Albion archaeology

FORMER
ROCKET PROPELLENT ESTABLISHMENT
WESTCOTT
SOLIDS AREA (SPA)

WESTCOTT VENTURE PARK
WOTTON UNDERWOOD

BUILDING RECORDING

Document: 2009/36
Version: 1.1
Project: WSPA

January 2009

Town / Parish	Wotton Underwood
Address	Westcott Venture Park
National Grid Reference	70201649
Planning application no.	*07/01511/APP*
Archive	Buckinghamshire County Museum
Client	Rockspring
Project no.	1341
Fieldwork	November/December 2008

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All photographs Nigel Macbeth, except *
* photographs Albion Archaeology

Preface

Every effort has been made in the preparation of this document to provide as complete a report as possible, within the terms of the specification. All statements and opinions in this document are offered in good faith. Albion Archaeology cannot accept responsibility for errors of fact or opinion resulting from data supplied by a third party, or for any loss or other consequence arising from decisions or actions made upon the basis of facts or opinions expressed in this document.

The project was managed on behalf of Albion Archaeology by Hester Cooper-Reade BA (hons) who also undertook the building recording and wrote this report. Ian Turner assisted with the survey and Jenny Ford carried out the oral history interviews and transcribed the results. All photographs were taken by Nigel Macbeth unless otherwise acknowledged. Joan Lightning BA(hons), AIFA, prepared the original plans and illustrations.

Acknowledgements

The project was commissioned by Goodman for their client Rockspring. Works were monitored on behalf of the local planning authority by David Radford and Sandy Kidd, County Archaeological Officer, Buckinghamshire County Council. Thanks are due to Ed Andrews, Stuart Marsh, Nigel Allsop, Rob Kinchin-Smith (RPS), Sandy Kid.

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December 2008/January 2009

Structure of this report

After the introductory Section 1, this report presents the results of the historic building survey. The survey requirements were for a record to Level 2 standard (English Heritage 2006). The report, however, includes background information to place the buildings in context, a description of the site and an overview of process and phasing, where possible to ascertain. Conclusions are presented in Section 4 and a number of separate appendices contain the detailed building descriptions and a information on content of archive. A selection of photographs and copies of the drawn plans are included to illustrate the text. Photographs of each individual building are included in Appendices 1 and 2.

Plans are based on those provided by the client and the various archive plans that exist of the site. For ease of reference building numbers used on the military plans have been used. The existence of the historic plans and use of field sketch planning has allowed a more detailed level of recording than that normally associated with a Level 2 report.

Historic measurements are given in feet and inches; where these relate to survey measurements the metric equivalent in also given. For historic descriptions the imperial measurement is used with the metric equivalent in brackets; otherwise the metric measurement is given with the imperial equivalent only if it is relevant to the description.

Compiled by	Checked by	Approved by
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Non-Technical Summary

Between November 2008 and January 2009 a project team from Albion Archaeology carried out a Level 2 (English Heritage 2006) historic building survey at the former RPE Westcott , on behalf of Rockspring. The work was a requirement of a planning condition compliance which was monitored on behalf of the local planning authority by the County Archaeological Officer.

As part of the project 54 buildings or building remains were recorded within the Solid Area and an additional eight buildings within the main area of the site. The summary record of the buildings with the main area of the site have been included as Appendix 2 but are not discussed as part of this report. The Solids Area is located in the south-western corner of the Westcott site and includes a number of processing and administrative buildings and storage magazines.

Westcott was one of the two sites (the other being Summerfield) of the Royal Ordnance Rocket Motors Division. . Until it became part of Royal Ordnance in the 1980s, the work at Westcott was co-ordinated by RAE Farnborough under the auspices of various government departments. Run from the defence budget, RAE Farnborough and is out stations were involved in most of the UK's space projects, which, until the mid-1960s, included sounding rocket, launch vehicle and satellite design, testing, construction and operation, both in-house and in association with industry. Westcott is perhaps most well known for its association with the Blue Streak missile, but the solid propellant technology developed on the site also had a lasting legacy and made an important contribution to the UK'ss commercial and military rocket capability.

Westcott.began life in 1943 as a wartime RAF airfield. The site was briefly used as a prisoner-of-war repatriation centre, before becoming the Guided Projectile Establishment, the first of many titles, in April 1946. Westcott was chosen for this role as a result of its central location and accessibility from other associated defence establishments. By the late 1940s the establishment at Westcott was associated with research into solid and liquid fuels, motor design and testing.

Westcott Rocket Propulsion Establishment (RPD), as it was most often known, was divided into three divisions under overall control of a Superintendent. The solid propellant division was mostly associated with guided missile applications, though research into upper atmosphere and meteorological rockets also took place. New propellants were developed in co-operation with the Explosive Research and Development Establishment at Waltham Abbey, whilst 'ironmongery' was developed in conjunction with other Royal Ordnance Factories and private companies. Flight magazine of 1956 comments that solid rockets almost monopolized the boost propulsion of missiles and test vehicles and that the development of slow-burning charges and lightweight bodies had, by then, put Westcott in a dominant position in the field of sustainer propulsion (Flight 1956).

Research into the various properties of different types of propellant grain and the combustion process was key to rocket motor design. Solid propellant was mixed, pressed, extruded, cut and cast in a series of traversed buildings in the south-west of the solids area. Other buildings were used for the investigation, design and testing of rocket motor tubes, igniters and other rocket components. Many of these processes used hazardous materials with a high risk of explosion. As a result a number of the buildings and storage areas were traversed or set apart and the administration block included a shifting house where staff and visitors would change into special clothing. Many of the buildings are of standard design, 19 were built to the specification for a Ministry of Works hut, a few such as SPA36 and 37 were purpose-built for a specific function.

Westcott Rocket Propulsion Establishment played an important role in the development of rocketry in the UK, for both ballistic weapons and space flight. Although the buildings themselves are of standard military construction and they no longer contain any plant and only a few fixtures and fittings, taken as a whole they form a significant element of Cold War history. A detailed record of the buildings, when made in combination with contemporary knowledge and historical site, has allowed some description of the processes and the general operation of the site. Buildings and processes, in particularly experimental ones, are largely overlooked in the record and the buildings at Westcott are an important contribution to study of the military built heritage of the Cold War and more recent periods.

Although many of the buildings are of similar construction and none stand out as examples worthy of preservation.

1. INTRODUCTION

1.1 Planning Background

As part of planning Application 07/01511 (submitted to Aylesbury Vale District Council), a number of the post-war buildings in the SPA (Solid Propellant Area) at the former Westcott Royal Ordnance factory have been selected for demolition.

The site has been identified as of particular interest in relation tot the development of rocketry during the Cold War. Several structures within the wider Venture Park have been identified as of national importance, although these are not within the application area itself.

As a result of the advice in PPGs 15 and 16, as reflected in policy HE 1 of the County Structure Plan and the archaeological policies of the District Local Plan and bearing in mind the significance of the site, planning consent is subject to archaeological condition. This is in accordance with advice received from their archaeological advisors, Buckinghamshire County Archaeological Service (BCAS).

> *No development shall take place until the applicant. Or their agents, or successors in title, have secured the implementation of a programme of archaeological buildings recording in accordance with a written scheme of investigation which has been submitted by the applicant and approved by the planning authority*

1.2 The Research Background

Much recent research into World War II remains has concentrated specifically on fortifications and airfields (Brown and Glazebrook eds. 2000, Glazebrook, ed. 1997); although the general importance and vulnerability of other World War II sites has been recognised for some time (English Heritage 1998). The inclusion of defence sites in archaeological record systems, largely as a result of English Heritage's Defence of Britain project, has led to increasing knowledge and interest in the subject (English Heritage 2003). Modern Military Matters (Schofield 2004), places research and development and manufacturing in Research Theme 2, and notes that whilst the topic has been widely studied by historians of technology, little archaeological research and recording work has been carried out. Although more work has been undertaken since the publication of Modern Military Matters, archaeological recording relating to the Cold War research and development establishments is still confined to one or two sites (Tuck 2004). For each of the research themes identified, *Modern Military Matters* noted the need for a better understanding through a record of the surviving structures as a key research aim for the future. This survey will make an important contribution to this research.

The study of industrial remains has been defined as an archaeological research priority of national importance in a draft research agenda by English Heritage (English Heritage 1998). The document stresses that site-specific studies are still needed to enhance our understanding of specific industries and single monument forms. There is also a need to place these industrial activities into the broader context. English Heritage's Monuments of War (1997) notes the complexity of Cold War sites and rapid loss of structures and equipment

The site has been identified as being of particular interest in relation to the development of rocketry (Cocroft 2000; Green, Giggins and Welch, 2007). Study of research and development sites, what was built, where and why it was needed has been identified as a gap in knowledge (Schofield 2004). Whilst none of the buildings selected for demolition are architecturally complex themselves, or of intrinsic national importance, they are of collective interest because of their association with the military testing process and the development of rocketry.

The Royal Ordnance site at Westcott, a former World War II airfield developed in 1946 as a rocket testing facility and during the early 1950s as a rocket research facility, is one of a handful of sites in Britain associated with the development and manufacture of rockets for military uses and upper atmosphere research. The site and its structures were used as a facility for the abortive British IRBM (Intermediate Range Ballistic Missile) Blue Streak.

1.3 Aims and Objectives

The purpose of the work as outlined in the Written Scheme of Investigation (2008 Albion Archaeology) produced to show how the work would comply with the brief (2008 BCAS) is a follows:

- Compile of a high quality photographic record of the site with both interior and exterior views of the building
- Produce an account for the plan, form, materials and construction, function, age and development of the building
- Produce an account for any fixtures and fittings associated with the buildings and their purpose
- Review of the local and regional historical context of the structures and processes recorded by the project
- Assess the function and significance of various components of the complex
- Produce of a high quality, fully integrated archive for long-term deposition in order to preserve by record the building in its current form prior to demolition

1.4 Site Location and Description

Fig. 1
Plates 1-2
The former Westcott Rocket Propulsion Establishment lies approximately 10km west of Aylesbury town centre in the parish of Wotton Underwood at NGR 70201649

The site is currently in use as a business park. The area subject to the recording brief is in the southern part of the site and contains former military buildings associated with the rocket research facility. Most recently these buildings have been subject to a variety of light industrial and office use, although many have remained empty since the closure of the Solid Area.

1.5 Stages of Work

Some of the structures on the main site required early demolition and so with the agreement of the County Archaeological Officer (CAO) these were added to the list of structures that required recording. Structures recorded on the main site were: H4a, H4b, H4c, 67, 187, 257, 306, S1, Z405. These are described in Appendix 2 of this report. Most of these buildings were recorded as part of a preliminary stage of works, followed up by the main recording of the SPA site and the remaining buildings from the list of those requiring early demolition on the main sites. Recording took place over several months between October and December 2008. Environmental concerns including presence of badger sets and roosting bats meant that access to a few of the buildings was limited or had to take place in accordance with the licenses in place. In some cases partial demolition of clearance work was required as part of the requirements for managing wildlife on the site. Where this was necessary full descriptive record sheets, including plans and accompanying photographs were submitted to the CAO for approval in advance of any works.

A full ‘archive report’ containing record sheets, plans and accompanying photographs was submitted to the CAO in advance of this more synthetic report which draws the results of the record together. The ‘archive report’ is included as a separate appendix and should be read in conjunction with this report.

1.6 The Report

This report is intended as a synthetic overview of the site, its historical background and the processes that took place there. It draws on primary and secondary documentary and cartographic sources, and a detailed photographic record and building recording survey of the site. Key aspects of the built and historical evidence are described here. Individual building descriptions including further information about their structure and form and the processes that took place in them are reproduced as an appendix which should be read alongside the main report.

The body of the report has been divided into separate sections to describe groups of buildings and/or different functions/processes. The technical development, political history and the science of space flight and rocketry are generally well covered in the literature, although there is very little accessible information on the processes involved or the operational workings of the various research establishments. In order to give the reader a better understanding of the technical and political background against which research into rocketry took place. the main body of the report is preceded by a reasonably full section giving the general background information including a description of rocketry with particular reference to solid fuel propellants and a summary of what can be deduced of the history of Westcott itself.

2. HISTORICAL BACKGROUND

2.1 Introduction

The history of rocketry is complex, but the technological, organisational and political context of the development of rocket science helps place the work of the government-run establishments such as Westcott into context. The many different research interests – space flight, upper atmosphere research, guided weapons, commercial and civil applications – led not only to technical complexity, but a vast array of different organisational structures and responsible bodies. The links between government departments, the research establishments, learned societies, industry and the competing requirements of secrecy, commercial sensitivity, funding and politics, meant projects were notoriously difficult to manage with many different areas and scientific disciplines taking responsibility for various aspects of the work. Because of these difficulties, and dependant on the prevailing political background, overall responsibility for missile and space research was subject to frequent change and re-organisation. Westcott was at the outset mostly involved in the development of rockets for guided weapons systems, although over the years work carried out there was also associated with the development of upper atmosphere research and space flight.

