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Mainstreaming Satellite Imagery in Slow-Onset Humanitarian Crisis Response

INTRODUCTION

The Lake Chad basin in central Africa—lying at the confluence of Nigeria, Niger, Cameroon, and Chad—has been an unstable and crisis-ridden environment for a decade or more. The border communities in all four nations grapple with food insecurity, violence perpetrated by the Islamic extremist group Boko Haram, and rapidly diminishing livelihoods. Lake Chad has been the subject of numerous studies engaging true-color satellite imagery and non-visible-light remote sensing instruments as a method of monitoring the lake's shrinking size.[1,2] However, the conclusions of these studies focus on the manifestations of climate change and thinly discuss how the lake retreat is impacting the *people* in the region—and it has, undoubtedly. Lake Chad is but one salient example of a larger issue in humanitarianism: satellite imaging technology is capable of monitoring environments *and* inhabitants at risk, but its full potential for humanitarian intervention into social, economic, and political conflict remains untapped.

How can remotely-sensed imagery help alleviate humanitarian crises? Available declassified case studies illustrate the dynamic applications for imagery in a disaster response. In Sudan, high resolution satellite imagery has identified mass graves and confirmed eyewitness accounts of military violence in an area inaccessible to journalists or diplomats, proving soldiers

[1] Alfa, Adeofun, and Ologunorisa, "Assessment of Changes in Aerial Extent of Lake Chad Using Satellite Remote Sensing Data."

[2] Policelli et al., "Lake Chad Total Surface Water Area as Derived from Land Surface Temperature and Radar Remote Sensing Data."

had lied about their behavior.[3] Images allowed aid groups to monitor the makeshift settlements of fleeing Syrian civilians waiting just beyond the Rukban border crossing into Jordan, and indicators of death and disease in the settlements was used to justify further aid action.[4] Both visible and radar images have also been used to detect existing or potential water sources near camps or vulnerable villages in central Africa to avoid having to truck tons of water to affected populations.[5]

Satellite imagery has been hailed as an essential tool in crisis response, and remote sensing and humanitarian aid have been called a "life-saving combination."[6] Indeed, the uptake of this data source in all stages of the disaster management cycle has been increasing in recent decades. However, not all sectors under the broad umbrella of "disaster response" have seen growth at the same rate or with the same efficacy. This paper argues that satellite imagery and remote sensing analysis have been unevenly applied to fast-onset natural disasters, leaving slow-onset humanitarian disasters in the dark.

To investigate this question, it is important to distinguish between *(a)* natural disasters and humanitarian crises and *(b)* rapid-onset and slow-onset disasters. Natural disasters comprise geophysical and hydrological crises, including earthquakes, hurricanes, volcano eruptions, and flooding. Though some of these conditions may be exacerbated by anthropogenic climate change (i.e. hurricanes, flooding), they are generally not thought to be human-caused. All these disasters are considered rapid-onset as well, since they occur on a daily or weekly time scale and may allow for short-notice early warning. A slow-onset natural disaster is one that "emerges gradually

[3] BBC, "Sudan's South Kordofan Fighting: 'Mass Graves Found.'"
[4] Taylor, "75,000 Syrians Are Trapped near Jordan's Border. Satellite Images Show Some Are Dying."
[5] Stenmark, John, "Geospatial Images Improve Humanitarian Aid Effort."
[6] Bally et al., "Remote Sensing and Humanitarian Aid - A Live-Saving Combination."

over time, often based on a confluence of different events"[7], such as drought, insect infestation, or desertification. For the purposes of this paper, humanitarian crises are distinguished from natural disasters by their less obvious "symptoms" in the visible landscape and their tendency to play out in the social realm; these include ethnic or religious conflicts, violence, or poverty. Food insecurity and famine can be treated as hybrids of slow-onset natural disaster and humanitarian crisis.

First, we briefly examine the history of how satellite imagery developed into an accessible tool for disaster management professionals. Next, we explore how the existing infrastructure for conducting humanitarian remote sensing came to skew towards natural disasters and describe the paucity of data about how widespread its deployment is. We outline two recommendations for how these imbalances may be rectified and conclude with an agenda for implementing these recommendations and prerequisites that will facilitate them.

PROBLEM DEFINITION

Problem One: Existing Satellite Imagery Charters

The costs of launching and maintaining a private satellite is beyond the fiscal realm of possibility for many humanitarian organizations. And it is safe to assume these groups will not begin collecting their own imagery with self-operated satellites until the technology becomes more affordable and feasible. Many aid agencies operate using *pro bono* imagery from governments and private satellite companies—either routine imagery that has already been taken or which the aid agency has requested for a specific geography of interest. In a way, these government space agencies and private companies become "gatekeepers" of this type of

[7] OCHA PDSB, "OCHA and Slow-Onset Emergencies."

imagery. Thus, it is critical to examine the existing pipelines that deliver imagery to crisis response organizations as a tool for assessing how effective the practice is and whether needs are being met. A review of these pipelines reveals that they are often designed with natural disaster response in mind. While this design is not necessarily bad, it is possible that the current humanitarian space has outgrown this model and is overdue for change.

