Archaeological Geophysics
Investigation of the Wright Brothers
1910 Hangar Site

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An archaeological geophysics investigation was conducted at the site of the Wright Brothers' 1910 hangar near Dayton, Ohio. The hangar was destroyed as part of base renovation during the buildup to World War II, and its exact location is unknown. The purpose of the investigation is to confirm the exact location of the hangar and to locate any buried artifacts from the Wright Brothers occupation of the site. Ground penetrating radar (GPR), electromagnetic, and magnetic surveys were conducted over a 68 × 100 m area, approximately centered on the suspected location of the hangar. Localized anomalies as well as areal anomalies are identified in the geophysical data. Rectangular anomalous areas are identified that are generally consistent with the suspected location of the hangar. A 1924 aerial photograph showing the hangar was digitally scanned and georeferenced to the site survey area. Two of the rectangular geophysical anomalous areas are consistent with the hangar location from the aerial photograph location. A third rectangular area, defined from GPR survey data, is immediately adjacent to the aerial photograph location. It is postulated that base engineers may have bulldozed the hangar debris onto an area adjacent to its original location and either burned it there or buried it in a trench. A prioritized exploratory program is proposed for investigating the sources of the geophysical anomalies. © 1994 John Wiley & Sons, Inc.

INTRODUCTION

Background

In 1910, Wilbur and Orville Wright constructed a hangar near Dayton, Ohio, that housed their Wright Company School of Aviation and the Wright Exhibition Company. The hangar site is on the Huffman Prairie, location of the Wright Brothers earlier flying experiments in 1904 and 1905. The aviation school operated until 1916, and the hangar remained on the Prairie until the late 1930s/early 1940s. In 1924 the hangar was used during the Dayton Air Show and International Air Races to display the Kitty Hawk, the plane that made the first sustained, controlled, powered flight in 1903; this was likely the last formal use of the hangar. The hangar was mistakenly destroyed, according to Air Force tradition, as part of "overzealous adherence to general orders to renovate the Base" and destroy all wooden hangars as part of the buildup associated with World War II (Babson, 1991; Brown, 1993).

The hangar site is on Wright-Patterson Air Force Base (WPAFB) property.
Although the site has remained largely undisturbed since the hangar was demolished, notable exceptions include construction of storm drainage lines across the site and installation of a concrete pylon (placed by Orville Wright in 1941) near the site of a smaller 1905 hangar. A bronze marker was placed near the location of the 1910 hangar, probably while surface debris and living memory could accurately locate the site (Babson, 1991). The bronze marker was located in 1990 by WPAFB surveyors. Also in 1990, a replica of the 1905 hangar was built in approximately the original location to celebrate the dedication of Huffman Prairie Flying Field as a National Historic Landmark by the U.S. Park Service. Subsequent to 1990, the bronze marker near the 1910 hangar site was removed and replaced by a larger concrete marker located approximately 2 m from the location of the bronze marker.

The 1910 hangar was a larger, more substantial, and longer-lived structure than the 1905 hangar. Some historic records indicate that the 1910 hangar size was 60 × 100 ft (nominal 18 × 30 m) in plan section; however, analyses of photographs indicate a likely approximate size of 48 × 70 ft (15 × 21 m) for the hangar (Brown, 1993). The roof was formed by five timber trusses supporting the roof joists, with a 14-ft eave height and 20-ft ridge height. Originally, the hangar was supported at the sides by wood post columns (likely 4 × 4 in. or 6 × 6 in.) at the truss locations; however, later photographs also show center columns. The wood columns must have been sunk into the ground to provide lateral stability. The hangar originally had a wood floor, which was removed sometime after 1924.

Figure 1 is an aerial photograph of the flying field and 1910 hangar taken in 1911 from a Wright Flyer. Apparent in Figure 1 are the front sliding doors in a fully open position. The support for the overhead sliding “rail” was three vertical wood post columns with diagonal braces; the columns were sunk into the ground and the braces were anchored in some way to the ground. The road behind the hangar in Figure 1 is Symmes Road; and a fence, paralleling Symmes Road, passes immediately behind the hangar. The road crossing Symmes Road in Figure 1 is Marl Road. An aerial photograph taken in 1924 from much higher altitude (Figure 2) shows that Symmes Road “dead ends” at Marl Road, no longer passing behind the hangar. Figure 3 is reproduced from a WPAFB brochure describing present day features of the National Historic Site and a walking trail through the site. Note that Symmes Road, Marl Road, and Hebble Creek Road (all evident in Figure 2) still exist, as well as other identifiable features in the aerial photographs. The outline of the Huffman Prairie Flying Field is obvious in Figure 2 by the vegetation patterns; the field boundaries may have been entirely fenced, as indicated in Figure 1 for the part of the boundary immediately adjacent to the hangar.