During the world wars the success of the armed forces became ever more dependent on scientific research. In the Second World War, the development of radar, jet engines, rockets, computers and the atomic bomb highlighted the role science in modern warfare. As a result of this emphasis, dedicated research establishments, often with highly specialised test equipment became a feature of the defence estate (Cocroft 2000). The importance of these establishments, grew throughout the Cold War and many were set up to investigate specific problems associated with new technologies, including nuclear weapons and jet propulsion.

Post-Second World War research into rocket propulsion and the manufacture of launch vehicles and missiles in the UK has been conducted in various locations, under the responsibility of various government departments and by various combinations of public and privately funded companies. From 1946 until recent times, Westcott has been the main location for government-funded rocket propulsion research. The government departments responsible for this research were at various time the Air Ministry (1918-1940), the Ministry of Aircraft Production (1940-46), the Ministry of Supply (1946-1959), the Ministry of Aviation (1959-1970), and from 1970 onwards Ministry of Defence.

2.2 Historical, Political and Technological Background

Prior to the Second World War much of the work on rocketry and space travel had been pursued by the amateur societies and it was only with the advent of the Second World War in 1939 that the government began to lend moderate support to the development of rocket propelled weapons.

Britain faced great changes in the post-war as the era of Empire gradually came to a close the country found itself in a period of economic uncertainty. As a result the UK was forced to reassess its role on the world stage. Aspiring to maintain world power status, Britain pursued the development of atomic weapons and invested heavily in military research and development. Britain's spend on science and technology in the post-war period rose from £6.6mil in 1945-6 to £30mill in 1950-1 and up to an estimated £295mill in 1967-8 (Goodwin 2008). However, the constant pressure on the British economy through this period and the changing political climate, in particular attitudes towards European cooperation meant that by the mid 1960s a number high profile technological projects had been axed (Goodwin 2008). However, in the immediate post-war period the Cold War had yet to begin in earnest and rocket research was largely concerned with the development of captured German technology. The impact of the German V2 bombers had been sufficient to ensure that, by the post-war period, there were a number of projects aimed at a range of military requirements from anti-aircraft defence to strategic bombardment (Baker 1978). Although the German V-2 rocket was neither accurate nor reliable, it represented an impressive technological achievement (Winter 1990) and its psychological impact meant that the development of rocket technology was widely assumed to have a significant role in future conflict.

A government report, completed in 1946, led to the amalgamation of the Ministry of Aircraft Production into the Ministry of Supply and creation of a Directorate of Guided Weapons Research and Development. This directorate was tasked with co-ordinating research and Royal Aircraft Establishment (RAE) Farnborough began to assume general direction of operations, including firing trials at Aberporth (simple firings were also carried out at Larkhill), Cardigan and rocket propulsion systems research and testing at Westcott. Apart from some knowledge of supersonic aerodynamics and rocket motors and the German experience, there had been little on which to base the work. However, an enormous amount of documentation on the V2 was found in Germany and shipped to the UK. The Herman Goering Institute was in Britain's occupation zone and captured papers and hardware were sent to the RAE Farnborough. A number of German scientists who had worked on the V-2 rockets went to work in US, USSR and Europe to help develop that technology in those countries. England obtained the services of Walter J. H. Riedel, von Braun's deputy, who, after a brief stint at RAE Farnborough, worked at Westcott until his death in 1968 (Winter 1990). RAE archives from 1944-46 imply that captured German information had a potentially large influence on the design of future UK aircraft and guided weapons systems (Dommett 2005)

In addition to Westcott, Cardigan and Aberproth, other establishments under the overall co-ordination of RAE Farnborough were the Radar Research Establishment Malvern, National Gas Turbine Establishment Pysestock, Signals Research and Development Establishment Christchurch, armament RDE Fort Halstead, Admiralty SRDE, Portsdown, Explosives RDE Waltham Abbey and the Weapons Research Establishment and long-range weapons ranges at Salisbury and Woomera (Lighthill 1965). From the autumn of 1953 the cost of experiments at Woomera and Salisbury were shared between Britain and Australia. In May 1954 discussions were held between the Ministry of Supply and the US Defense Department and other agencies with the aim of preventing duplication of effort in the missile field and the establishment of machinery for joint consultation and mutual sharing of problems.

Progress on rocket research, however, remained slow; although the situation changed somewhat when the USSR exploded its first nuclear weapon in 1949 and the Korean War begun the following year. In January 1951 the Labour government announced a three-year armament programme amongst concerns over the continued lack of an effective UK strike capability. Although Labour's defence spending was later cut back by Churchill's post-war government of October 1951, engagements between western spy planes and the growing Soviet defences, along with and the assessments of the growth of Soviet defences, showed that Britain's existing military response would be too vulnerable by 1960 to remain a credible deterrent (Dommett 2005). By end 1952 the Air Staff had therefore began to plan for the next generation of weapon systems.

The acceleration of the guided weapons programme and the new challenges of the space race meant that government contracts were being increasingly placed with private sector companies. As the Cold War progressed the distinction between 'civil' and 'military' projects were often largely meaningless, and although the two strands were overseen by their own respective departments, those involved with the civil elements of space research were usually also involved in defence work. To augment the work undertaken by the research establishments (and to provide the necessary production capability) there was close liaison with a number of universities and development contracts were placed with industry. To facilitate the exchange of ideas, technical staff were seconded to RAE and other establishments.

Against this background, Britain began work on its own intermediate range ballistic missile (IRBM). Called Blue Streak, it would have been capable of carrying a thermonuclear warhead across a distance of nearly 4,000km . The resultant activity was described by Minister of Supply, Duncan Sandys in 1954 (quoted in Twigge 2002):

> The work has been undertaken both in the Ministry's Experimental Establishments, practically all of which have made some contribution although the greater part has been carried out at RAE (G.W. Dept), the Rocket Propulsion Dept and at RRE and in industry, where, in addition to about 12 major contractors there are some 200 others covering about 450/500 contracts. Contracts engaged on major projects employ over 1600 White Paper staff

In May 1955, at about the same time that work began on the Blue Streak, Westcott outlined a specification for a rocket that could be used to test different types of warheads which could be fitted to the IRBM and other ballistic missiles that might be developed by the UK. The Black Knight rocket was developed in conjunction with the main contractors Saunders Roe and Armstrong Siddeley. Progress was rapid and although it would be several years before the Blue Streak IBRM was ready for flight trials, the Black Knight rocket was operational from 1958.

Black Knight was never intended as anything but a pure research vehicle to investigate hypersonic re-entry into the Earth's atmosphere, but by the time Blue Streak was cancelled in 1960, it had proved itself a valuable carrier of research payloads unconnected with the defunct missile (Flight International Magazine 1964b).

In many countries a key catalyst to the development of rocketry was the International Geophysics Year July 1957 – December 1958, an international co-operative programme deliberately timed to monitor the Earth during a period of pronounced solar activity. Whilst Britain had no plans to prepare a national satellite specifically to celebrate the IGY, the RAE in collaboration with the

Royal Society did promote the development of a simple sounding rocket called Skylark.

Prepared in a minimum of time the project was overseen by RPE, Westcott. The Skylark solid propellant rocket, comprised a cylindrical tube 43.2cm in diameter and nearly 4.6m long. The solid propellant Raven motor and several derivatives emerged as refinements were made to the chemical ratio of the propellant mixture (Baker 1978). The Raven was the largest motor of its type to be attempted in the UK at the time and made Skylark the first single-stage high performance solid propellant sounding rocket in the world. These motors could be further boosted by the addition of the Cuckoo 1A, Goldfinch IIA (a more powerful version) and Cuckoo III (which burnt more quickly. The motors used for Skylark were also used for other rockets and missiles produced by Britain as part of its space and guided weapons programme. This is yet another instance of the blurring of the boundary between civil and military, as different component parts of a Skylark could be used for a military missile (Goodwin 2008).

With the Skylark rocket, the solid propulsion section at RPE Westcott, under the control of J.H. Crook, provided the UK with an exceptionally efficient tool for probing the upper atmosphere and near space (Baker 1978). Research as a result of this programme included study of composition and properties of the atmosphere, magnetic field of earth, solar and stellar radiation (Goodwin 2008).

British research into guided missiles was closely bound up with the space programme. In many cases the rocket motors used were the same and one set of research informed the other. Britain’s programme during the late 50s and into the 60s was largely concentrated on the development of the Skylark rocket, satellite work with the USA, the development of sounding rockets for meteorological work and co-operation with Europe. As always there were a number of different strands to this research. The skylark project, for example began as a joint Royal Society and Ministry of Supply project and the Meteorological Office was also involved in some limited space research through its own programmes (Goodwin 2008). Some of the universities were also heavily involved in space research, particularly University College London and Birmingham (Goodwin 2008). When Sputnik 1 orbited the Earth in October 1957, the UK was perceived by as the only nation, after the Soviet Union and the US, that possessed the level of scientific and technological expertise necessary to pursue and equivalent space programme. This was largely due to the involvement of private industry and civil research in the military programmes.

During the Cold War scientists tended to find ways to stress the defence significance of their work in order to win military support (Goodwin 2008). Much military research also had civil applications and there has been a long history of discoveries made for military purposes later being applied commercially. Part of the role of the Ministry of Supply and its Research Establishments, was to assist the associated industries with practical help and allocation of public funds. This arrangement was a direct legacy of the UK industry’s organization to meet the exigencies of the Second World War and one that continued through until the mid- to late-1960s. As the European space programmes developed, so UK industry was able to tender for contracts, independently at first, but increasingly as members of pan-European industrial consortia. In the 1950s and early 1960s the sprawling UK aircraft industry underwent massive consolidation, leading to the formation of the British Aircraft Corporation and the Hawker Siddeley Group, which, in turn, were amalgamated as British Aerospace in 1977.

Co-ordination of the research and development programmes was the responsibility of the government ministry in charge at the time, and it was the ministry who placed contracts with private firms. The Minister of Defence and cabinet were ultimately responsible for political decisions which by 1961 were subject to scrutiny by the Research and Development Board chaired by a Permanent Secretary. In addition to the organisational set-up of the research establishments, the ministry included a Chief Scientist, a Controller of Aircraft and Controller of Guided Weapons along with a number of departments containing scientific and technical staff all involved in coordinating the work of the research establishments. The Chief Scientist reported annually on all research carried out by the ministry's establishments, or by private companies or university departments under contract. The Air Ministry merged with the other service ministries to form the Ministry of Defence in 1964 and from 1965 the Cabinet Office had an important role coordinating research programmes with the formation of the Communications, Electronics and Space Committee, thus emphasising the increasing importance of the space programme.

During the 1960s government was increasingly changing their attitude towards civil and military projects. In particular the Suez crisis underlined nervousness about Britain's over-stretched economic position, and subsequent concern over the level of inflation and public spending precipitated a political crisis for the Conservative Government. By the beginning of the 1960s there was widespread public discussion of economic stagnation and even decline (Goodwin 2008). The limitations of UK's planned strategic deterrent, based on the Blue Streak missile delivery system, had become increasingly clear and in 1960, against this political and economic backdrop, Blue Streak was abandoned in favour of the US Skybolt system.

Although highly sensitive to political change, European and international cooperation were key to the development of space and guided missile rocket research. By offering Blue Streak and bulk of associated UK infrastructure, experience and expertise for a possible European satellite launch vehicle programme (ELDO), Macmillan, the Prime Minister at the time, not only recovered some of the political lost ground as a result of cancellation but was able to demonstrate the UK's pedigree as a prospective member of the European Common Market. Similarly Heath's government in the early 1970s championed the idea of the European Space Agency as a way of proving the country's European credentials.

Following on from the Rothschild Report (1971) ministerial responsibility for space had moved from the abolished Ministry of Technology to the Department of Trade and Industry; and departmental responsibility for the RAE was moved into the new Ministry of Defence procurement executive. The DTI retained ministerial responsibility for space matters despite involvement of other departments.

The later 1980s, into the 1990s saw an increasing trend towards privatisation. Westcott and a number of other sites, including the site at Waltham Abbey with which it had strong links, were incorporated into Royal Ordnance plc in 1985. Royal Ordnance began increasingly to tender for external work and by the mid

1980s was involved in developing systems for missiles such as the Rapier, the Vertical Launch Seawolf missile and Alarm (an air-launched anti-radiation missile) (Flight International Magazine 1985). Royal Ordnance was subsequently sold to British Aerospace in 1987 and became BAE systems in 1999. Other Royal Ordnance sites were merged together to form the Defence Research Agency, later the Defence Evaluation and Research Agency. This in turn was split in the early 2000s with the major part becoming QinetiQ, the more sensitive parts being retained as the Defence Science and Technology Laboratory (Dstl).

2.3 Solid Propellant Rocketry

(See Table 1 for description of propellants)
Chemical rocket propulsion is the only method that can produce enough thrust to overcome the gravity of the Earth's surface. The chemical propellants used in rockets are solids, liquids or gases or a combination. Propulsion systems using solid propellants are generally called motors, those using liquid propellants engines. Different types of propellant are used for different purposes depending upon the type of thrust required. Some propellants for example produce toxic fumes and others cannot be easily stored or are not suitable for long duration missions. Rocket systems are classified in a variety of ways: by their nature of use (e.g., launch, altitude control, orbit adjustment, apogee kick motor, station keeping), by type of energy (chemical, electric, nuclear) and by the phase of the propellant (liquid, solid, hybrid). Solid propellant rockets are used as launch vehicles, boosters to assist other types of launch vehicle, and to change orbits and trajectories. Solid propellants are by far the simplest type of rocket propulsion system and are therefore more reliable (Rogers 2008).

