Archaeological and Environmental Forensic Science, Volume 2, Issue 1, 2021
DOI:10.1558/aefs.18050

Towards an Integrated Approach to Recording Military Aircraft Crash Sites

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Abstract

The forensic investigation of military aircraft crash sites has become in recent times part of mainstream traditional archaeology. Mostly amateur aircraft enthusiasts have undertaken the recovery of military aircraft crash sites without methodically recording the remains.

The sites covered in this paper have been approached based on recording the in-situ remains methodically using traditional and scientific methods used in the field of archaeology from fieldwalking, metal detecting and geophysics. The strategy and methodology used in this investigation showed how effective and important it is to recover as much of the remains as possible to place it into a meaningful context in order to understand the reasoning for why these aircraft came to a devasting end by crashing into the ground at great speed.

The excavations have involved Operation Nightingale – an MOD based recovery programme that specialises in archaeology.

This paper will demonstrate the importance of using such an integrated approach to the recovery of military aircraft crash sites from the Second World War by referring to specific case studies.

Keywords - Military, gradiometer, magnetometer, World War II, metal detecting, GPR, forensic

Introduction

Aircraft enthusiasts have often undertaken the investigation of Military Aircraft Crash Sites without any careful archaeological recording in the past. The enthusiasm for amateur aircraft enthusiasts to collect souvenirs from the sites became popular during the 1960's onwards. This has led to the problem of the wreckage being salvaged using a mechanical excavator or just dug out of the ground by hand without placing it into a meaningful archaeological context. This paper addresses these issues by moving towards an integrated approach using a number of techniques already established within the traditional field of archaeology.

Aircraft crash sites are fraught with many problems practically and legally as all wrecks are still the property of the Ministry of Defence (MoD; (De la Bédoyère 2001)). Enemy aircraft crash sites are normally regarded as the 'spoils' of war and are treated in the same way as British military aircraft in the UK. Aircraft of Allied Nations such as those of the USAAF also protected.

Since 1986, all Military Aircraft Crash Sites are under the Protection of Military Remains Act (PMRA) and a licence is required from the Ministry of Defence to excavate or recover a military aircraft ("Protection of Military Remains Act 1986"). The Historic England Guide (Historic England 2002) on the management of Military Aircraft Crash Sites was published in 2002 for guidance into how to record such remains. It is currently in the process of being reviewed (Holyoak 2002).

British Aviation Archaeological Council (BAAC) is the official national body in the United Kingdom for aviation archaeologists and researchers of historic aircraft crashes. At present, the council has some 21-member groups with an additional 10 individual research members in the UK and 4 associate members outside the UK (BAAC 2020).

Aviation Archaeology is a relatively new sub-discipline within the traditional field of archaeology. This subject area fits within the field of Conflict Archaeology as well as forensic investigations compared to the traditional field, as it falls within the area of historical and contemporary archaeology. Metal detecting has been used on a regular basis to locate military items on air crash sites in the past. Geophysics is not often used to map the remains of the debris that has been scattered widely after impact as well as locating the impact crater containing larger pieces of the wreckage such as the engine or reduction gear and props. Aircraft enthusiasts tend to use Foerster Ferex magnetometers (Figure 1) generally deployed to locate unexploded ordnance (UXO) but it has been used to detect the ferrous component of the crashed aircraft - the engine. These instruments are digital magnetometers with an analogue meter. The Ferex is useful in terms of locating a large signal but it does not map the extent of the impact zone or for that matter the entire debris field of the crash site. These aspects are important in attempting to piece together the final moments of the impact of the aircraft and what happened to the aircraft subsequent to its final resting place within an impact crater.

Fig.1 – Foerster Ferex magnetometers in use on the Great Fen Spitfire October 2015

'Wreckology' is a new phenomenon in describing the recovery of aircraft crash sites by enthusiasts due to the attitude towards uncovering the crashed airframes. The aircraft remains have never been archaeologically investigated, nor have they reported on their findings. The recovered aircraft parts tend to be for sale on eBay for untold sums of money or become museum objects without any consideration for their conservation or preservation long term. Many lie outside in the elements up against buildings that are used for other purposes to exhibit information about aircraft and airfields from the Second World War (Figure 2).

Figure 2 – Eden Camp – propeller in background.

Fig.3 – Location map showing aircraft crash sites investigated to date.

Recent examples have included the ‘Black Horse’, rare Mk 2 Spitfire, sponsored by Lloyds Bank (BBC 2016; Lloyds Banking Group 2015; MGN Ltd 2015) to recover the Merlin engine to be put on display at their London headquarters. These were known as ‘Presentation Spitfires’ and a unique opportunity to record the crash site archaeologically was sadly bypassed. The history behind the aircraft makes fascinating reading. During its lifetime, the Black Horse had suffered from a number of crashes such as engine failure and crash landing in strong winds. The Black Horse met its fatal end on the 12th July 1942 when it collided in mid-air with another spitfire. Fortunately, the pilot bailed out. On the 10th July 2015, historian and presenter Dan Snow and his team uncovered and excavated the remains of the Merlin engine. The methodology employed to recover the aircraft remains was not archaeologically undertaken. Unfortunately, the impact zone and debris field of the spitfire cannot be compared with the case studies mentioned in this paper.