The present work, as well as the work in the reports by Babson (1991) and Brown (1993), is part of a continuing effort to enhance the Huffman Prairie Flying Field National Historic Site. In particular, the most significant activity planned for the Site is the construction of a replica of the 1910 hangar. WPAFB
hopes to complete construction of a replica hangar in time for the Dayton Bicentennial celebration in 1996 and the centenary of powered flight in 2003. Construction of the replica in the exact location of the original hangar will enhance the realism. Also it is important to document and preserve to the maximum extent possible any remaining in situ evidence and artifacts of the Wright Brothers occupation of the site prior to construction activity at the site.

The Hangar Site Physiography and Geology

Huffman Prairie Flying Field is flat, with primarily topographic relief provided by numerous ground hog holes. The site is in the floodplain of the Mad River, and is part of the Till Plains section of the Central Lowlands physiographic province. During the time of the geophysical surveys (October 1993), the typical prairie grasses ranged in height from approximately 5 cm on the walking trails to as much as 30 cm elsewhere. Residual stubble from taller plants was soft and friable and posed no constraints on the geophysical surveys. The only trees near the survey area were along Marl Road. Soil and gravel were exposed in the ground hog holes and the excavated material. The soil is a black, very poorly drained organic soil of the Linwood series (Soil Conservation Service classification), and is approximately 1 m thick beneath the survey area. Beneath the soil are predominantly sands, gravels, and some discontinuous clay layers of the Mad River buried-valley aquifer system (glacial drift depos-
The sand and gravel aquifer is highly permeable, and is in excess of 40 m thick beneath the site. The aquifer is underlain by shale of Ordovician age (Dumouchelle et al., 1993). Water table depth beneath the site varies from 1.5 to 1.9 m during a typical year (U.S. Geological Survey, 1992).

Objectives

The present work supports a larger effort to develop and implement an archaeological management plan for the Huffman Prairie Site. Previous work
at the site includes archaeological site mapping and excavation. The specific objectives of the geophysical surveys are to (1) locate the actual hangar site as accurately as possible, (2) detect any remaining evidence of the hangar foundation, and (3) locate buried artifacts. The geophysical signature (if any exists) of the location of the hangar and its foundation (the wooden columns) is expected to be extremely subtle. Buried artifacts might consist of tools and aircraft parts; location and recovery of such artifacts is a high priority part of the overall effort to document and preserve the site. Artifacts, particularly those containing iron and other metals, that have not totally rusted and disintegrated can generally be located by the geophysical surveys.

THE PLAN OF INVESTIGATION

Concepts of the Geophysical Survey Methods

General

Geophysical methods used for archaeological investigations provide both qualitative and quantitative information regarding surficial and subsurface
materials, processes, and geometric relationships. The surficial and subsurface information can generally be classified in four categories: (1) surface features and their geometric relationships at a given point in time; (2) normal subsurface geology and its variation in vertical and horizontal directions; (3) culture-induced disturbances of the normal geology; (4) cultural artifacts within the normal geology or disturbed areas. Category (1) information includes surface or very-near surface information on topography, geomorphic features, and cultural features. The geophysical signature for category (2) above is considered the normal background for geophysical survey data. Geophysical signatures of categories (3) and (4) represent anomalies that are superimposed in some manner on the normal background. Thus the keys for any archaeological geophysics investigation are to identify and understand the normal background (normal geology) and then to interpret the significance of any anomalies relative to the normal background.

The geophysical methods applicable to archaeological investigations include airborne imagery (photography and multispectral imagery), airborne electromagnetic and magnetic surveying, and surface surveying. Surface geophysical surveying methods most applicable and frequently utilized for archaeological investigations can be classified as magnetic methods (total field and vertical gradient), electromagnetic (EM) methods, resistivity methods, and ground penetrating radar (GPR). GPR is an EM method, but it is sufficiently unique in terms of field procedures and data display and interpretation that it is usually considered separately. Seldom is only one geophysical method used for an archaeological geophysics investigation, rather multiple methods are utilized in a complementary and integrated manner. An anomalous feature or condition in the subsurface may not be detected by one geophysical method, but will often be detected by another method. When an anomalous feature is detected by more than one geophysical method, the significance and interpretation of the anomaly is enhanced and facilitated. The present investigation included GPR, total field magnetic, and electromagnetic surveys. Brief descriptions of the methods which follow are not intended to be comprehensive; more detail can be found in Scollar et al. (1990), Telford et al. (1990), Ward (1990), and Heimmer (1992).

