= Airborne real @-@ time cueing hyperspectral enhanced reconnaissance =

Airborne real @-@ time cueing hyperspectral enhanced reconnaissance , also known by the acronym ARCHER , is an aerial imaging system that produces ground images far more detailed than plain sight or ordinary aerial photography can . It is the most sophisticated unclassified hyperspectral imaging system available , according to U.S. Government officials . ARCHER can automatically scan detailed imaging for a given signature of the object being sought (such as a missing aircraft) , for abnormalities in the surrounding area , or for changes from previous recorded spectral signatures .

It has direct applications for search and rescue , counterdrug , disaster relief and impact assessment , and homeland security , and has been deployed by the Civil Air Patrol (CAP) in the US on the Australian @-@ built Gippsland GA8 Airvan fixed @-@ wing aircraft . CAP , the civilian auxiliary of the United States Air Force , is a volunteer education and public @-@ service non @-@ profit organization that conducts aircraft search and rescue in the US .

= = Overview = =

ARCHER is a daytime non @-@ invasive technology , which works by analyzing an object ? s reflected light . It cannot detect objects at night , underwater , under dense cover , underground , under snow or inside buildings . The system uses a special camera facing down through a quartz glass portal in the belly of the aircraft , which is typically flown at a standard mission altitude of 2500 feet (800 meters) and 100 knots (50 meters / second) ground speed .

The system software was developed by Space Computer Corporation of Los Angeles and the system hardware is supplied by NovaSol Corp. of Honolulu , Hawaii specifically for CAP . The ARCHER system is based on hyperspectral technology research and testing previously undertaken by the United States Naval Research Laboratory (NRL) and Air Force Research Laboratory (AFRL) . CAP developed ARCHER in cooperation with the NRL , AFRL and the United States Coast Guard Research & Development Center in the largest interagency project CAP has undertaken in its 74 @-@ year history .

Since 2003 , almost US $ 5 million authorized under the 2002 Defense Appropriations Act has been spent on development and deployment . As of January 2007 , CAP reported completing the initial deployment of 16 aircraft throughout the U.S. and training over 100 operators , but had only used the system on a few search and rescue missions , and had not credited it with being the first to find any wreckage . In searches in Georgia and Maryland during 2007 , ARCHER located the aircraft wreckage , but both accidents had no survivors , according to Col. Drew Alexa , director of advanced technology , and the ARCHER program manager at CAP . An ARCHER equipped aircraft from the Utah Wing of the Civil Air Patrol was used in the search for adventurer Steve Fossett in September 2007 . ARCHER did not locate Mr. Fossett , but was instrumental in uncovering eight previously uncharted crash sites in the high desert area of Nevada , some decades old .

Col. Alexa described the system to the press in 2007 : " The human eye sees basically three bands of light . The ARCHER sensor sees 50 . It can see things that are anomalous in the vegetation such as metal or something from an airplane wreckage . " Major Cynthia Ryan of the Nevada Civil Air Patrol , while also describing the system to the press in 2007 , stated , " ARCHER is essentially something used by the geosciences . It 's pretty sophisticated stuff ? beyond what the human eye can generally see , " She elaborated further , " It might see boulders , it might see trees , it might see mountains , sagebrush , whatever , but it goes ' not that ' or ' yes , that ' . The amazing part of this is that it can see as little as 10 per cent of the target , and extrapolate from there . "

In addition to the primary search and rescue mission , CAP has tested additional uses for ARCHER . For example , an ARCHER equipped CAP GA8 was used in a pilot project in Missouri in August 2005 to assess the suitability of the system for tracking hazardous material releases into the environment , and one was deployed to track oil spills in the aftermath of Hurricane Rita in Texas during September 2005 .

Since then , in the case of a flight originating in Missouri , the ARCHER system proved its

usefulness in October 2006 , when it found the wreckage in Antlers , Okla . The National Transportation and Safety Board was extremely pleased with the data ARCHER provided , which was later used to locate aircraft debris spread over miles of rough , wooded terrain . In July 2007 , the ARCHER system identified a flood @-@ borne oil spill originating in a Kansas oil refinery , that extended downstream and had invaded previously unsuspected reservoir areas . The client agencies (EPA , Coast Guard , and other federal and state agencies) found the data essential to quick remediation . In September 2008 , a Civil Air Patrol GA @-@ 8 from Texas Wing searched for a missing aircraft from Arkansas . It was found in Oklahoma , identified simultaneously by ground searchers and the overflying ARCHER system . Rather than a direct find , this was a validation of the system ? s accuracy and efficacy . In the subsequent recovery , it was found that the ARCHER plotted the debris area with great accuracy .