In a liquid propellant rocket engine, propellants are stored in tanks and fed into a combustion chamber or rocket thrust chamber by a pressurized gas or a pump. Although more complex and less reliable than solid propellant motors, rocket engines can be tested on the ground prior to launch, use propellants that can be stored for many years and usually produce non-toxic exhaust.

The solid rocket motor is simply a container filled with a solid propellant that, when ignited, expels hot gases through a nozzle. The propellant must burn at the proper rate to maintain the desired chamber pressure and have the structural rigidity to withstand the pressures of ignition and the subsequent dynamic loads.

Solid propellant is a mixture of chemicals consisting of fuel, oxidiser and a binding material. These are bonded together to form a compound called the grain, which is then moulded around a core. The core is then removed leaving a cavity in the grain, called the cavity core. The motor's performance is determined by the chemicals used in the grain, by the interior shape of the cavity and by the nozzle design. Typical chemicals used are powdered aluminium, the fuel, and ammonium perchlorate, the oxidiser. A synthetic rubber-like material such as polyurethance or polybutadiene is used to bind the fuel and oxidiser together into the required shape.

The ignition system is composed of an igniter propellant that can be made from the same chemicals as those in the main grain, or from different chemicals. The burning igniter propellant produces a lot of heat and gas very quickly, which rapidly fills the cavity in the grain and causes the grain to ignite. A pyrotechnic igniter generally consists of a sensitive primer ignited by an electric impulse, whilst the pyrogen igniter is essentially a small rocket motor that is designed to produce high pressure and hot gases, but not thrust.

The rocket motor casing is designed to withstand the great pressures and temperatures produced within the motor. It is usually made of a metal such as steel, aluminium or titanium, or a composite fibre-reinforced plastic. The lighter the casing, the more efficient the motor. To protect the casing from the heat inside, it is usually insulated, although the grain itself also insulates the casing during the initial stages of burning. The hot gases produced by the combustion of the propellant flow through the cavity and out through the nozzle. The nozzle is designed to expand and accelerate the hot gases to supersonic speeds and therefore must be able to withstand the hot temperatures and erosion caused by the gases.

The rubber-like organic insulator liner assures bonding of the grain to the motor case and acts as a thermal insulator. Bonding helps prevent the hot combustion gases accessing any surface of the grain not intended to burn, and, also, to prevent heat damage to the combustion chamber walls. To provide control the nozzle is often gimballed with sliding parts and to minimize erosion throat inserts are often used in the design; these are primarily made from pyrolytic graphite (Pisacane 2005). The surface of the nozzle can be protected by locating a cooler-burning propellant in the combustion chamber near the nozzle which forms a boundary layer of cooler gases. Special materials can also be used to provide either insulation, or enhanced heat transfer. Ablative materials such as refrasil, asbestos phenolic and graphite can be used selectively to carry heat away.

The amount of surface area of propellant around the cavity that is exposed to the high temperatures directly affects the thrust produced. A higher surface area will increase thrust but reduce the burn time, as the fuel will be used up more quickly. A constant thrust requires the burning surface area to be constant. This can be achieved by different cavity core designs, dependent on the amount of surface area exposed to burning. The most usual configuration of the grain involves a charge in the form of a hollow cylinder which burns on its inner surface. If a constant thrust is desired the inner cross-section of the grain is formed like a cog.

Once the rocket is ignited it cannot be varied from the predetermined thrust or duration and unless the rocket incorporates design features such as the ability to rotate or blow off the nozzle, the rocket will consume all of the fuel without any option for shutoff or thrust control, it can only be lit again if a second igniter is present. Most large motors take a few seconds for the grain to ignite. (Rogers, 2008)

Modern solid propellants are either Double-Base or Heterogeneous (Composite). Double-Base Powders are gelatinised colloidal mixtures of nitroglycerine and cellulose to which certain stabilizers have been added. Heterogeneous or Composite propellants are physical mixtures of a solid oxidizer in powder form and some form of solid fuel, such as a plastic or rubber-like material. Rocket motors which burn double-base fuel have greatest use in weaponry; rocket motors burning heterogeneous or composite fuel are used for propelling all kinds of military missiles and for sounding rockets. Both Cast and

Extruded Double-Base propellants have found extensive applications, mostly in smaller tactical missiles of older design.

At the beginning of the Second World War Extruded Double Base propellant (a cordite extrusion), Plastic Propellant (a composition of inorganic oxidisers and an uncured polymeric binder) and early production of Ammonium Nitrate Composites were available. By the end of the Second World War rockets were able to support Extruded Double Base propellant in up to 7½" charges. Even this size needed 15" diameter presses. Motors however could be built up from individual extrusions and motors of up to 10" diameter were in use during the last year of the war. Prior to the instigation of solid propellant research at Westcott, two other important developments occurred, namely the production of Cast Double Base charges at the Royal Arsenal, Woolwich, and the development of Guanadine Nitrate as a propellant for use in pressed charges by ICI (Harlow 1992).

Westcott had a key role research of the various binders, fuels and oxidisers that went into the propellants. The aim of most of this research was to raise the performance and reliability of the rocket, whilst lowering temperature of the burning grain and to develop a better understanding combustion process and reaction of chemical constituents. Work undertaken at Westcott involved casting of propellant gains, static firing, materials research into motor cases and nozzles, development of techniques for the ignition of the grain, grain configurations, thrust-vector control and thrust termination, mixing techniques, and the development of liners, bonding agents, stabilisers and catalysts.

The most commonly used modern solid propellant rocket is based on a polybutadiene synthetic rubber binder, with ammonium perchlorate as the oxidiser and some 12-16% aluminium powder.

Technical Term	Notes
Single-base propellant	Have a single active constituent such as nitrocellulose (gun cotton) or nitroglycerin. These are unstable and are not used for modern-day rockets
Double-base propellant	Double-base propellants form a homogeneous propellant grain from the mixture of two active ingredients, typically nitrocellulose (guncotton) and an energetic nitrated plasticiser, such as nitro-glycerin, that causes it to dissolve and harden into a uniform solid. Both the maor ingredients are explosives and function as a combined fuel and oxidiser.
Extruded Double Base propellant (EDB)	Propellant grain is formed by extrusion
Cast Double-Base propellant (CDB)	Propellant grain is formed by casting
Cast-modified double-base propellant	By adding crystalline nitramines (HMX or RDX) the performance and density of the propellant can be improved. A further improvement is to add an elastomeric (rubber like) binder. The resulting propellant is called elastomeric-

	modified cast double-base (EMCB)
Composite-Modified Double Base (CMDB)	This is formed through the addition of some solid ammonium perchlorate and aluminium to one of the double-base mixtures.
Composite or heterogeneous propellants	Contain a heterogeneous mixture of fuel and oxidizer as separate compounds suspended together in a hydrocarbon binder in the proper proportions to support combustion. The fuels are typically metal powders. The binder forms the constituents into a rubbery mass that because of its elastic property, reduces potential burning instabilities due to pressure variations. The chemical oxidizers and inorganic fuels are mixed in powder form with a liquid binder that holds them in suspension until the mixture is cured in an oven as a solid. Composite propellants are cast from a mix of solid (AP crystals, Al powder) and liquid (HTPB, PPG) ingredients Darkening agents, such as carbon black of lampblack, are added to suppress heat radiation so as to prevent below-surface ignition that would result in uncontrolled burning. The propellant is hardened by curing the liquid binder polymer with a small amount of curing agent, and curing it in an oven where it becomes solid. Conventional composite propellants us ammonium perchlorate as a crystalline oxidiser, aluminium powder as a metal fuel, an organic polymer with added plasticiser as an elastomeric binder Composite propellants makeup the majority of modern rockets. More advanced than homogeneous propellants.
Fuels	Aluminium powder, Beryllium powder, Magnesium powder, sodium powder, hydrocarbons, polymers, plastics, rubber. Metallic powders are added to increase energy release and hence combustion temperature.
Oxidisers	Ammonium perchlorate (AP) is the main oxidiser used in solid propellant rockets. A significant part of the history of rocketry involves the successful use of ammonium percholrate as an oxidiser (Hunley 1999). Ammonium Nitrate (AN) is also associated with TNT as the oxygen carrier for shell filling mixtures. Whilst very insensitive, it is itself a powerful explosive.

	Potassium perchlorate replaced by ammonium perchlorate late 1940s which reduced smoke and gave greater specific impulse
Binders	Acrylic acid, Polybutadiene-acrylic acid (PBAA), acrylonitrile, and butadiene terpolymer (PBAN), Carboxyl-terminated polybutadiene (CTPB), Hydroxyl-terminated ploybutadiene (HTPB), Tetramethylene tetranitramine, epoxides, Nitrocellulose, polyurethane, PVC plastisol
Plasticisers	Nitroglycerine, triethyleneglycol dinitrate, trimethylolethane
Curing Agents	Aziridines, epoxy resins, hexamethylene diisocyanate (HMDI)
Cordite	This propellant is a gelatinised mixture of guncotton, nitro-glycerine and mineral jelly, produced by incorporating the two former ingredients by means of a gelatinising solvent, adding the mineral jelly, ripening, and extruding by hydraulic press to solid or tubular filaments of various diameters.
Gunpowder	A mixture of charcoal, sulphur and potassium (or other) nitrate. Relatively slow burning weak explosive.
Sounding Rocket	A sounding rocket is a small rocket which is designed to carry experiments into the upper atmosphere and features a compartment below the nose cone that can accommodate scientific experiments. The rocket fired and once the correct altitude reached, the experiment is activated. Scientific data is either transmitted to ground receiving stations, or, after a brief period in flight, the rocket falls back to earth and is recovered so that the results may be obtained.

Table 1: *Technical terms and chemicals used in the manufacture of propellants***.**

2.4 Brief History of Westcott

The development of guided weapons in the UK represents a significant aspect of British defence strategy. Second only to military aircraft sector in terms of government R&D defence expenditure, guided weapons are central both to the work of the research establishments and the output of the British defence industry.

In the guided weapons field the defence R&D establishments were responsible for performing two major functions: firstly, to provide a focus of scientific expertise allowing the government and services to formulate new operational requirements and secondly, to facilitate a close working relationship between the military and industry. In both these tasks the establishments fulfilled a critical role in assessing technological risk & in judging cost effectiveness of major investments. (Twigge 2002)

After the Second World War RAE Farnborough became the main government space and guided missile technology centre. Run from the defence budget, RAE Farnborough and is out stations were involved in most of the UK's space projects, which, until the mid-1960s, included sounding rocket, launch vehicle and satellite design, testing, construction and operation, both in-house and in association with industry. Westcott was selected for research into rocket propulsion and by the late 1940s was associated with research into solid and liquid fuels, motor design and testing. Until it became part of Royal Ordnance, the work at Westcott was co-ordinated by RAE Farnborough under the auspices of various government departments. Other locations associated with this research in the post-war period included Waltham Abbey (explosives research and development), Caerwent (nitro glycerine manufacture), Powfoot/Ardeer (CDB powder manufacture); Chorley (igniter cartridges), Bishopton (manufacture of extruded double base propellant) and Summerfield run by Imperial Chemical Industries Ltd (cast double base technology).

Westcott was one of the two sites (the other being Summerfield) of the Royal Ordnance Rocket Motors Division and began life in 1943 as a wartime RAF airfield. The site was run down after the war, briefly being used as a prisoner-of-war repatriation centre before, becoming the Guided Projectile Establishment, the first of many titles, in April 1946. Westcott was chosen as a result of its central location and accessibility from other associated defence establishments. Use was made of the four large ex-RAF hangers and other blocks of buildings on the site and two of the runways were kept operational for daily shuttle flights between Westcott and RAE Farnborough (Flight Magazine 1947, 1956). A visit by representatives of Flight magazine in 1947 noted that permanent buildings, including laboratories and test beds were in the process of construction (1947).

By 1947 Westcott had been re-named the Rocket Propulsion Establishment, although by 1956 it is being referred to as the Rocket Propulsion Department. Later the RPE/RPD merged with the Explosives Research and Development Establishment (Waltham Abbey) to become the Propellants, Explosives and Rocket Motor Establishment (PERME). PERME then became part of the Royal Armament Research and Development Establishment (RARDE). By the time RARDE was reorganised into the Defence Research Agency in 1991, Westcott had been privatised and sold to British Aerospace.

Initially Westcott concentrated on the technology involved with liquid propulsion, exploiting knowledge from German sources (Harlow 1992). But, by 1948 a large facility for research into plastic composite solid propellants for boost and sustainer systems had been built as Westcott. The visit by the 'Flight' magazine representatives in 1947 mentions a team of 12 German scientists, housed in Nissan huts off the site and, although given a free hand to work on their own specialized work, they were not permitted access to all information on current developments (Flight 1947). Westcott soon became the principal Commonwealth establishment devoted to research into rocket propulsion.

