Very Small Satellites:
A Mechanism for the Early Detection of Mass Atrocities

by Dani Redmon

Swarms of blue-winged butterflies greedily cling to the tall, white, weedy beauty of the *Artemisia vulgaris* plant. However, beneath this carpet of alluring flora in the foothills surrounding the town of Srebrenica, Bosnia, hides an ugly secret: The earth below the meadow contains the final resting place for over 600 souls. This is not the only gravesite that dots the current landscape. Overall, 93 mass graves have been found—all forgotten victims of genocide.[1]

Introduction

Aerial and satellite imagery help detect gravesites in Bosnia by scanning vast swaths of *Artemisia vulgaris* vegetation and identifying ground temperature differentials.[2] The soil of a mass grave shows up warmer on spectral imagery due to the large presence of nitrogen, a natural chemical reaction generated by decomposing bodies. Sites are discovered using thermal imaging, geophysical prospection, remote sensing, and change-detection analysis to distinguish ground disturbances. Not only do satellite images provide hard evidence of past atrocities, but current satellite technology can also assist nongovernment organizations (NGOs), the Department of Defense (DoD), and other humanitarian groups by observing early warning indicators and behaviors associated with mass atrocities and genocide, well before these acts occur.

It is entirely feasible that within the next 15–20 years, very small satellites, called cube satellites (CubeSats) and nanosatellites, will revolutionize the way organizations can predict and identify the indications and warnings of genocide. Small satellite technology will enable expeditious situational understanding and response at every level of government—from aid workers providing humanitarian assistance on the ground, to policymakers, and eventually, to decisionmakers. Thus, rather than provide gruesome images of a genocidal aftermath, future small satellite technology may mitigate and deter genocidal acts by providing early warning detection. Lives will depend upon it.

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Genocide

There are horrific events unfolding around the world that meet one of the many definitions of genocide. However, for the purposes of this article, genocide is defined as any of the following acts committed with intent to destroy in whole or in part a national, ethnical, racial, or religious group:

- Killing members of the group.
- Causing serious bodily or mental harm to members of the group.
- Deliberately inflicting on the group conditions of life calculated to bring about its physical destruction in whole or in part.
- Imposing measures intended to prevent births within the group.
- Forcibly transferring children of the group to another group.[3]

Furthermore, genocide scholar, Dr. Scott Straus cautions that "mass atrocities take place in the context of a dynamic environment, in which escalating violence can be difficult to anticipate;" nevertheless, he postulates that there are eight common warning signs of a potential genocide:

1. Tension and polarization.
2. Apocalyptic public rhetoric.
3. Labeling civilian groups as the "enemy."
4. Development/deployment of irregular armed forces.
5. Stockpiling weapons.
6. Emergency or discriminatory legislation.
7. Removing moderates from leadership or public service.
8. Impunity for past crimes.[4]

For a full listing and breakdown of Straus's warning signs prior to mass atrocities and the indicators associated with these acts, refer to Annex A, Figure 1. This article seeks to examine items 4, 5, and 8 of Straus's warning signs. Moreover, the scope of this work will illustrate the capability of small satellite technology to serve as an early warning detection mechanism to observe indicators of genocide, with the goal of mitigating casualties.

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Uses of Satellite Imagery: The Satellite Sentinel Project

On December 29, 2010, activist and co-founder of the Enough Project John Prendergast and Hollywood actor George Clooney launched the Satellite Sentinel Project (SSP) in an ongoing effort to end genocide and crimes against humanity in Sub-Saharan Africa, particularly in the country of South Sudan. Prendergast and Clooney are close friends who share a dedicated interest in international human rights activism. During one notable conversation, Clooney submitted to Prendergast that they could "spy on the activity of warlords [in South Sudan] by aiming satellites right into their territories."[5] He got this innovative idea from his own dealings with the paparazzi. Clooney's Oscar-winning celebrity status is well known internationally, and his facial features are highly recognizable, due in part to the television satellite feeds that broadcast globally. Wherever he goes, swarms of adoring fans follow. However, what if the opposite were true? What if the identity of person associated with heinous acts of crimes

against humanity, mass atrocities, or genocide was to reach the same level of notoriety as a Hollywood celebrity? Would the evidence of crime caught on satellite imagery be enough to galvanize the world into action to stop genocide? Would it force decisionmakers and policymakers to take heed and respond?