In the 1990s, the United States and Europe began to see a rise in use and conversations about "geomatics" and its massive potential across disciplines.[8] This geographic information science revolution touched the humanitarian space as well. Even in the days before Web 2.0 humanitarians described GIS and remote sensing applications as "useful, time saving service[s] that helped organisations make informed decisions about a difficult, volatile region of the world"[9] and having a "useful role to play […] where conflict makes terrestrial work dangerous."[10] Conversations around this time were especially salient in the wake of the 1994 Rwandan genocide; humanitarian practitioners and theorists alike engaged in post-mortem discussions of what could have been done differently and what data would have been critical to possess.[11]

The field did not merely discuss the potential of geospatial intelligence. In the autumn of 2000 the International Charter "Space and Major Disasters", or simply the Charter, became fully operational. Conceived by the European and French space agencies with a mission of "providing a unified system of space data acquisition and delivery to those affected by natural or man-made disasters," the international agreement is the largest distributer of imagery for emergency

[8] Verjee and Fellow, "The Application of Geomatics in Complex Humanitarian Emergencies."
[9] Hallam, "Geographical Information Systems and the Management of Humanitarian Programmes."
[10] Hallam, "Satellite Imaging: A Useful Tool for Camp Planners?"
[11] The "JEEAR report" is perhaps the most formalized example of this analysis. For a summary, see Jackson, Laura, "Joint Evaluation of Emergency Assistance to Rwanda."

response in the world and now includes 125 member nations.[12,13] "Authorized users" within member nations may "activate" the Charter by submitting an application for imagery that defines a region of interest and describes the crisis to which that organization is responding. Additionally, in 2001 the United Nations Institute for Training and Research (UNITAR) founded its Operational Satellite Applications Programme (UNOSAT). Working by "providing a parallel service" to the Charter,[14] UNOSAT offers geospatial assistance to governments, humanitarian NGOs, and regional organizations alike for the sake of "human security, peace and socio-economic development."[15] Beyond providing imagery, UNOSAT conducts analyses in-house and delivers imagery-derived information to the groups requesting it.

However, historically and today, large-scale mechanisms like these respond to fast-onset disasters in far greater numbers than slow-onset disasters. In a 2016 study covered in *Science* magazine, a quantitative analysis of activations from five different international agreements over 14 years—including Charter and UNOSAT—show that 68% of responses were to floods and storms (with floods alone covering 50%). About 20% of responses were to geophysical disasters such as earthquakes, volcanoes, and landslides. The 9% of "Other" type activations included, among other things, biophysical crises (i.e., the 2015 Ebola outbreak) and search-and-rescue operations for crashed airplanes or sunken ships.[16,17] These results are not surprising; the Charter is "intentionally limited in scope" and explicitly is not activated in "monitoring of […] droughts and non-environment-related humanitarian emergencies."[18] If a humanitarian organization

[12] International Charter Space and Major Disasters, "About the Charter - International Disasters Charter."
[13] Voigt et al., "Global Trends in Satellite-Based Emergency Mapping."
[14] Verjee and Fellow, "The Application of Geomatics in Complex Humanitarian Emergencies."
[15] UNITAR, "What We Do."
[16] Voigt et al., "Global Trends in Satellite-Based Emergency Mapping."
[17] International Charter Space and Major Disasters, "Activations - International Disasters Charter."
[18] International Charter Space and Major Disasters, "Annual Report 2016."

wishes to obtain imagery, UNOSAT is often the recommended imagery venue[19] their expedited "Rapid Mapping" service or in a longer term contract spanning months or years.[20] Yet the ratio of mapping events UNOSAT responds to still skews towards natural disasters,[21] suggesting that even though UNOSAT is one of the few major imagery resources for humanitarian emergencies, its utilization is perhaps not what it could be.

Problem Two: Documentation of Humanitarian Imagery Applications

In general, documentation of the use of satellite imagery in slow-onset humanitarian crises occurs in decentralized case studies—either in mainstream media coverage summarizing an activation after the fact (see introduction above for examples), a backward-looking reflection on a deployment in journalism catered to the humanitarian professional, or in agency-authored reports covering only their own activity. In contrast, scholars have authored many review articles and meta-studies of satellite imagery application to fast-onset natural disasters.[22,23]