In 2011, a Spitfire was recovered from a remote peat bog in Donegal by an aviation archaeologist and enthusiast Jonny McNee who discovered the site. During the excavation, they uncovered six browning machine guns still with live ammunition had been removed by the bomb disposal team to be decommissioned and subsequently cleaned. Luckily, they were on hand to recover the ordnance for disposal. The excavation, however, was just another gaping hole with no health and safety considerations regarding trench edges. This is just another example of 'wreckology'. Mick Harkin, an eyewitness at the time of the crash in 1941 when he was only 17 discovered the remains of the plane with his friends after it went down. He said to the reporters at the time "We managed to get our hands on loads of bits and cases of ammunition, we took cases of bullets and dismantled all kinds of stuff, we hadn't the sense to know what it was we were dismantling so maybe I'm lucky I'm here at all' (Belfast Telegraph 2011).

Licences issued to enthusiasts like this, put themselves at risk when recovering aircraft remains. These 'aviation archaeologists' are not aware of the dangers they are putting themselves in when excavating the remains from Second World War aircraft crash sites.

The popular television programme 'Time Team' on Channel 4 filmed an episode excavating an aircraft crash site. In 1999, they followed the excavation of a B17 Flying Fortress at Reedham (Taylor 2000). On a site largely excavated by machine, they found that clashes between methodologies were soon evident. 'Already the differences in working methods between the aviation excavators and the Time Team archaeologists were beginning to clash' (Taylor 2000, 61) and that 'and so to the excavators, it made no sense to dig carefully around the remains with small trowels or record each layer carefully as the archaeologists, led by Phil Harding, were doing (ibid, 61). The Time Team felt that methodologies needed to change if as much evidence and information as possible from the crash site were to be retrieved 'The fact that the enthusiasts had done so many other excavations of aircraft did not really prove anything, because they had always tackled their sites so roughly. If they had used archaeological methods, they might have drawn different conclusions' (ibid, 10, 3.33).

Furthermore, their report on the work did not contain any archaeological references in the bibliography. By 2004 the situation had changed and the next Time Team investigation into aviation recovery (Ely 2005). The desk-based assessment (DBA) even included an element of geophysical survey prior to excavation work, but even then, there was no finds list in the report, and no archaeological bibliography. The report's author, Kerry Ely, stated that 'Aviation Archaeology is a relatively new genre, therefore, it is hoped that this excavation will set new precedents in the excavation of crashed aircraft (ibid, 10, 3.33).

A good example of a crash site investigated by geophysics was at Wierre-Effroy in France of a spitfire (Gaffney and Gater 2003). The magnetic survey produced three strong ferrous responses, also recorded by metal detector. Other isolated smaller magnetic anomalies were also recorded by both techniques. Test pits were dug over two of these strong anomalies, which revealed remains of modern machinery parts (Gaffney and Gater 2003, 175-77). One of the problems of using geophysics is being able to distinguish those associated with aircraft parts compared with other modern ferrous debris such as agricultural machinery.

Another recent project, a magnetometer survey was carried out in search of a crashed World War II B-29 bomber in Russell County, Kansas in 2005 (Rebar Jr 2005). This survey involved the university's geoscience department and the surrounding community. The geophysical survey was undertaken to determine if any aircraft wreckage at the crash site was still buried when the plane impacted the ground. Before this survey, an engine was recovered whilst drilling an oil well within the known crash site. The survey was carried out using a caesium vapour magnetometer. One small anomaly was recorded at the centre of the survey. The anomaly proved to be a piece of the plane's fuselage. However, no further fieldwork was carried out to locate other aircraft debris in the surrounding area of the site.

More recently, Christian (Christian 2014) as part of his PhD thesis suggested a method that both avocational and professional archaeologists alike may use by devising a phased investigation methodology. His methodology was tested on case studies in Scotland in an upland environment where many of the crash sites lie on the surface. Whereas the methodology discussed in this paper is, an integrated approach that can be used by all practitioners in the recovery of aircraft remains worldwide.

Further to Christian's (ibid) approach, O'Leary (O'Leary 2014) in his PhD research created a model that predicts where unexcavated human remains will be found within WWII bombardment and cargo aircraft crash sites based upon each individual duty station. The thesis critically examined JPACs (now DPAA) loss incidents based on the recovery of American Military personnel. The model determined where each crew member was recovered. The outcome indicated that crewmembers would be found within c.8m of their original position on board. Although not all aircraft crash sites contain the remains of the crew but this new approach uses a standard 4m x 4m grid system to control the recovery of the remains. Forensically, this is a good standard to follow.

However, more recently, excavations of a WWII RAF bomber, Halifax LV 881- ZA-V (Marter et al. 2017) and a Junker Ju88 (Wotherspoon 2018) has been excavated following a similar approach detailed in this paper. The author surveyed the latter example.

