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PRACTICE NOTE

Problems from Hell, Solution in the Heavens?: Identifying Obstacles and Opportunities for Employing Geospatial Technologies to Document and Mitigate Mass Atrocities

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At the evolving frontier of modern humanitarianism, non-governmental organizations are using satellite technology to monitor mass atrocities. As a documentation tool, satellites have the potential to collect important real-time evidence for alleged war crimes and crimes against humanity. However, the field remains experimental and ill-defined, while useful court evidence cannot be produced without a standard methodology and code of ethics. Members of the groundbreaking Satellite Sentinel Project review the historical development of satellite documentation and some of its landmark projects, and propose necessary measures to advance the field forward.

Introduction

Satellite imagery, as a type of remote sensing technology, can provide accurate and detailed information of a specific geographic region anywhere on Earth in a relatively short period of time. Traditional uses of satellite imagery include development planning and modeling, environmental conservation, oil and gas exploration, agriculture management, and meteorological modeling. For governments, the first entities who have had access to this asset, satellite imagery has traditionally been employed for intelligence gathering and military planning purposes.

Changes to US laws and policies in the 1990s allowed private companies to provide satellite imagery to a broader range of actors. This development enabled non-governmental actors (i.e. non-profit organizations, media, academia, etc.) to acquire previously classified geospatial imagery and task private satellites to collect new imagery. The humanitarian and human rights community soon began exploring the application of this technology to its unique advocacy and operational objectives. This trend has rapidly changed the longstanding paradigm for how satellite imagery has most often been employed. Once the sole province of militaries and intelligence services, this tool is now being used by non-governmental organisa-

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tions (NGOs) to support international justice mechanisms for holding perpetrators of crimes against humanity to account.

In order for satellite imagery analysis to become a more effective tool for these means, however, a currently absent framework of procedures and methodologies needs to be established to standardize and scale-up the efforts of non-governmental actors. This paper identifies operational feasibility, data reliability, and legal admissibility as the three key criteria that should be used to determine whether and how satellite imagery can be employed to document alleged war crimes and crimes against humanity. Three past landmark projects of remote sensing by NGOs are reviewed in context to the three criteria identified above.

History of Remote Sensing

a) Legality

Satellite imagery has already been admitted in cases at the International Criminal Court (ICC), International Court of Justice (ICJ), International Criminal Tribunal for the Former Yugoslavia (ICTY), and the Permanent Court of Arbitration (PCA) at The Hague. In one instance, in *Prosecutor v. Germain Katanga and Mathieu Ngudjolo Chui* brought by the ICC, satellite imagery was analyzed to establish the 'geographic configuration' of an area in which war crimes and crimes against humanity perpetrated by Germain Katanga and Mathieu Ngudjolo Chui allegedly took place during violence that broke out in the Democratic Republic of the Congo (DRC) beginning July 1, 2002 (ICC 2010). In another example, an ICJ case concerning the application of the International Convention on the Elimination of All Forms of Racial Discrimination (*Georgia v. Russian Federation*) admitted a Human Rights Watch report into evidence; UNOSAT satellite imagery documenting villages destroyed by intentional burnings carried out by Russian forces could thus be considered by the court (ICC 2008). Aerial imagery released by United States military intelligence has now also been used at the ICTY in criminal trials of members of the Bosnian Serb Army including Radislav Krstic and, most recently, the ongoing case against Ratko Mladic. These images were used to corroborate witness accounts of war crimes and crimes against humanity carried out in 1995 by identifying areas of disturbed earth indicating the presence of mass graves and by noting the presence of large groups of people and the vehicles witnesses described as those used to transport the victims. Satellite imagery has also been submitted to the PCA by both Eritrea and Ethiopia as evidence of human rights violations carried out by both sides between 1998 and 2000 during a war over their disputed border. These images corroborated the alleged intentional destruction of public structures carried out by Ethiopian forces (AAAS 2007).

b) The industry

Government commercialization of remote sensing technology began in the 1970s. At the time, the introduction of once exclusively military technology to civilian applications had begun in earnest, yielding several notable products. The most well-known of these products is what is now known as the internet, which began as a project called ARPANET. The US government also developed the initial Global Positioning System (GPS) in 1973 as a military navigation system. Since being made public, it has become a commonplace tool for individual and commercial navigation all over the world.

The US first attempted to privatize its 'Landsat' remote sensing program in 1972. Soon thereafter, the French government launched a rival program called '*Satellite pour l'Observation de la Terre*' (SPOT) in 1978. Privatization of the Landsat program ultimately failed due to high prices creating a barrier to private sector use, and it was returned to the government in the 1990s (Williamson 2001: 37). SPOT took advantage of Landsat's failure, marketing itself as a cheaper and more reliable alternative, eventually 'making the United States the largest national market for SPOT products' (Sourbès-Verger 2001: 195).

The watershed moments in the commercialization of remote sensing, however, did not come until the post-Cold War period of the 1990s. In 1992, Congress passed the Land Remote Sensing Policy Act and President Clinton issued a presidential directive to 'permit US firms to sell high-resolution satellite imagery' (Baker 2001: 5). The two US-based commercial remote sensing companies that dominate the industry today were founded in response to this policy change. GeoEye (formerly Space Imaging) launched IKONOS, 'the world's first high-resolution earth imaging satellite' in 1999, quickly followed by the QuickBird satellite from DigitalGlobe in 2001 (Ward 2010). Over the next decade, GeoEye expanded its fleet to include the OrbView-2, OrbView-3, GeoEye-1, and GeoEye-2 satellites, while DigitalGlobe launched the WorldView-1 and WorldView-2 satellites. Though most of their business has been conducted with the US government, these two firms have provided imagery for many humanitarian projects. In January 2013, DigitalGlobe purchased GeoEye and became the most prominent American company in the industry.

