rapidly gained autonomy and political dominance.

Beaverbrook's primary task was to achieve maximum output of existing aircraft types to meet the strategic requirement of the R.A.F. Following an investigation into German air strength the Air Ministry had estimated that a programme of aircraft production was required with an output figure of 2,450 aircraft per month. [49] Britain faced an unprecedented military

[46] Greenacre, *Churchill's Spearhead*, p. 46.

[47] J.D. Scott & R. Hughes, *Administration of War Production* (H.M.S.O.,1955), p. 291.

[48] Ibid.

[49] Ibid.

crisis and thus it was realised, even before M.A.P. came into existence, that the traditional method of production and procurement was inadequate to meet strategic necessity. [50]

Consequently, it was agreed with the Air Staff that production would be concentrated on a small number of aircraft types in order to achieve maximum efficiency as highlighted by Scott & Hughes:

> Effort should be concentrated on the five types of aircraft capable of making then most immediate contribution to saving the situation – Wellington, Blenheim, Whitley, Hurricane and Spitfire. Nothing – and the point was most emphatically driven home – was to be allowed to stand in the way of the maximum production of these types in the shortest possible period. [51]

The strategic situation took immediate priority in an effort to avert military disaster. It appeared that M.A.P. would operate as 'easily and flexibly' as Churchill had claimed the War Cabinet conducted its business in the House of Commons of 7 May 1940. [52]

However, the decision to produce only five aircraft types severely limited the future technological development of airborne forces. Although Churchill undoubtedly recognised the paramount importance of the military situation and the strategic necessity to produce numbers of proven aircraft types he still called for the formation of an airborne force. His minute of 22 June 1940 contained little appreciation of associated doctrine. For example Britain was not then in a position technologically to satisfy the primary concept. Churchill's

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[50] S. Ritchie, 'The Price of Air Power: Technological Change, Industrial Policy, and Military Aircraft Contracts in the Era of British Rearmament', *The Business History* Review, Vol. 71, 1997, pp. 82-111, pp. 95-96.

[51] Scott & R. Hughes, *Administration of War Production*, p. 293.

[52] Hansard Parliamentary Debates, House of Commons, Vol. 371, cc, 867-950, 7 May 1941.

demand for ‘a capability for the deployment of at least 5,000 parachute troops’ [53] was certainly not a strategic priority in June 1940 and such interference in the M.A.P. aircraft programme was entirely irresponsible.

Meanwhile on 19 June 1940 the newly appointed Parliamentary Secretary to the Ministry of Aircraft Production, Colonel Llewellin, was directly questioned by Mr Cocks, M.P. for Broxtowe in Nottinghamshire, with regard to the protocol for aircraft specifications, the procedure for variation and effect upon production efficiency:

> Mr Cocks asked the Parliamentary Secretary to the Ministry of Aircraft Production whether, in order to expedite production, he will cut out unnecessary elaborations in specifications; and, in view of the fact that aircraft inspection department inspectors have no authority to sanction variations from specifications but must submit all queries to the technical or designs staff for decision, he will see that these departments are adequately staffed to enable prompt replies to be given? [54]

Llewellin assured Cocks that close liaison already existed between design, production and maintenance directorates within M.A.P. to ensure that any unnecessarily complicated design specifications were eliminated before production. He continued to make assurances that:

> Suggestions from contractors for speeding up production are encouraged, and I am satisfied that consideration of such suggestions is not delayed by lack of adequate staff. In addition the local technical staffs stationed at firms

[53] T.N.A., CAB 120/262, Airborne Forces: Minute to War Cabinet, by Winston Churchill, 22 June 1940.

[54] Hansard Parliamentary Debates, House of Commons, Vol.362, cc, 143-144, 19 June 1940.

> have since the Ministry was formed been given wider discretionary power to release equipment not conforming precisely to specification. [55]

The technicalities and efficiencies of production were naturally of great interest but it is worth noting that the concentration of production on limited numbers of proven aircraft types also provided economic certainty.

In the Official History of *British War Production* Professor Postan recognised that variation in aircraft design was incredibly expensive and time consuming. Postan believed that aircraft were being designed and ordered 'without clear ideas about the comparative costs of different shapes and different methods of production of aircraft parts, which were made necessary by differences in design.' [56] Consequently, standardisation not only increased production but also provided a degree of cost certainty upon which the war economy was dependent.

In fact, the potential for the standardisation of components had been recognised in 1937 by the Air Ministry. Sir Ernest Lemon, Director General of Production (D.G.P.) at the Air Ministry initiated a cost evaluation exercise of different types of aircraft wings 'with a view to establishing standard wing costs, or even designing a standard wing'. [57] Standardisation was to prove essential in the production of assault gliders and associated airborne equipment.

Nevertheless, the defining characteristic of M.A.P. under Beaverbrook's administration throughout 1940 was its progress towards obtaining responsibility and ultimate control over the supply function of the Air Ministry. On 1 May 1941 Beaverbrook was succeeded by Colonel Moore-Brabazon as Minister of Aircraft Production and subsequently

[55] Ibid.

[56] Postan, *British War Production*, p. 464.

[57] Ibid, p. 465.

M.A.P. was reorganised in a more structured format whereby roles and responsibilities were clearly defined (See Appendix 2.). One tactic employed by production ministries was to overestimate the amounts of raw materials required to ensure sufficient allocation and they consequently 'grabbed at resources haphazard,' [58] a tactic repeatedly adopted by M.A.P. John Jewkes, a government economic advisor, found the planning machinery to be in such chaos that he believed he could contribute more to the war effort 'by sorting out the statistics and information on aircraft production than by remaining at the centre of government.' [59]

During this period the executive position, entitled Controller of Research and Development (C.R.D.), was created with responsibility for all aviation technical and scientific establishments. Air Marshal F.J. Linnell was appointed to the position in June 1941 and succeeded the eminent aviation scientist Sir Henry Tizard who had been temporarily supervising the research and development directorates in the transition period. [60]

In his capacity as C.R.D. Linnell was very influential in the technological development of the British airborne capability and thus requires early introduction. The involvement of Tizard, although not as direct, was also an important influence on this research as he remained associated with M.A.P. in an ex-officio capacity with regards to scientific research throughout the entire war. [61] Consequently, Tizard had the opportunity to voice his professional and personal opinion at the very heart of the aviation establishment, and although there is no direct evidence that he had any influence upon strategy, his professional reputation would have undoubtedly made him a very difficult man to ignore; particularly in light of the fact that the development of airborne forces went ahead regardless of both contemporary economic and scientific opinion.

[58] Booth,' Economic Advice at the Centre of British Government, 1939-1941', p. 666.
[59] Ibid, p. 672.
[60] J.D. Scott & R. Hughes, *Administration of War Production* (H.M.S.O., 1955), pp. 297-299.
[61] Ibid.

Scientific Influences

The importance of individual personalities in the development of a particular technology should not be underestimated, but it would be wrong to assume that such a factor was the only catalyst for development. Higham recognised that international affairs, political, and public opinion were also significant factors in the formulation of government policy and this was certainly evident during the development of the British airborne capability:

> If the international situation becomes urgent or appears critical, then official and public opinion attitudes toward national defence sharpen and a speed-up in purchasing takes place, even though many of the items now required will not be deliverable for many months. [62]

The successful demonstration of airborne warfare by the Germans in 1940 was used by some interested parties as evidence that the application of new technology could achieve significant strategic military results. Garro-Jones argued in the Commons for serious investigation into airborne warfare [63] and articles were also being published in popular magazines such as *Picture Post* which declared that 'This Wasn't New in 1899' [64] and referred to previous ambitions for an airborne force.

Public and political opinion were consequently stimulated and government policy was questioned in light of the British inability to field such a specialised military resource. [65] Paradoxically there was also a strong counter-argument from prominent members of the

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[62] Higham, 'Government, Companies and National Defence', p. 325.

[63] Hansard Parliamentary Debates, House of Commons, Vol. 361, cc, 750-1750, 4 June 1940.

[64] 'This Wasn't New in 1899', *Picture Post*, 6 April 1940, p. 31.

[65] Buckingham, *PARAS*, pp. 70-72.

scientific community that investment in new technology, or gadgets, would seriously compromise the effectiveness of Britain's offensive military capability. [66] This was an argument which appeared to have prevailed when production was focused upon limited numbers of proven aircraft types.

Churchill's self-appointment as Minister of Defence effectively ensured his personal control over the service chiefs. This gave him considerable influence upon the strategic direction and any subsequent technological and scientific investment required to convert policy into reality. Edgerton concisely summarised both the significance and the irregularity of the situation:

> Churchill was a great enthusiast for science and machines, particularly in relation to war, in a country where the elite, and especially the old aristocratic elite from which Churchill came, were thought to be either above such matters or sunk in rural idiocy. [67]

He believes that Churchill, through his passion for technology, was a break from the traditional model of the English aristocratic classes. But such enthusiasm did not necessarily qualify him to determine the technological investment of a limited wartime economy.

Churchill's preference for the 'mechanical forms of warfare, for machines over manpower,' [68] originated from his experiences during the Great War. During his tenure at the Admiralty he was the key player in the invention of the tank, which Michael Pattison has commented that he ironically entrusted the development to the Director of Naval

[66] Edgerton, *Britain's War Machine*, pp. 85-88.

[67] Ibid, p. 87.

[68] Ibid, p. 89.

Construction. [69] Edgerton confirms that 'he was a regular attendee at demonstrations of new gadgets and one who clearly believed that Britain had great reserves of ingenuity which would be critical for victory.' [70]

The key point in relation to the advancement of British airborne warfare was that Churchill was not averse to arguing for, or indeed accelerating, the development of any machine or technology that he believed would be militarily advantageous. His model for the conduct of the war-time economy meant that he could influence all aspects of technological progression. Although first-hand experience of the suffering endured by front line infantry during the Great War was probably the benevolent motive behind Churchill's technological ambitions, solidarity with infantry and preference for technology was no guarantee for military success.

Despite his profound interest in the field of invention, Churchill was not a scientist and required academic advice to realise his theories. In 1921 he was introduced to the Oxford physicist Frederick Lindemann, later Lord Cherwell, from which developed a life-long friendship which culminated in the latter becoming his primary council on all matters scientific. [71] However, the close relationship ultimately resulted in constant criticism concerning the technological direction of the war-time administration from members of the scientific community. The dispute is central to the exploration of the justification for the development of airborne warfare and it is important to establish its origin.

Bond and Murray have suggested that British politicians possessed significant defects with regard to military and strategic issues during the inter-war period.

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[69] M. Pattison, 'Scientists, Inventors and the Military in Britain, 1915-1919: The Munitions Department', *Social Studies of Science*, Vol. 13, No. 4, 1983, pp. 521-568, pp. 538-539.
[70] Edgerton, *Britain's War Machine*, p. 89.
[71] J. Colville, *The Churchillians* (London, 1981), pp. 31-34.

> With few British politicians possessing either interest or background in strategic affairs, it is not surprising that the British military, especially the army, found it difficult to persuade ministers of their needs and requirements. [72]

However, once Churchill assumed power the ignorance of previous governments was rapidly reversed and he assumed control of both military and strategic issues as Minister of Defence. Strategic direction, particularly in the development of airborne warfare, subsequently became determined at the political level rather than through the identification of the armed forces of a particular technology that satisfied a specific tactical or operational requirement.

Churchill's experience of the inertia of the inter-war period resulted in the creation of an effective wartime system of policy and decision that was undoubtedly key to the political effectiveness of Britain throughout the duration of the conflict. The consequence of such control, however, resulted in an ability to influence policy without a full appreciation of the military requirements or strategic realities, and ignorance of the opinions and expertise of the political and scientific communities.

Origins of the Scientific & Technological Debate

In order to understand such fundamental differences of opinion the research areas in which the key scientific personalities were engaged prior to the outbreak of the Second World War must be explored. [73] The argument between new versus established technology

[72] B. Bond & W. Murray, 'The British Armed Forces, 1918-1939', in *Military Effectiveness: Volume Two*, p. 98.

[73] M. Fortun & S.S. Schweber, 'Scientists and the Legacy of World War II: The Case of Operational Research (OR)', *Social Studies in Science*, Vol. 23, No. 4, 1993, pp. 595-642, pp. 600-601.

will then be referenced throughout the thesis in relation to the development of airborne forces.

The focus of scientific application to military problems during the 1930s was centred upon the potential application of radar for the detection of enemy bombers. The anxiety stemmed from a debate in the House of Commons on 10 November 1932 in which Stanley Baldwin made the demoralising prediction that 'The Bomber Will Always Get Through.' [74] Lindemann voiced concerns over Britain's ability to deploy adequate air defences against air bombardment, and with Churchill's political assistance, the scientist pressed for a high-level committee to urgently consider the problem.

In fact, at the time of Lindemann's proposal the Air Ministry had already established the Committee for the Scientific Survey of Air Defence (C.S.S.A.D.), with Henry Tizard as Chairman, which sat for the first time on 28 January 1935. Tizard was a skilled government scientist 'with a long experience of aeronautical technology and test flying.' [75] The Committee consisted of pre-eminent scientists and engineers and included H.E. Wimperis, Director of Scientific Research at the Air Ministry, P.M.S. Blackett [76] and A.V. Hill. [77] Lindemann was also invited to join the committee but initially delayed in acceptance probably out of suspicion that both Tizard and the Air Ministry had circumvented his own proposal that the scientific appraisal should be directed by the Committee of Imperial Defence.

Meanwhile, Lindemann's recommendation was acted upon by the government and was entitled the Air Defence Research Sub-Committee of the Committee of Imperial

[74] Hansard Parliamentary Debates, House of Commons, Vol. 270, cc, 525-641, 10 November 1932.

[75] R.V. Jones & W.S. Farren, 'Henry Thomas Tizard 1885-1959', *Biographical Memoirs of Fellows of the Royal Society*, Vol. 7, Nov. 1961, pp. 313-348, p. 332.

[76] P.M.S. Blackett was an experimental physicist who became a founder of Operational Research.

[77] A.V. Hill was Professor of biophysics at University College London.

Defence (C.I.D.) which first met on 10 April 1935. [78] Effectively, two separate groups had been formed with Tizard and Lindemann represented on both. The C.I.D. was principally concerned with the 'political and military decisions required to implement the air defence programme of research and development' [79] whilst the C.S.S.A.D. (Tizard Committee) concentrated on scientific research.

Nevertheless, when Lindemann finally did join the Tizard Committee his relationship was so thoroughly uneasy with the other members that in July 1936 both Hill and Blackett resigned. Speaking at the Tizard Memorial Lecture in 1960, Blackett gave his own account of the dispute between Tizard and Lindemann over the priorities for research and development in which it was evident that the relationship had become entirely unproductive:

> On one occasion Lindemann became so fierce with Tizard that the secretaries had to be sent out of the committee room so as to keep the squabble as private as possible. In August 1936, soon after this meeting, A.V. Hill and I decided that the Committee could not function satisfactorily under such conditions; so we resigned. [80]

The basis of the dispute stemmed from the fact that Lindemann wanted to concentrate efforts upon the development of aircraft detection by means of infra-red radiation and 'for the dropping of parachute-bombs' [81] into the path of enemy night bombers, [82] whilst the remainder of the Committee believed that the perfection of radar was the priority in terms of

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[78] N. Rose, *Churchill: An Unruly Life* (London, 1994), pp. 226-227.

[79] Ibid.

[80] B. Lovell, 'Patrick Maynard Stuart Blackett, Baron Blackett, of Chelsea', *Biographical Memoirs of Fellows of the Royal Society*, Vol. 21, 1975, pp. 1-115, p. 51.

[81] Ibid.

[82] T.N.A., AIR 2/1956, Research & Development (Code B 67/34): Vertical Dropping of Bombs by Parachute: Investigation, January 1936 – December 1940.

resources. Lindemann's preference for untested technological solutions to immediate problems of defence cannot be ignored and his close relationship with Churchill would have made opposition to the development of the airborne capability unlikely.

The Air Ministry simply reformed the Committee but did not extend an invitation to Lindemann, a pragmatic response in light of the importance of the research but a decision that undoubtedly cost them dearly once Churchill and Lindemann established themselves in Whitehall. Hore-Belisha believed that Churchill displayed an intense loyalty to friends, even if they did not agree politically, and that whilst 'you are a friend you can expect support to the hilt.' [83] However, once Churchill had formed an opinion, an opinion unquestionably influenced by Lindemann in all matters scientific, he would become an 'unrelenting opponent.' [84] There can be no doubt from Churchill's memoirs of the mutual dependence that existed between them:

> He was my trusted friend and confidant of twenty years. Together we had watched the advance and onset of world disaster. Together we had done our best to sound the alarm. And now we were in it, and I had the power to guide and arm our effort. [85]

Lovell identified that the decline in influence of the Air Ministry coincided with the abrupt decrease in the scientific authority of Tizard, Hill and Blackett in matters of defence. [86] Consequently, any professional scientific opposition to the development of airborne forces had been effectively removed long before the decision to procure such a method of warfare was taken.

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[83] C. Eade (ed.), *Churchill by his Contemporaries* (London, 1953), p. 399.

[84] Ibid.

[85] Churchill, *Their Finest Hour*, p. 312.

[86] B. Lovell, 'Blackett in War and Peace', *The Journal of the Operational Research Society'*, Vol. 39, No. 3, 1988, pp. 221-233, p. 222-224.

The significance of the scientific and technological development of radar was that it was an example of a service request for scientific assistance in the development of a strategic requirement, rather than a technological specification to which the manufacturers would respond. The importance of technology and scientific application were beginning to be realised amongst military staffs, but the personalities involved were also crucial. Tizard continued his close association with the Air Ministry throughout the 1930s on perfecting the technique of airborne detection and he accepted an appointment as Scientific Advisor to the Chief of Air Staff. However, upon the return of Churchill to the Admiralty in 1939, accompanied by Lindemann as his chief scientific and economic advisor, Tizard found his position in Whitehall increasingly difficult. [87]

Lindemann and the War-Time Government

Upon appointment as Prime Minister, Churchill assigned Lindemann as his personal scientific advisor with the joint role of offering advice and acting as the guardian and selector of all fellow scientists' entry to Downing Street. The scientific influence within the government was a direct result of the rapidly changing demands of war and the subsequent necessity for rapid technological development.

Due to the ever-changing requirements of the armed services new technological opportunities could easily be overlooked in the conduct of daily war-time administration and Churchill was determined not to miss an opportunity. Thomas Wilson argues that:

> Churchill was determined to prevent important proposals from drifting around Whitehall in their manila folders. Moreover, although the various departments had expert knowledge, they were by no means infallible. [88]

[87] Rose, *Churchill: An Unruly Life*, pp. 226-229.

[88] T. Wilson, *Churchill and the Prof* (London, 1995), p. 23.

However, despite Churchill's selection of specialist advisors he often found it difficult to resist interference in departmental business and was quite prepared to lecture departmental ministers on what he believed should be done. [89] Wilson suggested that it may well have been this spontaneous aspect of Churchill's character that resulted in the somewhat irregular job description that Lindemann ultimately fulfilled. [90]

Lindemann's remit was not simply confined to scientific matters. He was also head of 'S Branch', the Prime Minister's statistical section, and required to compile information from a wide variety of departments; a not insubstantial task according to Farren and Thompson:

> He had to summarize the monstrous mass of statistics thrown up by the administration so that the P.M. could see what was happening and grasp the essence of the big quantitative issues that arose for decision. [91]

Consequently, Lindemann was in the position of having the complete faith of Churchill but also of attracting the suspicion of ministers as noted by the Earl of Birkenhead:

> In spite of the immense usefulness of his work, his Section had no definite status. He was not a minister with a department behind him, yet he had the task of requiring statistics from them, often with the object of hostile scrutiny. Although never a member of the War Cabinet, he was in closer and more continuous contact with the Prime Minister than any other man. [92]

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[89] Ibid, pp. 22-23.

[90] Lindemann was made Lord Cherwell in 1941 but it was not until 1942 that he received any official standing within the government when he was appointed Paymaster General.

[91] W. Farren & G.P. Thomson, 'F.A. Lindemann, Viscount Cherwell: 1886-1957', *Biographical Memoirs of the Royal Society*, Vol. 14, 1958, pp. 45-71, p. 59.

[92] The Earl of Birkenhead, *The Prof in the Two Worlds* (London, 1961), p. 214.

Lindemann's team of statisticians analysed the figures collated by individual departments in order to ensure that they were both realistic and showed maximum productivity in the war economy. Edgerton believed that no scientist ever had more influence in British history, and probably no academic either. [93]

Lindemann's influence was significant, however, not necessarily because he had any direct involvement in the British airborne capability, but because he shared Churchill's passion for scientific gadgetry and had an in-depth knowledge of all aspects of the departmental war effort. Consequently, opportunities for the development of new technologies in the Churchill government were potentially abundant.

Yet the enthusiasm for invention which characterised the Churchill administration was not universal within the scientific community. Perhaps the most important scientific critic of the Churchill government was A.V. Hill, Professor of Biophysics at University College London. Hill believed that Churchill and Lindemann were responsible for wasting precious materiel resources and exploiting their position in government to sponsor unqualified technological development. In essence, he believed that production would be more efficient if effort was concentrated upon the improvement of existing weapons rather than in the development of new and unproven technologies. [94]

Hill considered that the development of new weaponry detracted from improvements in existing technology which ultimately resulted in a failure to anticipate future requirements

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[93] Edgerton, *Britain's War Machine*, p. 100.

[94] Ibid, p. 135.

and put British forces at a military disadvantage. He encapsulated his misgivings in an open letter printed in *The Times* on 1 July 1942. [95]

> The inferiority is not due to bad workmanship, but to a system which has failed to anticipate future tactical requirements in guns, projectiles, armour, and performance, failed to collect and analyse, and profit by previous operational experience, failed sometimes to obey the elementary rule that production must follow, not precede, development. [96]

Hill believed that the primary cause for the inferiority of British weaponry was that scientific and technological control was entirely practised at departmental level, usually subordinate to administration, and that there was insufficient scientific representation at central government.

Indeed, there was no technical staff to advise the Cabinet directly and objectively on scientific or technological matters and consequently no independent body to ensure that design and development was both efficient and technologically perceptive. As Hill observed:

> For operations, planning has been centralized in the Chiefs of Staff organization, for supply, in the Minister of Production. The third member of the trinity, dealing with research, design and development and quantitative planning of the use of technological resources, is altogether unrepresented at the highest level. [97]

[95] Hill's argument was framed upon the recent British defeat in Libya, whereby the failure was principally blamed upon the inferiority of British tanks, but the content was ultimately a criticism of the government's scientific approach:

[96] A.V. Hill, 'Science and War: Technical Advice at the Centre', *The Times*, 1 July 1942, p. 5.

[97] Ibid.

His personal experiences whilst serving on the Tizard Committee resulted in strong misgivings about Lindemann's monopoly within the government on all matters scientific.

Hill's concerns resonated in the establishment of a Scientific Advisory Committee to the War Cabinet formed of officers of the Royal Society. A similar committee had been established during the First World War but had failed to gain the desired influence. [98] The Committee's basic terms of reference were to advise the Lord President of the Council and appropriate government departments on any particular scientific problems and select suitable scientists with relevant expertise who might offer assistance. The committee was also instructed to ensure that the authorities were informed of any promising new scientific or technological developments. [99]

Zuckerman, a leading British scientific advisor throughout the Second World War, neatly summarised the influence of the scientists at the centre of the British establishment and ultimately found in favour of Hill and his colleagues in terms of their strategic influence:

> These germinal centres of wartime advice enjoyed different kinds of power. Cherwell's was immense because of his close friendship with Churchill. So too was Tizard's and also that of his colleagues – in particular Blackett, R.H. Fowler, G.I. Taylor, A.V. Hill and Charles Darwin. My own view is that during the war they exercised a much bigger influence on the body of

[98] A. Hull, 'War of Words: The Public Science of the British Scientific Community and the Origins of the Department of Scientific and Industrial Research', 1914-16', *The British Journal for the History of Science*, Vol. 32, No. 4, 1999, pp. 461-481, p. 468.

[99] B. Katz, 'Archibald Vivian Hill 1886-1977', *Biographical Memoirs of Fellows of the Royal Society*, Vol. 24, 1978, pp. 71-149, p. 118.

> British scientists as a whole than did Cherwell, whom on the other hand I would say had a bigger impact on events. [100]

Hill was also an advocate for what became one of the principal scientific and technological features of the British war effort, Operational Research (O.R.): that is to say the 'scientific investigation of military operations and the effectiveness of weapons in the field.' [101] The principles of O.R. are worth briefly exploring, and subsequently considering throughout this examination in reference to airborne capability.

Operational Research & Combined Operations

O.R. has been defined as 'numerical thinking about operations, with the aim of formulating conclusions which, applied to operations, may give a profitable return for a given expenditure of effort.' [102] Joseph McCloskey argues that in the modern scientific context the achievements of wartime British O.R. could appear almost trivial with the solutions 'little more than what appears in hindsight to be common sense.' [103] However, it did create the blueprint for future collaboration between the military, technological and scientific communities.

The most significant aspect of the O.R. methodology was the fact that it was the first time civilian scientists and engineers directly combined with military personnel to achieve maximum efficiency of available resources. Crowther & Whiddington argued that:

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[100] S. Zuckerman, 'Scientific Advice During and Since World War II', *Proceedings of the Royal Society. Series A, Mathematical and Physical Sciences*, Vol. 342, No. 1631, *A Discussion on the Effects of the Two World Wars on the Sciences in the United Kingdom*, 1975, pp. 465-480, p. 467.

[101] Edgerton, *Britain's War Machine*, p. 138.

[102] Air Ministry, *Operational Research in the R.A.F.*, (H.M.S.O., 1963), p. 17.

[103] J. McCloskey, 'British Operational Research in World War II', *Operational Research*, Vol. 35, No. 3, 1987, pp. 453-470, p. 453.

> The invention and improvement of equipment has long been, and will always be, one of science's chief contributions to the technique of warfare. In the war of 1939-1945, however, science entered in a new way; scientific method was applied more consistently and deliberately to the use of weapons and the conduct of military operations. [104]

Consequently, the early ambassadors of O.R. were able to advise designers directly and promptly about any particular technical deficiencies, work closely with manufacturers to accelerate research and development and, ultimately, advise the end-user upon the most efficient method of deploying both equipment and personnel.

The most obvious benefit of the application of O.R. was in the development of new technology and Crowther & Whiddington argued that the first identifiable starting point was in the study of radar equipment, [105] as discussed above in relation to the Tizard Committee. Tizard certainly believed that such cooperation was a unique phenomenon and wrote the following in 1946:

> Without such collaboration I feel confident that much time would have been wasted, and much scientific effort misdirected, which with our limited supply of men and resources we could not afford. [106]

Although there was no named scientist devoted specifically to the development of airborne warfare scientists such as P.M. Blackett, S. Zuckermann, and C.H. Waddington became

[104] J.G. Crowther & R. Whiddington, *Science at War*, (H.M.S.O., 1947), p. 91.
[105] Ibid, pp. 91-92.
[106] H.T. Tizard, 'Teamwork in Research', *Journal of the Franklin Institute*, Vol. 242, 1946, pp. 5-8, p. 8.

scientific advisors to the various military commands. [107] K. Brian Haley rightly identified Blackett as the leading exponent of the technique and was instrumental in establishing the reputation of scientific contribution at the operational level:

> He advocated adopting a scientific discipline with formal analysis to the studies that were not aimed at producing better weapons but more concerned with how to improve the use of existing ones and how to deploy troops, ships, aeroplanes, tanks, and guns more effectively. [108]

However, it is important to note that Blackett, along with other members of the scientific community such as Hill, did not just advocate the appliance of science to the development of new technology. In fact, they were more inclined to combine scientific investigative technique with operational analysis to improve the military effectiveness of existing hardware.

The application of scientific technique did not require the scientist employed to have any specialist knowledge of the work assigned, more the appliance of a scientific methodology and it remained the responsibility of the military headquarters staff to utilise or discard any analysis provided. [109] Although evidence of the application of the principles of O.R. cannot be documented during the development of the British airborne capability it was clear that the leading exponents were determined not to let the new techniques become an opportunity for the production of 'gadgetry'.

Ironically, Zuckerman's assessment of the influence of scientists on strategic matters is most perceptive in relation to the development of British airborne forces whereby all the

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[107] K. Haley, 'War and Peace: The First 25 Years of OR in Great Britain', *Operations Research*, Vol. 50, No. 1, 2002, pp. 82-88, p. 83.

[108] Ibid.

[109] H Larnder, 'The Origin of Operational Research', *Operations Research*, Vol. 32, 1984, pp. 465-475, p. 467.

protagonists were intrinsically linked. Without the inclination for new technology possessed by Churchill and Lindemann the development of a British airborne capability may never have commenced, but without the application of scientific principles, as championed in O.R., it is doubtful if deployment would have become an operational and tactical reality.

McCloskey believes that Lindemann undoubtedly supported the principles of O.R. but ultimately ensured that the priority for resource allocation was directed where he personally believed they would be best placed:

> Cherwell must be recognised for his interest in Bomber Command and his support of O.R. activities there. Moreover, because of his key position as scientific adviser to Churchill, he was in a position to advance – or obstruct- this use of scientific talent. [110]

Lindemann supported the application of radar technology to aircraft to enable Bomber Command to locate specific targets and thus increase accuracy and efficiency. He backed strategic bombing and his status allowed him to ensure that there was minimal interference in the administration of the campaign. This would suggest opposition to the competition created by airborne development. However, analysis into the effectiveness of airborne forces was conducted from early operational deployment and influenced the research and development programme accordingly. The scientific resource allocated to the progression of British airborne warfare would thus suggest that Lindemann was also supportive of the capability.

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[110] J.F. McCloskey, 'The Beginnings of Operational Research: 1934-1941', *Operations Research*, Vol. 35, No. 1, 1987, pp. 143-152, p. 150.

Conclusion

The strategic and economic situation that confronted Britain in 1940 was such that the British could not, in the words of Hancock, 'afford to indulge themselves in day-dreams of a magical multiplication of their forces and equipment.' [111] He argued that although the 'British were compelled to fight a defensive war: they fought it with an offensive spirit.' [112] Churchill had become increasingly concerned in June 1940 that the defensive position that Britain had been forced to adopt had the potential to severely undermine the morale of the armed forces. On 25 June 1940 the Chief of the Imperial General Staff reported to the War Cabinet that:

> A Memorandum had been widely circulated emphasising the need for instilling the offensive spirit into all ranks. The morale of the Army had inevitably suffered as a result of the series of retreats which had been forced upon them through no fault of their own, and every effort was being made to bring morale up to the highest possible level. [113]

The concern over morale was indeed justified and Hew Strachan has suggested that the crisis culminated in large-scale desertion, which peaked during the campaign in North Africa:

> In 1941-42 the British army confronted a crisis in its morale. It had been defeated on the battlefield; its equipment was poor; and its institutions seemed ill-adapted to the needs of a citizen army in a world war. [114]

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[111] W. Hancock, *British War Economy*, p. 214.

[112] Ibid.

[113] T.N.A., CAB 65/7/76, War Cabinet Conclusions WM (40) 181, 25 June 1940.

[114] H. Strachan, 'Training, Morale and Modern War', *Journal of Contemporary History*, Vol. 41, No. 2 2006, pp. 211-227, p. 223.

Consequently, the ability to launch airborne (and Commando) raids had both direct and in-direct military and psychological benefit.

The mechanics of the wartime administration were such that Churchill, surrounded by political, scientific and personal allies, could manipulate the direction of the economy to focus resources accordingly; whether for strategic military purposes or for the allusion that Britain was capable of further offensive action. His influence upon national investment in military technology was contrary to the contemporary scientific argument championed by Professor Hill and the subsequent methodology proposed by Millet and Murray for the analysis of operational effectiveness which asserted that the military should champion specific technological requirements. [115] The orientation of influence and the scientific debate is crucial to the understanding of the development of airborne warfare.

Strategic effectiveness, and the subsequent technological necessities, can be defined as the employment of the military to secure by force national goals as agreed by the political leadership. Millett and Murray suggest that strategic activity consist of plans which specify timescale, mission and objectives:

> Subsumed within the definition are the analysis and selection of strategic objectives and the linkage of those objectives to national goals through the mechanism of campaign or contingency plans. [116]

However, when this is applied to the technological development of British airborne warfare it is evident that there were serious shortcomings in terms of strategic effectiveness.

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[115] Millet, Murray & Watman, 'The Effectiveness of Military Organizations', in *Military Effectiveness: Volume One*, pp. 4-6.
[116] Ibid, p. 7.

Greenacre identifies the inadequacies of the original airborne doctrine [117] and the influence of Churchill resulted in the adoption of strategic goals that were neither operationally nor technologically possible in the short-term, nor capable or being adequately resourced for future exploitation. The development of airborne forces had failed to 'obey the elementary rule that production must follow, not precede, development' [118] as would be later argued by Professor Hill.

Moreover, regardless of the political ambition, technological investment, or the efficiency of its application, the British were not capable of reconciling the more fundamental requirements necessary to achieve military effectiveness in airborne warfare, such as the limitations in aircraft availability and their military capability. These factors will be explored in the following chapters.

[117] Greenacre, *Churchill's Spearhead*, p. 173.

[118] A.V. Hill, 'Science and War: Technical Advice at the Centre', *The Times*, 1 July 1942, p. 5.

Chapter Two: Central Landing School / Central Landing Establishment

Introduction

With the economic, scientific, and administrative background established attention can now be concentrated upon the actual technological development of the British airborne capability. The Central Landing School (C.L.S.) was established at R.A.F. Ringway, near Manchester, with the specific task of turning Churchill's request into an offensive reality.

The R.A.F. involvement in the development of airborne warfare was paramount from its inception and came at a time when Bomber Command was engaged in 'operations designed to reduce the scale of air attack' [1] on Britain and was focused upon strategic targets such as enemy aircraft factories and aluminium works. Nevertheless, despite the importance of these objectives precious resources were relinquished for the development of new technology.

The chapter will examine the early technological development and the resources required for the deployment of a British airborne capability. The procurement mechanism will be scrutinised in order to deduce whether sufficient strategic military requirement had been demonstrated to justify the necessary technological development.

[1] T.N.A., CAB 66/9/7, War Cabinet Weekly Résumé (No.43), by Chiefs of Staff Committee, 28 June 1940.

Early Development

Major John Rock of the Royal Engineers was initially tasked with the development of British airborne forces by the War Office but there were also R.A.F. officers involved in the embryonic planning and training period. These were chiefly Group Captain L.G. Harvey (Station Commander R.A.F. Ringway), Squadron Leader Louis Strange, and Wing Commander Sir Nigel Norman. [2]

Parachute training became the responsibility of the R.A.F. whilst the Army focused upon the military requirements and tactical considerations of airborne warfare, what Greenacre defined as the 'concept'. [3] By 5 July 1940 all pilots at the C.L.S. had passed on the Armstrong Whitworth Whitley, the primary aircraft allocated in accordance with M.A.P. concentration on particular aircraft types, [4] and on 6 July Strange obtained permission from Lord Egerton to use Tatton Park for parachute landings. This was sanctioned by the Air Ministry on July 8 and the following day the first training course started at the Central Landing School. [5]

However, the C.L.S. was also responsible for the development of all associated technology required by an operational airborne force. On 17 July a conference was held between the Commanding Officer, Chief Ground Instructor, Chief Landing Instructor and the Managing Director and General Manager of Messrs. Elliot and Accessories Limited regarding the manufacture of containers for carriage of equipment. The firm agreed to produce a specimen container for trial which was subsequently successfully dropped from the bomb bay of a Whitley on 2 August 1940. The container was loaded with equipment

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[2] A. Wood, *History of the World's Glider Forces* (Kent, 1990), p. 37.

[3] Greenacre, *Churchill's Spearhead*, p. 172.

[4] Scott & Hughes, *Administration of War Production*, pp. 291-292.

[5] T.N.A., AIR 29/512, C.L.S. Ringway, 8 July 1940.

consisting of 11 rifles, 100 rounds of ammunition and 1 Bren gun. [6] The technical development, and subsequent liaison of key stakeholders, had commenced.

The first army pupils to arrive at Ringway for parachute training were men of No.2 Commando and, after a course of ground training, the first live descents were made from a converted Whitley on 13 July. [7] Six Whitley bombers were initially transferred to the C.L.S but required extensive modification in order to be used for parachute training. In the first instance this involved the removal of the rear gun turret which was replaced by a platform from which the parachutist performed the jump.

It was soon necessary for the platform method of alighting to be replaced by a more realistic exit to give the parachutists experience of jumping under operational conditions. On 29 July tests were made with dummies to simulate the dropping of eight men on a single run but proved unsatisfactory as only the first and last dummy actually landed within the specified landing zone. Consequently, it was decided that the Irvin type parachute [8] then in use was unsuitable for airborne purposes and all trainees were sent away for a fortnight of tactical training under Army arrangements whilst an alternative substitute was sourced and tested. [9]

The platform method of jumping was far too clumsy to allow a 'stick' of ten parachutists to be deployed quickly from the Whitley and subsequently reach a designated landing zone in a reasonably close grouping. [10] The problem was resolved by means of cutting a hole in the floor of the aircraft through which parachutists could deploy swiftly via the 'static-line' technique. The static-line method required the rip-cord of the parachute to be fixed via a clip

[6] Ibid.

[7] Wood, *History of the World's Glider Forces*, p. 41.

[8] The Irvin parachute was the standard R.A.F. aircrew type.

[9] T.N.A., AIR 29/512, 29 July 1940.

[10] Ibid.

to a point on the aircraft fuselage. The parachute was consequently deployed by the weight of the parachutist pulling the cord on exit from the aircraft rather than having to be physically pulled once in free fall as with the Irvin. The Airborne Forces Manual described this modification:

> The Whitley V has a floor aperture occupying the hole originally provided for a bottom turret which is not fitted. The aperture is an oval hole 36 inches wide, by 40 inches long, and provides the means by which the paratroops leave the aircraft. The aperture is covered by two doors hinged to the bottom of the aircraft. These doors are semi-circular in shape and are secured, during flight, by means of two sliding bolts engaging with fitments on the floor of the fuselage. For action by paratroops each door is opened and hitched to one of the fuselage frames by means of a strap and press stud. [11]

Figure 1: Trainee Parachutists and R.A.F. Aircrew posed next to a Whitley Bomber
Source: Image Courtesy of the Assault Glider Trust

[11] J. Tanner (ed.), *R.A.F. Airborne Forces Manual* (London, 1979), pp. 12-13.

Although the inclusion of the aperture into the Whitley was a vast improvement upon the earlier method it still posed a series of hazards.

The major problem was that there was a tendency for the lower end of the body to become caught by the slipstream of the aircraft which resulted in a blow to the face from the edge of the aperture upon exit from the aircraft fuselage. [12] This became known as the 'Whitley kiss' and although the parachute would deploy regardless of whether the parachutist was conscious or not it was a major disadvantage during the landing stages of the descent. Lieutenant-Colonel Anthony Deane-Drummond recounted the following experience of parachuting from the Whitley in his memoirs:

> One of the difficulties of 'hole-jumping' was to make a completely clean exit without touching the sides. If you pushed off too hard, your face encountered the far edge as you went. If you slid out too gently, the parachute on your back bounced you off your side of the hole so that your face again met the far side! Nor did the slip-stream help, for as it acted first on the legs of the parachutist as he emerged from the aircraft, it tended to topple him over unless he went out perfectly straight. As may be imagined, there were quite a few bruised and bleeding faces walking about Knutsford and Ringway in those days, disfigured by what came to be called a 'Whitley Kiss.' [13]

In an attempt to reduce the effects of this phenomenon a windshield was fitted to the forward edge of the aperture to help divert the air-flow and a streamlined tail spat was also fitted to prevent the parachute and static-line from getting tangled in the tail wheel. [14] However,

[12] B. Gregory & J. Bachelor, *Airborne Warfare 1918-1945* (London, 1979), p. 42.

[13] Deane-Drummond, *Return Ticket*, pp. 15-16.

[14] Tanner (ed.), *R.A.F. Airborne Forces Manual*, pp. 14-15.

despite the minor technological modifications, the slipstream remained a common problem for all descents that were conducted through an aperture in the fuselage floor, particularly as no alternative aircraft were available.

On 27 July 1940 the Director of Combined Operations (D.C.O.), Admiral Keyes, carried out a brief inspection at Ringway to review the equipment and training of parachute troops. He subsequently wrote the following note to the Prime Minister regarding the suitability of the Whitley as a parachute aircraft:

> It is of the utmost importance that a more suitable plane than the Whitley bomber should be provided at once. After going into the matter with the R.A.F. Officer on my Staff and the Officers Commanding the Training Staff and the troops at Ringway, and myself dropping through the hole in the bottom of a stationary Whitley plane, with a squad of parachutists, I am strongly of the opinion that the Whitley machines are thoroughly unsatisfactory. [15]

Despite the protest the dependency upon obsolete equipment was further reinforced at a conference at the Air Ministry on 5 September 1940 where it was stated that any specialist aircraft would require research and design resource that would 'seriously compromise the production of aircraft for other purposes'. [16] The airborne forces had to make the most of available resources.

After the initial political enthusiasm it was clear that the airborne force was far from being a strategic priority with regards to aircraft provision, but without clear parameters for operations it would be unfair to claim that the Air Ministry were obstructive. At a conference

[15] T.N.A., CAB 120/262, Minute to Churchill, by Admiral Keyes, 27 July 1940.

[16] T.N.A., AIR 32/2, Provision of an Airborne Force, Author Unknown, 5 September 1940.

held at the Air Ministry on 4 September a minute was produced entitled ‘Note on the Employment of Airborne Troops’ [17] in which an attempt was made to produce some form of policy regarding the future development and subsequent deployment of an airborne capability.

After the potential for evacuation or extraction of airborne forces by air had been deemed unrealistic the report concluded that the only economical means for employing airborne forces were ‘under conditions of air superiority’ [18] and when that airborne force is expected to be ‘supported immediately by sufficient land forces to secure the whole situation.’ [19] With regard to future expenditure the Air Ministry recommendation was both pragmatic and clear:

> In view of the forgoing considerations, it seems essential, before a large expenditure of effort is put into the development of an airborne force, that the principles governing the employment of such a force should be established and, if possible, certain situations in which that airborne force might be employed should be examined to determine how the force should be constituted. [20]

However, despite the obvious need for clarification of the strategic requirement the training and development programme continued without clearly defined research parameters.

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[17] T.N.A., AIR 20/2829, Gliders: Military Employment, Note on the Employment of Airborne Troops, Author Unknown, 4 September 1940.

[18] Ibid.

[19] Ibid.

[20] Ibid.

Live descents through the Whitley aperture commenced at Ringway on 14 July 1940 and initially proved successful. The decision was taken at this time to stop the practice of preliminary ‘pull-off’, whereby the parachutists pulled the rip-cord prior to exiting the aircraft, and allow the parachute to open by means of the static-line alone. On 25 July twenty-one live landings were conducted at Tatton Park until, at the third drop from Whitely K.7230, Driver Evans of the Royal Army Service Corp (R.A.S.C.) was killed after his parachute failed to open upon withdrawal from the pack. Consequently, a signal was received from the Air Ministry at 16.45 in the afternoon that ordered all parachute training to cease until further orders. [21]

On 30 July successful trials were carried out with the alternative Quilter type parachute [22] which opened immediately down to 100 feet. After a conference between senior C.L.S. officers it was recommended ‘that no more live landings should be carried out until the parachute had been tested by 500 dummies’ and that Messrs. G. Quilter would send 500 covers for parachutes at the rate of 100 a week. [23] After extensive tests and evaluation it was concluded that the Quilter type would be suitable for live descents.

However, after an incident involving parachute lines becoming entangled it was deduced that the aircraft must be throttled down to 90 miles per hour to avoid fouling the parachute on the tail wheel which had been caused by the slipstream of the engine. [24] The C.L.S. not only had to train parachutists but also had to deduce the operating procedure for all aspects of parachute operations which included the flying technique of numerous aircraft types to ascertain maximum tactical and operational effectiveness.

[21] T.N.A., AIR 29/512, C.L.S. Ringway, 21 July 1940.

[22] In 1932 Raymond Quilter formed the G.Q. Parachute Company at Woking, Surrey. During the war he was Chairman of the parachute panel of the Airborne Forces Committee.

[23] T.N.A., AIR 29/512, C.L.S. Ringway, 30 July 1940.

[24] Air Ministry, *The Second World War 1939-1945, Royal Air Force, Airborne Forces*, pp. 20-22.

Despite approval for the staffing claim from C.L.S. personnel the Chief Ground Instructor was unable to proceed with further live drops from the Whitley until permission had been received from either the Director of Combined Operations or the Air Ministry (A.M.). In the interim a Bristol Bombay [25] aircraft was acquired from No. 271 Squadron on 6 August and 22 successful live descents were made on the evening of 13 August. In fact Keyes had championed the use of the Bombay in his note to Churchill on 27 July in preference to the Whitley:

> I was informed at the Air Ministry yesterday that the possibility of allocating some Bombays will be considered, but it will be some time before these are available, owing to a shortage of engines. [26]

The irony of the situation was that the D.C.O. was actually advocating the utilisation of a technology even more obsolete than the Whitley aircraft he wished it to replace. On 8 August the Air Ministry notified the C.L.S. that all Army trainees should pack their own parachutes but the approval for live descents to recommence from the Whitley was not discussed until 11 August. [27]

On 14 August live descents were resumed and research was begun at R.A.F. Henlow into the feasibility of making further modifications to the Whitley fuselage for parachute jumps. The first trials with a modified Whitley were undertaken at Ringway on 20 August but the rail-shutes for static-line attachment were found unsuitable and required further modification. [28] The instigation of modifications directly by the C.L.S. later caused

[25] The Bristol Bombay was a hybrid bomber/transport type that was started in 1931 but due delay in development it was effectively obsolete by the time it entered R.A.F. Service in 1939.
[26] T.N.A., CAB 120/262, Minute to Churchill, by Admiral Keyes, 27 July 1940.
[27] T.N.A., AIR 29/512, C.L.S. Ringway, 8 August 1940.
[28] T.N.A., AIR 29/512, C.L.S. Ringway, 20 August 1940.

concern at both the Air Ministry and M.A.P. and resulted in the formalisation of the technical development process.

Improvements in parachute stability were also being investigated at the Air Defence Research Establishment during this period by the aeronautical engineer, William Jolly Duncan. Duncan's main contribution was the application of scientific theory to the phenomenon of 'squidding' whereby the open rim of the parachute collapsed inwards 'without becoming completely deflated'. [29] This resulted in reduced drag and high speed landings that were completely unsuited to airborne operations.

Duncan subsequently contributed more widely to airborne forces development when he became Head of the Flight and Airborne Section at the Royal Aircraft Establishment in 1942. Although the section had a varied research programme it was tasked to assist in research into 'gliders and army assault problems in general.' [30] Civilian scientific support for the airborne forces contributed throughout the development process.