What is important to note at this stage is that aircraft manufactured during WWII was made out of light materials such as aluminium and magnesium alloys. The engine block(s) were the heaviest part of the aircraft. Geophysics is normally used to find parts that are detectable such as the engine blocks or reduction gears.

Since 2013, the authors have investigated a number of sites (Osgood 2014) (Masters 2016, Masters 2015) (Figure 4) which have benefitted from such an approach although the aviation enthusiasts are still not fully in agreement with this methodology.

The co-author of this paper through his role within the Ministry of Defence (MoD) has for some years, assisted the Joint Casualty and Compassionate Centre (JCCC) with the scrutiny of the applications under the Protection of Military Remains Act (PMRA) in order to recover components from military aviation crash sites. As part of this work, an increasing element of 'archaeology' has been added to the application process with a request for the provision of a Project Design (and subsequent excavation report) to be submitted to the local Historic Environment Record (HER). This additional requirement was included following negotiations between MoD, Historic England (formerly English Heritage) and the Association of Local Government Archaeological Officers (ALGAO).

LEGISLATION

As previously mentioned above, all military aircraft crash sites in the United Kingdom (UK), its territorial waters, or British aircraft in international waters, are protected sites under the Protection of Military Remains Act 1986 (PMRA). It is an offence under this act to tamper with, damage, move or unearth any items at such sites, unless the MoD has issued a licence authorizing such activity. Anyone wishing to recover a military aircraft, or excavate a military aircraft crash site in the UK is required to obtain a licence from JCCC, which is part of the Defence Business Services (DBS). Legislation in other countries may differ to that in the UK.

METHODOLOGY

The proposed approach to investigating aircraft crash sites from the Second World War has been tested over the past few years and each site has been approached differently depending on the circumstances of the crash site. A methodology devised by the author is shown in figure 4 below.

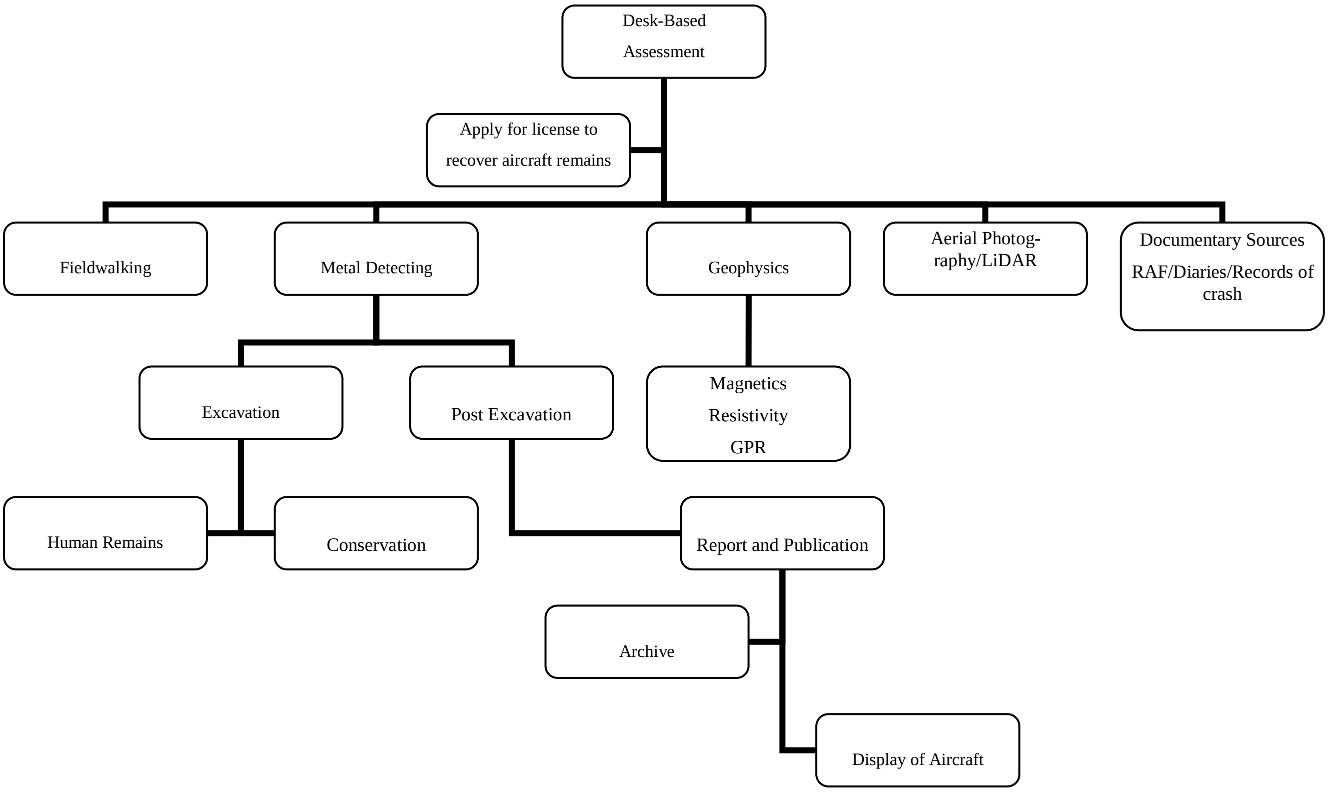
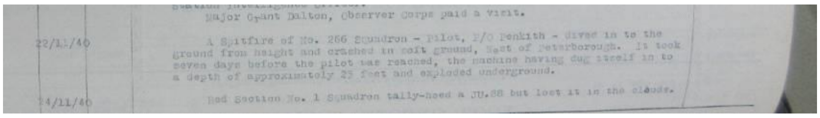