A 'resolution gap' exists between the resolution level of imagery available to civilians and that available to government intelligence agencies. The US federal government employs a policy of 'shutter control', regulating the resolution of imagery available to NGOs and private corporations. In particular, the Kyl-Bingaman Amendment, in Sec. 1064 of the *National Defense Authorization Act for Fiscal Year 1997* (104th US Congress 1997), was introduced to prohibit non-federal entities from acquiring high-resolution imagery 'more detailed or precise than satellite imagery of Israel that is available from commercial sources'. As more countries are launching commercial satellites each year, governments are likely to introduce similar policies that limit the maximum resolution in which civilians are allowed to view imagery of certain areas. As humanitarian aid professionals working in fields such as Darfur have noted, access to Very High Resolution (VHR) satellites with resolutions of 1 meter or higher, a level which makes single elements such as buildings and trees distinguishable, is crucially important as it allows for the individualized study of these components. Although the commercial satellite industry is calling for lower resolution restrictions, such policy changes are dependent on a major change in the shared consensus among governments supporting certain resolution restrictions.

c) The work flow

Remote sensing operations by non-governmental actors so far have established a 'general approach [that] involves using publicly or commercially accessible high-resolution satellite imagery to document the scale and method of human rights abuses and the areas affected by such abuses' (Kreps 2010: 179). In an April 2012 interview with CBC Radio, the co-author of this article and then-Director of Operations for the Satellite Sentinel Project (SSP) Nathaniel Raymond outlined three 'postures' in which satellite projects like SSP can monitor an international conflict. The 'detection posture' can occur before an alleged atrocity happens, with analysts working to predict whether and where threats to civilians exist by identifying signs indicating the build-up of forces and related infrastructure. During the early stage of alleged atrocities, analysts assume a 'deterrence posture', working to warn civilians of pending attacks and denying potential perpetrators the twin elements of surprise and impunity. Finally, after an atrocity has already occurred, analysts assume a 'documentation posture' by retrospectively recording evidence consistent with alleged crimes and gross violations of human rights, such as mass graves and intentionally burned structures (Raymond 2012). This paper focuses on what is required for projects in the third posture, 'documentation', to effectively gather evidence for international justice proceedings.

Table 1 provides a list of major humanitarian non-governmental efforts to use commercial satellite imagery to collect evidence of

Project	Location	Active Date	Satellite Imagery Provider	Information Analysis	Information Distributor	Website/Report link
Geospatial Technologies and Human Rights Project	Afghanistan, Burma, Chad, DR Congo, Ethiopia, Kyrgyzstan, Lebanon, Libya, Nigeria, Pakistan, Somalia, South Ossetia, Sri Lanka, Syria, and Zimbabwe	2006-Present	DigitalGlobe/GeoEye/ ImageSat International	American Association for the Advancement of Science	Amnesty International USA/Eyes on Pakistan/Human Rights Watch/Physicians for Human Rights	http://srhrl.aaas.org/geotech/index.shtml
Eyes on Darfur	Darfur, Sudan	2007-2009	ImageSat International, GeoEye, DigitalGlobe, Orbimage	American Association for the Advancement of Science	Amnesty International USA	http://www.eyesondarfur.org/
						http://srhrl.aaas.org/geotech/darfur/darfur.shtml (separate reports from AAAS)
Crisis in Darfur*	Darfur, Sudan	2007-2009	Google Earth	United States Holocaust Memorial Museum	Google Earth	http://www.ushmm.org/maps/projects/darfur/
Satellite Sentinel Project*	South Kordofan and Blue Nile, Sudan	2010-Present	DigitalGlobe	Harvard Humanitarian Initiative (2010-2012)/ UNITAR-UNOSAT (2011)/ Enough Project with DigitalGlobe (2012-present)	Enough Project/Not On Our Watch	http://www.satsentinel.org/
Syria Satellite Crowdsourcing Project*	Syria	2011	DigitalGlobe	Standby Task Force crowdsourced data	Amnesty International USA	http://standbytaskforce.ning.com/group/satellite
Somalia Satellite Crowdsourcing Project	Somalia	2011	DigitalGlobe	Standby Task Force crowdsourced data	UNHCR	http://blog.standbytaskforce.com/2011/11/02/crowdsourcing-satellite-imagery-tagging-to-support-unhcr-in-somalia/
Baba Amr report	Homs, Syria	2012	DigitalGlobe	Human Rights Watch	Human Rights Watch	http://www.hrw.org/news/2012/03/02/syria-new-satellite-images-show-homs-shelling
Human Rights in Burma	Burma	2012-2013	Astrium/DigitalGlobe	Human Rights Watch	Human Rights Watch	http://www.hrw.org/news/2012/10/26/burma-new-violence-arakan-state
						http://www.hrw.org/news/2012/11/17/burma-satellite-images-show-widespread-attacks-rohingya
						http://www.hrw.org/news/2013/04/01/burma-satellite-images-detail-destruction-meiktila

*Projects examined as case studies in this article

Table 1: Selected Humanitarian Projects of Commercial Satellite Imagery

alleged human rights crimes. These humanitarian and human rights remote sensing initiatives have so far had a few common components:

1. They tend to involve a coalition of actors, typically including an imagery provider (i.e. commercial satellite firms such as DigitalGlobe);
2. They involve an imagery analysis expert or experts working in partnership with an advocacy organization;
3. Lastly, they also often include the direct involvement of the initiative's funder.

Criterion A: Practical Applicability

When commercial satellite imagery proves useful in practice for non-governmental actors, it must yield a sufficient volume of actionable intelligence at a sustainable cost. The often extremely high cost of imagery and sometimes limited availability due to competing priorities for commercial providers and cloud cover are some of the barriers to entry human rights and humanitarian actors face when employing remote sensing analysis.

a) Costs

The major obstacle preventing widespread use of satellite imagery by civilian organizations is the high cost of proactively acquiring near real-time imagery. This means, simply, submitting a request (or tasking) to the satellite imagery provider to collect a current image of your preferred area of observation. The retail price for priority tasking DigitalGlobe's QuickBird, WorldView-1, or WorldView-2 satellite can average as much as US$40 per square kilometer. The SSP operated by regularly ordering multiple shots averaging130 x 80 kilometers, which was donated by DigitalGlobe. If consumers were to purchase such tasking at retail prices, its cost would be in excess of US$400,000 per shot.