On 26 August 1940 99 live descents were undertaken. However, on the 27 August a second fatal accident occurred at Tatton Park when Trooper Watts' parachute failed to open after withdrawal from the container. Mr Quilter was called to investigate the cause of the accident and after analysis it was decided to make alterations in the method by which the parachute was secured inside the container. [31] Consequently, a message was received from the A.M. suspending use of the 'Q' type parachute but was superseded on 30 August by a signal authorising use once modifications had been carried out. The same day two Whitley aircraft were despatched from Ringway to Brooklands with 150 parachutes for necessary

[29] E.F. Relf, 'William Jolly Duncan 1894-1960', *Biographical Memoirs of Fellows of the Royal Society*, Vol. 7, 1961, pp. 37-51, p. 45.

[30] Ibid.

[31] T.N.A., AIR 29/512, C.L.S. Ringway, 22 August 1940.

modification and by the end of the first week of September training had resumed with some 123 live descents recorded. By the end of September 1940 975 live descents had been achieved since the creation of the C.L.S. [32]

Despite progress technical issues continued to plague the training programme. On 27 September another incident occurred whereby a parachute caught on the tail wheel of a Whitley during a dummy drop and resulted in an investigation into the feasibility of fitting a shield or fairing. This modification was carried out by the Development Squadron which was successfully tested at Ringway on 16 November and an instruction was issued that all Whitley aircraft were to be fitted with the arrangement. The reliability of the training aircraft also remained a hindrance as on 2 October, upon receipt of jacks for the inspection of aircraft undercarriages, certain fittings were found to be fractured rendering all Whitley aircraft temporarily unserviceable. However, continued technical development did not prevent a third fatal accident which occurred on 19 November 1940 when Corporal Carter's parachute failed to open due to the static-line becoming disconnected from the chute-rail. [33]

Research into the production of a standard methodology for parachute procedure was not only confined to technological development and the application of custom manufactured apparatus. A significant contribution was also required from R.A.F. Medical Officers to ensure that procedures were carried out as safely and effectively as possible. Air Marshal Whittingham, Director-General of Medical Services, made the following observations concerning medical officer involvement which were published in *The British Medical Journal* in 1946:

> Duties were to advise on parachuting from a medical aspect, and, for this purpose, to make liaison with Army Airborne Forces and the R.A.F. Institute

[32] T.N.A., AIR 29/512, C.L.S. Ringway, 30 September 1940.

[33] T.N.A., AIR 29/512, C.L.S. Ringway, 19 November 1940.

of Aviation Medicine. Researches he [Medical Officers] undertook show that liability to injury on landing by parachute varies with age, weight, force of wind, and type of terrain. Statistics revealed that injuries were more frequent in those over 25 years of age than in younger persons; that the injury rate rose rapidly in those over 12 stone in weight, and the stronger the wind the greater was the risk of injury from wrong stance on landing. [34]

Unsurprisingly, the commonest parts of the body to be injured during training jumps were the legs, which accounted for 64% of all recorded accidents. Whittingham claimed that ‘the incidence of injuries during training was initially 4% of jumps, but subsequent to improved attachment of parachute harness and landing stance, it was reduced to 0.5% of jumps. The application of scientific analysis not only helped determine the most effective method of jumping but also ensured that only those physically suited to parachuting were selected.

Meanwhile, following a visit by Group Captain Bowman, Deputy Director Combined Operations (Air), notification was received from No. 22 Group [35] that a Glider Section would also be established at Ringway on 8 August. [36] The decision to form the glider section undoubtedly originated from an Air Staff note dated 12 August, author unknown, sent to Ismay regarding the potential strategic advantages of the assault glider. [37]

The report suggested that although German parachute forces had been successful in the Low Countries it may well have been the last time that such troops were deployed ‘on a

[34] H.E. Whittingham, ‘Progress of Aviation Medicine in the Royal Air Force and its Application to the Problems of Civil Aviation’, *The British Medical Journal*, Vol. 2, No. 4462, 13 June 1946, pp. 39-45, p. 43.

[35] No.22 Group R.A.F. became Army Co-operation Command on 1 December 1940.

[36] T.N.A. AIR 29/512, C.L.S. Ringway, 8 August 1940.

[37] T.N.A., AIR 120/262, Note to Ismay on Assault Gliders, Author Unknown, 12 August 1940.

serious scale in major operations.' [38] It would appear that the vulnerability of parachutists had been recognised by the Air Ministry, particularly once the element of tactical surprise had been compromised:

> We are beginning to incline to the view that dropping troops from the air by parachute is a clumsy and obsolescent method and that there are far more important possibilities in gliders. The Germans made excellent use of their parachute troops in the Low Countries by exploiting surprise, and by virtue of the fact that they had practically no opposition. But it seems to us at least possible that this may be the last time that parachute troops are used on a serious scale in a major operation. [39]

The Air Ministry believed that the glider could be an alternative method of deployment for airborne troops in either an air-landed or parachute capacity and had the potential to be more efficient and effective than parachutists dropped from transport aircraft:

> We are pressing ahead with the development of gliders, and have made good progress. The glider has all sorts of possibilities other than the carriage of troops, such as for increasing the endurance of heavy aircraft by refuelling in the air. [40]

Churchill was suspicious of the strategy after being previously informed that only 500 parachutists, some 10% of his initial request, had been selected for training. The Prime Minister responded that if gliders were considered a better capability than parachutists then the scheme should be seriously considered but he also expressed doubts that the pursuit of

[38] T.N.A., AIR 20/2829, 4 December 1940.

[39] T.N.A., CAB 120/262, Note to Ismay on Assault Gliders, Author Unknown, 12 August 1940.

[40] Ibid.

such experimental technology might have been detrimental to one that had already been proven. [41]

The Assault Glider

The concept of the assault glider was pioneered in Germany as a direct result of the restrictions imposed by the Versailles Treaty. The desire to beat the restrictions became an obsession that, to observers throughout the world, had simply manifested itself in the apparently innocuous past-time of sport gliding. [42] Many frustrated former pilots from the Imperial Germany Army Air Services of the Great War, the *Luftstreitkrafte*, embraced gliding as the only way to beat the ban and the glider became much more than a symbol of defiance when, during the 1920s, its potential future technological application as a military weapon was recognised*.* [43] Andrew Barros has argued that the *Rhön* glider competition was a valuable testing ground:

> It proved to be a critical laboratory for German aeronautical engineers and provided important lessons in aerodynamics, structural design, single long-span wings, thermodynamics and meteorology. A diverse and skilled group of aviation enthusiasts including Willy Messerschmitt and Kurt Student, then *Reichswehr* Captain (and later commander of German airborne troops), made a virtue out of the necessity imposed by the control regime. [44]

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[41] Otway, *Airborne Forces*, p. 22.

[42] P. Fritzsche, 'Machine Dreams: Airmindedness and the Reinvention of Germany', *The American Historical Review*, Vol. 98, No. 3, 1993, pp. 685-709.

[43] A.H.C.O., Enemy Airborne Forces, 2 December 1942.

[44] A. Barros, 'Razing Babel and the Problems of Constructing Peace: France, Great Britain, and Air Power, 1916-28', *The English Historical Review*, Vol. 126, No. 518, 2011, pp. 75-115, p. 88.

Subsequently the *Deutsche Forschungsanstalt fur Segelflug (D.F.S.),* the German Institute for Gliding, conducted exploratory military research for the German aero industry that included the development of the D.F.S. 230 military glider which was based upon a sailplane that had been originally designed for high altitude meteorological research. [45]

However, it was not only the German government which recognised that the existence of organised national gliding and soaring clubs had potential military benefits during the inter-war period. The British also acknowledged the importance of air-mindedness and offered financial incentives to cadets to complete their basic gliding qualifications. Although this was conducted on a much smaller scale in Britain than in Germany it does illustrate the fact that gliding was considered an important aspect of initial military pilot training. [46]

The D.F.S. 230 was principally designed to alleviate the fundamental deficiency of the limited carrying capacity of parachutists during the descent to a target. The German *Fallschirmjager* were dependent upon weapons containers that were dropped into action simultaneously, and this was one of the very first technical investigations undertaken by C.L.E. [47] Locating the weapons containers for essential supplies such as ammunition had to be undertaken before parachute forces could move off the drop zone and onto their objective. As a result of these restrictions the Germans realised that another method was required for the delivery of heavier weapons and supplies in support of parachutist forces if the airborne units were to become tactically and operationally effective.

A 1943 article in *Flight Magazine* on the British Horsa Glider summarized the relationship between glider-borne infantry and parachutists in the airborne context:

[45] Ibid.

[46] 'Gliding', *Picture Post*, 9 December 1939, pp. 24-27, p. 26.

[47] T.N.A., AIR 29/512, C.L.E. Ringway,, 10 December 1940

> From a purely military point of view the main function of a glider is, of course, the carrying of troops, the glider having certain advantages compared with the dropping of troops by individual parachutes. It is not that one takes the place of the other, but rather that they are complementary. The glider can be cut adrift from its tug and, if it is cast off at a substantial height, it can cover quite a respectable distance under perfect control, and in almost complete silence, and can land on almost any field, irrespective of size and surface conditions. [48]

It was this requirement that facilitated the concept and development of the assault glider as a weapon of modern warfare. The D.F.S. 230 was capable of carrying a variety of cargo or ten fully armed troops, including two pilots who were seated in tandem, and was towed by another aircraft to within range of its target. [49] The D.F.S. 230 secretly entered full scale production during 1937 which allowed nearly two years for the perfection of the assault glider technique before the outbreak of the Second World War. The British on the other hand had to effectively start development from scratch.

The Operation Records Book of the C.L.E. confirms the scale of development required. On 3 August notification was received that the glider flight comprised two Westland Wallace aircraft for the purpose of towing but delivery of these aircraft was later cancelled on 13 August. When it did arrive it consisted of an obsolete Avro 504 glider tug, 2 corporals, 3 Aircraftsmen and a civilian glider towed by a Fordson car. [50]

On 8 August the C.L.S. was informed that under orders of the Director of Combined Operations the object of the Glider Flight was to produce glider carrying aircraft. Wing

[48] 'Airspeed Horsa', *Flight Magazine*, 15 July 1943, pp. 64-67, p. 64.
[49] P. Harclerode, *Wings of War* (London, 2005), p. 38.
[50] T.N.A., AIR 29/512, C.L.S. Ringway, 3 August 1940.

Commander Buxton assumed command of all necessary experimentation and on 14 August No.22 Group confirmed that all Glider Flight personnel were to be posted to C.L.S. [51] for the formulation of an Experimental Glider Section. [52]

The primary obstacle to the development of glider-borne warfare, as with parachute operations, remained the availability of suitable aircraft. Although conversion of existing types for the role of parachute aircraft and glider tugs was not technically difficult it presented numerous engineering challenges. [53] Greenacre rightly identifies that any modification required significant resources and that 'apparently minor alterations took up a disproportionate amount of time and effort and many were required before a bomber could be used to drop parachutists.' [54] The effort involved in the modification of an aircraft for glider towing was even greater, particularly as larger gliders were produced, and this will be discussed in detail in following chapters. However, development also required specialist personnel and such expertise was not easily procured.

M. A. P. and the Treasury

The Ministry of Aircraft Production (M.A.P.) was created on 17 May 1940 to relieve the Air Ministry of responsibility for the procurement of aircraft and equipment. [55] Consequently, M.A.P. assumed responsibility for the development of the C.L.S. and the acquisition of additional specialist staff and resources to enable the new establishment to function and for technological investigation to proceed. Before recruitment to certain positions M.A.P. had to request permission for additional resources from the Treasury to ensure that the necessary finances were available.

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[51] 31 August 1940 C.L.E. was transferred to No. 22 (Training) Group R.A.F.

[52] T.N.A., AIR 29/512, C.L.S. Ringway, 14 August 1940.

[53] Otway, *Airborne Forces*, p. 24.

[54] Greenacre, *Churchill's Spearhead,* p. 69.

[55] Scott & R. Hughes, *Administration of War Production*, pp. 291-292.

The first such application for additional resources was sent on 5 September 1940 from M.A.P. to the Treasury Chambers. [56] Despite the economic situation and the limitations upon specialist resources M.A.P. submitted 'an urgent demand for some development staff in connection with Gliders, Parachutes and Rotachutes.' [57] The request was for six specialist technical staff with a guarantee that the posts would 'only be filled in so far as men of the required specialist qualifications' could be found. [58] Although the men were to be employed at Ringway they were to be regarded as on the strength of the Royal Aircraft Establishment, Farnborough, for payroll purpose. The administration of specialist personnel required close collaboration between the C.L.S., M.A.P. and the Royal Aircraft Establishment (R.A.E.).

The urgency for personnel meant that M.A.P. officials did not always follow Treasury recruitment protocol and approval was retrospectively sought after appointments had already been made. As Scott & Hughes pointed out:

> It was Lord Beaverbrook's practice simply to notify the Parliamentary Secretary of his wishes in regard to new appointments and promotions in the higher ranks of the Ministry, and also in regard to the salaries to be paid. [59]

This was the case in regard to the recruitment of Mr W.S. Shackleton, the proprietor of a specialist aviation engineering consultancy, [60] 'for special work in connection with gliders and specialist landing devices.' [61]

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[56] T.N.A., T 162/755, Ministry of Aircraft Production: A.F.E.E. Development Staff, Request for Development Staff, by R.A. Grieve, 5 September 1940.

[57] Ibid.

[58] Ibid.

[59] Scott & Hughes, *Administration of War Production*, p. 314.

[60] 'Classified Advertisements', *Flight Magazine*, 20 June 1940, p. 26.

[61] T.N.A., T 162/755, Request to Recruit W.S. Shackleton, by R.A. Grieve, 11 October 1940.

M.A.P. considered Mr Shackleton to be ‘a man of much distinction – of the £2000 a year class in the Aircraft Industry,’ [62] but it was unable to secure his services full-time and consequently negotiated a fee of eighty guineas a month on the basis of 22 days’ work. The Treasury approved the procurement of Mr Shackleton’s services on 31 October but mistakenly assumed that he would be appointed to the position of Principal Technical Officer (P.T.O.) as detailed in the correspondence of 5 September. Consequently, the following M.A.P. response regarding Mr Shackleton’s duties was received at the Treasury on 8 November:

> The duties which Mr Shackleton will carry out are of a somewhat different order. It is anticipated that at least five firms will be engaged on the design of various prototypes of gliders in view of the considerable expansion which is taking place in this direction. Moreover production of an approved type is beginning shortly and will be in the hands of woodworking firms hitherto outside the aircraft industry. [63]

It was certainly not made clear that Mr Shackleton was considered an additional appointment above the posts previously authorised but M.A.P. continued to argue its position and made a clear distinction between the need for contractual management and technological development:

> Clearly it will be essential to have available a man of wide experience capable of dealing with the numerous problems arising in such a situation and of sufficient authority to meet the firms’ designers and the senior serving officers concerned on level terms. It is for these duties of a technical supervisory that we purpose using Mr Shackleton’s services but

[62] Ibid.

[63] T.N.A., T 162/755, Letter Explaining Shackleton’s Duties, by R.A. Grieve, 6 November 1940.

> as these will not be available in a full time capacity we desire to use him as a consultant – not in a specific post. [64]

The Treasury agreed on 11 November 1940 to the terms of Shackleton's appointment in addition to the six posts previously sanctioned but requested that M.A.P. reported on the progress on the situation in two months' time. [65] However, a summary of the work in which Shackleton was engaged was not submitted to the Treasury until December 1941 when work was sufficiently progressed to enable Shackleton 'to hand over his duties to the technical staff responsible.' [66]

Despite the late report on progress, M.A.P. warned that it might have to utilise Shackleton's services in a consultancy capacity in the future at additional cost. Further extracts from the correspondence between M.A.P. and the Treasury will feature throughout the main body of the research but it is important to remember that technological progression was dependent upon the close co-operation of a variety of governmental departments and the availability of the technical specialists required. The growing demands of the technological research programme consequently required restructuring to accommodate additional research responsibilities.

Central Landing Establishment

Following the increased scope of research work it was decided that a new organisation should be formed that would be responsible for all aspects of airborne forces, training and technological development. Ultimately the parachute commitment was severely curtailed and the technological emphasis was focused upon the development of glider-borne troops and

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[64] Ibid.

[65] T.N.A., T 162/755, Letter from Treasury to M.A.P., by J.B.L. Munro, 11 November 1940.

[66] T.N.A., T 162/755, Letter from M.A.P. to Treasury, by R.N. Bradley, 31 December 1941.

their associated equipment. [67] At a conference held at Ringway on 12 September 1940 between C.L.S. and No.22 Group personnel it was decided that the future technical programme would be most efficiently conducted through the creation of a Central Landing Establishment (C.L.E.). The Establishment would amalgamate the existing Central Landing School and Glider Flight but also include a dedicated Technical Development Unit. [68]

Consequently, on 18 September 1940, Squadron Leader Strange was tasked to form the Central Landing Establishment with Group Captain Harvey retaining command of the C.L.S. and this was completed the following day. [69] On 1 October 1940 the Central Landing School Headquarters was officially formed and it was decided that the C.L.S. and Glider Flight should operate as independent, but intrinsically linked units, within the Establishment (See Appendix 3).

Despite the use of obsolete equipment the Station regularly conducted demonstrations of the developing new technology for high profile visitors. On 26 September 1940 His Royal Highness the Duke of Kent observed a demonstration of the assault glider technique accompanied by live parachute descents on the aerodrome. The royal demonstration was followed on 4 October by an inspection by Anthony Eden. [70] Eden's visit was conducted 4 months after his exchange with Mr Garro-Jones in the House of Commons on the government's failure to investigate the potential for airborne warfare [71] and although the infrastructure for research had been implemented, the technology required further extensive development and resource.

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[67] Air Ministry, *The Second World War 1939-1945, Royal Air Force, Airborne Forces*, pp. 22-23.

[68] Otway, *Airborne Forces*, p. 30.

[69] T.N.A., AIR 29/512, C.L.S. Ringway, 18 September 1940.

[70] T.N.A., AIR 29/512, C.L.S. Ringway, 4 October 1940.

[71] Hansard Parliamentary Debates, House of Commons, Vol. 361, cc, 750-1 750, 4 June 1940.

Following the creation of the C.L.E. the glider training programme progressed rapidly and on 16 October R.A.F. Ratcliffe and R.A.F. Rearsby aerodromes in Leicestershire were allocated to C.L.E. for the utilisation of the Glider Training Squadron. On the 26 October the Glider Training Squadron (G.T.S.) conducted its first operational exercise near Macclesfield in which two gliders landed in small fields adjoining a railway viaduct, the supposed objective. [72]

Despite an ambitious training programme the unit was still awaiting a purpose manufactured assault glider and consequently civilian gliders had to be acquired as an interim arrangement. On 28 October 1940 Flying Officer Davie departed Ringway tasked with the examination of civilian gliders for impressment into service with the G.T.S. During the period of detachment Davie was temporarily attached to No.41 (Maintenance) Group Headquarters which had previously compiled a list of gliders in civilian ownership throughout the country that required inspection pending possible selection for use with the Glider Training Squadron and the associated Development Unit. [73]

Development Unit

On 22 October 1940 Establishment No. WAR/AC/116A was received from the War Office formally approving the creation of the Development Unit (D.U.) [74] (See Appendix 4) Previously the O.R.B. had been dedicated to the activities of the Central Landing School but on formation of the C.L.E. the document was sub-divided to incorporate the individual sections and for the purpose of the following discussion the focus will be primarily based upon the technological development of the D.U. but will continue to reference other sections of Establishment activity as appropriate.

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[72] T.N.A., AIR 29/513, A.F.E.E. Operations Records Book Appendices 1940-1942, 26 October 1940.
[73] T.N.A., AIR 29/512, D.U. Ringway, 28 October 1940.
[74] Ibid.

On 2 November Wing Commander Buxton assumed command of the Development Unit and Flight Lieutenant Williams, Flying Officer Davie and Flying Officer Kronfeld reported for duty the same day, the last of which deserves some special attention. He was a much respected German-born Jewish champion glider pilot and aircraft designer. Kronfeld was the first glider pilot to fly over the Alps, cross the British Channel and achieve an altitude 2,500 metres in a glider. However, in 1933 the Nazi Party banned all Jews from flying and Kronfeld moved to Austria to continue his passion before finally relocating to England in 1938 where he became a British citizen the following year. [75] Upon the outbreak of the Second World War Kronfeld joined the R.A.F. and was recorded on 3 October 1940 as a Pilot Officer on probation in the *London Gazette* [76] before he was posted to the D.U. where he remained on military glider development for the duration of the war.

Development work began almost immediately and it was recorded in the D.U. Operation Records Book on 7 November that a tail trimming device had been fitted to a Minimoa glider [77] to add stability. [78] This was presumably one of the civilian gliders impressed into service by the Glider Training Squadron. [79] However, there is evidence to suggest that despite progress the fundamental strategic parameters of research and development required for the production of a British airborne capability remained undefined.

In the meantime, Group Captain Harvey attempted to evaluate the envisaged functions of an airborne force in a document produced at Ringway on 31 October 1940 for the Air Staff. Harvey's attempt at producing some form of strategic function and

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[75] W. Laqueur, *Generation Exodus: The Fate of Young Jewish Refugees from Nazi Germany* (London, 2004), p. 74.

[76] 'General Duties Branch', *London Gazette*, 5 November 1940, Issue 34986, p. 6402.

[77] The Minimoa was actually a German sailplane manufactured by Göppingen and first flown in 1935. It would appear that the British were utilising both the German doctrine, professional expertise and selected hardware in the development of their own airborne capability.

[78] T.N.A., AIR 29/512, D.U. Ringway, 7 November 1940.

[79] T.N.A., AIR 29/512, 28 October 1940.

corresponding developmental requirements was one of the first official policy documents produced for the fledgling British airborne capability:

> The development of very large air forces has made it possible for theatres of war to be changed almost overnight, particularly when air superiority enables the landing of airborne and seaborne troops. It is necessary therefore to consider to what extent a highly trained striking force, capable of being airborne, could influence operations within 500 miles from an air base. [80]

The appreciation of the strategic situation and scope of investigation was entirely accurate and it was also recognised from the outset that if Germany possessed such a force as described above this had serious implications upon the British army:

> Large numbers of our own troops are more or less immobilized in areas which may not be entirely favourable to our plans for this reason on this account. It has been stated that as many as 14 Divisions are employed on the guarding of vulnerable points largely because of the fear of attack in which airborne troops might be engaged. [81]

Harvey concluded that there were six potential functions that could be undertaken by airborne forces:

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[80] T.N.A., AIR 32/2, Airborne Forces, by Group Captain Harvey, 31 October 1940.
[81] Ibid.

- Immobilisation of large numbers of enemy troops ‘in dispositions unfavourable to their strategy.’ [82]

- Form the spearhead for offensive action with a range of 500 miles from a suitable airfield.

- Operate as a self-contained force for small localised action capable of being supplied by air.

- Utilised for ‘planting’ of saboteurs, agents and other irregular troops in enemy territories.

- Be utilised for air transport for towed gliders containing personnel, rations and equipment. The perceived advantage being that such a method of delivery would greatly supplement the scope of usefulness of operational bomber aircraft.

- The ‘bringing into the war effort to a greater extent the woodworking trade’ [83] which could undertake the building of gliders.

The potential functions were all feasible but required extensive technological investment and formalisation into a doctrine in which the efforts of all stakeholders could be focused to achieve maximum efficiency. At the time of writing Harvey believed that 500 fully trained parachute troops could be available by March 1941; ‘1,000 lightly equipped’ glider-borne troops could be ready by September 1941, and an airborne force exceeding 3,000 could be made available ‘by concentrated effort’ in May 1942. [84]

[82] Ibid.

[83] Ibid.

[84] Ibid.

Harvey's report closed with a summary of the immediate decisions required if an airborne capability was to be made a reality. These included clarification of whether the aspiration was really going to be taken seriously, and if so, given the length of time required for training, was this to be available. Clarification was also sought as to whether a relatively small-scale development programme was required in the short term that could be expanded upon in the future if necessary. Such fundamental questions by the Commanding Officer of the C.L.E. suggests that very little policy development had taken place beyond Churchill's initial minute calling for 5,000 parachute troops. [85] It is also interesting to note that there was no formal response produced by either the Air Ministry or War Office to Harvey's document. The lack of clarity in both doctrine and concept remained prevalent throughout the entire research and development programme as will be evidenced from the variety of technological investigations undertaken.

Despite the obvious deficiency in strategic policy, the D.U. soon began to address some of the fundamental technological challenges associated with the technique of glider towing and on 14 November 1940 a Cable Angle indicator had been designed and was undergoing tests. The importance of the design and development of this particular instrument to the military effectiveness of glider forces will be discussed in detail later.

Indeed, the work of the D.U. was a strange mixture of obsolescent machinery, as witnessed in the utilisation of redundant aircraft as tugs, and innovative technology. A pertinent example of such technology was the design and development of the Rotachute. The concept was for a one-man rotating wing parachute suitable for launching from aircraft that would give the paratroop the following advantage:

[85] T.N.A., CAB, 120/262, Airborne Forces: Minute to War Cabinet, by Winston Churchill, 22 June 1940.

> It was hoped that this type of parachute could be made steerable so that a more accurate approach to a particular spot on the ground could be made. It would have the further advantage of relieving the great demand on silk or similar material required for the conventional parachute. [86]

On 5 November 1940 it was recorded that a model Rotachute was launched successfully from a Tiger Moth aircraft and by the 11 November a full scale model weighting 300 lbs. had been assembled awaiting balloon test. [87] By 17 November 1940 general arrangement drawings had been completed for the manufacture of the Rotachute R.O.1. and more detailed drawings for components of a 10 foot Rotachute model were ready at the close of the month. [88] Early in 1941 Mr Grinstead, Deputy Director Research & Development Technical (D.D.R.D.T.) at M.A.P. had visited the A.R. III Construction Co., an independent specialist contractor, and the latter was subsequently tasked with the manufacture and development of the Rotachute. [89]

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The general development of practical solutions to the problems encountered during paratrooping and glider towing remained the main responsibility of the unit and it was involved in a wide variety of research and experimentation in order to make deployment as efficient, safe and effective as possible. [90] Accidents remained a constant threat to the development programme and following the fatal incident on 19 November 1940 involving Corporal Carter a modified strop-hook was designed and issued to all paratroops (drawing

[86] T.N.A., AVIA 21/247, Work of the Airborne Forces Experimental Establishment 1940-1945, by W.G. Jennings, 31 December 1949.
[87] T.N.A., AIR 29/512, D.U. Ringway, 5-11 November 1940.
[88] T.N.A., AIR 29/512, D.U. Ringway, 17-30 November 1940.
[89] T.N.A., AIR 29/512, D.U. Ringway, 21 February 1941.
[90] Otway, *Airborne Forces*, pp. 30-31.

C.L.E. 2) on 27 November to prevent the recurrence of the static-line not being connected properly to an aircraft fuselage. [91]

A rapid research and design response to any technical problem encountered was crucial to minimise the potential for delay and allow training to commence with limited disruption. The method of deploying paratroops underwent constant refinement and further modifications were undertaken on 20 November to three Whitley aircraft that were fitted with tail wheel spats. Whitley K.7220 was also fitted with doors to close over static-line attachments to prevent premature detachment or interference. [92]

On 1 December 1940 the Development Unit was transferred from No. 22 Group to No. 70 Group, Army Co-operation Group, thus further reinforcing the diverse stakeholder relationship. Modification and conversion of a further 3 Whitley aircraft fitted with doors for closing over static-lines continued and on 10 December a system for dropping containers for service use from the bomb-bay of Whitley V aircraft was devised in conjunction with Armstrong Whitworth. [93] Close liaison with manufacturers was crucial to ensure the quick production of parts or modification to airframes for particular procedures not previously envisaged and on 17 December the D.U. completed a joint design project with Hawker Aircraft Co. in the manufacture of quick release mechanisms for glider tow ropes.

In addition to the heavy development commitment the unit was also responsible for supporting its parent Establishment in preparation for exercises. On 12 December orders for an operational exercise were issued notifying the C.L.E. that they were required to take part 'employing troops transported by air and landed by parachutes and gliders.' [94] The exercise

[91] T.N.A., AIR 29/513, A.F.E.E. O.R.B. Appendices 1940-1942, 19 November 1940.
[92] T.N.A., AIR 29/512, D.U. Ringway, 20 November 1940.
[93] T.N.A., AIR 29/512, D.U. Ringway, 10 December 1940.
[94] T.N.A., AIR 29/513, 12 December 1940.

took place the following day at Tatton Park and was witnessed by the Chief of the Imperial General Staff, General Dill. As interest by senior military officers and government officials in the work of the C.L.E. intensified the Establishment began to further expand to meet increased training requirements.

On 30 December 1940 a movement order was issued with the intention of relocating a detachment of the Glider Training Squadron to R.A.F. Haddenham, near Thame in Buckinghamshire, where it was to 'undertake the training of glider pilot instructors in accordance with a syllabus which will follow. Special instruction in regard to aircraft and glider flying will be issued.' [95] The Temporary Headquarters was located at Yolsum House, Haddenham, under the Command of Squadron Leader Hervey and the relocation commenced between 31 December 1940 and 1 January 1941.

Although the technical development, along with the supporting infrastructure, was proceeding Otway concedes that there was still a lack of clear policy with regard to the airborne concept and consequent direction of the research programme:

> There was no clear idea as to how airborne forces would fit into the developing picture and therefore how they should be organized. Throughout 1940, and most of 1941, ideas on their employment were by no means definite and were not agreed either in principle or in detail by the two main organizations – the War Office and the Air Ministry. [96]

Such ambiguity does not suggest such forces were a strategic military priority and reaffirms the theory that airborne forces were more the result of the personal ambition of the Prime Minister in his capacity of Minister of Defence than the demands of the military establishment. Consequently, development had commenced without clear research

[95] T.N.A., AIR 29/513, A.F.E.E. O.R.B. Appendices 1940-1942, 30 December 1940.

[96] Otway, *Airborne Forces*, p. 25.

parameters which resulted in the design of glider aircraft that required tugs that were not then available and glider-borne troops that had yet to be identified. Yet, despite the confusion the British pressed ahead with operational planning in full knowledge of the strategic, tactical and operational limitations then apparent.

Operation Colossus

Before any further study of the Development Unit is undertaken attention must briefly turned to the parachute element of the airborne forces. On 10 February 1941 the technological investment in, and training of, these forces were applied operationally in the first British airborne operation of World War Two, codenamed Operation Colossus. The objective of the mission was primarily the destruction of the Tragino Aqueduct in southern Italy. [97] The operation itself involved only a small force of British parachutists and although the target was of dubious strategic military importance the mission had two specific objectives.

Firstly, the operation was designed to lower the morale of the Italian civilian population by demonstrating that Italian home soil was not invulnerable to allied offensive action. Secondly, and more importantly, the operation was instigated to raise the morale of the British paratroopers under instruction at the Central Landing School, Ringway. Lack of aircraft and strategic direction meant that the initial intake of trainees qualified long before any actual operations had been conceived. By February 1941, following intensive training, the parachute Commandos of No.11 S.A.S. Battalion had thus become restless and eager for offensive action. Indeed, the issue of morale amongst airborne forces remained a significant concern for allied commanders throughout the war, particularly as the

[97] Harclerode, *Wings of War*, pp. 199-201.

opportunities for the deployment of airborne troops became increasingly infrequent from D-Day onwards. [98]

Fifty men, codenamed 'Force X', under the command of Major Pritchard of the Royal Welch Fusiliers, were assembled for the operation. Force X, which included a Royal Engineers demolition party and Italian interpreters, all underwent intensive, if not hurried, training for the operation using a mock-up of the aqueduct which had been erected at Tatton Park. The accuracy of the training programme can be attributed to the fact that the British military authorities possessed detailed plans of the Tragino aqueduct which had been passed onto them by a London-based firm of engineers who had been responsible for its design. [99] Although the model of the area constructed at Ringway proved valuable, the importance of accurate intelligence was highlighted as one of the most important lessons learnt from the operation when it was found that the target area contained two aqueducts rather than one. [100]

By 7 February the training was complete and Pritchard and his men emplaned in eight Armstrong Whitworth Whitley bombers at R.A.F. Mildenhall in Suffolk to commence a flight of nearly 1,000 miles to Malta. Force X arrived on 9 February where six of the Whitleys were loaded with weapons containers for the forthcoming operation whilst the other two aircraft were equipped with full bomb loads in order to facilitate a diversionary attack upon the railway marshalling yards at Foggia. Incidentally, a further eight Whitley bomber aircraft required modification to the airborne role before the operation was deemed logistically possible. [101]

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[98] J. Bassett, 'Past Airborne Employment', *Military Affairs*, Vol. 12, No. 4, 1948, pp. 206-216, p. 208.

[99] Ibid.

[100] Air Ministry, *The Second World War 1939-1945, Royal Air Force, Airborne Forces*, p. 28.

[101] T.N.A., CAB 106/6, Account of Operation Colossus, Combined Operations Raid in Italy, by Lieutenant A.J. Dean Drummond, 1942.

On 10 February the eight Whitleys left Malta on course for Italy. The drop zone was located close to the snow-capped Monte Vulture and somewhat down the mountain side in cultivated farmland. [102] The R.A.F. was tasked with the safe delivery of the airborne force to the drop zone but, once the parachutists had alighted from the aircraft, their responsibility ended and the airborne force was on its own. Once the objective was successfully neutralized the parachutists faced the most difficult part of any airborne operation: extraction.

After Force X had succeeded in destroying their target they were required to withdraw on foot towards the mouth of the Sele River. An ambitious rendezvous had been organised for the evening of 15/16 February with the submarine HMS *Triumph* which would return the airborne troops to the United Kingdom. Five of the six Whitleys dropped their sticks of parachutists on target from where the airborne forces eventually retrieved their weapons and explosives from the parachute containers simultaneously dropped from the aircraft. The sappers made their way to the aqueduct encountering no opposition and laid the explosive charges and the structure was successfully breached.[103]

Despite achieving total surprise and the successful destruction of the objective none of the fifty parachutists managed to make the rendezvous with HMS *Triumph* and most of the force was captured on the morning of 12 February, spending the rest of the war in captivity until the Italian surrender in September 1943. Anthony Deane-Drummond successfully escaped captivity but recalled his reaction upon learning of the extraction method in his memoirs:

[102] Ibid.

[103] Bassett, 'Past Airborne Employment', p. 208.

> I may say although the blowing up of the bridge had been practised and rehearsed to the minutest detail, the actual orders for getting to the coast were necessarily vague. [104]

The problem of successfully extracting airborne troops after they have achieved their primary objectives remained one of the most significant operational challenges throughout the war. Despite dedicated research and development the technology was not capable of ensuring self-sufficiency.

Indeed, when news of Operation Colossus was reported in the British press *The Times* suggested that escape was impossible and ascribed a form of media martyrdom to those parachutists involved:

> The landing of British parachutists in a lonely part of south Italy, on the borders of the provinces of Lucania and Calabria, has caused great surprise in Italy at the daring of the whole enterprise and at the high spirit of sacrifice on the part of those engaged; for as far as one can guess escape is virtually impossible unless the object of the operation, which the Italians suggest to have been sabotage, was achieved quickly and the parachutists were taken quickly off. [105]

Although it is clear that the journals had no clue as to the method of evacuation allocated to the parachutists involved in Operation Colossus one cannot blame the correspondent for failing to comprehend how the force could possibly be retrieved once it had achieved its objective.

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[104] Deane-Drummond, *Return Ticket,* p. 22.

[105] 'Parachute Raid on Italy', *The Times*, 17 February 1941, p. 4.

The operation had a limited strategic value. But it did provide the British with valuable information from an O.R. perspective that shaped future technological development. Aside from the obvious problems of extraction the method of dropping containers independently of the parachutists was scrutinised, particularly in terms of the delay between the parachutist landing and locating weapons. [106] Consequently, research and development into improving the carrying capacity of parachutes became a primary activity throughout the remainder of the war. One particular direct technological improvement was the incorporation of longer lift-webs into the design of X Type parachute. [107] Lift-webs were first introduced to aircrew Irvin parachutes in the 1920s as described in a contemporary article:

> When near the ground and preparing for a landing, a sitting position in the harness is retained, but with the knees lower than the hips and muscles relaxed. Lift webs over the head are grasped and on the instant of contact with earth and before the parachute can collapse the body is lifted briskly by pulling on the lift webs. That action greatly helps to absorb the landing shock. Nothing is gained by merely lifting the body before the feet touch as the impact is merely delayed and not lessened. [108]

Lengthening the lift-webs allowed for the parachutist to carry more direct weight in the form of rifle valises [109] and kitbags [110] and subsequently reduced their dependency on supply containers.

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[106] N. Cherry, *Striking Back: Britain's Airborne and Commando Raids 1940-1942* (Solihull, 2009), pp. 105-106.

[107] T.N.A., AVIA 21/78, Live Descents with X Type Mk.I Parachute Fitted with Long Lift Webs, March-September 1942.

[108] 'The Irvin Air Chute Company Great Britain Limited', *Flight Magazine*, 11 October 1928, pp. 886-888, p. 887.

[109] T.N.A., AVIA 21/125, Paratrooping with Rifle Valises, April-December 1944.

Otway believed that such improvements to tactical and operational effectiveness, although technologically simple, could only be made through analysis obtained during operational conditions and believed that Colossus provided valuable 'technological experience on which were based many of the later developments for parachutists aircraft and their equipment.' [111] Unfortunately, considerable technological barriers had yet to be resolved and the development of the assault glider was deemed the most effective method of achieving military effectiveness.

Glider Procurement & Development

Following the Air Ministry recommendation for the development of the assault glider M.A.P. issued Specification X10/40, based upon Operational Requirement No.87 for a troop carrying glider. [112] General Aircraft Limited (G.A.L.) [113] won the tender and produced a prototype of their G.A.L. 48 Hotspur which made its maiden flight in February 1941. [114] Although never used operationally the Hotspur proved a useful stopgap for training purposes and enabled the D.U. to experiment, evaluate and subsequently redesign the principles of assault gliders and towing techniques in an attempt to achieve the maximum possible military effectiveness in glider-borne operations. [115]

The procurement process for the acquisition of new military aircraft was based upon an Operational Requirement, a general description of the aircraft type, which was then issued by M.A.P. to the aviation industry for the purpose of producing a manufacturers'

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[110] T.N.A., AVIA 21/126, Paratrooping with Kitbags, February-October 1944.

[111] Otway, *Airborne Forces*, p. 65.

[112] T.N.A., AIR 2/7551, Glider (Code B, 5/8): Gliders Development & Policy, February 1941 - September 1942.

[113] Then based at Hanworth, near Feltham, in the London Borough of Hounslow,

[114] G. Endres, *British Aircraft Manufacturers Since 1909* (Surrey, 1995), pp. 68-69.

[115] Ministry of Information, *By Air to Battle*, (H.M.S.O. 1945), pp. 19-21.

tender. [116] The table below lists the specification, corresponding Operational Requirement, and name of the main glider types utilised by British airborne forces in both training and operational capacities during World War Two. The 'X' was the M.A.P. designation letter for an unpowered aircraft; the first number denoted the specification number; and the final number referred to the year of issue.

Specification	O.R.	Description	Glider	Manufacturer
X.10/40	O.R. 87	Troop Carrying Glider (7 troops)	Hotspur I	General Aircraft Ltd.
X.22/40	O.R. 87	Production Order	Hotspur II	General Aircraft Ltd.
X. 23/40	O.R. 87	Production Order	Hotspur II	General Aircraft Ltd.
X. 25/40	O.R. 98	Troop Carrying Glider (14 Troops)	Hengist	Slingsby Sailplanes Ltd.
X. 26/40	O.R. 99	Troop Carry Glider (24-36 Troops)	Horsa	Airspeed Ltd.
X.27/40	O.R. 100	Cargo Glider Capable of Carrying 7 Ton	Hamilcar	General Aircraft Ltd.

Table 1: Operational Requirements Issued by M.A.P. for Unpowered Aircraft
Source: Author

It was the responsibility of the D.U. to coordinate the development programme and work closely with successful manufacturers to ensure that the final production version of the specified type was suitable for its intended military purpose. On 1 January 1941 the first reference to the Hengist glider was recorded when Wing Commander Buxton and Mr Shackleton visited Slingsby Sailplanes Ltd. at Kirbymoorside [117] to inspect mock-up of the glider to Specification 25/40 and agree modifications. [118] Clearly, Shackleton was involved in

[116] C. Sinnot, *The R.A.F. and Aircraft Design 1923-1939: Air Staff Operational Requirements* (London, 2001), pp. 25-26.
[117] Slingsby Sailplanes was founded by furniture manufacturer, Fredrick Slingsby, and relocated from Scarborough to Kirbymoorside in 1934.
[118] T.N.A., AIR 29/512, D.U. Ringway, 1 January 1941.

the process of glider procurement as noted in previous correspondence between the M.A.P. and the Treasury. [119] D.U. staff attended regular conferences with Slingsby during the development of the Hengist, four in January alone, [120] but despite extensive research and development the glider did not enter production beyond prototype stage.

Despite the Hengist only being in the mock-up stage of development the expectation for success was high and exercises were carried out to simulate the future landing of large bodies of troops by glider. On 2 January Exercise Instruction No. 4 was received in which the C.L.E. was required to participate in Operation 'Dragon' which was conducted between 5 and 8 January 1941. The exercise was 'for the purpose of demonstrating how troops may be transported by air and surprise pin-point landings made at predetermined places by parachute and gliders.' [121] It was noted that although the actual number of airborne forces taking part was relatively small, it was intended to show that much larger numbers could be employed when necessary. [122]

Meanwhile, a close working relationship with contractors was vital in the development of all associated airborne materiel. On 2 January Wing Commander Buxton visited Mr Lobelle of Messrs R. Malcolm Limited at Slough [123] to discuss the redesign of towing gear for gliders and on the following day visited Messrs Sperry Ltd. [124] to discuss the design and manufacture of limitless artificial horizons and de-icing instruments. [125]

[119] T.N.A., T 162/755, Letter Explaining Shackleton's Duties, by R.A. Grieve, 6 November 1940.
[120] T.N.A., AIR 29/512, D.U. Ringway, January 1941.
[121] T.N.A., AIR 29/513, A.F.E.E. O.R.B. Appendices 1940-1942, 5 January 1941.
[122] Ibid.
[123] R. Malcolm Ltd. Was founded in 1936 and was a specialist aviation sub-contractor for M.A.P. Marcel Lobelle joined the company in 1939 and had previously held the position of Chief Designer at Fairey Aviation.
[124] Sperry Gyroscope Ltd. Was an American owned manufacturer of aircraft and marine instruments registered in Middlesex.
[125] T.N.A., AIR 29/512, D.U. Ringway, 3 January 1941.

The utilisation of obsolete airframes for training purposes continued out of necessity and on 10 January 1941 representatives from the D.U. travelled to R.A.F. Tern Hill in Shropshire to deduce the suitability of Bristol Bombay aircraft for further parachute training purposes. [126] Two days later Mr Quilter, of G.Q. Parachute Co Ltd., Woking, attended Ringway to discuss parachute fittings for the Bombay and the aircraft. [127]

January 1941 was a particularly busy month and presented further opportunities for the D.U. to influence the development of the assault gliders under production. On 14 January Wing Commander Buxton attended an R.A.E. conference to discuss the prototype G.A.L. Hotspur glider and on 21 January the first test flight was conducted by Flying Officer Davie and Flying Officer Kronfeld. What is interesting about the involvement of Davie and Kronfeld in the first test flight of the Hotspur is that it did not conform to established procedure whereby initial tests of all aircraft were supposed to be undertaken at Farnborough, thus further illustrating the confusion with regard to roles and responsibilities in the field of technological development that undoubtedly originated from the lack of strategic direction.

The R.A.E. was responsible for all initial type trials for new aircraft and, in the case of gliders, C.L.E. was then supposed to conduct operational trials. However, the necessity of rapid development may well have taken precedence over protocol. Once the initial type trials were completed the next phase of the development process involved detailed collaboration between the D.U. and G.A.L. to evaluate the flying characteristics of the aircraft and identify any necessary modifications.

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[126] The Bristol Bombay was a pre-war dual purpose design bomber troop-carrier. It was an all metal twin engine monoplane construction and although entirely obsolete by the time it entered service in 1939 it was used mainly for transport duties in the Middle East.

[127] T.N.A., AIR 29/512, D.U. Ringway, 12 January 1941.

With the Hotspur in development, the Horsa encountered problems. Following the issue of Specification X.26/40, and the subsequent award of the contract, Airspeed began design work on the Horsa in December 1940 at Salisbury Hall in Hertfordshire and the project was closely supervised by the company's Technical Director, Hessel Tiltman. Airspeed was originally housed in the unlikely location of a disused bus-depot in York but had moved to Portsmouth aerodrome in 1933 when orders outweighed production capabilities. [128]

Following the purchase of the majority of the company shares by De Havilland in 1940 the design department was relocated to Salisbury Hall. [129] Historians have often expressed astonishment that it only took ten months for the first prototype Horsa aircraft to make its maiden flight in September 1941 as Postan noted:

> When the airframe was single in design and construction; when its design was not linked with the hazards of a parallel engine development; when the operational requirements were simple and above all did not impose on the design a multiplicity of operational roles; when the 'users' made up their minds early and did not find themselves under the compulsion to modify the original design by stages; where new and identical capacity not previously engaged in the design and production of other types could be brought in, it proved possible to put airframes (in this case gliders) into the air with very little trouble or delay. [130]

[128] Endres, *British Aircraft Manufacturers Since 1909*, pp. 8-10.

[129] M. Stratton, 'Skating Rinks to Shadow Factories: the Evolution of British Aircraft Manufacturing Complexes', *Industrial Archaeology Review*, XVIII, No.2, 1996, pp. 223-244, pp. 223-224.

[130] W. Hancock (ed.), *History of the Second World War: Design & Development of Weapons* (Manchester, 1964), p. 153.

However, there was evidence that the design and production process was not without difficulty. [131] The following entry was recorded in the D.U. Operation Records Book on 15 January 1941 and suggests that the research, design and production of the aircraft was in no way near as efficient as has previously been assumed:

> Wing Commander Buxton inspected mock-up of 26/40 glider at Messrs Airspeed Ltd. Flying Officer Davie visited Messrs Phillips & Powis Ltd., later Miles Aircraft Ltd., a subcontractor for the Horsa based in Reading to discuss the design and the reason for the slow progress. It was deduced that this was due to the company being unwilling to invest in the programme without a clear future policy and consequently a guarantee of future return on their investment. [132]

The reluctance of Messrs Phillips & Powis [133] to invest in the production of the Horsa indicates that the industry did not have confidence that the airborne forces' programme would be completed. However, it could also have resulted from the introduction of complex competitive tendering frameworks and fixed priced contracts which capped sub-contractor profit margins. [134] These additional contractual restrictions coupled with the complexity and uncertainty of the glider procurement processes may well have been the source of sub-contractor reluctance.