Westcott RPE/RPD was divided into three divisions under overall control of the Superintendent. Division I was responsible for liquid propellant motors for guided missile and aircraft applications. In 1956 some of the key areas of research included development of turbo-pumps, feed lines and valving, beatings and control systems (Flight Magazine 1956). Division II was the solid propellant division, mostly associated with guided missile applications. New propellants were developed in co-operation with the Explosive Research and Development Establishment at Waltham Abbey, whilst 'ironmongery' was developed in conjunction with other Royal Ordnance Factories and private companies. Flight magazine of 1956 comments that solid rockets almost monopolized the boost propulsion of missiles and test vehicles and that the development of slow-burning charges and lightweight bodies had, by then, put Westcott in a dominant position in the field of sustainer propulsion (Flight 1956). Division III was engaged in basic research into combustion, materials, chemistry, fabrication, quality control and other similar tasks. This Division also maintained a number of technical committees under the auspices of various scientific bodies and government departments. Combustion in particular was a major area of research as most of what was known related to combustion using oxygen from the air. Again the 1956 issue of Flight magazine notes that whilst universities contributed to much of this research, safety requirements often restricted the scope of their contribution.

A team from Flight Magazine visited Westcott once more in 1964 and reported many changes since the last visit. By the mid 1960s Westcott was principally charged with providing a solid foundation of knowledge that would enable Britain to preserve its capability in the field of rocket propulsion; thus underlining the research-based nature of work undertaken there. RPE continued to work closely with its sister site at Waltham Abbey, where research was concentrated on the manufacture of propellants and their chemistry, and with Bristol-Aerojet Ltd based at Banwell and who made research and development hardware to RPE design.

By 1985 Royal Ordnance PLC was gearing up for privatisation and began bidding for contracts in the US Strategic Defence Initiative (SDI, Star Wars) programme. Conscious that it could no longer depend on contracts from the MoD, Royal Ordnance began making plans for diversification. Arms and munitions would remain the bulk of its work, but development for the civil space market was becoming increasingly important, as were extensions to the military programme to include the use of rocket motors in anti-tank and underwater weapons (Flight 1985).

Although liquid propellants was a significant area of research, Flight magazine noted on its visit in 1964 that the vast majority of RPE motors, at least those within the public realm, used solid propellants. These included a 36" diameter motor, apparently the largest fired at RPE (Flight 1964a). RPE has constructed various of these so-called "battleship" test specimens; although igniter failure prevented a firing during the 1964 visit. Most of the solid propellant rocket motors developed at Westcott were named after birds, often the smaller the bird the larger the rocket (Stuart Marsh pers. com.).

Solid rocket motors researched at Westcott included the Raven for use with the Skylark high-altitude research vehicle and developed for firing as part of the International Geophysical Year. The Cuckoo motor was used as a booster for the Skylark rocket and powered the second stage of Black Knight re-entry vehicle and accelerated the test equipment to high speed in its journey back to Earth (Flight 1961). A Raven rocket seen during the 1956 visit by Flight magazine was described a 180" long and delivering a thrust of 11,500lb for 30 seconds, allowing it to take a vehicle to an altitude of 100 miles in 2½ minutes.

The cases of these rockets were being made with a new technology that allowed the construction of helically-welded cases of u.h.t. steel sheet. Other rocket motors inspected in 1964 included the Raven IIb, Gosling XV, Gosling VA, Lobster, Linnet and Magpie (each described as a “sustainer unit with long blastpipe (doubtless for a guided weapon)”), Imp and Snifter (small lateral-thrust units used for altitude control and parachute ejection), Smokey Joe (a 17”-diameter motor with a welded steel case and long blast pipe, so-called because the plastic propellant burns smokily and gives low thrust for long duration), Bantam III (a meteorological rocket), Chick (a tandem boost motor for the Skua vehicle), Rook (a boost motor for the Jaguar vehicle), and a couple of 17” and 10” experimental rockets. The Chick launched a meteorological rocket and was considered an extremely economical and reliable system that could be tracked by a moderately-priced radar and used a propellant that his cheap to manufacture (Flight 1961). The Gosling, on the other hand was the power unit of ground-to-air guided weapons (Flight 1966). Another motor utilizing 260lb cordite filling was the Mayfly. Similar in size to the Raven, the Mayfly was used in groups of four or more to provide a thrust of 15,000lb for 3½ sec. The Lapwing motor with a moderate specific impulse, end-burning charge bonded to a helically-wound steel case, powered the Petrel sounding rocket (Flight 1966). When on display, most of these solid propellant rockets would have been exhibited in SPA4, designated as the rocket motor exhibition building.

Westcott was also involved in test firings of the liquid propellant Blue Streak Rocket engine; test firings of the complete vehicle taking place at Spadeadam in Cumbria.

The basic design of the rocket engine for Black Knight was evolved at Westcott; as were the propulsion units for the upper atmosphere research vehicle, Skylark, the high speed research vehicles Jaguar and Leopard, and the meteorological rocket, Skua. The initial work in adapting American designs for engines for Blue Streak was done at RPE, and the establishment continued to support the later development of the engines by Rolls Royce (Flight International Magazine 1967). Black Knight was propelled by the Gamma rocket motor produced by Armstrong Siddeley and also developed by RPD Westcott. The £5m Black Knight project under Ministry of Supply contract was the joint responsibility of the Ballistic Missile Division and Westcott, but also involved a number of private companies including the Saunders-Roe Division of Westland Aircraft who developed the airframe, and Armstrong-Siddely who manufactured and undertook a large part of the design work on the engine, in this case a Gamma motor developed by RPE and using liquid propellants. Solid propellants were however used in the Cuckoo which acted as a second stage motor. Another RPE designed motor, the Imp, was used as a Third Stage Motor to ensure that the test body was separated from the debris of the second stage.

By the mid 1980s Westcott was involved in developing systems for missiles such as the Rapier, the Vertical Launch Seawolf Missile and Alarm (Air-launched Anti Radiation Missile).

Scientific research into general problems or areas where knowledge needed to be improved formed a significant aspect of the work at Westcott. Study of the problems associated with the burning of solid charges for ballistic missiles or space rockets and developing a greater understanding of chemical reactions during combustion were always key areas of research. Non-classified research at the time of the 1964 visit included a variety of experiments designed at understanding the combustion process and achieving a better design for rocket cases and nozzles.

Work undertaken in the establishments provided:

- direct support of projects under development
- provision and maintenance of large capital equipment for common use by the military and industry, including firing ranges, wind tunnels and testing facilities.
- exploratory research aimed at improving existing equipment or establishing the next generation of technology.
- basic research likely to be of assistance to the British defence industry
- provision of expert advice to the government, allowing the evaluation of work undertaken by industry under contract and the effective monitoring of extramural research work
- contributions to work undertaken by industry, particularly in the development stage of projects where no civil application possible

A major part of the research undertaken at Westcott was carried out under contracts with industry. Contracts were generally used for pre-feasibility work and the design and manufacture of experimental hardware generated by the research activities of the establishments. In 1950, for example, there were at least 13 establishments undertaking research work on guided weapons (Twigge 2002).

The standard of basic research carried out at the establishments has been open to question with many arguing that it was generally too academic and therefore marginal to production (Twigge 2002). The establishments, however, had a key role in managing complex programmes involving wide range of organisations and were expected to play full role in engagement with industry, especially in the development stage of projects where no civil application possible. Independent expert advice was provided to government and the future of many defence projects often depended on this advice. The establishments were often accused of an inability to judge cost effectiveness and estimate full cost of testing and implementation. This needs to be weighed against their role in providing continuity of thought, process, and knowledge. Despite these difficulties the engineering techniques pioneered by British scientists compare favourably with development in USA, with British expertise in design of rocket motors, re-entry vehicles and silo construction reportedly forming a significant element in the US ICBM programme (Twigge 2002).

3. BUILDING RECORDING: DESCRIPTION AND ANALYSIS

3.1 Methodology: Building Recording

Throughout the project the standards set in the IFA *Standard and Guidance for the Archaeological Investigation and Recording of Standing Buildings and Structures* and English Heritage's *Understanding Historic Buildings* (2006) have been adhered to. All work has been done in accordance with the IFA Code of Conduct.

The site survey comprised detailed examination of the buildings, compilation of a plan record of the structures using existing survey and historic plans, with the addition of measured sketch plans, and a photographic survey. The requirement was for a survey at English Heritage Level 2 standard (2006), although in order to complement the existing historic plans measured sketch plans were produced as part of the site record. In addition the use of digital photographs meant that more detailed external and internal photographs could be taken. The photographic survey was undertaken using high quality, high resolution digital photographs. The photographs will be deposited in .tiff format. A selection of the photographs have been reproduced to illustrate the report.

A number of historic plans mostly architectural and engineering drawings, dating from the 1950s through to the 1980s were available. These plans will be deposited as part of the project archive.

A full range of photographs were taken of individual structures, detailed points of interest and the buildings in their context. Internal access to some buildings was not possible, although in most cases similar types were recorded elsewhere within the study area. All surviving buildings and parts of buildings were recorded photographically regardless of condition, although this was done in less detail within buildings that were repeated as a better example elsewhere.

At the time of the survey conditions were good and vegetation clearance had taken place around most of the buildings. A number of environmental restrictions were in place as a result of legally protected species such as badgers and bats. Although this did limit some access and meant that it was necessary to agree the early demolition of some buildings, the survey was not significantly affected.

Identification of the former use of the buildings is largely the result of some initial research undertaken by Rob Kinchin-Smith (RPS) who spoke to a number pf past and present employees. Further information was obtained from Ed Andrews and Stuart Marsh who had both worked on the site when it was in operation, available archive plans and historic telephone extension lists which included building number and function.

3.2 Results of Survey

3.2.1 General Description of Site and Its Layout

Fig.s 1-3

The site is located on relatively flat ground with the buildings laid out in standard pattern, largely according to function (Fig. 2). The buildings are generally of one storey brick construction, either with pre-cast concrete slab, or pitched roofs. The solids area is within a separately fenced compound located in the south-west corner of the main site. It formerly contained some 52 buildings, five of which have since been demolished.

The current development area does not include the whole RPE site, although some buildings outside the Solids Area and which required early demolition were recorded. A description of the latter set of buildings has been included as Appendix 2.

3.2.2 Infra-Structure

Fig. 2

Access gates are located along the northern and eastern boundaries of the solids area (Plate 3). The two access gates along the northern boundary were beyond an additional gated area and would presumably have been used only by authorised personnel. One of these access points led directly to the X-ray and Ultrasound building, SPA41. This meant that the building could be accessed from both within and outside the solids area and thus used by teams working in other areas of the complex. The main entrance to the site was towards the southern end of the eastern boundary close by the administration, office and canteen buildings and the shifting area.

Movement around the site was via a series of single-track, interlinked concrete roadways with the spaces in between roads and buildings laid to grass. It is likely that vehicles and pedestrians would have been restricted to the roadways which, particularly around the danger buildings, would have been kept clean in order to decrease the likelihood of sparks from grit and debris. All buildings were accessible from the roadways and those buildings that would have been used for the testing or assembly of larger components were usually surrounded by a concrete apron, no doubt to facilitate vehicular access and ensure a larger clean area where explosives were being used.

Steam was delivered around the Solids Area through a network of asbestos-lagged, metal steam pipes which formed a 6”-8” diameter steam main with smaller spurs supplying individual buildings (Plate 4). The steam pipes were still present in the Solids Area, although they had been removed in other parts of the Westcott site. Heat from the pipes inside most of the operational buildings was controlled via fan heaters.

A number of inspection pits and junction boxes for the steam pipe system and other infra-structure were doted around the site (see Fig. 2).

All the electrical fittings on site were of standard spark and flame-proof design (Plate 5). Cable-work generally ran below ground with exposed wiring into the buildings being fed through metal conduits. External telephones in a protective spark-proof cover are still present on some of the buildings (Plate 6a). Most of the explosives storage or propellant extrusion/casting buildings had drencher systems and most other buildings were provided with an external stand pipe. In addition, fire alarm points were located beside the roadways, at safe distance from the buildings (Plate 6b).

Lightning protection was an important factor in the design of the factory and the buildings were protected by large conductor poles and earth straps (Plate 7).

In common with other sites of a similar nature, Westcott had a burning ground for disposal of surplus and poor quality explosives. Explosives were thinly laid out so that they would deflagrate and not detonate. Small devices would be burnt in cages, larger ones would be milled and the contents burned separately. It was common for ash residues derived from the burning to be disposed of across the site. (Brockwell, 1998). The burning ground at Westcott, Z site, was located in an isolated area south of the main operational area.

3.2.3 Ministry of Works Huts

Fig. 2
(Plates 8-11)
Approximately two-fifths of the buildings within the solid propellants area at Westcott were standard Ministry of Works huts of a type first introduced during the Second World War. The Ministry of Works hut was a sectional structure comprising a pre-cast concrete frame typically constructed to form a 18’ or 24’ span with a roof pitch of 22.5° (Ministry of Works 1943, Francis 1996). The gable posts at each of the ends take the form of a rectangle with the externally-facing edge cut way to give a curved external face. The gable ends frames were usually strengthened with the addition of a tie beam and two vertical piers.