Cost is particularly problematic for non-governmental and relief organizations, which generally do not have funding for testing technology. In 2001, Bjorgo wrote that prices could be further hiked when tasked to operate over complex and volatile environments, 'because the satellites must be programmed to acquire previously unplanned images' (2001: 423). While since then technological advancements in satellite programming procedures have made this process more manageable, in a crisis situation analysts would need multiple shots to be taken over a single location in a short period of time to detect change in the area's baseline data as events evolve. This would still put strains over the project's cost-management, and requires the satellite company to prioritize those immediate shots over other prior commitments. Non-governmental actors must therefore find sufficient funding, receive donations, or identify other ways to overcome the cost barrier to capture evidence of an alleged atrocity in near real-time.

b) Cloud cover

Another major limitation to documenting a crisis situation in near real-time is weather conditions. The geographic location of the crisis plays a crucial role. Since satellite shots cannot penetrate cloud-cover, 'the area of interest must be cloud free, [which] severely limits the ability to use such images in humanitarian relief operations' (Bjorgo 2001: 423). In equatorial regions or regions with persistent rainy seasons, satellite collection operations are often very difficult. Cloud cover limited the use of satellite technology in Kosovo (Bjorgo 2001: 418), and allowed Indian nuclear testing to occur during the rainy season despite persistent satellite coverage by US spy satellites. On the other hand, in certain areas such as Sudan, vast open areas are optimal for extracting the maximum amount of information.

'Dense ground cover', such as jungles and thick vegetation, can have a similarly obscuring effect (Kreps 2010: 185). In certain cases, significant observations were extracted despite both cloud cover and heavy forestation. Regardless, the successful tasking of satellites involves identifying specific time windows for the vehicle to attempt a collection of imagery, especially during a region's rainy season.

c) Timelines of case processing

In March 2012, the ICC issued its first verdict since the signing of the Rome Statute on July 1, 2002, convicting Congolese warlord Lubanga Dyilo of conscripting child soldiers (UN News Center 2012). The timeline of a court proceeding is the exact opposite of the extremely time-sensitive and time-dependent tempo of satellite surveillance. As analysts have pointed out, 'the main problem with assessing court cases…from a geospatial perspective is they can drag on for years' (Bromley 2012). Because of the aforementioned cost restraints of satellite imagery, projects often cannot afford to take timely images that could later be used as evidence when alleged crimes are occurring, continue those operations for the full length of a protracted conflict, or even purchase archived images retrospectively. Because the satellite imagery providers either did not have the actionable intelligence to know to collect certain images and/or financial incentive to do so, imagery that could have captured evidence of alleged mass atrocities is often not collected in time to catch a potential criminal act in progress.

Thus, by the time court investigators begin to look for evidence, the monitoring efforts of NGOs are likely to have expended their limited budgets and concluded their operations. This significant limitation also highlights the necessity for establishing crosscutting strategies for prospective planning of satellite imagery tasking and methodical record keeping of the resulting shots. Ideally, monitoring operations should proactively coordinate with satellite imagery providers to consider collecting imagery that may contain potential legal evidence, even if the NGOs conducting the operations cannot afford them at the moment. Additionally, monitoring operations must have an extensive archive of the shots they take throughout the conflict and the potential evidence they contain to allow court investigators the ability to access those archival shots in the future. Until these procedures and operational infrastructure are developed between NGOs, court investigators, and the satellite imagery providers themselves, unique, potentially crucial evidence is being routinely lost on a regular basis because it is never collected.

Criterion B: Data Reliability

In an international humanitarian conflict, satellite imagery is primarily able to offer two types of potential evidence: the identification of observable objects and changes in the position, behavior, and condition of those observable objects over a period of time.

a) Identifying observables

An observable is a term for anything contained in the imagery with a distinctive shape and size which may be of interest to the analyst. Examples of these points of interest may include aircraft, ships, tanks, artillery, camps for displaced persons or armed actors, and shelling craters or other evidence of damage. After detecting an observable in the imagery, analysts consider its attributes in order to identify it as a specific point of interest. These attributes include: tone or hue, shape, size, texture, pattern, shadow, site, scale, its association with other observables, and overall context (Baker *et al* 2001: 536–37). In a humanitarian crisis situation, identification of these observables can provide significant, timely, and unique forms of information. For example, satellite imagery can be used to detect 'tire tracks that might indicate troop movements or convoys of displaced people; burned or burning villages…; possible refugee camps…; and recently overturned soil, which could indicate the location of mass graves' (Litfin 2001: 477).

There are limitations to the information satellite imagery can yield. As Litfin points out, satellite imagery can only be used to detect 'a relatively small portion of possible human rights violations', typically including 'the large-scale violation of human rights that accompanies campaigns of genocide' (2001: 476). Unlike military and government agencies, who have had decades to train their

analysts and construct detailed processes for pattern identification, trade craft of humanitarian remote sensing analysts is still in its earliest infancy, currently lacking the type of agreed pedagogy and technical standards necessary for reliably categorizing observables and identifying repeating patterns. Moreover, ground collaboration is essential for satellite analysis, as eyewitnesses can tell analysts where to look and where to direct satellite tasking, as well as confirm and identify the observables that analysts find. Even if analysts can independently make confident claims on certain observables, they cannot often be used to explain causality or directly point fingers on the agents culpable. Support from eyewitnesses thus also plays the crucial role of placing the investigation in proper context. However, while ground reporting has been used by several groups to corroborate satellite imagery collection, the procedure lacks commonly accepted ethical and operational standards to protect potential witnesses, ensure chain of custody of evidence, and improve the accuracy and usability of field-derived data from relatively non-permissive environments.

b) Temporality

In addition to identifying points of interest, satellite imagery is capable of providing a timeline narrative of the situation. Even though context and causality cannot be confidently established without information from the ground, repeated shots of troop movements and maneuvers in an area over a long period of time can reveal some clues about intent. Through repeatedly tasking the satellite to take pictures of the same location and then comparing new and archived images to one another, analysts are able to produce before-and-after comparisons of specific points of interest. The ability to describe a location before and after a certain event creates a narrative of change, a record of the changing conditions of a location that can be used to explain how an event may have transpired. For example, a study at Yale used MODIS and SPOT satellites as well as the remote sensing application 'normalized difference vegetation index' (NDVI) to document the 'return of natural vegetation coverage...in formerly agrarian and livestock grazing ranges' in the Darfur region of Sudan between 2003 and 2007 (Schimmer 2008). The authors concluded through before-and-after comparisons that this phenomenon corresponded to, and is a result of, the human displacements caused by systematic violence perpetrated in the region.