The manufacture of gliders was highly dependent upon the work of non-aviation specialist sub-contractors and the materials chosen for their construction were primarily non-

[131] Wood, *History of the World's Glider Forces*, p. 158.

[132] T.N.A., AIR 29/512, D.U. Ringway, 15 January 1941.

[133] Phillips & Powis began as aero engineers and were based at Woodley airfield in Reading. In 1933 the company completed their first independent design and commenced manufacture of light aircraft in 1934. The firm secured numerous Air Ministry contracts, particularly for the Miles Master trainer, and the M.A.P. requisitioned Risboro' Furninture during World War Two to produce exclusively for the company. In 1943 the firm became Miles Aircraft Ltd.

[134] Ashworth, *Contracts and Finance*, p. 98.

essential, but this still required assurance to the industries involved that their initial investment in production capacity would be rewarded. Consequently, the gliders were manufactured almost entirely from wood in numerous sections before final assembly at R.A.F. Maintenance Units (M.U.) and their associated Aircraft Storage Units (A.S.U.s). It would appear that certain sub-contractors were unwilling to invest in the Horsa programme without the guarantee of future orders to justify the capital outlay in materials, equipment and personnel. There was certainly evidence that glider production was being delayed as late as 1944 due to lack of components from sub-contractors. [135]

Notwithstanding these difficulties, the second Hotspur Glider (B.V. 138) was delivered on 6 February after modification to the ailerons, upon the recommendation from the D.U. Test flights were undertaken at R.A.E. Farnborough on 10 February, this time in accordance with protocol, and the following day B.V. 138 underwent operational performance trials at Ringway and the modifications were considered 'a great improvement on first model.' [136]

Close liaison with contractors continued and on 12 February Flying Officer Kronfeld attended a further meeting at Slingsby regarding the Hengist and Wing Commander Buxton and Flying Officer Kronfeld visited again on 22 February. [137] Similarly, numerous meetings were held regarding the development of the Horsa and on 17 February Wing Commander Buxton visited Airpseed Ltd. On 21 February Flying Officer Davie visited Philip & Powis Ltd., Bracknell, to discuss the Horsa design and Flying Officer Davie flew from R.A.F. Thame to inspect the glider mock-up the following day. [138] However, despite the close liaison between

[135] T.N.A., AIR 29/967, O.R.B. No. 9 Maintenance Unit R.A.F. Cosford, March 1939 - December 1945.
[136] T.N.A., AIR 29/512, D.U. Ringway, 6-10 February 1941.
[137] T.N.A., AIR 29/512, D.U. Ringway, 12-22 February 1941.
[138] T.N.A., AIR 29/512, D.U. Ringway, 21-22 February 1941.

client and manufacturer the future composition of the airborne force was still undecided and the type of loads to be carried largely undefined. [139]

Flight tests of the Hotspur produced valuable information in relation to the functionality of glider/tug combinations and resulted in numerous modifications and improvements. On 13 March 1941 Mr Boothroyd, a G.A.L. draughtsman, visited the D.U. at Ringway literally to draw the necessary modifications to the Hotspur glider whilst on site. [140] Following further development and modification the third Hotspur glider, B.V. 140, was delivered on 17 March to R.A.E. for evaluation flights.

Despite the intensity of the development programme and the innovative nature of the work in progress on 1 March 1941 Wing Commander Buxton was unexpectedly attached to R.A.F. Church Fenton for temporary engineering duties. Flying Officer Davie assumed command of the Unit and was replaced by Flight Lieutenant Williams upon his return from leave. On 14 March information was received that Buxton had been permanently posted to No. 54 (Night-Fighter) O.T.U. which left the Unit under temporary command at a crucial period in the development programme. The situation was not rectified until 9 April 1941 when Squadron Leader Brie R.A.F.O. was posted from 74 Wing and assumed command. Brie was subsequently appointed to the unpaid Acting Rank of Wing Commander on 1 June 1941. [141] Further reorganisation commenced on 19 March when Flying Officer Kronfeld and Flying Officer Pitkethley were transferred from D.U. Flight to Development Unit Headquarters staff for design and modification work.

Flight trials with the Hotspur glider formed an integral part of the research programme, during this period but the tug aircraft available remained inadequate for operational

[139] Otway, *Airborne Forces*, p. 24.

[140] T.N.A., AIR 29/512, D.U. Ringway, 13 March 1941.

[141] T.N.A., AIR 29/512, D.U. Ringway, 9 April - 1 June 1941.

purposes. The primary aircraft available was the Hawker Hector [142] and on 27 March 1941 initial test flights were conducted with Hotspur B.V. 140 and Hector No. 9755. After tug pilot procedures had been established a twenty minute satisfactory general flying test was undertaken with the combination on 30 March but the Hector remained underpowered.

Following further research and evaluation flights by the D.U. it was considered that the Hotspur could be demonstrated to the Glider Training Squadron. Consequently, Hotspur B.V. 140 was transported by road to Haddenham on 5 April 1941 and this was followed by a liaison visit from Flying Officer Fender to brief flying personnel about the handling characteristics of the aircraft. [143]

Research and development on all equipment associated with assault gliders was also an on-going responsibility of the D.U. Following a visit on 21 March to discuss the development of tow cables by Mr Farquharson and Mr Lobelle of Messrs R. Malcolm Ltd, tests were conducted on 12 April of tow ropes that had been manufactured from 300 feet of manila rope and 50 feet of wire cabling. [144] Two tows of the Hotspur glider towed by a Hector tug proved satisfactory. [145]

Following this, on 21 April Mr Shackleton held a conference with Squadron Leader Brie at R.A.F. Ringway regarding the Hotspur glider and the first performance tests were conducted on the Hotspur with B.V. 138 glider and Hector tug. By 26 April the work of the unit had attracted sufficient interest to warrant a visit by the Prime Minister and Air Marshal Barratt, Air Officer-Commanding-in-Chief No. 70 Group. Personnel from the D.U. gave a

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[142] The Hawker Hector was an all-metal bi-plane which entered service in 1936. It was originally intended for Army Co-operation duties but was soon superseded by the Westland Lysander. Less than 200 aircraft were produced.

[143] T.N.A., AIR 29/512, D.U. Ringway, 5 April 1941.

[144] T.N.A., AVIA 21/10, Hotspur Tow Cables by R. Malcolm Ltd 1941, March - July 1941.

[145] T.N.A., AIR 29/512, D.U. Ringway, 12 April 1941.

demonstration of the Hotspur glider and a mock-up of the Horsa glider arrived by road from the Airspeed factory at London Colney. [146] Yet Otway suggests Churchill was not entirely impressed:

> He was left in no doubt as to the hopelessness of accomplishing the ambitious programme laid down six months earlier, if the existing priorities for allotment of resources were to remain. [147]

After all the initial investment the demonstration only comprised parachute drops from six Whitleys, the landing of five civilian sailplanes and the lone Hotspur.

By May 1941 the D.U. began to consider the further application of technology to enhance the overall tactical and operational effectiveness of glider and tug combinations. One obvious advantage was the ability of the pilots of both aircraft to communicate in flight and on 10 May 1941 Captain North, Army liaison officer, visited R.A.E. Farnborough to discuss experiments on glider-tug communication techniques. By 16 June research and development had progressed sufficiently for the first flight tests to be conducted by which observers of both tug aircraft and glider could communicate whilst in flight. Lieutenant Peacock visited R.A.E. Farnborough on 2 July and discussed the test carried out into inter-communication between tug and glider. The telephone sets and tug ropes under investigation by R.A.E. were subsequently brought back to Ringway for further experimentation by D.U. [148]

The functionality of the gliders in development was also being considered with particular reference to load capability, despite no official strategic requirement being issued.

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[146] Ibid, 26 April 1941.

[147] Otway, *Airborne forces*, p. 30.

[148] T.N.A., AIR 29/512, D.U. Ringway, 2 July 1941.

On 14 May experiments were conducted on new flooring for the loading ramp and the fuselage opening of the Horsa glider. These were installed in the mock-up by Airspeed. Interestingly, army troops were used for the test and this may well represent the first time that the end-user was introduced to their future method of operational deployment. [149]

Technological Innovation

Another aspect of potential future functionality under investigation was the utilisation of the Hotspur, [150] Hengist and Horsa for paratrooping. The possibility was first presented in a report on 12 September 1940 by Flight Lieutenant Hodges, C.L.S. Intelligence Officer, at the Central Landing School, following a discussion that had taken place at an Air Ministry meeting earlier that month. Hodges argued for the gliders then under development to be designed with exit doors in order to facilitate future experimentation to prove the feasibility, or otherwise, of parachuting from gliders. He concluded that:

> If this proves to be a practical proposition, and the towing of gliders can be successfully undertaken at night, my belief is that such a method would enable troops to be landed in greater safety and with greater definiteness as regards place and time. [151]

Ultimately, Hodge's was advocating the disembarkation of parachute troops from a glider in preference to the disembarkation of air-landed troops by landing the glider on the site of an operation. This would only be undertaken once suitable preparations had been made on the ground to receive the glider-borne troops and equipment.

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[149] T.N.A., AIR 29/512, D.U. Ringway, 14 May 1941.

[150] T.N.A., AVIA 21/1, Paratroop Dropping from Hotspur Glider: Investigation & Tests, February - October 1941.

[151] T.N.A., AIR 32/2, Paratrooping from Gliders, by Flight Lieutenant Hodges, 12 September 1940.

In essence the theory was entirely logical in both ensuring the accuracy of delivery and providing a prepared environment for the eventual landing of gliders. However, the Intelligence Officer failed to appreciate the scientific and technological limitations of such a proposal, as was evident from his closing paragraph:

> Can we not envisage Whitley bombers, with little, if any modification, towing maybe two or three, troop-carrying gliders, each with 30 men, disembarking their 'goods' by parachute at a predetermined site and at a pre-arranged time; and then, having successfully disposed of their loads, returning with their appendages to the greater security of this Island? [152]

Despite Hodge's enthusiasm the towing of gliders proved far more difficult than anyone first perceived and the availability of aircraft capable of such a task, let alone the necessary modifications, ultimately limited both the tactical and operational effectiveness of the airborne force throughout the course of the conflict. The opinion was typical of the time and a gross underestimation of the technological and materiel investment required.

Nevertheless, on 15 July 1941 Flying Officer Pitkethly, along with M.A.P. representatives, visited the works of Harris Lebus in Tottenham to attend a conference on the subject of parachute static-lines for the Horsa glider: [153]

> It had previously been decided that the strop panel layout for the sides of the machine as in Whitley aircraft was definitely out of the question for the Horsa and a mock-up of a proposed rail type attachment was fitted to the prototype of the Horsa glider by Messrs Lebus. The mock-up was inspected and considered satisfactory in the aft door position but not in the forward position. For the forward

[152] Ibid.

[153] T.N.A., AIR 29/512, D.U. Ringway, 15 July 1941.

> door it was decided that the rail should be placed directly athwartships, instead of diagonally in the roof. This gives a much better layout of the men at 'action stations' and will allow a more rapid stick of paratroops to be dropped. [154]

Although the concept of using gliders for the deployment of parachutists was discussed with contractors during the development phase it took nearly two years before detailed flight trials and performance tests were undertaken.

Between April 1943 and March 1944 a series of flight trials were conducted at the A.F.E.E. that had the potential to fundamentally alter the entire character and military effectiveness of glider-borne operations in the final years of the war. The final report, not issued until May 1944, outlined the parameters for the investigation:

> [To] investigate whether the Horsa I glider was suitable for paratroop operations involving the dropping of sticks of troops simultaneously from both fuselage doors together with containers from the wing cells, and if so the most suitable installation was to be determined and tested, making the minimum possible modifications and additions to the airframe. [155]

The investigation was to ascertain whether the Horsa assault could be effectively utilised as a rather elaborate airborne 'trailer' or 'caravan'. Under this arrangement the tug aircraft could also contain a stick of parachutists or be bulk loaded with supplies for use by the parachutists once they had landed. The report continued:

[154] Ibid.

[155] T.N.A., AVIA 21/139, Horsa I Glider for Paratroop Operations: Trials (P.106) April 1943 - March 1944, 27 May 1944.

> In the original design of the Horsa, at a stage when it was considered that the glider might be required for paratrooping, certain equipment was incorporated including two strong points in the fuselage, and container racks in the wings with a manually operated release in the fuselage. This equipment was not used as the requirement was held in abeyance for a considerable time. When the glider was again considered for paratrooping and tests were put in hand at this establishment it was found that the above equipment was unsatisfactory and a considerable amount of modification was necessary. This report covers paratrooping from the Horsa whether or not simultaneous dropping from the tug and glider occurs, and a drill and technique have been included which are applicable in both cases. [156]

The 'airborne caravan' technique certainly had a considerable number of advantages and this may well have explained the suggestion by the Air Ministry that gliders had the potential to be more effective for the delivery of airborne troops. [157] The most obvious advantage was the increase in the number of parachutists capable of being deployed at any one time. The need for a purpose-built aircraft for use by airborne soldiers remained the most restrictive factor in Britain's capability to launch large-scale airborne operations throughout the war.

Consequently, British airborne forces were dependent upon American troop-carrier resources during the majority of operations in which they were involved. However, the utilisation of the Horsa glider airframe to extend the parachute carrying capabilities of modified bomber aircraft could not only potentially improve the military effectiveness of the British force but also enable them to operate autonomously.

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[156] Ibid.

[157] T.N.A., CAB 120/262, Note to Ismay on Assault Gliders, Author Unknown,12 August 1940.

The use of the Horsa glider would also have been far cheaper than developing a bespoke British-built aircraft specifically for the airborne/transport role and would this would have undoubtedly been agreeable to the R.A.F. which would have been, to a large extent, absolved of its responsibility to continually source aircraft for conversion. The paratroop option could also have potentially reduced the attrition rate of another significant commodity in the glider-borne aspect of airborne operations, namely glider pilots. [158]

It is most likely that the perceived operational advantages of this method of deployment were major factors in the comprehensive and meticulous nature of the A.F.E.E. investigation. This encompassed the following parameters:

- Design of suitable installation with necessary modification to the glider
- Investigation of strop length of both doors to ensure safe development of the parachutes
- Jumping technique and investigation of stick length at normal dropping speeds
- Dropping containers with and without delaying devices in a stick of men
- Handling technique for dropping
- Retrieval of strops and bags after use
- Loading for 10, 15 and 20 paratroopers
- Movement of centre of gravity position of glider. [159]

All of the above required detailed analysis and continuous testing in order to ensure the technique was practicable for operational use. In the eleven months of testing which began

[158] Ministry of Information, *By Air to Battle*, pp. 138-139.
[159] T.N.A., AVIA 21/139, Horsa I Glider for Paratroop Operations: Trials (P.106) April 1943 - March 1944, 27 May 1944.

in April 1943 some 320 live parachute descents were made from the Horsa glider [160] as the technique was developed, evaluated, and finally perfected. The following conclusions were drawn:

(1) With the modifications and additions described in this report the Horsa I is considered suitable for carrying and dropping 20 fully equipped paratroops with or without twenty 40 lb. kitbags or rifle valises, or thirteen 60 lb. kitbags. A crew of four must be carried consisting of two pilots and two dispatchers.

(2) Mk III containers loaded to 350 lbs. may only may be carried and dropped from any of the eight racks, with the provision that the racks, other than the outer one on each wing are used, the undercarriage must be jettisoned. Mk III containers loaded to 400 lbs. may be carried on any or all of the inboard and outboard racks. Delay devices should always be used on the containers in order to avoid interference.

(3) The containers are released by manually operated switches, either from the pilot's or the dispatcher's position the undercarriage. The strop length for the rear door is ten inches. [161]

Such analyses crucial to the development of the A.F.E.E.'s future research programme. However, despite the perceptiveness of the C.L.E. personnel the reality of developing a concept to the point of implementation was a substantially longer process, and this attracted

[160] T.N.A., AIR 29/512, A.F.E.E. Shreburn-in-Elmet, April 1943.

[161] T.N.A., AVIA 21/139, Horsa I Glider for Paratroop Operations: Trials (P.106) April 1943 - March 1944, 27 May 1944.

significant criticism from Major-General Browning in September 1942. [162] Technological investigations will be discussed in detail below.

Conclusion

Notwithstanding the change of strategic direction whereby glider development assumed precedence over the enlargement of the parachute force, [163] there remained some fundamental over-riding obstacles that not only delayed physical and technological development but also brought into question the future sustainability of the airborne capability and its ultimate operational and tactical effectiveness. On 5 December 1940 the Vice Chief of the Air Staff produced a minute entitled 'Training of Airborne Forces' and concluded that:

> A most important point is that all progress is being delayed by the lack of a decision by the Chiefs of Staff with regard to the details and the date of the proposed airborne operation. Without such a decision it is impossible to decide the priorities which are necessary if the development of that airborne force is to proceed. [164]

Although one must be wary of the blame being apportioned solely to the Chiefs of Staff the essence of the argument was accurate. Without clear strategic parameters the technological development of the airborne capability could not be conducted in a logical and efficient manner. Consequently, the lack of consensus regarding future deployment meant that strategic effectiveness, particularly in terms of offensive operation, was severely compromised.

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[162] T.N.A., AVIA 10/135, Attack on A.F.E.E. by Major-General Browning, 26 September 1942.
[163] T.N.A., CAB 120/262, Note to Ismay on Assault Gliders, Author Unknown, 12 August 1940.
[164] T.N.A., 20/2829, Training of Airborne Forces, by Air Chief Marshal Freeman, 5 December 1940.

Despite the creation of the Development Unit the majority of the research and development was relatively straightforward; a programme that Buckingham has described as 'prosaic'. [165] Apart from the glider programme the bulk of the research was focused upon the conversion of existing military technology for application in the airborne role. However, the technological investment could not reconcile the restriction in available resources, particularly with regard to aircraft that were simply not designed to accommodate parachutists or tow gliders.

The Air Ministry recommendation that gliders were a more suitable means of troop movement than deployment by parachutist not only resulted in the need for significant technological and scientific investigation but also created further pressure on the R.A.F. to provide aircraft. The problem was effectively doubled in that the Air Ministry not only had to find aircraft suitable for conversion to the parachute role but also aircraft that could be utilised as glider tugs. The technological development of the glider programme was undoubtedly a success and the design and associated hardware were produced both quickly and efficiently but the aircraft resources required to achieve overall military effectiveness remained unattainable.

Investigation into the capability of all glider types produced for the deployment of parachutists offered an interesting operational and tactical alternative but ultimately did not overcome the need for a suitable tug aircraft. Similarly, as the capacity of the Horsa and Hamilcar gliders was increased to meet operational requirements, inadequate consideration was given to the availability and suitability of existing aircraft for the purpose of towing. Consequently, disconnect existed between the limitations and availability of aircraft resources and the aspiration, or vagueness, of the airborne doctrine that could not be resolved by the professionalization of either the scientific or technological resources

[165] Buckingham, *PARAS*, p. 113.

committed to the airborne forces programme in 1941. The investment in the Airborne Forces Experimental Establishment the following year, a dedicated research and experimental facility, simply confirmed the materiel deficiencies and exploration of the scientific and technological detail is required to fully appreciate these restrictions.

Chapter Three: Experimental Flight &Technical Development Section

Introduction

The multiple stakeholders involved in the development of airborne technology as evidenced in previous chapters, combined with an absence of strategic direction, [1] resulted in inevitable duplication with regards to responsibilities, particularly in certain areas of the research programme. Despite the robustness of the central government administration strategic ambiguity resulted in difficulties implementing the technical development programme and subsequent co-ordinated planning at the tactical and operational level.

Although Otway considers the creation of airborne forces testament to the close co-operation between the Army and R.A.F., [2] Greenacre has argued that despite the harmony of the central administration there was little evidence that such coordination existed below the political aspirations of the Minister of Defence:

> Fundamental disagreements over the structure, organisation and employment of future airborne forces became impossible to resolve at Chiefs of Staff level. [3]

Consequently, without an established concept and doctrine the technological development was inevitably slow and involved abortive and repetitive research. Whilst the Joint Planning Staff were working on airborne policy the Directorate of Combined Operations was

[1] T.N.A., CAB 120/262, Airborne Forces: Minute to War Cabinet, by Winston Churchill, 22 June 1940.
[2] Otway, *Airborne Forces*, pp. 4-5.
[3] Greenacre, *Churchill's Spearhead*, p. 51.

simultaneously deploying the airborne capability and reviewing the intelligence gathered by means of O.R. Until a clear strategic direction was determined the technological development programme was frequently reviewed and culminated in the formation of the A.F.E.E. in 1942. But it could not reconcile the fact that production almost always preceded development.

The chapter examines the gradual professionalization of the research and development programme and the methodology upon which future technical investigations were conducted and reported. Without clearly defined roles and responsibilities the often self-identified aspirations of the technical development programme could not be achieved.

Clarification of Roles and Responsibilities

By April 1941 it had become apparent that there was a duplication of responsibilities between C.L.E., M.A.P. R.A.E. and greater clarity was required. Consequently, Air Marshal R.M. Hill, Director-General Research and Development (D.G.R.D.) at the Air Ministry, called a conference on 16 April to ascertain the relative responsibilities of M.A.P. and C.L.E. [4] The research areas in question comprised glider development, the development and application of associated technology, and the design of specialist equipment for trials of apparatus used in landing operations. The conference was attended by representatives of all stakeholder groups including the Air Ministry, War Office and M.A.P. (See Appendix 5)

Hill opened the conference and stated that there was confusion, due to lack of strategic direction, as to what aspects of research and development should be conducted at C.L.E., M.A.P., and R.A.E. He believed that this was mainly due to the rapid growth of the C.L.E. and that it had subsequently become ‘essential to organise the development work at the Establishment to meet the needs of all concerned in the various spheres of work

[4] T.N.A., AIR 29/513, Notes on Air Ministry Conference, by Air Marshal Hill, 16 April 1941.

undertaken.' [5] The lack of direction, as recognised by the Air Ministry, was further evidence that development of the airborne concept was difficult to coordinate efficiently due to the ambiguity of the doctrine. [6]

The conference also aimed to determine to what extent the work was technical, experimental and operational in order to ensure that development responsibilities were allocated to the most suitable establishment. Major Curme, Operational Requirements (A.M.), gave a brief explanation of the origin of the C.L.E:

> Its original purpose was the training of parachutists following the wish expressed by the Prime Minister that 5,000 parachutists should be trained. Its official formation followed a conference held on September 5 1940, and was sponsored by D.M.C. It was decided at that conference that the C.L.E. should comprise three sections: Parachute Training Section, Glider Training Section and Technical Development Section [7]

It is interesting to note that no reference to technical development was noted yet despite a lack of official sanction for development D.G.R.D. emphasised that no criticism was directed against the C.L.E. and that the initiative shown by them in finding solutions to technical difficulties under exceptional circumstances was admirable.

However, C.L.E. had now reached a stage whereby 'it was considered dangerous to allow it to continue to grow without proper organisation in relation to other branches associated with glider and parachute development.' [8] It was also believed that past

[5] Ibid.

[6] Greenacre, *Churchill's Spearhead*, pp. 170-172.

[7] T.N.A., AIR 29/513, Notes on Air Ministry Conference, by Air Marshal Hill, 16 April 1941.

[8] Ibid.

experience had proved that technical development and operational work were best separated. Although this amalgamation of roles had worked perfectly well at C.L.E. from the perspective of providing technical solutions it had not conformed to established procedures. [9]

Air Commodore Mansell, Air Ministry Director of Operational Requirements (D.O.R.), referenced instances where C.L.E. had initiated investigation of technical points affecting policy without consultation or reference to the Air Staff. One such example was the direct instruction to G.A.L. regarding modification to the Hotspur. He also highlighted further occasions where the C.L.E. had not followed procedure and had given instruction to a variety of manufacturing firms without first approaching the Assistant Chief of the Air Staff responsible for Tactics and Requirements, A.C.A.S. (T).

However, in defence of the C.L.E., the confusion with regard to protocol probably originated from the instruction from the Director of Combined Operations on 8 August 1940 that the C.L.S. was responsible for the production of ‘glider carrying aircraft’ and the subsequent establishment of the Glider Flight at Ringway. [10] The strong political backing was certainly not complemented by strategic guidance in the organisation of those stakeholders responsible for development.

The apparent disregard of formal process could well have resulted in all future technical development work being placed with establishments outside the C.L.E., however, it was instead decided that a Technical Development Section (T.D.S.) should be set up at Ringway under the direct control of M.A.P. to undertake the following parameters of operation. It would be under D.T.D control, M.A.P. would be responsible for administration, the head of the Section would be a P.T.O. and there should be a civilian technical staff

[9] Ibid.

[10] T.N.A., AIR 29/512, C.L.S. Ringway, 8 August 1940.

sufficient to cope with the technical and scientific work assigned to it. The T.D.S. would be responsible for dealing with technical problems arising from operational experience and would answer technical questions in connection with the use of different types of aircraft for parachutists. It would consider C.L.E. proposals for modifications but they would be submitted to D.T.D. for final approval. Questions affecting strategic policy would be referred by the Unit to the Air Ministry through the normal channels and no action on such questions would be taken by the T.D.S. without prior Air Ministry agreement. [11] In addition to the duties outlined above the Section was required to produce periodical technical reports.

It was concluded that the T.D.S. would be mainly focused upon the experimental, technological and research aspects of the work; and that the new Section would not alter the existing procedure whereby gliders went to R.A.E. for type trials before C.L.E. for operational trials. Close liaison was envisaged between the C.L.E. and the R.A.E. so that personnel form Ringway could take part in the type trials in order that the end-user could influence design during the development stages. [12] In reality, with regard to glider, this had already been happening but the arrangement was a retrospective approval of process.

The principles regarding the terms of engagement for the T.D.S. were thus comprehensively established. The advantage of the Section working closely with the C.L.E., although it was to be administered by M.A.P., was that technical questions could be both identified and answered swiftly. However, Hill was determined to ensure that all future technical investigation, and subsequent solutions, followed the correct procedures and that the C.L.E. conformed to conventional practice. Consequently, on 5 August 1941 the Development Unit was reorganised and divided into two separate sections: Experimental Flight and the Technical Development Section. The creation of these two sections was the

[11] T.N.A., AIR 29/513, Notes on Air Ministry Conference, by Air Marshal Hill, 16 April 1941.
[12] Ibid.

second stage in the evolution of the technological aspect of the airborne forces and formal recognition of its contribution towards tactical and operational development. [13]

The Experimental Flight comprised all personnel from the D.U. flight and was put under the command of Flight Lieutenant Fender. The Technical Development Section comprised the remaining officers and sufficient other ranks for technical purposes strengthened by the addition of nine civilian scientific staff from M.A.P., one of whom, Dr Bennett, assumed control as Chief Technical Officer (C.T.O.). [14]

However, the inconsistency with regards to roles and responsibilities was not simply confined to research establishments and friction was also evident within central government. Greenacre argues that this was essentially due to a 'lack of coordination across the many ministries and departments' [15] involved in the development of the airborne force. This was particularly apparent in the development of suitable aircraft. The War Office, Air Ministry, M.A.P. and the Ministry of Supply were all heavily involved in this matter but no one department was responsible for clear direction of the programme or with the executive authority to make decisions. [16] Consequently, technical coordination was increasingly difficult and thus was reflected in the work of the T.D.S.

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[13] T.N.A., AIR 29/512, D.U. Ringway, 5 August 1941.

[14] Dr. J.A.J. Bennett was a pioneer of helicopter flight and designed the C-40 Autogiro, the first direct lift aircraft. Bennett worked for Fairey Aviation in the post war period and became Professor of Aerodynamics at the College of Aeronautics at Cranfield in 1954.

[15] Greenacre, *Churchill's Spearhead*, p.71.

[16] T.N.A., AVIA 15/1530, Research & Development Programmes for Airborne Forces, February 1941 - 31 March 1942.

Scope of Technological Development and Investigation

On 8 August a meeting was held at the Ministry of Aircraft Production in Millbank, London, to deduce the parameters of the research programme of the Technical Development Section at Ringway. [17] The conference was attended by the following personnel:

Ministry of Aircraft Production
Mr Grinsted (D.D.R.D.T.) (Chairman)
Dr Roxbee Cox (D.D.S.R.1.)
Captain Liptrot (A.D.R.D.T. 1.)
Dr Walker (A.D.R.D.L.)
Squadron Leader Hayes (R.D.T.2.)
Central Landing Establishment
Group Captain Harvey (C.O.)
Wing Commander Norman (S.A.S.O.)
Dr Bennett (C.T.O.)
No. 70 Group
Squadron Leader Colebrook (D.M.C.)
Squadron Leader MacPherson (A.C.) [18]

Table 2: List of Delegates for M.A.P. Conference 8 August 1941
Source: T.N.A., AIR 29/513, Technical Development Section Conference, 8 August 1941

[17] T.N.A., AIR 29/512, T.D.S. Ringway 8 August 1941.

[18] T.N.A., AIR 29/513, A.F.E.E. O.R.B. Appendices 1940-1942, 8 Aug 1941.

The meeting settled the organisation of the Technical Development Section, broadly in line with the recommendation of D.G.R.D., and the roles and responsibilities of key personnel. The Section was to be organised upon the same principles as other Ministry of Aircraft Production research Establishments whereby the C.T.O., Dr Bennett, was responsible directly to Group Captain Harvey as Commanding Officer of the C.L.E. for all aspects of Station compliance but general administration and research and experimental work was coordinated by M.A.P.

Consequently, Dr Bennett oversaw the technical element of the C.L.E.'s activities and M.A.P. corresponded directly with him on all contractual and design matters. [19] It was also agreed that a monthly report of the technical work undertaken at C.L.E. would be compiled by the Head of the Section and a quarterly meeting at M.A.P. would be instigated to discuss the technical programme and ascertain future direction and policy.

The work of the Technical Development Section was thus invariably initiated by M.A.P., and on occasion by the Commanding Officer of the Establishment. The Chief Technical Officer was required to maintain close contact with M.A.P. Headquarters and frequently visit R.A.E. for research purposes. The Section effectively became a separate entity within the Central Landing Establishment and consisted of the Glider Training Squadron (G.T.S.), Parachute Training Squadron (P.T.S.), Exercise Unit (E.U.), Experimental Flight (E. Ft.) and the Technical Development Section (T.D.S.). [20]
The research and development remit of the Technical Development Section broadly comprised the following responsibilities which will be examined thematically:

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[19] T.N.A., AIR 29/513, A.F.E.E. O.R.B. Appendices 1940-1942, 8 August 1941.
[20] Ibid.

Trials and Development of Gliders:

The work of the C.L.E. and M.A.P. remained intrinsically linked through the R.A.E. which maintained all responsibility for the first flight trials of any prototype aircraft with the aim of determining whether it was, in essence, a 'good aeroplane.' Once the initial examinations had been satisfactorily completed all further development was undertaken by the C.L.E. which was responsible for carrying out performance trials broadly in line with those of other Service aircraft conducted at Boscombe Down. [21]

Glider Equipment:

Technical development was solely the responsibility of the T.D.S. and it was concluded that the C.L.E. would 'undertake the development of special equipment for use in the operation of gliders, experimental equipment for trials of gliders and apparatus used in landing operations.' [22]

Gliders under Construction by Contractors:

Representatives of the T.D.S. and M.A.P. were required to make joint visits to firms to discuss technical and prototype development. The Chief Technical Officer was authorised to instruct contractors by telephone as long as M.A.P. was informed and retained control over the prioritisation of contractor performance and development schedules.

[21] T.N.A., 29/513, A.F.E.E. O.R.B. Appendices 1940-1942, 8 August 1941.

[22] Ibid.

Parachutes:

The T.D.S. assumed responsibility for the testing and development of parachutes relating to paratroops and equipment in line with Army requirements. The remit of the T.D.S. fell broadly into two categories. Firstly, the development of parachutes used in landing operations such as the statichute and associated equipment; and secondly, the design, construction and performance testing of such equipment as containers for weapons, ammunition and radio sets.

Modifications to Aircraft for Paratroop Dropping:

One of the main functions of the T.D.S. was the modification of existing aircraft designs for the purpose of paratroop dropping and to determine whether a particular aircraft was suitable or not. It became the responsibility of C.L.E. to produce trial installations for aircraft in collaboration with manufacturers and then conduct all necessary experimentation. With regards to these modifications it was recorded that 'the C.O. of the Establishment is permitted to take this responsibility as far as one of a type is concerned, which should be considered as a flying mock-up' [23] but major modifications required the prior approval of M.A.P.

Rotary Wing Aircraft:

The development of rotachutes was controlled by the Chief Technical Officer, as was Autogiro experimentation conducted by A.R.III Construction (Hafner Giroplane) on behalf of M.A.P. [24]

[23] T.N.A., AIR 29/512, T.D.S. Ringway, August-September 1941.
[24] Ibid.

Modifications to Tug Aircraft:

Aircraft tug requirements were the responsibility of the Director of Operational Requirements and the work was conducted by the R.A.E. However, C.L.E. representatives were required to attend mock-up conferences at manufacturers' works to discuss further research and conduct operational experimentation.

Co-ordination and Allocation of Work:

The meeting to discuss this role of the T.D.S. on 8 August was particularly important in that it clarified the division of work between the C.L.E. and R.A.E. in relation to the development and trial of gliders and reiterated the close working relationship required between the two Establishments. [25] Decisions were made upon the responsibilities for future developmental work and included a wide variety of research questions. Research was to be conducted into glider stability problems with a view to developing semi-automatic and twin-towing techniques, the collation of statistical records of glider accelerations and tow cable tensions, and the design of automatic winches to deal with cable snatches. [26]

Exceptions

Naturally the research included, technical issues concerning the technological development of aircraft. Initial flight tests would thus be conducted at R.A.E. on glider prototypes such as the Horsa and Hengist but contractor flight trials and official acceptance tests would be managed by C.L.E. This was the most pragmatic solution as C.L.E. was responsible for accommodating all service requirements. However, there was one aspect of

[25] T.N.A., AIR 29/513, A.F.E.E. O.R.B. Appendices 1940-1942, 8 August 1941.

[26] Ibid.

the research programme that R.A.E. requested to retain independently: experimentation with rocket assistance for glider take off. [27]

The scheme was devised to alleviate the forces expended on the tug aircraft, particularly during take-off when engine oil temperatures were found to increase disproportionately. [28] The rockets were attached directly to Horsa and Hamilcar gliders in order to increase take-off speed simultaneously with the tug aircraft. [29] The only recorded experimentation with the Horsa was with a Whitley tug in 1943 and although deemed 'successful' it required further significant technological development and was never used operationally. [30] Such abortive experimentation would not have been necessary if the strategic direction of airborne forces had been sufficiently clear.

However, the utilitarian design of the Hamilcar afforded the simple installation of two Bristol Mercury engines in which it became a powered freighter. The introduction of such engines did not alleviate the requirement for a tug aircraft but it did mean that once the desired altitude had been reached the engines could be throttled back for economy and a Hamilcar X and Halifax tug combination could provide an operational range of over 600 miles. In a contemporary article in *Flight Magazine* it was 'envisaged that the Hamilcar X might be very useful to a civil concern' [31] pending availability of Halifax aircraft. Unfortunately, the concept was not subsequently utilised by either military or civil operators, probably due to the introduction of dedicated powered freighter types, such as the Bristol Type 170 which entered service in 1946.

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[27] T.N.A., AVIA 15/1291, Rocket Assisted Take Off for Gliders, October 1941 - July 1945.

[28] Otway, *Airborne Forces*, pp. 395-396.

[29] T.N.A., AVIA 6/10261, Horsa Glider: Rocket Assisted Take-Off Tests, March - September 1943.

[30] T.N.A., AVIA 6/10351, Whitley Aircraft Towing Horsa Glider: Rocket Assisted Take-Off Tests, March - July 1943.

[31] 'Hamilcar X', *Flight Magazine*, 15 November 1945, pp. 532-533, p. 533.

Despite continued restructuring and development to improve the effectiveness of the T.D.S. the Senior Technical Officer position sanctioned by the Treasury in September 1940 remained vacant for a further year. On 9 September 1941 M.A.P. enquired about appointing to the position. The favoured candidate was currently employed on a higher salary at the Air Registration Board. However, M.A.P. confirmed that the applicant displayed 'willingness to forego some money in order to take up as position more valuable to the war effort.' [32] The Treasury approved the appointment at the revised salary on 16 September but on the following condition:

> This is not to be regarded as a precedent for filling S.T.O. posts at rates above the minimum of the scale, and is also on the understanding that Mr Fraser will not receive any subsistence allowance or billeting allowance for working at Ringway. [33]

Despite some progress suitably qualified personnel remained difficult to procure. But following the reorganisation into a more recognised research establishment under M.A.P. administration, the development programme continued in line with the parameters set out above.

Experimental Flight & Technical Development Section

The first monthly technical report issued by the T.D.S. (1/41) covered the period from 8 August to 8 September 1941, in line with the principle of submitting such a document established at the meeting with M.A.P. at Millbank. [34] The reports were comprehensive and

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[32] T.N.A., T 162/755, Letter from M.A.P. to the Treasury, by D.H.R. Gates, 9 September 1941.

[33] T.N.A., T 162/755, Letter from Treasury to M.A.P., by A.W. Gomme, 16 September 1941.

[34] T.N.A., AIR 29/512, T.D.S. Ringway, 8 August 1941.

are abundant in technical detail but it is worth summarising the research and development work recorded in the first report produced for two reasons.

Firstly, it represented the first time that the experimental work of the C.L.E. was professionally presented in accordance with M.A.P. requirements. Secondly, the report not only identified the origins of the core tactical and operational practices later utilised by airborne forces but also contained evidence of ambitious technological 'gadgetry'. The format of the report was broken up into the following sections according to the experimental work undertaken during any one period.

Technical Report 1/41

Gliders:

One of the articles in the report was entitled 'modification to Hotspur for Parachute dropping' and detailed experiments undertaken with this glider type compiled for a M.A.P. report dated 29 August 1941. [35] The tests were predominantly to determine the effect of opening the doors in flight and of trailing static-lines and equipment bags. However, it was recorded that during a flight test intended for dropping dummies from Hotspur B.V. 199 the forward door, when opened, was forced out of its frame against the leading edge of the main wing by the slipstream and resulted in an emergency landing. [36] Despite these initial difficulties tests were continued to determine seating positions for paratroops and investigations into the ease of exit were carried out with fully equipped personnel resulting in the successful simultaneous dropping of two dummies from both fuselage doors.

[35] T.N.A., AVIA 21/1, Paratroop Dropping from Hotspur Glider: Investigation and Tests, March - August 1941.

[36] T.N.A., AIR 29/513, Report 1/41, 29 August 1941.

However, the glider type itself required intensive and detailed modification in order to improve its design and the T.D.S. was required to provide drawings and recommendations to manufacturers. [37] Some eighteen modification drawings were required ranging from relatively simple operational additions, such as rear and front footsteps, to integral structural changes which included the redesign of flap controls. [38] Despite the realisation that the Hotspur had been operationally superseded by the larger Horsa and Hamilcar the level of attention afforded to the aircraft can only have been conducted for experimental purposes. Given the scale of development required to satisfy the requirement of the airborne capability further research on the Hotspur could be interpreted as scientific indulgence but in reality it was the only glider then available upon which experimentation could be conducted.

Scientific research was also being carried out at R.A.E. in late 1941 into the problem of keeping glider landing speeds as low as possible during the delivery of troops and supplies to the battlefield. In the case of the Horsa and Hamilcar the aircraft were equipped with substantial pneumatically-controlled flaps supplied from compressed air bottles. Louis Hagen described the importance of the Horsa flaps during Operation Market Garden in his memoirs:

> Half flaps down and our gliding angle steepens suddenly. Another fifteen degrees to starboard and we are just about over our landing area. Full flaps down and our nose is now pointing directly to the ground. The flaps keeping our speed constant and just above stalling speed. [39]

[37] T.N.A., AIR 29/512, Report 1/41, August - September 1941.
[38] T.N.A., AVIA 21/12, Essential Modifications to Hotspur II Glider for Training & Operational Purposes, 1941.
[39] L. Hagen, *Diary of a Glider Pilot* (London, 1945), p. 13.

However, a more ambitious technique was investigated by Owen and Young, two aeronautical engineers based at Farnborough. [40]

The concept was based upon the ignition of cordite charges immediately prior to landing which would act as an injector channelled through ducts in the wings. The air could then be manipulated to flow over the flaps and subsequently sucked over the ailerons to maximise lift and thus reduce landing speed. Following wind tunnel tests to ascertain the practical arrangement of duct designs a scheme for full scale investigation was recommended. [41] However, research was abandoned after it was realised that the results would not be ready in time to allow large scale production to commence. [42] The introduction of such an accelerant into the structure of a wooden wing root does appear ambitious but it is a good example of the type of solutions envisaged in the development process, however impracticable operationally.

In addition to the modifications required to the gliders themselves extensive work was undertaken in the design of associated ground equipment [43] and nineteen drawings were produced for the manufacture of items such as trestle tables for assembly and repair of glider assemblages, tow bars for tractor towing of gliders on the ground and drums for the carriage and stowage of tow rope cables. [44]

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[40] A.D. Young & J. Lighthill, ‘Paul Robert Owen 1920-1990’, *Biographical Memoirs of the Royal Society*, Vol.38, 1992, pp. 269-285, p. 271.

[41] T.N.A., AVIA 6/10124, Cordite Injector Scheme for Boundary Layer Control: Tests, January - June 1942.

[42] Young & Lighthill, ‘Paul Robert Owen 1920-1990’, pp. 271-272.

[43] T.N.A., AVIA 21/4, Ground Equipment for Hotspur Glider, February - October 1942.

[44] T.N.A., AIR 29/513, Report 2/41, September - October 1941.

Glider Equipment:

Another important aspect of research as identified in the first T.D.S. report was inter-communication technology between tug and glider for the purpose of military effectiveness. There were obvious operational and tactical disadvantages of pilots being unable to communicate in flight. This was overcome by the installation of the standard Army D.8 telephone into the cockpit of both glider and tug connected via a telephone cable attached to the tow rope. Although the solution was relatively low-tech it was invaluable for operational purposes. [45] Full reports into the installation and operation of such devices were issued in 1942 and became standard installations in all gliders thereafter. [46]

Tugs:

With regards to tug aircraft experiments were conducted on two potential aircraft for operational use with the Hotspur glider. The first was the Westland Lysander [47] which had proved satisfactory [48] but the second, the American Curtiss Tomahawk, proved more challenging due to difficulties in making modifications to the stressed all-metal skin construction of the aircraft. Further complications with the Tomahawk arose from the increased towing speeds at which the glider would have to operate. [49] The conversion of aircraft for the purpose of towing (Appendix 6) remained complicated mainly due to the fact that glider development and manufacture had commenced before the identification of suitable tug aircraft. Such strategic oversight and the amount of time spent evaluating often obsolete aircraft types does not suggest that development was considered a priority.

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[45] Ibid.

[46] T.N.A., AVIA 21/22, Present Position of Direct Wire Communication Between Tug & Glider, 18 February 1942.

[47] T.N.A., AVIA 21/3, Suitability of Lysander Aircraft as Tug for Hotspur Glider, June - October 1941.

[48] T.N.A., AVIA 21/336, Suitability of Lysander for Tugging, August 1941.

[49] T.N.A., AIR 29/513, A.F.E.E. O.R.B. Appendices 1940-1942, August - September 1941.

Paratroop Aircraft:

The suitability of a number of heavy bombers for the purpose of paratroop dropping had been investigated and suggested modifications had been developed but, as with glider tugs, there was a significant delay before some of the aircraft could be released for experimental purposes and no guarantee that they would ever be available in sufficient numbers for airborne forces to achieve tactical and operational effectiveness:

Aircraft Type	**Availability**
Vickers Wellington	Few days
Vickers Warwick	1 January 1942
Avro Manchester	2 months
Handley Page Halifax	4 weeks (if M.A.P. agreed priority)
Short Stirling	Ruled out meantime
Consolidated Liberator	None available at present
Vickers Valencia	1 inspected at Cranwell on 26 January 1941

Table 3: List of Aircraft Identified for Parachute Purposes as of August 1941
Source: T.N.A., AIR 29/513, Report 1/41, 8 September 1941

Although Greenacre argues that modification was technologically straightforward it required the allocation of a particular aircraft type for airborne forces in the first instance and then considerable time for the development of a satisfactory dropping technique. Once again, resource allocation caused considerable delay and abortive research which culminated in delay to operational deployment. [50]

[50] Greenacre, *Churchill's Spearhead,* p. 69.

Paratroop Equipment:

The majority of bespoke design was focused around equipment containers and their stowage in gliders or tug aircraft. At the time the T.D.S. report was issued three different types of container had been manufactured to carry a variety of equipment. Investigations were also underway into the production of plastic containers to replace the external woodwork of the existing types in order to prolong their serviceability, particularly under training conditions. [51]

Investigations were further conducted to overcome a wide variety of difficulties in the ground handling of containers. [52] These included the illumination for night operations and quick release mechanisms to aid the removal of the parachute from the container once on the ground. [53] Although such experimentation may appear relatively mundane, it was crucial to the tactical and operational effectiveness of the airborne forces.

Statichutes:

Extensive tests were undertaken to ensure that statichutes, parachutes deployed by means of a static-line, operated safely and effectively. [54] This aspect of the experimental work was critical to operational effectiveness to minimise the risk of fatal accidents such as those experienced during the training programme. [55] Yet the inability to source a dedicated aircraft type for paratroop operation ultimately delayed statichute development and standardisation of design.

[51] T.N.A., AIR 29/513, A.F.E.E. O.R.B. Appendices 1940-1942, August - September 1941.

[52] T.N.A., AVIA 21/48, Note on Drifting of Collapsible Trolley, January - March 1941.

[53] T.N.A., AVIA 21/54, Service Trials of Approved Parachute Containers, January - April 1941.

[54] T.N.A., AVIA 21/342, Deployment of ‘A’ Type Statichutes: Experiments, March - July 1942.

[55] T.N.A., AIR 29/512, D.U. Ringway, 21 July 1940.

