What I Learned from Geolocating 1,000 Satellite Images

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In the autumn of 2024, I set down to create a unique dataset on war and armed conflict. I pored over hundreds of satellite images of everything from refugee camps, artillery gun lines, trench systems, through to blown up bridges and the aftermath of missile strikes. Each image was dutifully geolocated on Google Maps, tagged with keywords, and a reference added for attribution. It was a mammoth undertaking. In what turned into a multi-month project, I had inadvertently conducted a meta-study of how satellite imagery is used in Western press and civil society. I learned not just about its role in framing and driving narratives, but also how even disparate data points, when corralled and brought to order, present a wealth of information for those seeking it.

But first, a short prelude to explain why I did this.

I am a forensic imagery analyst. I interpret footage captured by satellites, drones and mobile devices to make sense of complex environments. I seek to answer questions such as: what happened here? When did it happen? And what are the military, humanitarian, or international law implications? I create analytical products that enable others to make decisions. Of the resources commonly used in my field, satellite imagery is a mainstay in the Open-Source Intelligence (OSINT) operator's toolkit. Whether you are mapping incidents, monitoring changes, or exploring the topography of an area of interest, satellite and aerial imagery are integral to the research process of amateur sleuths and professionals alike. However, there are two interlinked problems when it comes to accessing data: availability and cost. High-resolution, commercial imagery offers excellent coverage but comes with a hefty price tag for those without a funding stream to draw upon. And, while there are satellite resources freely available online, they have notable limitations in spatial and temporal resolution. Google Earth Pro, a widely used tool, offers excellent 30 cm and 50 cm imagery, but may not update an area for months or even years. Meanwhile, Sentinel and Landsat satellites provide outstanding re-visit coverage every five to eight days, but at 10 m and 30 m spatial resolution. These circumstances have prompted OSINT researchers like myself to turn to innovative solutions to find new or novel data sources. This is how *The Vault* – as I call it – came into being.

The fact is, high-resolution imagery is being posted online regularly, but there is a nuance; these images are snapshots of current events, often never intended as research material in their own right. News outlets, for example, publish satellite imagery in their reporting, either as the main 'scoop' of the story or as an illustrative visual. An oil refinery may have been attacked, a build-up of military forces observed, or a secretive nuclear facility spotted for the first time; all these developments are likely to be depicted in an image of the general area and an accompanying close-up of the point of interest. These pictorial representations provide an accessible medium with obvious appeal to readerships: we can see and judge for ourselves the story being described.

Beyond the mainstream media, satellite images have also become a regular feature in government press releases, NGO investigative reports, think tank case studies, and OSINT activism. The prevalence of these snippets of imagery is such that their inclusion in storytelling, truth-seeking, and the daily churn of news reporting is now the norm. We are not talking hundreds of images published a week – it is more like a dozen at best – but the numbers quickly build up. In this, I spotted an opportunity.

Individual images have limited use, but by pooling them their explanatory potential gains much greater weight and utility. I envisioned a comprehensive repository of publicly released images, pinned to points on a map and placed

into chronological order. It would serve as a ready-made research tool that showed the broader context of actions in time and space. For the analytical community, it also supported the identification of objects, such as equipment, fortifications and damage types, by providing a body of exemplars to compare against. This was my objective: an archive, a training tool, and an activity tracker, all rolled into one.

With this outcome in mind, I set myself a target of finding and geolocating 1,000 images from 2020 to 2024 to get *The Vault* off the ground. Here are three things I learned in the process.

Satellite imagery is used as a visual commodity

It will seem an obvious point, but the underlying purpose of publishing satellite imagery is to convey information. What differs, however, is the motivation and intent that sit behind this information-sharing act. Let us explore this further. Media organisations typically treat satellite imagery like a commodity. It is used to catch the eye with evocative, emotive and tantalising detail, showing something new, unexpected, secret, contrarian, or even appalling. Many of the images I found online were present only to portray the reality of recent events, such as widescale destruction, human suffering, marauding armies, and scenes of atrocities. In Russia's war against Ukraine, there is no shortage of examples: the blowing up of the Nova Kakhovka Dam, the Bucha Massacre, and Russia's missile strike against Mariupol Drama Theatre; all were broadcast across the media space in the form of satellite images and have become part and parcel of our collective memory.

These depictions of war and armed conflict exist to meet the demand of public consumption and to drive readership figures. This may sound macabre, with undertones of entertainment through vicarious experience, but there is nonetheless a place for this type of reportage in modern society. The inclusion of an image, even ostensibly as eye-candy, has the effect of enriching media reporting. Satellite imagery pulls back the curtain and reveals the ugly mess of war, transporting the reader beyond solely textual descriptions and inviting them to see the truth for themselves. This latter point is important as satellite imagery as a medium is inherently imbued with credibility and source integrity, which brings us neatly to the investigative realm.

Satellite imagery helps us to determine ground truth

Whereas the bulk of imagery I collated came from mainstream media, a smaller, but nonetheless influential, subset was found in OSINT investigations. This is a rapidly growing field of inquiry used to monitor developments in, among other areas, human rights, nuclear proliferation and environmental affairs.

In the last decade, journalists, think tanks and NGOs have increasingly incorporated OSINT methodology into their reporting, within which sits satellite imagery analysis. What was previously a niche domain has since become common practice in a burgeoning community of data scientists and visual researchers. The impetus behind the phenomenal rise of OSINT lies in a fundamental change in modern society's information landscape. The ubiquity of social media and proliferation of personal electronic devices, whether phones, dashcams or security cameras, has resulted in a tsunami of multimedia content. This data boom has given us unparalleled insight into war from the ground up, allowing us to geospatially document incidents to the level of individual streets and buildings. It has helped us to create detailed chronologies, identify persons of interest, verify claims, and track novel metrics of war, such as visually-confirmed military losses.