Figure 4 – Methodology for investigating aircraft crash sites

Desk-based assessment (DBA) should be undertaken prior to obtaining a licence to recover the remains. A DBA should cover all known details about the aircraft from RAF records, newspaper articles or cuttings, oral history, diaries and any other secondary sources about the crash site. Invariably this can be quite frustrating because the records may not be that detailed. Some of the RAF records will only give you an approximate location and brief description about it (Figure 4).



Major Grant Dalton, Observer Corps paid a visit.

22/11/40 A Spitfire of No. 266 Squadron - Pilot, P/O Penkith - dived in to the ground from height and crashed in soft ground, East of Peterborough. It took seven days before the pilot was reached, the machine having dug itself in to a depth of approximately 23 feet and exploded underground.

24/11/40 Red Section No. 1 Squadron tally-hoed a JU.88 but lost it in the clouds.

Figure 4 – RAF logbook details

The next stage will be to apply for a licence in order to undertake the next level of investigation as this will involve removal of items from the field. It is illegal to do this without proper authorisation and the person may face criminal action including archaeologists! Once the permissions have been granted, the principal investigator will be responsible for the archaeological recovery of the remains. It is important to map these finds along with the metal detecting survey so that the debris field can be visualised in GIS or AutoCAD software. The debris field as can be seen in the case studies below show how important it is when mapped against the geophysical survey results (Fig 6).

Geophysical survey techniques are an important asset to the mapping of the crash site in particular the impact crater. Magnetometry is most important in terms of locating the impact zone where the engine and prop has gone into the ground first creating a crater. Beyond this impact zone, other parts of the aircraft such as the pitot tube and other component parts of the engine such as the starter motor and gearbox can be located. These parts tend to break off on impact and in some cases with the amount of fuel on board from the explosion of the engine (and fragments of the engine); they tend to break off and found a few meters away from the main block. This was the case for the Holme Spitfire, Cambridgeshire (Haskins, A;Fairbairn, J;Brown 2016).

Ground Penetrating Radar (GPR) has been successful to a certain extent in detecting the size and depth of the impact craters unless the site is on peat/clay deposits where the attenuated signal tends to be weak. In these circumstances, the author has found that the best technique on soils and geology of this type is electrical resistance tomography, also known as ERT or EM38 (Masters 2016). Other techniques that the author has not tested to date are EM31 and EM61. Recent research has experimented with the use of X-ray fluorescence (XRF) alongside standard techniques as above (Booth et al. 2017, 2019). The trial survey has shown promising results.

More recently, an excavation of a bomber site ((Marter et al. 2017) was undertaken in Germany. It is interesting to note that a research project was initiated due to illegal activity by metal detectorists. The initial assessment of the crash site used a rapid geomagnetic prospection survey that revealed significant scatters of material across a wide area ((Marter et al. 2017, 29-30). This was the first time that archaeologically and systematically investigated in Hesse ((Alders, P., Gottwald, M., Hubbard, S., Mank, M., Marter, Ph., Recker, U., Röder and Visser 2015).

Developing a research strategy was important in this project considering crash sites like this have little protection still in Germany unlike the UK. Although curatorial bodies such as Hesse n ARCHAOLOGIE are attempting to implement a more rigorous approach of investigation.

These surveys should be undertaken in advance of any intrusive groundwork such as an archaeological excavation. Excavation is destructive, which means that all finds must be 3D recorded whilst removing the soil from the impact zone and associated debris field. Modern civil or military aircraft crash sites are meticulously recorded in order to understand the reasons behind their fatal end. All of the aircraft remains as well as body parts are recorded prior to the recovery during the investigation process. This integrated approach is doing exactly the same but from an archaeological/historical/contemporary point of view.

Excavation is time consuming when recovering aircraft remains. All health and safety precautions must be in place before any actual digging is undertaken and that adequate fencing of the area of investigation must be put in place not only to protect the personnel working on the site but also visitors to the site.

Military aircraft crash sites are deemed unsafe to undertake any recovery of the remains overall due to the likelihood of finding live ammunition and unexploded ordnance (UXO). It should be mandatory to have Explosive

Ordnance Disposal (EOD) cover on site at all times when archaeologically excavating the remains of military aircraft crash sites or for that matter any sites that have been involved in modern conflict.