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It was under these auspices that Clooney and Prendergast paired up with commercial satellite company DigitalGlobe. Within the geospatial community, DigitalGlobe is one of several companies that produce high-resolution Earth imagery, along with accompanying data and analysis capabilities. The SSP was founded under the premise of observing the nefarious activities of warlords within South Sudan and to stop genocide before it happened. It is a nonprofit organization that operates with this mission:

> DigitalGlobe satellites passing over Sudan and South Sudan capture imagery of possible threats to civilians, detect bombed and razed villages, or note other evidence of pending mass violence. Experts at DigitalGlobe work with the Enough Project to analyze imagery and information from sources on the ground to produce reports. The Enough Project then releases to the press and policymakers and sounds the alarm by notifying major news organizations and a mobile network of activists on Twitter and Facebook.[6]

As a result of the DigitalGlobe imagery and the company's satellite orbital schedule, the SSP became the first public endeavor to regularly monitor hot zones for potential instances of violent activity with the aim of genocide prevention. In fact, so useful is the analyzed data that the SSP has become the *de facto* source for identifying adverse or threat activities for many NGOs and humanitarian organizations planning outreach missions and/or traveling through dangerous regions of Sub-Saharan Africa.

It is interesting to note that there are many within the Department of State (State), NGOs, and humanitarian circles that rely almost exclusively on the services provided by the SSP; however, these same organizations have no real knowledge of how and under what circumstances the SSP was founded, only that its products are relevant to their current needs. For example, Alison Giffen, the Peacekeeping Program Director at the Center for Civilians in Conflict (CIVIC), admitted to using satellite imagery provided by the SSP in preparation for a recent aid mission to Africa. She states that "intelligence plays an important role" in ensuring safe humanitarian operations for aid organizations, regardless of the mission. "I almost don't want to use the U.S. intelligence community's research because of the fear of being unable to protect the humanitarian workers that report information or provide intelligence."[7] Often, any association a humanitarian worker has with a DoD agency is potentially dangerous. In volatile areas, many people conjecture that foreign aid is just another way for the U.S. to freely spy on a populace. For example, the opposition party might kill locals caught communicating with humanitarians because they are labeled as collaborators or traitors. Giffen is not alone in her assessment. Many aid workers and non-profit organizations eschew association with the U.S. government because it disrupts humanitarian operations.

Intelligence and information sharing between U.S. government agencies (i.e., DoD and State) and aid organizations is difficult to navigate. Dissemination is virtually non-existent between

agencies and partners for reasons of maintaining vital national security protocols. Additionally, when intelligence is declassified for field use, it is often untimely, overcome by events, and has little remaining value. Coincidentally, the U.S. government is one of the largest consumers of commercial satellite imagery. The irony is that much of the satellite imagery used by the U.S. government is otherwise unclassified and available for public purchase via companies such as DigitalGlobe, GeoEye, and Worldview. Thus, in regard to satellite imagery, the SSP fills a void created by governmental bureaucracy and red tape. Theoretically, if both images are a product of the same commercial satellite process, then there is little reason for the image to be classified in the first place. Suffice it to say, there exists a need for an independent means of acquiring satellite imagery separate from the commercial market and predicated solely upon the inclinations of the satellite owner.

Commercial Satellites Versus Small Satellites

Implementation of small satellite technology will revolutionize the way governments, corporations, international organizations, humanitarian groups, and private users collect information. It will be "easier to respond quickly to sudden refugee movements, to document and publicize large-scale atrocities, to monitor environmental degradation, or to manage international disputes before they escalate to full-scale wars. The United Nations, for example, is studying whether satellite imagery could help to significantly curtail drug trafficking and narcotics production over the next 10 years."[8]

There is no doubt that the commercial satellite company DigitalGlobe provides some of the best images on the market, and it is **almost** affordable. The company boasts that it can take photos at 50-centimeter resolution or better—about the equivalent ground area of home plate on a baseball field—from 177 kilometers away in outer space, traveling in orbit at 24,000 kilometers per hour.[9] The current cost for a multispectral satellite image from DigitalGlobe is approximately $23 per square kilometer per new image, requiring a minimum purchase order of at least 25 square kilometers.[10] Should the SSP wish to monitor the 1,937 kilometers border shared between Sudan and Southern Sudan, it would cost the organization approximately $44,551 per day (at minimum) for one orbital pass over the location of interest. The total cost for one year equates to $16,261,115.