Statichute Equipment:

The T.D.S. report included a paragraph entitled 'Statichute Attachments for Gliders' which provides evidence that the gliders then in production were indeed expected to be capable of deploying paratroops as an operational requirement: [56]

> Discussions with firms and other M.A.P. departments have taken place. For the Horsa, a rail type attachment was considered the most suitable, and modifications to the mock-up of the arrangement designed by the Airspeed Company have been suggested. For the Hengist, Messrs. Slingsby have been given the requirements for the static attachments and these are being designed to fit at the top of the trailing edge of each door. A mock-up of the fittings has been made by the firm. [57]

Research and development activity also focused upon procedures associated with operational and training use. The problem of parachute transport and maintenance were another important part of the C.L.E. remit. Designs were consequently prepared for the conversion of a R.A.F. Stores Trailer for the transport of 160 statichutes, vehicles for drying and hanging statichutes, mobile workshops equipped with sewing machines for repair works and the installation of mobile packing tables. [58]

Rotary Wing Aircraft:

By September 1941 the design of the A.R.III Construction Company full-scale Rotachute was all but completed and 12 prototypes were being manufactured by Messrs. F.

[56] T.N.A., AIR 32/2, Paratrooping from Gliders, by Flight Lieutenant Hodges, 12 September 1940.
[57] T.N.A., AIR 29/513, A.F.E.E. O.R.B. Appendices 1940-1942, August - September 1941.
[58] T.N.A., AVIA 21/247, Work of the Airborne Forces Experimental Establishment 1940-1945, by W.G. Jennings, 31 December 1949.

Hills & Sons. [59] However, due to the unique nature of the aircraft trials test apparatus needed to be specially designed for evaluation purposes. The A.R.III Construction Company was also involved in the design and development of Autogiros and will be examined below. [60]

Monthly Reports: September 1941 – January 1942

With the format of the monthly reports now established the thesis can now examine them both thematically and chronologically to determine the pattern of development and technological progression which culminated in the capability available at the time of the formation of A.F.E.E. [61]

Gliders:

Report 2/41 stated that on 10 September 1941 a full military load test comprising a crew of seven, and ballast that totalled 2000 lbs, was carried out with the Hotspur II. [62] Stalling tests and all relevant performance data were also completed. [63] However, the only available tug was the Hawker Hector and the performance limitation had already been identified. [64] The main finding was that the glider became unstable at speeds over 135 mph in the low-tow position and pilots notes were drafted accordingly. Such information was crucial in determining a practicable piloting technique of blind towing [65] via instruments and under operational conditions. [66]

[59] F. Hills & Sons were a small-scale aircraft manufacturer based in Trafford Park, Manchester.
[60] T.N.A., AVIA 21/24, Rotachute Trials (G.26), 2 April 1942.
[61] Otway, *Airborne Forces*, p. 50.
[62] T.N.A., AIR 29/513, Report 2/41, 10 September 1941.
[63] T.N.A., AVIA 21/5, Hotspur Glider: Full Load Tests (T.D.S./G.6), September 1941 - July 1942.
[64] T.N.A., AVIA 21/250, Hector Aircraft Towing Hotspur Glider (T.5), 6 November 1942.
[65] T.N.A., AIR 29/512, T.D.S. Ringway, 16 September 1941.
[66] T.N.A., AVIA 21/19, Suggested Methods of Blind Towing (T.D.S./G.21), February - December 1942.

The position of the glider in relation to the tug aircraft was critical. The most efficient and safest flight position had to be identified for inclusion in pilot's notes and relevant training syllabuses. It was also crucial in determining the effective military range, maximum load and speed of any such combination for the purposes of operational planning and target identification. [67] The following experiments were conducted on 16 September 1941:

> The rate of descent figures for a Hotspur II was requested so that approximations could be made as to the operational range of the aircraft. An estimate of 500 feet per minute at 80 indicated air speed was suggested based upon the observations of flight tests carried out to date. [68]

In order to achieve maximum range the undercarriage assembly of the Hotspur, as with all British assault gliders, was designed so that it could be jettisoned after take-off in order to reduce weight and thus increase operational range. The glider would then land on a belly skid.

During 7 and 8 October full load take-off and landing tests were conducted with the Hotspur II but problems were encountered when the starboard undercarriage did not release. [69] The same tests were conducted the following day but once again there were difficulties with the undercarriage jettison system which caused damage to the tail plane and subsequent experimentation was conducted with the undercarriage assembly locked in position. [70]

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[67] T.N.A., AVIA 21/16, Hotspur II: Comparative Trim and Stick Forces Tests for Low-Hook and Nose-Hook Towing, February - December 1941.

[68] T.N.A., AIR 29/512, Experimental Flight O.R.B. Ringway, 16 September 1941.

[69] T.N.A., AVIA 21/337, Hotspur II Glider: Tests (G.28), 23 April 1942.

[70] T.N.A., AIR 29/512, Experimental Flight O.R.B. Ringway, 9 October 1941.

Glider Pilot H.N. 'Andy' Andrews underwent training in the Hotspur in 1943 and detailed the flying characteristics of the glider and the advantages of keeping the undercarriage locked:

> The stick (mostly the spade grip) was reasonably easy to use, and sensitive. However, perhaps the hardest thing of all to get used to was the position of the legs and feet in close relation to the nose, the skid and, ultimately, the ground in landing. There were twin wheels under each wing, originally designed to be jettisoned, but actually used in position. It was found to be much easier to manoeuvre on the ground and quicker, therefore, for practice flights. [71]

The development works required extensive, and repetitive, evaluation with different glider and tug combinations. The following extract from Report 4/41 gives an indication of the nature of the experimental trials undertaken by T.D.S.:

> Tests have been made with a nose-towed glider flying below the tug and no difficulty was experienced in passing through, nor from the slip-stream. Preliminary trim, stick force and stability tests have given satisfactory results. [72]

The slip-stream produced by the tugs propeller(s) could cause significant turbulence for the glider that could result in decreased fuel efficiency, or in extreme cases, the breakage of the two-rope itself which had been investigated at the Glider Training Squadron. [73]

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[71] H.N. Andrews, *So, You Wanted to Fly, Eh?* (British Columbia, 1997), p. 33.

[72] T.N.A., AIR 29/513, Report 4/41, 8 December 1941.

[73] T.N.A., AVIA 21/9, Failure of Hotspur Tow Cables Used by G.T.S. Thame, February - August 1941.

Consequently, the position of the tow cable attachment to both the tug and the glider required close investigation and was an important aspect of the A.F.E.E. programme. Glider Pilot Alexander Morrison recalled the experience of releasing a Hotspur glider from a Harvard glider tug aircraft during training at No.1 Glider Training School, R.A.F. Croughton: [74]

> There was a loud 'clunk' and I could see the tow rope whipping behind the complete silence that prevailed. The noise of the slipstream then suddenly disappeared and we seemed to be suspended like a huge bird in the heavens. [75]

A conference was held on 26 September to discuss the operational requirements for a Mark III Hotspur glider. The conference comprised representatives from both the M.A.P. and General Aircraft. The main conclusions drawn were that the dropping of parachute troops was no longer a requirement, stalling speeds should be lowered, the controls should be improved and that towing speeds should be raised. [76] But despite the recommendations a Mark III Hotspur never entered full scale production as the aircraft was superseded by the larger glider types, although a prototype Mark III was built and tested in 1942. [77]

Meanwhile, 31 December 1941 experimental work had begun into the feasibility of using the Whitley V to tow two Hotspur gliders simultaneously. [78] Initial tests were conducted

[74] Further details regarding the organisation of Glider Training Schools and the associated syllabus are contained in Appendix 7.

[75] A. Morrison, *Silent Invader* (Shrewsbury, 1999), p. 20.

[76] T.N.A., AIR 29/513, Conference on Hotspur III, 26 September 1941.

[77] T.N.A., AVIA 21/31, Hotspur III Glider BV.200: Diving Trials (G.33), 11 July 1942.

[78] T.N.A., AVIA 21/17, Multiple Towing: Preliminary Notes (G.32), 10 July 1942.

with the glider attached to a single tow cable in a 'fly-cast' technique but this proved unsatisfactory and investigations were continued with separate tow cables. [79]

The investigation into the twin tow technique was a further example of the T.D.S. attempting to maximise the military effectiveness of the glider-tug combination whilst simultaneously minimising the number of tug aircraft required. The research concluded that the technique was feasible but that a more powerful tug would be required. In fairness, however, the concept was not entirely new and had been demonstrated operationally by German airborne forces through the twin tow of D.F.S. 230 gliders by a Junkers JU.52.

Another fundamental aspect of the research programme initiated in December 1941 was to determine the technical requirements for night operations. Trials were conducted with a Hotspur and Lysander tug and included a glide path indicator attached to the tug that produced a narrow beam of light to aid the glider pilot in following the correct flight path. [80] Each component required design and extensive trials to ensure optimum functionality without making the combination easily identifiable from the ground.

However, research was not only confined to the functionality of the technology and end-user comfort had to be considered, although this had not been relatively neglected prior to construction orders being placed. Consequently, air sickness tests were undertaken in order to identify the suitability of both gliders and glider-borne infantry for operational purposes. John Ellis has argued that:

> Purely physical constraints could be demoralising. Air-sickness was a serious problem, especially in gliders, where the normal instability of aircraft was complicated by a continuous to-and-fro movement as the glider

[79] T.N.A., AIR 29/513, Report 5/41, 31 December 1941.

[80] Ibid.

> repeatedly pulled against the slack of the towing hawser. Most men were sick on most trips and the floor of the glider was soon awash with vomit. [81]

Report 5/41 noted that air sickness tests were being conducted using a Hotspur II glider and the O.R.B. stated that on 2 January 1942 further air sickness trials were being undertaken 'following the need to test the suitability of glider-borne troops for combat purposes.' [82] Additional tests included the internal temperatures of the glider and its effects upon troops. [83]

Tests continued into 1942 and it was reported in Report 1/42 that Hotspur BT.548 was being modified to include a ventilation system and lighting for further air-sickness trials. [84] However, the main workhorse of air-landed troops became the Horsa in which passengers sat on wooden benches either side of the fuselage. Although securely strapped-in the surging motion of the glider whilst on tow invariably caused nausea that 'despite efforts to develop airsickness remedies' [85] was never overcome.

Test flying during January 1942 was, however, severely curtailed by both weather conditions and airfield infrastructure improvements. Despite the limited activity some research was undertaken which included preparation for the second prototype Horsa to be flown to R.A.F. Snaith by a Wellington III tug. [86]

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[81] J. Ellis, *World War II: The Sharp End* (London, 1990), p. 64.

[82] T.N.A., AIR 29/512, Experimental Flight O.R.B. Ringway, 2 January 1942.

[83] T.N.A., AVIA 21/11, Hotspur Glider Internal Temperatures (T.D.S./G.13), October - December 1941.

[84] T.N.A., AIR 29/513, Report 1/42, by J.A.J. Bennett, 31 January 1942.

[85] P. Harclerode, *'Go To It!': The Illustrated History of the 6th Airborne Division* (London, 2000), p. 29.

[86] T.N.A., AVIA 21/34, Horsa Glider Tests: Parts 1-5 (T.D.S./G.36), 1942, 8 December 1942 - 9 August 1943.

Glider Equipment:

The main focus of research and development contained in Report 2/41 during September 1941 was the installation of 'blind-flying' instruments in Hotspur BT.483 which included a tug position indicator, a device that later became known as the 'angle of dangle'. [87] This allowed the glider pilot to determine the relative position of the glider to the tug aircraft and thus maintain the most efficient and safest flying position. However, it was recorded that trouble had been experienced with the tow cables jamming in the quick release mechanism which resulted in the glider not being able to release itself from the tug aircraft. [88] Consequently, it was realised that a standard quick release mechanism was necessary and requirements were defined and numerous examples were subsequently tested. [89]

By Report 3/41 arrangements had been made to work collaboratively with a wide range of stakeholders to develop inter-glider, tug-to-glider and air-to-ground communication techniques. A conference was requested to define the Army's radio requirements and a Signals Branch of the T.D.S. was established to conduct this aspect of the work.

[87] T.N.A., AIR 29/513, Report 2/41, September 1941.

[88] Ibid.

[89] T.N.A., AVIA 21/18, Malcolm No. 4A Quick Release Mechanism, January - July 1942.

Ibid.

Figure 2: Sketch of Intercommunication Method for Hotspur Glider
Source: T.N.A., AVIA 21/22, Present Position of Direct Wire Communication Between Tug & Glider, 18 February 1942

At a conference on 27 October 1941 further requirements for glider ground equipment were identified and the standardisation of equipment for all glider operations was beginning to develop. One such example was the redesign of the cable drum trolley for the Hotspur tow cables so that it could be utilised to carry the drums for the Hengist, Horsa and Hamilcar. [90] Similarly, a prototype of the standard ‘Lobelle’ towing hook had been received by the T.D.S. and satisfactory flight tests had been conducted. [91]

[90] T.N.A., AIR 29/512, M.A.P. Conference of Glider Ground Equipment, 27 October 1941.
[91] Ibid.

Tugs:

Report 2/41, ending 8 October 1941, recorded that the Westland Aircraft Company had made successful modifications to Lysander V.9517 for the purpose of glider towing. [92] Arrangements had also been made with 30 M.U. Sealand for the conversion of further Lysander and Hector aircraft for glider towing. In November it was reported that following a M.A.P. conference all available Hector aircraft, estimated to be 40, would be converted for glider towing at A.F.E. rather than by independent contractors. Rollason Aircraft Service [93] was already in the process of converting 25 Hector aircraft for this purpose. [94]

Report 4/41 detailed further modifications carried out directly by A.F.E. in an attempt to identify suitable glider tugs. [95] Experiments had been carried out on two Whitley V aircraft and a Hawker Audax bi-plane, a successor to the Hawker Hart. It was also reported that a Wellington III was imminently expected for flight tests with the Horsa.

By 31 December the Hawker Audax modifications had been completed and arrangements had been made for engine cooling trials on the Wellington III before towing the prototype Horsa glider. It was also recorded in Report 5/41 that Stirling, Halifax and Albemarle tugs were expected shortly at T.D.S. for prototype trials. [96] The wide variety of aircraft types on test required additional experimentation with no guarantee that suitable numbers could be supplied for operational purposes.

[92] T.N.A. AIR 29/513, Report 2/41, 8 October 1941.

[93] Rollason Aircraft Service was an aircraft maintenance an overhaul contractor founded in 1935 at Croydon Airport. During world War Two the firm also acquired a factory in Llanberis, North Wales.

[94] T.N.A., AIR 29/513, M.A.P. Conference on Hector Aircraft, 24 October 1941.

[95] T.N.A., AIR 29/513, Report 4/41, 8 December 1941.

[96] T.N.A, AIR 29/513, Report 5/41, 31 December 1941.

Conversion of aircraft for evaluation as tugs remained a key aspect of the work and the following paragraph was included in Report 1/42 issued in January 1942:

> The conversion at A.F.E.E. of one Whitley V for glider towing has been completed and work on the second Whitley V is in progress. A third set of modified drawings, however, has been received from Armstrong Whitworth and both Whitleys are being modified accordingly. [97]

It is interesting to note from the above paragraph that it was stated that A.F.E.E. was conducting the modification work. This could simply have been an error with the addition of an E to Airborne Forces Establishment or, in the absence of the document containing a precise date when the report was issued, have been transcribed after the official formation of the A.F.E.E. on 16 February.

Paratroop Aircraft:

On 23 September 1941 dummy dropping was carried out from a Wellington aircraft. [98] An Armstrong Whitworth Albemarle and Lockheed Hudson were also examined with a view to assessing their suitability for paratroop dropping. [99] A mock-up of the proposed modifications to the Albemarle were completed and tested. [100]

There is evidence of close liaison between the T.D.S. and contractors throughout the period as paratroop requirements, and the aircraft available to fulfil them, gradually became more clearly defined. By 8 November 1941 3 Halifax aircraft, the first of which arrived at

[97] T.N.A, AIR 29/513, Report 1/42, 31 January 1942.

[98] T.N.A., AIR 29/512, Experimental Flight O.R.B. Ringway, 21 September 1941.

[99] T.N.A., AVIA 21/53, Suitability of Hudson Aircraft for Parachuting, September - October 1941.

[100] T.N.A., AIR 29/512, Experimental Flight O.R.B. Ringway, 21 September 1941.

Ringway on 12 October, [101] had been modified as the mock-up upon which standard Handley Page Test Installations (T.I.) could be based. Arrangements had also been made for the conversion of an Avro Manchester and an Albemarle for paratroop dropping once the manufacturers had made the necessary structural alterations. It is interesting to observe that gliders also appear in the 'paratroop aircraft' section of the report reinforcing the desire to utilise gliders for paratrooping and container dropping. It was reported that statichute attachments and container requirements for the Hengist and Horsa had been discussed in detail with the manufacturers. [102] On 9 October 1941 representatives of the T.D.S. visited Slingsby to view the prototype Hengist glider. [103]

Meanwhile, the War Office also requested that arrangements were made to enable parachute training in India. [104] A Hudson III, delivered to Ringway on 22 October, [105] was modified for statichute training by 'hole technique' [106] and instructions received that a further 12 aircraft were to be modified as quickly as possible for training in India. By 8 December 1941 modifications had been completed to Hudson AE.507 as the prototype and trials with single sticks of four men had proved satisfactory [107] and tests with double sticks of four men had been included in the programme. [108]

A second aircraft, Hudson V.9228, was modified in order to test the slide method of paratrooping by which the individual paratroops exited the aircraft by means of a slide

[101] T.N.A., AIR 29/512, Experimental Flight O.R.B. Ringway, 12 October 1941.
[102] T.N.A., AIR 29/513, Report 3/41, 8 November 1941.
[103] T.N.A., AIR 29/512, Experimental Flight O.R.B. Ringway, 9 October 1941.
[104] T.N.A., AVIA 21/51, Parachute Training Under Tropical Conditions, October - December 1941.
[105] T.N.A., AIR 29/512, Experimental Flight O.R.B. Ringway, 22 October 1941.
[106] T.N.A., AVIA 21/55, Modification of Hudson for Parachuting by Hole Technique, October - December 1941.
[107] T.N.A., AVIA 21/53, Suitability of Hudson Aircraft for Parachuting, September - October 1941.
[108] Ibid.

through the fuselage floor. [109] It was recorded that the method required the development of a new statichuting technique before it could be approved for training or subsequent operational use but by 31 December 1941 a solution had been devised which allowed a stick of seven men to be dropped. The aircraft was subsequently sent back to the manufacturers to enable the necessary T.I. drawings to be prepared.

By the end of 1941 further aircraft had been identified as potentially suitable for paratroop purposes. Representatives from A.V. Roe worked at Ringway throughout December in co-operation with technical staff to produce the T.I. drawings for the Manchester and Lancaster to be modified for paratroops, [110] and trials with both aircraft types were completed the following March. [111] However, despite the paratrooping principle being proved technically possible with a wide variety of aircraft types no single type was identified that could carry sufficient numbers. The wide range of aircraft on test as potential parachute and tug aircraft suggests uncertainty rather than systematic scientific analysis into suitability.

Paratroop Equipment:

Report 2/41 listed a range of research, development, test and modifications undertaken on a wide variety of support equipment. The following extract is an indication of the amount of technological development and manufacture necessary to equip a fully operational airborne force:

> No. 18 W/T set container has been approved by the R.A.E. Prototypes of the No. 11 W/T set container and the mortar baseplate and the collapsible

[109] T.N.A., AVIA 21/56, New Method of De-Planing Paratroops, November - December 1941.
[110] T.N.A., AIR 29/513, Report 5/41, 31 December 1941.
[111] T.N.A., AVIA 21/79, Trials of Lancaster and Manchester for Paratroop Operations, February - August 1942, 28 December 1942.

trolley cradles have been completed and are at Farnborough for strength tests. No. 11 W/T set container has been modified to take a No. 19 W/T set, when available. Drawings of the training type of Mk. 1and Mk. II containers have been completed. A prototype of a dimly illuminated container for night operations has been built and tested, and a minor modification has been made. [112]

All the detailed drawings had been completed for the manufacture of the equipment listed above by the following month (Report 3/41). Improvements and economies were continually made in order to make all associated materiel operationally effective.

The work included the re-design of containers and their statichutes so that as much equipment could be carried as possible. In Report 4/41 progress in the development of the Mk. III container was recorded:

A new type of statichute pack has been manufactured which occupies less space than those for Mk. I and Mk. II containers. This enables the Mk. III container to carry everything required, including the motor board, with the exception of the anti-tank gun. [113]

The continual evaluation sought to ensure that there was time for troops to receive adequate training with airborne equipment. By 31 December 1941 Mk. I containers were fitted with collapsible wheels and a handle 'so that it could be towed behind any commandeered vehicle' [114] and the prototype had been sent to No. 1 Parachute Battalion for approval and practicality assessment prior to descent tests.

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[112] T.N.A., AIR 29/513, Report 2/41, 8 October 1941.
[113] T.N.A., AIR 29/513, Report 4/41, 8 December 1941.
[114] T.N.A., AIR 29/513, Report 5/41, 31 December 1941.

In Report 1/42 further progress had been made in the development of equipment that would increase the military effectiveness of airborne forces once on the ground. It was recorded that 'detail drawings are in hand for the conversion of vehicles required for the transport column of a Battalion' [115] which culminated in the development of the airborne jeep and Tetrarch tank.

However, there is evidence that certain tactical issues, outside physical hardware, were also being considered at the T.D.S. by January 1942 and it was recognised that disorientation of enemy defences was as important to achieving operational success as specialist weaponry. [116]

> A paratroop dummy for tactical purposes has been made and satisfactory descents have been carried out. A batch of ten are being manufactured to enable the technique to be developed for dropping a stick of dummies. [117]

One of the first recorded instances of dummies being dropped was during the Normandy landings in an operation entitled 'Titanic' which involved some 300 dummy parachutists being released. The ploy was relatively successful and caused some members of the German high command to continue to believe that Normandy was simply a feint for an allied invasion in the Pas-de Calais. [118] However, not every German was fooled as *Gefreite* Walter Hermes of the 21st Panzer Division recalled:

[115] T.N.A., AIR 29/513, Report 1/42, 31 January 1942.
[116] T.N.A., AVIA 21/62, Paratroop Dummies: Tests (T.D.S./P.22), January - April 1942.
[117] T.N.A., AIR 29/513, Report 1/42, 31 December 1942.
[118] A. Beevor, *D-Day* (London, 2009), p. 54.

> I reported to the sergeant major's office and he said to me, 'Do you want to see our first prisoner? He's standing right there by the door.' I quickly turned round and saw not a man but a life size dummy made of some kind of rubber and hung all over with firecrackers. There were some more firecrackers in boxes on the sergeant major's desk. I said, 'By God, if the allies expect to win the invasion with this sort of thing, they're crazy. They're just trying to scare us.' [119]

Statichutes/Parachutes:

Between 8 September and 8 November 1941 128 dummy drops had been completed with the Mk. II Statichute and it was reported that one incident 'involving a defective canopy was being investigated.' [120] The trial and development required considerable photographic work in order for each stage of the process in which the canopy was deployed to be analysed which simplified the process of evaluation and allowed for prompt modifications to be made as necessary.

One element of the design and development process in which photographic evidence was crucial was the ability to determine the effect of changes in static-line installation upon the clearance of an aircraft tail-plane. By 8 December 1941 sixty-two dummy drops had been completed with the Mk. II statichute but the weather conditions and a lack of test facilities had delayed research. [121] Consequently, the programme had focused upon statistical analysis and the design of a system that delayed the opening of container

[119] R. Miller, *Nothing Less Than Victory* (London, 1993), p. 230.

[120] T.N.A., AIR 29/513, Report 3/41, 8 November 1941.

[121] T.N.A., AIR 29/513, Report 4/41, 8 December 1941.

statichutes in order to obviate the necessity for time intervals of one to two seconds between the dropping of troops and containers. [122]

The amount of time taken to exit the aircraft, by either paratroops or the despatch of containers, had a significant effect upon the grouping of troops and equipment on the landing zone and subsequent operational effectiveness. The advantage of such a system was that the troops and equipment could be landed closely together thus reducing the distance between paratroop and their fighting apparatus.

In Report 5/41 issued on 31 December 1941 the term ‘statichute’ was discontinued and replaced by ‘parachute’. During December problems were experienced with the Mk. II static-line parachute (previously referred to as the Mk. II statichute) and evaluation work was temporarily suspended pending investigation:

> The Mk. II static-line parachute has exhibited an irregularity of deployment and further research is required before statistical trials are resumed. The work has been temporarily transferred to Henlow where better packing facilities are available. [123]

The transfer of the research to R.A.F. Henlow (where the R.A.F. had a facility for testing bale-out parachutes) is interesting as following the conference of 8 August 1941 at M.A.P. the responsibility for all parachute research and development was devolved to T.D.S. However, it may have been possible that the T.D.S. staff were continuing the work programme off-site to utilise improved facilities rather than Henlow personnel conducting the research on their behalf.

[122] T.N.A., AVIA 21/340, Relative Positions of Containers and Men during Deployment of their Respective Statichutes (T.D.S./P.3), January 1941.

[123] T.N.A., AIR 29/513, Report 5/41, 31 December 1941.

Statichute/Parachute Equipment:

Between 8 October and 8 November 1941 'detailed drawings were completed for the Sten-gun case as a replacement for the obsolescent Smith and Wesson gun and ammunition variety.' [124] However, the objective of the T.D.S. was not restricted to the design, manufacture and trial of purpose made equipment. They were also responsible for developing the operational procedures under which the R.A.F. would operate and thus maximise the operational capabilities of the airborne force.

One such aspect of this work involved the training of aircrew in the dropping of parachutists to ensure that all the fundamentals of flight were correct so as not to jeopardise the effectiveness, or the safety, of the troops involved. For example, Report 4/41 detailed a dummy that had been designed for release from the bomb bay of the Whitley so that squadrons operating the aircraft type could begin the necessary training. [125]

One the ground, by 31 December the design of a parachute simulator had also been completed which allowed for more realistic training and thus reduced the dependency on aircraft flying hours. [126] Although new to the British, the technology had actually been proven in Russia during the 1930s as the Soviet Regime continued a national drive to promote public interest in aviation that had commenced prior to the First World War. [127] Such machines were constructed throughout the Soviet Union in public parks to encourage physical exercise amongst the civilian population. [128]

[124] T.N.A., AIR 29/513, Report 3/41, 8 November 1941.

[125] T.N.A., AIR 29/513, Report 4/41, 8 December 1941.

[126] T.N.A., AVIA 21/64, Parachute Synthetic Trainer (T.D.S./P.25), 25 April 1942.

[127] S. Palmer, 'On Wings of Courage: Public "Airmindedness" and National Identity in Late Imperial Russia', *Russian Review*, Vol. 54, No. 2, 1995, pp. 209-226, pp. 213-215.

[128] F.O. Miksche, *Paratroops* (London, 1943), p.15.

The synthetic parachute trainer was a relatively simple device from a technological perspective and consisted primarily of a spool fastened to a steel spindle which had a two bladed rotary air brake at one end. A steel cable was attached to the pupil's parachute harness and then wound onto the drum so that the air brake was driven during descent. [129] The low inertia of the fan resulted in an initial downward acceleration representative of free-fall from an aircraft and the 'acceleration was exponentially reduced to zero during the descent.' [130] These devices were mounted in batteries of either six or eight over platforms near the roof of an aircraft hangar and 'played a large part in the preliminary training of parachutists.' [131]

The installation of such a machine was a good example of how simple technology could increase the effectiveness of training and reduce the requirement for materiel resources. However, it also had the negative side effect of producing qualified parachutists far more quickly than airborne strategists could identify suitable operations.

Rotary Wing Aircraft:

The work on Rotary Wing Aircraft was particularly specialist and was initially undertaken on behalf of M.A.P. by an external contractor. The A.R.III Construction Company was established in 1934 by an Austrian aero-engineer named Raoul Hafner. During the 1920s Hafner had produced a series of prototype helicopters before he turned his attention to autogiro design. [132] The principal technological difference between the two aircraft types

[129] T.N.A., AVIA 21/247, Work of the Airborne Forces Experimental Establishment 1940-1945, by W.G. Jennings, 31 December 1949.
[130] Ibid.
[131] Ibid.
[132] Research was primarily funded by the Scottish cotton millionaire Major Jack Coates and in 1933 Hafner moved to Heston aerodrome to continue work on his designs and achieved success with the A.R.III Gyroplane which was widely demonstrated.

was that the autogiro was a hybrid between a fixed wing aeroplane and a helicopter that comprised a set of conventional wings and a tail but with a rotor mounted on a vertical shaft above the fuselage. However, unlike a helicopter, the autogiro rotor was not powered directly and was thus completely free to rotate on its shaft. The rotor was thus turned by the action of airflow over the blades and provided a certain amount of vertical lift. This was known as autorotation. [133]

Rotary-wing aircraft development was firmly split between the proponents of the autogiro and the helicopter during the 1930s and on 14 October 1937 Hafner had the opportunity to advocate rotating wing technology in a lecture to the Royal Aeronautical Society. [134] It would appear that Hafner presented a compelling and charismatic argument and the following review was published in *Flight Magazine* on 21 October 1937:

> Rarely in the long and distinguished history of the Royal Aeronautical Society has a lecturer managed to please and satisfy every section of his audience. Generally the unfortunate speaker must perforce talk right over the heads of some of those present (for let it not be thought that *all* who attend the meetings of the R.Ae.S. are learned scientists), or else he must run the risk, by keeping to generalities, of having a large proportion of the audience coming away with a feeling that they did not learn very much after all. Mr. R. Hafner, the Austrian inventor and designer of the Hafner gyroplane, achieved the apparently impossible last Thursday, when, at the first Royal Aeronautical Society Meeting of the present session, he explained his rotating wing aircraft. [135]

[133] J. Leishman, *Principles of Helicopter Aerodynamics* (Cambridge, 2006), pp. 19-21.
[134] 'Gyromancy', *Flight Magazine*, 21 October 1937, pp. 407-410, p. 407.
[135] Ibid.

The presentation was not without challenge and an interesting and polite exchange of scientific opinion was published between Hafner and Dr Bennett, later C.T.O. at Ringway, in the subsequent issues of *Flight Magazine*. On October 28 Dr Bennett complimented Hafner on ‘designing such a neat and spectacular machine’ [136] to which Hafner responded on November 11 thanking Bennett for his comments which were ‘the more appreciated in view of his acknowledged position in the rotating-wing field.’ [137] Rotary-wing design was the zenith of the aviation technology of the day and the lecture closed by thanking Hafner ‘for having the good sense to come to England for the further development of his ideas.

Figure 3: Raoul Hafner’s Home Office Exemption Card
Source: T.N.A., HO 396/228, Aliens Department: Internees Index (R. Hafner), 19 October 1939

Unfortunately for Hafner the European political situation ensured that he was classed as an alien. Indeed, whilst conducting research at Pobjoy-Short of Rochester he was interned following Britain’s declaration of war. Although The Home Office alien internee index recorded that Hafner was ‘exempted from internment and restrictions’ following a tribunal held on 19 October 1939 it would appear he was not released until 18 September 1940. [138]

[136] J.A.J. Bennett, ‘Gyroplane and Autogiro’, *Flight Magazine*, 28 October 1937, pp. 25-26.
[137] R. Hafner, ‘Hafner and Cierva Gyroplanes’, *Flight Magazine*, 11 November 1937, pp. 471-473.
[138] T.N.A., HO 396/228, Aliens Department: Internees Index (R. Hafner), 19 October 1939.

Following his release the A.R.III Construction Company was employed directly by the Air Ministry, and subsequently M.A.P., on the development of rotary-wing designs for military application. Hafner and his team were initially located at the C.L.E. before amalgamation upon the establishment of the A.F.E.E. where they developed the rotachute and rota-buggy designs. [139]

However, on 23 September 1941, Mr H. Grinsted, Deputy Director Research & Development (Technical) M.A.P., drafted an internal letter that suggested the termination of the contract with the A.R.III Construction Company and the direct government employment of the staff involved:

> They would be employed upon the completion of their present autogiro work, and also upon the development of gliders, equipment for us in gliders and equipment for paratroop operations. The advantage of this arrangement would be less expense to M.A.P. for such autogiro design work as is required, the availability of Hafner and the others for work urgently required on the glider and paratroop equipment programme, and the termination of the inconvenience of having a private company accommodated at an R.A.F. Station. [140]

Grinsted also suggested that the ending of the relationship with the A.R.III Construction Company would require additional civilian staff positions within the Technical Development

[139] The Rota-buggy was essentially a Jeep equipped with a rota-kite capable of being dropped by air. The design complied to Air Ministry Specification 10/42 and was manufactured by R. Malcolm Ltd. Although initial trials proved successful the capability of the Horsa and Hamilcar to carry vehicles ensured that further development was abandoned.

[140] T.N.A., AVIA 15/1130, Minute on Mr Hafner (Ref: S.B. 30485), by H. Grinsted, 23 September 1941.

Section at Ringway. [141] The arrangement was formally agreed between M.A.P. and the Directors of A.R.III Construction, Mr Hafner and Mr Welsh.

The C.L.E. Technical Reports detail the progress of the rotary-wing development. Report 2/41 detailed tests that had been conducted with a full-scale 15 ft. rotor mounted on a lorry and these had proved satisfactory. The design of the full-scale Rotachute was completed and manufacture was underway. By November 1941 the component parts of the rotachute were completed and the aircraft was undergoing assembly. Evaluation was also being conducted into the operational use of the Autogyro and an example with modified controls was tested in October 1941 and, after further modification, was flown to Duxford on 15 October. [142]

Figure 4: Detail of Rotachute Design

Source: T.N.A., AVIA 21/24, Rotachute Trials (G.26), 2 April 1942

[141] T.N.A., AVIA 15/1130, Minute on A.R.III Construction Company, by H. Grinsted, 10 October 1941.

[142] T.N.A., AIR 29/512, Experimental Flight O.R.B. Ringway, 15 October 1941.

In report 5/41 it was recorded that two full-scale Rotachute prototypes had been assembled and that one of which was being mounted onto a lorry for ground trials. [143] In January 1942 three hours of test flying had been conducted from this installation and experimentation had progressed to launches from a winch towed sledge. [144] Despite progress the following recommendations were made by the Airborne Forces Committee on 4 September 1942:

> Lieutenant-Colonel Walch (Airborne Division) said that a Rotachute for carrying a man was put up as an operational requirement and forwarded by War Office. Squadron Leader Waddington said that a Rotachute was not practicable as a man dropper, although it had possibilities for vehicles. Lieutenant-Colonel Walch expressed the wish to see the equipment before it was finally rejected as a man carrier, and it was AGREED that a party from Airborne Division should visit A.F.E.E. at an early date. [145]

Following a visit later that month all work on rotachute designs was considered impracticable for operational use. The specialist nature of the work was ultimately abortive for the purpose of airborne forces but later made a significant contribution to British helicopter design. [146]

Further Developments

By October 1941 the War Office realised that the size of the developing airborne force, despite the strategic and technological limitations, required reorganisation into a larger formation under the control of a single senior officer. Consequently, on the 29th of the same month, General Alan Brooke appointed Major-General F.A.M. Browning head of all airborne

[143] T.N.A, AIR 29/513, Report 5/41, 31 December 1941.

[144] T.N.A., AIR 29/513, Report 1/42, 31 January 1942.

[145] T.N.A., AIR 20/5500, Minutes of the Airborne Forces Committee, 4 September 1942.

[146] T.N.A., AVIA 21/220, Development of the Rotachute (Res/2), by R. Hafner, 19 October 1942.

forces which were soon renamed the 1st Airborne Division. Major-General Frost made the following comment in his memoirs upon learning of the selection:

> General 'Boy' Browning, known to the regular officers as the most famous Adjutant Sandhurst had ever had, was to command the Division. We began to realise that we were destined to do far more than land behind enemy lines and carry out raids or act as guerrillas. [147]

Upon appointment it was unclear if the airborne force would ever operate at more than Brigade strength but Brooke was determined to give it divisional status since 'apart from reasons of morale, and convenience at home, it also served to impress the enemy.' [148] The psychological role of airborne forces must not be underestimated and proved as relevant as their actual offensive capability.

Following his appointment, Browning accompanied Group Captain Harvey on a visit to the T.D.S. on 13 November primarily to inspect the mock-up of the Horsa glider. [149] Brooke then interviewed Browning on 20 November to determine the progress he had made with the Airborne Division and concluded in his diary that 'at last, after many uphill moments, it is beginning to make strides.' [150] By late January 1942 the T.D.S. was working on the performance trials of the Horsa and on the 24 of the month Flight Lieutenant Fender visited R.A.F. Station Snaith, Yorkshire, and inspected the airfield with a view to the practicability of undertaking the Horsa glider flight tests at the aerodrome.

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[147] J. Frost, *A Drop Too Many* (Barnsley, 2009), p. 29.

[148] Air Ministry, *The Second World War 1939-1945, Royal Air Force, Airborne Forces*, p. 37.

[149] T.N.A., AIR 29/512, Experimental Flight O.R.B. Ringway, 13 November 1941.

[150] A. Danchev & D. Todman (ed.), *War Diaries 1939-1945: Field Marshal Lord Alanbrooke* (London, 2001), p. 201.

Alongside this, the production of glider prototypes continued and the first Hamilcar glider arrived by road at Ringway from R.A.F. Station Snaith on 29 January 1942. [151] However, although the appointment of a Divisional Commander and the delivery of gliders was visible progress, but the lack of strategic direction and suitable tugs remained restrictive.

Conclusion

The formalisation of roles and responsibilities with regard to the development of an airborne capability undoubtedly provided much needed clarity between the Air Ministry, Royal Aircraft Establishment, Ministry of Aircraft Production, and ultimately, the Technical Development Section. The introduction of standard procedure for technical investigation and reporting meant that all stakeholders were regularly informed of progress. The programme could then be managed according to the requirements of both the strategic concept and doctrine.

The Technical Development Section was subsequently responsible for the technological development of all aspects of airborne forces requirements. The first formal Technical Report, compiled between the 8 August and 8 September 1941, [152] detailed research parameters that included both the innovative new technology of the rotary wing experiments and low-tech modifications of tow cables and fasteners. But despite the professionalization of the research programme the available technology and allocation of resources remained restrictive to future development as evidenced by the lack of aircraft available for experimentation. Consequently, the technical programme contained abortive research into aircraft types that were either entirely unsuitable for the purpose or would never be available in sufficient numbers for operational purposes.

[151] T.N.A., AIR 29/512, Experimental Flight O.R.B. Ringway, 29 January 1942.
[152] T.N.A., AIR 29/513, Report 1/41, 8 September 1941.

The need to experiment with such a variety of aircraft types, especially after both training of parachutists was sufficiently advanced and assault gliders were in physical production, is evidence that the airborne forces' programme lacked a dedicated and realistic strategic vision. The training of parachutists and production of assault gliders prior to the identification of suitable aircraft to achieve both tactical and operational effectiveness thus resulted in a vast technical programme that was difficult to achieve.

The political drive for the production of a British airborne capability overrode the technological capacity and availability of the necessary materiel and although the T.D.S. worked determinedly to discover solutions it was always at a disadvantage. When one considers the worrying economic and strategic military position of Britain at this time it is difficult to reconcile the development of the airborne force under such conditions. Nevertheless, the development continued and an independent experimental establishment was created to serve the newly created airborne division. But the limitations of the available technology soon caused conflict and frustration between the A.F.E.E. and the end-user.

Chapter Four: Airborne Forces Experimental Establishment

Introduction

By February 1942 it was believed that the development of airborne forces in Britain had reached a stage whereby glider training, parachute training and technical development required separation. Consequently, the Airborne Forces Establishment was disbanded and the responsibility for training was passed to regular Army and R.A.F. units.

On 16 February, in response to War Office Establishment Order WAR/AC/168, the Airborne Forces Experimental Establishment was formed to conduct further technical development of airborne warfare [1] However, Greenacre has argued that despite the formation of the establishment in reality it remained under resourced, with only one officer responsible for the development of parachute equipment, albeit with a small professional staff. [2]

A.F.E.E. was positioned in No. 70 Group under Army Co-operation Command for administrative purposes but worked directly to the M.A.P. for technical matters. [3] Yet, Group Captain Harvey retained a degree of autonomy with regards to technical development and had authority to conduct any exploratory trials that he deemed to be beneficial at the direct request of the Airborne Division or any of the R.A.F. Commands concerned in the training and provision of equipment for the airborne force. [4]

[1] T.N.A., AIR 29/512, A.F.E.E. Sherburn-in-Elmet, 16 February 1942.

[2] Greenacre, *Churchill's Spearhead*, p. 54.

[3] Otway, *Airborne Forces*, p. 50.

[4] T.N.A., AIR 29/513, Notes on Air Ministry Conference, by Air Marshal Hill, 16 April 1941.

The chapter examines the function of the A.F.E.E. from its inception to disbandment in 1950. The technological progression of the Establishment will be measured against the wider development of the British airborne capability in order to determine whether the investment was justified and achieved any technological advantage in the post-war period.

A.F.E.E. Organisation

The new Establishment comprised all personnel of the Headquarters, Technical Development Section, and Experimental Flight of the Airborne Forces Establishment with Group Captain Harvey in command. [5] The A.F.E.E. also assumed responsibility for the station workshops at R.A.F. Ringway. Harvey attended a conference at M.A.P. on 20 February with Air Marshal Linnell, Controller of Research and Development, regarding general policy on the allocation of work and visited the ministry again on 26 February to determine the future expansion programme and decide the responsibility and location for contractor glider trial facilities. [6]

However, it was not only the technical programme that required definition but also the staff complement that would conduct and administer the research programme. Following the decision to establish the A.F.E.E. as an independent M.A.P. experimental establishment further negotiation with the Treasury was required in order to ensure that an adequate number of specialist technical experts were procured.

Consequently, on 17 January 1942 M.A.P. requested an additional two Senior Technical Officer (S.T.O.) posts to satisfy the A.F.E.E. programme. It was also requested that the appointments were made directly to the establishment rather than being an addition to the R.A.E. complement at Boscombe Down:

[5] T.N.A., AIR 29/512, A.F.E.E. Sherburn-in-Elmet, 20 February 1942.

[6] T.N.A. AIR 29/513, A.F.E.E. O.R.B. Appendices 1940-1942, 26 February 1942.

> At a recent conference held at this Department, the civilian staff requirements of the Airborne Forces Experimental Establishment were reviewed in light of the decision that this should in future be an Establishment administered and controlled by this Ministry on similar lines to Boscombe Down. [7]

The procurement procedure allowed the Establishment delegated authority to make appointments between certain grades but formal permission was required for the addition of senior positions. [8] The Treasury was informed of any changes made within the delegated authority of the Establishment by quarterly return. However, it would appear that M.A.P. had utilised rather more discretion than it was entitled to, prompting the Treasury official assigned to the request, to comment in the margin that they ‘certainly have gone ahead on their own regarding this complement!’ [9]

Consequently, the Treasury conducted its own assessment with regards to appointments previously approved in comparison with those M.A.P. currently employed in January 1941 and the further additions they had requested (Table 4). Despite the discrepancies in approved and actual personnel strength, Treasury officials conceded that M.A.P. had delegated authority for appointment to the positions of Technical Officers and below and that the complement did not ‘look extravagant’. [10]

[7] T.N.A., T 162/755, Letter from M.A.P. to the Treasury, by E. Bone, 17 January 1942.

[8] T.N.A., T 162/755, Internal M.A.P. Memo, by S.G. Innes, 26 January 1942.

[9] Ibid.

[10] Ibid.

Position	Treasury Approved	A.F.E.E. in Post	A.F.E.E. Requested
Principal Technical Officer	1	1	1
Senior Technical Officer	1	3	4
Technical Officer	4	6	7
Assistant I	-	-	1
Assistant II	-	3	3
Assistant III	-	3	7
Designer	-	-	1
Draughtsman I	1	2	3
Draughtsman II	-	-	2
Administration Service Clerk I	-	1	1
Administration Service Clerk III	-	-	1
Temporary Clerk	-	1	2
Shorthand Typist	-	2	3
TOTAL	**7**	**22**	**36**

Table 4: Treasury Analysis of Technical Development Section strength as of January 1942
Source: T.N.A., T 162/755, Internal M.A.P. Memo, by S.G. Innes, 26 January 1942

A formal reply to the M.A.P. request was sent on 13 February 1942 and although it was believed that four S.T.O. posts created a 'top heavy complement' [11] it was recognised that A.F.E.E. was a 'new and relatively urgent service'. [12] Consequently, the request was approved on the condition that the situation would be reviewed bi-annually. The financial and human resource arrangements required serious attention in addition to the challenges of the

[11] Ibid.

[12] Ibid.

technical programme but the difficulty in obtaining the required professional expertise did not resemble any 'urgency,' particularly as the airborne capability was about to be deployed for the second time.

Bruneval Raid (Operation Biting)

The additional human resources reluctantly granted by the Treasury in February was to be somewhat justified later the same month when the airborne forces were presented with another opportunity to enhance their reputation as an effective fighting force with the capability to 'strike a mortal blow' as envisioned by Otway. [13]

The Germans had constructed a series of radar installations along the French coast to which British scientists attributed an increased interception and casualty rate of Bomber Command aircraft. [14] However, there was also concern that the German technology was capable of picking-up data traffic from the Telecommunication Research Establishment where all new British radio technology was designed and tested. [15] Consequently, the gathering of further information about the capabilities of German radio detection installations became of paramount importance both to the Air Staff, through the reduction in aircraft losses from intelligent coordinated searchlight and anti-aircraft gunnery, [16] and to the scientific community. The primary objective of Operation Biting was not to harass the enemy, as Churchill had originally decreed, [17] but to steal his technology.

[13] Otway, *Airborne Forces*, p.2.

[14] Ibid, p.65.

[15] R.V. Jones, 'A Concurrence in Learning and Arms', *The Journal of the Operational Research Society*, Vol. 33, No. 9, 1982, pp. 779-791, p. 790.

[16] Air Ministry, *The Second World War 1939-1945, Royal Air Force, Airborne Forces,* pp. 57-58.

[17] T.N.A., CAB 120/262, Airborne Forces: Minute to War Cabinet, by Winston Churchill, 22 June 1940.

The installations were well defended against seaborne attack, thus rendering a Commando operation impracticable, and consequently an airborne assault was selected as the preferred method of achieving the objective. The installation selected for attack was located on Cap d'Antifer to the north of the French village of Bruneval situated between the ports of Le Havre and Dieppe in northern France. [18] The airborne contingent chosen for the operation was the newly formed 'C' Company of the 2nd Parachute Battalion under the command of Major J.D. Frost, who was later immortalised for his defence of the road bridge at Arnhem during Operation Market Garden in 1944.

'C' Company was to be delivered to its drop zone by Whitley aircraft of No.51 Squadron R.A.F. and then extracted by means of Royal Navy landing craft. The Naval Force also contained a further thirty-two officers and men of the Royal Fusiliers and South Wales Borderers to assist by covering the withdrawal of the landing craft. [19] The airborne force was assigned specific tasks and split into three groups, each of which was forty men strong and named after famous sailors.