As previously mentioned above, the aircraft may have been carrying a large amount of fuel on board and upon impact into the ground, the aircraft may have exploded. Not only that but also the fuel and oil would have seeped into the ground making this highly volatile if it met a naked flame. Therefore, these measures must be in place to prevent such fatal events happening during the excavation of the aircraft remains. Oxygen bottles would have been a vital component on board especially when the pilot/s reached altitudes of around 28,000ft. These are highly explosive and need to be recovered if found with due care and attention and disposed of by a qualified EOD person. This leads onto the next important point regarding ammunition and bombs. Qualified personnel should handle by EOD personnel on site and not by archaeologists, UXO, as these will require disposing of offsite. However, not all crash sites contain such items but such cover is vitally important to the safety of all working on site as well as any visitors to the site.

3D recording of the impact crater and the aircraft remains especially the engine and props are important in terms of reconstructing the direction and angle the aircraft crashed into the ground. This has been successfully undertaken on a number of crash sites that the authors have been recording since 2013. In addition, the use of time-lapse photography found to be invaluable with the Great Fen Spitfire site (James Fairbairn, Oxford Archaeology East (OAE)).

FIELDWALKING AND METAL DETECTING

Surface finds should be recorded by fieldwalking ploughed fields to recover as much evidence as possible about the crash site. An area should be divided into 20m grid squares in order to undertake a detailed surface collection to plot the location of the finds using a handheld GPS and subsequently map these in a GIS/Autocad software program. Alternatively, the transect method of fieldwalking can also be used.

Where the fields are under grass or fallow cultivation the use of metal detectors are required to map and recover the finds. Much of the aircraft were constructed of aluminium and this would be undetectable using standard geophysical techniques such as magnetometry. By mapping these remains, it is possible to gain a more comprehensive understanding of the debris field as shown in figure 5 of the Upavon and Great Fen Spitfire crash sites.

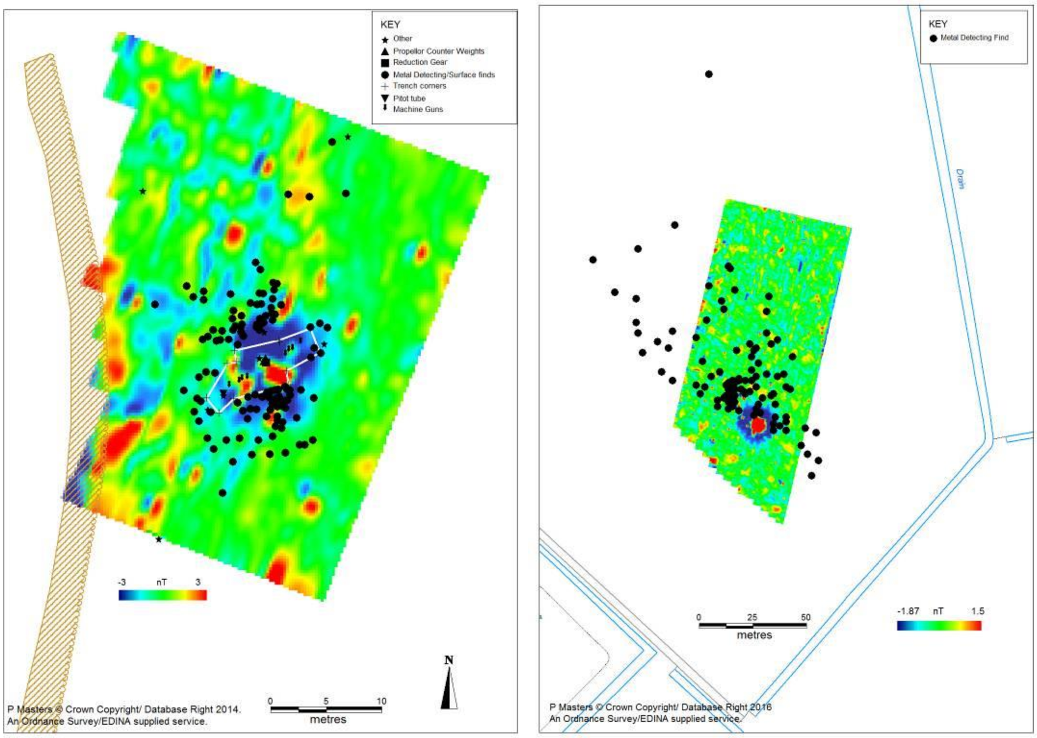


Figure 5 – Debris field mapped with magnetometer survey results for (left) Upavon (right) Great Fen spitfire sites

GEOPHYSICS

Magnetometry has played an important role in the mapping of crash sites especially the impact zone to date. The magnetic signatures recorded have shown differences in whether the aircraft has nose-dived such as the Upavon Spitfire or any other crash site. In comparison, aircraft that belly flopped into the ground have shown a completely different signature and a good example of this is the Liberator at Lyneham (Figure 6).

