

Uh-Oh, It's UXO!

A Global Differential GPS Solution for Clearing Unexploded Ordnance



Hauling heavy equipment across nearly 59,000 acres of north Texas plains is a tough way to hunt for and remove unexploded ordnance from a former Army base. Maintaining the line-of-sight data communications links and power supply needed to employ RTK-GPS positioning makes the task even trickier. That's why one environmental restoration company turned to a satellite-based differential GPS system to expedite their work and reduce costs along the way.

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Photos: Gerald Braddock, Eric Treible, Terry Willis

At any given time along a large swath of rural, northern Texas you might witness a loud, dirty ritual. A handful of men standing still in the middle of a field, their expectant eyes fixed on the same point. Just about the time your gaze sets on the same point, it happens: a deep sound like the forceful downbeat of a drum cracks through the air and the dirt-caked ground explodes in a dusty plume of metal and sand. The cloud dissipates and the men, satisfied that the World War II-era munition has been successfully destroyed, move on to their next pin-flagged target.

It's an almost daily exercise for the survey and "dig" teams of Parsons Corporation and USA Environmental who together for the past four years have been steadily clearing the once-active infantry and artillery training facility Camp Howze and returning the 59,000 acres of land to its former cattle-grazing condition.

Officially designated as the Former Camp Howze Removal Project (FCHRP), the Texas effort is part of a long-standing U.S. Army Corps of Engineers (USACE) program to clean up unexploded ordnance (UXO) remnants at former military training bases around the globe. And it's one

in which Parsons, an engineering and construction firm based in Pasadena, California, has been heavily involved for the past 15 years. During that time, Parsons survey and explosives teams have located, unearthed, and recycled or destroyed more than a billion pounds of munitions, fragments, and other range-related items.

Unlike the typical short-term UXO removal projects of the past, the FCHRP has already required four years of dedicated labor and doesn't as yet have a fixed end point. The USACE funding approach enables the teams to stay on site until either the money runs out or all the ordnance is found and cleared, says Terry Willis, Parsons field data manager for FCHRP. Such unusual circumstances make budgeting for operational costs and developing highly efficient and productive work methods that much more critical, says Willis, because any substantial funding cuts by Congress could mean the end of the project.

An additional motivation for taking an open-ended approach to the FCHRP could be that all of the former Camp Howze land is privately owned and is home to families who have lived and worked there for more than 50 years. Each family must grant consent to the teams to clear individual parcels. Despite the fact that their house or barn could be sitting on a land mine or other ordnance, many people are



Using the GSBAS system, the survey team navigates to predetermined points on the ground and once at the location, they stake the target with a pin flag at its precise position. (inset) Historical photo of Camp Howze.

rather complacent and don't see the urgency in having the munitions removed, Willis says. Even though field teams have found artillery rounds eight feet from people's doorsteps, acquiring the necessary consent to access the property has been a time-consuming process.

“Although RTK-GPS is extremely accurate, its complexity, bulk, and expense make it less than ideal for [our] purposes.”

The Basis for Going Baseless

The rather atypical FCHRP presented Parsons with the opportunity to arm the project teams with their own atypical survey “weapon” — a global satellite-based augmentation system (GSBAS) that provides corrected GPS positioning without the use of base stations.

Although Parsons had never before employed the GSBAS technology in its numerous UXO removal projects, given the way the GSBAS has performed so far on the Texas project, Willis predicts that similar systems will become as common place in the field as the shovels and the explosives used to remove munitions.

Previously, Parsons' UXO-removal teams employed real-time kinematic GPS (RTK-GPS) systems to create search grids, find and stake out anomalies for investigation, and record the position of munitions found. RTK techniques require the broadcast of differential corrections to the GPS signals' carrier phase measurements. These corrections are transmitted via a high-speed data modem from a base station to roving GPS receivers.

“Although RTK-GPS is extremely accurate,” says Willis, “its complexity, bulk, and expense make it less than ideal for Parsons' purposes.” Since putting the GSBAS system to use in the field, the Camp Howze team has virtually eliminated its need for RTK-GPS in the majority of the fieldwork, obtaining decimeter accuracy for one-third the cost of an RTK-GPS unit.

