Images from above: A review of aerial assessment in support of humanitarian response operations

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Summary

Aerial assessment is generally conducted by satellite, manned aircraft, or drones. It can play an important role in understanding the magnitude, geographic scope, scale, and severity of a disaster. However, aerial assessment has not necessarily been well leveraged in humanitarian response and well integrated with other components of an operation. This is due to a number of reasons ranging from complications around technical expertise to political restrictions.

In this study we've explored some of the challenges surrounding aerial assessment and have identified a range of recommendations that fall generally into four categories: (1) tools, (2) partnerships, (3) assessment literacy, and (4) cross-cutting issues that apply to aerial assessment but also more broadly to the perpetual puzzle of improving how information can better support disaster response.

The study is intended to be accessible for a broad range of humanitarians, not just those with preexisting experience of aerial assessment, and therefore includes foundational information in the initial sections. The study seeks to highlight key issues and opportunities, but not provide a definite plan of action. Rather, we hope it serves as a useful review and aggregation of thoughts from some of the leaders in areas related to aerial assessment, as a starting point for sparking conversations and additional research, prioritizing and planning next steps, and as a tool to support coordination and alignment of future work on these topics.

Background

The International Federation of Red Cross Red Crescent Societies (IFRC) and National Societies (NS) have been evolving their use of aerial and satellite remotely sensed data in disaster response operations, with early examples including after the Haiti earthquake of 2010. Recently, IFRC's Global Surge and Information Management Teams together with multiple NS have been collaborating in the Assessment and Planning in Emergencies working group to improve and adapt emergency needs assessment for the Red Cross Red Crescent network. As part of IFRC initiatives to optimize emergency response surge processes, a new concept was defined for a team dedicated to needs assessment and analysis in support of a National Society; an Assessment Cell. In 2019, IFRC deployed the first Assessment Cell in response to Tropical Cyclone Idai in Mozambique. The Assessment Cell collaborated and coordinated with the United Nations Office for the Coordination of Humanitarian Affairs (UN OCHA), the United Nations Disaster Assessment and Coordination (UNDAC) teams, and other organisations to help all humanitarian humanitarian responders better understand the magnitude and severity of the disaster.

Gaining an understanding of the disaster was challenged by the large area to be assessed, damaged transportation infrastructure, and other factors. Thanks to a partnership the IFRC holds with Airbus Foundation, substantial helicopter assets were available to conduct aerial assessment and deliver aid in Mozambique. The outputs from the helicopter assessment were well received by responding organisations. However, the methodology was developed rapidly and it was acknowledged that there should be efforts to establish more standardised approaches to integrating aerial assessment into humanitarian response and planning processes. It was acknowledged in operation reviews that such a workstream would require attention at the inter-agency level and within the UNDAC Assessment and Analysis Cell at the global level.

This study was conducted by the IFRC for a high-level examination of the state of aerial assessment in humanitarian response. Although conducted through the lens of the Red Cross and Red Crescent network, the study sought to include the experiences, expertise, and knowledge of individuals from both within, and external to, the network. It sought to explore a couple of core questions. **How has aerial assessment been leveraged in response, both successfully and without effect? How can the use of aerial assessment be improved or expanded in the future to better account for organisational capacities, changing technologies, and the evolving landscape of humanitarian response?**

What is aerial assessment?

Aerial assessment in disaster response

Aerial assessment, for the purpose of this study, is analysis processes conducted using remotely sensed data from orbital or aerial platforms to support humanitarian disaster response activities. Aerial assessment can be utilized for disaster preparedness but that is outside the scope of this study. The platforms used include satellites, manned aircraft such as planes or helicopters, and emerging technologies such as drones. The analysis processes are intended to improve situational awareness, coordination, identification of needs, and prioritization and allocation of resources. There are numerous challenges when conducting assessment in a disaster response including but not limited to: urgency, competing priorities, limited resources, access limitations, often rapidly evolving situations, and damaged infrastructure such as that for transportation and telecommunications. There are both limitations and opportunities in leveraging aerial assessment to capture information that might otherwise be invisible from the ground.

Orbital and aerial platforms

Satellites are capable of collecting images of large sections of the surface of the Earth from space. Due to the cost and challenges involved with operating satellites, imagery collection by satellite is generally conducted by governments or large commercial companies. The cost of purchasing imagery may be quite high; however, humanitarian organisations can often access satellite imagery through partnerships and other agreements at reduced cost or no-cost for the duration of a disaster response. The tasking of satellites, choosing what portion of the Earth's surface to capture, may be prioritized based on the needs of paying customers or atmospheric conditions such as clouds and imagery of the right place and at the right time may not always be available. Depending on the satellites and sensors involved, the frequency of image capture for a given location as well as the resolution of the images can vary. The best resolution available is generally around 40cm (1 pixel in the image is equivalent to 40x40 cm on the ground). Changes in satellite technology are increasing resolutions and decreasing revisit times.

Manned **aircraft** such as planes and helicopters can carry observers capable of recording notes during a flight and/or sensors such as cameras that may be mounted to the aircraft or carried by one of the people onboard. Though less expensive and more accessible than satellites, manned aircraft can still carry high costs, need infrastructure such as landing strips and refueling points, and require skilled maintenance technicians and pilots. Aircraft are more flexibly tasked than satellites and may be able to fly beneath certain atmospheric conditions such as cloud cover that obscurs views from a satellite. Proximity to the Earth's surface also results in higher resolution imagery but reduced area coverage. Getting map-like images of large areas via aircraft requires specialized equipment and pilots.