The line separating popular media reporting and OSINT investigation lies foremost in the rigour of the publication's methodology. Satellite imagery is not used simply to feed an audience hungry for content, but instead to problem solve, establish facts, and create knowledge. Multiple sources of information are fused and interrogated in the pursuit of a research goal. For many, it is an exercise of truth-seeking. The results have the potential to shape public and government awareness of a situation and how it unfolded. It shifts the conversation towards a need for clarity and an evidence-based appraisal of critical moments in world events. Moreover, it empowers those who are seeking accountability and meaning.

Satellite imagery is often used in OSINT investigations as one of many information feeds within a holistic approach to

determining ground truth. It can help to corroborate sources, identify equipment, detect changes in the physical environment, and attribute actions to conflict parties. When it comes to publication, it is often through annotated satellite imagery that the findings are presented. These are the images that I sought out for inclusion in *The Vault*: not just a picture, but an intelligence product that contributes in a meaningful way to public discourse. However, annotated satellite imagery of this type, with overlaid diagrams, labels and scales, was the exception.

As I built up my back catalogue of images for processing, I quickly came to the realisation that much of my data was missing important details on their provenance. This presented geolocation challenges and regularly tested *The Vault's* threshold for inclusion, which leads to my final observation.

Not all satellite imagery shared online is equal

Given satellite imagery's primary role as a visual commodity, its use in popular media is often bereft of details helpful to the would-be researcher. Even basic elements, such as the date of the image or location of the subject matter (beyond a general description) are commonly omitted. To reiterate an earlier point, this characteristic is to be expected as such imagery is ordinarily illustrative in purpose and not intended for deeper examination. It did reveal, however, that not all users of satellite imagery share the same information standards. This disparity encouraged me to review images and the publishing source with a more critical eye.

I learned that certain publications were more reliable than others, normally providing, at the very least, a date, approximate location and rudimentary description. Associated Press, Business Insider, CNN, Reuters and The War Zone all fall into this category. Other outlets inserted little more than the mandatory copyright acknowledgement of the satellite provider. Then there were the worst offenders: news aggregators, content farms and social media bots. I came to notice how articles from major news agencies were reposted, repackaged or outright plagiarised, with the satellite imagery co-opted for maximum effect. This 'cloned reporting' led to imagery being cropped, crudely edited, or mislabelled with incorrect locations and dates, all of which detracted from the integrity and clarity of the information being presented. Increasingly, I turned to a trusted set of websites that were often the first to receive and publish new releases, usually from Maxar Technologies and Planet Labs. It meant that I held off including images in *The Vault* until I found a reliable source over a second-order, syndicated version. Quality, as they say, is better than quantity.

From a technical perspective, I faced difficulties in geolocating images when context was either absent or limited. North arrows were a rare occurrence, and grid references even rarer, necessitating a reliance on analytical tradecraft to pin down a camera view. Some images showed obvious locations – airports, nuclear facilities and bridges – whereas others displayed only a sliver of a city or a patch of agricultural plain. Confronted with a close-up shot of a sprawling suburb, I looked for irregular and noticeable shapes, patterns in building layout, distinct roofing colours, or the positioning of road systems. In countryside settings, individual fields or tracts of land could be identified by the presence of wood blocks, hedgerows, intersecting tracks, and the occasional lone building standing in the open. It was like a game, eventually leading to a rush of dopamine when the location of a particularly tricky scene finally revealed itself.

Some images took minutes to find, others are still lurking in a spreadsheet on my hard drive, awaiting a jolt of inspiration or the off chance of newly published information adding another piece to the puzzle. It became easier as *The Vault* snowballed in size. I could see how some locations were periodically revisited. Recurring coverage was most obvious for sites with special military, economic or political significance – such as airports, power stations and naval facilities – but others reflected the longevity of wars affecting the same towns and cities over many years. As more satellite images were added, and I returned to familiar areas, I recognised landmarks, buildings and public spaces. I no longer had to spend half an hour or more comparing images to find a street or apartment block.*The Vault* was doing exactly what I had intended it do: it was a visual compendium of modern-day war.

When I finally reached the 1,000-image target, it was an anti-climax. As a solitary researcher, plugging away at this project every day over the months, there was no customer to please or formal deadline in mind. I created *The Vault* for many reasons: an intellectual challenge, a proof of concept, and a small contribution to this peculiar and ill-defined mass that we call the OSINT community. Reaching the 1,000 mark did not feel like a celebratory finish line. Instead,

looking at the mass of dots that now populates *The Vault's* map, I was quietly content. It confirmed the value of what I had created, but it also showed that my work had only just begun. With each day, another set of images may be released, bringing with it an opportunity to flex my geolocation muscles once again. *The Vault* will continue to build in size, one image at a time.

About the author:

William Goodhind is an investigator and researcher with Contested Ground, an open-access research project that conducts satellite imagery analysis on war and armed conflict. His analysis and expert commentary has been featured in current affairs and investigative reporting by Euronews, EU Observer, Los Angeles Times and The Washington Post. In 2024, he contributed to a series of Pulitzer Prize finalist articles by the Washington Post's visual forensics team on the situation in Gaza. William previously worked with the OSCE Special Monitoring Mission to Ukraine as a Monitoring Officer, patrol leader and imagery analyst between 2015-17 and 2020-22.