A departure from local real-time differential GPS systems, the GSBAS relies on a global network of base stations to calculate and compensate for clock and orbit errors in the satellite transmissions. Broadcast of the DGPS corrections, available globally in real time, eliminates the need for local base stations, which in turn eliminates the

struggle to maintain communication links to a source of local corrections. In short, users are no longer tethered to a base station for precise positioning.

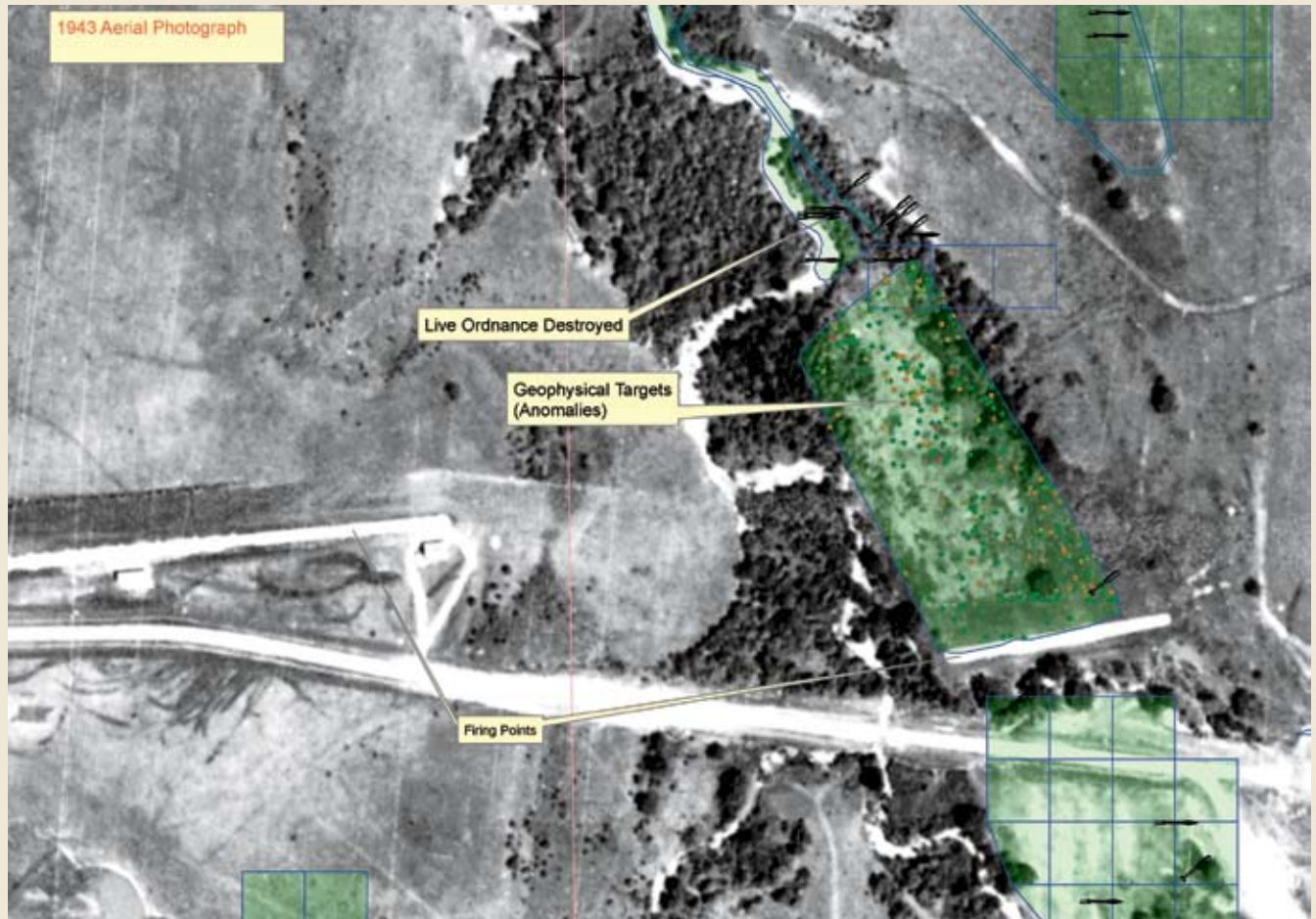
Recycling a Metallic Past

For four years, from 1942 to 1946, Camp Howze was the temporary home for thousands of soldiers as they prepared for battle overseas. Located along the Texas-Oklahoma border about 55 miles North of Dallas, the camp offered an immense area for training forces, artillery ranges, libraries, chapels, theaters, banking facilities, and even a camp newspaper.

For the last four years, however, former Camp Howze has been the temporary home of the Parsons and USA Environmental teams as they continually search for the telltale metallic signs of the camp's previous incarnation.

When their FCHRP activities began in 2002, the Parsons team started out with very scant historical and practical knowledge of the area, having only a few sheets of county property maps and background information on the camp itself provided by the U.S. Army. This information included engineering maps with the approximate locations of artillery ranges, aerial photos of the facility from 1943 (see **Figure 1**), and written records from units that trained there.

CLEARING UNEXPLODED ORDNANCE



FIGURES 1 AND 2 The former Camp Howze geographic information system (GIS) contains a host of site-related information including aerial photos from 1943 and 1995, which the teams use both to map what they find in the field and to pinpoint other potential hot spots to investigate. The red, light green, and dark green circles indicate anomalies – potential UXO – detected by the geophysical survey and their relative ordnance potential; red signifies the

Parsons then obtained updated aerial photos of the site taken in 1995 (see **Figure 2**) and records of what project managers call “phase one properties,” occupied properties or buildings believed to be near or on former range or training areas. All of these data sets were incorporated as layers into a geographical information system (GIS) to begin to identify logical areas to investigate for UXOs. Of critical importance for prioritizing their efforts was the identification of current high-traffic areas where private citizens live, work, and play.