= = Technical description = =

The major ARCHER subsystem components include :
advanced hyperspectral imaging (HSI) system with a resolution of one square meter per pixel .
panchromatic high @-@ resolution imaging (HRI) camera with a resolution of 8 cm x 8 cm (3 in x 3 in) per pixel .
global positioning system (GPS) integrated with an inertial navigation system (INS)

= = = Hyperspectral imager = = =

The passive hyperspectral imaging spectroscopy remote sensor observes a target in multi @-@ spectral bands . The HSI camera separates the image spectra into 52 " bins " from 500 nanometers (nm) wavelength at the blue end of the visible spectrum to 1100 nm in the infrared , giving the camera a spectral resolution of 11 @.@ 5 nm . Although ARCHER records data in all 52 bands , the computational algorithms only use the first 40 bands , from 500 nm to 960 nm because the bands above 960 nm are too noisy to be useful . For comparison , the normal human eye will respond to wavelengths from approximately 400 to 700 nm , and is trichromatic , meaning the eye 's cone cells only sense light in three spectral bands .
As the ARCHER aircraft flies over a search area , reflected sunlight is collected by the HSI camera lens . The collected light passes through a set of lenses that focus the light to form an image of the ground . The imaging system uses a pushbroom approach to image acquisition . With the pushbroom approach , the focusing slit reduces the image height to the equivalent of one vertical pixel , creating a horizontal line image .
The horizontal line image is then projected onto a diffraction grating , which is a very finely etched reflecting surface that disperses light into its spectra . The diffraction grating is specially constructed and positioned to create a two @-@ dimensional (2D) spectrum image from the horizontal line image . The spectra are projected vertically , i.e. , perpendicular to the line image , by the design and arrangement of the diffraction grating .
The 2D spectrum image projects onto a charge @-@ coupled device (CCD) two @-@ dimensional image sensor , which is aligned so that the horizontal pixels are parallel to the image 's horizontal . As a result , the vertical pixels are coincident to the spectra produced from the diffraction grating . Each column of pixels receives the spectrum of one horizontal pixel from the original image . The arrangement of vertical pixel sensors in the CCD divides the spectrum into distinct and non @-@ overlapping intervals . The CCD output consists of electrical signals for 52 spectral bands for each of 504 horizontal image pixels .
The on @-@ board computer records the CCD output signal at a frame rate of sixty times each second . At an aircraft altitude of 2 @,@ 500 ft AGL and a speed of 100 knots , a 60 Hz frame rate equates to a ground image resolution of approximately one square meter per pixel . Thus , every frame captured from the CCD contains the spectral data for a ground swath that is approximately one meter long and 500 meters wide .

= = = High @-@ resolution imager = = =

A high @-@ resolution imaging (HRI) black @-@ and @-@ white , or panchromatic , camera is mounted adjacent to the HSI camera to enable both cameras to capture the same reflected light . The HRI camera uses a pushbroom approach just like the HSI camera with a similar lens and slit arrangement to limit the incoming light to a thin , wide beam . However , the HRI camera does not have a diffraction grating to disperse the incoming reflected light . Instead , the light is directed to a wider CCD to capture more image data . Because it captures a single line of the ground image per frame , it is called a line scan camera . The HRI CCD is 6 @,@ 144 pixels wide and one pixel high . It operates at a frame rate of 720 Hz . At ARCHER search speed and altitude (100 knots over the ground at 2 @,@ 500 ft AGL) each pixel in the black @-@ and @-@ white image represents a 3 inch by 3 inch area of the ground . This high resolution adds the capability to identify some objects .

= = = Processing = = =

A monitor in the cockpit displays detailed images in real time , and the system also logs the image and Global Positioning System data at a rate of 30 gigabytes (GB) per hour for later analysis . The on @-@ board data processing system performs numerous real @-@ time processing functions including data acquisition and recording , raw data correction , target detection , cueing and chipping , precision image geo @-@ registration , and display and dissemination of image products and target cue information .

ARCHER has three methods for locating targets :

signature matching where reflected light is matched to spectral signatures

anomaly detection using a statistical model of the pixels in the image to determine the probability that a pixel does not match the profile , and

change detection which executes a pixel @-@ by @-@ pixel comparison of the current image against ground conditions that were obtained in a previous mission over the same area .

In change detection , scene changes are identified , and new , moved or departed targets are highlighted for evaluation . In spectral signature matching , the system can be programmed with the parameters of a missing aircraft , such as paint colors , to alert the operators of possible wreckage . It can also be used to look for specific materials , such as petroleum products or other chemicals released into the environment , or even ordinary items like commonly available blue polyethylene tarpaulins . In an impact assessment role , information on the location of blue tarps used to temporarily repair buildings damaged in a storm can help direct disaster relief efforts ; in a counterdrug role , a blue tarp located in a remote area could be associated with illegal activity .