**Aerial Photography**

Aerial photography is used in the present investigation for assessment of the present surface site conditions in relation to conditions at the time of site occupation by the 1910 hangar. An aerial photograph showing the 1910 hangar (Figure 2) was digitally scanned and georeferenced to a digitized current WPAFB facilities map (similar to Figure 3). The digitized imagery and map information can be directly referenced to the site survey grid and geophysical survey anomaly maps.
Ground Penetrating Radar Surveying

GPR is an electromagnetic geophysical method typically utilizing electromagnetic frequencies of 50 MHz to 1 GHz. The method includes a transmitter (Tx) and receiver (Rx) that are pulled or moved on the surface a fixed distance apart along profile lines. The Tx emits a short pulse of electromagnetic energy that propagates into the subsurface, reflects from interfaces between different geologic materials or conditions (such as the water table) and objects or other features within the subsurface, and is then recorded (by a graphic recorder or on magnetic tape or computer disk). GPR antennae are commonly classified by the center frequency of the pulse emitted by the Tx. For the present work, a 300 MHz antenna was used. Figure 4(a) is a cartoon illustrating a GPR survey over some subsurface reflectors and the resulting graphic GPR record. The graphic record represents amplitude of the electromagnetic signal at the Rx as a function of the horizontal distance (from some starting point on a survey line to the center of the Tx–Rx pair) and the two-way (down and up) travel time of the signal. An illustration of the manner in which the electromagnetic signal (amplitude versus time) is converted into what is shown on the graphic record is given in Figure 4(b).

The GPR system prints time lines and distance markers on the record. The distance markers are triggered by the surveyor as the Tx–Rx pair passes a flagged or known location. Between the triggered distance marks, the data are acquired virtually continuously, depending on the walking speed of the surveyor and the rate at which the system records Tx pulses. For a typical recording rate of 25 scans/s and a walking speed of 1 m/s, a record will be obtained every 4 cm. To convert the time scale to a depth scale, time must be multiplied by the appropriate propagation velocity for electromagnetic waves in the geologic material (either by directly measuring velocity in some way or by using a typical velocity for the material). An electromagnetic wave velocity of $1 \times 10^8$ m/s (corresponding to a dielectric permittivity of 9) is accepted as appropriate for estimating depths for the GPR surveys at the hangar site.

GPR surveying is capable of extremely high resolution mapping of the subsurface, both vertically and horizontally. The applicability of GPR is extremely site-specific; with very limited depths of investigation in soils with high electrical conductivity, e.g., soils with high clay contents and/or high water contents. An elementary GPR overview, including the concepts in this section, can be found in Butler (1992).

Magnetic Surveying

Magnetic surveying involves measurements of the total magnetic field strength as a function of position over the survey site. The magnetic survey at the hangar site was conducted using a proton precession magnetometer with a measurement accuracy of ±1 nT (nanoTesla). The normal earth's magnetic field strength at the site is approximately 55,200 nT. Materials on the surface
Figure 4. Ground penetrating radar (GPR) surveying: (a) GPR survey concepts; (b) GPR graphic record.
or in the subsurface containing iron and certain other materials with high magnetic susceptibility or remnant magnetization (for example, fired bricks or stones can have remnant magnetization) will produce magnetic anomalies, relative to the normal earth's magnetic field strength, that are detected and mapped by the magnetic survey. The magnetometer was operated in a "walking" data acquisition mode, i.e., data were acquired at fixed time intervals while the surveyor walked along survey lines at a slow rate. A time interval of 1 s was used, resulting in a measurement at least every 1 m along the survey lines. The data are corrected for time variations of the magnetic field by reoccupying base stations frequently during the survey. Magnetic survey data are presented as magnetic field strength anomaly contour maps; the anomaly magnitudes are defined relative to the value 55,200 nT. For well-defined localized magnetic anomalies, it is possible to estimate depths for causative subsurface features based on characteristics of the anomaly (magnitude, spatial extent).