As **drones** have moved from large systems that are only a tool of militaries, to smaller systems which are

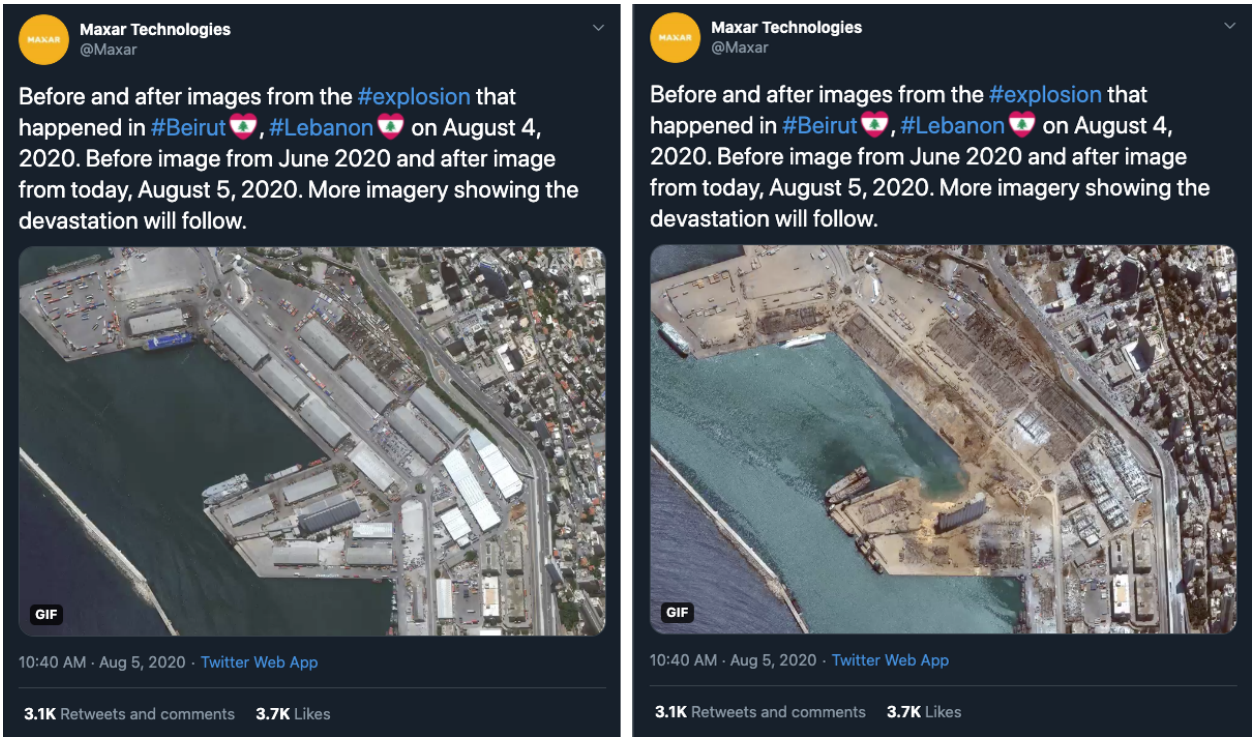

Fig. 1: Before and after images of the 2020 explosion in Beirut | *Credit: Maxar Technologies, @Maxar_*

Fig. 2: A helicopter being used for assessment after Cyclone Idai in Mozambique | *Credit: IFRC*

commercially available and affordable to average consumers, they have increasingly been used to capture images from the sky for activities such as humanitarian response. Drones can be easily transported and tasked, launched on short notice to take advantage of opportunities such as breaks in the weather, and can capture very high resolution images. However, drones are often limited to capturing only small areas by factors such as short battery life and altitude limitations imposed by aviation regulations, and can be damaged by rain or excessive wind. Despite these limitations there are examples such as Nepalese drone pilots mapping 138 kilometers of roads using a single drone like the one in the image below, and altitude restrictions are legal not technical so exemptions are simply a matter of establishing the right agreements and protocols.

Fig. 3: Uganda Flying Labs, Uganda Red Cross, and community members | *Credit: Uganda Flying Labs*

Assessment objectives

Aerial assessment can be used for **context awareness**. This begins with the utility of pre-crisis imagery in helping responders better understand the answers to questions such as: How rural or urban is the affected area? What is the general topography and the arrangement of features such as highways, rivers, and coastlines? Google Earth has been helping people explore the world in this way since its launch in 2005. Such capability to explore can be of great utility for disaster responders, especially those that may be traveling from other areas of the affected country or even other parts of the world.

A few pictures from above can give a **rapid situational awareness** and an important perspective not possible from ground observations and can often be easily collected and disseminated. Simple pictures, even without deriving additional data through analysis, can be a valuable piece of the puzzle in the early stages of a response.

There are also objectives that relate to advocacy. For example, a form of situational awareness are **fly-overs by individuals** targeting priority areas and involving key individuals such as organisation or agency leaders. A fly-over can give a key individual a better grasp of the situation, helping them be more expressive in their communication and highlight the severity of a situation.

Pictures for rapid situational awareness may also play a key role as materials for **media coverage** and bringing awareness to the public. The expression "a picture is worth a thousand words" should be considered when competing for the public's attention amongst click-bait headlines and 280-character Tweets. A good visual can help when launching a funding appeal.

Aerial assessment can be used for more advanced **impact analysis** that would otherwise be difficult to conduct for reasons such as size of the affected area or access constraints for ground-based methods. An objective of such analysis might be to determine the extent of a flood or understand the percentages of structures destroyed by a cyclone in different towns.