Long-term, persistent monitoring of a situation can also lead to an inevitable interaction between the monitor and the perpetrator. As Litfin cautions, there exists 'the possibility that perpetrators, knowing the sun-synchronous orbit of imaging satellites, could camouflage their actions' (2001: 479). Kreps also underlines 'the predictable timing of [satellite]...revisit rates' as a key challenge, as 'perpetrators could easily time particular atrocities for a time when a satellite is not overhead' (2010: 185). Therefore, a successful analysis project will have to adapt to the actions of the perpetrator in real-time by adopting a dynamic strategy to surmount any counter-monitoring strategies used by those being surveyed.

c) Expert opinion

Analyses by NGOs have often also been prone to human and mechanical error, which leads to misidentifying and under-identifying observables. In 2001, Baker observed that NGO analysts 'generally lack the training, experience, and resources required to make consistently accurate interpretations of overhead images, particularly when compared with more-experienced imagery analysts found at government agencies, commercial remote sensing firms, and some university departments' (Baker *et al* 2001: 534). Imagery analysts, or even the image data provider themselves, could be motivated to deliberately distort image data in order to produce findings consistent with their conjectures. Moreover, errors of judgment and time con-

straints in a crisis situation could lead inexperienced analysts to make inadvertent errors.[1] Since then, steps have been taken to mitigate this credibility issue. For example, the American Association for the Advancement of Science (AAAS) has employed university-trained analysts who produce separate reports that are then provided to advocacy and human rights organizations, while the SSP's analysis team is operated out of Harvard University. Nevertheless, the numbers of trained NGO analysts who have actually acquired experience working on humanitarian crises are still limited. Moreover, the changing terrains and characteristics in different locations require a larger pool of experienced analysts to be adequately prepared for all contingencies. To avoid deliberate errors, non-governmental actors should operate under a strict code of ethics and acquire imagery from reputable commercial satellite providers with expert analytic support and training. There are a limited number of providers currently on the market and the few reliable partners are easy to identify. To mitigate inadvertent errors, analysts employed by non-governmental actors should closely engage with experienced remote sensing experts. Ideally, they should work together to revise findings before they are released to the media. Finally, there is a third type of error: contextual over-extrapolation. There exists a high potential for organizations motivated by achieving public policy advocacy objectives to over-extrapolate what can be shown through analysis of satellite-derived data. Because analysts are trying to find as many observables as possible, with the belief that their efforts may prevent atrocities and save lives, they are predisposed to discover more data than may actually be present in an image. This unique problem for mass atrocity-focused imagery analysts can be mitigated by separating the analysis and advocacy of a monitoring operation, and through using independent third-party analysts to check public facing products for accuracy and objectivity. The independent work of AAAS represents a positive shift towards addressing this concern, but it remains a problem that the industry should remain keenly aware of and continue to try to avoid.

Criterion C: Legal Admissibility

Currently, there is no international body with a mandate to regulate the use and exploration of space, nor are there binding and unambiguous standards for the admissibility of remote sensing data in international courts and tribunals.

While satellite imagery has been admitted as evidence at the ICC to corroborate witness testimony of human rights abuses, it has not yet been admitted as dispositive evidence of mass atrocities. Recognizing the complex nature of various crimes and conflicts, international criminal law tends to be more lenient towards evidence admission. Both the ICC and international criminal tribunals allow for 'the admission of all relevant and necessary evidence', bypassing the 'complex and technical rules of evidence' of the common law system (Schabas 2007: 294).

Rather than specific and unambiguous procedural rules, admissibility requirements for evidence in international criminal courts and tribunals are guided by more general principles. The Rome Statute, which governs procedures at the ICC, includes Article 69 concerning rules of evidence: 'The parties may submit evidence relevant to the case.... The Court shall have the authority to request the submission of all evidence that it considers necessary for the determination of the truth' (Rome Statute 1998). Therefore, two relevant questions regarding the admissibility of remote sensing data are (a) whether there is a legal basis for denying admission of this evidence, and (b) whether this type of evidence could be treated as dispositive of human rights abuses.

a) Legal basis for denying admission of evidence

Remote sensing data must pass the standard for inadmissibility under Article 69(7) of the Rome Statute which precludes the admission of evidence obtained 'in violation of [the

Rome] Statute or internationally recognized human rights' if 'the violation casts substantial doubt on the reliability of the evidence' or if admission 'would be antithetical to and would seriously damage the integrity of the proceedings' (Rome Statute 1998).

While there is no binding international law that speaks directly to whether or not collecting remote sensing data of a territory within another country would constitute a violation of internationally recognized human rights, there are principles contained in three UN General Assembly resolutions and one treaty that bear some authority on this issue. Provisions of the *UN Treaty on Principles Governing the Activities of the States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies* state that activities in space must be carried out 'exclusively for peaceful purposes'. 'Peaceful purposes' is also generally accepted today to include non-aggressive military uses (Ito 2011: 24). Such activities must endeavor to foster international cooperation and to benefit all states 'irrespective of their degree of economic or scientific development' (UN - Outer Space Treaty 1967: 207–210). Additionally, remote sensing data should be collected according to the licensing procedures and regulations of the member state authorizing the activity; that member state is responsible for enforcing regulations to comply with the treaty (Ito 2011: 27–28).

