



One of the temples at Palmyra before IS destroyed it (© Dario Bajurin)

# THE UNBELIEVABLE TRUTH

CLAIMS THAT THE ISLAMIC STATE HAD DELIBERATELY DESTROYED IMPORTANT ARCHAEOLOGICAL SITES IN NORTHERN IRAQ PROMPTED GERMAN ARCHAEOLOGISTS TO LOOK TO THE SKIES FOR VERIFICATION. KEVIN CORBLEY REPORTS ON HOW THEY WERE ABLE TO DISCOVER WHAT HAD HAPPENED USING SATELLITE IMAGERY

When the international media reported in March that the Islamic State (IS) had destroyed two cultural heritage sites in Northern Iraq, the public outcry from around the globe was loud and immediate. However, the German Archaeological Institute (DAI) cautioned against overreaction until the scope of the damage could be assessed with very high resolution (VHR) satellite imagery, as it DAI remained hopeful the unconfirmed reports of destruction had been exaggerated or even fabricated.

“We archaeologists were not able to figure out what actually happened [when the initial reports were published],” says Margarete van Ess, deputy director of the DAI Orient Department. “There were rumours the sites were not destroyed.”

Based in Berlin, DAI performs fundamental archaeological research with the goal of deepening understanding of historical culture. Its Orient Department, once based in Baghdad but compelled to cease active fieldwork in Iraq in 2003, was involved in archaeological research at the two sites reportedly targeted by IS: Nimrud and Hatra. At the time of the withdrawal more than a decade ago, scientists in the department began experimenting with satellite remote sensing to safely monitor heritage sites where instability made visits nearly impossible.

DAI decided to apply its remote sensing knowledge to assess conditions in Nimrud and Hatra. Within days of the first media reports, the archaeologists had enlisted support from European Space Imaging (EUSI) and the German Aerospace Center (DLR) to assist with the endeavour. Both archived and new images acquired by state-of-the-art satellites were obtained by EUSI and provided to DLR for processing and analysis.

Unfortunately, the VHR imagery ultimately confirmed extensive damage at one of the two sites. The centrepiece palace at Nimrud had been almost completely destroyed. But what was more chilling to the archaeologists was the disturbing timeline of events revealed by the satellites – most of the destruction had been inflicted after the media reports and ensuing public reaction.

## Monitoring cultural heritage

Just outside modern-day Mosul, Nimrud was the second great capital of the Assyrian Empire as it expanded across the region. A major tourist attraction until a decade ago, Nimrud was home to the sprawling palace of Neo Assyrian King Ashurnasirpal II built in the ninth century BC. Remarkable stone reliefs had been excavated at the palace as early as the 19th

century, with some finding their way to the British Museum. Many others remained on site in the palace and buildings on the grounds.

Less than 100km away, the World Heritage Site of Hatra was an incredibly well-preserved city constructed between the first and third centuries AD by the Parthian people and eventually becoming one of the largest in Mesopotamia. Feared even by the Romans, the Parthians built elaborate temples adorned with intricate friezes and stone carvings on their interior walls. Despite the age of the site, several temples stood largely intact at Hatra.

Vandalism at unguarded sites by looters looking for items to sell on the black market is a constant fear in the archaeological community. Shortly after DAI withdrew its personnel from Iraq due to instability in 2003, this concern only heightened and the need for continuous unbiased monitoring of dangerous places became a sought-after priority.

The proof-of-concept project, which focused on another important site in Iraq called Uruk, was discontinued due to lack of political support, but not before the DAI participants made valuable progress in learning how to analyse and interpret the condition of archaeological sites with satellite imagery.

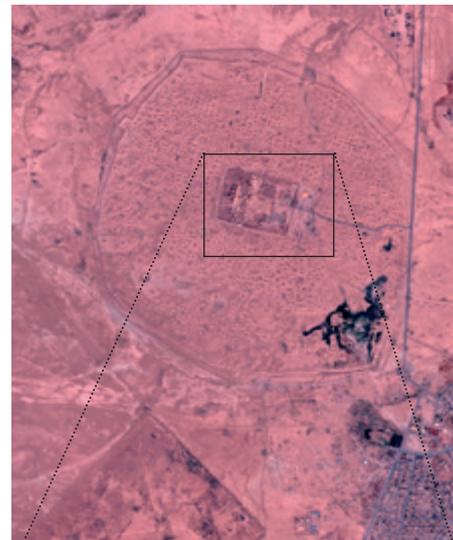
In that case, the imagery was captured by the IKONOS satellite, which provides 1m-spatial resolution. Van Ess explains that sites like Uruk, Nimrud and Hatra usually are in ruins when they are found, which makes assessing damage difficult. Ultimately, however, the DAI