'Nelson' Group under Lieutenant Charteris was to be dropped first in order to neutralise the shore defences ahead of the arrival of the landing craft and silence the garrison of Bruneval itself. 'Drake' Group under Lieutenant Young contained both Major Frost and Flight Sergeant Cox, an expert R.A.F. radio mechanic who was responsible for dismantling the radar. This group was tasked with storming the radar station itself. 'Rodney' Group was commanded by Lieutenant Timothy and tasked with containing a one hundred strong force of German troops garrisoned in an enclosure known as 'La Presbytere' situated some 400 yards north of the radar station. [20]

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[18] Cherry, *Striking Back*, p. 183.

[19] Ministry of Information, *By Air to Battle*, pp. 30-32.

[20] G.G. Norton, *The Red Devils* (London, 1984), pp. 9-12.

As soon as the radar had been dismantled each group was to be withdrawn to the beach and evacuated by means of the naval landing craft. The gathering of detailed aerial photographs and intelligence was crucial in the construction of accurate scale models to be used in the briefing of the parachutists. The importance of accurate intelligence was another lesson learnt from Colossus whereby the airborne force discovered that the objective was constructed of reinforced concrete rather than masonry for which the explosive experts had prepared. [21]

With all intelligence gathered and favourable weather conditions reported the operation commenced on the evening of 27/28 February 1942. The flight was uneventful and the drop successful apart from half of Lieutenant Charteris' force being deployed some two miles short of the target. Drake group was entirely successful in achieving its objective, with both the radar station and the troops stationed at 'La Presbytere' being taken by complete surprise. However, upon withdrawal to the beach this group sustained casualties from shore defences that had yet to be cleared by Lieutenant Charteris' overly dispersed force. [22] Communications were further hampered by radio failure which resulted in a breakdown of contact between the airborne forces and the waiting naval force. [23]

Indeed, breakdown in radio communication was a constant hazard to airborne operations during the Second World War. The effects of poor radio communication had not been satisfactorily addressed by September 1944 and had a devastating effect upon the 1st Airborne Division, particularly amongst Lieutenant-Colonel Frost's forces at the Arnhem road bridge, during Operation Market Garden. [24]

[21] Deane-Drummond, *Return Ticket*, pp. 27-28.

[22] Harclerode, *Wings of War*, pp. 212-214.

[23] Norton, *Red Devils*, pp. 12-14.

[24] W. Buckingham, *Arnhem 1944* (Stroud, 2004), pp. 234-235.

Fortunately, whilst the majority of ‘C’ Company were pinned down on the beach by the shore defences, the rest of ‘Nelson’ Group arrived and quickly subdued the enemy resistance. Shortly after 0200 hours the entire force was concentrated on the beach and made contact with the naval craft by means of emergency Very signal. Despite fierce enemy fire the airborne force and vital radar equipment were successfully withdrawn from the beach with the loss of six killed, five wounded and six missing. [25]

The Bruneval Raid not only gave the newly established Parachute Regiment its first battle honour but also gave the British public heart at a time when they had witnessed very little military success. Consequently, the War Office encouraged full media coverage of the raid and the King approved the award of numerous decorations ‘for daring skill, and seamanship in successful Combined Operations against the enemy at Bruneval.’ [26]

Although the decorations were undoubtedly deserved the omission of any awards for the role of the R.A.F. pilots of No.51 Squadron, or of Fighter Command, who launched a diversionary raid to draw off enemy aircraft, is notable. Without the full cooperation and the navigational skills of the R.A.F. pilots there would have been no operation for other forces to have participated in. The contribution of the Airborne Forces Establishment and the newly created Airborne Forces Experimental Establishment to the success of the operation was also overlooked. This may have been understandable in terms of maintaining security, but it may well have prompted the Station Adjutant to record in the O.R.B. on 28 February that the ‘Establishment and the A.F.E. were closely associated in the preparation for this operation not only in connection with the training of the paratroops and the design of equipment but in the actual preparation for the operation itself.’ [27]

[25] T.N.A., CAB 66/22/42, War Cabinet Weekly Résumé (No. 131), by Chiefs of Staff, 5 March 1942.

[26] ‘Daring in Combined Operations’, *The Times*, 16 May 1942, p. 2.

[27] T.N.A., AIR 29/512, A.F.E.E. Sherburn-in-Elmet, 28 February 1942.

Interestingly, those decorations awarded to airborne personnel only listed their parent regiments and there is no mention of the Parachute Regiment as an autonomous unit (See Appendix 8). The notion that they were only attached to the Airborne Division, as if on a secondment, is curious but could well reflect just how much work was required to create an independent airborne force amongst the more established regiments of the British Army and the determination of those regiments to retain their men. Peter Fleming argued that:

> All armies, however, have a strong prejudice against what the British Army in those days called 'gladiators'. Picked troops are all very well, but they have to be picked from somewhere, and commanding officers take it amiss when their most promising young officers and NCOs are posted, or ask for a posting, to some new-fangled corps or unit with a supposedly glamorous role. [28]

The fact that the parent regiments of most of the parachutists involved in the raid were stationed in the United Kingdom is a good indication as to why there was no shortage of requests amongst regulars for service in the airborne forces. [29]

The Bruneval operation was an operational success which accelerated British knowledge of German radar technology [30] and also resulted in the relocation of the Telecommunications Research Establishment to Malvern, beyond the range of German radio detection capabilities. [31] It also demonstrated that extraction by sea was feasible, if not the most practicable technique. A demonstration for the King and Queen of British parachute forces soon after the Bruneval Raid further enhanced the status of British airborne forces. *The Times* reported the following on 26 March 1942:

[28] P. Fleming, *Invasion* (London, 1958), p. 64.

[29] Thomas, 'The Importance of Commando Operations in Modern Warfare 1939-82', pp. 694-696.

[30] T.N.A., AIR 20/1546, German R.D.F. Equipment Captured at Bruneval: First Technical Report, April 1942 - February 1943.

[31] Jones, 'A Concurrence in Learning and Arms', p. 790.

> The King and Queen saw the parachute troops in action. A flight of black painted Wellington bombers flew over the aerodrome and one by one white and coloured parachutes opened out as men dropped from the aircraft. A formidable company of parachute troops was soon on the ground. The men came over at the double and lined up to be inspected by the King and Queen. [32]

The opportunity to demonstrate the effectiveness of the Parachute Regiment in front of such distinguished guests may have been just as useful to General Browning, in terms of obtaining resources for his airborne troops, as was the successful outcome of the Bruneval operation itself.

Indeed, Frost believed that both Browning and Churchill used the success of the Bruneval raid as justification for further requests of aircraft from the Air Ministry for the purpose of both experimentation and operational deployment. [33] Churchill also assembled the War Cabinet on 3 March for an analysis of the operation from those who took part and 'reasserted before them his belief in the future of airborne forces.' [34] However, Biting was a relatively small-scale affair and only the second such parachute operation conducted by the British since training commenced some 20 months previous. Despite the good publicity the British were incapable of achieving the divisional strength deployment of airborne troops without the procurement of American aircraft and materiel.

[32] 'Royal Visit to R.A.F. Bomber Stations', *The Times*, 26 March 1942, p. 2.

[33] Frost, *A Drop Too Many*, p. 33-36.

[34] Otway, *Airborne Forces*, p. 70.

Further Development

Away from operations the development programme continued to gain momentum but on 8 March the prototype Horsa glider crashed due to the port engine of the Whitley tug catching alight. The poor performance of tug aircraft became a recurrent theme. Fortunately there were no casualties and a replacement Horsa was delivered on 10 March in time for a visit by Colonel Hicks, 2nd in Command of the 1st Airlanding Brigade, to the Establishment. [35]

Further visits were conducted throughout the month and on 11 March Captain Elliot, Bomber Command Liaison Officer, departed A.F.E.E. after a short visit in possession of completed copies of lectures that had been prepared at the Establishment concerning the training of Bomber Crews in the practice of parachute dropping. [36] yet Elliot's lectures may well have been premature since no single aircraft type had been identified in adequate numbers for the purpose of parachute drops.

In the same vein, numerous aircraft types were still being tested in the glider programme. The first trials were conducted with a Miles Master II, a two seat monoplane advanced trainer, and twin Hotspur glider combination on 13 April. [37] However, the experiment was unsuccessful due to the poor performance of the tug engine which required the design and installation of a revised oil cooling system.

Meanwhile, the professionalism of the A.F.E.E. was reinforced on 27 April when Sir Robert Renwick [38] visited from the Air Ministry to discuss technological production in his capacity as Chairman of the Committee for the development, supply, transport and storage

[35] T.N.A., AIR 29/512, A.F.E.E. Sherburn-in-Elmet, 10 March 1942.

[36] T.N.A., AIR 29/512, A.F.E.E. Sherburn-in-Elmet, 11 March 1942.

[37] T.N.A., AVIA 21/30, Multiple Glider Towing (T.D.S./G.32), 10 July 1942.

[38] Sir Robert Renwick: Controller of Communications Equipment at Ministry of Aircraft Production (1942 – 1945), Chairman of Airborne Forces Committee (1943 – 1945).

of all equipment of the Airborne Forces (later the Airborne Forces Committee). Consequently, regular contact was maintained between A.F.E.E. and the Airborne Forces Committee and Group Captain Harvey attended a further meeting on 6 June. [39] Otway argues that the Committee covered a 'lot of useful ground and considerably speeded up the supply of equipment to airborne forces.' [40]

The reorganisation of the Establishment continued and on 16 May 1942 Harvey attended a conference at the Air Ministry where it was decided that the A.F.E.E. should move to its own dedicated airfield at Sherburn-in-Elmet as soon as accommodation was available. [41] On 10 June Air Marshal Linnell visited the Unit to discuss future organisation and experimentation and on 15 June a detachment of the Development Squadron based at R.A.F. Snaith, moved to R.A.F. Sherburn-in-Elmet under the command of Squadron Leader Nesbit-Dufort. By 1 July 1942 A.F.E.E. was established there and transferred from Army Co-operation Command to R.A.F. No. 21 Group Flying Training Command with detachments remaining at both Snaith and Ringway for research purposes. [42] Subsequent entries in the O.R.B. were entitled Sherburn-in-Elmet.

Nevertheless, close co-operation with personnel from other establishments remained paramount to the development programme and on 9 July Wing Commander Howard, Liaison Officer Bomber Command, visited A.F.E.E. in connection with the modification of bomber aircraft for parachute purposes. This was followed on the 21st by a visit from Flight Lieutenant Armstrong of P.1 (Discipline) No. 21 Group to discuss the Form 765 (C) procedure, the return of forced landings and flying accidents documentation.

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[39] T.N.A., AIR 29/512, A.F.E.E. Sherburn-in-Elmet, 6 June 1942.

[40] Otway, *Airborne Forces*, p. 52.

[41] T.N.A., AIR 29/512, A.F.E.E. Sherburn-in-Elmet, 16 May 1942.

[42] T.N.A., AIR 29/512, A.F.E.E. Sherburn-in-Elmet, 1 July 1942.

By August 1942 A.F.E.E. was required to undertake performance tests on the Hamilcar glider and Group Captain Harvey held a conference at Newmarket on 2 August following full load trials of the aircraft undertaken by General Aircraft Ltd. Consequently, on 6 August, four members of the Development Squadron proceeded on detachment to Newmarket to conduct service trials. [43] The functionality of the Hamilcar was soon under evaluation and on 18 August a conference was held at Newmarket to discuss the procedure for the jettisoning of the Hamilcar undercarriage and the following day full load tests were undertaken. [44]

Following this conference it was decided to fit parachutes to the undercarriage components of operational Hamilcar gliders. The modification was completed on 3 September and the first tests of this installation were conducted at Newmarket the next day. On 8 September the final service trial tests were completed at Newmarket but the Hamilcar was damaged owing to the collapse of the undercarriage during take-off. [45] Hamilcar D.R. 851 arrived at R.A.F. Snaith on 21 September and proceeded to R.A.F. Riccall, [46] and on 23 September Colonel Green of the American Mission accompanied Flight Lieutenant Kronfeld on a test flight. A second prototype, D.P. 210, arrived at Riccall from Newmarket on 29 September. [47]

Ministry Bureaucracy

Subsequent to Sir Robert Renwick's visit A.F.E.E. took the opportunity on 2 May 1942 to approach M.A.P. for the further professional resources in support of the technical development programme (See Appendix 9). The demand of the flight test programme

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[43] T.N.A., AVIA 21/33, Hamilcar Glider: Data & Tests: Parts 1-6 (T.D.S./G.35), 19 October 1942 - 13 August 1943.

[44] T.N.A., AIR 29/512, A.F.E.E. Sherburn-in-Elmet, 18 August 1942.

[45] T.N.A. AIR 29/512, A.F.E.E. Sherburn-in-Elmet, 8 September 1942.

[46] R.A.F. Ricall was a Heavy Bomber Conversion Unit in Yorkshire that trained crews on the Halifax.

[47] T.N.A., AIR 29/512, A.F.E.E. Sherburn-in-Elmet, 29 September 1942.

required the additional staff resource in Technical Development Section 1. However, Grinsted (D.D.R.D.T.) recommended that the two Technical Assistant II positions sought should be resourced from elsewhere within M.A.P. and transferred from either the Aircraft & Armament Experimental Establishment (A. & A.E.E.) [48] or Marine Aircraft Experimental Establishment (M.A.E.E.) [49] for the purpose. [50]

It was accepted that the additional technical assistants could be found from new entrants who would not necessarily require aircraft experience. However, A.F.E.E. required that further resources be seconded from other research Establishments in the short-term for the progression of immediate research priorities. As Grinsted recommended:

> I think that for proper progress it will be necessary to arrange for at least two men, preferably of Technical Officer standing, thoroughly experienced in aircraft performance testing to be transferred if only on temporary loan from R.A.E. It will take some time to find the five additional T.A.IIIs and it is essential that A.F.E.E. should have immediate assistance to enable all the important work to proceed. [51]

The provision of additional technical staff of sufficient qualification and experience was at a premium and consequently there was competition between the various M.A.P. Establishments to present a case for the procurement of expertise. Mr Rowe, Director of

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[48] The A. & A.E.E. was relocated to Boscombe Down in Wiltshire in 1939 and had a broad remit which included armament trials, aircraft performance and acceptance trials and the evaluation of rogue handling and enemy aircraft.
[49] The M.A.E.E. was located at Helensburgh in Scotland and was primarily concerned with the development of seaplanes and flying boats. It was administered by the Royal Aircraft Establishment.
[50] T.N.A., AVIA 15/1130, Minute following Renwick’s Visit to M.A.P. (Ref: S.B. 17654), by H. Grinsted, 2 May 1942.
[51] Ibid.

Technical Development (D.T.D.), believed that A.F.E.E. had used the visit of Renwick to their advantage:

> A.F.E.E. have obviously obtained the impression that priorities on Airborne Forces have been raised since the appointment of Sir Robert Renwick as general coordinator; hence they took the opportunity of his visit on 24.4.42 to raise questions of staffing etc., required to make headway at the higher rate. I think this action is justifiable in the circumstances, but I have written to the C.O. asking him to ensure that he puts his requests for staff through the normal channels in future. [52]

Despite the gentle reminder to Group Captain Harvey with regards to procurement protocol Rowe recommended to C.R.D. that the new establishment should be approved. However, Air Marshal Sorley's adjutant responded on 28 May with modifications that included the deletion of the five technical assistant posts and the re-grading of the four technical officer positions to Flight Lieutenants. Sorley requested that M.A.P. 'take the necessary action to establish these posts' [53] and that he be informed when this had been completed so that posting action with the Air Ministry could be instituted.

Although C.R.D. approved the establishment with amendments the provision for a section to undertake live drops in the trial of parachute installations had not been progressed and D.D.R.D.T was forced to write on behalf of A.F.E.E. on 9 June 1942 regarding the urgency of the matter:

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[52] . T.N.A., AVIA 15/1130, Minute following Renwick's Visit to M.A.P. (Ref: S.B. 30485), by N.E. Rowe, 5 May 1942.

[53] T.N.A., AVIA 15/1130, Minute on M.A.P. Staffing (Ref: S.B. 30485), on behalf of C.R.D., 28 May 1942.

> The establishment of the R.A.F. personnel required, and in particular, parachute jumpers is now much more urgent, in view of the proposed move of the A.F.E.E. from Ringway to Sherburn-in-Elmet which is due to take place very shortly, in fact, the advance parties are already in Sherburn I believe. May urgent action, therefore, be taken on this particular matter of establishing a section for parachute dropping personnel and arrangements made which will ensure that the actual men posted for this duty are not retained too long on dangerous duties of this description. [54]

Grinsted not only recognised the need to ensure that provision for this element of the technical programme was made but also that the experimental work was inherently dangerous. Therefore he proposed a system of frequent replacements of trained men from the Parachute Training School to mitigate the risks involved. [55]

However, the general opinion within M.A.P. was that further information was required from Harvey with regard to the exact employment of the additional personnel before the request could be approved; somewhat ironic considering Harvey had previously requested further information regarding the tactical requirements of the entire enterprise. Consequently, M.A.P. sent a letter to Harvey that requested clarification of his requirements for this function and the situation continued to be debated internally.

Although A.F.E.E. had successfully developed into a semi-autonomous research institution and was in the process of transferring to its own R.A.F. station it was thus not immune from bureaucratic red tape and there was no guarantee that the staff required would

[54] T.N.A., AVIA 15/1130, Memo on Parachute Training School Personnel, on behalf of D.D.R.D.T., 9 June 1942.
[55] Ibid.

be made available. Indeed, Grinsted made the following comments on 10 June 1942 in an internal memorandum that was copied to A.F.E.E.

> We would ask that your request for two sergeant parachute training instructors should be held back pending reply. We feel that instructors will be wasted on this type of duty and what we need are Army personnel trained in parachute jumping and the number we require is 12 as previously stated. I believe it is true that army Officers and other personnel are already shown on the A.F.E.E. Establishment, therefore, no difficulty should be found in establishing a number of parachute troops. [56]

It was certainly true that Army personnel were present on the A.F.E.E. staff as it was crucial that the end-user was involved in all stages of the development process to ensure operational requirements were achieved. Major Redwood was the senior Army Liaison Officer attached to A.F.E.E. and at the time of writing he was employed in procuring various Army stores and weaponry for the purpose of experimentation. [57]

M.A.P. was also unhappy with the terminology of the A.F.E.E. request for additional resources and Grinsted concluded that the correct term for ‘parachute repairers’, as stated in the original request, should be ‘Fabric Workers’ as the Ministry had found the former term misleading. [58] Grinsted also referred to the need for further information in regard to the request for six Aircraft Hands to perform general duties although he was relatively well informed as to the nature of their proposed employment:

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[56] T.N.A., AVIA 15/1130, Memo on Parachute Training Personnel, on behalf of D.D.R.D.T., 10 June 1942.

[57] T.N.A., AVIA 10/135, Attack on A.F.E.E., by Major-General Browning, 26 September 1942.

[58] T.N.A., AVIA 15/1130, Memo on Parachute Training Personnel, on behalf of D.D.R.D.T., 10 June 1942.

> We are aware that there is a good deal of unskilled work arising in connection with these experimental drops, not only in dummy drops but in live drops as well. In the latter case, it is essential that the parachute be left lying in precisely the position in which it drops and therefore at some later stage there is unskilled work involved in collecting these parachutes. [59]

Harvey submitted a further explanation of his personnel requirements which were subsequently approved by M.A.P. on 15 July 1942. However, Grinsted had to write directly to C.R.D. on 23 September because the issue had still not been resolved and had consequently resulted in a direct impact upon the development programme:

> Our work on parachute development has definitely suffered of late, delay having occurred on most important tests. In our view it is definitely necessary to include such personnel in our own establishment. [60]

The issue was finally resolved on 24 September when the C.R.D. approved the additional posts but it had taken some five months of justification and review, all of which added pressure and delay to the technical programme. [61] The pedantic nature of the process certainly does not indicate that the A.F.E.E. and its research were afforded any form of preferential treatment.

Although research was undoubtedly essential, the dedication of the A.F.E.E. to experimentation, which caused subsequent delay to production and deployment, provoked antagonism between the Establishment and the Army. Despite the intensive development

[59] Ibid.

[60] T.N.A., AVIA 15/1130, Minutes Regarding Proposals of Photographers at A.F.E.E., on behalf of D.D.R.D.T., 23 September 1942.

[61] T.N.A., AVIA 15/1130, Approval of Minute No. 51, by W.M. Picke (on behalf of C.R.D.), 24 September 1942.

programme, reorganisation, relocation, the progress achieved by the Establishment was not considered satisfactory by Major-General Browning. [62] The following section will examine the nature of Browning's criticism and determine whether fault lay with the management of the research programme by A.F.E.E. or a more deep routed problem of insufficient strategic direction.

Attack on A.F.E.E. by Major-General Browning

Major-General Browning first visited the Establishment in November 1941 [63] but developed concerns with regard to the productivity and capacity of the A.F.E.E. to conduct the necessary research and development required for the further development of airborne warfare. Browning outlined his misgivings in a dated 26 September 1942 to Colonel Llewellin, then Minister of Aircraft Production. The principal criticism was that the A.F.E.E. personnel were slow to carry out experiments and once completed, their conclusions were often erroneous:

> They have been consistently behind their programme (and far behind it). They take a long time to carry out any experiment or trial which has been ordered by M.A.P., and on completion of this extended trial they are often proved to be inaccurate. This has been proved by the Airborne Division and 38 Wing [64] by local trials which, quite unofficial I own, have been carried out owing to the abysmal slowness and lack of enterprise of A.F.E.E. [65]

[62] T.N.A., AVIA 10/135, Attack on A.F.E.E., by Major-General Browning, 26 September 1942.
[63] T.N.A., AIR 29/512, Experimental Flight O.R.B. Ringway, 13 November 1941.
[64] 38 Wing was formed on 15 January 1942 for the coordination and training of airborne forces. It was initially equipped with the Whitley, then the only aircraft available in sufficient numbers.
[65] T.N.A., AVIA 10/135, Letter to the Minister of Aircraft Production, by Major-General Browning, 26 September 1942.

Frost's analogy of Browning as the 'most famous Adjutant' [66] Sandhurst ever had suggests that he might not have been accustomed to the necessary flexibility of present at a research establishment or the limited resources available. Indeed he complained that:

> I have definite proof that aircrews, and others connected with the trials, are invariably half-an-hour to an hour late starting their work, they leave off work when they feel like it, and the whole thing is run on lackadaisical and slipshod lines. [67]

Browning also accused the A.F.E.E. of obstructiveness through its claims that certain procedures were not operationally feasible when they had been continuously demonstrated on exercises and had 'become an accepted method in airborne affairs.' [68]

Browning listed some examples of what he believed to be incorrect conclusions drawn from recent experimentation. The first concerned the number of men that could be dropped from a Wellington bomber. A.F.E.E. had recommended the maximum number was 8 whilst the airborne division had 'consistently dropped 10', [69] which Browning argued was the 'operational normality'; a rather ostentatious claim as the Wellington was never used operationally for the deployment of airborne forces.

Browning also accused the A.F.E.E. of negligence concerning the capability of the Whitley:

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[66] Frost, *A Drop Too Many* (Barnsley, 2009), p. 29.

[67] T.N.A., AVIA 10/135, Letter to the Minister of Aircraft Production, by Major-General Browning, 26 September 1942.

[68] Ibid.

[69] Ibid.

> Trials with the Whitley V and Horsa have been going on under M.A.P., both by A.F.E.E. and Airspeeds for the last six months. It was not until the Heavy Glider Conversion Unit was started at Brize Norton for converting glider pilots from Hotspur to the Horsa, that it was discovered that the Whitley was a totally unsuitable tug for operational use. [70]

He had identified the key issue of aircraft provision, as had Keyes in July 1940, [71] but laid the blame at entirely the wrong door. The A.F.E.E., and its predecessors, could only make the best they could with the limited resources available; the fact remained that airborne forces were certainly not deemed a strategic priority in terms of the provision of existing aircraft suitable for their purposes.

Browning was further dissatisfied with the speed at which experimentation and technological solutions were supplied by A.F.E.E. in response to War Office Operational Requirements. Particular reference was made to the dropping of weaponry by parachute which included the 3.7 Howitzer, 6 Pounder and 2 Pounder Anti-Tank guns and 20mm Hispano Cannon, although the specific Operational Requirements do not appear to have been recorded. [72]

> This was an urgent requirement put in months ago. Little action, so far as I can find out, has been taken, and the failure in the respect is having increasingly regrettable effects in connection with proposed operations. [73]

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[70] Ibid.

[71] T.N.A., CAB 120/262, Minute to Churchill, by Admiral Keyes, 27 July 1940.

[72] T.N.A., AIR 2/7792, Army (Code B/88), Review of Airborne Forces: Operational Requirements, February 1942 - October 1943.

[73] T.N.A., AVIA 10/135, Letter to the Minister of Aircraft Production, by Major-General Browning, 26 September 1942.

Similar criticism was directed at research into the feasibility of the Albemarle as a glider tug. Browning argued that 38 Wing had managed to acquire one aircraft and complete the trials in two days and justified the distortion of roles and responsibilities thus:

> We fully realise that it is not the function of 38 Wing to carry out experiments, but with a war on our hands these answers must be produced. [74]

In fact, Browning applied to the Air Ministry for the creation of a technical development flight at 38 Wing in order to undertake essential trials on work that A.F.E.E. had supposedly failed to produce. [75] His list of complaints closed with the following paragraph:

> I would emphasise that there is plenty of enthusiasm about for Airborne Forces, mostly in the Army, less in the R.A.F., and a great deal in M.A.P., except, apparently, in A.F.E.E. [76]

Browning's criticisms were, in many respects, justified but complaining about the A.F.E.E. was not going to solve the underlying strategic shortcomings that ultimately caused disruption to the development programme.

The accusations instigated a series of correspondence from a variety of stakeholders involved in the technical development of the airborne force. Lieutenant-General Sir Ronald Weeks, Deputy Chief of the Imperial General Staff, sent a letter to Air Marshal F.J. Linnell (C.R.D.), at Ministry of Aircraft Production on 30 September 1942:

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[74] Ibid.

[75] Ibid.

[76] Ibid.

> Gale [Major-General Sir R.N. Gale: War Office Specialist Director Airborne] has told me of the letter Browning has addressed to the Minister of Aircraft Production. He has also told me of your wish that no action should be taken in connection with this letter. [77]

Weeks believed that great progress had been made towards solving the technical problems connected with airborne forces and commented that 'the concrete evidence of the great advance that has been made in the last twelve months would, I am sure, dumbfound most critics.' [78] The empathy expressed in the last paragraph of Weeks' letter was appreciated by Air Marshal Linnell who responded on 30 September:

> I should like many things to be going at double the speed in the development line but the very magnitude of the programme has been one of the difficulties. However, I hope that we have cleared off the worst of our troubles now and the fact that the Unit is at last established in its own Station should make things easier for the future. [79]

The correspondence does suggest that senior officers were sympathetic to the technical difficulties involved in the creation of the new technology and that, although Browning's frustration at the pace of development was recognised, his actions were not necessarily supported. However, the criticisms did result in an official investigation by Air Commodore McEntecart, Deputy Controller Research and Development (D.C.R.D.), and Group Captain

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[77] T.N.A., AVIA 10/135, Letter to Air Marshal Linnell, by Lieutenant-General Sir Ronald Weeks, 30 September 1942.

[78] Ibid.

[79] T.N.A., AVIA 10/135, Letter to Lieutenant-General Sir Ronald Weeks, by Air Marshal Linnell, 30 September 1942

Vernon, Deputy Director of Technical Development (D.D.T.D.) into the points raised by Browning. [80]

Response to Major-General Browning's Criticism

Browning failed to appreciate that R.A.F. Sherburn-in-Elmet required extensive structural modification which had commenced immediately from the time of the A.F.E.E. occupation and was not completed until December 1942. Despite the simplification and standardisation of temporary construction then employed by the Design Branches of the Air Ministry to expedite production, shortage of materials and labour delayed progress. [81]

Due to these difficulties the flying programme was redistributed between Sherburn, Ringway, Ricknall and Snaith whilst the construction of new runways and associated buildings was taking place. At the time of Browning's criticisms the infrastructure was not in place for the entire Establishment to be accommodated on station and a large proportion remained on detachment at Ringway which further complicated the research programme. [82]

Consequently, the investigation concluded that it was considered that maximum effort was being made on the reconstruction and the work of the Establishment was being carried out as efficiently as conditions allowed. [83] Similarly, morale and discipline at the Establishment did not appear to reflect the criticism in Browning's letter. McEntecart and Vernon concluded that:

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[80] T.N.A., AIR 29/512, A.F.E.E. Sherburn-in-Elmet, 1 October 1942.

[81] W. Anderson & G. Biggs, 'Design and Lay-Out for Airfields in War', in *The Civil Engineer in War: A Symposium of Papers on War-Time Engineering Problems* (London, 1948), pp. 86-88.

[82] Ibid.

[83] T.N.A., AVIA 10/135, Report on a Visit to A.F.E.E., by Air Commodore McEntecart & Group Captain Vernon, 1 October 1942.

> The morale of the Station is considered to be good, particularly so under the present difficult circumstances. There is enthusiasm for the work and a healthy keenness displayed by the Commanding Officer and the heads of the Flying and Technical Sections. It is difficult accurately to assess this owing to the Unit being dispersed with detachments to so many widely separated centres, but it is considered from what was seen at Sherburn that it would be comparable with that at other Experimental Establishments, and is satisfactory. [84]

The report also recognised the substantial reorganisation that had been undertaken since formation on 16 February 1942. The restructure included the addition of new senior staff, both service and civilian, and it was believed that these appointments would return substantial efficiencies once construction work was completed. [85]

However, despite the fact that the investigation did not reveal any substantial matters of concern certain recommendations were made. The most significant of which was a change in Commanding Officer, although it was clearly stated that this was no reflection upon the performance of Group Captain Harvey:

> It is now recommended that a change in Commanding Officer would be desirable. In this respect it is, however, strongly emphasised that this recommendation is based mainly on the fact that the present Commanding Officer has been in charge of this Unit since its formation, and should now be given a change. It is in no way associated with the comments in Major-General Browning's letter. [86]

[84] Ibid.
[85] Ibid.
[86] Ibid.

The replacement of such a senior member of personnel who had been involved with the development of the airborne capability from the outset and pushed for the formulation of strategic policy [87] can only have been detrimental to the success of the research programme. Despite the denial, it would appear that the decision to replace Harvey was made simply for political reasons to placate Browning.

Technical Points

The investigation also addressed various technical issues. With regards to the issue of the number of men that could be carried and dropped from the Wellington there would appear to have been inconsistencies in the Army requirements. It was concluded that eight was the maximum number of men that could be carried and dropped after the comfort of troops and the range of the aircraft were taken into consideration. [88] However, the Army amended this requirement to increase the maximum number of paratroops to ten and although this had been demonstrated to be feasible at 38 Wing it had not been approved by A.F.E.E. as suitable under operational conditions. It was concluded that the increased capacity was acceptable 'if longer sticks, cramped accommodation, and shorter range can be accepted as operational normalities.' [89]

The issue of the unsuitability of the Whitley V as a tug aircraft for the Horsa glider was more fundamental than simply a failure by A.F.E.E. to notify the Heavy Glider Conversion Unit and the limitations of the aircraft had been extensively documented. [90] The problem of obtaining suitable aircraft capable of conversion to the airborne role remained throughout the

[87] T.N.A., AIR 32/2, Airborne Forces, by Group Captain Harvey, 31 October 1940.
[88] T.N.A., AVIA 21/68, Wellington IC for Paratroop Operations (T.D.S./P.30): Trials, August - 31 October 1942.
[89] T.N.A. AVIA 10/135, A.F.E.E. Response to Major-General Browning's Letter, by R.D.L.2., 1 October 1942.
[90] T.N.A., AVIA 21/32, Whitley V as Tug for Gliders: Parts 1-3 & 5 (T.D.S./G.34), June 1942 - September 1943.

course of the war but became particularly prominent once the larger gliders entered service. The problems experienced at R.A.F. Brize Norton were summarised as follows:

> The main trouble at Brize Norton is attributable to the fact that the size of the aerodrome is less than two thirds of the distance required to meet the conditions laid down in the clearance. This has been aggravated by the Unit flying with a heavier Whitley load than the one specified in the clearance. Subsequent to release high oil temperatures were experienced when towing the Horsa at full load during the summer. Improved oil cooling was achieved by modification, and Flying Training Command confirmed on the 21 September that as a result their difficulties have been considerably reduced. [91]

Other methods were recorded as being under urgent consideration to 'still further to improve the Whitley V's performance as a tug, as well as improving the glider.' [92] Despite Browning's frustration there was little more that could be achieved by the way of experimentation with that particular aircraft type. The first Horsa prototype was not actually delivered to A.F.E.E. until March 1942 and on the 8th of the month the aircraft crashed due to the port engine of the Whitley towing tug catching alight. [93] The reality had little to do with the performance of the A.F.E.E. but with the fact that the Whitley was not capable as an operational tug and it was recorded that 'repeated efforts through the Airborne Forces Committee have been made to obtain more powerful tugs, but none were available.' [94]

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[91] T.N.A. AVIA 10/135, A.F.E.E. Response to Major-General Browning's Letter, by R.D.L.2., 1 October 1942.

[92] Ibid.

[93] T.N.A., AIR 29/512, A.F.E.E. Sherburn-in-Elmet, 8 March 1942.

[94] T.N.A. AVIA 10/135, A.F.E.E. Response to Major-General Browning's Letter, by R.D.L.2., 1 October 1942.

With regards to the carriage and deployment by parachute of Heavy Equipment, A.F.E.E. maintained that it had only been asked for advice as to the practicability of carriage and dropping of this equipment and that, contrary to Browning's insistence, there had never been an operational requirement issued for this function. [95] Indeed, 'it was considered that this could best be done between M.A.P. and the various contractors, the A.F.E.E. not being called upon to carry out practical tests.' [96] The report also included the following paragraph with regards to the Heavy Equipment to which Browning referred:

> On 24 September Air Staff informed us that they had no commitment for transporting such specialised items of military equipment, and did not consider diverting technical capacity justified until it was clear that it was proved necessary. [97]

Nevertheless, every effort was being made to realise the practicality of the request and Major Redwood, attached to M.A.P. in an Army liaison capacity, was in the process of trying to obtain drawings and the Army equipment listed.

However, the equipment arrived in various stages with the 6 lb. gun being delivered at the end of August 1942 and other parts later. The 3.7 Howitzer or 20 mm. Hispano Cannon for example had not been made available for experimentation at the time of Browning's letter. [98] But once equipment was available for the purpose of experimentation thorough evaluation was undertaken and, with regard to the dropping the 75mm Pack Howitzer M1, extensive analysis was conducted between 1943 and 1944. [99]

[95] Ibid.

[96] Ibid.

[97] Ibid.

[98] Ibid.

[99] T.N.A., AVIA 21/97, Dropping of 75mm American Pack Howitzer M1 (T.D.S./P.61), November 1942 1943 – February 1943, 19 April 1943.

The points raised regarding the Albemarle could not be considered in isolation of the wider recurrent theme that aircraft were utilised for purposes for which they had not originally been designed and that the production of gliders had preceded strategic developments. The initial request concerning the Albemarle was that investigations be conducted into its suitability as a paratroop aircraft rather than as a glider tug. However, the first reports into paratrooping from the aircraft were not issued until 1943 [100] and 1944. [101]

Meanwhile, in August 1942, emphasis was placed on the necessity for its clearance as a glider tug aircraft but owing to various technical troubles an example was not available for tests until 6 September. [102] By the end of October 1942 investigations were nearly complete but despite better performances being achieved through the application of different flying techniques the type could not be given full clearance as a tug due to the fact that cylinder temperatures remained in excess by 15° - 25° 'of the permissible engine limitations.' [103]

The fact that the Albemarle/Horsa combination had been flown by 38 Wing was not satisfactory technical evidence of its suitability as an operational aircraft. The performance evaluation conducted by A.F.E.E. calibrated for all climatic conditions and 38 Wing had no way of correcting to standard conditions or means of measuring engine cylinder temperatures. Consequently, although flight in the autumn might have easily been achieved it did not guarantee that a similar flight could be conducted under operational conditions on

[100] T.N.A., AVIA 21/100, Albemarle I Aircraft P.1438 for Paratrooping Operations (T.D.S./P.64): Trials, March 1943 - July 1943.

[101] T.N.A., AVIA 21/150, Albemarle I, II & V Aircraft as Troop Transport (T.D.S./P.117), April - July 1944.

[102] T.N.A. AVIA 10/135, A.F.E.E. Response to Major-General Browning's Letter, by R.D.L.2., 1 October 1942.

[103] Ibid.

the hottest day of summer. The report summarised the importance of comprehensive flight trials as thus:

> It is considered that the writer of the letter fails to appreciate fully all that is involved in testing and acquiring data to enable an aircraft to be given full clearance for operational use. Such clearance has got to cover the full range of temperatures between summer and winter, and without reducing the results obtained on one particular flight to cover this range a complete clearance such as is expected from an Experimental Establishment cannot be given. [104]

It would appear from the correspondence and subsequent investigation that Browning's criticism of A.F.E.E. was largely unfounded. However, apart from the sympathy conveyed by Lieutenant-General Weeks, the majority of the responses were generated by R.A.F. personnel who might naturally be defensive of any criticism of their service.

Although it is clear that Browning did not fully appreciate the complexities of the technical programme there was some truth in his closing observations that the R.A.F. appeared to lack enthusiasm for airborne forces. [105] This was particularly evident in the difficulties experienced by Air Marshal Linnell in the acquisition of estate and aircraft from the Air Ministry for the purpose of glider development. It was an ironic situation, particularly as the technical development of gliders had been instigated upon Air Ministry recommendations. [106]

[104] Ibid.

[105] T.N.A., AVIA 10/135, Letter to the Minister of Aircraft Production, by Major-General Browning, 26 September 1942.

[106] T.N.A., AIR 120/262, Note to Ismay on Assault Gliders, Author Unknown, 12 August 1940.

The following comments from Linnell dated 5 August 1942 to Director of Operations, Air Ministry, on the use of Hartford Bridge Aerodrome for Glider Development clearly demonstrated the tension and frustration between the key stakeholders and justified Browning's accusation with regards to lack of cooperation from the R.A.F.:

> From the correspondence on this and other similar matters where I have been forced to seek further accommodation from the Air Ministry for glider development, one cannot escape the idea that a feeling prevails in the Air Ministry and outside in the R.A.F. that this type of activity is being undertaken by the M.A.P. more as a matter of pure research than as an urgent operational development. It would help me greatly if you would correct this impression whenever it comes to your notice. [107]

The inference that the work of M.A.P., and thus A.F.E.E., was more of a theoretical orientation rather than a strategic operational requirement is not too dissimilar to Browning's constant insistence that 38 Wing had solved practical problems far more quickly than the dedicated experimental establishment. However, despite Linnell's connection to M.A.P. he displayed a certain sympathy with the Air Ministry's position:

> Nobody would be more thankful than I to see the last of glider development and to be able to direct the very great development effort engaged thereon, into other channels. But we have a definite and pressing commitment to the Air Staff to complete the development programme which will enable the Airborne Force to be fully prepared by a date in 1943. I am asking for

[107] T.N.A., AVIA 10/135, Memo to C.R.D., by Air Marshal Linnell, 5 August 1942.

nothing more than the bare minimum to enable us to complete this programme. [108]

The correspondence does not suggest that the development of airborne forces was a strategic priority but rather supports the evidence that technological development was politically driven. Despite the allocation of an airfield for the purpose of technical development there remained inadequate resource allocation in terms of aircraft and specialist personnel to pursue the application of the technology.

Acquisition of Aircraft and the Competition for Resources

The procurement of aircraft, particularly for the purpose of glider towing, remained a constant impediment to the development of airborne forces and the issue regarding the Albemarle highlighted the circumstances in which the A.F.E.E. had to operate. [109] As with the necessary utilisation of the Hawker Hector and Bristol Bombay by the C.L.S. and C.L.E. [110] the introduction of the Albemarle into R.A.F. service as a glider tug simply continued the British tradition of using obsolete aircraft types to fill the gap in airborne forces provision.

With regards to equipment, notwithstanding the constraints of weight and size when transported by air, the General Staff had control over procurement and development in line with operational requirements. Such control, however, did not apply with regard to the provision of aircraft for either training or operational purposes. [111] The Air Ministry produced guidelines in 1940 relating to aircraft provision that set the precedent for all future development. It was made clear that aircraft would only undertake parachute dropping duties as a secondary role and those types provided for training should also be available for

[108] Ibid.

[109] Air Ministry, *The Second World War 1939-1945, Royal Air Force, Airborne Forces*, pp. 42-43.

[110] T.N.A., AIR 29/512, D.U. Ringway, 27 March 1941.

[111] Air Ministry, *The Second World War 1939-1945, Royal Air Force, Airborne Forces*, p. 42.

operational duties to avoid unnecessary familiarisation training. [112] The function of glider towing had then yet to be considered. This would explain the initial dependence upon the Whitley and Greenacre has argued that it was issued even though it was obviously unsuitable for the purpose:

> It was admitted that the Whitley was technically far from ideal. The paratroops had to jump through a hole in the floor, a difficult and sometimes dangerous procedure. The best method of exiting an aircraft was through large doors in the side of the fuselage, as preferred by the Germans with their Junkers 52. [113]

However, although the Whitley was not suited to the airborne role at least it had initially been utilised in the bombing function for which it was originally designed. This was not the case with the Albemarle.

The Albemarle A.W.41 was the victim of a series of complex changes to specification and consequent modifications that ensured the aircraft had become technologically obsolete long before it entered service. The contract was originally awarded to the Bristol Aeroplane Company in 1938 for the production of a bomber aircraft but responsibility was transferred to Armstrong Whitworth after the specification was changed to that of a reconnaissance bomber. [114] There were striking similarities between the production technique of the Albemarle and that employed on assault gliders in that it was designed to be produced by a wide variety of non-aviation specialist subcontractors using limited materials. Oliver Tapper notes that:

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[112] T.N.A., AIR 2/7338, Airborne Forces: Provision of Aircraft, D Plans, 12 August 1940.

[113] J. Greenacre, *Churchill's Spearhead*, p. 66.

[114] O. Tapper, *Armstrong Whitworth Aircraft* (London, 1973), pp. 276-277.

> As an insurance against a possible shortage of exotic alloys and the devastation of British aircraft factories; the A.W.41 was to be built mainly of wood and steel, and was to be extensively sub-contracted to a variety of firms whose skills would not be fully employed on other war work. [115]

Although the principle was logical it resulted in a complex supply chain that was dependent upon the productivity of over one thousand sub-contractors scattered across the United Kingdom and this severely delayed production.

Meanwhile, in a contemporary article the construction technique was deemed to contain 'considerable ingenuity' [116] and the procurement process was also thought innovative:

> It is an interesting aspect of production methods that the Albemarle is completely sub-contracted to firms ranging from furniture makers to manufacturers of hairdressing equipment, and, the machine being split up into a number of major sections, all that is done finally is to assemble these sections into the complete aircraft. [117]

The procurement and manufacturing processes utilised in the production of the Albemarle and assault gliders were indeed similar but the implications for the former were inhibitive to performance.

Consequently, by the time solutions to the manufacturing techniques had been implemented and the aircraft was produced in numbers it was effectively redundant in its

[115] Ibid.

[116] 'Armstrong Whitworth Albemarle', *Flight Magazine*, 27 January 1944, pp. 87-91, p. 87.

[117] Ibid.

intended function. George Peden defends the aircraft industry and blames the procurement process for such obsolescence:

> British warplanes did not always fulfil their potential or the Air Staff's hope, but problems tended to arise from a mismatch of strategic or tactical doctrine with technical possibilities rather than with shortcomings of British aircraft design. [118]

In terms of the Albemarle the war-time administration was clearly aware of the difficulties. On 5 January 1942 the Minister of Supply (J.T.C. Moore-Brabazon), the Secretary of State for Air (Sinclair) and the Minister of Aircraft Production (Beaverbrook) presented a Joint Memorandum to the War Cabinet concerning the Albemarle.

The report concluded that, despite the delay, if the current contract for 500 airframes was cancelled then the government would have committed to 'expenditure in excess of 7¾ million pounds for no ultimate output.' [119] Consequently, the memorandum recommended that the current order for 500 aircraft should be completed as Albemarle deliveries would play a useful part in alleviating aircraft shortages and the first 200 aircraft would be employed as advanced trainers for Bomber Command. The following 300 aircraft could be employed as special transport/glider-tugs:

> At a later date, Albemarle deliveries in this form would be a welcome contribution to aircraft supply, as without them it would be a matter of great

[118] G. C. Peden, *Arms, Economics and British Strategy* (Cambridge, 2007), p. 115.

[119] T.N.A., CAB 66/20/40, War Cabinet Memorandum: The Albemarle Aircraft, by Lord Beaverbrook, A.H.M. Sinclair & J.T.C. Moore-Brabazon, 5 January 1942.

> difficulty to provide the aircraft needed for the transport and airborne forces role. [120]

Hence the future association of the Albemarle with airborne forces, despite its recognised deficiencies, was assured and there was little that the A.F.E.E. could produce to improve both tactical and operational effectiveness apart from creating safe operating procedures that were invariably below the expectations of the end-user.

Tapper argued that the production of the Albemarle did prove that 'extensive sub-contracting by firms entirely ignorant of aircraft construction could, given time, be made to work effectively' [121] and this was certainly the contemporary opinion:

> All in all the Albemarle, although officially classified as a second-line aircraft, appears to be a very good although unorthodox job, and when it is considered that well over 1,000 sub-contractors are engaged in its manufacture and there is no parent factory in the true sense of the term – only an assembly base – then those many people who have been concerned in its production deserve a very real measure of appreciation. [122]

However, such a technique was problematic in terms of meeting strategic military demand within the context of the war-time economy due to logistics and the supply of component parts. Should the principle have been applied holistically to the process of aircraft manufacture and procurement then it would have undoubtedly failed to meet production targets with disastrous strategic consequences.

[120] Ibid.

[121] Tapper, *Armstrong Whitworth Aircraft*, p. 285.

[122] 'Armstrong Whitworth Albemarle', *Flight Magazine*, p. 91.

In the Official History of the control of material Hurstfield concludes that 'an allocation system can function fairly smoothly as long as some coherent plan is followed.' [123] If a strategic requirement was clearly identified then the flexibility of the procurement system was crucial to successful production. However, without a clear strategic concept the limitations of the multiple sub-contract procurement system chosen for the production of gliders were obvious. If glider manufacture, and the subsequent development of airborne warfare had been a strategic priority from the outset it would have been unlikely that such a procurement method would have been adopted.