An example of impact analysis is from July 2018 when a landslide struck hard-to-reach villages in a remote and impoverished area of Panjshir province, Afghanistan. Due to the logistic challenges of reaching the affected area, World Food Program (WFP) and the Afghanistan National Disaster Management Authority (ANDMA) requested iMMAP to use satellite imagery to assess the situation. iMMAP was able to use panchromatic satellite images from before and after the landslide to estimate the number of houses destroyed. Their analysis resulted in a number much different from initial, anecdotal reports but which was very close to the actual number confirmed after responders were able to assess the site in person.

Another example of impact analysis is from March 2019 when Cyclone Idai swept through Mozambique causing extensive damage with high speed winds and heavy rains. The IFRC, through a partnership with Airbus as well as coordination with other responding agencies, was able to mobilize helicopters and fixed wing planes for visual observations to follow up an analysis by the United Nations Operational Satellite Applications Programme (UNOSAT) and the United Nations Institute for Training and Research (UNITAR) detecting flooding extent with infrared satellite imagery. Numerous flights over 6 days were used to cover

Fig. 4: Drone footage of displaced persons camps in Cox's Bazar, Bangladesh recorded by the Disasters Emergency Committee was shared widely in the media | *Credit: The Guardian*

the large swathe of land that had been affected by the storm. A grid system was used to organize the coverage and mobile data collection forms filled out on smartphones were used to collect the data.

Impact analysis can extend to **monitoring** of slow onset and protracted disasters. Shifts in shelter and settlement dynamics are one example of data that can often be measured with aerial assessment. For example, REACH has used satellite-detected agricultural activity as a proxy for insecurity. Through observations of how crop production diminished or disappeared over time in the Lake Chad adjacent regions of Nigeria they could work to understand conflict in the area.

Aerial assessment can also be used for **critical incident identification**. This could be related to search and rescue activities to find people with emergency needs. It could also be recording the location of points of interest; for example, affected transportation infrastructure such as destroyed bridges.

Aerial assessment can be useful for **inspection of unsafe or difficult to access locations**. Drones have been used to inspect things like the underside of bridges and tops of wind turbines. They can be used to examine damage to buildings after an earthquake or industrial accident to help determine if it's safe for responders to enter on foot. For example, after an explosion in a field the German Red Cross used a drone to help determine if the cause was old WWII ordinance and if there were risks for the responding police and fire department personnel. The drone let them check for a sinkhole or old mining path without potentially endangering the first responders.

Fig. 5: German Red Cross investigation for Police of a self explosion of a 250 kg. WWII aircraft bomb in Ahlbach, Germany | *Credit: Kai Brunner, German Red Cross - Kreisverband Limburg e.V., 2019*

There are a few examples of aerial assessment being used for **advanced analysis for program implementation**. For example, in Cox's Bazar, Bangladesh the drone-collected aerial imagery of the displaced persons camps was used to produce a digital elevation model and 1-meter contours. Details on the elevation and slope of land throughout the camps was useful for a range of purposes including: identifying locations for infrastructure like footpaths, communal shelters, and latrines; and prioritizing areas at high-risk of landslides or flooding for mitigation activities.

Challenges

Urgency of disaster response

As with all other elements of disaster response, aerial assessment is subject to **urgency due to impacts of disaster on lives and livelihoods**. Crisis necessitates haste in relief activities if the suffering of people is to be minimized. Haste in relief activities necessitates haste in data collection and analysis if the information is to be impactful in planning and operations. Funding and focus has historically often been on expertise that frequently has to be deployed to a disaster instead of local expertise that is already present, exacerbating urgency-related difficulties.

Even with partnerships to gain direct access to assessment assets like helicopters, the delay between the idea of using them and getting them in place can be long. The granularity of data desired from an assessment is likely to require more time to collect than can reasonably be used in an emergency response. There are tradeoffs between level of detail, spatial resolution, and collection costs. After data collection, analysis also takes time and a single analysis may need to meet the needs of as many responders as possible as it will not be possible to conduct a customized analysis for each one. Once information products are disseminated, the rapidly changing nature of many disasters will reduce their useful lifespan. Depending on the stage and type of disaster, the results of an assessment may be outdated and irrelevant as soon as the next day.

As with all information management related processes in disaster response, aerial assessment has the challenge of urgency in completing the cycle to get the right information, in the right format, to the right persons, at the right time.

Community engagement

Aerial imagery is generally collected without a way for populations to opt out. **Affected communities should be engaged in humanitarian response activities**, as recognized in the commitments to localisation within the Grand Bargain and other platitudes in organisations' missions and strategies. There has been progress in community engagement and accountability but the urgency of disaster response is still being used as a reason for failing to adequately involve affected populations in the response decisions that impact their lives and livelihoods. Community engagement is essential in drone projects, when the imaging platform is something that will likely be both seen and heard. However, decreased likelihood of the surveillance tool being surveilled by the affected population, as is the case with satellites, should not be used to ignore community engagement.

Fig. 6: Community disaster preparedness exercises using drone collected imagery | *Credit: Philippine Red Cross*

Data pipelines

The data used in aerial assessment may create challenges. Satellite imagery may be available; however, if there is an **imprecise or inaccurate area of interest**, in either time or geographic location, it may take time to search through many satellite images in search of ones that contain relevant details. Mission planning for manned aircraft also benefits from accurate information for tasking. Ensuring the collection of the right type of data can **require skilled personnel to inform and manage the imagery acquisition**.

Procuring imagery can be **expensive**, and although there may be agreements in place for discounted or free access to imagery for humanitarian activities, awareness of the processes to leverage the agreements may be limited. Additionally, use of the imagery may be complicated by **restrictive licensing**. It can be a slow and difficult process to get permission to, for example, display the imagery itself publicly and not just display a derived map layer.