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Sixteen million plus dollars for commercial satellite imagery seems like a large price tag. However, when factoring in the maintenance requirements of sustaining a commercial satellite constellation, the ground infrastructure, and operating staff needed to provide essential satellite uplinks, downlinks, and data streams and then adding the analyst feedback for processing a raw image and the resolution quality of that image, the actual cost to the customer is relatively low. A company like DigitalGlobe has been in business for over a decade and claims a robust collection of "high-resolution global coverage, a 17-year time-lapse image library, and best-in-class technology and tools to provide accurate, mission-critical information about our changing planet."[11] Access to a decades-long imagery archive is a critical component for determining physical indicators and behaviors of genocide as it unfolds over time. Being able to visually track the development and deployment of irregular armed forces and the potential stockpiling of weapons over a fluid timeline versus disparate,

unconnected events, provides vital evidence for the identification of genocidal activity.[12]

Despite the benefits of using commercial satellite imagery, there are significant drawbacks hindering its applicability. One satellite could not physically or theoretically cover the entire border between Sudan and South Sudan in one pass. When a large commercial satellite is forced to transfer into a different orbital plane, it consumes a lot of fuel. Satellites are not like long-haul airplanes—there is no apparatus invented yet that provides mid-air refueling of a satellite in space. Once a satellite launches into orbit, it carries with it the amount of fuel necessary for its planned mission requirements, all the way through its demise—end of life (EOL). According to space safety regulations, when "spacecraft and orbital stages are orbiting in low earth orbit (LEO)…they will re-enter the Earth's atmosphere within 25 years of mission completion" or by its EOL, whichever comes first.[13] Commercial satellite companies service many customers. Imagery requests are scheduled according to the docket of priorities, availability of satellite resources, and customer importance. It is unlikely that a satellite company would move all its satellite potential for the sake of one customer when other customers are vying for the same resources.

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Though a 17-year archived library of satellite imagery is an advantage to the customer, it poses a notable risk as well. DigitalGlobe is an American company; however, it does not owe its loyalty or product allegiance to any one person, business, corporation, or country. Should a humanitarian organization such as the SSP purchase commercial satellite imagery of areas of interest along the South Sudan border, those images would be populated to the commercial satellite company's imagery database. Those images would be available for viewing and purchase by potential third party interlopers, which could endanger humanitarian operations and threaten the livelihood of an unsuspecting populace.

Small satellites and nanosatellites are not hindered by the same EOL restrictions and fuel consumption requirements of the commercial satellite industry. By design, small satellites and nanosatellites are more agile, flexible, and affordable than their larger commercial rivals. In fact, small satellite technology is a growing market that is leveraged by universities, governments, industry, and satellite hobbyists alike, due to the ease of accessibility, diverse applications, and operational cost-benefit outcomes.

A small satellite usually weighs less than 1,000 pounds (454 kilograms) and is approximately the size of a 5-drawer filing cabinet. A nanosatellite is a special class of small satellite, typically weighing between 3–15 pounds (1.4–6.8 kilograms) and ranging in size from a soda can to a shoebox. The term CubeSat is derived from its characteristic cube-shaped design. It too is a type of nanosatellite. As small satellite and nanosatellite markets mature, each new satellite company will market its products through proprietary branding measures. For instance, the company Planet Labs Inc. created its own version of nanosatellites and calls them "dove satellites."[14] A large constellation of dove satellites is fittingly called a "flock."

On the low end, it costs roughly $16,190 per kilogram to launch a small satellite into space.[15] Therefore, a constellation made up of 15 small satellites, weighing 22 kilograms (50 pounds) each, costs approximately $12,142,500. Add to that calculation $10,000 for the berthing requirements and $150,000 for launch fees per satellite and the total becomes $12,292,500—by no means inexpensive but markedly less

costly than commercial imagery. Keep in mind that the more weight and technological options added to the small satellite architecture, the more expensive the price tag.

Besides the $12.2 million cost, there are operational expenditures (established satellite ground and space architecture and an in-house analytic capability) associated with small satellite technology, which allows the commercial satellite industry to maintain a strong advantage. Arguably, once the initial financial output is committed to establish the necessary satellite architecture, operators, and analysts, the benefits far exceed the expense. The payoff is that the owner has complete autonomy over the desired location for satellite overwatch in real-time, controls the length and timing of the flight path, and maintains the rights on all imagery as a part of the company's intellectual property.