“Once we identify the areas to investigate, we determine which methods for removing ordnance will be the most effective based on many factors such as accessibility, terrain, vegetative cover, time of year and land-owner consent,” says Willis. In the case of Camp Howze, all of those factors led to the decision to couple standard search tools with new technology to improve efficiency.

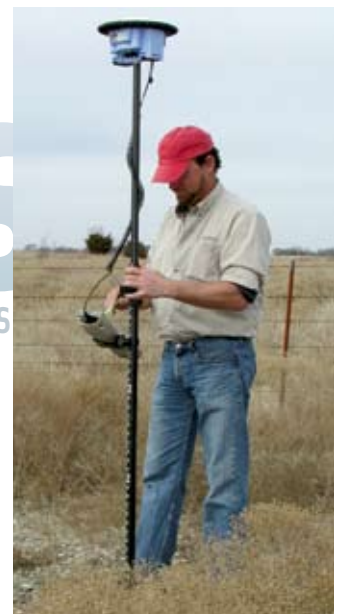
The two most common investigative tools are what Willis calls “magnetometer (Mag) and Dig” — a thorough, yet costly and time-consuming process of manually clearing smaller areas with the aid of shovels and handheld metal detectors — and “digital geophysics,” a survey technique that uses large, highly sophisticated electromagnetic sensors to detect the presence of buried metal objects. As the latter method can rapidly cover a much larger territory, Parsons first applied the

technique to perform a geophysical survey in combination with RTK-GPS to pinpoint suspected unexploded munitions.

To perform the geophysical survey, three computer-controlled electromagnetic sensors are connected together to create a three-meter wide sensing array. The sensors are then physically pulled by an all-terrain vehicle (see accompanying photo on page 27) over the area of interest to detect the presence of metal items in the ground and record their positions. The readings

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Pictured is Ed McVey, one member of the two-man survey team with the GSBAS receiver and a data collector. Because the GSBAS system doesn't require a base station, the team could initialize the system in less than five minutes.





highest potential of ordnance. The firing points indicate the point from where the ordnance was fired. All live ordnance Destroyed indications refer to those destroyed during the current project. Field data are entered using PDAs and fed into a database that is directly linked to the GIS.

from the electromagnetic sensors coupled with the continuous GPS readings are postprocessed to generate coordinates of anomalies, that is, possible UXOs, which are then added to the GIS. All uploaded position readings are tied to Texas North Central State Plane coordinates.