Within the internal or annual reports of humanitarian non-profits, natural disaster response is allotted greater coverage with prose, statistics, and infographics as well. The World Humanitarian Data and Trends 2018 report dedicates a full two-page spread to mapping and documenting responses to natural disasters that year, but makes no mention of satellite imagery being useful in other contexts.[24] The Humanitarian OpenStreetMap Team (HOT) annual report, with an intended audience of donors to the project, dedicates a world map to the major crises to which the crowdsourced mapping website has responded that year; in years 2015 and 2016 these

[19] UN OCHA, "Satellite Imagery." OCHA's wiki-style website providing a "toolbox" of information management resources cite the Charter for use in natural disasters and UNOSAT "for any other situations."
[20] UNOSAT, "Portfolio."
[21] Voigt et al., "Global Trends in Satellite-Based Emergency Mapping."
[22] Gillespie et al., "Assessment and Prediction of Natural Hazards from Satellite Imagery."
[23] Joyce et al., "A Review of the Status of Satellite Remote Sensing and Image Processing Techniques for Mapping Natural Hazards and Disasters."
[24] "World Humanitarian Data and Trends 2018."

pages only depict natural disasters.[25,26] In year 2017 six of the seven disasters on the response map were natural disasters, the exception being an Ebola outbreak.[27]

While activations of international satellite agreements like the Charter and UNOSAT are recorded in archives easily viewable by the public, professionals, and academics, humanitarian imagery requests are either not present in these archives (in the case of the Charter) or difficult to extract and aggregate. It is also unclear whether imagery requests *directly* to the philanthropic arms of private satellite companies—like the DigitalGlobe Foundation or Planet Lab's Disaster Data program—are aggregated or accounted for anywhere in a public forum. Without holistic statistics documenting when, where, and how satellite imagery is being used by humanitarians, geospatial professionals assisting aid efforts cannot learn best practices from their peers. Both the satellite industry and the humanitarian sector cannot accurately track how demand for this data product is changing, and catching misuses of imagery in responses becomes even more challenging.

RECOMMENDATIONS

Recommendation One:

Inter-governmental partnerships such as the Charter and UNOSAT, member states of these partnerships, and imagery providers (public and private satellite operators) must establish administrative and financial support for slow-onset disasters and complex emergencies at the same level as current support for fast-onset natural disasters. This could be achieved by *(a)* making existing imagery pipelines activatable for conflicts beyond natural disasters; *(b)* creating

[25] Humanitarian OpenStreetMap Team, "Annual Report 2015."
[26] Humanitarian OpenStreetMap Team, "Annual Report 2016."
[27] Humanitarian OpenStreetMap Team, "Annual Report 2017."

a new organization or branch of an existing one that processes imagery requests solely for humanitarian disasters; or *(c)* directing more resources to UNOSAT—particularly its Rapid Mapping program—while simultaneously directing more humanitarians towards that service to maximize needs being fulfilled.

Recommendation Two:

Humanitarian imagery pipelines, along with other clusters in the humanitarian aid system, must develop robust ways of tracking when and how imagery is used in humanitarian responses, to the extent possible considering privacy. The humanitarian field may then document its usage of this method to the same extent that it documents the usage of imagery in natural disasters. A resulting database of this information maintained by a suitable UN branch—akin to the existing activation databases the Charter and UNOSAT share online—will allow humanitarians, fast-onset emergency responders, scholars, and the satellite industry to monitor how the sector is expanding or contracting. Expansion of documentation can and should be implemented regardless of whether existing imagery pipelines began responding to more humanitarian cases as in Recommendation One above, and regardless of whether real usage of satellite imagery in humanitarian contexts increases or decreases.

AGENDA FOR IMPLEMENTATION

Implementing Recommendation One

The benefit of expanding the Charter's mandate to include humanitarian responses lies in not having to reinvent the wheel; existing Charter infrastructure and staff will respond to this new influx of activations using the capacities they have already perfected. Many countries are familiar with how the Charter operates, and existing authorized users likely have protocols for

handling the geospatial data from a Charter request, in addition to existing relationships with Charter representatives themselves. Compared to pushing more humanitarian users to UNOSAT's model, expanding the Charter's mandate also means that requesting organizations receive primarily images as opposed to pre-processed data products. This enables the requesters to conduct the analyses *they* see fit using their own staff and technology, ensuring the commensurability of their results with the existing data management plans of the requesting organization.

To expand the Charter's mandate, its leadership must rewrite the criteria for authorized user membership and revise the activation application to consider humanitarian causes. Only a few line-items on the application must change: for example, the requirement that one be a disaster management authority that coordinates disaster aid in their country, which excludes many international NGOs and those focused on topics like education. But before revision, the Charter leadership must discuss reasonable membership criteria with potential humanitarian users and incorporate that feedback into the final standards. The leadership should ask about current imagery analysis needs and response tasks, from the perspective of both humanitarian headquarters and field staff, at a set of organizations representative of the humanitarian sector (public, private, religious, international, domestic, etc.). Humanitarian staff dealing directly with imagery should be asked what minimum capacities they believe an aid organization should have to become a member of this "Charter 2.0".