The UN Remote Sensing Principles (Sensing Principles) are not binding, but they are authoritative and are given influential weight because they were unanimously adopted in the General Assembly (Ito 2011: 55). The Sensing Principles articulate with greater specificity how states should cooperate with respect to sharing data and, while it is not stated so explicitly, Atsiyu Ito argues that the language suggests that collecting remote sensing data of another state's territory is not subject to the consent or demands of the sensed state (2011: 63). In fact, more explicit terms regarding prior consent by sensed states were proposed but ultimately not included in the final document (Ito 2011: 53).

Furthermore, the history of regulating space law has its roots in preserving the free and non-appropriable nature of space itself, monitoring countries to avoid an impending attack, cooperating with developing states without space programs (Ito 2011), and evaluating land use and risks to the environment (UNGA 1986).

These interpretations of existing space law legislation suggest that remote sensing data collected to monitor mass human rights violations would fall within the admissibility requirement of Article 69(7) of the Rome Statute because this data was obtained with the peaceful purpose of protecting human rights and does not undermine any other goals of these pieces of legislation.

b) Remote sensing data as dispositive evidence

Remote sensing evidence then must also be 'necessary for the determination of the truth' (Rome Statute 1998: Article 69(3)) and relevant based on its 'probative value', taking into consideration 'any prejudice that such evidence may cause to a fair trial or to a fair evaluation of the testimony of a witness' (UNGA 1998: Article 69(4)). William Schabas presents standards for interpreting Article 69(4) that were used in Trial Chamber 1 in Lubanga and in the Pre-Trial Chamber in Katanga. There, the courts decided that evidence must be '*prima facie* relevant…in that it relates to the matters that are properly to be considered by the Chamber', reliable in that it is 'voluntary, truthful, and trustworthy' (2010: 843), and have probative value in that it has 'intrinsic coherence' that is not '*prima facie* absent' and therefore inadmissible. Schabas posits with respect to the prejudicial effect of evidence that courts use this standard mainly to prevent prejudicial information from being disclosed to a jury and is 'of doubtful importance in the case of professional judges' (2010: 844).

With respect to reliability, Hettling points out that '[a] judge is only able to verify the authenticity of a satellite image if a scientific expert analyzes and interprets the data for

him' (2008: 146). Therefore, the reliability of satellite imagery as evidence would be greatly enhanced when it is submitted with expert witness testimony. Hettling further argues that the expert should ideally be independent from the party submitting the evidence, either 'chosen and appointed by the Court' or agreed upon by 'both parties' (2008: 166). Art. 64(6)(d) of the Rome Statute, which allows the chambers to '[o]rder the production of evidence in addition to that already collected prior to the trial or presented during the trial by the parties', legally enables the introduction of court-appointed witnesses at the ICC. The court then does not have to be concerned that their witness testimony may end up favoring one party at trial.

Regarding the relevance and probative value of satellite imagery, imagery has already been admitted in cases at the ICC, ICJ, ICTY, and the Permanent Court of Arbitration at The Hague. In the ICC case *Prosecutor v. Germain Katanga and Mathieu Ngudjolo Chui*, satellite imagery was analyzed to establish the 'geographic configuration' of an area in which war crimes and crimes against humanity perpetrated by the defendants allegedly took place during the violence in the DRC beginning July 1, 2002.

Another example comes from the ICJ in the case *Application of the International Convention on the Elimination of All Forms of Racial Discrimination (Georgia v. Russian Federation)* in which a Human Rights Watch report was admitted into evidence; as such, UNOSAT satellite imagery documenting villages destroyed by intentional burnings carried out by Russian forces could be considered by the court. Satellite aerial imagery released by US military intelligence has now also been used at the ICTY in criminal trials of members of the Bosnian Serb Army including Radislav Krstic and, most recently, the ongoing case against Ratko Mladic. These images were used to corroborate witness accounts of war crimes and crimes against humanity by showing areas of disturbed earth that indicated the presence of mass graves and by noting the presence of vehicles that witnesses described as those used to transport victims (ICTY 'Rules of Procedure and Evidence'). Satellite imagery has also been submitted to the Permanent Court of Arbitration by both Eritrea and Ethiopia as evidence of human rights violations carried out between 1998 and 2000 during a war over a border dispute. These images indicated the intentional destruction of public structures that were bombed or razed by Ethiopian forces (AAAS 2007).

These examples suggest that the relevance and probative value of satellite imagery is generally recognized by these courts. Therefore, while the extent to which satellite evidence may be considered dispositive of human rights violations is yet to be determined more definitively, there is a solid basis for anticipating that satellite imagery will play a significant role in the future of holding perpetrators of gross violations of human rights accountable.

Case Study 1: Crisis in Darfur

On April 10, 2007, Google and the United States Holocaust Memorial Museum (USHMM) announced a partnership to launch the Crisis in Darfur project, to be embedded in a new 'Global Awareness' layer in Google Earth. Dedicated to 'draw attention to a serious crisis underway…[and] highlight the humanitarian potentials of new information technologies', the project pursued an advocacy objective from the outset. The USHMM 'approached Google after learning [that] Google Earth software had been downloaded by 200 million people worldwide' (Parks 2009: 535–6). The insertion of Crisis in Darfur images into standard Google Earth downloads, shown in **figure 1**, proved an effective means of introducing the issue to a much wider audience. However, because the partnership was oriented towards raising public awareness, it failed to actually provide intelligence to actors on the ground and help prevent the progression of violence. As such,