Although the construction method of the hut was set out in a government manual, which included such detail as the precise depth of post foundations, it is clear that the actual reality of on-the-ground construction and type of wall cladding led to a number of variations as far as overall measurement was concerned. The length of the huts was dictated by the number of sections added, usually, though not always, at 6’ gaps. The frame could be in-filled by a number of different materials though for most military use this was single-skin brick or concrete block. At Westcott some of the operational and administration huts used a combination of concrete block and double-skin brick walls, although most were of single-skin brick.

The huts, which could be erected by a gang of four men, were set up on prepared ground from which turf and top layers of soil had been stripped. Ground preparation was kept to a minimum and a hardcore sub-base was used only if necessary (Ministry of Works 1943). The frame comprised opposing pairs of posts each supporting a concrete rib secured at the apex. The frame was pre-drilled and the structure fixed on site using bolts to secure the ribs to the posts and a pin at the apex

The huts were designed to be clad in 3” of 6” asbestos cement roof sheets with a corrugated apex tube (Ministry of Works 1943). Window openings were of standard sizes, usually, but not always, running the whole width of the bay and with concrete sills and lintels. Above roof height, gable ends which were not fully made of brick were clad with asbestos cement roof and often had a central vent with wooden louvres.

Internally the hut was divided into rooms using simple board partitioning, although occasionally brick or concrete block. Buildings used as operational or administration areas were often fully clad with board, no doubt to provide a bit of extra insulation, otherwise the roof was clad and the bare walls painted. Extensions forming porches, small store/plant rooms or office/reception areas were added to some huts.

Given the site numbering system and type of building, it is likely that the Ministry of Works Huts were mostly erected during 1947 when the solids area was being constructed. The MoW huts should not however be seen as exclusively earlier. Due to the various functions required, other operational buildings would have been built at the same time as the MoW huts, but with a different structural design.

Building No.	Functional Area	Detailed Function	Location
SPA1	Admin & Welfare	Offices/Shifting House	South East
SPA2	Admin & Welfare	Canteen	South East
SPA3	Operational	Tube spraying/Coating	South East
SPA4	Admin & Welfare/Operational	Mixing Glues/Exhibition	South East
SPA6	Operational	Cordite Magazine	South
SPA12	Operational (traversed)	Cutting	South West
SPA16	Other Magazine & Storage	Cordite, Propellant & Rocket Motor Magazine	Central
SPA18	Other Magazine & Storage	Small Rocket Motor Magazine	North West
SPA19	Other Magazine & Storage	Small Rocket Motor Magazine	North West
SPA20	Traversed Magazine	Cordite, Propellant & Rocket Motor Magazine	North West
SPA21	Traversed Magazine	Rocket Motor Magazine	North West
SPA23	Operational	Pyro-Section (work room with ovens)	Central
SPA24	Operational	Pyro Section (making and filling igniters, pellet press)	Central
SPA25	Operational	Pyro Section (making and filling igniters, pellet press)	Central
SPA26	Operational	Pyro Section (making and filling igniters)	Central
SPA28	Operational	Cordite Turning	Central
SPA30	Other Magazine & Storage	Cordite & Propellant Magazine	North West
SPA32	Operational	Cordite Workshop	Central
SPA34	Operational	Cutting (plastic propellant, cutter and knives)	South East

Table 2: *Summary list of Ministry of Works huts*

3.2.4 Administration, Welfare and Maintenance Buildings

Fig.s 2-3

The administration and welfare buildings (SPA1, SPA2) are located as a group close by the eastern access point (Plates 4b, 11). In addition, a number of toilet blocks and a separate tea-room are located elsewhere within the solids area (SPA 43, SPA52, SPA55). Although some processing work took place in SPA 4, it also housed a rocket motor exhibition where visitors could be shown some examples of the non-classified work taking place on the site.

Anyone entering the explosives area would have passed through a shifting area in order to enter the 'clean' danger area (Plate 11b). The shifting areas for the solids division were located within the southern section of SPA1 indicating that those working at or visiting the site would have used the eastern gate. Although there were some other access points along the northern boundary of the area, these were within an already secure areas and, in the case of SPA41 the X-Ray & Ultrasound building, separately fenced. The canteen and entrance to the administration block was on the ‘dirty’ side of the site and therefore both buildings could be accessed by administration and office staff who did not need to enter areas of the site where there was potential danger of explosion and where classified research was taking place.

Those entering the main shifting rooms would have done so via double doors on the ‘dirty’ side. To allow some control of movement there was a small internal lobby area around each of the doorways. Typically the shifting room would have been furnished with lockers, rows of clothes pegs and benches. Employees would remove any items that might cause sparks, in particular metallic items, matches and cigarette lighters, before changing into work clothes that would have included overalls and special rubber-soled shoes. They would then have stepped over the low central barrier into the ‘clean’ side of the room before going out into the ‘danger’ area.

SPA1 is a good example of a typical MoW hut, with the addition of a covered verandah and centrally-placed water tower above the shower block. The northern half of SPA1 has been divided into offices by a series of wooden board and brick partitions, whilst the southern half forms the employee and visitors shifting houses. At the southern end of the building two shifting house rooms are divided by a shower and toilet block accessed alternately from each of the shifting rooms. The northern most shifting room was provided with three shower cubicles and six toilet cubicles, the southernmost with four shower cubicles and five toilet cubicles. The showers and toilet cubicles were located on the clean side and would, therefore not have been used by office workers who had not been through the shifting process. Although it is possible that one of the shifting rooms was reserved for female workers, the number of female workers was likely to have been limited, at least in the early stages of the life of the establishment.

Given the likely numbers working in the solids area the canteen is relatively small, and comprises a small kitchen/storage area, ?servery and seating area. The canteen was more likely an area where people could buy drinks and light refreshments or eat food they had brought in themselves.

SPA4 would mostly have been given over to the exhibition of rocket motors for site visitors. Glue-mixing, the other function of the building, was likely to have taken place in a smaller room at the eastern end of the building. As articles in Flight magazine indicate (Flight 1947, Flight 1964) it was common for the site to be visited by groups from the trade press, or from other organisations and companies involved in related research. With many parts of the site hazardous or restricted, the SPA4 building located close by the main entrance was a convenient place to show visitors some of the rocket motors developed by Westcott.

Separate toilet blocks were located in the south-western corner of the solids area amongst the explosive magazines and pressing houses and the north-eastern corner. The latter is a more recent addition to the site, extant in 1985. SPA50, SPA51 and SPA52 are located in the same area and of similar brickwork and design. This and the use of later numbers in the sequence suggests that these were contemporary and amongst the latest buildings constructed on the site.

The risk of spark necessitated the use of electric trucks for travel around site and garage SPA39 was designated at an electric-truck charging point. Although the cladding on this building is relatively recent in date, electric trucks would have been used throughout the life of the factory and it is likely the basic frame of this building was constructed at a much earlier date.

Building No.	***Type***	***Detailed Function***	***Location***
SPA1	MoW Hut	Offices/Shifting House	South East
SPA2	MoW Hut	Canteen	South East
(SPA4)	MoW Hut	Rocket Motor Display	South East
SPA39	Steel frame, clad with corrugated sheet	Electric Truck Charging Garage	Central
SPA43	Brick, flat roof	Toilets	South West
SPA44	Brick, flat-roof	Tool Store	South West
SPA52	Brick, flat roof	Toilets	South East
SPA54	Brick, flat roofed	Compressor Building for SPA41	North West
SPA55	Brick, flat roof	Tea Room for SPA41	South West

Table 3: *Summary list of administration and welfare buildings*

3.2.5 Traversed Magazines

Figs. 2-3

A number of potentially dangerous high explosives would have been stored in the Solids Area, although the research-based nature of the work taking place meant that in most cases small quantities only would have been required (Stuart Marsh pers. com.). The chemicals and explosives required for making propellant and igniter charges were stored in a mixture of traversed magazines and standard huts (see 3.2.6 below).

The traversed storage magazines were located away from the similarly traversed processing buildings which formed a group in the far south-west of the site. SPA5 had been demolished prior to the survey, although the blast mound with its concrete revetment was still extant. Demolition arisings within the traversed area of SPA5 suggest that the storage building may have been a MoW hut. SPA20 and SPA21 also contained MoW huts (Plates 12-13). The nature of the likely explosion meant that lightweight buildings, particularly buildings with lightweight roofs that would lift off in a blast, were often preferred to the more substantial flat-roofed buildings. Unlike the other traversed magazines SPA22 was a small flat-roofed building with two compartments for storing igniters and pyrotechnic powders.

Rocket motors, presumably complete ones, were also stored in SPA22 and exclusively in SPA21. The presence of lifting crane within SPA21 confirms this as a likely use for that building (Plate 13b).

The doors to all these buildings were metal-clad (Plate 7a). Various preventative measures were taken to ensure the risk of sparks that could result in explosion or fire was minimised. All electrical circuitry was external and all the electrical fittings were flame- and spark-proof (Plates 5 and 7). Some buildings where explosion was a potential hazard, would have had a dousing system, though this was not evident in the storage buildings. Each of the magazines did however have an external stand pipe, though more likely as a result of the general need for water than specifically for fire prevention. The lightning conductor poles and earth straps are particularly evident on building SPA21 (Plate 7b). Internally smooth joins between wall and floor-surface minimized the build up of grit and explosive-laden dust.

It was important to store explosives at the correct temperature. The steam piping system was therefore used to heat the magazines via unlagged steam pipes, the flow of heat being adjusted from an external control box.

In all examples, the earth mounded blast walls have a reinforced concrete slab revetment. To minimise the impact of any blast, entrance through the mound was via a concrete-lined tunnel set at a ‘dog-leg’ to the building entrance

Other than internal light fittings, some signage and the cranes for heavy lifting in SPA21, the buildings were empty of fixtures and fittings. We know that SPA21 stored ‘Category V’ explosives. Category 5 is the general category for ammunition, bombs, explosives, mines, fuzes, detonators, pyrotechnics, missiles, rockets, propellants, and associated items and would have applied to most, if not all , the material stored at Westcott.

Building No.	***Type***	***Detailed Function***	***Location***
SPA5	Demolished	Explosives Magazine	South East
SPA20	MoW Hut	Cordite, Propellant & Rocket Motor Magazine	North West
SPA21	MoW Hut	Rocket Motor Magazine	North West
SPA22	Brick, flat-roof	Igniters & Pyrotechnic Powders	North East

Table 4: *Summary list of traversed magazines*

3.2.6 Other Magazines and Storage

Figs. 2-3

Stored correctly, many of the raw materials used in the solids area required little more than a controlled environment within a regular building set at a safe distance from the other buildings in the area. Cordite, for example, when lightly confined, such as in a wooden box, presents only a fire risk and is therefore relatively stable. Although one of the traversed magazines was reserved for some cordite storage, cordite was also stored in the MoW huts SPA6, SPA16 and SPA30 (Plates 9, 14). Other propellant materials were also stored in SPA30 and the remains of large box of Ammonium Perchlorate seen in this hut at the time of the survey, is indeed suggestive of this.

Once complete the rockets would have been stored in protected areas, either within a traversed magazine or one of the outlying stores. As might be expected the building used for the storage of larger rockets (SPA17, Plate 15a-background)) was more substantially built than the two small MoW huts (SPA18, SPA19 – Plate 10a) used for the storage of smaller rocket motors.

Other storage buildings included SPA27 for igniter components and SPA53 adjacent to the X-ray and ultrasound building, SPA41, and designated for the storage of X-ray cassettes and films. Signage on one of the doors indicates that SPA27 was also used for storage of ‘unidentified equipment’.

The stability of propellants for long-term storage, particularly given the type of environment in which missiles might ultimately be used, was a significant factor in their design. Building SPA47 (Plate 15) which was temperature controlled for long-term cycling would have been used to test stability of small quantities of propellant, small rocket motors, or scaled versions of large ones, during exposure to a cycle of low and high temperatures. This was done in order to calculate the age limit of rocket motors beyond which they might become unstable or fail. This long, narrow building, situated towards the edge of the site and away from nearby buildings, comprised two compartments, A and B, each lined with concrete block and with doors at either end. Internal ducting and holes punched through the wall are suggestive of the temperature regulating systems that would have been in operation during the building's use. Switchgear and plant were contained in a small porch-like extension at the eastern end of the building

Building No.	***Type***	***Function***	***Location***
SPA6	MoW Hut	Cordite Magazine	South
SPA16	MoW Hut	Cordite, Propellant & Rocket Motor Magazine	Central
SPA17	Brick, flat-roof	Large Rocket Motor Magazine	
SPA18	MoW Hut	Small Rocket Motor Magazine	North West
SPA19	MoW Hut	Small Rocket Motor Magazine	North West
SPA27	Brick, pitched roof	Igniter Components	Central
SPA30	MoW Hut	Cordite & Propellant Magazine	North West
SPA47	Brick, barely-pitched roof	Temperature-Controlled Magazine for Long-Term cycling	Central
SPA53	Concrete sectional with concrete frame, pitched roof	Storage of X-Ray Cassettes & Film	North West

Table 5: *Summary list of other magazines and storage buildings*

3.2.7 Operational Buildings: Processing, Testing and Research

Fig. 2-3, 5

Most buildings within the solids area were associated with the research function and would have been used for different processes associated either with the mixing, extrusion and curing of propellant, or the design and construction of rocket motors and their components. Neither propellant, nor rocket motors were constructed on anything approaching manufacturing scale, but the process of research would have nevertheless involved the construction of operational rocket motors for test firing and investigation. As rocket motors could only be fired once, a number of tests would have been done on scaled-down models of the design. After some initial research on specific aspects of the design, it was common practice to place a contract with industry for the remainder of the research and development process. In most cases the scientists at Westcott would have worked closely with the companies selected for contract work, maintaining their role in certain aspects of the research, seconding staff or providing certain testing facilities.