Despite initial support for multiple sub-contract manufacturing techniques, aviation journalists eventually became critical of the Albemarle and its associated procurement process. The following extract, entitled 'Dumbo of British Aircraft', was published in *The Times* on 27 January 1944:

> There is now in substantial production in England an aeroplane which those engaged in making it have nicknamed 'Dumbo' after the unwanted baby elephant of film fame. The Albemarle is the first British operational type of aircraft to be fitted with a tricycle undercarriage. It was designed at a time when the authorities expected a scarcity of light alloys and other specialized aircraft materials and when there was anxiety as to the adequacy of skilled aircraft manufacturing facilities. For those reasons wood and steel were used almost exclusively. Production is largely undertaken by sub-contracting firms, such as furniture manufacturers and shop fitters. [124]

[123] Hurstfield, *The Control of Raw Materials*, p. 89.

[124] "Dumbo" of British Aircraft', *The Times*, 27 January 1944, p. 6.

Edgerton argues that the failure of the Whitley in the 1930s as a bomber aircraft condemned Armstrong Whitworth to the role of an aviation specialist sub-contractor during the war and the company's reputation as a respected design firm consequently suffered. [125] Certainly the association of Armstrong Whitworth aircraft with airborne forces proved an unfortunate coincidence.

The poor performance of the Albemarle was also of increasing concern to the government and the controversy surrounding the aircraft continued throughout 1942. During a meeting of the War Cabinet on 11 September the future production of this aircraft was, once again, very much in the balance. The Committee on National Expenditure (C.N.E.) had submitted a report on the Albemarle to the Prime Minister. The C.N.E. considered its findings to be so damning that it had agreed that the evaluation should not be published on the grounds that it would be 'prejudicial to the public interest.' [126] The minutes of the War Cabinet meeting included the following extract:

> The Select Committee had reached the view that the money expended on the production of this aircraft had largely been wasted, and that its production should be stopped as soon as possible. [127]

Consequently, it was in the interests of the Air Ministry and M.A.P. to utilise the Albemarle to save embarrassment and the airborne forces were desperate for aircraft. But despite its poor performance A.F.E.E. encountered competition for procurement of the aircraft type.

At a War Cabinet meeting on 14 September 1942, the Minister of Production, Oliver Lyttelton, reported that the Soviet Union had requested transport aircraft from the British

[125] Edgerton, *England and The Aeroplane*, p. 116.
[126] T.N.A., CAB 65/19/28, War Cabinet Conclusions, 11 September 1942.
[127] Ibid.

government.[128] Although Lyttelton had regretfully informed the Soviet Ambassador, M. Maisky, that there were no transport aircraft in production in the United Kingdom and only one type under large scale production in the United States (the C-47 Dakota), he promised to investigate the feasibility of converting other aircraft for the purpose of transport:

> On enquiry he had found that there were 45 Albemarles available in maintenance units which in about 4 weeks could be converted to carry 20 men apiece. If further machines of this type were taken from production, we could supply to Russia 20 Albemarles a month up to a total of 250.[129]

The supply of transport aircraft, albeit converted Albemarles, to Russia in preference over British airborne forces not only resulted in continued Albemarle production but also further delay to the airborne forces programme. This further indicated that it was not a strategic priority.

The situation was not destined to improve and a survey into munitions production, conducted by Lyttelton, concluded that of the 23,671 aircraft produced in the United Kingdom in 1942 not one was a transport type.[130] The problem with producing a bespoke airborne design was not only the time in which a new type could be brought into service but also, more crucially, 'the loss in current output arising from alterations to tooling and falling labour productivity on unfamiliar operations'.[131] The policy that invariably remained one of continuous modification to existing types in order to minimise disruption to established production. Such a justification for the limitations to the flexibility of mass production was fundamentally detrimental to the development of airborne warfare.

[128] T.N.A., CAB 65/27/40, War Cabinet Conclusions (42) 124, 14 September 1942.
[129] Ibid.
[130] T.N.A., CAB 66/36/9, Munitions Production July-December 1942, by Oliver Lyttleton, 21 April 1943.
[131] J. Zeitlin, 'Flexibility and Mass Production: Aircraft Manufacture in Britain, the United States, and Germany, 1939-1945', *Technology and Culture*, Vol. 36, No. 1, 1995, pp. 46-79, pp. 53-54.

With extensive alterations the Whitley and Albemarle could be converted for operational use by airborne forces but even so the numbers produced in 1942 were only 540 and 165 respectively. [132] The reduction in the production of the Whitley was due to the fact that it had been superseded by the large four-engine bomber types. Under the inter-war expansion Scheme F it had been envisaged that the Whitley was simply a stop-gap production type that would be obsolete by 1939 when it was to be replaced by larger bomber versions such as the Vickers Wellington and Handley Page Hampden. [133] Then, after the entry of the U.S.A. into the war, the bulk of R.A.F. transport aircraft were provided by the United States and the table below displays the figures for the 1942 and 1943 agreements. [134]

Transport Type	**1942 Agreements**	**1942 Deliveries**	**1943 Agreements**
Argus C-61	126	114	-
Dakota C-47, 53	10	12	600
Lodestar C-60	22	31	-

Table 5: Transport Aircraft deliveries under Lend-Lease Agreement
Source: T.N.A., CAB 66/36/9, Munitions Production July-December 1942, by Oliver Lyttleton, 21 April 1943

Alongside this, the British were planning to put into production a transport aircraft based upon the Avro Lancaster, the York, and this was represented in the aircraft production schedule for 1943. However, although the York entered service with the R.A.F. in 1944 it was not suitable for use either in the parachute or glider towing role. British airborne

[132] T.N.A., CAB 66/36/9, Munitions Production July-December 1942, by Oliver Lyttleton, 21 April 1943.
[133] M. Smith, 'Planning and Building the British Bomber Force', *The Business History Review*, Vol. 54, No.1, 1980, pp. 35-62.
[134] T.N.A., CAB 66/36/9, Munitions Production July-December 1942, by Oliver Lyttleton, 21 April 1943.

operations were destined to remain dependent upon the supply of the Douglas Dakota and by the end of the war the R.A.F. had received approximately one-fifth, some 2,000 aircraft, of the total production under the Lend Lease agreement. [135]

Meanwhile, in May 1942 Churchill presided over a meeting of the Chiefs of Staff and stressed the importance of maintain the adequate aircraft supply or risk severely damaging the morale of the airborne troops who had seen little active service since training commenced in 1940. [136] The Prime Minister was told that such a reallocation of resources would reduce the bombing effort and the general consensus was that the situation could only be rectified through the Lend-Lease programme. [137] The following table clearly illustrates the British deficiency in the production of transport aircraft in comparison to the United States. The 92 transport aircraft scheduled for production by the British in 1943 were all Avro Yorks.

1942 (Actual Deliveries) Transport Aircraft			
United States	**United Kingdom**	**Total**	**UK as Percentage of Total**
1,980	**-**	1,980	**-**
1943 (Programmes) Transport Aircraft			
United States	**United Kingdom**	**Total**	**UK as Percentage of Total**
8,315	92	8,407	1%

Table 6: Comparison between British & American Transport Aircraft Production
Source: T.N.A., CAB 66/36/9, Munitions Production July-December 1942, by Oliver Lyttleton, 21 April 1943

[135] A. Pearce, *Lend Lease Aircraft in World War II* (Frome & London, 1996), p. 103.
[136] T.N.A., CAB 120/262, Airborne Forces: Minute to War Cabinet, by Winston Churchill, 22 June 1940.
[137] Air Ministry, *The Second World War 1939-1945, Royal Air Force, Airborne Forces*, p. 42.

The report from which these figures were taken fully acknowledged that the 'big American programme for transport aircraft has no material counterpart in the United Kingdom' [138] and in February 1943 the topic of transport aircraft production was debated in the House of Lords. Lord Strabolgi made the following observations on the problems of production:

> With regard to the question of transport planes, may I just make this observation? There is a shortage of certain raw materials and finished materials needed for the construction of combat planes. That is bound to be the case with the enormous programme of construction in this country, in the United States, in Canada, and in Australia, and now that India has joined in making aeroplanes. There is bound, therefore, to be a shortage of material, but you can make your commercial aircraft, your transport planes, of materials not required for the combat planes. You can make them, for example, of low carbon steel, of which there is a great plenitude both here and on the other side of the Atlantic, and you can make them of wood. [139]

Strabolgi's suggestions were in fact remarkably similar to those principles upon which the Albemarle had been manufactured. But the fact remained that the development of an airborne force without any foresight into the production of the aircraft necessary for its deployment was a failure in strategic planning and ensured that the British would always be reliant upon American assistance.

However, in October 1942 a further significant event occurred that curtailed the development of British airborne forces. Churchill put pressure on the Secretary of State for Air to increase the operational bomber squadrons based in the United Kingdom from 32 to

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[138] Pearce, *Lend Lease Aircraft in World War II*, pp. 103-105.

[139] Hansard Parliamentary Debates, House of Lords, Vol. 125, cc, 983-1046, 10 February 1943.

50 by the end of the year. In a report entitled the 'Strength of Bomber Command' [140] Sir Archibald Sinclair concluded that this was only possible if other commitments were temporarily and significantly reduced.

With regard to airborne forces Sinclair argued that 'to carry out the 50 squadron plan the flow of heavy and medium bombers to the Airborne Forces must be suspended over the next two months. This will mean that the Airborne Division must curtail its training programme and live for a time on its existing resources.' [141] The Prime Minster agreed with Sinclair's proposal and made the following response on 16 October:

> I agree that the development of the Airborne Division may be retarded for two months within the limits you suggest; but it will certainly have to be expanded and pressed forward in the spring, as it may have a great strategic and political role to play in the summer of 1943. [142]

It would appear that, even on the rare occasions when A.F.E.E. was able to source an aircraft capable of conducting performance trials, more important strategic developments took priority. However, Sinclair also warned that the diversion of aircraft from Bomber Command, however obsolete, would have an adverse effect on training:

> The Airborne Forces constitute a heavy commitment for medium bombers, which though obsolescent, are suitable for operational bomber training. Over 100 medium bombers are already so employed, and during the next

[140] T.N.A., CAB 66/30/11, Strength of Bomber Command: Exchange of Minutes between the Prime Minister and the Secretary of State for Air, by E.E. Bridges, 23 October 1942.
[141] Ibid.
[142] Ibid.

two months about 100 additional bombers will be needed to provide for further expansion and wastage. [143]

The result for the A.F.E.E. was inevitable. In October 1942 three Halifax aircraft, supplied to A.F.E.E. for the purpose of conducting experiments into the suitability of the type for paratrooping and glider towing, were removed to 38 Wing upon order of the Air Ministry. Investigation into the suitability of the Halifax for troop operations was conducted between November 1942 and August 1944 as and when aircraft were available. [144]

On 28 October 1942 Linnell wrote to the Chief of the Air Staff, Air Chief Marshal Sir Charles Portal, explaining the implications of limited aircraft availability upon the development programme and requested the support of the Air Ministry should further criticism result from the subsequent delay:

> The loss of these aircraft will inevitably cause a set-back in the very full programme which we are striving to complete for the Airborne Forces. We are constantly being pressed to hasten the answers to the outstanding problems. [145]

Portal sent the following response:

> The operation for which the Halifaxes are required was approved by the Chiefs of Staff and you cannot reasonably be criticised for resulting delays.

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[143] Ibid.

[144] T.N.A., AVIA 21/345, Halifax Aircraft: Trials for Troop Operations: Parts 1-3 (T.D.S./P.38), November 1942.

[145] T.N.A., AVIA 10/135, Letter to Air Chief Marshal Sir Charles Portal, by Air Marshal Linnell, 28 October 1942.

> If you are, you will certainly have the full support of the Air Staff in explaining them. [146]

Ironically, the operation to which Portal referred was likely the first allied glider-borne deployment of the War, Operation Freshman. However, Browning's accusations, and the associated correspondence, do suggest that the relationship between the key stakeholders was not always harmonious. Phillip Meilinger argues that inter-service tension was never far from the surface and originated in the inter-war period during when the competition for resources resulted in the competition amongst the three services to maintain autonomy:

> When funds are slashed there is a tendency for inter-service rivalries to flare as each service scrambles for its share of a severely shrinking budget. Post war Britain was no exception to this tendency. In a sense, the RAF's independent status was partly a millstone around its neck. In the inter-war period it found itself constantly on the defensive against the other services and the Treasury, who saw it as a frail and youthful little brother easily bullied. [147]

Naturally, this made the development of an operational doctrine for an airborne force more complicated. Not only was it dependent upon the close co-operation and shared resources of both the army and R.A.F. but Bond & Murray have suggested it also had to overcome an ambivalent attitude towards the introduction of new technology:

> There was a conspicuous lack of drive toward inter-arm and inter-service co-operation in the 1930s. The resulting ill effects became all too apparent

[146] T.N.A. AVIA 10/135, Letter to Air Marshal Linnell, by Air Chief Marshal Portal, 28 October 1942.

[147] P. Meilinger, 'Trenchard and "Morale Bombing": The Evolution of Royal Air Force Doctrine Before World War II', *The Journal of Military History*, Vol. 60, No. 2, 1996, pp. 243-270, p. 252.

in Norway and the western desert. Even in the area of combined operations (the use of air, sea, and ground to make a landing on enemy-held territory), where the British excelled in the Second World War, the record is less impressive. [148]

Throughout 1942 the Air Ministry had defended the strategic bombing policy in light of War Office demands for further resources for the deployment of airborne troops. In reality the Air Ministry was in favour of maintaining a small airborne force but believed that the resource requirement for large-scale airborne operations would be better utilised to 'substantially increase the size of the [bomber] attack on Germany.' [149] Invariably, the priority of the bombing policy prevailed but even though there were not enough aircraft to satisfy both requirements Churchill still insisted upon the development of an airborne capability.

Interference from the Air Ministry was not the only cause of delay to the research programme. Throughout October 1942 poor visibility and low cloud interrupted test work at Sherburn and there were only two dated entries in the Operation Records Book. But despite the poor conditions tug tests were carried out on the Albemarle, Wellington III [150] and Whitley V. Trials on the Douglas Dakota C-47, including the dropping of various carriers [151] and containers, [152] were also concluded for the first time. [153] Nevertheless, the weather conditions

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[148] B. Bond & W. Murray, 'The British Armed Forces, 1918-1939', in *Military Effectiveness: Volume Two*, pp. 111-112.

[149] Air Ministry, *The Second World War 1939-1945, Royal Air Force, Airborne Forces*, p. 47.

[150] T.N.A. AVIA 21/251, Wellington III Aircraft Towing Horsa Glider: Engine Cooling Tests Part 1 (T.5), June – November 1942, 20 January 1943.

[151] T.N.A., AVIA 21/71, Everest Carriers: Dropping Tests from Douglas C.47 Aircraft (T.D.S./P.35), October - December 1942 .

[152] T.N.A., AVIA 21/75, Dropping Tests of Panniers from Douglas C.47 Aircraft (T.D.S./P.39), October - December 1942.

[153] T.N.A., AIR 29/512, A.F.E.E. Sherburn-in-Elmet, November 1942.

at the airfield were inevitably restrictive and may well explain the Air Ministry's willingness to allocate Sherburn to the A.F.E.E. as it was unsuitable for operational use.

Operation Freshman

It is worth briefly examining Operation Freshman because its failure substantiated the argument presented by A.F.E.E. that without sufficient testing and the acquisition of performance data the operational and tactical effectiveness of any aircraft was compromised. The objective was the destruction of the Norsk Hydro Electric Plant in Norway which was the only considerable source of 'heavy water' [154] in Europe (a crucial ingredient in the development of atomic weapons). [155]

German scientists were amongst the first to recognise the significance of this substance in atomic weapons research. Early in 1940 a leading German industrialist had approached Norsk-Hydro with an interest in purchasing their entire stock of heavy water and produced a contract for increased output and regular supply. The other material crucial to the production of atomic weapons was uranium oxide, which the Germans possessed in abundance after the occupation of Belgium. At the time of their surrender in May 1940 the Belgians had the largest stock of this material in Europe. [156]

Access to the hydro electric facility was particularly restricted. The plant was surrounded by mountains and located roughly sixty miles due west from Oslo and eighty miles from the coast. [157] Due to the difficult location of the plant it was decided that it would be impossible to destroy it through conventional bombing, or through the landing of sea-

[154] In appearance heavy water was no different to ordinary water and was similarly composed of hydrogen and oxygen. Its method of production was via the repeated electrolysis of ordinary water.
[155] G. Molhollin, 'Heavy Water Cheaters', *Foreign Policy*, No. 69, Winter 1987-88, pp. 100-119, p. 101.
[156] Ibid, p. 103.
[157] R. Wiggan, *Operation Freshman* (London, 1986) p. 27.

borne troops and too risky to drop parachutists over the mountainous terrain without high casualties being sustained and alerting the enemy. Consequently, it was decided to deliver a team that consisted of 34 Royal Engineers from the 1st Airborne Division to the objective by means of two Horsa gliders, utilising their silent approach and thus retaining the element of surprise. The decision to utilise the Horsa glider could have been due to the urgency attached to the operation but it would appear somewhat cavalier to trust in the success of an untested technology. Nevertheless, the temptation to deploy glider-borne infantry may have proved too great.

The operation was conducted under the guidance of Combined Operations which requested three Handley Page Halifax bombers from the Ministry of Aircraft Production in September 1942, as alluded to by Portal. [158] The initial request to supply aircraft was refused and it required pressure from the Chief of Staff Committee to persuade the Air Ministry to provide two aircraft for the operation. [159]

Ultimately, due to weather restrictions over Scandinavia in the winter months, the operation was implemented with haste. On 19 November the force departed from Skitten airfield in Scotland *en route* to southern Norway. It soon became apparent to the tug crews that the promise of good weather over Scandinavia and a full moon to aid the location of the target was not forthcoming. In an attempt to escape the thick cloud above, one of the combinations flew below the cloud base to aid navigation. It is not known exactly what happened but the Halifax (W7801) struck the side of a mountain, killing the crew, whilst the Horsa (HS114) made a forced landing that killed the pilots and injured several of the occupants. The other combination was more fortunate and approached the Norwegian coastline at 10,000 feet where, as promised, the weather finally began to improve.

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[158] T.N.A. AVIA 10/135, Letter to Air Marshal Linnell, by Air Chief Marshal Portal, 28 October 1942.
[159] Wiggan, *Operation Freshman*, pp. 25-26.

Unfortunately, the Rebecca/Eureka navigation device that was to guide the combination to the target area was unserviceable, making locating the hydro plant impossible.

The Rebecca airborne transceiver and Eureka ground based transponder was a short-range radio navigation system that was capable of calculating the co-ordinates of a particular location. The technology originated from research into Air Inception techniques for night-fighters. The system was developed between 1940 and 1942 by Robert Hanbury Brown and John Pringle of the Telecommunications Research Establishment. [160] This establishment had previously collaborated with the Central Landing Establishment on the development of inter-communication between glider and the tug aircraft. [161]

Pringle recognised that Air Inception (A.I.) transceiver technology could be beneficial for airborne forces use and began experimentation with Hanbury by 'placing a transponder at an agreed spot and arranging for an A.I. equipped aircraft to release a smoke signal within a few yards of the hidden beacon.' [162] The technique was successfully demonstrated and the Rebecca/Eureka was developed for the Special Operation Executive. [163] Operation Freshman was the first operational deployment of the device and, although unsuccessful, following further refinement the system proved critical to the success of future British airborne operations. Freshman was a clear example of the benefits of operational research and that the application of new technology had the potential to significantly improve operational effectiveness.

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[160] J. Davis & B. Lovell, 'Robert Hanbury Brown 1916-2002', *Biographical Memoirs of Fellows of the Royal Society*, Vol. 49, 2003, pp. 83-106, pp. 87-88.

[161] T.N.A., AVIA 21/22, Present Position of Direct Wire Communication Between Tug & Glider, 18 February 1942.

[162] Davis & Lovell, 'Robert Hanbury Brown 1916-2002', pp. 83-106, p. 88.

[163] T.N.A., AVIA 26/272, Prototype Rebecca and Eureka Mk.1B Equipment, T.R.E. Technical Reports, 1 January - 31 December 1942.

However, unable to locate the target in deteriorating weather conditions, Squadron Leader Wilkinson was forced to turn for home with the Horsa still in tow. [164] Whilst crossing the coast the combination was further hampered by heavy cloud and icing conditions which resulted in the two aircraft parting, probably due to the tow rope icing and consequently breaking. The second glider, Horsa (DP 349), crashed a short distance from its counterpart and all the survivors were captured and became prisoners of the Gestapo. The failure of the operation, and the loss of a tug aircraft and crew, was not the greatest advertisement for the utilisation of glider-borne infantry and further supported A.F.E.E. in its claim that intensive experimentation and trial were necessary prior to the operational deployment of new technologies. For the personnel that actually survived the crash landings, however, the worst was still to come.

On 18 October 1942 Hitler issued a *Fuehrer Befehl* to all German commanders that accused Germany's enemies of conducting warfare using methods outside the international agreements of the Geneva Convention:

> For some considerable time, our enemies have been using methods of prosecuting war which are outside the internationally agreed terms of the Geneva Convention. Members of the so-called Commandos are behaving in a particularly brutal and underhand manner; it has been established that they themselves are, in some cases, recruiting convicted criminals who have been released in enemy territories. It has emerged from intercepted orders, that they are instructed, not only to shackle prisoners, but to kill, without hesitation, even unarmed prisoners, at any time when they believe that, as prisoners, they would constitute an obstacle to the furtherance of their objective, or might

[164] Wiggan, *Operation Freshman*, pp. 25-27.

> prove any other kind of encumbrance. Finally, orders have been found, in which the killing of prisoners is a fundamental requirement. [165]

In order to counteract the 'brutal and underhand manner' Hitler authorized the execution of all captured members of the special forces regardless of whether they were caught in uniform or armed. Consequently, the 23 survivors of Operation Freshman were executed in accordance with the following order:

> I order therefore: From hence forth, all those belonging to so-called Commando operations, either in Europe or in Africa, in enemy engagement with German Troops, even if they have the outward appearance of uniformed soldiers or fighting units, with or without weapons, either in battle or taking flight, should be wiped out, down to the last man. It is, in this case, quite immaterial whether they approach their operations by sea and air, or whether they arrive by parachute. Even when these individuals appear to be preparing to give themselves up, when they are discovered, they are, without exception, to be shown no mercy. In each instance, a detailed report on the incident is to be made available to the Supreme Commander, for publication in Armed Forces dispatches. [166]

The outcome of the operation exemplified the difficulties of effecting successful glider-borne operations and is evidence that the enthusiasm of the airborne forces to become operational was not sufficiently tempered by proven technological capability. More detailed research, development and training were required before the entire airborne contingent could become

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[165] A.G.T.A., 2006.2, *Fuehrer Befehl*, 18 October 1942.

[166] Ibid.

an effective operational force. However, the *Fuehrer Befehl* does confirm that the psychological effect of potential airborne operations did have an impact upon the enemy. [167]

Figure 5: In 1945 members of 1st Airborne Division stationed in Norway oversaw the exhumation of those members of Operation Freshman executed by the Germans The five bodies above were the survivors from Horsa DP349 and were reinterred at the Commonwealth War Graves plot at Vestre Gravlund near Oslo

Source: Image Courtesy of Glider Pilot Regiment Association Midland Branch

[167] Air Ministry, *The Second World War 1939-1945, Royal Air Force, Airborne Forces*, p. 239.

Further Delays

As during Operation Freshman, poor weather conditions were also experienced in England. This resulted in limited flight trials by A.F.E.E. in November 1942 but some experimentation with supply dropping from the Douglas C-47 was possible. [168] However, the Operation Records book entries for December were almost exclusively focused upon meteorological conditions, all of which were unfavourable for the purposes of experimental flying. There were a total of 8 non-flying days due to rain and low cloud and the weather was so poor throughout the duration of the month that tests were recorded as 'attempted' rather than 'carried out'. Consequently, the research and development programme was severely disrupted. [169]

However, despite continued poor weather and a further period of five consecutive none flying days between 16 and 21 January 1943 the month proved an intensive period of trials of glider and tug combinations and experimentation into the dropping of men and equipment from a variety of aircraft. One of the most significant trials undertaken was a tugging test of a Halifax and Hamilcar combination [170] that included an unsuccessful dive test of a Hamilcar at full load from 10,000 feet. It was recorded that upon landing the nose door opened and was consequently ripped off which caused damage to the wings and fuselage. [171] Despite the set-back the further availability of Halifax aircraft to A.F.E.E. following the withdrawal of 3 aircraft the previous October was a positive development.

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[168] T.N.A., AVIA 21/75, Dropping Tests of Panniers from Douglas C.47 Aircraft (T.D.S./P.39), October - December 1942.

[169] T.N.A., AIR 29/512, A.F.E.E. Sherburn-in-Elmet, December 1942.

[170] T.N.A., AVIA 21/252, Halifax Aircraft Towing Horsa & Hamilcar Gliders, Parts 2-4 (T.1), October 1943 - December 1945.

[171] T.N.A., AIR 29/512, A.F.E.E. Sherburn-in-Elmet, 30 January 1943.

In the meantime, in January 1943, following the failure of Operation Freshman, a public relations exercise was organised at Bulford Camp [172] to demonstrate the effectiveness and safety of the assault glider. [173] The audience consisted of senior military personnel and members of parliament who were all invited to join an air experience flight in two Horsa gliders. Unfortunately, the demonstration ended in disaster when both gliders crashed upon landing. Lawrence Wright, of the Glider Pilot Regiment, witnessed the incident and noted the following in his memoirs:

> The first pilot, perhaps distracted by the bunch of top officers breathing down his neck, misjudged the moment; landing in an uphill swerve, he wiped off first his nose-wheel, then the skid, then most of the floor of the glider, leaving a trail of firewood, bowler hats and brief-cases. [174]

The second pilot crashed onto the slope of Bulford Down in less spectacular fashion which nevertheless ended with some shaken politicians. Fortunately, the only casualties were Ellen Wilkinson, Parliamentary Secretary to the Minister of Home Security, who suffered a broken ankle and General Browning whom Wright recalled, 'wore a sling awhile.' [175] Despite the disaster technical investigations continued and it was rumoured that far from opposing the future development of the airborne force the politicians were 'inordinately proud of their share in the hazards of war, and dined out for weeks on the story.' [176]

The recording of incidents such as that experienced with the Hamilcar above demonstrated the importance of the work undertaken by the A.F.E.E. in ensuring that such

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172 The 1st Parachute Camp relocated from Harwick to Bulford Camp, Wiltshire, in 1942.

173 M. Dank, *The Glider Gang* (London, 1977), pp. 47-48.

174 L. Wright, *The Wooden Sword: The Untold Story of the Glider in World War II* (London, 1967), p. 100.

175 Ibid.

176 Ibid, p. 101.

occurrences were minimized. On 1 February Hengist glider and Whitley tug combination trials were undertaken [177] but on 4 February the Hengist was damaged due to the bifurcation of the tow rope. On the same day a Horsa was also damaged when it overshot the runway whilst carrying out a skid landing. Consequently, by 9 February all Establishment gliders were reported unserviceable. [178]

On February 12 the O.R.B. recorded extreme weather conditions that resulted in a hangar door being blown off and damage to a hangar roof. However, despite the conditions Horsa DP.493 was successfully ferried by air from No. 9 Maintenance Unit (M.U.) located at R.A.F. Cosford in Shropshire and a second Horsa, DG. 782, was also collected from the same location some two weeks later. The relationship between A.F.E.E. and No.9 Maintenance Unit is worth exploring in some detail in order to put the production, assembly and distribution processes of the Horsa, and indeed all British military gliders, into context and define the relationships that existed between stakeholders. But we need first to outline the manufacturing process.

Manufacturing Techniques: The Horsa Glider

The manufacturing techniques and processes utilised by the British in the production of wooden airframes during World War Two employed the application of some of the world's first advanced composite materials. [179] The technological knowledge transfer between material science and the woodworking industries cannot be underestimated and resulted in the application of new materials, processes and factory organization in the post-war period. For the purpose of this examination technological advances in manufacturing techniques will

[177] T.N.A., AVIA 21/264, Whitley V Aircraft Towing Hengist Glider (T.14), April 1943.

[178] T.N.A., AIR 29/512, A.F.E.E. Sherburn-in-Elmet, 9 February 1943.

[179] D. H. Middleton, "Composite Developments in Aircraft Structures - Part 1", *Aircraft Engineering and Aerospace Technology*, Vol. 64, Issue 5, 1992, pp. 2 - 8.

be confined to the context of the Horsa glider but the processes and technology were also employed in the production of other glider types utilised by British airborne forces.

Plywood had been used extensively in the production of aircraft during World War I but its application as a structural material involved many disadvantages, mainly due to the limitations of the adhesives then available. These glues were almost exclusively manufactured from animal or vegetable material and thus were not durable over long periods of time. They also encouraged parasitic growth which was difficult to detect and caused weaknesses within the aircraft structure. [180] Consequently, the limitations in material science resulted in the aircraft industry investigating alternative methods of construction principally in metal. This had already commenced late in World War I when aircraft grade timber became scarce.

Peter Fearon has suggested that the British government was aware of the limitations of wooden construction and consequently the Air Ministry specified all-metal airframes in tender documentation for military machines in the inter-war period:

> One of the prime reasons for this emphasis was that in a future war Britain could not depend on the necessary imports of timber for the airframe industry to expand rapidly. Other advantages in using metal were not hard to find. Such aircraft were easier to store, they were more robust in use and less prone to deterioration, particularly in the tropics, a great advantage in an economy-minded age. [181]

[180] Ibid.

[181] P. Fearon, 'The British Airframe Industry and the State, 1918-35', *The Economic History Review*, New Series, Vol. 27, No. 2, 1974, pp. 236-251, p. 239.

As late as 1937, in an article entitled ‘All-Metal Construction’ published in a popular contemporary journal, Marcus Langley maintained that only metal could be used in the construction of large airframes:

> It would scarcely be possible, for example, to contain within the thickness of the wing sufficient material to withstand the heavy loads on it unless that material were a strong metal capable of carrying high stresses. Although this argument does not hold for small machines, the medium and large-sized aircraft can be built with a lower weight in metal than in wood. The dividing line occurs where a weight of about 5,000lb. is reached. [182]

However, Peden presents the counter-argument that the preference of metal construction by the Air Ministry was detrimental to technological development:

> The move from wood to metal did not necessarily represent progress: the bias of American aircraft designers in favour of metal precluded promising projects involving wood, such as the de Havilland Mosquito of the Second World War, which drew upon the firm’s experience of using wood in the 1930s. [183]

Although Peden used the Mosquito as the basis for his argument the technological contribution of the glider programme to manufacturing techniques should not be underestimated.

[182] M. Langley, ‘All-Metal Construction: How Light Metals are Assembled to Produce Strong Airframes’, *Wonders of World Aviation*, Vol.1, 1937, pp. 169-174, p. 169.
[183] Peden, *Arms, Economics and British Strategy*, p. 116.

Indeed, in little over three years after Langley's article the technology of wooden construction had advanced to the extent which allowed Airspeed to design the Horsa with a wingspan of 88ft. and a fully loaded weight of 15,250lb. Such design was made possible by the development of synthetic resin adhesives. The new materials and developments in bonding techniques immediately preceding and during the Second World War allowed for the manufacture of plywood and other laminates of greatly improved structural qualities that were suitable for use in aviation.

The primary chemical advancement in adhesive technology, a significant development that resulted in Air Ministry policy towards the manufacture of wooden airframes being relaxed, [184] was the production of synthetic resins which were classified into two distinct groups; thermo-setting and thermo-plastic. Both processes required the application of heat and high-pressures in order to form a permanent bond between composite materials, thus a strong laminated material could be formed. The primary difference between the two adhesives was that thermo-setting resins, once set, were permanently fixed and thus could not be manipulated to liquefy or flux again, whereas thermo-plastics did not experience any chemical change and could be reheated and subsequently engineered into a desired shape and maintained that form once reset. [185]

With the technological progression in the production of wooden airframes established attention can now be turned to their application in the manufacture of the Horsa glider. The design of the Horsa not only had to incorporate the requirements of the armed forces but also the production capabilities of the woodworking industries to ensure mass-production was achieved as quickly and efficiently as possible. Hence all aspects of design,

[184] E. Lund, 'The Industrial History of Strategy: Re-evaluating the Wartime Record of the British Aviation Industry in Comparative Perspective, 1919-1945', *The Journal of Military History*, Vol. 62, No. 1, 1998, pp. 75-99, pp. 92-93.

[185] Middleton, "Composite Developments in Aircraft Structures, pp. 5-7.

manufacture, and the materials employed were intrinsically linked and can be considered in terms of Operational Research, as identified by Crowther and Whiddington, which was not simply confined to the analysis of operational deployment but also applied to production. [186]

In terms of the Horsa glider, scientific application was evident in both design and production. The cylindrical form of the fuselage avoided the complexities of double curvatures and the need for moulding the plywood skin which allowed sheets to be wrapped around the structure with minimum preparation. [187] The responsibility for developing the production techniques was through collaboration between the Airspeed production office and furniture manufacturer Harris Lebus; the latter of which devised a variety of ingenious methods of manufacture. [188] Unfortunately, no archival record exists of the development undertaken by the firm but the production techniques were printed in contemporary publications.

Ultimately, following the finalisation of the production process, work was extensively sub-contracted, principally to furniture and automotive firms. The primary advantages of sub-contracts have been already explored and this offered the opportunity for increased production. However, they were also more difficult to manage as they were one stage further removed from the relationship between M.A.P and the principal contractor, Airspeed. The Official History identified two principal types of contract, both of which were employed in the production of the Horsa:

> Sub-contracts fell into two broad categories, those for the supply to a main contractor of materials or specialised components or the performance of a

[186] Crowther & Whiddington, *Science at War*, pp. 91-92.

[187] W. E. Goff, 'The Horsa Glider – Part I.', *The Aeroplane: Aircraft Production Supplement*, October 1943, pp. 1-10, p. 3.

[188] 'Ferry to Ambassador: A Record of Airspeed Achievement over Twenty Years'. *Flight Magazine*, 23 February 1951, pp. 217-288, p. 221.

> particular process in manufacture; and those by which a main contractor sub-let part of an order for which he had not sufficient capacity immediately available. [189]

For ease of production all component Horsa parts were machined to practically finished size before being stored and then issued to each assembly department as and when required. The airframe was further divided for ease of production; for example the circular cross-section of the fuselage was sub-divided into six separate sections which could be manufactured independently as individual assemblies termed barrels. Goff notes:

> These sections became to be known as barrel and the method of building as barrel construction. The barrel conception suggested rotation and led to the design of revolving fixtures for the assembly of each section. [190]

The component parts in each barrel were principally bulkheads and frames manufactured from laminated spruce. These were formed into jigs following the application of adhesives and clamped together to provide the necessary high-pressure bond. An electrical heating system, invented by the organic chemist Dr. Norman Adrian De Bruyne, then reduced the curing time of the thermo-setting resins from hours to minutes thus accelerating production. A metal strip was introduced to the jig which was connected to a transformer, completing a circuit which heated the entire assembly to the required temperature. [191]

The adhesives mainly employed in the manufacture of Horsa bulkheads and frames were Beetle Cement and Gordon Aerolite. The latter was also developed by Dr. De Bruyne and had been approved for use in aircraft manufacture by the Air Ministry in 1937. Although

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[189] W. Ashworth, *Contracts and Finance* (London, 1953), p. 95.
[190] Goff, 'The Horsa Glider – Part I.', p. 3.
[191] Ibid.

the sale of Gordon Aerolite was initially slow the furniture industry quickly recognised its qualities and it ‘was the first synthetic structural composite material to be seriously used in the construction of aircraft.’ [192] Ultimately the product qualities proved so successful that the R.A.E. reported in 1940 that it could become a viable substitute for Duralumin fasteners. [193]

Once the necessary components had been manufactured each barrel was assembled on a rotatable fixture that allowed workers to remain at floor level throughout the process. After the basic structure of frames and bulkheads had been assembled the skin could be applied via rotating the entire barrel. The skin consisted of preassembled sheets of Birch plywood bonded together in a large heated press and then the entire panel was glued onto the structural framework using Beetle Cement.

The skin was laid diagonally in order to mitigate excess torsion throughout the fuselage when subjected to heavy strains. [194] The quality of the plywood was rigorously tested and manufactured in accordance with two separate British Standard Specifications, for either stressed or unstressed parts, to ensure that it was suitable for aviation use. The specification was detailed as follows in a 1946 publication:

> Plywood built with Birch veneers which are of even texture and straight grain is essential for all stressed parts; knotty, curly grained wood must not be used, as such wood is likely to crack along the annual rings when subjected to strain. The inner core and gluing is finally tested by passing

[192] A. J. Kinloch,’ Norman Adrian De Bruyne: 8 November 1904-7 March 1997’, *Biographical Memoirs of Fellows of the Royal Society*, Vol. 46, Nov. 2000, pp. 126-143, p.134.

[193] Duralumin was the principal metal alloy employed in stressed skin airframe manufacture. Fasteners were solid rivets applied by means of a pneumatic drill and snap process which closed between separate components.

[194] A. Wood & T. Linn, *Plywoods: The Development, Manufacture and Application* (London, 1946), pp. 404-405.

> thin sheets of plywood over a specifically constructed box housing lights of high intensity. By so doing the course of the grain is easily followed and any defects can be spotted by the inspector. [195]

Due to the scale of the completed barrel it was not practicable to utilise the electronic method of curing the thermo-resin and thus large clamps were wrapped around the entire structure until the adhesive had set. However, considerable time was saved in the production process by the application of the rotating fixture and the 1943 supplement produced in *The Aeroplane* stated that the scheme had 'proved very successful and considerable savings in man-hours have been achieved as a result.' [196]

Another example of close collaboration between design and production was evident in the process by which the completed barrels were connected together to form a complete fuselage section. The technique required each section to overlap towards the tail of the glider and thus alleviated the need for traditional complicated scarfed joints. The method was described in *The Aeroplane* as:

> One of the most important factors in making possible the barrel system of production. This arrangement, in fact, was a notable example of the co-operation and understanding established between design and production staffs before manufacture commenced. [197]

The joint was formed by expanding the aft section of each barrel with a special expander operated by a series of bulkhead mounted cams. Once expanded the skin of the leading barrel could be located over the one immediately behind and fixed with adhesive. The two

[195] Ibid,p. 404.
[196] Goff, 'The Horsa Glider – Part I.', p. 7.
[197] Ibid.

sections were then clamped together with a steel band until the adhesive had set. The entire fuselage was thus constructed via the technique and supported on trolleys to ease assembly.

Although the close co-operation between designers and manufacturers undoubtedly resulted in the efficient flow system by which component parts and airframe sections for the Horsa were produced, modifications were inevitable and had to be retrospectively introduced into the production process. One such example occurred in the requirement for the structure beneath the fuselage floor to be sprayed with cellulose dope prior to final assembly; the entire airframe required this treatment as a preservative against the growth of organic material. The process of sending each section to the main dope shop would have severely compromised the efficiency of the production line and thus an alternative solution had to be sought. [198]

In order to accommodate this requirement each fuselage section was effectively turned into a self-contained spray booth on the shop floor through the introduction of a fan that distributed the dope evenly throughout the internal structure thus allowing production to continue unimpaired. [199] The final process involved the covering of the entire structure with madapolam, [200] which was doped in order to form a tight fit that waterproofed the structure and generally protected the airframe from the elements. However, by May 1942 the Ministry of Supply experienced problems meeting the demand for cotton as many fabric workers had been recruited into munitions factories and M.A.P. for work in aviation. Consequently, M.A.P. had to relinquish 50 specialist workers per month from April 1943 to the Ministry of Labour in

[198] Ibid, p. 9.

[199] Ibid, pp. 9-10.

[200] Madapolam is strong cotton fabric manufactured with a linen weave pattern that creates good absorption qualities which makes it particularly suitable for treatment with aircraft dope to provide torsion over monocoque structures. It is often referred to as Irish Linen.

order to maintain supply; even when building aircraft from non-essential materials shortages were experienced. [201]

The production of the Horsa wing and tail units required a different methodology to that employing in the manufacture of the fuselage bulkheads because they contained more numerous components of widely varied size. The primary components in the Horsa wing and tail assembly were spars, constructed from laminated spruce, attached to which were a series of ribs of various sizes which determined the aerofoil of the wing. The outer wing panels, although large, were of relatively simple design and single spar construction. As Goff describes,

> Forward of the main spar, the position of which is roughly at one-third of the chord from the leading edge, the wing is covered with plywood skin. Structurally this portion is the main section of the wing and forms a torsion box of D section. Aft of the main spar the wing structure consists of light, lattice-type trailing ribs extending to the aileron and flap spar. Of this portion, only the aileron shroud and a corresponding chord-wise portion of the upper surface are covered with plywood skin. [202]

Where required, the plywood skin was manufactured and installed as previously described but in order to reduce weight the intermediate section between the main spar and the trailing edge of the wing was fabric covered and doped directly onto the wing ribs and associated structure. [203]

[201] Hurstfield, *The Control of Raw Materials*, pp. 322-323.
[202] W. E. Goff, 'The Horsa Glider – Part II.', *The Aeroplane: Aircraft Production Supplement*, November 1943, pp. 11-22, p. 10.
[203] Ibid.

However, despite the obvious success of the design and the associated technological knowledge transfer between multitudes of interdependent industries, the intensity of the programme caused disruption in the assembly and distribution spheres. On 4 September 1942 the issue of the Horsa Spares Schedule was discussed by the Airborne Forces Committee. Certain members raised concerns about 'the serious delays which had taken place in completion of the spares schedule' [204] and requested that help could be given to Airspeed:

> The possibility of obtaining assistance was discussed, but it was AGREED that draftsmen could be transferred only at the expense of more urgent work, and, although the meeting recognised the difficulties experienced in using an abbreviated schedule, it was AGREED that no alternative was open. [205]

The spares schedule was crucial not only for repair but also for essential modifications as required through performance evaluation by A.F.E.E. The shortage of specialist personnel was an obvious problem that was not only experienced by M.A.P. but also at contractor level and consequently required close cooperation with both the Ministry of Labour and the Treasury to ensure that all elements of the programme operated as efficiently as possible.

Despite the technological ingenuity evident at both the design and production phases, the availability of parts was restricted through the complexity of the supply chain and the absence of strategic coordination, particularly in terms of tug aircraft provision. Consequently, there was a detrimental effect upon the assembly and distribution of completed gliders and unnecessary effort expended that could have been applied effectively elsewhere.

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[204] T.N.A., AIR 20/5500, Minutes of the Airborne Forces Committee, 4 September 1942.
[205] Ibid.

Glider Manufacture, Assembly and Distribution

As previously stated the manufacture of glider components was the responsibility of a wide range of non-aviation specialist sub-contractors working on behalf of M.A.P. These included motor vehicle companies such as Austin Motors Limited which manufactured 368 Horsa fuselage sections and 798 centre fuselage sections between 1942 and 1945 at the Castle Bromwich Factory in Birmingham [206] and Morris Motors at Cowley which manufactured numerous glider components. [207] The L.M.S. Railway works at Derby were also employed in wing manufacture, [208] further emphasising the diversity of the supply chain.

However, component manufacturers were not responsible for the assembly of the finished aircraft and thus a complex supply chain was required in order to complete the transaction between manufacturer and supplier in the first instance, and supplier to end-user in the second. Thus contractors supplied components to M.A.P. who then managed the assembly process before operational issue to the services. The complexity of the supply chain was further exacerbated when the reluctance of contractors to commit to large capital expenditure, as experienced with Phillips & Powis during prototype development, [209] was transferred to the production sphere.

The initial order for 400 Horsa gliders was actually placed by the Chief of the Air Staff and Vice Chief of the Imperial General Staff, Major-General Nye, in February 1941 and the Air Ministry ordered a further 200 aircraft for investigation into their suitability as bomb carriers, all of which were to be delivered in the summer of 1942. However, the Air Ministry

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[206] R. Smith, *British Built Aircraft: Central & Eastern England* (Gloucestershire, 2004), pp. 55-58.

[207] D.W. Holder, ‘Richard Morris, First Lord Nuffield 1877-1963’, *Biographical Memoirs of the Royal Society*, Vol.12, 1966, pp. 387-404, p. 395.

[208] H. Hartley, ‘William Arthur Stanier 1876-1965’, *Biographical Memoirs of the Royal Society*, Vol. 12, 1966, pp. 488-500, p. 500.

[209] T.N.A., AIR 29/512, C.L.E. Ringway, 15 January 1941.

later cancelled the additional 200 aircraft and the reduction in the order resulted in a review of the delivery date. Consequently, M.A.P. informed the Air Ministry that due to the decreased production the aircraft could not be expected until February 1943 due to revision of sub-contractor involvement and programme. [210]

The reason for the delay was that any 'greater delivery would involve an increased jigging programme out of all proportion to the size of the total order.' [211] Ultimately, following a meeting between Harris Lebus and the Director General of Aircraft Production on 27 July 1941, neither M.A.P. nor the manufacturer considered the expenditure of any further capital required for rapid production to be justified unless the Air Ministry could assure them that the provision for additional production capacity would be exploited at some future date. [212] It would appear that despite the commitment to research and development there were still considerable difficulties in achieving operational deployment primarily because production commenced prior to the establishment of strategic policy and resource availability.

The absence of a defined concept made it difficult for the Air Ministry to give any certainty with regard to future production and resulted in a compromise in which M.A.P. promised that 300 Horsa aircraft could be delivered by July 1942 as long as the order was restored to the original figure of 600. [213] Ironically, even whist the new target was being negotiated the Air Ministry realised that it did not have anywhere near enough suitable aircraft available to act as tugs.

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[210] T.N.A., AVIA 15/1499, Horsa Group Committee: Minutes of Meetings on Production Matters, February 1943.

[211] Air Ministry, *The Second World War 1939-1945, Royal Air Force, Airborne Forces*, p. 13.

[212] Ibid.

[213] T.N.A., AVIA 15/1499, Horsa Group Committee: Minutes of Meetings on Production Matters, February 1943.