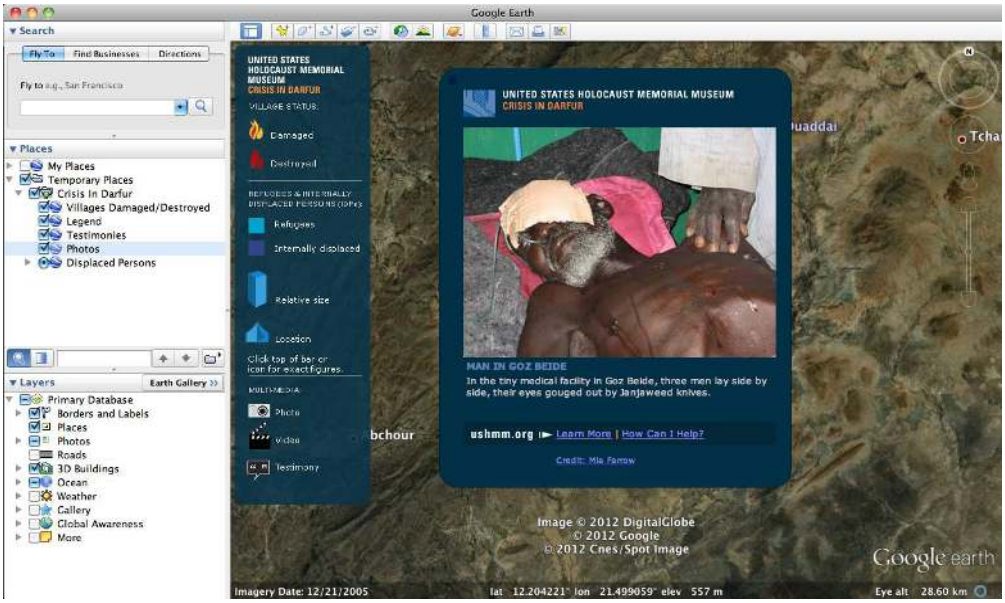

Figure 1: USHMM report overlaying Google Earth satellite imagery. The caption reads: 'In the tiny medical facility in Goz Beide, three men lay side by side, their eyes gouged out by Janjaweed knives.'

the advocacy perspective of Crisis in Darfur damages its legal reliability.

Parks points out that Crisis in Darfur 'satellite images are traversed in favor of closer views and representations of humans, many of which feature injured bodies and/or displaced women and children' (2009: 538). While such presentation may be useful in an advocacy setting, it undermines the scientific legitimacy of the project when attempting to use these materials as evidence. In court, this methodology would likely encounter questioning regarding its neutrality and reliability. The dilemma that some projects face, as showcased here, is that they must rely upon an advocacy organization to garner media attention and funds to run the program. However, the political agenda of these organizations have the potential to influence and undermine the credibility of the analysis produced.

In addition, Crisis in Darfur cannot take on a 'detection posture'. Its inability to conduct the forward analysis of predicting where the next attack may happen is a major limit to its utility on the ground. Parks laments the retrospective nature of Crisis in Darfur as 'an archive of violent conflict that unfolded while being observed but without intervention' (2009: 540). Moreover, without conducting analysis through before-and-after shots and monitoring the conflict over the period of time when it was actually happening, Crisis in Darfur loses its documentation value in court. The dataset the project provides records factual information such as which villages were attacked and where those villages are located. However, it does not support forensic sense-making in the sense of helping investigators determine the intent of the perpetrators, which would be crucial for a court conviction.

Crisis in Darfur is a crucial project in that it was, along with the Eyes on Darfur project, one of the first projects that garnered significant media attention and showcased the potential of satellite imagery in a humanitarian setting. However, the analysis it provides is more suited for a media campaign rather than as evidence in a court of law.

Case Study 2: Satellite Sentinel Project

In 2010, actor George Clooney and Enough Project co-founder John Prendergast conceived the Satellite Sentinel Project (SSP), a collaboration of Clooney's Not On Our Watch organization (funding), the Enough Project (advocacy), DigitalGlobe (imagery provider/analysis), and the Harvard Humanitarian Initiative (analysis). Initially, SSP was established as a warning system for possible conflicts along the border of Sudan and soon-to-be independent South Sudan. When South Sudan gained independence in the summer of 2011 and conflicts erupted, SSP began to identify IDP camps and burned villages in near real-time and documented evidence of war crimes and crimes against humanity.[2]

The work of SSP is notable because it overcomes the shortcoming cited in criteria B(b) that satellite imagery cannot be used to establish intent. Instead of simply identifying observables for documentation, SSP's reports provide a narrative of intent. The project claims to have uncovered evidence that demonstrates the systematic and indiscriminate targeting of civilians by the Sudanese Armed Forces (SAF). In Report 20, as shown in **figure 2**, SSP published before-and-after imagery showing a compound allegedly belonging to the Sudanese Central Reserve Police (CRP), claiming that they 'significantly built up the fortifications and reinforced the vehicles and personnel present at that facility during the time period that CRP forces were allegedly abducting, detaining, torturing, and killing internally displaced persons seeking refuge there.' Having received eyewitness accounts suggesting the killing of civilian SPLM-N supporters, SSP analysts offered a map depicting satellite imagery of the area prior to the reinforcement to the witness who then 'independently identified the CRP training center' on the map (SSP