Through considerable postprocessing of the geophysical survey data, the Parsons' geophysicists plot positions of the anomalies on digital maps and "flag" them through color-coded points to signify the level of probability of being UXOs.

Following their usual practice, at this stage the field teams would have used RTK-GPS to reacquire and flag the real-world points of potential targets detected by the geophysical survey. At the former Camp Howze, however, Willis chose to depart from tradition.

Given the terrain extremes in this region of rural Texas, the large study area, high-accuracy requirements, limited labor resources and indefinite work schedule, Parsons needed a cost-effective and user-friendly survey solution that would enable UXO technicians to efficiently locate anomalies and precisely position them.

"We opted for the satellite-based system approach for a number of reasons, one of which was the considerable cost savings over an RTK-GPS rental," he says. "Because it doesn't require a base station, we don't have line-of-sight issues nor

need to spend considerable time troubleshooting communications and power supply issues. So, we can be much more productive in the field. And the simplicity of the system makes it much easier for the teams — who are not trained surveyors — to set up and use."

Unearthing UXO

On any given day, Willis and his teams use the GIS as a logistical planning tool to map out clearing strategies based on the digitally flagged hot spots indicating the highest probability of buried munitions. The team imports those coordinates into the controller software of the receiver, and the Mag/Dig teams head to the site. Once on site, the two-person survey team uses a "quick-start" feature built into the GSBAS receiver software that enables the system to reach full position accuracy immediately by using a previously surveyed position to initialize the navigation function. This set up process takes "less than five minutes," says Willis, after which the survey team uses the satellite-based system to navigate to the predetermined points on the ground, where they stake the targets with pin flags.

Following relatively closely behind the survey team, the dig team of three to seven UXO technicians armed with

CLEARING UNEXPLODED ORDNANCE



(top) Dig team members Ricardo Corona and Gary Base use the metal detector to verify the presence of metal, and if the signal is positive, they gingerly dig it up. Any unearthed munitions are carefully inspected to determine if they need to be destroyed.

(above) To date, the teams have destroyed more than 860 live unexploded ordnance at Camp Howze, including this 60-millimeter high explosive mortar.

(left) Any unearthed live munitions are sufficiently destroyed in situ.

shovels and handheld magnetometers investigate each flagged point. They use the metal detector to verify the presence of metal, and, if the indications are affirmative, they gingerly dig up the object. Should they unearth any munitions, they carefully inspect the UXO to determine if it needs to be destroyed. To neutralize the ordnance they set explosives and destroy it on the spot. All discovered ordnance is properly and precisely recorded — type, position, and confirmed destruction — and the collected field data uploaded into the GIS.

“Although the GIS was not originally a requirement, it has become the information backbone of the project,” says Willis. “It’s a planning tool for UXO searches and the main repository for what we find in the field. It maintains all of the data layers that we have accumulated and created over the past four years, including aerial photos, topographic maps, scans of annotated response maps, parcel boundaries, and pipeline data to provide us with a comprehensive graphical resource. And because it’s tied into the field database, data from daily operations can be displayed geographically in various ways.”



The Parsons' towed array system includes a foam marking system (red tank, green boom arms, and red paddles), used as a lane marker to keep the driver on course; four-wheel ATV with field laptop, RTK GPS receiver (white square on top), electronics packages, auxiliary batteries, and home-made surrey top, and the towed array cart itself.

To date, with the combination of the GSBAS, the GIS, and their conventional Mag/Dig tools, the survey and UXO-removal teams have cleared more than 1,800 acres of Camp Howze's most hazardous areas. Along the way, they have destroyed more than 860 live ordnance items, including mortars, artillery shells, anti-tank rockets, hand grenades, and land mines.