Air Chief Marshal, Sir Wilfred Freeman, Vice Chief of the Air Staff (V.C.A.S.) wrote to Major-General Nye on the 27 November 1941 to explain why the original order had been reduced. It is interesting to note that Freeman had previously occupied the position of Air Member for Research and Development and coordinated the rearmament of the R.A.F. prior to the responsibility being passed over to M.A.P. Consequently, Freeman was well placed to assess the reality of the glider programme and quantified the investment by stating that 'some idea of the total labour involved is gained from the fact that the cost of the order for Horsas in Great Britain alone' [214] was in excess of 3¼ million pounds. The note explained that the decision to reduce the order to 400 was based upon 'the number required to transport a Brigade Group' and the necessity for '400 Wellingtons or similar type aircraft to pull them.' [215] Although Freeman conceded that there could feasibly be two trips, even then 200 tugs would be required, and at the time of writing there were only 100 aircraft available that were capable of towing a Horsa glider. [216]

The War Office had not actually defined the number of gliders for production above those required for each operation but an approximation was calculated on 19 February 1941 based upon three airborne operations per year. Consequently, gliders were required in thousands rather than hundreds but production targets for the corresponding number of tug aircraft remained unresolved. [217]

The deficiency of tug aircraft, coupled with the inability to reconcile the strategic reality with the political aspiration, severely compromised the tactical and operational effectiveness of British airborne forces. The most acute example was the number of lifts required to deliver sufficient troop numbers during Operation Market Garden in which the

[214] T.N.A., AIR 20/2829, Letter to Major-General Nye, by Air Chief Marshal Freeman, 27 November 1941.
[215] Ibid.
[216] Ibid.
[217] T.N.A., AIR 2/7551, Glider (Code B, 5/8): Gliders Development & Policy, 19 February 1941.

enemy were able to isolate and neutralise small groups of airborne troops before reinforcements could arrive. [218]

However, the increased order of Horsas also had implications for both logistics and storage because there was no immediate idea of when the gliders would be used. The final assembly of Hotspur, Horsa and Hamilcar glider components was the responsibility of R.A.F. Aircraft Storage Units. A.S.U.s were created during the rearmament period to manage the storage and distribution of aircraft and components produced in the factory supply chain. Scott and Hughes summarise the principal responsibilities of the units as:

> Stores for reserve aircraft in transit from factory to squadron, but they also served as stores for obsolescent aircraft in transit to training squadrons or elsewhere, and as assembly shops for operational equipment. [219]

With regard to assault gliders the units were further responsible for all aspects of assembly and initially nine units were considered sufficient but this was later reduced to three and numbers 6, 9 and 15 Maintenance Units were allocated the task and set a production target of no less than 50 Horsa gliders per month. [220]

It is important to deduce the significance of the decision to allocate the task of assembly to such units and consider the strategic consequences. In a War Cabinet meeting on 6 September 1940 Beaverbrook argued that the Ministry of Supply should prioritise the construction of 50 new airfields for the purpose of A.S.U. accommodation. [221] Yet following Beaverbrook's request for prioritisation the Minister of Supply pointed out that the grant of

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[218] C. Hibbert, *The Battle of Arnhem* (London, 1963), pp. 34-35.

[219] Scott & Hughes, *Administration of War Production*, p. 359.

[220] T.N.A., AVIA 15/658, Organisation & Administration between 41 Group R.A.F. & M.A.P, February - May 1941.

[221] T.N.A., CAB 65/9/6, War Cabinet Conclusions 244 (40), 6 September 1940.

special priority ‘would necessarily operate to some extent to defer the completion of other essential works, for example, filling factories’, [222] another task considered a priority by M.A.P. Allocation of limited resources was critical and compromise was crucial to success but it also meant that there was little room for any extravagance not directly associated with strategic necessity. Indeed the diversion of resources to facilitate the development and deployment of the British airborne capability was a regular phenomenon but the airborne forces did not always benefit. A report concerning R.A.F. manpower requirements for 1944 suggested that the reallocation of bomber squadrons to the airborne forces would reduce the projected expansion of heavy bomber squadrons and this resulted in the curtailment of aircraft provision to the airborne troops. [223]

Figure 6 : Completed Centre Fuselage Section at Longbridge
Source: Image Courtesy of the British Motor Industry Heritage Trust

[222] Ibid.
[223] T.N.A., CAB 66/41/25, Manpower Requirements of the Royal Air Force For 1944, by A.H.M. Sinclair, 30 September 1943.

To return to the assembly of the assault glider, the processes involved remain little recorded and it is worth exploring the work of 9 M.U., R.A.F. Cosford, in some detail in order to put the scale of the exercise into context. Final assembly of the Horsa commenced at R.A.F. Cosford in May 1942 and on 30 July the following was recorded in the Operation Records Book:

> The first Horsa glider produced by the unit was towed away be a Halifax. It is understood that this glider was among the first produced by Horsa Holding Units and satisfaction was felt that its teething troubles had been quickly and satisfactorily overcome due to the good work put in by the glider erection staff. [224]

Although the teething troubles were not detailed it can be assumed that the nature of assembly would have required significant practice before maximum efficiency was achieved.

On 26 August Wing Commander Russell, HQ 41 Group, [225] visited the unit regarding the glider programme and reported satisfaction with the progress in output. [226] From September 1942 the Cosford glider programme focused entirely upon full-time Horsa production and by October 30 gliders were raised to the 'ready for air test' state. On 18 November it was recorded that Horsa DP.499 was ready for operational use. This was the fiftieth Horsa produced by the Unit. [227]

However, just as the logistics of assembly and storage were becoming effective a revision in the total number of gliders required, probably instigated following Sinclair's report

[224] T.N.A., AIR 29/967, O.R.B. No. 9 Maintenance Unit R.A.F. Cosford, 30 July 1942.

[225] R.A.F. 41 Group was part of R.A.F. Maintenance Command. M.A.P. assumed technical control of 41 Group in 1940.

[226] T.N.A., AIR 29/967, O.R.B. No. 9 Maintenance Unit R.A.F. Cosford 26 August 1942.

[227] T.N.A., AIR 29/967, O.R.B. No. 9 Maintenance Unit R.A.F. Cosford, 18 November 1942.

on the strength of Bomber Command, [228] had the potential to cause serious disruption at associated A.S.U.s. The Airborne Forces Committee meeting on 20 November 1942 opened with the news that a proposal was being considered by the Chiefs of Staff to substantially reduce the Horsa programme. In essence the decision was to either continue the production until an agreed number of aircraft had been produced and then close the programme down altogether, or slow down production and regulate the flow of deliveries form the contractors:

> In the course of the general discussion the second alternative was favoured. Wing Commander Patton (Overseer, Airspeed) said that by slowing down production it would be possible to incorporate the maximum number of modifications on the production line. [229]

Any change in the production programme had consequences upon both assembly and storage arrangements for completed gliders. It was desired that 41 Group should continue to assemble the Horsa but Wing Commander Russell pointed out that accommodation was becoming increasingly limited and 'it would be necessary to rely upon hangar accommodation erected at airfields.' [230]

The initial theory was that the gliders would be rapidly required and would thus not need under-cover storage. However, by November 1942 production was such that the disassembly of main planes was necessary to accommodate hangar storage to avoid deterioration to airframes through exposure to the elements. [231] The lack of an identified operation in which the accumulated materiel could be deployed had significant logistical implications.

[228] T.N.A., CAB 66/30/11, Strength of Bomber Command, by E.E. Bridges, 23 October 1942.
[229] T.N.A., AIR 20/5500, Minutes of the Airborne Forces Committee, 20 November 1942.
[230] Ibid.
[231] Ibid.

Fear of a reduction of the airborne forces programme may well explain the hurried addition of parachutists to the North African Campaign. However, British airborne deployment during Operation Torch in November 1942 was not only hampered by limited aircraft provision, but also by a lack of appreciation by senior military personnel of airborne forces' capability. The parachutists of the British 3rd Battalion, commanded by Lieutenant-Colonel Pine-Coffin, were deployed with complete disregard of the strategic and tactical limitations of such forces.

The objective, issued to the 1st Battalion for 14 November 1942, was to pick a drop zone near Beja and push east until the enemy was found. [232] Once located the parachutists were to stay with the enemy. John Weeks succinctly described the foolhardiness of such a mission objective:

> This was a remarkable battle plan as it had no clear objective and committed the battalion to the most dangerous type of warfare that can face airborne units, namely a lone battle in strange country with no follow-up force and little hope of resupply. [233]

Fortunately for the battalion the mission was postponed due to bad weather and did not take place until 16 November allowing the parachutists to link up quickly with advancing ground forces. The use of lightly armed parachutists in such an operation was undoubtedly an unnecessary risk of an expensive asset, but may not have been entirely the result of understanding on behalf of senior officers.

[232] Otway, *Airborne Forces,* pp. 74-75.

[233] J. Weeks, *Assault from the Sky* (Trowbridge, 1988), p.53.

A recurrent theme throughout the Second World War was that of sustaining morale amongst the highly trained and motivated men of the airborne forces. [234] Once out in theatre it is likely that proponents of airborne warfare, such as Browning, would have been eager for airborne forces to have been at the forefront of the fighting in order to raise the profile of the force. The commitment of parachutists to battle in a seemingly pointless mission appears to reflect a political, rather than a military, agenda that was certainly present at the time.

The final allied airborne action in North Africa commenced on 29 November. Lieutenant-Colonel John Frost's 2nd Battalion was dropped onto Depienne airfield with the objective of destroying aircraft based at Ouda, some twenty miles away. [235] The distance Frost's men were expected to cover on foot, before potentially having to engage the enemy in combat, and then achieve their objective, was remarkable and once again highlighted the lack of strategy and complete disregard of tactical and operational limitations. Despite the detailed research and technological development the correct application of the airborne capability remained misunderstood.

Back in Britain, the revised Horsa programme prevailed but manufacture steadily increased as the war progressed and the Minister of Aircraft Production confirmed a production target of 706 Horsas in 1943 and 120 Hamilcars. [236] On 2 December 1942 a conference was held on glider production at HQ No. 41 Group. The programme was discussed in detail and it was decided to confine it to just two units, of which Cosford was one. [237]

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[234] Air Ministry, *The Second World War 1939-1945, Royal Air Force, Airborne Forces*, pp. 37-38.

[235] Otway, *Airborne Forces*, pp. 78-80.

[236] T.N.A., CAB 66/36/9, Munitions Production July-December 1942, by Oliver Lyttleton, 21 April 1943.

[237] T.N.A., AIR 29/967, O.R.B. No. 9 Maintenance Unit R.A.F. Cosford, 2 December 1942.

As assembly output increased so did the requirement for air tests and the ferrying of gliders to other units. In order to maximise the efficient delivery of completed airframes a Glider Tug Flight was formed on 21 April 1943 under order of the Air Ministry. [238] This flight was comprised of 14 Whitley aircraft tasks with the transport of Horsa gliders to numerous Maintenance Units and their associated A.S.U.s for storage pending operational use (See Table 7.).

Unit	**RAF Station**	**County**
20 M.U.	RAF Aston Down	Gloucestershire
39 M.U.	RAF Colerne	Wiltshire
48 M.U.	RAF Hawarden	Cheshire
29 M.U.	RAF High Ercall	Shropshire
10 M.U. [239]	RAF Hullavington	Wiltshire
5 M.U.	RAF Kemble	Gloucestershire
51 M.U.	RAF Lichfield	Staffordshire
8 M.U.	RAF Little Rissington	Gloucestershire
No. 3 Aircraft Preparation Unit	RAF Llandow	Glamorganshire
19 & 32 M.U.	RAF St Athan	Glamorganshire
27 M.U.	RAF Shawbury	Shropshire
15 M.U.	RAF Wroughton	Wiltshire

Table 7: List of RAF Maintenance Units Utilised for Horsa Glider Storage
Source: Author

[238] T.N.A., AIR 29/967, O.R.B. No. 9 Maintenance Unit R.A.F. Cosford, 21 April 1943.
[239] RAF Hullavington was originally the home of 9 M.U. prior to relocation at Cosford.

Unfortunately, the entries in the Cosford O.R.B. are poorly detailed between December 1942 and March 1944 but improved substantially from this date onwards which allows for a detailed analysis of Horsa production at the unit. It was recorded for the first time on 30 April that the Horsa production target was not reached due to lack of components, [240] although the official history claimed that there were no Horsa glider shortages from June 1942 onwards. [241]

Indeed, component shortages became a recurrent theme throughout 1944 but a steady output of aircraft was still maintained. Devons argues that the management of component supply was the most difficult aspect of aircraft manufacture and this was particularly relevant to the sub-contract procurement processes employed in the manufacture of assault gliders:

> One of the most difficult tasks in aircraft production was to ensure that the plans for the production of these components fitted in with the plans for the output of complete aircraft and the need for spares. [242]

However, although some production delay was experienced in the Horsa programme it was minimal in comparison with that of the Hamilcar.

General Aircraft promised that 50 Hamilcar gliders would be delivered by the end of 1941 but total production only reached that number in 1944. Consequently, in the autumn of 1942 M.A.P. had become so concerned at the production rate that it appointed an Industrial Panel comprising three non-aviation specialist executives to carry out an investigation at General Aircraft Limited. The Industrial Panel issued its report on 24 September 1942 and

[240] T.N.A., AIR 29/967, O.R.B. No. 9 Maintenance Unit R.A.F. Cosford, 30 April 1944.

[241] Air Ministry, *The Second World War 1939-1945, Royal Air Force, Airborne Forces*, p. 62.

[242] Devons, *Planning In Practice*, p. 165.

concluded that G.A.L. had severely underestimated its own capacity to deliver the contract and original production figures were widely ambitious. [243]

Inadequacy amongst G.A.L. senior management also meant that the main sub-contractors responsible for component manufacture of the aircraft, principally The Birmingham Railway Carriage and Wagon Company and the Cooperative Wholesale Society, could not achieve production targets through lack of materials and fixings. On 28 July 1942 M.A.P. set up the Hamilcar Production Group [244] which effectively assumed control of the sub-contractor framework. The capability of General Aircraft was also scrutinised by the Select Committee on National Expenditure which was desperate to obtain a copy of the report prepared by the members of the Industrial Panel. [245] Nevertheless, despite the additional administrative resource, the poor performance of the parent company remained restrictive and only 344 Hamilcars had been produced by the time production ended in 1946.

By the end of 1944 some military strategists were beginning to believe that the assault glider would have little operational use post-war, particularly after the technological development of the helicopter. Air Vice-Marshal Collier, however, believed that they could but utilised in special airborne operations but only when the destruction of more valuable aircraft types could be negated:

> Gliders have a strong claim to employment and survival for special airborne operations. Even if helicopters could be developed capable of landing and

[243] T.N.A., BT 28/424, General Aircraft Ltd: Enquiry into Effectiveness of Management for Production of Hamilcar Gliders, 24 September 1942.

[244] T.N.A., AVIA 9/29, Sir Robert Renwick's Committee on Glider and Ancillary Equipment, 28 July 1942.

[245] T.N.A., CAB 66/36/10, Select Committee on National Expenditure WP (43) 160, by J. Anderson, 17 April 1943.

> rising vertically, it might still be found more economical to use gliders at points where enemy action could be expected to cause the destruction of the majority of craft affecting the landing. On the other hand the glider is less economical than the powered aircraft for normal air supply operations, provided that powered aircraft are available which can carry the same bulky equipment as gliders. Eventually it may be found that development of the parachute or of the rotor may enable us to land bulky equipment and numbers of troops by means of parachute and rotor. Developments of this sort would constitute a threat to the survival of the glider. [246]

On 1 August 1945 the Glider Tug Flight was disbanded at R.A.F. Cosford [247] from which point the remaining gliders produced were destined for Long Term Storage. But despite the cessation of production the Unit's association with gliders continued well into the 1950s.

The O.R.B. recorded on 30 November 1945 that 49 Horsa gliders had been prepared for storage and 17 Hadrian gliders had also been accepted. The British association with the American WACO CG-4A, renamed the Hadrian in British service, was first recorded at A.F.E.E. on 21 February 1943 when flight trials were conducted with the Whitley. [248] In December 1945 a further 10 Horsa and 10 Hadrian gliders were received at Cosford. [249]
In November 1945 policy dictated that the majority of airframes were stored in the open and consequently damage was sustained to 19 gliders on the night of 29/30 January 1945 during

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[246] A.C. Collier, 'Air Transport', *Journal of the Royal United Service Institution*, 90, 1944, p. 44.
[247] Ibid.
* These figures are indicative as production between 31 October and 31 December was not recorded in the O.R.B. but they do indicate the scale of the assembly programme.
[248] T.N.A., AVIA 21/37, Hadrian I Glider: Handling and Performance Tests (T.D.S./G.39), February - May 1943, 25 September 1943.
[249] T.N.A., AIR 29/967, O.R.B. No. 9 Maintenance Unit R.A.F. Cosford, December 1945.

high winds. The remaining Hadrian gliders were eventually scrapped by civilian engineers from Airspeed Ltd. on 31 October 1946. [250]

Throughout 1946 there were numerous occasions when Horsa gliders were once again listed on monthly production targets, presumably for trial at A.F.E.E. Most notably 16 Horsa I and 19 Horsa II gliders were produced between July and September 1946 although there is no evidence as to whether they were delivered. [251] The future application of gliders was raised in parliament in February 1947 and questions were asked as to whether they had been considered for use by the Air Training Corps or been privately sold and broken up for materials. The Secretary of State for Air, Mr Noel-Baker, made the following reply as to the number of gliders that had been scrapped:

> Since the end of the war, 1,295 gliders belonging to the Royal Air Force have been declared surplus to our needs, and 982 have been scrapped on the authority of the Ministry of Supply. [252]

Noel-Baker also confirmed that a further 300 had been bought on the private market for use as gliders but that the sale for raw materials had proved difficult as they contained 'very hard laminated plywood which takes a great deal of labour to break down and is almost unsalable, even as firewood.' [253]

Nevertheless, in 1949 it was recorded that numerous modifications were undertaken at Cosford to Horsa airframes and these may well have been utilised in numerous A.F.E.E.

[250] T.N.A., AIR 27/1459, O.R.B. No.9 Maintenance Unit R.A.F. Cosford January 1946 - December 1950, 31 October 1946.
[251] T.N.A., AIR 27/1459, July - September 1946.
[252] Hansard Parliamentary Debates, House of Commons, Vol. 433, cc, 341 341, 12 February 1947.
[253] Ibid.

investigations into the suitability of the Vickers Valletta as an Horsa tug [254] and similar experimentation conducted into the performance of the Handley Page Hastings. [255] On 30 April 1950 4 Horsa Mk.II aircraft were sent to an unknown destination presumably for technical purposes, although by then the A.F.E.E. had been amalgamated by A. & A.E.E. [256]

On 30 June 1950 information was received that 121 gliders were to be downgraded to Non-Effective Airframe status. Consequently, these airframes were disposed of by burning, a task that was recorded as ‘practically complete’ on 31 January 1951.[257] The final reference to the aircraft type was on 31 October 1954 when 15 Horsa airframes were collected by a private purchaser, presumably for materials. [258]

Despite the disposals the Horsa did make an unlikely contribution to the technical development of the De Havilland Comet, the world’s first jet-powered airliner. Aubrey Jackson summarises the importance of the Horsa in the development of the aircraft flight deck:

> Four-crew occupied the flight deck in the nose, the all-weather visibility from which had been carefully determined by means of flight trials with a repeatedly modified Airspeed Horsa towed by a Halifax. [259]

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[254] T.N.A., AVIA 21/308, Valetta Aircraft Towing a Horsa II Glider: Parts 1-3 (T.59), September 1948 - February 1949.

[255] T.N.A., AVIA 21/310, Hastings Aircraft Towing a Horsa II Glider: Performance and Cooling Under Temperate Summer Tropical Conditions (T.61), July 1948 - June 1949.

[256] T.N.A., AIR 27/1459, 30 April 1950.

[257] T.N.A., AIR 27/2007, O.R.B. No.9 Maintenance Unit R.A.F. Cosford January 1951 – May 1953, 31 January 1951.

[258] T.N.A., AIR 29/2084, O.R.B. No.9 Maintenance Unit R.A.F. Cosford January 1954 – May 1956, 31 October 1954.

[259] A.J. Jackson, *De Havilland Aircraft Since 1909* (London, 1978), p. 453.

The Comet also incorporated a tricycle undercarriage after the operational advantages of the design had been proven on both the Horsa and the Albemarle, both unlikely technological contributors to British jet-engine aircraft technology. In a 1952 article in *Flight Magazine* it was stated that a mock-up of the proposed Comet cockpit was fitted to a Horsa because the fuselage diameter was the same dimension as the rear bulkhead of the nose:

> Frequently the company's chief test pilot, John Cunningham, was to be found during the winter of 1946-47 at the control of the Horsa while the pilot of the tug scoured the sky for rain storms. [260]

Although the military application of the airborne glider had undoubtedly reached its technological zenith in 1940s the Horsa was still able to make a small contribution to the future development of British aviation technology.

A.F.E.E. March 1943 – December 1945

Despite the work of 9 M.U. at R.A.F. Cosford on the Horsa, in reality the A.F.E.E. were still in the very early stages of performance trials with the aircraft in March 1943. Weather conditions at Sherburn-in-Elmet continued to obstruct the flying programme and winds gusting to 30 miles per hour across the runway were recorded on 2 March that rendered two Albemarle tugs unserviceable following performance evaluation trials. [261] By 3 March all Horsa aircraft were deemed unserviceable and a replacement glider was collected from R.A.F. Cosford the following day but weather conditions were such that all flying was

[260] 'The Tale of the Comet: It's Past Development, Present Characteristics and Power Plant', *Flight Magazine*, 25 April 1952, pp. 495-499, p. 497.

[261] T.N.A., AVIA 21/268, Albemarle Aircraft Towing Horsa Glider: Parts 1 (T.18), March - April 1943, 23 October 1943.

abandoned later in the month due to winds in excess of 50 miles per hour gusting across the runway. [262]

A significant change in senior management took place on 6 March 1943 following the recommendations made in the report submitted by Air Commodore McEntecart and Group Captain Vernon on 1 October 1942. [263] Group Captain Ubee was posted to the Establishment and assumed command on 11 March 1943. In February 1943 contractors from Slingsby began to undertake trials at Sherburn-in-Elmet with the Hengist and Whitley tug. On 18 March tests revealed that the glider centre of gravity was some five inches beyond the aft limit and it was not until 28 March that representatives of the firm attempted further trials following modifications.

However, trials had to be abandoned on 2 April due to the recurrence of the fault. [264] Despite continued efforts and experimentation the Hengist force landed at Acaster on 4 April and was damaged after a similar incident at Sherburn the following day. Trials recommenced with Hengist 676 towed by a Whitley on 9 April although the future of the aircraft type was already under question as it was far behind the Horsa programme and was ultimately deemed incapable of satisfying the tactical and operational requirements of the airborne force. [265]

One notable visit was conducted on March 24 when Major-General Lee, General Officer Commanding-in-Chief 101st American Airborne Division, visited the Station accompanied by Group Captain Vernon, Deputy Director Technical Development at M.A.P., in connection with experimental work. This was an example of allied co-operation in the

[262] T.N.A., AIR 29/512, A.F.E.E. Sherburn-in-Elmet, 3 March 1943.

[263] T.N.A., AVIA 10/135, Report on a Visit to A.F.E.E., by Air Commodore McEntecart & Group Captain Vernon, 1 October 1942.

[264] T.N.A., AVIA 21/264, Whitley V Aircraft Towing Hengist Glider (T.14), April 1943.

[265] T.N.A., AIR 29/512, A.F.E.E. Sherburn-in-Elmet, 24 March 1943.

development of new technologies. In fact, Anglo-American knowledge transfer had already been initiated in relation to the construction of wooden aircraft due to a mutual dependence upon material sources. The majority of the timber employed in the construction of British wooden aircraft was only available in significant quantities from either the United States or Canada, principally fir, spruce and birch. Home sourced timber was mainly utilised in mining due to labour shortages of skilled woodsmen which prevented exploitation of material. [266]

On July 2 1943 the British Air Commission in Washington extended an invitation, on behalf of M.A.P., to the U.S. Department of Agriculture for representatives of the Forest Products Laboratory to visit England. The exchange was for the purpose of 'strengthening the present collaboration between our two countries on researches into the uses of timber in aircraft construction' and a report entitled 'The Use of Wood for Aircraft in the United Kingdom' was published in June 1944: [267]

> Ministry of Aircraft production officials most effectively arranged for interviews, conferences, travel, and visits to and with practically all of the United Kingdom governmental, industrial, and scientific operators and personnel concerned with wood aircraft and wood propellers. All in all, approximately 25 industrial operations were visited, and 73 industrial representatives, both technical and managerial, were interviewed.
> Of the United Kingdom government, 10 technical and research organizations were visited and 47 technical and scientific personnel interviewed. [268]

[266] Hurstfield, *The Control of Raw Materials*, p. 317.

[267] T.N.A., AVIA 10/111, The Use of Wood for Aircraft in the UK: Report by U.S. Forest Production Mission, by United States Department of Agriculture, June 1944.

[268] Ibid.

The specific aspect of interest in relation to A.F.E.E. was that the U.S. delegation conducted a visit to General Aircraft Limited to analyse the techniques utilised in the construction of the Hamilcar.

The most significant aspect of this evaluation was that the Hamilcar had been designed by means of mathematics alone and although A.F.E.E. was responsible for performance tests and modifications the aircraft had undergone little or no prototype trial before issue to the Establishment:

> General Aircraft Ltd. designed the Hamilcar glider completely by mathematical methods and no actual tests were made, although a half-sized prototype was constructed to check flying characteristics. The full-sized glider was then built and flown without being statically tested. In the design all the fundamental data available were employed, including much from the Forest Products Laboratory.[269]

Although the report recognised that the manufacturing techniques were the most effective then available it did consider the Hamilcar to be 'slightly above the best size for an all-wood construction from the point of view of maximum strength for the weight.' [270] Nevertheless, the Hamilcar design proved technically successful, notwithstanding the production complications. [271] The report conceded that General Aircraft and DeHavilland, the latter of which was then working on the Mosquito and in ownership of Airspeed, were the 'two most forward looking companies' [272] then designing in wood and that they set an example of what

[269] Ibid.

[270] Ibid.

[271] T.N.A., BT 28/424, General Aircraft Ltd: Enquiry into Effectiveness of Management for Production of Hamilcar Gliders, 24 September 1942.

[272] T.N.A., AVIA 10/111, The Use of Wood for Aircraft in the UK: Report by U.S. Forest Production Mission, by United States Department of Agriculture, June 1944.

could be achieved through a scientific understanding of the properties of timber and experience in its application.

Research Programme

The weather conditions were poor early 1943 [273] but dropping tests with panniers from the Horsa glider were completed. [274] Fortunately, the weather then improved considerably and resulted in a period of intensive flying activity of different glider/tug combinations. Experimental work continued throughout July and included dummy and live parachute drops from the Horsa glider. [275] Air Marshal Babington, Air Officer Commanding Flying Training Command, Air Vice Marshal Jones, Controller of Research & Development, and Group Captain Vernon, Director of Technical Development at the Ministry of Aircraft Production, visited the Station on 12 July to see for themselves the work of the Establishment.

However, on 19 July M.A.P. reported to the Treasury that the pressure of the experimental programme had resulted in delays and consequently a re-assessment of A.F.E.E. staffing had been undertaken. Additional resources were requested because, due to the demand for aircraft, it had been discovered that modifications had not been adequately tested before they were issued for service use:

> One of the prime causes of the delays has been due to the fact that flight trials have taken place without the latest up to date modifications being incorporated in the towing aircraft; furthermore, independent checking action at Headquarters has revealed that aircraft have been passed for

[273] T.N.A., AIR 29/512, A.F.E.E. Sherburn-in-Elmet, April - May 1943.
[274] T.N.A., AVIA 21/91, Dropping Tests of Panniers from Horsa Glider (T.D.S./P.54), September 1942, 22 January 1943.
[275] T.N.A., AIR 29/512, A.F.E.E. Sherburn-in-Elmet, 15-29 July 1943.

issue to the Service on which modifications have been made and to which essential equipment has been added which have resulted in an impracticable or unsafe centre of gravity. [276]

It could be construed from previous correspondence between M.A.P. and the Treasury that this was yet another attempt to secure additional A.F.E.E. resources. However, entries in the O.R.B. certainly suggested a high level of activity when the weather permitted and service pressures were evident as witnessed in General Browning's observations. [277] M.A.P. continued to detail the exact nature of the failures at A.F.E.E. as justification for urgent additional senior scientific support:

> These failures are attributable to the over loading of the staff employed at A.F.E.E. in T.D.S. 1 and T.D.S. 2 Sections which deal respectively with tug and glider performance, and there is a need for a senior and experienced officer to be employed to ensure that such modifications to aircraft which have a bearing on the work carried out at A.F.E.E. are incorporated in the aircraft before the flight tests are made. [278]

The dangers associated with the issue of aircraft for service use which had not undergone adequate flight trials and scientific analysis were obvious and consequently attracted little scrutiny from Treasury officials.

A hand written note dated 27 July contained in the relevant National Archive file agreed to this request:

[276] T.N.A., T 162/755, Letter to A.W. Gomme, by R.E. Bone, 19 July 1943.
[277] T.N.A., AVIA 10/135, Attack on A.F.E.E., by Major-General Browning, 26 September 1942.
[278] T.N.A., T 162/755, Letter to A.W. Gomme, by R.E. Bone, 19 July 1943.

> This is yet another case where we cannot afford to quibble about a post in view of the urgency with which certain defects must be put right. But here again the job, as such, should not last very long and we should ask for review in say 6 months' time. [279]

Consequently, formal approval for the creation of an additional Senior Technical Officer was granted on 30 July. [280]

Cooperation may well have been due to the fact that in July 1943, despite the lack of research and evaluation of the technology; British airborne forces were deployed in Sicily during Operation Husky. The 1st Air Landing Brigade was tasked with the capture of the Ponte Grande Bridge which spanned the canal at the entrance to the sea port of Syracuse. Once secured the Brigade was then expected to capture and secure the entire port in anticipation of the arrival of the seaborne forces. [281] Some 2,000 men from the Brigade embarked from North Africa on the evening of 9 July in Horsa and WACO CG-4A assault gliders towed by Dakotas from 51 Wing USAAF and a small detachment of aircraft from 38 Wing RAF. However, adverse weather conditions and inexperienced American tug crews severely compromised operational effectiveness. [282] Many gliders were dropped too short and landed in the sea which resulted in many troops being drowned.

The indiscipline and inexperience of the American tug pilots was again prevalent on 13 July when a large British airborne force was tasked with the capture of the Primosole Bridge. Under the command of Brigadier Lathbury, 1,856 men of the 1st Airborne Division were flown by night from North Africa in 113 parachute aircraft and 16 gliders. As they

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[279] T.N.A, T 162/755, Internal Memo, by S.G. Innes, 27 July 1943.

[280] T.N.A, T 162/755, Letter to R.E. Bone, by S.G. Innes, 30 July 1943.

[281] Lord Carver, *War In Italy 1943-1945* (London, 2001), p. 11.

[282] Otway, *Airborne Forces*, pp. 119-121.

approached the coast they were engaged by anti-aircraft fire which resulted in the aircrews becoming scattered and confused. The result was that only 295 officers and men, some 16% of the original force allocated to the task, were dropped accurately enough to carry out the operation. [283] The strategic ineffectiveness of the British to provide adequate tug aircraft in accordance with the glider programme resulted in a dependency upon poor quality American assistance that the technical programme was incapable of resolving.

The dangers associated with an intensive experimental flying programme, coupled with major redevelopment of the Station, resulted in numerous accidents and subsequent delay. On 28 July 1943 a contractor's lorry carrying out resurfacing works collided with a Short Stirling during resurfacing works: 'The lorry belonging to Cawood, Wharton & Company was badly damaged; the driver, Mr. Stiano, received a four inch laceration of scalp which necessitated the insertion of eight stiches.' [284] A further accident occurred on 11 August that involved a Hudson aircraft, piloted by the Station Commander, Group Captain Ubee, crashing in a field some 2 miles from Sherburn-in-Elmet. The crew were all rescued but treated for injuries, and Group Captain Colquhoun was posted to A.F.E.E. to take command of the Station whilst Ubee recovered. [285] Although it is unclear what activity the aircraft was involved in, extensive air tests were conducted with the type throughout 1943 including experimentation to determine its suitability as a tug for the Horsa, [286] Hadrian (WACO CG-4A), [287] and twin towing of the Hotspur. [288] The technical programme could not keep pace with the desire to engage the forces on operations.

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[283] Norton, *The Red Devils,* p. 29.

[284] T.N.A., AIR 29/512, A.F.E.E. Sherburn-in-Elmet, 28 July 1943.

[285] T.N.A., AIR 29/512, A.F.E.E. Sherburn-in-Elmet, 11 August 1943.

[286] T.N.A., AVIA 21/256, Hudson III Aircraft V.9228 Towing a Horsa Glider (T.7), July 1943 - September 1943.

[287] T.N.A., AVIA 21/258, Hudson III Aircraft V.9228 as Tug for a WACO Glider, Part 2 (T.8), March 1943, 3 May 1943.

[288] T.N.A., AVIA 21/257, Hudson III Aircraft V.9228 Towing Two Hotspur Gliders, Part 1 (T.8), February 1943, 16 March 1943.

Weather remained favourable throughout September and experimental work, predominantly with glider towing and container dropping, continued with the addition of the Vickers Warwick [289] which was trialled as a glider tug. [290] Interestingly, trials were still continuing with the Slingsby Hengist towed by a Whitley tug even though by this late stage it was obvious that the glider was both unsuitable and production unachievable for operational use. Such experimentation with a redundant type would appear somewhat indulgent following the previous assertion of the pressure of the research programme. On 20 September a successful test was carried out with a Hamilcar and Stirling tug combination [291] but due to strong winds the trials was recorded as 'shaky'. [292]

Unfortunately, flying accidents remained frequent and on 20 December a Court of Inquiry convened to investigate and report on a flying accident a few days earlier involving another A.F.E.E. Hudson. The aircraft crashed on the south west corner of the aerodrome and the three occupants, Flight Lieutenant Palmer, Lieutenant Murphy R.A.M.C. and Corporal Mason were all thrown from the aircraft. All patients were transferred to York Military Hospital but Corporal Mason's injuries, a compound fracture of the skull, proved fatal and he died at 20.15 hours. On 30 December 1943 a further Court of Inquiry was convened to investigate and report on a flying accident which occurred three days earlier involving the death of Private Daly. On 23 February 1944 Mr Walker, a civilian employee of the Ministry of Aircraft Production, sustained multiple injuries during experimental flying and was admitted to the Station Sick Quarters. [293] Numerous experimental flights were recorded in the O.R.B. for the day of Mr Walker's crash. Despite the conditions being noted as 'showery all day with

[289] The Vickers Warwick was a larger version of the successful Wellington. It was initially conceived as a bomber during the 1930s but was found to be under-powered. The aircraft served in a variety of roles including Coastal Command, Transport Command and Civilian passenger services.
[290] T.N.A., AVIA 21/277, Warwick I Aircraft BV.230 Towing a Hadrian Glider (T.27), September 1943.
[291] T.N.A., AVIA 21/263, Stirling I Aircraft BK.645 Towing Hamilcar Glider (T.13), May 1943, 23 August 1943.
[292] T.N.A., AIR 29/512, A.F.E.E. Sherburn-in-Elmet, 20 September 1943.
[293] T.N.A., AIR 29/512, A.F.E.E. Sherburn-in-Elmet, 23 February 1944.

heavy cloud,' it is likely that the injuries were sustained during towing tests between either a Horsa and Halifax or Albemarle and Horsa tug combination. [294]

Meanwhile, M.A.P. submitted a short report on 14 January 1944 to the Treasury in relation to the additional Senior Technical Officer approved on 19 July the previous year. The report requested the extension of the position:

> We have carefully considered the position in the light of prevailing circumstances and are satisfied that there is still a need for a senior and experienced officer to be employed on this work. [295]

The post was subsequently extended on 24 January by the Treasury on the same terms as it was previously granted. [296]

Senior Officers continued to visit the Station to inspect its work and on 9 April 1944 Brigadier Davies, Deputy Director Air, Brigadier Flavell, Commandant Airborne Establishment, Lieutenant Colonel Franlyn, War Office, and Lieutenant Colonel Deakin, Airborne Forces Development Centre, arrived to observe the experimental dropping of a Tractor Unit and 6 – Pounder Gun combination by Halifax. [297] The tests had first been conducted by A.F.E.E. on the 22 and 23 November 1943. [298] The A.F.E.E. also received numerous scientific visitors. Mr Coombes and Dr Woods of the Department of the Council of Scientific and Industrial Research, Australian Government, were in attendance on 13 July 1944.

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[294] Ibid.

[295] T.N.A., T 162/755, Letter to A.W. Gomme, by R.E. Bone, 14 January 1944.

[296] T.N.A., T 162/755, Letter to R.E. Bone, from S.G. Innes, 24 January 1944.

[297] T.N.A., AVIA 21/146, Anti-Tank 6 Pdr. Gun and Ford 5 CWT Car: Dropping Tests (T.D.S./P.113), March - June 1944.

[298] T.N.A., AIR 29/512, A.F.E.E. Sherburn-in-Elmet, 23 November 1943.

Despite the repetitive nature of the research and evaluation programme some interesting technological experimentation took place. For example, air tests were conducted with the Whitley for the first time 26 July 1944 to determine the practicability of twin towing the Horsa glider. [299] Although the Whitley V had already been proved underpowered as an operational tug it would appear ambitious to have attempted such an experiment. However, the combination was tested throughout the rest of the month and one can assume that the technique would only have been employed for the purpose of ferrying empty aircraft.

Throughout 1944 more heavy-bombers became available for experimental purposes as production increased and in August flight trials were predominantly conducted with a Lancaster and Hamilcar combination. [300] The O.R.B. detailed a variety of heavy bomber types attached to A.F.E.E., including the Lancaster, Halifax [301] and Short Stirling. [302] Experiments were also conducted on 26 July with a Whitley pick-up of a Hotspur glider and further ‘successful’ tests of the technique were conducted on 22 August. [303] The method by which pick-up was achieved involved the erection of a scaffold in front of the glider with the tow rope draped across the top. The modified tug could fly low over the apparatus and snatch the tow rope with an arrestor hook, similar to those used by naval aircraft for landing on aircraft carriers. This technique was used by the British during the Burma campaign to evacuate wounded via CG-4A and extensively by the Americans to retrieve gliders from Holland following Operation Market Garden. [304]

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[299] T.N.A., AVIA 21/280, Whitely Aircraft: Twin Tugging of Horsa Gliders (T.30), by W.G. Mends & J.H. Bishop, May - August 1943, 15 January 1944.

[300] T.N.A., AVIA 21/286, Lancaster III Towing a Hamilcar Glider (T.36), October 1944.

[301] T.N.A., AVIA 21/132, Supply Dropping of Containers from Halifax II and V Aircraft (P.99), September 1944.

[302] T.N.A., AVIA 21/282, Stirling IV Aircraft EF.432 Towing Hamilcar Glider (T.32),October 1944.

[303] T.N.A., AIR 29/512, A.F.E.E. Sherburn-in-Elmet, 22 August 1944.

[304] T.N.A., AIR 37/962, IX Troop Carrier Command Report on Operation Market, May 1945.

Glider towing and live paratroop equipment descents were the principal activities at A.F.E.E. throughout the remainder of 1944 and into early 1945. However, further disruption occurred with the relocation of A.F.E.E. to R.A.F. Beaulieu in Hampshire in January 1944. The weather conditions in Yorkshire had proved particularly unfavourable for experimental flying and relocation was inevitable if the programme was to provide rapid and effective technical solutions.

Once in Hampshire the most significant addition to the technical programme was the responsibility for helicopter development and flight tests commenced in September 1945. Helicopter air-log tests were undertaken in October 1945, although the type was not recorded. But observation tests were undertaken with a captured German machine, although no reference to the type or manufacturer was noted. [305] However, a report was submitted in 1946 that detailed flight tests of a captured German Foche-Achgelis FA-223. [306] The design was originally intended as a substitute to E-boats in mine laying attacks. [307] and in 1940 became the first helicopter in the world to obtain production status. [308] Rotary wing aircraft development and testing thus became a substantial part of the A.F.E.E. programme and understanding German technology was an important aspect of analysis.

M.A.P. & Treasury Correspondence (August 1944 – June 1945)

On 30 August 1944 M.A.P. sent the Treasury a further report regarding the Senior Technical Officer position that had been sanctioned on 30 July 1943 and subsequently

[305] T.N.A., AIR 29/512, A.F.E.E. Beaulieu, October 1945.

[306] T.N.A., AVIA 21/238, Foche-Achgelis FA-223 Helicopter No. V14 (Res/20), January 1948 – July 1949.

[307] 'German Helicopters', *Flight Magazine*, 15 August 1946, pp. 157-157, p. 157.

[308] The FA-223 was a twin three-bladed rotor design and carried two pilots and up to four passengers or an equivalent load.

extended on 14 January 1944. [309] Once again, M.A.P. argued that there was little prospect of the disappearance of the position for the duration of the war but it did suggest that the post could potentially be down-graded, presumably to allow A.F.E.E. control of the staff complement under delegated authority:

> We have now reviewed the duties of this post and are satisfied that there is still need for a senior and experienced officer to be employed on this work. There are no prospects of a decline in the amount of work during the war with Germany and Japan. [310]

The Treasury formally agreed to a six month extension on 6 September 1944 but added that 'we hope that at the end of that period it will be possible for you to downgrade this post.' [311]

Additional scientific staff were needed in order to meet the demands of the experimental programme. After the relocation of A.F.E.E. to R.A.F. Beaulieu in December 1944 Mr Reffell, a representative of M.A.P., visited the Establishment in April 1945 to assess a proposal for these recruits. He submitted a summary to the Treasury on 28 April 1945 with the recommendation that a Principal Technical Officer be appointed:

> The new man will be required to act as Chief Engineer and Deputy to the Chief Technical Officer and to superintend the work of certain sections. The work of A.F.E.E. is very varied and extensive including Gliders and towing apparatus, transport work (including the transport of troops and equipment), parachutes (both man carrying and supplies dropping), the

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[309] T.N.A., T 162/755, Letter to F.C. Newton, by L.N. Reffell, 30 August 1944.
[310] Ibid.
[311] T.N.A., T 162/755, Letter to L.N. Reffell, by F.C. Newton, 6 September 1944.

> design of containers for supplies dropping and, latterly, performance testing of rotary wing aircraft. [312]

Despite the war in Europe drawing to a close the pressure on the A.F.E.E. to continue experimental work was not in decline.

In fact, the responsibility for conducting performance trails on the rotary wing aircraft undoubtedly added considerable pressure on the existing programme, not least because the technology was almost entirely untested despite previous experimentation with Rotachutes. Mr W.G. Jennings, Chief Technical Officer at A.F.E.E. from August 1942, noted the following with regards to the technicalities of Helicopter performance testing in 1945: [313]

> It was appreciated that before acceptance tests could be carried out it would be necessary to establish a suitable testing technique, both from the performance and handling aspects, since the required functions and the method of flight of a helicopter are appreciably different from those associated with fixed wing aircraft. [314]

A.F.E.E. was allocated American Sikorsky R.4 for the purpose of developing a technique for the testing of prototype helicopters. The R.4, named the Hoverfly by the British, was designed in 1941 and entered production in 1943, principally for deployment in the anti-submarine campaign. Consequently, 'all the practical knowledge and experience' [315] in Britain with regard to helicopter performance was initially based on this aircraft.

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[312] T.N.A., T 162/755, Letter to F.C. Newton, by L.N. Reffell, 28 April 1945.
[313] T.N.A., AVIA 21/247, Work of the Airborne Forces Experimental Establishment 1940-1945, by W.G. Jennings, 31 December 1949.
[314] Ibid.
[315] R. Brie, 'Forced Landing by Helicopter: Some Imperfectly Understood Aspects of the Correct Technique Discussed', *Flight Magazine*, 21 November 1946, pp. 565-566, p. 565.

The majority of research and development was conducted at A.F.E.E. with full reports published in 1946. [316] Reffell alluded to the importance of the rotary wing programme and its inherent complexities in a request to the Treasury for additional resources:

> This is entirely new work so far as A.F.E.E. are concerned and promises to be considerable in scope. At the moment they have 3 specimens of the new Sikorsky Helicopter which are to be subject to performance and handling trials. As this is the first time that a Helicopter has been fully performance tested a great deal of work requires to be done including the development of special instruments for recording purposes. None of the aircraft instruments, airspeed indicators, altimeters and drift indicators are suitable in their present form because they do not respond to changes at the bottom of the range; for example, the airspeed indicator shows no reading at all until a speed of the order of 20 or 30 miles per hour is reached. [317]

However, in addition to the Sikorsky Helicopters already delivered to A.F.E.E. the Cierva Company was also building two prototypes for the M.A.P. and the Bristol Aircraft Company was engaged in design work on a British type. Consequently, the rotary wing aspect of the A.F.E.E. programme was set to increase and M.A.P. believed that a separate specialist section was necessary to conduct the programme of works. [318]

[316] T.N.A., AVIA 21/237, Hoverfly I Helicopter K.K.978: Investigation into the Technique of Performance Measurement on Helicopters (Res/19), July - October 1946.
[317] T.N.A., T 162/755, Letter from M.A.P. to the Treasury, by L.N. Reffell, 25 April 1945.
[318] Ibid.

The M.A.P. request for further additional resource was understandably carefully considered by the Treasury and the relevant file contains a considered internal letter written on 10 May 1945 that analysed the position. In the period between Reffell's request and the Treasury response the war in Europe had concluded with the unconditional surrender of Germany on 7 May. [319] Although the Treasury acknowledged that this could be used as a justification for a reduction in the size of A.F.E.E., it also recognised the importance of the work undertaken by the Establishment and the on-going conflict in the Far East:

> The consequential increase in the scale of operations against Japan is bound, I suggest, to lead to a corresponding addition in the load of A.F.E.E. By its very nature the Establishment is likely to be quasi-permanent, though not at its present strength perhaps, and the creation of a new sub-section to deal with helicopter work seems sound in principle and reasonable in effect, particularly having regard to the nature of the terrain to be conquered, or rather won back, in the Far East. [320]

Reference to the potential technical capability of the helicopter and its military application was quite surprising and would suggest that the Treasury was well informed with regard to its technical development, although the potential for helicopter operations was debated well into the 1950s. The Treasury consented to the new post on 15 May 1945 but included the condition that the Principal Technical Officer was approved 'subject to your being able to offset the addition by the surrender of a P.T.O. post elsewhere' [321] within the M.A.P.

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[319] L.F. Ellis, *Victory in the West Volume II: The Defeat of Germany* (London, 2004), pp. 347-348.

[320] T.N.A., T 162/755, Internal Treasury Memo, by Mr Andrews, 10 May 1945.

[321] T.N.A., T 162/755, Letter from the Treasury to M.A.P., by F.C. Newton, 15 May 1945.

The prospect of losing a P.T.O. position elsewhere prompted Reffell to stress that the specialist nature of the A.F.E.E. made it impossible to economise through the reduction in strength of other Experimental Establishments. His response on 29 May included the following explanation:

> I can see no prospect in the immediate future of offering up a P.T.O. post to offset the addition; indeed, I have a number of proposals involving further posts at this level. The work of the A.F.E.E. is, in general, unrelated to that of any other establishment or directorate and the work which the new P.T.O. would undertake does not therefore afford any relief elsewhere. [322]

The Treasury responded on 1 June 1945 and reluctantly accepted that the post was an addition. However, disappointment was expressed and Reffell was reminded that the situation regarding delegated authority on establishments would be subject to Treasury Circular 9/45 [323] and that the 'major problems of the dimensions of M.A.P.' [324] would soon be considered more comprehensively as a separate issue.