Implementing Recommendation Two

To make Recommendation Two a reality, the humanitarian community must *(a)* agree upon what imagery usage is safe to disclose within what timeframes and, relatedly, *(b)* create minimum standards for which imagery applications are mandatory to report and which should

never be publicly reported. For example, if UNOCHA publicly announces they are referencing rapidly-acquired satellite imagery to respond to a tsunami on coastal Thailand, this is not exactly breaking news; moreover, this announcement being public likely would not change a civilian's behavior on the ground. But what are the implications if UNOCHA publicly announces they are referencing rapidly-acquired imagery to monitor the road network connecting a refugee camp, an abandoned village, and a hospital? Perhaps looters will target the village, or violent insurgents will target the camp now that they know its vulnerability and hints at its location. Or, knowing that humanitarians are actively monitoring *those* given locations, militias may target other civilian locations that are not "under the microscope."[28]

The protection of affected populations should be paramount in any disaster response context, and it is critical that humanitarian responders remain sensitive to this mandate when developing reporting statistics for satellite humanitarian response. The UN branch (or other entity) deemed best for maintaining this database could survey current and retired aid workers about what they deem a suitable "grace period" after which it is safe to reveal surveying activities, based on their field experiences. Information describing the imagery used, frequency of imagery, and analysis methods could then be shared on a web platform for the benefit of other humanitarian professionals and scholars (with entries "public" or "visible only to humanitarians" as needed).

LIMITATIONS

Of course, before expanding the Charter, its leadership must guarantee and affirm publicly that it has enough expertise and resources to accommodate a new humanitarian

[28] For other examples, see Raymond, Caitlin Howarth, and Jonathan Hutson, "Crisis Mapping Needs an Ethical Compass."

caseload. Expanding the Charter could increase the demands and workload of satellites and technicians (the "providers" in the Charter) already trying to keep up with an increasing occurrence of fast-onset natural disasters. Since human-scale phenomena are much smaller than environmental-scale phenomena like landslides and wildfires, opening the Charter to humanitarian conflicts could put extra demand on particularly high-resolution satellites (i.e. sub-meter scale) that are able to resolve things like tents, ground water wells, and tire tracks.

Any service aiding disaster response tasks are queued in relation to their urgency, and the most urgent imagery requests for current fast-onset disasters should remain at the top of the list. However, some safeguards would have to be put in place to prevent less-time-sensitive imagery requests from getting pushed down the task list for too long (for example, monitoring drought). Yet even with these safeguards in place the impact of the outlined recommendations on relief *outcomes* may not be distributed equally. Urban and high population areas tend to dominate the number of activations for imagery in fast-onset natural disasters.[29] This makes sense: humanitarianism operates with the ethos to help where there is the greatest need, and when disaster strikes a high population area the casualties and damages to infrastructure may logically be higher. Even if it becomes easier for humanitarians to acquire timely images of crises and monitor what their colleagues are doing, rural or pastoral hazards may continue to get de-prioritized by sheer lack of requests.

Lastly, all of these recommendations are predicated on the presence of funding to support these measures: funding from national space programs, UN budgets, or international unions. For example, Copernicus (an image delivery mechanism similar to the Charter) is strongly supported by the finances and policies of the European Commission, and it is the only mechanism that still

[29] Voigt et al., "Global Trends in Satellite-Based Emergency Mapping."

increases the number of activations it takes on each year while others have stalled.[30] It costs time and money to task a satellite to take imagery—will funders be swayed by a plea to devote more resources to a greater number of places with small and/or rural populations, the kinds of conflicts that already fail to fulfill their fundraising goals 20% behind the global average?[31]

CONCLUSION

In 2017 alone, almost half of the record-high 345 satellites launched into space were earth observation satellites.[32] The satellite imaging industry is rapidly expanding, and the humanitarian sector, wisely, hopes to not get left behind. Attempting to fill the information gap created in part by lackluster state-supported imagery pipelines for humanitarians, various volunteer and technical communities (VTCs) have developed systems for accessing satellite imagery and outsourcing imagery analysis to serve disaster response or mitigation. In many cases, VTCs like Humanitarian OpenStreetMap Team (HOT), Ushahidi and others will do the footwork of acquiring satellite imagery and producing imagery-derived data products, sending the data products to the requesting response agency. But it is naïve, perhaps even irresponsible, to think that VTCs will *completely* fill the niche of timely geospatial intelligence delivery for humanitarian responders. Until the deployment of satellites in human conflicts becomes streamlined on the governmental level, well-documented, and mainstream, there will remain vulnerable populations we cannot see.

[30] Voigt et al.
[31] "World Humanitarian Data and Trends 2018."
[32] Satellite Industry Association, "SIA Releases 2018 SSIR."

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