It can be **prohibitively slow to transfer the large size and volume of data**. Imagery can be many gigabytes or even terabytes and a challenge to transfer even under good conditions. Good conditions are rare in disasters; impacted areas may have had connectivity challenges pre-disaster, and communication technology infrastructure may be damaged or destroyed by disaster. Connectivity challenges and difficulties in transferring data also means **limitations in accessing remote cloud server resources for processing** that may require lots of computing power. In some cases processing has become less an issue, less a bottleneck; for example PiX4D, an industry leader in photogrammetry software, is now faster in processing drone imagery.

Extracting accurate insights from data may **require specific expertise for analysis**. This includes hazard-

specific expertise and contextual knowledge. Floodwater can inundate a house and recede leaving serious issues that are invisible in an overhead image such as destroyed belongings and health hazards linked to mold. Communities in parts of the world may remove roofing in advance of tropical storms, a preventative measure that could be incorrectly interpreted as damage if observed by the wrong analyst.

Technical and logistic limitations of imagery collection platforms

Access to and availability of satellite imagery has improved in recent years, however there are still limitations. **Satellite imagery can be expensive, not high enough resolution, impacted by atmospheric conditions, and/or unavailable for the required time and place**. Satellite imagery can be obscured by cloud cover and certain natural disasters such as storms are accompanied by an increased likelihood of such conditions. Certain parts of the world have a higher percentage of days each year with such conditions. The tasking of satellites may be prioritized based on the needs of governments and other large, paying customers. While understanding large disasters may end up being everyone's priority; disasters of limited magnitude and severity may not be a wide priority.

Imagery assessment via **manned aircraft requires highly trained personnel, the aircraft itself, flight infrastructure, and periods for safe missions**. Purchasing, maintaining, and operating aircraft is expensive. Flying aircraft requires trained pilots. Aircraft also require landing areas and a place to refuel. Certain mapping activities, not just taking individual pictures with a handheld camera, will require specialized hardware and software for the aircraft.

Drones can fill an imagery collection niche but **drones may be limited by regulations, perception concerns, safety concerns, challenges getting kit to the area of interest, and/or limited area coverage**. Prolific use of drones for conflict in some countries can make it challenging to get and use them. For example, there may be negative public perception of drones or the producers of drones may have implemented geofencing in armed conflict areas preventing their drone products from being activated for takeoff. The airspace in a disaster can be complex, and it can be complex to ensure that drones don't interfere with manned aircraft conducting search and rescue, supply drops, and other key activities. Constraints in a disaster can limit access to technical support and the supply chains for drone equipment, challenges that may only be partially mitigated with lots of redundancies in terms of chargers and batteries and such. The logistics of getting equipment on the ground can be difficult, especially when responding organisations look to international teams rather than local experts or if damaged transportation infrastructure prevents a drone team from reaching the area to be assessed. Drones have limited coverage due to factors such as battery life and regulations on flying drones beyond the visual line of site of the pilot.

Coordination and cooperation

When there is **failure to coordinate and cooperate** between disaster responders it can result in duplication of assessment efforts, delayed analysis, and conflicting understandings of the situation. This can even occur within a single group, as evident for example when individuals of an organisation report out different numbers for the same metric.

Lack of coordination in assessment and analysis might be due to any number of reasons. There may be a **lack of required time**. Coordination takes time especially when it hasn't been prepared for in advance, and time is in short supply in a disaster. There may be **deficient or overlapping roles and responsibilities** because they are poorly defined, not adequately disseminated, ignored, not properly agreed upon, and/or not adapted to the situation at hand. Applying roles and responsibilities can be challenging due to variations between disasters in magnitude, available connectivity, who is on the ground and when they arrive, capacities of different teams, and other factors. There seems to be a **lack of awareness around coordination mechanisms**. Responding groups may have **different information needs**, both real and perceived. Groups may assume that the questions they want to answer in an assessment are different from the questions of other groups. The various groups responding to a disaster may have **non-compatible data management systems and processes**. And unfortunately, there may be **competition among groups** and a group may desire to hold onto information in order to accelerate their own response plans or pursuit of funding.

Best use of resources and opportunity cost

For every minute a responder is awake during a disaster there are a multitude of possible actions that they could be undertaking. When conducting assessment it can be **challenging to get a reasonably accurate answer in a reasonable amount of time** so that resources can be pivoted to reaching affected people. There is a need to balance the various stages of assessment and invest the appropriate amount of resources and time to get the intended result in order to move on to planning, decision-making, and relief activities.

> *I spent a whole day flying over a hurricane-affected zone, and I didn't know anything different that I could use in my planning.*

> *You sometimes end up with someone just pretending to be in Top Gun and misusing resources that could otherwise be used better for other purposes.*

An assessment requires a budget, but a first assessment is needed before it is likely to be known how large the budget for an operation will be. There is also opportunity cost; the **loss of other possible choices**. Money spent on an assessment is money that can't be used in direct support of affected people. Using a helicopter to take pictures may preclude it from being used to transport vital relief goods.

Data literacy among operational decision makers, partners, and end-users

Technical specialists sometimes seem to be speaking different languages when communicating with managers or leadership. It can be **difficult to set expectations** and scale to something reasonable based on time, budget, and technical constraints. Those difficulties are exacerbated when there is not clear communication between the people responsible for carrying out an assessment and the people deciding if an assessment happens and expecting to use the results.