Most aircraft were made with aluminium making this undetectable using magnetometry as this is not ferrous. Other techniques can be used to map other metals on site such as the EM61 or EM31. Metal detectors are the best for mapping and recovering other non-ferrous materials from such crash sites in order to map the debris field on the surface prior to any intrusive works. This allows for a greater understanding of the crash site in terms of the direction of impact whether it was a vertical nosedive, at an acute angle or belly flop along the ground. A recent paper given at the Modern Conflict Research Symposium (MCRS) in Salford by Christopher Eck (Eck 2020) on Military Aircraft Site Types Associated with the Recovery of Missing Personnel Remains. He has identified eight different crash types; some identified in this paper. One exception to these types is ditching a complete plane in the sea or on the foreshore such as the Lightning P38 at Harlech, Wales.

Figure 6 – Magnetometer survey results of the Liberator, Lynham, Wiltshire

Once the site has been surveyed by magnetometer depending on the soils and geology, ground penetrating radar (GPR) would be the next technique to use to map the depth and size of the impact crater. Survey lines for GPR should be spaced at 0.5m apart with readings taken every 0.05m (minimum configuration).

The Upavon Spitfire produced a good response (Figure 7) in mapping the impact crater. However, the survey area at the time was under thick grass and made moving the antenna across the surface difficult without a second person pushing it from behind. Ideally, the ground should first be cleared of any debris or grass cut level with the ground to ensure proper contact with the surface to prevent any unnecessary artefacts being recorded in the data.

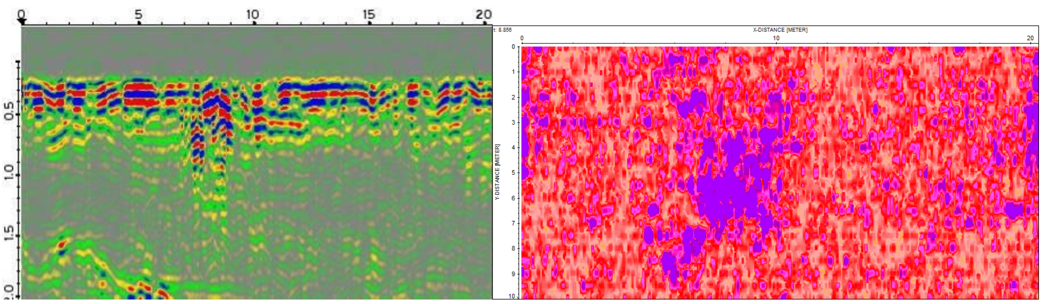


Figure 7 – Upavon spitfire GPR profile and horizontal time slice of impact crater

As mentioned above, certain soils and underlying geology is not receptive to GPR, in particular on clay and peaty wet ground. Along coastal foreshore regions is yet another problem as GPR does not respond favourably in saline conditions (Alastair Ruffell pers comm). However, recent work at Harlech has shown that GPR worked due to fresh water running through the crash site from the dunes ((Masters 2016).

EXCAVATION

Once the initial investigation of the crash site has been completed, if it is necessary to excavate then the following should be considered: EOD cover, Health and Safety, fuel/oil and depth of remains.

Human Remains

In most cases with some exceptions the person/s undertaking the recovery of an aircraft crash site will not encounter human remains. However, expecting the unexpected can be a daunting experience especially if the remains of one of the crew are found during the excavations. It is at this point that certain protocols must be followed through. When human remains are first encountered you must contact JCCC immediately as set out in the licence issued by them. JCCC and then you will be required to contact the local coroner's office in order to make sure that these are not the remains of something more suspicious.

Following specific protocols in the recovery of aircraft crash remains cannot be stressed more fully here as they are extremely important especially when human remains are encountered. One issue that comes to mind is when media are involved it is important to make sure that dignity, respect and above all that the human remains are kept from public view at all times.

Case Studies

Three case studies have been included in this paper to demonstrate how effective the integrated approach is to recording aircraft crash sites.

Spitfire P9503

On October 27th 1940, at the latter end of the Battle of Britain, Spitfire Mk1a P9503, piloted by Pilot Officer Paul Baillon, was shot down by a German bomber. The Spitfire crashed close to Lidbury Camp on Salisbury Plain where it remained for over 70 years. In 2013, a geophysical survey and excavation of the remains took place with an archaeological team – as part of Operation Nightingale – excavated this site to recover the remaining elements to establish the nature of the crash, the surviving conditions of materials and to set standards for future recovery of military aircraft crash sites.

Spitfire P9503 crashed to the south of Upavon airfield at approximately NGR SU 165 535. P/O Paul Baillon bailed out successfully. Throughout the Battle of Britain, Spitfire P9503 had brought down an enemy aircraft on

October 15th 1940 when flown by Fl Lt John Dundas DFC and bar. This aircraft, a BF110, was the 99th aerial victory for 609 (West Riding) Sqn Royal Auxillary Air Force – the first Spitfire Squadron of the RAF to gain '100' kills in the Second World War. Unfortunately, Fl Lt Dundas was killed on the 28th November 1940 just after having shot down the leading Luftwaffe ace, Helmut Wick, over the English Channel. Co-incidentally, Wick had just shot down and killed P9503's former pilot P/O Paul Baillon in the same engagement ((Osgood 2014, 5).