Although the future of the Establishment was not certain in June 1945 the technological development of the helicopter was a critical work stream that required detailed investigation and had the potential to realise strategic advantages in the post-war era. The development of airborne forces, prior to the arrival of the Hoverfly at A.F.E.E., had primarily been confined to the modification of existing technology, particularly redundant aircraft, and the design of assault gliders to satisfy the requirements of an ambiguous and frequently changing strategic vision. However, the post-war technical policy was an opportunity to re-

[322] T.N.A., T162/755, Letter from M.A.P. to the Treasury, by L.N. Reffell, 29 May 1945.
[323] T.N.A., T 162/808, Control: Delegation of Authority on Establishment and Man-Power Questions.
[324] T.N.A., T 162/755, Letter from Treasury to M.A.P, by F.C. Newton, 1 June 1945.

position the future development of the British airborne capability and provide an aircraft with the capability to deliver both troops and equipment with maximum tactical and operational effectiveness.

Future Technical Policy: 1945

The surrender of Japan on 2 September 1945, coupled with the Treasury Review, resulted in an assessment by M.A.P. of the future technical policy of A.F.E.E. which commenced with a summary of the current experimental programme on 26 September 1945. The report argued that before any drastic decision was taken on the future of the Establishment both the Air Staff and War Office would need to be consulted because the majority of the future and current works had been requested directly by them. [325] However, the report recognised that the division of work between A.F.E.E. and R.A.E. could well be rationalised to achieve some of the efficiencies to which the Treasury had previously alluded.

For example, with regard to the dropping of heavy equipment the R.A.E. was responsible for all prototype parachute canopy design and liaison between the Ministry of Supply and associated contractor frameworks. Once airworthiness had been established the parachute was then passed to A.F.E.E. for technological development in order to assess suitability against tactical and operational requirements prior to service issue. It was suggested that all such development works could be undertaken by A.F.E.E. with consequent economy in flying hours and personnel, both flying and technical. [326]

A similar arrangement existed with regard to parachute development and the same argument was presented for concentration of future research at A.F.E.E. In fact, the ‘ad hoc’ arrangement by which research was conducted at the Establishment during the war,

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[325] T.N.A., AVIA 15/2253, Minute to D.D.R.D.T., by D.D.T.D., 26 September 1945.
[326] Ibid.

determined by the need for a rapid answer to Airborne Forces' problems, meant that A.F.E.E. was capable of dealing with a broad range of technological enquiries. Helicopter development notwithstanding, the Establishment was also well placed to deal with most aircraft types:

> With regard to transport aircraft it is suggested that since these types will follow in their main outline well tried aerodynamic features, it should be agreed that A.F.E.E. should take on all flight testing acceptance tests. [327]

The conduct of such work at A.F.E.E. had the additional advantage that the aircraft could also be proved for such roles as paratrooping, supply dropping and pick-up and glider towing all at the same Establishment with further economies in flying hours. [328] The potential for saving through the amalgamation of functions conducted by the two Establishments was obviously worthy of exploration but the specialist aspect of the A.F.E.E. workload was primarily concerned with the technological development of Airborne Forces.

Although it was appreciated by A.F.E.E. that the future of the British airborne capability had yet to be determined it did stress that further development was required to maximise the military effectiveness of the existing technology:

> Although, at present, there is no indication of what the future Army Policy will be in respect of airborne forces, there are indications that for some years to come (say five years) we will still be concerned with gliders and towing thereof. In this field there is room for considerable improvement in towing technique and instrumentation for cloud and night flying. In addition

[327] Ibid.
[328] Ibid.

we are still concerned about the snatch loads which come on to the rope and its elimination. [329]

The five year prediction was fairly accurate as A.F.E.E. was disbanded on 14 September 1950 and the staff and equipment were relocated to A. & A.E.E. at Boscombe Down with the helicopter research re-allocated to R.A.F. Andover.

Although rotary wing aircraft hid the potential to offer a new strategic dimension to airborne operations, the short-term and long-term tests schedule submitted with the A.F.E.E. report in September 1945 show that the technical programme was predominantly a perpetuation of exploring efficiencies in existing technology. The short-term programme (See Appendix 10) primarily consisted of numerous tests into the capabilities of different aircraft as glider tugs and parachute aircraft, such as the Handley Page Hastings and Avro York, [330] heavy equipment dropping, and the development of glider pick-up installations. [331] The exceptions included an examination of the Hamilcar X, [332] the powered high-capacity cargo glider, and flight tests of variants of the Sikorsky helicopter. [333] The long-term test schedule (See Appendix 11) was predominantly dedicated to maximising the effectiveness of existing glider and parachute technology.

However, the continued investment in glider technology, despite the arrival of the helicopter, was not necessarily as outdated as it might first appear. The development of the

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[329] Ibid.

[330] T.N.A., AVIA 21/301, York C. Mk,I Aircraft Towing Horsa II Glider: Performance and Cooling Trials for Temperate Summer Conditions (T.51), July 1946.

[331] T.N.A., AVIA 21/321, Pick-Up of Horsa I & Horsa II Glider by Dakota Aircraft (E.6), October 1944 – April 1945, 25 July 1945.

[332] T.N.A., AVIA 21/42, Hamilcar X Glider: Performance in Free Flight under Tropical Conditions, Parts 1-4 (G.44), July 1945 - May 1947.

[333] T.N.A., AVIA 21/330, Hoverfly II Helicopter: Determination of Weight and C.G. Limits, Performance & Handling Tests, Parts 1-2 (Rota), March 1947 - June 1950.

British airborne capability was still a relatively new technology in September 1945 and the assault glider technique was less than five years old. During the war there had been little time or capacity to concentrate on perfecting the technique of glider warfare due to service demands to solve other immediate problems and respond to operational requirements. [334] Furthermore, although the development of rotary wing aircraft had commenced, and its future potential had been recognised, the technology was very much in its infancy and the glider remained the only delivery mechanism capable of delivering well equipped troops behind enemy lines. [335]

In his post-war report on the Establishment the Chief Technical Officer, Mr Jennings, made the following comment with regards to the A.F.E.E. connection with helicopter development:

> There is a strong link between Airborne Forces requirements and helicopters since it is possible that, in the future, some of these requirements may best be met by a helicopter; and aircraft of this type may prove invaluable for lifting, transporting, and putting down at a particular spot a heavy item of military equipment such as a gun or tank. [336]

However, Horsa gliders remained on the strength and maintenance schedules of No.9 Maintenance Unit as late as 1954. [337]

The technological remit of the A.F.E.E. was fundamentally unique and multi-disciplined within the M.A.P. hierarchy. Consequently, the Establishment was responsible for

[334] T.N.A., AVIA 15/2253, A.F.E.E. Future Research Policy, by AD/RD Airborne, 22 September 1945.
[335] Ibid.
[336] T.N.A., AVIA 21/247, Work of the Airborne Forces Experimental Establishment 1940-1945, by W.G. Jennings, 31 December 1949.
[337] T.N.A., AIR 29/2084, O.R.B. No.9 Maintenance Unit R.A.F. Cosford, May 1954.

providing technical solutions for a variety of stakeholders, including the R.A.F. and the Army. In fact the A.F.E.E. was briefly a tri-service research institution when it collaborated with the Fleet Air Arm on the application of rotary wing aircraft for utilisation at sea in 1945. [338]

Figure 7: Sikorsky Hoverfly Mark I A.F.E.E. before transfer to the Admiralty in 1949
Source: Imperial War Museum (Catalogue Number: ATP 14253C)

The importance of A.F.E.E. to more than one Service was reiterated in a recommendation on the future of the Establishment by the Assistant Director Research & Design (Airborne) on 25 October 1945. The minute was submitted to the M.A.P. Controller of Research and Development and detailed two main reasons why the Establishment should be retained:

(a) If the work is undertaken at an aerodrome where other M.A.P. test work is proceeding, such as Boscombe Down, serious difficulties will arise as other flying must cease in the vicinity when any glider towing, supply dropping or parachuting test work is required.

[338] T.N.A., ADM 1/17419, AVIATION (90) Reports Issued by Ministry of Aircraft Production, 1945.

> (b) In addition to serving the R.A.F. in the development of its equipment we also have a similar responsibility to the Army. If we merge their work into an Establishment primarily undertaking acceptance tests etc. for the R.A.F. in will be a disservice to the Army. [339]

The role of A.F.E.E. collaboration with the R.A.F. and Army in pursuit of shared technological objectives should not be underestimated and became a significant factor in the argument for its post-war retention as an autonomous research facility. Consequently, the minute included a list of potential future additional responsibilities: performance testing of military transport types, routine statistical parachute tests as, at present, undertaken at Henlow, and full-scale tests in conjunction with R.A.E. of airborne equipment developed by that Establishment [340]

Following a visit by Air Marshal Sir Alec Coryton, C.R.D., and Mr Woodburn, Parliamentary Secretary to the Minister of Aircraft Production, on 15 November 1945 the A.F.E.E. absorbed the above responsibilities, notwithstanding those concerned with the performance testing of helicopters, into their varied and specialist research programme until they were finally disbanded in 1950. [341]

Conclusion

A.F.E.E. and its predecessors were fundamental to the technical development of the British airborne capability, and consequently justified in their role regardless of the strategic deficiencies inherent in the concept and doctrine. The Establishment had a diverse portfolio

[339] T.N.A., AVIA 15/2253, Memorandum on Future of A.F.E.E., by A.D./R.D. Airborne, 25 October 1945.

[340] Ibid.

[341] T.N.A., AIR 29/514, A.F.E.E. O.R.B. June 1944 - December 1945, 15 November 1945.

and, despite initial criticism, [342] the complexities of the research programme were invariably successfully conducted in challenging circumstances. But, despite the creation of an autonomous research Establishment dedicated to the technological development of airborne warfare, the provision of material resource and continued ambiguity of strategic policy ultimately proved restrictive.

The deficiency in suitable aircraft was the most inhibiting factor from the perspective of technological development. This was evident through the amount of research programme time dedicated to the trial of a multitude of aircraft throughout the life of the Establishment. The programme was essentially confined to modification of whatever type was available at any particular moment in time. Had the airborne force been considered a strategic priority the allocation of more suitable aircraft may well been undertaken and have accelerated the large-scale deployment of the force prior to 1944. However, the airborne troops were dependent upon aircraft totally unsuitable for purpose and, despite extensive technical modification, performance could not be adequately improved.

This was particularly evident in terms of the glider programme whereby the momentum of technical development ultimately stagnated through the unavailability of suitable tug aircraft. The disconnection between aircraft availability and operational requirements [343] was beyond the capability of the A.F.E.E. to resolve, although the organisation provided technical solutions as far as was scientifically possible within the confines of resource availability. Ultimately, the production of assault gliders and training of parachutists before detailed technological investigation into the method of delivery had been

[342] T.N.A., AVIA 10/135, Attack on A.F.E.E., by Major-General Browning, 26 September 1942.

[343] T.N.A., AIR 2/7792, Army (Code B/88), Review of Airborne Forces: Operational Requirements, February 1942 - October 1943.

conducted remained an insurmountable obstacle and resulted in an often abortive research programme involving numerous aircraft types.

The continuation of research into the assault after the war was conducted simultaneously with the development of the helicopter in order to ensure that some tactical capability was retained during the technological progression. Although the limitations of the existing technology were well documented, ultimately the maintenance of a continued psychological threat of an airborne operation upon an enemy may well have been considered as important as the actual offensive capability.

Conclusion

In little over five years Britain had developed a substantial airborne resource that comprised two divisions and associated specialist equipment. The programme required extensive scientific investigation and subsequent technical development to achieve viability but this was ultimately restricted due to the availability of suitable resources.

The first requirement of technological development, as argued by Millet and Murray, was to achieve political support as explored in chapter one. This permitted the establishment of an efficient, centrally organised working relationship between wide varieties of stakeholders that ranged from government ministries to independent non-specialist manufacturers. Without such co-operation the relevant progression in the fields of science and technology could not have been exploited for the development and production of new weapons and techniques of military deployment. Hacker has argued that the relationship between technology and the armed forces requires further substantial historical examination in order to fully understand technological development and its application to the battlefield:

> Technological innovation has historically answered more to military purpose than commonly allowed, ingenious weapons having held Western imaginations in thrall since the Middle Ages. Unfortunately, guides to the history of technology tend to obscure the links by making ‘military technology’ a residual category: fortifications dis- appear into architecture, battleships and bombers into transportation, explosives into chemical technology. [344]

[344] B. Hacker, ‘Engineering a New Order: Military Institutions, Technical Education, and the Rise of the Industrial State’, *Technology and Culture*, Vol. 34, No. 1, 1993, pp. 1-27, p. 25.

Professor R.V. Jones believed that World War Two created greater solidarity between scientists and military personnel which produced the blueprint for Operational Research whereby both parties benefitted from shared intelligence in the production of new technology and efficiencies in existing weaponry:

> The threat was so urgent that traditional barriers, particularly between scientists and serving officers, were breached as the two sides worked jointly in their efforts to devise new weapons and techniques with which to counter the common enemy. [345]

However, this did not necessarily mean that the benefits of such resources were dedicated to the identification and discovery of the most effective weapons and techniques as identified through strategic military requirements.

Without the tenacity of Churchill, and subsequent support from his closest political and scientific colleagues, the technological investment in the development of an independent British airborne capability may well have remained limited to small-scale investigation. But in hindsight, this resulted in the realisation of a personal ambition rather than a strategic military vision.

Indeed, with regard to British airborne capability, and the allocation of scarce resources, it would be difficult to suggest that the new technology made a definitive strategic contribution to overall national military effectiveness in offensive operations. Murray rightly argues that Churchill's management of the central government administration was tight and that he 'hammered his advisors and the system into effectively allocating and utilizing

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[345] A.V. Hill, 'R.A.F. Scientific Intelligence', *Royal Air Force Historical Society: Air Intelligence Symposium*, 1997, pp. 13-20, p. 15.

available resources.' [346] Yet it also provided the opportunity for strategic interference without a full appreciation of the technological and consequent strategic limitations. Mary Kaldor believes that the British military establishment wanted more powerful existing weapons, rather than its replacement by new technology, thus reinforcing the argument that strategic development of airborne warfare was politically, rather than militarily, driven. [347]

What an analysis of the technological development of airborne warfare demonstrates was that strategic effectiveness, the second component of successful technological development as identified by Millet and Murray, was prohibitive. [348] Strategic doctrine concerning the capability of British airborne forces remained confused throughout the course of the conflict and this was consequently detrimental to operational effectiveness. Buckingham argues that the lack of clarity contained in Churchill's initial minute in 1940 regarding development 'arose directly from his habit of framing broad concepts in dramatic language and leaving the details for others.' [349] Unfortunately, 'others' did not flesh out his vision with sufficient clear mindedness.

The ambiguity contained in the airborne doctrine had implications for the tactical effectiveness of the new resource and, consequently, all associated technological investigation. Tactical effectiveness is defined as 'the specific techniques used by combat units to fight engagements in order to secure operational objectives.' [350] These techniques include the mechanism for the movement of forces, the provision of destructive firepower and

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[346] W. Murray, 'British Military Effectiveness in the Second World War', in A. Millett & W. Murray (eds.), *Military Effectiveness: Volume Three, The Second World War* (Cambridge, 2010), p. 93.

[347] M. Kaldor, 'The Weapons Succession Process,' *World Politics*, Vol. 38, No. 4, 1986, pp. 557-595, pp. 584-586.

[348] Millet, Murray & Watman, 'The Effectiveness of Military Organizations', in *Military Effectiveness: Volume One*, pp. 1-3.

[349] Buckingham, *PARAS*, p. 62.

[350] Millet, Murray & Watman, 'The Effectiveness of Military Organizations', in *Military Effectiveness: Volume One*, p. 19.

the logistical support directly required. With reference to airborne forces, extensive technological development was required to provide the capability for troop movement, but the issue of adequate destructive firepower was never fully resolved, and the logistical resources in terms of aircraft were never available without compromising the effectiveness of other forces in theatre through disruption to the supply chain.

Consequently, investment in airborne technology cannot be easily reconciled with the problematic economic and strategic situation which confronted the British in the summer of 1940 and beyond. The combination of the structure of central government, and key personalities therein, allowed for the development of a capability without a clear policy or evidence of a strategic military requirement beyond the broad objective of defeat of Germany. This probably explains why the British airborne capability was invariably under resourced, as evidenced throughout chapters three and four, and technological development was continuously restricted.

The combination of the inability to allocate suitable aircraft, inadequate research facilities and treasury bureaucracy culminated in an airborne weapon that was incapable of autonomous operation. [351] In fact, following an Air Ministry conference on 9 September 1940 on the deployment of Airborne Forces, Ismay provided the following conclusions for Churchill that recognised the limitations:

> As I see it, the fundamental obstacle to going large on airborne troops is that we cannot at present afford to divert either bomber pilots, or large numbers of bombing aircraft (whether for towing gliders, or for dropping parachutists) from their primary role. [352]

[351] B. Bond & W. Murray, 'The British Armed Forces, 1918-1939', in *Military Effectiveness: Volume Two*, pp. 111-114.
[352] T.N.A., CAB 120/262, Minute on Airborne Forces, by Major-General Ismay, 10 September 1940.

The A.F.E.E. and its predecessors undoubtedly achieved considerable success in the modification of existing military equipment for airborne application, and learnt quickly through the utilisation of Operational Research techniques, but in reality the majority of the work was both low-tech and time consuming.

Where innovative development was required, particularly in terms of glider development, the relevant technological research was largely successful and crucial to future operational effectiveness. Unfortunately, the failure to solve the problem of the availability of suitable tug aircraft at the inception of the programme resulted in extensive delays to operational deployment and subsequent military effectiveness that could not be mitigated through the technological resources available to the A.F.E.E. Even when the problems of the glider production programme had begun to be resolved the shortage of tug aircraft remained restrictive. Indeed, on 21 March 1942 Air Chief Marshal Freeman wrote to the Chief of the Air Staff regarding the availability of suitable aircraft for use by the airborne forces: 'we are badly behindhand, or at least M.A.P. are, in the modification of bombers for towing gliders and for dropping parachute troops.' [353]

Ironically, even after the arrival of the helicopter at A.F.E.E, an aircraft design with the potential to fulfil every aspect of the airborne forces requirements, technological development remained focused upon the improvement of already obsolete hardware which suggests that the British remained fixated with the airborne method despite the inherent technological and strategic disadvantages.

The evidence suggests that the technological development of British airborne forces can be examined in two distinct phases. Between 1940 and 1943, technological limitations in

[353] T.N.A, AIR 20/2829, Letter to Chief of the Air Staff, by Air Marshal Freeman, 21 March 1942.

aircraft design and availability were restrictive to the development of a substantial airborne capability. However, following the introduction of significant numbers of American transport aircraft under the lend lease agreement, [354] the potential for large-scale deployment rapidly increased from 1944 onwards. Unfortunately, by the time sufficient numbers of aircraft became available the deployment of airborne forces had become increasingly detrimental to conventional offensive infantry operations and threatened to compromise holistic allied tactical and operational effectiveness. The inter-war scientific debate regarding the improvement in efficiency of established technology over new technology would appear to have been correct in terms of the British airborne experience.

Evidence that the airborne capability compromised more orthodox operations increased following the rapid collapse of German forces in France in 1944 which put immense pressure upon the allied supply system and resulted in a prioritised allocation of resources. Transport aircraft became critical in the supply role and were used to relieve the pressure on the ports and consequently increased the logistical capabilities of the units fighting on the front line. The Air Ministry Official Monograph concluded that an ‘enigma’ existed between the creation of the airborne technology and the opportunity for its application:

> Probably the main drawback to the launching of a large scale airborne operation is the fact that, both for training purposes and when airborne forces are being maintained at readiness for sudden demands, large numbers of transport aircraft may be tied up when they might be better employed elsewhere. [355]

[354] A. Pearce, *Lend Lease Aircraft in World War II*, pp. 103-105.

[355] Air Ministry, *The Second World War 1939-1945, Royal Air Force, Airborne Forces*, p. 239.

Airborne operations required the diversion of transport aircraft and, regardless of the developments in airborne technology by the A.F.E.E. and its predecessors, that investment wasted without the diversion of considerable additional airpower resources.

General Eisenhower recalled in his memoirs that the planning of such an Allied airborne operation near Tournai in 1944 caused significant disruption to the supply chain in Normandy:

> Withdrawal of air transport in preparation for it caused a six-day suspension of air supply to the advancing armies that cost them 5,000 tons of supplies. In petrol that would have been equivalent to 1½ million gallons – enough to have carried two armies to the Rhine without pausing, while the enemy were still in chaos. [356]

The scepticism of senior military commanders to deploy airborne operations was understandable, particularly when scarce resources could leave front line troops vulnerable to a counter-offensive. In fact on 26 July 1944 General Taylor, commander of the U.S. 101st Airborne Division, suggested that approximately six weeks would be necessary for the preparation of an effective airborne operation. [357] Consequently, planned airborne assaults were often cancelled due to the successful capture of prospective targets by conventional ground forces. This would suggest that Professor Hill's assertion that British war production would have been more effectively concentrated upon the improvement of existing weapons rather than the development of new and unproven technologies, to be correct. [358] The effective restriction of the fighting capabilities of mechanised front line units in order to

[356] D.D. Eisenhower, *Crusade in Europe* (London, 1957), p. 563.
[357] T.N.A., WO 219/2882, Mounting of Future Airborne Operations, by General M. Taylor, 26 July 1944.
[358] Edgerton, *Britain's War Machine*, p. 100.

prepare for the launch of an airborne operation would not have been logical, particularly if the application of the new technology could not guarantee success.

However, it would be wrong to suggest that such a culmination of misdirection was exclusive in the development of airborne forces. Meilinger has argued that the R.A.F. had also suffered from a similar disconnection between the available technology and the prescribed military doctrine of the service. During the confused and reactive nature of the inter-war period expansion schemes, implemented to counter the growing threat of the *Luftwaffe*, the primary function of the force had suffered neglect:

> As a consequence, despite twenty years of doctrine that emphasized the primacy of offensive airpower, the RAF was woefully unprepared to conduct such operations once war broke out. It was one of the first great shocks of the war to discover that Bomber Command was too small, too poorly equipped, and too ill-trained to carry out the role scripted for it. Not for the first or last time in air warfare the technology had failed to keep pace with the doctrine devised to employ it. [359]

The implications of such a disconnect for British airborne forces culminated in the launch, and subsequent catastrophic failure, of Operation Market Garden in which the British 1st Airborne Division was practically annihilated. Astonishingly only seven days were required from the order to instigate the planning phase of Market Garden on 10 September 1944 to the actual launch seven days later.

Historians have previously attributed this condensed gestation and implementation period to the fact that a series of airborne operations had been planned and subsequently

[359] Meilinger, 'Trenchard and "Morale Bombing": The Evolution of Royal Air Force Doctrine Before World War II', p. 268.

cancelled since the Normandy invasion. In the case of the 1st Airborne Division it had been in readiness to support the 6th Airborne Division in Normandy ever since 6 June. As Middlebrook notes: 'since then, no less than fifteen further operations had been planned but then cancelled, usually because ground forces reached the landing area first.' [360] The fact that numerous airborne operations had been repeatedly planned and cancelled was not necessarily beneficial. In fact the continuous cancellations, rather than improving the efficiency of planning staffs, may well have had a negative effect on the outcome of the operation. In the repetitiveness of briefings, loading of aircraft, and subsequent stand-downs would have been utterly demoralising and some troops began to talk of a '1st Stillborn Division.' [361]

Nevertheless, what became clear at Arnhem was that despite the technological investment in the British airborne capability the resource requirements generally outweighed operational effectiveness on the battlefield. The technology was not capable of producing a method of delivery that could be quickly and efficiently implemented, particularly in the case of glider-borne forces, and despite continual technological efficiencies it was impossible to improve the speed of deployment without severely compromising operational outcome.

If the British did in fact realise they were incapable of producing the resources required for the successful deployment of airborne forces, particularly with regards to the provision of suitable transport aircraft, then it would suggest that investment in the technique was continued for purposes other than battlefield success or simply to placate Churchill particularly in the post D-Day period. An important factor was the need to ensure that enemy troops were withdrawn from the front line to guard strategic targets against the threat of a potential airborne operation. The Air Ministry Official Monograph stated that the psychological effect of airborne forces upon an enemy had a 'moral impact out of all

[360] M. Middlebrook, *Arnhem 1944* (London, 1995), p. 6.

[361] Buckingham, *Arnhem 1944*, p. 67.

proportion to the size of force employed.' [362] Consequently, the British airborne capability had a psychological quality that could well have outweighed the importance of the application of the technology on the battlefield.

Indeed, Buckingham suggests that Churchill's demand for an airborne capability was a direct result of the Dunkirk evacuations and was just as important in providing a 'psychological safety valve.' [363] This would certainly appear correct with regard to the British experience. In fact the instigation of airborne operations for the purpose of damaging enemy morale and paradoxically raising morale was actually referenced in Airborne Operations Pamphlet No.1 which, rather tellingly, was not actually published by the War Office until 1944:

> The use of airborne forces behind the enemy forward troops may cause the latter to think that some disaster has occurred and thus reduce their powers of resistance. It creates alarm on the lines of communication and may force commanders of reserves into unsound action. If hostile communications centres can be captured, under favourable circumstances it may be possible to plunge the enemy into extreme confusion. [364]

Although the pamphlet closed with 'the extent of the morale effect varies with the discipline of the enemy, the efficiency of his communications and the moment which the airborne troops are used', [365] this did provide a convenient, if un-measurable, performance indicator that could be used as a justification should an operation not achieve the desired outcome, such as with the glorification of the defeat of the 1 British Airborne Division at Arnhem.

[362] Air Ministry, *The Second World War 1939-1945, Royal Air Force, Airborne Forces*, p. 239.
[363] Buckingham, *PARAS*, p. 63.
[364] A.G.T.A., AGT 2009.14, Airborne Operations Pamphlet Number 1 (War Office 1944).
[365] Ibid.

Clearly, the technological development of a British airborne capability was incapable of achieving maximum military effectiveness alone. But the political determination was never equated into a realistic strategic direction which ultimately compromised the tactical and operational effectiveness of the airborne forces through a lack of fundamental resource allocation. The lack of consensus on strategy, which created ambiguity within the doctrine and concept, resulted in misguided technological investment that although largely successful in terms of scientific analysis, remained difficult to reconcile with the economic and military realities faced by Britain throughout the conflict and the immediate post-war period.

There remains much research to be undertaken on the importance of military technology in a wartime context. Edgerton has identified that military aviation has often been considered a civilian development:

> Remarkably after the Second World War standard reference sources on the history of twentieth-century technology still treated, and treat, aviation under transportation, and military aviation within the larger context of civilian aviation. [366]

He has also suggested that accounts of twentieth century British scientific accomplishments have concentrated on national civilian bodies with ‘science’ in their title, the Department for Scientific and Industrial Research for example. [367] This examination of the A.F.E.E. and the development of glider for purely military function certainly challenges such historiographical anomalies.

[366] Edgerton, *Warfare State*, p. 316.
[367] Ibid.

Ultimately, the development of a British airborne capability was politically driven rather than the result of a demonstrable strategic military requirement. Consequently, the parameters for technological development remained highly variable and the A.F.E.E. achieved credible results in very difficult conditions. But this had little influence upon the holistic military effectiveness of the British forces during World War Two or indeed during the post-war period.

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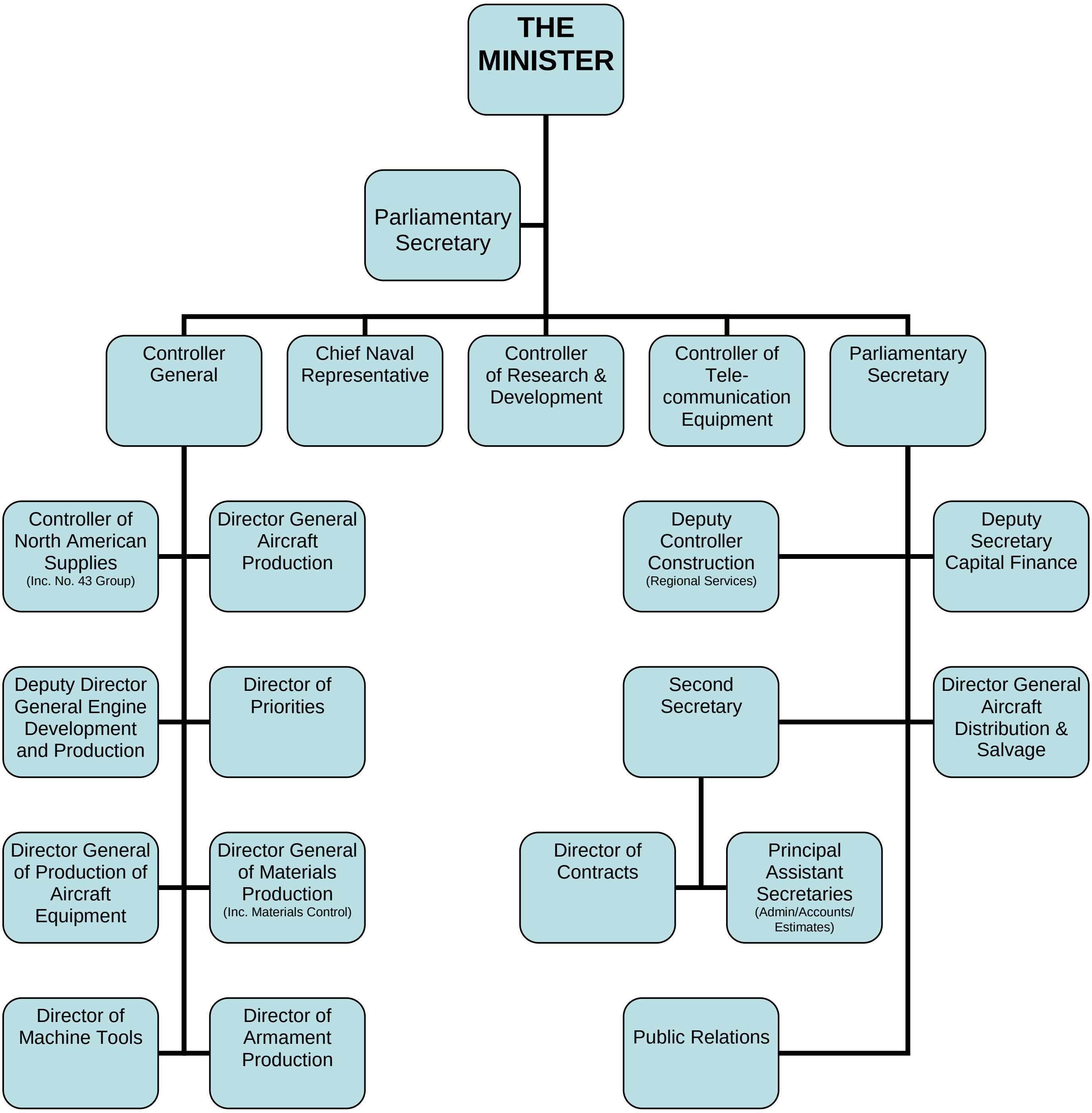

Source: Scott & Hughes, *Administration of War Production* (H.M.S.O., 1955)

Appendix 3: Central Landing School Structure 1 October 1940

Headquarters	Personnel
Commandant	Group Captain Harvey
S.A.S.O.	Wing Commander Norman
Squadron Leader Admin.	Squadron Leader Newnham
Intelligence	Flight Lieutenant Hodges
Parachute Training Squadron	**Personnel**
Officer Commanding	Squadron Leader Strange
Chief Instructor	Squadron Leader Benham
Chief Flying Instructor	Flight Lieutenant Fielden
Flying Duties	Flight Lieutenant Romanoff Flying Officer McMonnies Pilot Officer Cutler Pilot Officer O'Neill
Development Unit	**Personnel**
Officer Commanding	Wing Commander Buxton
Parachute Duties	Flight Lieutenant Williams
Flying Duties	Flying Officer Davie
Glider Training Squadron	**Personnel**
Officer Commanding	Flying Officer Hervey
Flying Duties	Flying Officer Davies Flying Officer Wilkinson

Source: T.N.A., AIR 29/513, A.F.E.E. O.R.B. Appendices 1940-1942, 1 October 1940

Appendix 4: Establishment No. WAR/AC/116A 1940

Personnel (Officers)	**Rank & Quantity**
Officer Commanding	Wing Commander
Adjutant	Flying Officer
Engineer	Flight Lieutenant
Flying	Flight Lieutenant (1) Flying Officer (3)
Principal Technical Officer	Civilian
Senior Technical Officer	Civilian
Technical Officers	Civilian (4)
Airframes	**Engines**
Heyford (1)	Kestrel (II)
Whitely (1)	Merlin (2)
Hector (3)	Dagger (3)
Tiger Moth (1)	Gipsy (1)
Avro (2)	Lynx (2)
Gliders	
Miscellaneous (6) Troop Carriers (6) Wellesley (1)	
Mechanical Transport	
Towing Cars (3) Motorcycle (1)	

Source: T.N.A., AIR 29/513, A.F.E.E. O.R.B. Appendices 1940-1942, 22 October 1940

Appendix 5: Delegates at Air Ministry Conference 16 April 1941

Air Ministry:

Air Commodore R.D. Mansell: Director of Operational Requirements (D.O.R.)

Group Captain F.A. Norton: Deputy Director Technical Development (D.D.T.D.)

War Office:

Major D.C. Curme: Operational Requirements (A.M.) & Staff Duties (W.O.)

Squadron Leader R.M. Colebrook: Defence Ministers Committee (D.M.C.)

Ministry of Aircraft Production:

Mr H. Grinsted: Deputy Director Research & Development Technical (D.D.R.D.T.)

Dr H. Roxbee Cox: Deputy Director Scientific Research (D.D.S.R.1)

Source: T.N.A., AIR 29/513, A.F.E.E. O.R.B. Appendices 1940-1942, 16 April 1941

Appendix 6: Situation into Research Regarding Glider Tugs

Glider Type	Glider Tug	Situation as of 28 August 1941
G.A.L. Hamilcar	Short Stirling	The firm had been asked to investigate necessary modification but a Test Installation (T.I.) had not been requested.
	Handley Page Halifax II	T.I. and incorporation in production aircraft requested and design was in progress. It was estimated that production aircraft (from the 151st onwards) would be fitted with equipment as standard from March 1942.
	Avro Lancaster	T.I. and incorporation in production aircraft was requested but design work could not commence until October due to existing work in the design department.
	Avro Manchester	Only an investigation had been requested and as the production of the aircraft had been completed (superseded by the Lancaster) the aircraft was practically ruled out as a tug.
Airspeed Horsa	Armstrong Whitworth Whitley	T.I. only had been requested. One aircraft (P.5104) had been specially modified for experimental purposes.
Slingsby Hengist	Vickers Wellington	T.I. and incorporation into production aircraft had been requested with the T.I. completed by 1 October. Vickers unable to confirm when production aircraft would next be available.
	Armstrong Whitworth Albemarle	Firm requested to investigate necessary modifications.
	Handley Page Halifax	One machine (L.7244) modified for experimental use.

G.A.L. Hotspur	Hawker Hector	Malcolm Aviation was in the process of converting 25 machines, a further 75 were available if required.
	Westland Lysander	C.L.E. had completed a test installation and Westland's were considering the design.
	Curtiss Tomahawk	D.O.R. had requested performance data for assessment.

Source: T.N.A., AIR 29/513, Report 1/41, 8 September 1941

Appendix 7: Glider Training Schools

Flying training for the glider pilots was the responsibility of R.A.F. Elementary Flight Training Schools where students qualified on trainers such as the De Havilland Tiger Moth before converting to gliders. The increase in glider capability resulted in an increased demand for tug aircraft and crews and on 15 January 1942 the Army Cooperation Command of the R.A.F. formed No. 38 (Airborne Forces) Wing specifically detailed to provide aircraft for facilitating training and operations. During the same month 297 Squadron was formed at R.A.F. Netheravon on Salisbury Plain in Wiltshire and was equipped with Whitley Mark V Rolls-Royce Merlin engined aircraft for parachute training. The squadron was then moved to R.A.F. Hurn near Bournemouth on 5 June 1941. 296 Squadron was formed at Ringway from the old glider exercise squadron and was equipped with Hawker Hectors and Hawker Harts for the purpose of glider towing. 296 (Glider Towing) Squadron did not receive Whitleys until it moved to Netheravon in June, after the departure of 297. [1]

No. 1 G.T.S. School had remained at R.A.F. Thame when the training was divided into two separate establishments in December 1941. However, by early summer of 1942 No.1 Glider Training School was in desperate need of a larger airfield to meet its training requirements, and after careful deliberation by Flying Training Command, R.A.F. Croughton, in Northamptonshire, was selected. On 19 July 1942 No.1 Glider Training School (G.T.S.) began relocating from Buckinghamshire and was fully operational the following month. [2] On the same day that No.1 G.T.S. commenced its move to Broughton from R.A.F. Thame, Headquarters Flying Training Command, based near Reading in Berkshire, issued a pamphlet entitled 'Notes on Glider Training' and a flying syllabus for all trainee pilots. The booklet opened with the following welcoming message for all new recruits:

[1] Wood, *History of the World's Glider Forces* pp.38-39.

[2] Ibid.

1) The function of the Glider Training School is to produce pilots with sufficient knowledge and skill to handle gliders efficiently on the ground and in the air
2) In order that full use may be made of the equipment and space available, great importance should be attached to the ground organization and to the co-ordination of the tug pilot, glider pilot and ground crew
3) Good ground organization, coupled with a high standard of flying discipline, will enable a maximum numbers of tows to operate without interference or delay. [3]

The insistence upon good ground organisation in order to enable a maximum number of tows is a good indication of just how tight the training schedule for new recruits was. The timetable could not afford obstructions on the runway caused by indiscipline as this would cause substantial delays in the training programme. The pamphlet issued by Flying Training Command constantly stressed the importance of keeping schedule and losing as little time as possible in take-off, landings and retrieving the gliders ready for the next tow:

> In order to avoid misunderstanding and loss of time, the different members of the ground crew should be given numbers according to their duties and should wear different coloured armlets or some similar distinguishing feature. When Tow Masters take over a fresh detachment, there will then be no misunderstanding as to the duties being carried out by each member of the detachment. Efficient team work is a matter of the greatest importance, and members of the ground crew should be familiar with each other's duties and with the recognized signals. [4]

[3] A.G.T.A. 2009.16, Notes on Glider Training, 19 July 1942.
[4] Ibid.

The training schedule was particularly labour intensive for R.A.F. personnel and each tow line (for each individual glider and tug combination) required a ground crew comprised of at least five men:

i) N.C.O. i/c ground crews
ii) Rigger of the Tug, who acts as relay signaller
iii) Rigger of gliders
iv) Two or more A.C.H.s
v) Tractor Driver [5]

The flying syllabus was split into a series of day and night flying exercises, both dual and solo, which each student had to pass in order to gain their wings. The training syllabus was extremely intensive and only when an instructor was confident in a pupil's ability could he commence onto exercise number 10, practice flights made with 'live loads'. A live load literally meant using passengers in order to simulate the experience of combat flying and the flying syllabus included the following stipulations:

> Exercise 10.
> Carrying of Full Live Load – Dual and Solo
> Provided that the C.O. or C.I. considers the pupil is competent, the pupil may carry a full live load, subject to his completing:
> i) Successful dual and live load flights
> ii) Not less than 34 successful solo flights in the Hotspur
> iii) At least 4 solo flights with full ballast loads. [6]

[5] Ibid.
[6] Ibid.

Once completed the pupil could then commence cross-country flights before moving onto night flying exercises. The flying syllabus notes contained the following advice on cross-country exercises in order to remind the pilot that even whilst on tow it was important to retain some idea of geographical location.

> Although map reading is generally considered impracticable when flying solo in a glider on tow an intelligent interest must nevertheless be taken by glider pilots in the route made good when flying cross country. [7]

Once competent the pupil would undertake a series of solo cross-country flights. The two hours cross country-flight, listed below was the final exercise before qualification and was a solo formation flight with full live load:

Croughton-Leighton Buzzard	23 miles
Leighton Buzzard – Market Harborough	40 miles
Market Harborough – Kidlington (land)	47 miles
Kidlington – Cricklade	27 miles
Cricklade – Alcester	39 miles
Alcester – Croughton	33 miles
Total	209 miles [8]

[7] Ibid.

The suggestion that map reading whilst on tow was impracticable is due to the fact that this stage of the flight required maximum concentration from the glider pilot in order to maintain a smooth flight path behind the tug, if a glider pilot got into difficulty whilst on tow the weight of the glider was more than capable of flipping the tug aircraft.

[8] Ibid.

Appendix 8: Decorations & Awards for Operation Biting

Distinguished Service Cross

Acting Commander F.A.N. Cook R.A.N.

Temporary Lieutenant D.J. Quick R.N.V.R.

Temporary Lieutenant (Engineer Branch) C.W.J. Coles R.N.V.R.

Distinguished Service Medal

Able Seaman J.T. Bland

Stocker 1sr Class C.W. Hurst

'In recognition of gallant and distinguished services in successful Combined Operations against the enemy at Bruneval:'

Military Cross

Second Lieutenant E.B.C. Charteris, K.O.S.B. (attached Airborne Division) (Wentworth Surrey)

Captain (Temporary Major) J.D. Frost, Cameronians (Scottish Rifles) (attached Airborne Division) (Nowshere India)

Military Medal

Corporal (Acting Sergeant) G. McKenzie, Black Watch (W. Highland Regiment) (attached Airborne Division) (Crieff, Perthshire)

Sergeant D. Grieve, Seaforth Highlanders (Rosshire Buffs, Duke of Albany's) (attached Airborne Division) (Glasgow) [9]

[9] 'Daring in Combined Operations', *The Times*, 16 May 1942, p.2

Appendix 9: Additional Staff Requested by A.F.E.E. Following a Visit by Sir Robert Renwick

Technical Development Section 1: **Flight Testing of Tugs & Gliders and the Development Work of Gliders**
Technical Assistant II (T.A.II x2) Technical Assistant III (T.A.III x5)
Technical Development Section 2: **Parachute Installations and the Transport & Dropping of Equipment in Aircraft**
Technical Officers or Flight Lieutenants (T.O. x4) Technical Assistant II or Flying Officer/Pilot Officers (T.A.II x4)
For a Section to Undertake Live Drops in the Trial of Parachute Installations
Parachute Troops (x12) Sergeant Parachute Packer (x1) Corporal Parachute Packer (x1) Corporal Aircraft Hand (x1) Parachute Packers (x3) Parachute Repairers (x2) Aircraft Hands (A.C.H.S. x6)
For Flight Records, Technical Records & General Clerical Duties
Temporary Male Clerk for Flight Records (x1) Temporary Female Clerks for Technical Records and General Clerical Duties (x2)
Additional Staff
General Duties Observer Sergeant (G.D. x4) For duties in aircraft undertaking flights where navigation and general assistance to the pilot in the towing aircraft is necessary.

Source: T.N.A., AVIA 15/1130, Minute following Renwick's Visit to M.A.P., 5 May 1942

Appendix 10: A.F.E.E. Short-Term Test Programme September 1945

Short-Term Tests	Remarks
Flight Test of TX.3/43	Specification TX.3/43 was issued in 1943 for a two seat training glider. The contract was awarded to General Aircraft who built two prototypes of the G.A.L. 55. The work was recorded as not yet started but it is interesting to note that work on the aircraft was being continued at such a late stage and the prototype was actually air tested in December 1945. [10]
Flight Tests of Hamilcar X	The Hamilcar X was produced following the issue of O.R. 160 and was a powered version of the cargo glider built to Air Ministry Specification X.4/44 The work is recorded as being well in hand and the first entry in the O.R.B. was recorded on 3 November 1945. [11]
Test of Hastings as a Glider Tug Test of York as a Glider Tug	The Hastings and York were transport variants of the Halifax and Lancaster respectively. Work had not yet started when the report was submitted.
Test of Miles Martinet as a Glider Tug	The Martinet was a single seat monoplane trainer and thus only capable of towing a Hotspur. The Hotspur remained the principal training glider and this is probably why the G.A.L. 55 was never put into production. Work had not yet started.
Flight Tests of Rotakite	The advance in helicopter design had effectively made the Rotakite variant technologically redundant and few tests had been recorded.
Anson Mail Pick-up Installation Tests Auster Light Mail Pick-up Installation Tests	The capability for aircraft to pick-up cargo mid-flight had obvious benefits and work was well in hand.
Dakota Live Pick-up Installation Tests Dakota Cable Laying Installation Tests	Live pick-up of stationary gliders had first been attempted by A.F.E.E. in April 1943. The advantage being the recovery of gliders after operational use. Cable-laying from aircraft was much more efficient, if not technologically

[10] T.N.A., AIR 29/514, A.F.E.E. O.R.B. June 1944 - December 1945, December 1945.
[11] T.N.A., AIR 29/514, A.F.E.E. O.R.B. June 1944 - December 1945, 3 November 1945.

	challenging, that conducting the operation by hand.
Test of York for Paratrooping Test of Hastings for Paratrooping	The Hastings replaced the Avro York when it came into service in 1948 and consequently became a key paratroop aircraft. The fact that preparations were underway into its suitability for paratrooping in 1945 proves the A.F.E.E. assertion that they were best placed to deal with all aspects of flight performance tests transport aircraft.
Dropping of Heavy Equipment: This included a wide variety of items including tractors, assault boats, trailers and motorcycles	Much of the work was well in hand and unique to A.F.E.E.
Test of Halifax for Troop Carrying Test of York for Troop Carrying Test of Hastings for Troop Carrying	The lack of a purpose built troop carrying aircraft meant that existing types required modification and such investigations naturally fell to A.F.E.E. although no works had commenced.
Flight Test of R-4B Helicopter Flight Tests of R-6 Helicopter	Helicopter performance testing became a major part of the A.F.E.E. function and work was well underway in September 1945.

Source: T.N.A., AVIA 15/2253, A.F.E.E. Future Technical Policy, 22 September 1945

Appendix 11: A.F.E.E. Long-Term Test Programme September 1945

Long-Term Tests	Remarks
Effect of Glider on Tug Stability Measurements of Tow Rope Forces Improvements in Tow Cables Improvements in Glider Pick-up Technique	All of the tests were recorded as being ‘well in hand’ but the future application of such improvements remained uncertain.
Auto Release of Parachutes Measure of Shock on Parachute Opening Development of Shock Eliminator	The work had all started and was directly linked to the function of dropping of heavy equipment.

Source: T.N.A., AVIA 15/2253, A.F.E.E. Future Technical Policy, 22 September 1945