Soon, small satellite technology will become less of an experimental science and more of a tool for common usage. The rapid expansion of cell phone technology within the last twenty years has enabled people to carry a practical, cost effective means of communication and computing power. Moore describes a phenomenon in which computing power doubles every two years until components and parts are smaller but contain more computing power.[16] So too will be the expansion of the small satellite industry. It will only be a matter of time before every household might be able to afford a small satellite of its own.

Conclusion

In 2015, the SSP discontinued posting the imagery results of its satellite missions but not for the reasons one would think. On the website, raw satellite data (provided by DigitalGlobe) is no longer available to the public for downloading, commentary, or analysis. Some conjecture this is due to the ability of a potential adversary to exploit and access imagery posted on the website for its own nefarious designs. The unfortunate reality is this: the enemy can leverage the same commercial satellite imagery as humanitarian organizations—ones like the SSP—and use it to hide evidence of genocide. All they have to do is buy it.

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Currently, in Bosnia, Kosovo, and the former Balkan states there exist pockets of radicals on all sides of the political spectrum that are intent on finding mass graves in order to avoid a war crime indictment. In their malfeasance, it is common practice for guilty parties to dig up mass graves and rebury the bodies as a single entity within a local cemetery. These actions are not fueled by apology or remorse for the purpose of reconciling the past; instead, it is a deception mechanism designed to trick the sensors of a passing satellite. Margaret Cox, a forensic anthropologist, recalls an event in Kosovo:

> There was one grave that was considered to be very important for indictment purposes… It was related to the massacre of women and children in a specific place and we were asked to find that grave. By that stage the perpetrators knew that satellite imagery was being used, so they changed their *modus operandi*. Instead of digging mass graves, they moved towards burying people in individual graves in legitimate cemeteries in Kosovo.

There was also deliberate mining of graves to deter investigators. [Additionally], razor-blades were put inside body cavities to either harm or deter the pathologists from doing their work. The genocide is highly systemized and disposal and deterrent is all built into

the process."[17]

For humanitarian organizations, policymakers, and decisionmakers across the globe the application of small satellite technology provides an autonomous means to alert the international community of potential indications and warnings of mass atrocities, and it can produce the evidence necessary to incriminate persons guilty of genocide (past or present).

Arguably, small satellite technology is very experimental and part of an immature market; however, it is a part of a burgeoning field of study and grows exponentially every year. As small satellite technology gets better and becomes more affordable, it is inevitable that private industries, corporations, and everyday citizens will want to harness the power it provides. For governments, aid workers, and victims of mass atrocity, it could mean the difference between life and death. ***IAJ***

NOTES

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16 Gordon E. Moore, "Cramming More Components onto Integrated Circuits," *Proceedings of the IEEE,* Vol. 86, No. 1, January 1998, pp. 82–85, reprinted from *Electronics*, Vol. 38, No.8, April 19,1965, pp. 114-117, http://www.cs.utexas.edu/~fussell/courses/cs352h /papers/moore.pdf, accessed on April 28, 2018.

17 Warner, paragraph 15.

Annex A

The table below depicts the eight common warning signs and associated indicators which could trigger a mass atrocity.

Tension and polarization	Widening gulf between groups either in social life or in conflict; situation is charged with emotion, anxiety, and fear.
Apocalyptic public rhetoric	Leaders claim they face a great danger and in doing so justify violence.
Labeling civilian groups as the "enemy"	Descriptions of a particular group as dangerous, homogenous, or worthless.
Development/deployment of irregular armed forces	Increased empowerment and arming of irregular armed groups that may be tasked with attacking civilian populations.
Stockpiling weapons	Significant accumulation of weapons, especially weapons that could be used against civilian populations.
Emergency or discriminatory legislation	Authorities create laws to facilitate or support state-led and/or group-targeted violence.
Removing moderates from leadership or public service	Those interested in perpetrating or supporting violent act remove political opposition to such crimes
Impunity for past crimes	Acts of violence that go unpunished indicate a willingness to condone violence against civilians and may give a green light for more violence in the future

Figure 1. Warning Signs Before Mass Atrocity
(Source: Scott Straus, "Fundamentals of Genocide and Mass Atrocity Prevention," United States Holocaust Memorial Museum, Washington D.C., 2015, p. 76)