The different process involved in creating a composite solid propellant are binder preparation, oxidisers preparation, propellant mixing, casting and curing (Marks 2006). Although Westcott did not manufacture propellant on a large scale it would have experimented with different propellant mixes and on occasion helped out Waltham Abbey if that site did not have the capacity to meet demand. (Stuart Marsh pers. com)

There are two methods of holding the grain in the case. Cartridge-loaded or freestanding grains are manufactured separately from the case by extrusion or moulding and then loaded into or assembled in the case. In case-bonded grains the case is used as the mould and the propellant is cast directly into the case and is bonded to the case or case insulation (Sutton & Biblarz 2000). The propellant is generally cast or extruded into the required shape, and it then inserted into the chamber and bonded to the wall of the rocket tube. The end faces of the charge, which should not burn, are coated with an insulating inhibitor, and the other surfaces of the chamber are insulated (Turner 2008). After the ingredients for a cast propellant have been thoroughly mixed, the resulting viscous fluid is poured, usually under vacuum to prevent the formation of voids, directly into the chamber of the rocket motor which contains a suitable mandrel for producing the desired configuration for the grain (Marks 2006). As a result of motor developments of the past three decades, many grain configurations are available to motor designers. However, as methods evolved for increasing the propellant burning rate, the number of configurations needed decreased (Sutton & Biblarz 2000).

In addition to pouring the propellant into the rocket tube, the mixture can be formed as a dry mixture. During dry mixing the propellant is packed and compacted into a motor casing or mould and heated to ensure fusion of the mixture. To remove air, the dry blend is subject to vacuum during the fusion process. Thermocouple probes are placed at various locations to ensure correct temperatures were reached. It is possible that the group of metal cable ducts seen in building SPA8 (Plate 18b) indicate this process. The fused blend is then allowed to cool and solidify. No special process is required for this and the propellant is simply exposed to ambient temperatures to allow gradual solidification. The whole process takes at little as 8 hours, compared to the 5 to 15 days that it takes to cure propellant chemically. The dry mixing, a more recently invented process, usually involves machine finishing of the grain in order to cut it to size once it had been formed (MTCR, nd).

These activities are much easier if the motor is made in sections, and large ones may consist of several identical cylindrical sections with each form separately case-bonded into its section. For very large boosters the grain is cast directly into the casing section after the insulation is installed, The sections are then joined together to make a complete booster. The joints between sections have to be gas tight and they also have to transmit the forces arising from the high thrust boosters. The factory joint is assembled before the charge is installed, and results from the need to make up large booster casings from steel elements of a manageable size. These joints can be protected by insulation before the grain is installed. (Turner 2008)

Research into the various properties of different types of propellant grain and the combustion process was key to rocket motor design. Propellant was mixed, pressed, extruded, cut and cast in a series of traversed buildings in the south-west of the solids area. At Westcott there is no evidence in the solids area for large cast or cure pits which would have been permanent site features. It is, of course, likely that most processes using large-scale or highly specialised manufacturing equipment would have been out-sourced to industry.

Propellant was mixed in buildings SPA8 and SPA48. SPA48 (Plates 16-18) is clearly the more modern of the two buildings and probably represents the move towards the use of more complex propellants and the ability to construct much larger rocket motors. Both buildings have separate rooms to house plant, monitoring equipment and motors. Observation windows in SPA48 indicated that most of the processes would have been controlled remotely at a safe distance. SPA48 comprised rooms offering some blast protection and in which the motor, plant and monitoring equipment was housed, and had a large steel-framed shed to the rear within a concrete blast wall and earth bund. Although most of the operational plant and equipment has been removed from this building, it is probable that the long shed to the rear of the mixing rooms in both these buildings would have been used for the casting of propellant grain directly into rocket motor tubes. The casting process either involved mixing of the propellant into a viscous mass to which a chemical curing agent was then added, or dry mixing.

Whatever process was used, movement of materials would have been limited so it is likely that mixing and pouring would have taken place close to each other. This was particularly the case where chemical curing was used, as the amount of time available to fill the rocket casing before the propellant set was limited.

Buildings SPA9 and SPA10 (Plate 19) are listed as press houses and the remains within them were consistent with the extrusion and pressing of propellant, the other method for forming the grain. Both these buildings are built to the same design: a long shed with a separate room at one end. The long shed to the rear of the separate engine and operating room in SPA9 still retained the support beds for the extrusion machinery (Plate 19b). A photograph in a 1964 edition of ‘Flight’ magazine shows an experimental “battleship” 36in solid-propellant rocket motor sitting in its cradle in what appears to be building SPA9 or SPA10. Two other, smaller scale pressing buildings SPA14 and SPA15 (Plate 20) were located amongst the other traversed buildings, along the western perimeter of the site. The traverse and its concrete revetment is all that survives of SPA15. The building within SPA14 was almost completely demolished with the exception of the fragmentary remains of a wall. Holes within the wall and the layout of the surviving ground slab suggested that the engine and operating equipment were housed in a separate room; consistent with a press. The overall size of SPA14 and SPA15 suggested that, in contrast to SPA9 and SPA10, only small amounts of plastic explosive for the smaller rocket motors were pressed here.

A number of the rockets developed at Westcott would have used cordite as the main component of the propellant. Rocket motors such as the Gosling 1 used a cordite charge. Buildings SPA7 (Plate 21) and SPA32 were designated as cordite processing and cordite workshop, whilst SPA28 was used for cordite turning. As cordite was relatively stable it was often stored in magazines constructed from unprotected MoW huts SPA6 (Plate 14), SPA16, SPA30 (Plate 9); although it was also stored in the traversed magazine SPA20 (Plate 12). Cordite was processed in a number of ways. A common way was to extrude it through a press into long rods, which would then be bundled together to make up the propellant charge. These rods varied from very thin ones used in small-arms ammunition to large ones used for heavy shells and as rocket propellant. The presses for medium-sized rods were commonly called Tangye presses, and these would be housed in a press house similar to the buildings suggested by the remains of SPA14 and SPA15 (Plaste 20). Cordite would be pressed damp, and the extruded rods would be cut to length in one ot the cutting houses (SPA11, SPA12 and SPA34, Plates 22, 23, 24a).

Unless the propellant was directly cast as a viscous mixture into the motor tubes, some form of cutting would be required. As a protective measure, cutting machinery was operated from a separate room with viewing holes. SPA12 (Plates 22-23a) was the largest cutting house and contained the mounting block for the cutting equipment. Given the length of the building, it is likely that the large plastic propellant grain was cut here. The cutting equipment was operated from a separate compartment with a tinted-glass viewing window allowing the operator to keep an eye on proceedings, either directly or, more likely, via a monitor screen. SPA11 (Plate 23b) was more likely used for cordite cutting and was conveniently located adjacent to one of the smaller press buildings (SPA14). Although SPA11 had been largely demolished the separate operation room and viewing holes and drive shaft were still extant in the remaining walls. Both SPA11 and SPA12 were traversed, unlike SPA34 (Plate 10b, 24a), a MoW hut designated as plastic propellant cutter and knives. This building was relatively close by SPA28, cordite turning and SPA33 pressing and filling of small rocket motors, and it is likely that trimming of cordite and other propellant for the smaller rocket motors would have taken place here. SPA34 had two small windowless rooms at one end, but was otherwise devoid of any fixtures and fittings that might indicate function. The heavily blast protected SPA42, is designated as for abrasive cutting (Plates 24b-25). This building comprised six windowless compartments the brick walls of which were lined with concrete block. There were two larger and more substantially-built rooms forming the western and eastern gable ends of the building. The other rooms, with external access only, were set one either side of each of the main compartments. The larger compartments each had steel clad doors signed "DO NOT CLOSE THESE DOORS WHEN STAFF ARE IN THIS ROOM". Although any cutting would not have taken place when personnel were in the room, there are not observation windows or externally operated switches. It is possible that the cutting machinery could be set up and switched on without the need for external observation. The size of the room precludes the cutting of large propellant grain, although smaller sized propellant or other rocket components may have been cut and shaped. Holes in the larger rooms for extraction ducting suggests the presence of fumes or dust and, along with the risk of explosions, indicates why personnel were not to be shut in the room.

The propellant within the rocket motor had to be ignited. Unsuccessful firings were often the result of faulty igniters and these were also subject to extensive research. The small, three-bay MoW huts SPA23 – SPA26 (Plate 8a) were designated as the pyro-section and concerned with the making and processing of igniters. Similar propellant mixtures were often used for the ignition process and although the huts were devoid of any fixtures and fittings their designations are suggestive of former function. SPA23 was a work room with ovens, the ovens, no doubt used for curing the small quantities of plastic propellant needed in the igniters. The remaining three huts, SPA24 – SPA26 contained pellet presses and were where the igniters were made and filled. In common with other pyrotechnic charges the igniters could contain explosive pellets pressed from plastic propellant. SPA49 also designated as for making and filling igniters, in addition to pellet making is of a different character and structural build to the cluster of MoW huts making up the pyro-section. A large brick-built structure with a mono-pitch roof, SPA49 is nevertheless close by the other buildings in the pyro-section. SPA49 is clearly of a later build. At its western end, the building contains two larger compartments, accessed externally. The remainder of the building comprises a corridor running along the southern wall and partitions forming five bays open to the corridor. It would seem likely that the two compartments formed the workshop areas containing the pellet pressing machinery, whilst the manufacture off the igniters themselves took place in the separate bays ranged along the northern wall of the building. The various pyro-section buildings were close by the traversed magazine SPA20 which would have been a convenient location for the storage of the cordite and propellant used in the igniter process. The igniter testing building was similarly located in the general area of these buildings.

Another key component of the rocket motor was the rocket tube. The MoW hut SPA3, close by the shifting house and administration building, was noted as for tube spraying and coating. A process involving the empty rocket tubes would have presented little risk. The electrical switch with its signing “fume cupboard extract fan” is consistent with a process involving paint and solvents. The length of the building (18.40m) and RSJ for a former overhead hoist running parallel to the eastern, long wall of the building suggests that some of the larger rocket tubes, or sections of tubes, were handled here. Rocket motor tubes could have been stored and inspected prior to filling in building SPA36 (Plate 26). Using a series of rope hoists, the rocket tubes could have been placed vertically in the large tower at the north-western end of the building and inspected from the various staging posts set at various levels within the tower. A ramp up to a door part way up the tower gave access to a gallery from which tubes could be viewed and inspected. The motor for a the hoist mechanism was located beneath the ramp. Rockets could have been brought into the building horizontally via double doors in the southern gable wall of the lower part of the building. Work benches and hoists suggest inspection and possibly assembly of a rocket tubes were taking place in this building. It is not clear whether this building was associated with the assembly and inspection of tubes before filling or whether it was associated with the assembly and inspection of motor tubes that had previously been filled with propellant. Of reasonable substantial built, the building was not protected, although it was located on its own and could be easily reached from both the propellant areas in the south-west corner and the coating and tape winding building, SPA37

SPA37 (Plate 27-28) is an unusual building with a tall mansard type roof, partially clad in lightweight corrugated sheeting but with significant internal blast and fire protection. The size of the building, height of the roof, along with the ramp and internal steps leading to a high level working/viewing platform suggests that SPA37 was designed to contain large machinery. The building was divided into a large compartment where the main process took place and a smaller area protected with a thick blast wall and fire proof doors (Plate 28). This smaller area may have been for storage of components/manufactured items or for use as a refuge during the more hazardous parts of the process. The former is perhaps most likely.