> *I try to explain. This is what you're asking for, this is how long it will take, this is what we'll have at the end. And then I ask, are you still interested in it?*

Turnover across the system, in country offices, government agencies, and other places, can mean it is a new set of people even in a single country from disaster to disaster. During a single disaster response staff may also rotate frequently. It may be **necessary to frequently restart conversations** around topics such as what is or isn't visible in aerial imagery. And there is limited time to teach or train in a disaster. The end-users of assessment don't always know what's possible, what to ask for, what they're getting, and how to interpret the information.

> *Just because data is presented, doesn't mean it's the whole picture. We need to play a role in educating people not just about the utility of the information products, but also the limitations.*

Conditions such as the environment in the aftermath of a disaster are chaotic, and such **conditions of uncertainty are psychologically challenging for people**. So people may seek out things that make the situation tangible and "safe" for them. They may hang on certain things, such as a color or phrase, in order to generate certainty about the future even if the evidence is not complete.

> *I saw the map and said, 'Oh God that's red, let's go to red.' And we went to red. And that's how we did our first distribution.*

There are gaps and risks to any assessment process. End-users may have a **poor understanding of assessment limitations**. It can be challenging to, for example, present probabilistic forecasts to decision makers and simultaneously help them unpack assumptions baked into statistical models. It may be difficult to visually represent uncertainty in analysis.

Linking data to decision making

The link between data and decision making can be unclear. Assessment is sometimes described as reactive and **used to justify actions already planned**. An opinion sometimes expressed is that an operation will largely do what it's going to do. Or that factors outside of the focus of most assessment, such as organisation politics, end up having an outsized effect on the path of a response.

> *Too often, the indicator of success is the number of maps we produce; we don't evaluate how or if the maps were used.*

A product may be generally described as “useful” but there will be a lack of evidence regarding its utility. There can be a disconnect between the level of detail in information products and the anecdotes operational leaders provide for how they use those information products in planning and decision-making. Despite sometimes very large investments in assessment, various stakeholders in the process still end up asking, “for what?”

Other times, there is a disconnect between the production of information products and the other pieces of the humanitarian response cycle. There are times when **assessment is completed too late**. Outputs of an assessment need to be available during the window for decision making. If it takes too long, decision-makers will form their plans based on other things and once there is an established narrative, changing the trajectory can be difficult.

Fig. 7: Discussing aerial assessment results in Mozambique after Cyclone Idai | *Credit: IFRC*

Recommendations

Better data tools

Anecdotally, aerial assessment conducted by the IFRC has had weak or otherwise poorly developed methodologies. Assessment would benefit from development of **actionable sampling methodologies** adapted for disaster response contexts and the profile(s) or likely participating organisation(s). Such methodologies should be supported by accessible tools. For example, Flowminder Foundation has developed GridSample as a tool to select clusters for household surveys using gridded population data. However, GridSample seems more suited to research and not the time and resource limited urgency of a disaster response. There are additional resources on robust data collection in complex settings. Data Collection in Fragile States, published by the World Bank, explores real-world examples for scenarios such as statistical samples without established sampling frames, dealing with non-standardised admin boundaries, and dealing with outdated or otherwise inaccurate population statistics. Existing work could serve as a foundation on which to build guidance for the IFRC and member National Societies.

Assessment activities can be opportunistic and be conducted by the most immediately available person. It would be beneficial to put in preparedness measures, guidance, and/or processes to help ensure that **assessment implementers are properly trained, equipped, and tasked**. Methodology and processes need to match the capacities of data collectors. Data collection tools also need to be properly contextualized. There was an assessment post-earthquake in which an observer on a helicopter did not receive proper guidance and so did not collect meaningful notes nor images; essentially wasting the money and time spent on the flyover. Estimating population, understanding what damage you're seeing, and other visual interpretations of an aerial view or image takes experience and training. It is vital to optimize the time of analysts, whether internal or in partnerships, especially in high tempo operations.

> *How do we structure the assessment so that it's more useful than a random guy hanging out a helicopter and saying, 'Oh it's really bad' or 'Oh, it's really wet'?*

It would be beneficial to identify ways to better **link aerial assessment to other sources of data** such as on-the-ground surveys. Research has been done in this space such as work by Sabine Loos et al. estimating damages from earthquakes via a framework that combines a limited number of accurate field surveys with comprehensive but uncertain analysis from forecasts or remote sensing. Another example of combination of data sources is work by the World Bank with drone imagery, street level imagery, and point cloud elevation data to identify structures with greater earthquake vulnerability in Guatemala. Also, the Earthquake Engineering Field Investigation Team (EEFIT) has explored the use of drone imagery and 360º camera imagery to conduct post-earthquake building surveys. Aerial assessment and field surveys could be leveraged for results of greater value that are more than the sum of the parts. There can sometimes be an overabundance of data; PDC's DisasterAWARE Emergency Operations Programme (EMOPS) platform brings together lots of data layers into one place and while people can easily get access to EMOPS they may not know how to best leverage the available data layers.

There are opportunities to **leverage advances in data science** including artificial intelligence (AI), machine learning (ML) techniques, and other technologies to better sift through massive amounts of assessment data. There are many groups working in this space. The Global Facility for Disaster Reduction and Recovery (GFDRR) has published a Machine Learning for Disaster Risk Management Guidance Note. The Open Data Cube (ODC) is a non-profit, open source project supporting interactive data science and scientific computing using satellite data. iMMAP is currently setting up its own Analysis Ready Data Cube based on the ODC technology, which allows a substantial historical baseline on which to compare rapid change at the time of a disaster. Companies are helping their clients leverage these new technologies without needing to write code, such as Switzerland-based Picterra and their tools to help users create workflows to detect objects and patterns on satellite and aerial imagery. It will be important to pair any use of algorithms with increased socialization of possible gaps and limitations in the analysis. Human analysts have cognitive biases; machine algorithms are designed by humans and will therefore also have biases.