One of the first tasks was to find the aircraft by undertaking a desktop research, which included the following:

Operational diary research, literature review, archive research with the Air Historic Branch, RAF air photographs, Historic Environment Record (HER – UK only), walkover survey, walkover survey using metal-detectors to detect for aluminium, and geophysical survey.

During the walkover survey by Richard Osgood and with stakeholders such as Cpl Paul Turner, Operation Nightingale, no airframe or crater was visible in the area. Following this, Richard Osgood undertook a metal-detector survey using a Foerster Ferex magnetometer traditionally used for UXO detection in region of the crash site. The magnetometer produced extremely high readings in the presumed area of the crash site.

After this initial investigation, a magnetometer and ground penetrating radar survey was undertaken by the author. The magnetometer survey results of P9503UP with the excavation trench superimposed and outlying stray finds marked as stars show the darker area of the crater with a central high reading (large red anomaly) of the engine components (Figure 4, shown as a triangle).

GPR survey was successful at determining the size and shape of the crater. The depth was approximately 1.5m (Figure 8). A series of transects were surveyed in both directions in order to produce time slices.

The geophysics was then backed up by a non-intrusive metal detection survey. Each find spot was flagged and plotted to map the debris field (Figure 10). By doing this it was possible to ascertain the spitfire's impact path. Once the crash site had been located then the recovery of the airframe would be the next step of investigation.

Figure 8 – Metal detecting survey with finds marked with flags of the debris field

The excavation trench initially measured 4m x 4m, sited over the strongest geophysical responses. All stripping was done by hand with turves set aside for reinstatement after the excavation as this is a Site of Special Scientific Interest (SSSI). The extent of land to be stripped was determined following the survey results (Figure 6). From previous examples of Spitfire crashes, the impact area can be relatively confined (a circular area c.2.5m in diameter (once the elements left on the surface such as the wings are discounted). An example of this is illustrated in the existing Historic England guide ((Historic England 2002, 6). Also present was an RAF low-loader in the event of there being airframe components that would need mechanical removal and transportation. This should always be incorporated into the aircraft crash-site project designs.

Excavation of the impact crater confirmed the geophysical survey results and it was possible to from the detailed recording of the site to determine the type of crash. The P9503 when shot down went into a vertical dive and crashed into the chalk. The pitot tube (measuring air speed; Figure 11) was found vertically stuck into chalk supporting the crash theory.

Figure 9 – Upavon spitfire Pito tube vertically stuck in the chalk.

Hurricane

The second study looks at a hurricane crash site. In July 2015, a survey of the Hurricane P3700 Mk1 aircraft was shot down on the 9th September 1940, during the Battle of Britain. The aircraft was piloted by F/Sg Wunsche, a Polish National who bailed out after being shot down by a German air attack. The aircraft did a nosedive into the hillside above Saddlescombe Farm, Saddlescombe, situated to the north of Brighton, West Sussex. The land is currently owned by the National Trust (NT) and the farm is tenanted by Camilla and Roley Puzey.

Operation Nightingale and Worthing Archaeological Society (WAS) assisted with the recovery and recording of the aircraft remains. The excavation trench measured approximately 4m x 4m. The impact crater was about 1.5m in diameter and 1.5m deep. The trench was dug by hand due to the landowner not wanting his crop damaged. An important point when attempting to get permission from the landowner and what will be permissible in their eyes.

The main parts of the aircraft recovered were the propeller hub, reduction gear, cylinders and pistons. The ground truthing confirmed the magnetic signatures that clearly illustrate the responses from these aircraft pieces. This is similar to the Spitfire crash sites on Salisbury Plain and Holme Fen (Figure 6).

Holme Fen Spitfire X4593, Cambridgeshire

The third example is a spitfire that crashed in the fens of Cambridgeshire. The first stage of the investigation and recovery of the Mk1a Spitfire required metal detecting and geophysical surveys ((Masters 2015; Haskins, A;Fairbairn, J;Brown 2016). This was essential in order to locate the exact spot of the crash site. From RAF records and oral histories of the site, the precise location was not known. A grid reference of the site had been recorded in the records. Upon undertaking the geophysical survey, it was found that the grid reference was 60m away from the exact spot. Like previous investigations (see above), the debris field and geophysics correlate well with the anomalies detected by magnetometer (Figure 6).

In October 2015, OAE undertook the excavation and recovery of the remains of the Spitfire Mk1a X4593 'Kerala' (Haskins, A;Fairbairn, J;Brown 2016). During a routine training flight, the X4593 crashed into Holme fen on 22nd November 1940 and the Pilot Officer Harold E Penketh was killed. Following the crash, a recovery team was deployed to excavate down to the crashed aircraft according to the MoD records. During the excavation in October 2015, evidence was found of this subsequent excavation and recovery of P/O Penketh along with an RAF mess plate (Figure 12) left by the recovery team as a marker.

Figure 10 – RAF Mess plate, Holme Fen Spitfire

The remains of the spitfire were found in-situ comprising of the engine block, parts of the cockpit along with other airframe pieces as well ammunition. These were found at a depth of -6.27m OD below sea level. In addition to the aircraft itself, personal effects were also recovered including his cigarette case with his initials on and his watch.