**Electromagnetic Surveying**

Two electromagnetic (EM) instruments were used at the hangar site, both identical in physical concept. One instrument, designated EM38, is a shallow depth of investigation device. The second instrument, designated EM31, has a greater depth of investigation. Both instruments contain a Tx and Rx in a single housing, with the following characteristics:

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Frequency (kHz)</th>
<th>Separation (m)</th>
<th>Approximate Depth of Investigation (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>EM38</td>
<td>14.6</td>
<td>1.00</td>
<td>1.5</td>
</tr>
<tr>
<td>EM31</td>
<td>9.8</td>
<td>3.66</td>
<td>5</td>
</tr>
</tbody>
</table>

Figure 5 shows the EM31 during a survey at the hangar site. The approximate depths of investigation given for these instruments should be used only as "rules of thumb" and are for the horizontal coplanar Tx–Rx coil orientation. The rule of thumb depth of investigation for the EM31 accounts for the fact that the instrument is carried approximately 1 m above the ground.

The Tx generates a time-varying magnetic field (the primary field) that interacts with subsurface materials to induce electrical currents and secondary magnetic fields. Secondary magnetic fields from subsurface materials are detected by the Rx along with the primary field. Figure 6(a) illustrates the concept of operation of the EM instruments. Tx and Rx are shown as horizontal coplanar coils at or near the surface, and the Rx is shown being influenced by both the primary magnetic field and the secondary magnetic field. The EM instruments can measure both a component in-phase with the primary field and a component 90° out-of-phase (called the quadrature component) with the primary field. The quadrature component is directly proportional to the electrical conductivity of
Figure 5. The EM31 during a survey at the hangar site. Flying Field Flag #6 is shown in the background. The small flags define a $4 \times 4$ m grid over the $100 \times 68$ m survey area.

Figure 6. Concepts of EM induction surveying. (a) EM induction: (Tx) transmitter; (Rx) receiver; (I) current; (Hp) primary field; (Hs) secondary or induced field. (b) EM31 response versus depth for instrument carried at “hip-height.” (c) Concept of EM anomaly and background for a hypothetical geologic section.
the subsurface feature and is expressed in mS/m (milliSiemen/meter), while the in-phase component is expressed in ppt (parts per thousand) of the primary field. Conductivity measured by the EM instruments is properly termed an apparent conductivity and represents a weighted volume average of true conductivity of materials within the volume of investigation of the instruments; Figure 6(b) illustrates the depth weighting (relative sensitivity) for the EM31. The in-phase component is primarily used for detection of subsurface metallic objects. Magnitude and spatial width of the secondary field detected by the Rx depends on the electrical conductivity of the subsurface anomalous feature as well as its size and depth. When the Tx and Rx are moved together along a surface profile over a subsurface anomalous feature, an anomaly will be detected (1) if the subsurface feature is within the depth of investigation of the instrument and (2) if the feature is sufficiently large relative to the spacing between surface measurement points; the anomaly will be relative to the normal background (Figure 6(c)). EM data are acquired on profile lines, and then processed to give EM anomaly contour maps.

The Site Survey Grid

After review of historical documents, WPAFB base maps, and aerial photographs, a survey area was selected to encompass the most likely location of the 1910 hangar and the locations indicated on base maps (some discrepancies exist). The area, 100 m × 68 m, was approximately centered on the likely location. The northeast corner of the survey area was colocated with Flag #6 of the present Huffman Flying Field markers (Figure 7), and the northern, long side of the area is along a line from Flag #6 to Flag #7. The survey area is shown in Figure 8. The area was flagged on a 4-m grid with plastic (nonconductive) pin flags. Establishing the survey grid required approximately 1/2-day for a two-person crew. Location coordinates (OE, ON) are assigned to the southwest corner of the area; consequently, the coordinates of the northeast corner are (100E, 68N). Grid north (along the short dimension of the survey area) is rotated by approximately 18° relative to geographic north.

Semipermanent features noted on the site map (Figure 8) are the concrete marker, Flag #6 (Figure 7), and walking tour pole markers. All of these features are connected by mowed walking paths, also shown on the map. Transient features noted on the map are ground hog holes. The holes are as large as 30 cm in diameter and many apparently extend well into the glacial gravels beneath the soil (based on considerable amounts of gravel in excavated material). Both semipermanent and transient features are important for reference and for correlation with locations of geophysical anomalies. For reference completeness, the archaeological excavations of 1990 assign location coordinates (500N, 400E—geographic north and east) to the location of the original bronze marker; this corresponds approximately to location (68E, 52N) in the present grid coordinates.
Figure 7. Flying Field Flag #6; survey grid coordinates (0E, 68N).
Geophysical Surveys

The geophysical surveys conducted at the 1910 hanger site are detailed in the following tabulation.