Aerial assessment data can have value well beyond the initial assessment purposes and processes could be developed to **better leverage aerial data for additional value-adds**. One of the first uses that might come to mind is the updating of open source geographic data sources such as OpenStreetMap. The assessment data also might be used to help plan for, and transition into, recovery programming after a disaster. In some cases, using aerial data after the initial assessment and in other ways might require examining the licensing applied when humanitarians are given access to imagery.

Fig. 8: Tablet being used for mobile data collection in a helicopter | *Credit: IFRC*

Improve partnerships

There are opportunities to **reinforce and improve coordination with partners, especially local partners**. It is important to understand the strengths and capacities of involved organisations and allocate roles and responsibilities accordingly in order to maximize efficiencies. Local experts and capacities are key to efficiencies. Partnerships should be local-focused and work to jointly improve methodologies and organisational interoperability.

The IFRC and various National Societies have arrangements in place for discounted or free access to imagery and other resources, with examples such as the US State Department's MapGive program, an agreement with Airbus, and coordination with national disaster management agencies. IFRC has joined The International Charter Space and Major Disasters after signing a Memorandum of Understanding in 2017 that enables the activation of the Charter via UNOSAT for IFRC Operations. However, the number and type of arrangements that may be applicable in a given situation is not always well known. There are organisations, such as UNOSAT-UNITAR, that maintain specific technical expertise as part of their mission and duplicating their capacities may not be necessary. Civ-mil coordination may also be an important component. Some IFRC operations have had a person deployed specifically to support it. It might be leveraged better if there was additional work on preemptive establishment of protocols for collaboration and sharing information. Simple tools can play a key role, such as this UAV Mission record template created by UAViators for the 2015 Nepal Earthquake.

> *An operation team will always be smaller than you want and the team might not have a full complement of strong profiles. The gaps fall on information management and that person will get tasked with activities outside of their core skills because they have information and know things.*

Improve assessment literacy

The use of aerial assessment needs to be decided in balance with the situation, and it would be beneficial to have a detailed **decision matrix for the various different tools** similar to the iMMAP - CartONG Humanitarian NOMAD project for mobile data collection. When choosing a tool, it should be understood if it is the best tool to use. Such a matrix could be divided into information for operational leadership such as estimated cost, as well as more technical information such as a catalogue of different sensors. A guide to aerial assessment tools should cover topics such as: reasonable geographic scope and scale, resolution, timeframe, cost, required assets and expertise, and expected outputs. If you talk to a drone operator they may tell you that they can accomplish something, but you need to weigh the costs and other options. If it's a huge area you may need to go with satellite imagery. In some cases, when you need certain information, it may make sense to conduct a household survey. Additionally, a decision matrix would help explain assessment progression and what can be expected at each stage. For example, assessment might progress from manual review of satellite imagery with some cloud cover, to a flood extent analysis using multispectral satellite data, to a helicopter review of key areas of interest, to a detailed ground survey.

> *For any tool people need to understand it exists and the need for it before they begin requesting it.*

The IFRC should continue to adapt and grow data literacy initiatives and **connections between information management and operations leadership**. Part of this might be documented feedback cycles to review products and understand how products are being used – or not used – and what can be done to improve or create new products. Analyses and products created without a close connection to the operations management team risk producing things that are not used or otherwise not useful. It can be difficult to train operations management on the technical aspects of assessment and it can be difficult to train analysts on soft skills and a general knowledge of operation politics; but getting the two sides to communicate effectively and understand each other is vital.

> *As an operations leader when you have good information management you have confidence when you're talking, no matter who walks through the door.*

Assessment might improve if there was better, consolidated **guidance around effective information dissemination**. How do we make data products tangible for people who don't work with data day-to-day? What happens when information requests from operations managers are not standardized? MapAction has progressed on this with Health and Food Security sectors in relation to their map products; reviewing what they've produced and classifying the products, looking to other organisations to see how they've approached the issue, doing a literature review on the cluster, and then conducting a series of interviews. Producing a bunch of products and "seeing what sticks" is not a good long term strategy. If decision makers are unsure that information products are timely and useful, it can be counterproductive to overwhelm them with a flood of different products and initiatives. Analysts might not always be aware of the full range of value-add from various products. How do you curate a story but also include interactive elements? It is necessary to balance the exploratory analysis possible through interactive visualizations with the capacities of the intended audience, both the audience's available time and their skills. How do you effectively convey the limitations of an analysis? These questions all relate to the perennial information management challenge of getting the right person, the right data, at the right time, in the right format.

> *We are increasingly less a passive producer of products, just posting maps we make on a wall and saying 'look at all our maps' and instead actively working to make sure people are using the information properly.*

Cross-cutting considerations

Improvements to assessment should focus on being **applicable to a majority of operations** and not just those major ones that occur once a year or even more infrequently. There are issues that need to be considered in all humanitarian work such as data rights and privacy, climate change, green response, and urbanization. Large, sudden onset disasters usually get the most media coverage, donor interest and scrutiny. It is the response operations for those that have large budgets and lots of resources. There are many smaller operations with limited resources and budgets.

As part of the 2016 Grand Bargain the signatories committed to localization, to "making principled humanitarian action as local as possible and as international as necessary." Setting aside a discussion of the full definition of localization and actual progress on the commitment; any improvements to assessment should consider and involve **local groups and local capacity**. Improvements to assessment should include exploring how to transfer power and agency into the hands of affected communities. Where possible, key roles in assessment should not be limited to large organisations and institutions. For example, by

supporting and promoting initiatives like WeRobotics and Flying Labs to localize expertise and technology access.