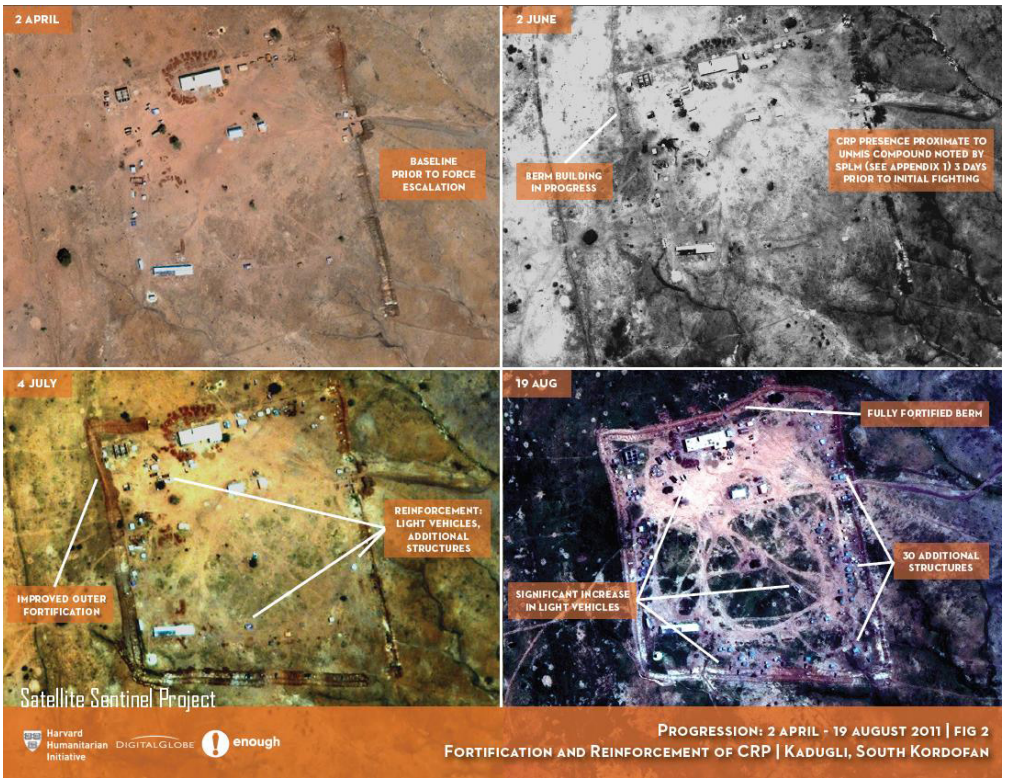

Figure 2: SSP-17 Imagery on fortification of the CRP over time.

Figure 3: SSP-18 Imagery of SAF Checkpoints around Kadugli.

2011c). Once the map was returned with the witness identification, SSP was then able to positively confirm the build-up of the identified location by analyzing both archival and then-current imagery of the area.

This method of analyzing before-and-after imagery was also instrumental in identifying a likely intent to conceal reported mass graves. Rather than the traditional method of identifying observables, SSP continually monitored the area by repeatedly collecting up-to-date satellite imagery of the same location, which allowed for the construction of a thorough narrative. This documentation of *intent* will likely be much more convincing in court (SSP 2011b).

In **figure 3**, SSP identified 'six [military] checkpoints' on DigitalGlobe imagery, which was consistent with information from a report released from the United Nations High Commissioner for Human Rights (UNHCHR) suggesting that the 'SAF blocked all major roads in and around Kadugli', the capital of Sudan's South Kordofan (SSP 2011a).

In this case, observables from several different shots were combined and collaborated with contextual information obtained from field reports of a third organization. As a result, SSP again established a dynamic narrative establishing intent to cut off outside assistance and 'prevent…ambulances from reaching wounded civilians in need of medical care' (Special Report 2011). Analysis which combined information derived from different observables therefore enhanced the documentation power of the satellite imagery.

Case Study 3: Standby Task Force Satellite Imagery Project

The Standby Task Force (SBTF) was founded in 2010 as a network of volunteers available 'to provide dedicated live mapping support to…organizations in the humanitarian, human rights, election monitoring,

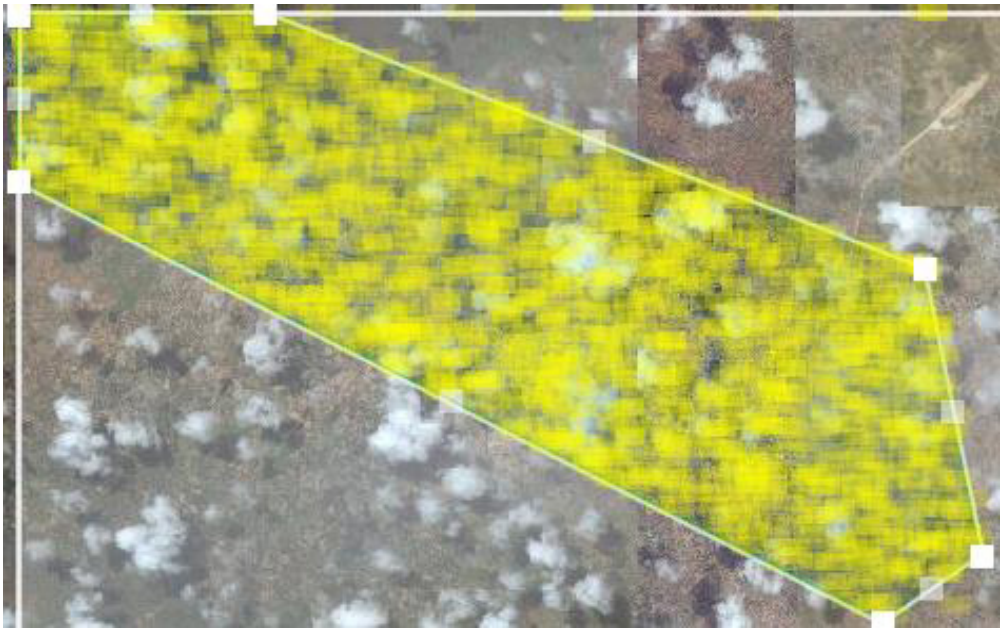

Figure 4: SBTF Micro-tasking of Syria Imagery.

and media space' (The Standby Task Force 2012). In September 2011, the SBTF Satellite Imagery Team launched an 'experimental pilot project', which analyzed imagery on Syria made available by DigitalGlobe as a part of a report produced by Amnesty International-USA (AI-USA).

While the SBTF project is much smaller in size and scope than the other case studies in this paper, it has pioneered the integration of crisis mapping and crowd-sourced data into satellite imagery analysis. The concept of crowdsourcing, according to a definition proposed by Estellés and González, is 'a type of participative online activity in which an individual, an institution, a non-profit organization, or a company proposes to a group of individuals...the voluntary undertaking of a task...[that] entails mutual benefit' (2012: 197). According to Patrick Meier, co-founder of the SBTF, the intelligence contained in massive amounts of satellite data produced everyday lacks the corresponding analytical human capital, as 'professional satellite imagery experts who have plenty of time to volunteer their skills are far and few between'. SBTF addresses this issue by applying the concept of crowdsourcing, slicing up imagery into small sections and micro-tasking them to its network of volunteers who divide up the work usually tackled by single analysts and collectively 'scan and tag vast volumes of satellite imagery data' (Meier 2011). **Figure 4** shows a cloud of yellow triangles, representing sliced images given to individual volunteers at SBTF.