Remains of several temples and ancient walls (2004) (© 101st Sustainment Brigade, 101st Airborne Division (AA) Public Affairs)



Hatra ruins in 2008 (© Lance Cpl. Albert F. Hunt, U.S. Marine Corps)



Hatra on June 13



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Nimrud on July 11 2011 (GeoEye-1), April 1 2015 (WorldView-2) and April 20 2015 (WorldView-2)

archaeologists used change detection techniques and the Definiens eCognition program to differentiate accidental changes of the ruins from deliberate holes dug by looters. This experience would give van Ess and her team confidence that they could accurately gauge what was happening at Nimrud and Hatra.

### Assessing the attacks

On March 5, unconfirmed reports began circulating in the media that Nimrud and Hatra had been ravaged by the IS. People living nearby Nimrud were said to hear heavy machinery and explosions. Prompted in part by public uproar, politicians pushed the United Nations to issue a formal condemnation, but DAI convinced German leaders to temper emotions until the truth could be learned.

"Responding based on rumours could be counter-productive," said van Ess. "Everyone was really fearing that major things had happened, but nobody knew exactly what."

The institute reached out to European Space Imaging (EUSI) to supply archived historical images of the two sites as well as new images acquired after the early-March media reports. A partner in the WorldView Global Alliance, EUSI has direct access to VHR imagery acquired by all satellites operated by DigitalGlobe. These satellites include GeoEye-1, WorldView-2 and WorldView-3.

In addition, EUSI maintains a vast archive of imagery collected previously by these and other satellites, including IKONOS and QuickBird. Archived images from prior to the March 2015 media reports would be used as the 'before' data set while new acquisitions would serve as the 'after' images in the change detection process.

To establish baseline conditions at the two sites leading up to the rumoured destruction, EUSI obtained archived cloud-free, 40cm-resolution image data acquired by the GeoEye-1 satellite over Nimrud in July 2011 and Hatra in June 2013. New VHR imagery was then captured with the WorldView-2 and WorldView-3 over the same areas in late March and early April 2015 after reports of the attacks.

The 2015 image data was downloaded directly from the satellites at the German receiving station operated by the DLR in cooperation with EUSI. The DLR Department of Georisks and Civil Security performed the image processing and analysis at its facility just outside Munich. This department has extensive and long standing experience in creating rapid assessment maps in the wake of disasters for delivery to first responders and public safety officials worldwide.

"For each of the data sets, we pan-sharpened the data and then co-registered the images [from different] dates in preparation for change detection," says department head Professor Guenter Strunz.

Pan-sharpening takes higher resolution, panchromatic (greyscale) image data and fuses it with slightly lower resolution imagery from the four spectral bands to create a single image that combines the spatial detail of the pan data with the spectral information of the other data.

State-of-the-art change detection methodologies, such as image differencing and image ratioing, were then applied. As the aim was

the monitoring of human-made objects, vegetation indices such as the Normalized Difference Vegetation Index (NDVI) based on the near infrared (NIR) and the red channel were used to exclude in a first step vegetated areas within the area of interest.

DLR performed the data pre-processing in the Erdas IMAGINE software. Further analysis was done in the ArcGIS software. All data was stored in GeoTiff.

"Our analysts visually examined the change detection image sets to see if and where damage had occurred," says Professor Strunz.

Almost no damage was found at Hatra, but the images revealed several areas of change in Nimrud. According to van Ess, the imagery showed piles of rubble and scraping patterns – possibly made by bulldozers – in the earth near the front entrance of the main palace until the April 1 image. The palace itself, however, remained largely intact as it was seen in the 2013 imagery. While damage indeed existed, DAI did not consider it devastating.

But dramatic new information was about to change the ending of the story.