> *Human contact is key when designing an operation.*

Full consideration should be given to **modular and open systems and technologies**. Software licensing can be expensive and make it challenging to train, grow collaboration, and scale analysis teams. The IFRC SIMS network guides its members in the use of the free and open source QGIS software for geographic analysis and map making. The software is accessible to anyone and the skills gained are easily applied to later work. Another open source software is OpenDroneMap; it allows anyone to process aerial imagery. Imagery can be shared on the OpenAerialMap platform. Tools like MapSwipe help crowd-source analysis. Staff at REACH have been creating R packages. R is a free and open source software environment for statistical computing, and packages allow methodologies and processes to be easily shared between analysts. Supporting open supports collaboration and accessibility. Building and using modular tools improves adaptability and potential for pooling resources for things like learning, maintenance, and development. The risk of relying on the whims of a single company for your tools is highlighted by Joe Morrison (@mouthofmorrison) who notes during a tweet thread on the geospatial industry that Google Earth Engine "will probably be unceremoniously killed by Google at some point without explanation and an entire era of research will suddenly be impossible to reproduce."

> *With large, complex systems lots of effort can be spent on building the system while failing to educate the users on the tools. It's important to recognize the role people play in the processes and invest in them as well.*

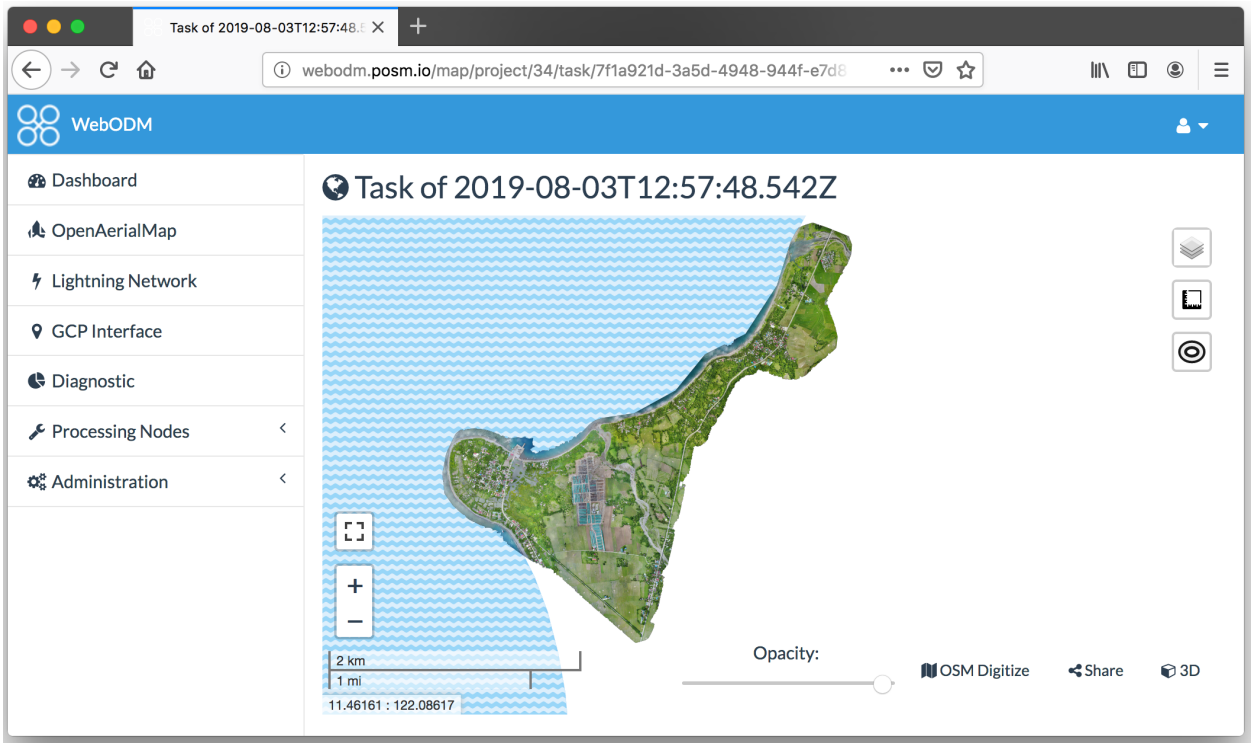

Fig. 9: Processed drone imagery with OpenDroneMap in WebODM

Consideration should also be given to **open data**. Humanitarians are among the many groups recognizing

the value of OpenStreetMap (OSM). Data portals such as Humanitarian Data Exchange (HDX) are widely used for sharing and accessing data key to activities throughout the disaster cycle. Donors are creating open data policies and more organisations are publishing data to the International Aid Transparency Initiative (IATI) Standard. Open data, when appropriate, improves efficiencies and creates additional value.

The recommendation on partnerships speaks to organisations leveraging their strengths. The Red Cross Red Crescent network should **focus on volunteers**. Volunteers may be good at interacting with people and getting awareness, but they are not always adept at passing along what they know in a useful manner. If trusted and properly empowered, they can likely provide the most detailed and most accurate assessment information possible. Because National Society volunteers are community members, the Red Cross Red Crescent network has an invaluable presence on the ground when disaster hits.

> *Red Cross and Red Crescent Volunteers are able to meet, talk, and engage with disaster affected communities rather than flying over their villages, no matter where!*

Most importantly, **remember the mission**. Assessment is intimately linked to data; data privacy and data rights are key considerations as we strive to maintain humanitarian principles. A data-driven decision can still be biased or replacing one gap or oversight with another as we strive to reach the most vulnerable.