**GPR Surveys (see Figure 9):** along E–W lines spaced by 4 m, from 0N to 60N; along N–S lines spaced by 8 m, from 8E to 96E; Based on anomalous indications, additional lines were surveyed—50N; 54N; 52E; 54E; 60E; 68E.

**Magnetic Surveys:** Along N–S lines spaced by 2 m, from 0E to 100E, with measurement spacing ≤1 m along the lines, for a total of approximately 4660 measurements.

**Electromagnetic Surveys:** EM31. Along E–W lines spaced by 4 m, from 0N to 68N, with measurement spacing of 4 m, for a total of 368 measurements of both in-phase and quadrature components. EM38. Along E–W lines spaced by 2 m, from 0N to 68N, with measurement spacing of 2 m, for a total of 1785 measurements of quadrature component.

The geophysical data acquisition required approximately 2 days for a three-person crew.
THE INVESTIGATION RESULTS

Geophysical Anomaly Maps

Magnetic Survey Results

A magnetic anomaly contour map is shown in Figure 10, with a contour interval of 30 nT (some of the anomalies indicated were originally identified on a 5 nT contour map that was severely impacted by a "herring-bone" pattern effect). Specific anomalies are labeled with symbols A–G on Figure 10. Anomaly A is caused by metal associated with Flying Field Flag #6 (Figure 7, flagpole and reinforced concrete); the remainder of the magnetic anomalies have unknown causes. Anomaly B is particularly significant; the object causing the anomaly is at depth 3.5 m or shallower and located approximately at (47.5E, 47N). Table 1 gives grid locations for the magnetic anomalies A–G, as well as anomalies H–K, which were detected on the 5 nT contour map.

Electromagnetic Survey Results

Results of the EM31 electromagnetic survey are shown in Figures 11 and 12. Figure 11 is a contour map of apparent conductivity in mS/m and reveals relatively uniform conditions over the site on a scale of 4–5 m (4 m measure-
ment spacing and 5 m depth of investigation). The apparent conductivity varies slowly spatially from 8 to 12 mS/m except for anomaly A at (0E, 68N), where conductivities as high as 15 mS/m are measured, due to metals associated with Flying Field Flag #6 (Figure 7). Slightly higher conductivities occur in the central and right central areas of the survey grid, suggesting (1) a slight change in soil composition, (2) an increase in water content, or (3) perhaps an increase in occurrence of small, scattered, conductive cultural artifacts. Three anomalies are labeled on the in-phase contour map in Figure 12: (1) anomaly A is caused by Flying Field Flag #6; (2) anomaly B corresponds in location to magnetic anomaly B; (3) anomaly C corresponds in location to the concrete and bronze monument at (68E, 52N).

The EM38 survey results are shown in Figure 13, where the contours are apparent conductivity in mS/m over the site on a scale of 1–2 m (2 m measurement spacing and 1.5 m depth of investigation). The map contains many localized anomalies, indicated by labels I–XIV, and general background conductivity varying between 8 and 12 mS/m in agreement with the EM31 results. Table II gives location coordinates for the localized anomalies. As indicated in Table II, only anomaly I is caused by a known feature. Features causing anomalies II–XIV are <1.5 m deep and very likely <1 m deep. Nine of the
Table I. Magnetic anomaly locations.

<table>
<thead>
<tr>
<th>Magnetic Anomaly</th>
<th>Location</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0E, 68N</td>
<td>Flying Field Flag #6</td>
</tr>
<tr>
<td>B</td>
<td>47.5E, 47N</td>
<td>Maximum depth 3.5 m</td>
</tr>
<tr>
<td>C</td>
<td>50E, 35N</td>
<td>&lt;2 m depth</td>
</tr>
<tr>
<td>D</td>
<td>50E, 2N</td>
<td>&lt;1 m depth</td>
</tr>
<tr>
<td>E</td>
<td>46E, 0N</td>
<td>&lt;1 m depth</td>
</tr>
<tr>
<td>F</td>
<td>98E, 13N</td>
<td>&lt;1 m depth</td>
</tr>
<tr>
<td>G</td>
<td>84E, 68N</td>
<td>&lt;1 m depth</td>
</tr>
<tr>
<td>H</td>
<td>26E, 10N</td>
<td>&lt;1 m depth</td>
</tr>
<tr>
<td>I</td>
<td>38E, 40N</td>
<td>&lt;1 m depth</td>
</tr>
<tr>
<td>J</td>
<td>34E, 44N</td>
<td>&lt;1 m depth</td>
</tr>
<tr>
<td>K</td>
<td>36E, 34N</td>
<td>&lt;2 m depth</td>
</tr>
</tbody>
</table>