The building’s designated function was for coating and tape winding. Filament or tape-winding machines were used to make rocket motor cases that required high strength-to-weight ratio. Winding machines lie strong fibres coasted with an epoxy or polyester resin onto rotating mandrels in prescribed patterns. The winding machines look and operate like a lathe. The filaments used in this process are often coated using a process known as chemical vapour deposition or physical vapour deposition. Both processes are similar although the CVD chamber operates at a high temperature and requires a gas supply, a large power supply, water inlets for cooling and vacuum pumps. The rocket motor tubes are insulated with low density, high-heat-resistant materials and then lined with a thin layer of chemicals to help the solid propellant adhere to the case insulation. The lining is usually applied on site before propellant casting. One method of installing the thermal line is to install it onto a mandrel prior to the motor case filament winding operation. (MTCR, nd)

The size and weight of the winding machines varies, but those for large rocket motor segments are over 10m in length and up to 5m high. Coating and tape winding of small cordite charges, would not have required such a large building. However tape winding and coating of large rocket motor tubes required large equipment and, in some cases, safety measures on account of heat and gases used in the process. (MTCR nd)

Once the various components of the rocket motor had been manufactured they were assembled in buildings SPA33 and SPA38 (Plates 29-30). SPA38 was the larger of the assembly buildings. It was a rectangular, double height building well-lit by two rows of windows along each of the long elevations. Internally there were work benches along each of the long walls and an overhead 3-ton crane. Access into the building was through double doors which would have limited the size of rocket motors assembled here. It is likely that many of the larger rocket motors developed at Westcott would have been constructed as scaled-down models, the main hardware production being undertaken by the industrial contractors. SPA33 (Plate 30), was a smaller brick-built structure with a mono-pitch roof and was designated as for the filing and pressing of small plastic propellant rocket motors. Although this building contained good examples of internal steam pipe work, there were no other fixtures and fitting other than the standard spark- and flame-proof electrics.

SPA4 is located near by the main administration block and shifting house and although it was principally used as a display are for unclassified rocket motors, it was also used for mixing glues. As a minor and comparatively hazard-free process requiring only a small space, glue mixing could be carried out in a convenient building

Once the rocket motors or their components had been manufactured they would have been quality inspected and stencilled. Rocket motors could only be fired once and so whether one-offs produced for research purposes, or manufactured in batches, consistency and quality inspection were a vital part of the process. Buildings SPA31 and SPA35 were designated as quality assurance and stencil buildings. SPA35 was the slightly more substantial building and contained lifting gear. Its location close to the propellant production buildings suggests that the propellant grain would have been inspected here. There is little to indicate former use in either of the buildings, although SPA33 contained a number of work benches and storage units labelled various ‘spanners & pliers’, ‘tools’ and ‘tape banding machine’. It is not clear whether these are *in situ* or removed from another building for storage after closure of the solid areas.

Buildings SPA50 and SPA51 (Plate 31a) are of similar size and design. They come at the end of the numbering sequence and were clearly built more recently than most of the other buildings within the solids area. The scheme design plan for building SPA50 is dated to 1979. Building SPA50, the cartridge processing building, would have been associated with the research and development of igniter components. The plans show that it contained a work bench and, in a separate room, a press. External brick-built barriers in front of each of the doors, were designed to offer blast protection to the surrounding area. Record plans dating from 1984 exist for SPA51 and show that the building contained a de-humidifier capable of keeping the building at a constant 25% humidity. This plan labels the building as a 'pyrotechnics building' suggesting its association with igniter components.

The X-ray and Ultrasound building SPA41 (Plate 41b) would have played a role in quality inspection and testing. Propellant grain and rocket motor components would have been X-rayed and subjected to ultrasonic tests at various stages in the manufacturing and research process. X-ray was used, for example, to check for faults in the newly manufactured propellant grain and for examination of motor casings, linings and igniter components before and after firing. Located on the edge of the SPA area and also accessed from other areas of the site the facilities would also have been used by other areas of the establishment.

Igniters were tested in a small building located in the north-east corner of the solids area, SPA45 (Plate 32). For safety reasons this building was set on its own in a fenced area and comprised three compartments, a protected testing room and remote operation and monitoring rooms. An adjustable plate (Plate 32b), to which a mirror would have been fixed, allowed a view of the process through a small viewing window. It is likely that the testing process would have been photographed or filmed for viewing on a monitor screen.

Building No.	***Type***	***Function***	***Location***
SPA3	MoW Hut	Tube spraying/Coating	South East
SPA4	MoW Hut	Mixing Glues/Exhibition	South East
SPA7	Brick, pitched roof (see SPA13)	Cordite Processing	South West
SPA8	Brick, pitched roof, traversed	Pugmill	South West
SPA9	Brick, pitched roof, traversed	Press	South West
SPA10	Brick, pitched roof, traversed	Press	South West
SPA11	Mostly Demolished (see SPA14), traversed	Cutter	South West
SPA12	MoW Hut	Cutting	South West
SPA13	Brick, pitched roof (see SPA7)	Plastic Motor Assembly	South
SPA14	Mostly Demolished (see SPA11), traversed	Press	South West
SPA15	Demolished, traversed	Press	South West
SPA23	MoW Hut	Pyro-Section (work room with ovens)	Central
SPA24	MoW Hut	Pyro Section (making and filling igniters, pellet press)	Central
SPA25	MoW Hut	Pyro Section (making and filling igniters, pellet press)	Central
SPA26	MoW Hut	Pyro Section (making and filling igniters)	Central
SPA28	MoW Hut	Cordite Turning	Central
SPA29	Demolished	?	Central
SPA31	Brick, shallow-pitched roof	Stencil/QA Inspection	Central

SPA32	MoW Hut	Cordite Workshop	Central
SPA33	Brick, mono-pitched roof	Pressing and filling of small plastic propellant rocket motors	Central
SPA34	MoW Hut	Cutting (plastic propellant, cutter and knives)	South East
SPA35	Brick, pitched roof	Stencil/QA Inspection	South
SPA36	Brick pitched roof with flat-roofed tower at one end	Rocket motor tubes	South West
SPA37	Brick and corrugated sheet steel, high mansard style roof	Coating and tape winding	Central
SPA38	Brick with pitched roof, double-storey height	Cordite Motor Assembly	Central
SPA41	Brick/concrete, flat roof	X Ray and Ultrasound	North West
SPA42	Brick/Concrete, pitched roof	Abrasive Cutting	Central
SPA45	Brick, flat-roof	Igniter Test	North East
SPA46	Brick, mono-pitch roof	Cleaning Plastic Propellant Components	South West
SPA48	Steel frame, concrete block, corrugated sheet-clad walls and pitched roof, traversed	Pugmill	South
SPA49	Brick, flat-roof	Making & Filling Igniters, Pellet Making	North East
SPA50	Brick, barely pitched roof	Cartridge Processing	North East
SPA51	Brick, barely pitched roof	Assembly and Breakdown of Rocket Motors/ pyrotechnic Building	North

Table 6: *Summary list of operational buildings: processing, testing and research*

3.3 Process and Design of the Solids Area

Fig 3

In common with the other research establishments, Westcott would have had on site facilities for storage, assembly and testing, along with supporting services such as workshops, drawing officers and administration. As an ex-RAF base, centrally located, Westcott was largely chosen as research establishment on account of good air and road transport links which ensured efficient communication and liaison with Farnborough and the other RAE sites. Although detailed design and development was often carried out by industry, the research establishment offered support in the form of specific research, testing and the technological monitoring of projects. The weapons research establishments had a significant role in all stages of development (Lighthill 1965) and, in addition, Westcott undertook some occasional and limited manufacture when its sister site at Waltham Abbey was busy (Stuart Marsh pers. com.).

The organisational structure of the Research Establishments is relevant to the processes that were undertaken there and the design of the site. RAE Farnborough was divided into departments, of which the rocket propulsion establishment based as Westcott was one. Each department was then divided into teams or divisions, of which there were three at Westcott (see below 2.4). The department was overseen by the departmental head or chief superintendent. Within the whole of the RAE there were around 50 divisional heads, each managing an average of 30 qualified scientists and engineers (QSEs) (Lighthill 1965). Part of the role of the departmental chief superintendent was to exercise scientific supervision and leadership, in addition to managing staff and budgets.

Within the overall structure of RAE Farnborough, groups of departments were co-ordinated by a Deputy Director who sat on the Board of Management. Other members of the Board of Management included the Chief Engineer with overall responsibility for workshops, inspection, maintenance of equipment and buildings, drawing offices etc.,. the Commanding Officer in charge of test pilots, the senior RAF officer in overall charge of all serving officers and the Secretary, a senior civil servant, who was responsible for finance, personnel and general administration. The Director of the Board of Management was responsible to the Ministry. Lighthill (1965) comments that the Board of Management met every fortnight and that there was a culture of careful consultation of local and intermediate management. Some idea of the prevailing culture can be ascertained from the comment that "…Deputy Directors…continually need to hold small meetings of experts from different departments…". The emphasis on structured consultation was evidenced by the joint consultation machinery to allow discussion on matters affecting civilian and military employees. Discussion on staff matters was through the Staff Association's elected officers, either informally or through a formal mechanism such as the Whitley Committee; whilst matters affecting industrial personnel was discussed with members of the Shop Stewards Committee again informally of through meetings of the Joint Factory Committee. Employees involved in research were made up of qualified scientists and engineers (QSE), laboratory assistants and technicians. The QSE included scientific, experimental and engineer classes of the civil service as well as technical serving officers.

In addition to the general organisational structure of operations, the processes undertaken on a sensitive site with many high risk explosive buildings, impacted on the layout of the site and the design of the buildings. In most cases the distance between explosive buildings was governed by regulation. In a contemporary account written during the Second World War, Boucher and Bagley describe some of the war time regulation governing explosive sites (1940). Although Westcott was operational after the war, it is likely that the site would have been erected using similar regulations. Relatively small amounts of raw material were handled and stored at Westcott, although the design and layout of the site shows that consideration was given to the spacing between the danger buildings.

Large distances between the buildings on site created difficulties for the design and maintenance of intra-factory piping, wiring, ventilation and other aspects of the infra structure. On most military sites each process had a characteristic range of building types and ancillary buildings were of standard design (Francis 1996). However it was always recognised that the speed of new development, whether as a result of technological improvement, or the introduction of new systems, meant that flexibility within the standard design was essential. This was particularly the case on sites such as Westcott, where buildings no doubt had to be adapted for new processes and specific tests.

Westcott was set up between 1946 and 1948 and would therefore have been regulated by the 1937 Factories Act which a decade earlier had set down new standards for working conditions including separation of the sexes, washing and toilet facilities, guarding of machinery, ventilation and light. Crown factories were not exempt from this act, and although they might be freed from its provisions in an emergency, the design of the site would have met all the necessary requirements (Cocroft, 2000).

A number of design measures were used to prevent and limit the effects of explosion and fire. During a thunderstorm it was normal to withdraw all workpeople from danger buildings (Boucher & Bagley, 1940). Buildings were fitted with lightning conductors and earthed copper strapping (Plate 7). For buildings with traverses, the normal lightning protection comprised four rods would be placed at equidistant positions on top of the surrounded mounds, each rod carrying four or five points raised 6 ft above the elevation of the ridge and 12ft distant from the walls of the building. The conductors were welded to earth rings connected to an earth plate situated in moist ground. There is ample evidence for lightning conductors poles at Westcott and a number of the buildings retained their copper earth wires. In some magazines a grid of copper straps would have been embedded beneath the asphalt and, in the most sensitive buildings, meters were fixed by the doors to monitor body static. Most process buildings were equipped with an overhead drencher system connected to the factory's high pressure water main. If the buildings were lit electrically the mains were usually set at least 15 ft from the exterior of the buildings with a branch cable that could be completely disconnected in a thunderstorm (Boucher and Bagley, 1940).

Certain buildings were traversed. Generally these were the high explosive storage magazines and those buildings where processes involving danger of explosion took place. The traverses were designed to contain explosion. Where buildings were traversed the intra-factory distances could be halved (Boucher & Bagley, 1940). Mounds were constructed of earth, sand or any waste material which could be suitably consolidated. The apex of the mound was specified as 3ft in width with a slope of 45º and a height of 8ft. To avoid dust mounds were compacted and turf-covered (Plates 12, 19, 20, 23b).

Explosive contaminated dust and grit was a particular hazard. Internally the walls were plastered and painted to produce a clean washable surface. Floor coverings were either gritless asphalt or linoleum, and were regularly washed. Sometimes open-textured hair carpet was laid in rooms where sensitive dusts were likely to accumulate. Joints were taped and varnished to increase dust protection. Doors universally opened outwards for rapid egress and were closed automatically by brass weights suspended in the door frame.

Sites would have their own self-contained power supply; usually from a boiler house or boiler houses which heated the buildings via a series of interconnected steam pipes (Plate 4). Steam was considered advantageous as low pressure exhaust steam could be used for heating and/or drying purposes (Boucher & Bagley, 1940). Buildings were often simply heated through un-lagged pipes (Plate 30b). Alternatively fan heaters were used (Plate 14b) or the steam was converted in a plenum heater house to warm air blown through conduits into the buildings (Cocroft, 2000).

Electricity was usually delivered through a three phase system with an earth conductor. A 400-440 volt supply enabled a lower voltage for lighting and any motor in the proximity to sensitive processes, whilst maintaining full pressure for heavier motors in safer positions. No special provision needed to be made for overhead electric cables, although bare conductors on poles were not placed within 20ft of a danger building. All artificial lighting was electric with wiring carried in small-bore metal pipes (Plate 18b). Where explosive vapours and dust was likely present switch boxes were of the flame-proof type, usually attached to the exterior of the building (Plates 5, 7a, 8a). Artificial lighting was via bulbs sealed in spark proof bulkhead units (Plate 24a) set into the walls or suspended from the ceilings. (Boucher & Bagley, 1940).