The excavation was recorded using a Leica 1200 GPS and base station. Main elements within the impact crater were 3D recorded using photogrammetric techniques. The 3D reconstruction of the impact crater (Figure 14) has shed a new light on how to reconstruct the crash site including all the major pieces of the aircraft and how they carried out the original recovery of the pilot and aircraft remains.

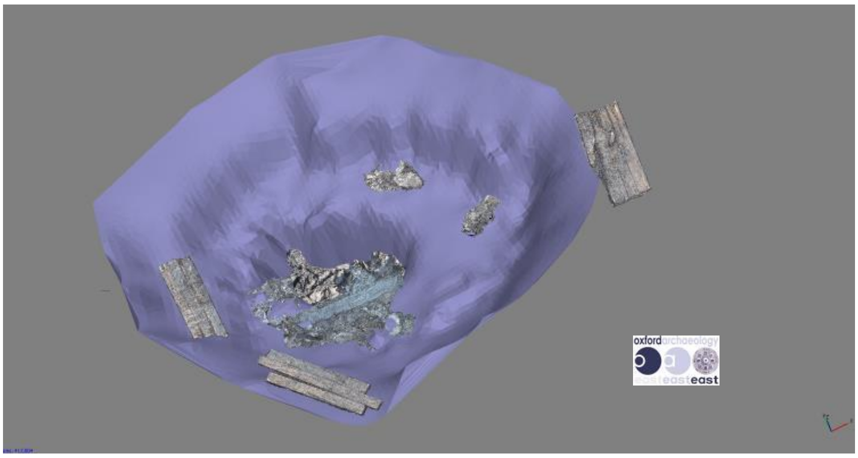


Figure 11 – 3D reconstruction of the impact crater. Courtesy of Oxford Archaeology East

Following the recovery, the remains of the spitfire were taken to the Pathfinder Museum, RAF Wyton for conservation and display. The strategy and protocols followed in this example is what is required to fully understand the evidence and the context in which the remains are found. This is the future in terms of recording aircraft remains in the UK and could be adopted worldwide.

MEDIA

Not in all cases will the media be involved but today we also have social media such as Facebook and Twitter and so information can get out quite quickly these days. Where human remains are likely to be encountered it is vitally important to make sure none of this information has been tweeted. Tweeting is disrespectful to the living relatives and family of the pilot/s/aircrew and this leads to everyone knowing about it before them. This recently happened during the recovery of Spitfire X 4593 'Kerala' as there were so many people on site it was practically impossible to prevent this from happening. Although saying that, an initial briefing was given to all those who came to the site.

MEMORIALISATION

Personal items found belonging to the pilots/crew give us a tiny window to glimpse into the human aspects of aircraft crash sites – tangible link with the past. A good case in point is Harold Penketh's cigarette case as mentioned one of the case study's above. Eye-witness accounts can provide good information about the fate of pilots or crew members even with careful removal, a number of personal items have survived in the ground for more than 70 years.

Community involvement of where the crash occurred is an important part of the archaeological investigation as previously mentioned in the paper. A memorial service at the end of an excavation is necessary as a form of closure that allows for a time of reflection. This is also out of respect for those that fought for our freedoms today.

Conclusions

An integrated approach to the recording and recovery of military aircraft crash sites is essential to fully understanding the full impact. The case studies referred to in this paper, in particular the Holme Fen Spitfire, have been successful in bringing together archaeologists, aircraft experts, amateurs and volunteers to record a number of distinctive aircraft types. This has allowed a story to be told by piecing the evidence together in an archaeological and forensic way.

The standard methodology proposed in this paper will help future investigations bring together a comprehensive understanding of the impact that the aircraft had on the landscape and reconstruct how the aircraft crashed at high speed into the ground. It is possible to do this without using high-end tech equipment and a large budget to do this type of investigation. A handheld GPS and a DSLR camera at the basic level is all that is required to record the debris field. As regards excavation, this can be done archaeologically without causing damage to the buried remains. This will allow for a full recovery of all of the elements of the aircraft and provide a meaningful context.

In recent times with the legislation in place, the looting of military aircraft crash sites for souvenirs has dwindled. This paper has hopefully made a step in right direction to bringing together a better way to understanding aviation archaeology. This is especially poignant in terms of what impact the aircraft can have on the landscape.

Acknowledgements

The authors would like to thank the Wyvern Historical Society volunteers, Operational Nightingale, and personnel from the Royal Airforce, in particular Graham Moore, Darius Smith, Paul Turner and Peter Atkinson. Also to the landowners whom have given their kind permission to carry out such investigations on their land. Finally, to the many volunteers who have been involved with many of the projects over the last five or so years.

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2021-05-23

Masters P, Osgood R. (2021) Towards an integrated approach to recording military aircraft crash sites. Archaeological and Environmental Forensic Science, Volume 2, Issue 1, 2021, pp. 19-38
https://doi.org/10.1558/aefs.18050