### Video is released

As the interpretation was ongoing, IS released video footage on April 3 for Hatra and April 11 for Nimrud that purported to depict the actual attacks on both sites. The BBC described the videos as showing the militants using bulldozers at Nimrud followed by explosives to level some of the buildings on the site. Vandalism at Hatra, as depicted in the video, focused on the use of sledgehammers and automatic rifles to deface the stone artefacts on the walls inside the temples.

At DAI's request, EUSI tasked the DigitalGlobe satellites to capture even newer images following release of the videos. WorldView-2 images were collected over Nimrud on April 20 and Hatra on April 6. These datasets were made immediately available to the DLR for processing and analysis. This time the results were frightening.

"We had to be careful [in our interpretation] because of haze in the imagery," says Strunz. "But you can clearly see the damages in the middle and the northern part of the main palace, where most of the ancient buildings and walls were completely destroyed in the Nimrud image from April 20."

For further investigations DLR delivered the processed satellite imagery as well as a report describing the results of the image analysis to DAI.

Van Ess confirmed the demolished buildings were the main palace where many of the priceless stone reliefs were located. The degree of devastation and patterns of debris around these structures indicated they had been demolished with explosives. This interpretation correlated with depictions in the video.

"Without the satellite imagery, we would not have been informed [that] the major destruction took place after April 1," says van Ess.

The mid-April image acquisitions over Hatra, on the other hand, continued to reveal no external damage to temples in the ancient



'City under siege'. Assyrian wall relief, from about 728 BC, from Nimrud, Central Palace. Now in British Museum. © Ealdgyth



A winged lion from the north-west palace of Ashurnasirpal II (Nimrud 883-859 BC) at the British Museum in London. © Aiwok



The ruins of Palmyra in 2008. © James Gordon from Los Angeles, California, USA

city. DLR concluded this was because the IS vandalism had been focused solely on the stone relief carvings on internal vertical walls – which would be impossible to see in nadir-looking images. The videos displayed no attacks on the Hatra temple structures and imagery confirmed this.

### What this means

DAI has evaluated the remote sensing project on several levels. From a scientific perspective, the loss of irreplaceable artefacts and structures at Hatra and Nimrud are unmitigated catastrophes in the world of archaeology and beyond. If there is any good news, however, the use of remote sensing technology proved to be an accurate and unbiased tool for monitoring vulnerable world heritage sites.

“Imagery enabled us to determine where and when the destruction occurred,” says van Ess, adding that DAI hopes these events will persuade the German government to fund an ongoing monitoring programme for cultural heritage sites using satellite imagery.

Van Ess and DAI believe there are other conclusions to be made about IS based on the sequence of events documented by satellite in Northern Iraq. The critical point to be stressed is that the IS attacks actually took place after the original media reports in early March.

“The destruction took place in early April in the case of Nimrud,” says van Ess. “This could mean IS is observing the reaction of the world and will follow what people are fearing.”

She concludes that it is possible to assume that once IS saw the significant reaction to rumours of attacks on Nimrud and Hatra, the militants realised that actual attacks would be quite devastating to the psyche of the world. This may have prompted them to move forward with the attacks on the two sites as well as others since then.

Just a few months later, IS announced it had blown up the Baalshamin and the Bel



The northern Palmyrene mountain belt and temple in 2006 © James Gordon from Los Angeles, California, US

Temple in Palmyra, virtually wiping it from the face of the Earth. Again, EUSI obtained WorldView-2 images of the UNESCO heritage site in Syria on August 27 and September 2 and sent them to DLR for analysis, confirming the annihilation had occurred between those two dates, as IS had announced.

“Deliberate destruction of cultural heritage is one of the weapons IS uses to radically change the way of life in the regions conquered,” says van Ess. “Destruction of religious buildings... is meant to destroy the beliefs of societies in the region.”

## DELIBERATE DESTRUCTION OF CULTURAL HERITAGE IS ONE OF THE WEAPONS IS USES TO RADICALLY CHANGE THE WAY OF LIFE IN THE REGIONS CONQUERED

**Kevin Corbley is a business consultant with expertise in the geospatial industry (kevin@corbleycommunications.com)**



The temples at Palmyra before IS destroyed them



The temples at Palmyra afterwards



The Temple of Bel in Palmyra before IS destroyed it



The temple of Bel afterwards



The tombs at Palmyra before IS destroyed them



The tombs at Palmyra afterwards