Power was supplied to the machinery in a number of ways. In the case of a danger building, this was usually by way of a motor housed externally (Plate 18c)). Where there was less risk, the motor was attached directly to the machine. In processes using hydraulic power, this was usually delivered from pumps and control gear, again housed in a separate self-contained unit, (Cocroft, 2000). The use of separate engine rooms meant that workshops could be left as open shells, which could then be arranged and re-arranged as new demands dictated. To reduce the need for and cost of heavily armoured buildings, shielding was given to individual pieces of dangerous process machinery by enclosing them in an armoured partition, behind which a single operative could work or control the process remotely. Although all the plant had been removed from the Solids Area, it is likely that this sort of arrangement would have been in place for some of the processes undertaken there.

For efficiency and safety the administration buildings were usually grouped together near an entrance (Plates 3b, 4b).

The inner core of each of the research areas would have been classified as a ‘clean’ area with all workers and visitors passing through a shifting house before entry (Plate 11b). The shifting house at Westcott was located within building SPA1. In the Shifting House the workers changed into buttonless and pocketless clothing and rubber safety shoes (Francis 1996). Rubber galoshes were used to prevent both the ingress of grit and build-up of static. All contraband (prohibited) items (metal hair grips, cigarettes etc.) were handed in, before those waiting to enter the ‘clean’ area were searched. Once ready to enter the factory, workers stepped over an 18”-high board into the clean area.

The processes carried out in the Solids Area at Westcott were all associated with solid propellant and the various components making up the rocket motor. Design issues related to the propellant are mostly concerned with selection of the propellant type and the mounting and protection of the propellant in the casing. The thrust stability of a solid propellant rocket is very complicated as supply of combustible material is dependant on conditions in the combustion chamber, and there is an increased chance for instability to arise and propagate. Associated with stability is thrust control. Thrust depends on rate of supply of combustible propellant; which in turn depends on the pressure and temperature at the burning surface, as it cannot be actively controlled. The solid propellant motor continues to thrust until all the propellant is exhausted. These design issues are central to the correct performance of a solid propellant motor and would have formed a large part of the research undertaken at Westcott.

Testing of rockets involved the application of a number of techniques including the use of high-speed cameras and X rays (Dunning, 1966). X-ray would have been used to detect faults and problems with component parts of rocket motors. X ray expertise often cited as key development in UK space science (Millard 2005). Solid motors cannot be test-fired and so reliability has to be established by analogy and by quality control. Although used by other areas of the site, the X-ray and Ultrasound building was most used in relation to solids research and was therefore located on the edge of the Solids Area.

Static rocket motor tests took place at Westcott, though not in the Solids Area. In these tests the rocket motor was anchored and information fed to a series of instruments that measured thrust of motor, weight and pressure of gases. P2 test bed altered in 1956 to become the largest of its type in Britain (Flight 1956). Conventional rig for vertical firing and could handle motors with of over 20,000lb thrust.

Other aspects of rocket design that would have been researched at Westcott included studying the action of various fuels and effect of their intense heat on various type of nozzle, the use of booster motors to assist take-off, gyroscopes to guide flights along straight paths, cooling systems, range finders to record altitudes and speed, automatic parachutes for return to earth.

3.4 Process Flow

Figs. 3-5

Based on designated function it is possible to ascertain some aspects of the spatial organisation of the processes being undertaken within the solids area at Westcott. Given the changing nature of research and development work and numerous projects current at any one time the precise nature of work in various buildings on the site may well have changed through time, although it is likely that in most cases the general function remained the same not least on account of the fixed equipment and general design of the buildings. Unlike a factory process, Westcott was not concerned with the production of rockets and their components and as such the buildings are not arranged as a production line. Rather buildings are roughly grouped according to activity, hazard mitigation and general efficiency of access.

The location of buildings storing raw materials was largely dictated by the needs of safety and, other than SPA5 and SPA6, they were at some distance from the main propellant processing buildings in the south-west corner of the Solids Area. Most of the storage buildings, for raw materials, components and completed rocket motors were located in the north-western corner of the Solids Area. Mixing, pressing/ extrusion, cutting and direct filling of rocket motor tubes would have taken place in the mainly traversed buildings in the south-west corner of the Solids Area, the main danger area. Rocket motor tubes were manufactured or made ready for filling in SPA36 and SPA37 close by the propellant processing areas. Where the propellant had not been cast directly into the rocket motor tubes, filling took place in SPA13 and SPA38. These buildings were in easy reach of both the rocket motor tube buildings and the propellant processing area.

A cluster of less substantial propellant buildings towards the centre of the site (SPA28, SPA32, SPA33, SPA34) were associated with small-scale cordite propellant processing. Use of small quantities of relatively stable cordite required less safety provision than that seen in the south-west corner. These buildings were more likely associated with small rocket motors and the development of igniters

'Abrasive' cutting, perhaps associated with rocket components, rather than propellant grain, took place in SPA42. This building was located towards the northern end of the site, west of the igniter area.

Igniter production and testing took place in the north-eastern corner of the site. The MoW huts (SPA23 – SPA26) were later augmented by several newer buildings (SPA49-51) and a small igniter testing facility (SPA45).

Long-term cycling (SPA47) took place close to the rocket motor stores (SPA17-19) and the X-ray and Ultrasound building SPA41 was located in a separate compound in the north-western corner of the Solids Area.

As might be expected, the main administration buildings, including a small exhibition area, SPA4, were located close by the site entrance along the eastern perimeter of the Solids Area.

3.5 Phasing

Fig. 4

The precise phasing of the site is unclear and although most of the buildings would have been erected at the time the SPA section was established there are a number of buildings exhibiting the use of different brick types and construction methods which suggest a later date. The probable later buildings include SPA41, SPA44, SPA48, SPA50, SPA51, SPA52, SPA53, SPA54. SPA17, SPA27, SPA39 and SPA40 . There were different in character to the other brick-built structures on the site and surviving archive plans suggest a number were built, or planned, in the early or mid 1980s at the time the site was incorporated into Royal Ordnance plc. Given the site numbering system the higher numbers are more likely to denote later buildings.

It is possible that some of the obviously later buildings with lower numbers have replaced earlier buildings.

Table 7: *Summary list of buildings by SPA number*

Building No.	***Type***	***Function***	***Location***
SPA1	MoW Hut	Offices/Shifting House	South East
SPA2	MoW Hut	Canteen	South East
SPA3	MoW Hut	Tube spraying/Coating	South East
SPA4	MoW Hut	Mixing Glues/Exhibition	South East
SPA5	Demolished	Explosives Magazine	South East
SPA6	MoW Hut	Cordite Magazine	South
SPA7	Brick, pitched roof (see SPA13)	Cordite Processing	South West
SPA8	Brick, pitched roof, traversed	Pugmill	South West
SPA9	Brick, pitched roof, traversed	Press	South West
SPA10	Brick, pitched roof, traversed	Press	South West
SPA11	Mostly Demolished (see SPA14), traversed	Cutter	South West
SPA12	MoW Hut	Cutting	South West
SPA13	Brick, pitched roof (see SPA7)	Plastic Motor Assembly	South
SPA14	Mostly Demolished (see SPA11), traversed	Press	South West
SPA15	Demolished, traversed	Press	South West
SPA16	MoW Hut	Cordite, Propellant & Rocket Motor Magazine	Central
SPA17	Brick, flat-roof	Large Rocket Motor Magazine	
SPA18	MoW Hut	Small Rocket Motor Magazine	North West
SPA19	MoW Hut	Small Rocket Motor Magazine	North West
SPA20	MoW Hut	Cordite, Propellant & Rocket Motor Magazine	North West
SPA21	MoW Hut	Rocket Motor Magazine	North West
SPA22	Brick, flat-roof	Igniters & Pyrotechnic Powders	North East
SPA23	MoW Hut	Pyro-Section (work room with ovens)	Central
SPA24	MoW Hut	Pyro Section (making and filling igniters, pellet press)	Central
SPA25	MoW Hut	Pyro Section (making and filling igniters, pellet press)	Central
SPA26	MoW Hut	Pyro Section (making and filling igniters)	Central
SPA27	Brick, pitched roof	Igniter Components	Central
SPA28	MoW Hut	Cordite Turning	Central
SPA29	Demolished	?	Central
SPA30	MoW Hut	Cordite & Propellant Magazine	North West
SPA31	Brick, shallow-pitched roof	Stencil/QA Inspection	Central
SPA32	MoW Hut	Cordite Workshop	Central
SPA33	Brick, mono-pitched roof	Pressing and fililng of small plastic propellant rocket motors	Central
SPA34	MoW Hut	Cutting (plastic propellant, cutter and knives)	South East
SPA35	Brick, pitched roof	Stencil/QA Inspection	South
SPA36	Brick pitched roof with flat-roofed tower at one end	Rocket motor tubes	South West
SPA37	Brick and corrugated sheet steel, high mansard style roof	Coating and tape winding of cordite charges	Central
SPA38	Brick with pitched roof, double-storey height	Cordite Motor Assembley	Central
SPA39	Steel frame, clad with corrugated sheet	Electric Truck Charging Garage	Central

SPA40	Brick with pitched roof	Unknown, ?storage/garage	South-East
SPA41	Brick/concrete, flat roof	X Ray and Ultrasound	North West
SPA42	Brick/Concrete, pitched roof	Abrasive Cutting	Central
SPA43	Brick, flat roof	Toilets	South West
SPA44	Brick, flat-roof	Tool Store	South West
SPA45	Brick, flat-roof	Igniter Test	North East
SPA46	Brick, mono-pitch roof	Cleaning Plastic Propellant Components	South West
SPA47	Brick, barely-pitched roof	Temperature-Controlled Magazine for Long-Term cycling	Central
SPA48	Steel frame, concrete block, corrugated sheet-clad walls and pitched roof, traversed	Pugmill	South
SPA49	Brick, flat-roof	Making & Filling Igniters, Pellet Making	North East
SPA50	Brick, barely pitched roof	Cartridge Processing	North East
SPA51	Brick, barely pitched roof	Assembly and Breakdown of Rocket Motors/ pyro-technic Building	North
SPA52	Brick, flat roof	Toilets	South East
SPA53	Concrete sectional with concrete frame, pitched roof	Storage of X-Ray Cassettes & Film	North West
SPA54	Brick, flat roofed	Compressor Building for SPA41	North West
SPA55	Brick, flat roof	Tea Room for SPA41	South West

4. SUMMARY AND ASSESSMENT

Westcott Rocket Propulsion Establishment played an important role in the development of rocketry in the UK, for both ballistic weapons and space flight. Although the buildings themselves are of standard military construction and they no longer contain any plant and only a few fixtures and fittings, taken as a whole they form a significant element of Cold War history. A detailed record of the buildings, when made in combination with contemporary knowledge and historical site, has allowed some description of the processes and the general operation of the site. Buildings and processes, in particularly experimental ones, are largely overlooked in the record and the buildings at Westcott are an important contribution to study of the military built heritage of the Cold War and more recent periods.

Although many of the buildings are of similar construction and none stand out as examples worthy of preservation, it was found that key components of a specific building type (e.g., the Ministry of Works Hut) were best recorded across a number of buildings, rather than from one exemplar. It was not necessary, however, to record all elements in all buildings all of the time. The use of high quality digital photography (to be archived as .tiff images) made this type of recording particularly effective and ensured that a full record could be made.

As with many sites of this nature, even a partial understanding requires the assistance of those who are able to give contemporary accounts of the work undertaken there. Although, under the requirements of a level 2 survey (English Heritage 2006) full background and oral history research has not been undertaken for this project, sufficient information has been collated to ensure a basic understanding of the processes involved and how they link to building design and function. Ed Andrews and Stuart Moss made an important contribution to the project and were able to clarify a number of points relating to the site and its operation. Information on processes, particularly those that were undertaken as part of military research, is not easy to come by and this, along with the absence of any *in-situ* plant, means that some of the suggestions made as to function and process are tentative. The research that has been undertaken as part of this project, along with the detailed built heritage record should ensure that there is a high quality upon which to base any future more detailed study.

All the fixtures and fittings observed on within the Solids Area are of standard type and of little intrinsic value. None would warrant removal from site for preservation.

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6. ARCHIVE AND RECORD

6.1 Archive

6.1.1 Summary of Archive Contents

Report (hard and pdf digital copy)

Set of survey plans as provided (digital)

Survey drawings (paper and film dating from 1950s to 1980s)

Field notes

CAD drawings – digital and hard copy, detailed survey plan based on architect's drawings

Digital photographs – saved on CD format (.tiff)
Prints on archival quality paper

6.1.2 Arrangements for Long-Term Deposition

The project archive will be deposited at Buckinghamshire County Museum. Copies of the report will be deposited with the relevant Historic Environment Record and with the National Monuments Record: Buildings

7. CONTENTS OF APPENDICES

7.1 Appendix 1: Building Records (Solids Area)

7.2 Appendix 2: Building Records (Main Site)