labeled, localized anomalies are in a rectangular area bounded approximately by coordinate lines 25N, 48N, 33E, and 55E; this area is shown in Figure 14. Other localized anomalies with smaller magnitude are not included in Table II, and several of them are in the rectangular area.

The localized anomalies in Table II are low or negative anomalies, which

Figure 11. EM31 conductivity contour map; contour interval 1 mS/m.
indicate that the likely cause of the anomalies are shallow, buried metallic objects. In addition, there is a significant positive anomaly trend (>12 mS/m), beginning at approximately 0E, 0N and extending to the vicinity of (55E, 68N). The positive anomaly trend is shown in Figure 14, where the conductivity contours are for magnitudes ≥12 mS/m. Whether this high conductivity trend is due to geologic origins or to some relic of previous site use is unknown. The source of the anomaly is broad, shallow, and not continuous along the trend.

GPR Survey Results

GPR survey records from this site are typically 0.28 × 1.35 m in size; and, since 34 different lines were surveyed, reproducing all the GPR records in a convenient size is impractical. Only selected portions of the GPR records that illustrate typical features are included here. The GPR records were examined and classified by the following criteria: (1) undisturbed areas; (2) “shallow,” extensively disturbed areas (<1 m); (3) “deep,” extensively disturbed areas (>1 m); (4) anomalous area or feature; (5) localized anomaly. Undisturbed areas have no significant, identifiable anomalous subsurface conditions, i.e., uniform conditions laterally and also vertically, except for near-horizontal strata (Figures 15–17). Localized anomalies appear as hyperbolic signatures.
GEOPHYSICAL LOCATION, WRIGHT BROTHERS 1910 HANGAR

EM38 CONDUCTIVITY

Figure 13. EM38 conductivity contour map; contour interval 2 mS/m.

Table II. EM38 conductivity anomaly locations.

<table>
<thead>
<tr>
<th>Conductivity Anomaly</th>
<th>Location</th>
<th>Comments</th>
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</thead>
<tbody>
<tr>
<td>I</td>
<td>0E, 68N</td>
<td>Flying Field Flag #6</td>
</tr>
<tr>
<td>II</td>
<td>48E, 47.5N</td>
<td>Magnetic anomaly B</td>
</tr>
<tr>
<td>III</td>
<td>52E, 44N</td>
<td></td>
</tr>
<tr>
<td>IV</td>
<td>54E, 37.5N</td>
<td></td>
</tr>
<tr>
<td>V</td>
<td>54E, 37.5N</td>
<td></td>
</tr>
<tr>
<td>VI</td>
<td>48E, 36N</td>
<td></td>
</tr>
<tr>
<td>VII</td>
<td>46E, 28N</td>
<td></td>
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<td>VIII</td>
<td>44E, 26N</td>
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<tr>
<td>IX</td>
<td>40E, 36N</td>
<td></td>
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<tr>
<td>X</td>
<td>34E, 36N</td>
<td></td>
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<td>XI</td>
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<tr>
<td>XII</td>
<td>74E, 50N</td>
<td></td>
</tr>
<tr>
<td>XIII</td>
<td>68E, 58N</td>
<td></td>
</tr>
<tr>
<td>XIV</td>
<td>30E, 2N</td>
<td></td>
</tr>
</tbody>
</table>
Figure 14. EM38 high conductivity zones (>12 mS/m) and rectangular area enclosing 9 localized anomalies; vpmypit omyrths; 2 mS/m.

opening downward (Figure 16); the size of the hyperbola depends on the size and depth of the subsurface feature relative to the wavelengths of the GPR. The 1 m depth selected to classify “shallow” versus “deep” disturbed areas is arbitrary. An example of a shallow, extensively disturbed area is shown in Figure 16; individual, localized anomalies can sometimes be identified in disturbed areas, but in general they are too small and closely spaced for individual identification. An anomalous area and a deep, extensively disturbed area are shown in Figure 17. The anomalous area in Figure 17 has a definite signature that extends over approximately 10 m laterally and is also identifiable on other survey lines (0N, 8N, 12N, 16N); anomalous areas like this one may be geologic in origin.