The SBTF crowd-sourcing system is useful in greatly increasing the speed of analysis. However, this model also faces a series of challenges regarding reliability. One potential issue is the lack of expertise of the volunteers. Untrained volunteers are much more likely to make inadvertent errors, as outlined in criterion B(c), and could seriously undermine the reliability of the analysis. SBTF attempts to mitigate this disadvantage by asking experienced analysts to filter their work. The inexperienced volunteers are 'provided with documentation that explains how to spot military vehicles, troop movements, checkpoints, and aircraft', and are responsible for simply identifying observables. Then,

a team from AI-USA will 'analyze images that have been tagged by at least three volunteers' (Ungerleider 2011). While this procedure certainly lowers the likelihood of false identifications, it cannot prevent volunteers from omitting certain observables that may only be obvious to more experienced analysts. SBTF volunteers will also be unable to perform analyses that require more advanced GIS skills and software technology, such as infrared and multispectral analysis. Moreover, micro-tasking and slicing imagery may prevent analysts from being able to 'connect the dots' between various observables and forming a greater contextual understanding of the situation. Since the volunteer looking at each slice of imagery is different each time, they could also miss out important changes in before-and-after shots which would help construct the timeline narrative in criterion B(b).

Implications

The commercialization of satellite imagery is leading humanitarianism toward a historic and momentous occasion: the application of satellite imagery to international criminal justice, as a tool of evidence collection, could permanently transform how the international community allocates accountability to perpetrators of mass atrocities. This paper established three criteria for the construction of useful, reliable, and admissible evidence for international criminal courts. By following these criteria, humanitarian satellite imagery projects could take a great step towards producing quality output, but the industry still faces some significant challenges. As such, some significant improvements will be necessary for the above criteria to be met and create useful intelligence for the courts.

a) Building a system

The techniques of analysis and compilation of satellite data for documentation of humanitarian crises should be developed into a structured discipline. The establishment of a procedure or guideline for sense-making, which all similar projects could follow, would maximize efficiency and increase reliability. The procedures should include elements of technical analysis often used by professional government-employed analysts, such as the use of GIS software for infrared analysis. This would help mitigate the issue of inadvertent errors in criterion B(c). Moreover, these procedures should also concentrate on the specific application of satellite imagery analysis for crisis monitoring and documentation. This includes addressing methods of ground confirmation and communication with eyewitnesses as mentioned in criterion B(a). It would also include establishing research capacities and considering context and establishing long-term monitoring, as mentioned in criterion B(b). Ideally, organizations that have gained experience from successful projects would then set up training and certification programs for new analysts and other organizations interested in starting their own projects. In this manner, humanitarian applications of satellite imagery can be transformed from independent projects attached to a wide variety of academic, governmental, and non-governmental institutions of varying credibility into a coherent, reputable, scientific discipline.

b) Neutrality

Thus far, non-profit human rights groups have been the instigators of commercial satellite projects. Their participation is often necessary to secure funding, raise awareness, or obtain human capital. However, these groups sometimes already carry an agenda regarding the policy issue before the project is assembled, or feel pressured to overstate data or produce information in certain manners and time intervals in order to maintain media attention. As such, the evidence produced in this process could lose credibility in court if the defense attorney can prove that the scientific process of analysis had been influenced or undermined. As mentioned in

criterion C(a), it would then be necessary for the court to call on an outside expert witness to re-analyze the evidence. Therefore, if such projects were to be employed in greater numbers and their work submitted to international criminal courts, the establishment of a third-party verifying organization would be necessary. This organization should be composed of analysts with experience in humanitarian applications of satellite imagery, but at the same time remain non-partisan and unaffiliated with any organization with an explicit issue-agenda. The establishment of such a credible organization from which the court could call expert witnesses would greatly enhance the credibility of satellite imagery evidence produced by non-government projects.

c) Establishing legal precedence

Although satellite imagery has been submitted and considered by the ICC and ICTY, none have so far been formally admitted as evidence. The industry came close in 2011 when, according to TIME Magazine, the ICC reviewed and based 'a significant portion' of their new investigation against Sudanese Defense Minister Abdelrahim Mohamed Hussein for possible war crimes on data collected by the SSP (Benjamin 2011). Being used by the prosecution does not create legal precedence for the evidence since it was never officially submitted in court. Nevertheless, it demonstrates the validity and usefulness of such products for international criminal justice. A first ICC case where satellite imagery, created for the type of projects described in this article, is accepted as evidence would establish crucial legal precedence. As a result, not only would the admittance of satellite imagery in the future be much more feasible and streamlined in the legal sense, it would also encourage current chief prosecutor Fatou Bensouda and her successors to add satellite imagery to their investigation toolkit and look toward satellite projects for useful evidence. In turn, this would encourage the formation of more projects that are better funded and greater in scope. Existing projects and analysts will also likely devote more time toward documenting evidence of war crimes and violations.

The advent of civilian-analyzed satellite imagery changes the way in which non-military actors and bystanders can actively participate to help prevent atrocities and help convict those responsible for them. The current conflict in Syria, for example, comes to mind as an area where effective satellite technology could be immediately deployed to aid humanitarian efforts, as well as to increase accountability of the massive human rights violations that are taking place there. Eventually, the development and wide-range employment of this new form of war photography in international criminal justice may be a game-changer in setting up a system of accountability in an increasingly unstable modern world.

Notes

[1] Baker provides a more in-depth discussion of possible errors in his article.

[2] The authors of this article were all previously affiliated with this project.

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