Stars in Their Eyes

Although Camp Howze stretches across nearly 59,000 acres, FCHRP mandate is not to sweep 100 percent of the land but rather to investigate and clear the most zones constituting the greatest hazard to the public. Willis says that adding the satellite-based system to the fieldwork is helping Parsons to fulfill that charter more efficiently than with their previous RTK-GPS solution, predominantly because they can achieve near RTK-GPS accuracy without a base station.

"We work four, 10-hour days per week," says Willis. "If you spend an hour setting up a base station and another half hour to tear it down, you've lost at least an hour and a half of operational time, provided you don't have any trouble with it during the day. In rural, rough terrain, radio line of sight is a problem, and it can be a long trip back to the base if we lose the radio signal." Also, powering the base for an entire day can be a challenge, he says. Parsons teams have used marine deep-cycle batteries to power the equipment and sometimes the power supply still wouldn't last an

entire day. Cellular RTK was considered for its convenience, but the existence of many cellular "dead zones" in the area precluded its use.

"Because our survey team directly supports our dig team, both teams will normally have to shut down operations if something happens to the base station," Willis adds. "It is costly to keep a dig team in the field. If they're forced to stop work because the survey equipment is down, it's very expensive."

FCHRP requirements dictate that the teams position any ordnance they discover to within one foot. Willis says the satellite-based unit performs well enough for them to meet this standard. "The decimeter accuracy provided by the system is actually more than we require for this project," he says.

Because heavy thunderstorms and tornadoes are the only weather-related phenomena that will force the crews inside, the Mag/Dig teams need rugged equipment that's also portable.

"The [GSBAS] system fits into a single carry case; so, much of the weight and bulk is reduced to a manageable size," says Willis. "That simplicity and compactness makes it very reliable because it's easy to transport into the field, set up and to use."

Willis feels confident that the cost-effectiveness of the system will help Parsons to win similar projects in the future. "When bidding on these projects, it helps to be able to shave



The compactness and rugged reliability of the GSBAS field equipment – pictured here in its carrying case – makes it a user-friendly system.

mentation System (GSBAS) and SF-2040G integrated StarFire receiver from **NavCom Technology**, Torrance, California, USA. The teams use Allegro field PCs from **Juniper Systems, Inc.**, Logan, Utah. The handheld GA-52cx magnetometers

thousands of dollars off the cost by simply changing a piece of equipment,” he says.

In the meantime, people in this rural part of Texas can still count on witnessing a handful of men, staring at a fixed point in the distance, waiting for the inevitable explosion of dirt and metal.

Manufacturers

The real-time differential system used by the Parsons team is the StarFire Global Satellite-Based Aug-


mentation System (GSBAS) and SF-2040G integrated StarFire receiver from **NavCom Technology**, Torrance, California, USA. The teams use Allegro field PCs from **Juniper Systems, Inc.**, Logan, Utah. The handheld GA-52cx magnetometers

came from **Schonstedt Instrument Company**, Kearneysville, West Virginia, USA. They used SurvCE field data collection software from **Carlson Software, Inc.**, Maysville, Kentucky, USA, and ArcGIS from **ESRI**, Redlands, California, USA. Field data are entered using PDAs from **Palm, Inc.**, Sunnyvale, California, with Pen Dragon software from **Pendragon Software Corporation**, Libertyville, Illinois, and then fed into a **Microsoft** Access database that is directly linked to the GIS.

Trimble 5700 and 4700 GPS receivers from **Trimble Navigation, Ltd.**, Sunnyvale, California, USA, were used for the RTK-GPS surveys and, for the geophysical surveys, EM61 MkII electromagnetic instruments from **Geonics, Ltd.**, Mississauga, Ontario, Canada.

GIS image sources: The 1943 aerial photos came from the U.S. Army. Parsons georeferenced them. The 1995 photos came from the U.S. government’s Geospatial One Stop. The project also uses 2004 infrared photos from the U.S. Department of Agriculture’s Farm Service Administration.

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