Localized anomalies are potential cultural artifacts; buried tools and aircraft parts could produce localized GPR anomalies. The most obvious and significant localized anomalies are indicated in Figure 18; the figure also shows two anomalous areas (see Figure 17) and shallow and deep disturbed areas. The number associated with each localized anomaly marker is the approximate depth in meters. During the conduct of the GPR surveys, a “significant anomalous area” was detected; the GPR signature of this anomalous area is shown in Figure 19.
Figure 15. GPR survey line 60N from 0E to 28E, illustrating appearance of record for relatively uniform or undisturbed conditions (300 MHz antenna).

Figure 16. GPR survey line 68E from 4N to 40N, illustrating appearance of record for a shallow, extensively disturbed zone and a localized anomaly (18 in. storm drain).
Figure 17. GPR survey line 4N from 4E to 52E, illustrating appearance of record for an anomalous area and a deep, extensively disturbed zone.

Figure 18. Summary location map of GPR anomalies.
Figure 19. GPR survey line 52N from 44E to 72E, showing the "significant anomalous area," initially interpreted as the hangar foundation.

for east–west survey along line 52N. This anomalous area was detected on east–west lines as well as north–south survey lines and defines an approximately rectangular area (see Figure 18). Even during the conduct of the surveys, the possibility that the anomalous area could be the location of the hangar was suggested. The GPR signature is complex, as indicated in Figure 19. A large number of localized anomalies are within the rectangular area. The localized anomaly on north–south survey line 68E (Figure 16) is interpreted to be caused by the concrete storm drain (18 in. diameter) which crosses the site. The storm drain is detected on at least 10 of the north–south survey lines, and its interpreted location is shown as the dashed line (approximately east–west across the survey area) in Figure 18 and other figures which follow.

Airborne Photography and Facilities Map Integration

Results of scanning the 1924 aerial photograph (Figure 2) and georeferencing to digitized current WPAFB facilities map information (e.g., Figure 3) is shown in Figure 20. The hangar location shown on a current facilities map and the current site survey area are shown relative to the image of the hangar. An enlarged version of the hangar image is shown in Figure 21, superimposed on the survey grid and site features (Figure 8).

Integration of the Results

Figure 22 represents an attempt to display the key results in a concise form. Included in Figure 22 are GPR anomalies, magnetic anomalies, in-phase EM
Figure 20. Scanned version of 1924 aerial photograph of the flying field area and hangar, with the survey area identified.
Figure 21. Survey grid superimposed on an enlarged version of the scanned 1924 photograph.
anomalies, EM conductivity anomalies, ground hog holes, location of the existing 1910 hangar monument, the anomalous GPR rectangular area (from Figure 18), a possible extension of the rectangular anomalous area, the rectangular area with a high concentration of EM anomalies (from Figure 14), and an outline of the hangar as revealed in the 1924 aerial photograph. The possible extension of the rectangular GPR anomalous area was deduced from a detailed examination of the GPR records subsequent to georeferencing the 1924 aerial photograph of the hangar to the site survey grid, and may not have been noted otherwise.

Several of the localized GPR anomalies are possibly caused by ground hog holes; these GPR anomalies are indicated in Figure 22 by shaded squares. The preceding is an example of a geophysical anomaly produced by a nongeologic and noncultural feature. In the shallow subsurface, the only objects which typically produce localized magnetic anomalies will be cultural features and artifacts, such as iron-containing metals or fired bricks or rocks; thus all magnetic anomalies should be considered significant. Also, any location where more than one geophysical method indicates an anomaly must be considered significant.
GEOPHYSICAL LOCATION, WRIGHT BROTHERS 1910 HANGAR

The “dashed” rectangular area in Figure 22 was originally defined based on enclosing nine localized electromagnetic anomalies. It is highly significant that the dashed area also encloses five magnetic anomalies, numerous localized GPR anomalies, and completely encloses the hangar location indicated by the aerial photograph (“solid” rectangular area). The “dot–dash” rectangular area in Figure 22, originally defined based on a distinctive GPR anomaly signature, encloses numerous localized GPR anomalies and three localized EM anomalies. The dot–dash area is immediately adjacent to the hangar location indicated by the aerial photograph.

Figure 23 is a site survey grid and current feature map with the 1990 archaeological excavation plan superimposed. The shaded, circular area indicates the location of a high concentration of glass debris and other artifacts found near the surface. Also, the locations of buried wood and a 1910 penney found in excavated blocks are indicated. Most of the artifacts found are within the rectangular, significant GPR anomalous area.

Recommendations

Based on the integrated methods results, follow-up archaeological investigations (excavations) should be concentrated in the rectangular areas indicated in Figure 22. The highest priority excavation sites should be centered on locations where magnetic anomalies are located and where multiple geophysical anomalies are indicated. Magnetic anomaly locations are given in Table I. Excavation at a magnetic anomaly location should extend at least to the depth indicated in Table I and outward from the location at least to a 1-m radius. The shaded boxes in Figure 24 indicate multiple geophysical anomaly areas. Some of the multiple geophysical anomaly areas in Figure 24 include some of the magnetic anomalies from Table I. The significance of the remaining GPR and EM anomalies cannot be assessed; it is recommended that, at a minimum, remaining anomaly locations within and immediately adjacent to the rectangular areas in Figure 22 be investigated. Additional localized anomalies and anomalous areas should clearly have lower priority than the locations and areas discussed above.

ASSESSMENT AND CONCLUSIONS

Results of application of historical document search, early 1900s aerial photography, and surface geophysical surveying for locating and documenting any remaining in situ evidence of the Wright Brothers’ 1910 hangar are presented. Specifically, determining the exact location of the hangar, identifying the nature of the hangar foundation, and locating any buried artifacts such as tools and aircraft parts were objectives of the work.

The following tabulation assesses the results of this work:
Figure 23. Superposition of archaeological excavation plan, site survey grid, geophysical anomalous areas, and hangar location from 1924 aerial photograph.
a. A 100 × 68 m site survey grid was established that encompasses the apparent location of the 1910 hangar; existing features at the site are referenced to the site survey grid system.

b. A 1924 aerial photograph that shows the 1910 hangar was scanned and referenced to the site survey grid system; the area of the hangar image is approximately 14 × 23 m (46 × 75 ft).

c. The plan map of prior archaeological excavation at the site is referenced to the site survey grid system.

d. An approximately rectangular area is defined, based on a distinctive GPR (ground penetrating radar) signature noted on several GPR survey lines; the area is 13.5 × 32 m (44 × 105 ft) and is immediately adjacent to the location of the aerial image of the hangar.

e. An approximately rectangular area is defined that encompasses a large number of EM (electromagnetic) conductivity anomalies; this rectangular area completely encompasses the aerial image of the 1910 hangar and overlaps slightly the rectangular GPR anomalous area discussed in e; the area is 22 × 23 m (72 × 75 ft).

f. Subsequent to referencing the aerial photograph to the site survey grid
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system, a detailed examination of the GPR records identified an anomalous area approximately colocated with the aerial hangar image.
g. A large number of localized GPR, magnetic, and EM conductivity anomalies are located within the rectangular areas discussed above.
h. Six anomalous areas are defined that are indicated by more than one geophysical anomaly; additional localized and areal geophysical anomalies are identified throughout the site survey area.
i. A concrete storm drain, crossing the survey site, is detected and mapped by the geophysical surveys.

The results of the investigations indicate geophysical anomalous areas that are consistent with the location of the 1910 Wright Brothers' hangar as recorded by period aerial photography. An additional geophysical anomalous area is located immediately adjacent to the hangar location. This additional anomalous area encloses the locations of discovery of the majority of surface and very shallow buried cultural debris and artifacts. The significance of the additional anomalous area adjacent to the hangar location is not immediately apparent. A possible explanation is given in Babson (1991, p. 8); it is suggested that the high concentration of cultural debris and artifacts "may represent displacement of materials from the 1910 hangar by bulldozer or other heavy equipment when it was torn down." It is also possible that debris from destruction of the hangar may have been buried or burned adjacent to its original location. Burial of the debris in a trench could explain the details of the "significant anomalous area" (Figure 19). Numerous localized geophysical anomalies are identified that may represent buried artifacts from the use of the site by the Wright Brothers. A prioritized approach to investigation of the anomalous areas and localized anomalies is presented.

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REFERENCES


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