> *Don't forget who we are as the Red Cross Red Crescent because of some new technology. You need to check and respect each of the 7 fundamental principles with all our activities.*

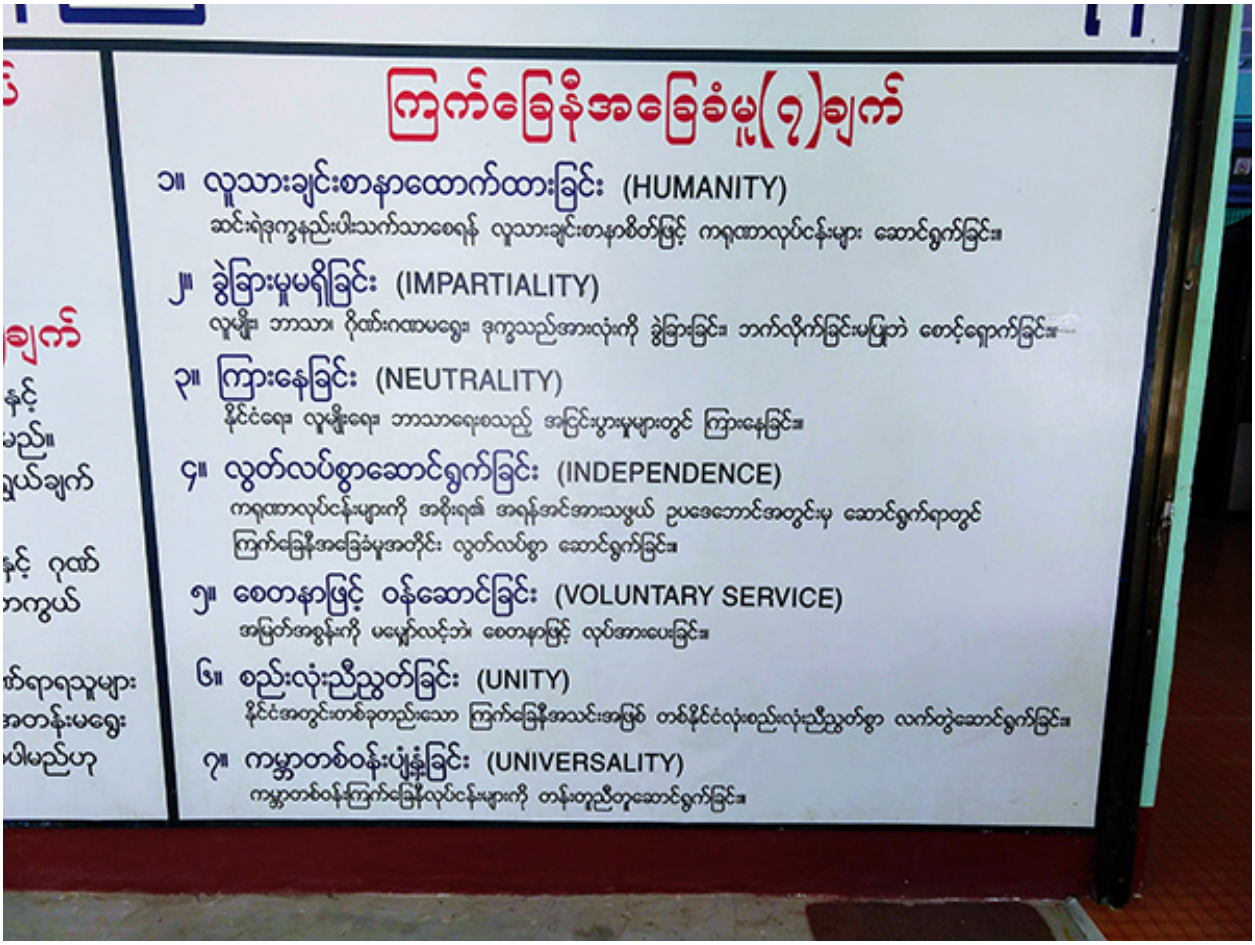

Fig. 10: The 7 fundamental principles on a wall in a Myanmar Red Cross branch | *Credit: Dan Joseph, American Red Cross*

Next Steps

National Societies can identify specific areas that they are well-placed to advance, engage volunteers, share their successes and failures with the wider network, remember the strengths of the Movement, watch that technology does not erode their humanitarian mission, and remember the 7 fundamental principles. They can invest in people as it is important to have champions of good assessment processes, and not just shiny technology. The IFRC can play a key role in weaving assessment-focused initiatives into existing initiatives to create a coherent strategy, promoting global networks of sharing, elevating local champions, and empowering local action. International organisations with technical expertise can explore how to engage with and invest in their audiences and the affected communities they ultimately want to support. There are roles for everyone in improving aerial assessment in support of humanitarian response operations.

Fig. 11: "Let's make the world a better place!" on the wall at Turkish Red Crescent | *Credit: Dan Joseph, American Red Cross*

Acknowledgments

Methodology

This study was co-led by the American Red Cross and the IFRC.

The American Red Cross and IFRC Information Management teams reviewed relevant and publicly available documents published in recent years and conducted interviews of approximately 1 hour each with key stakeholders duration following a structured questionnaire.

In total, 21 interviews with 39 humanitarians and subject matter experts representing IFRC, American Red Cross, British Red Cross, Canadian Red Cross, OCHA/UNDAC, iMMAP, MapAction, REACH, UNOSAT-UNITAR, WeRobotics, and Pacific Disaster Center were interviewed. In order to capture a diversity of experiences in regards to aerial assessment, the profiles of those interviewed included individuals from the domains of information management, GIS and spatial analysis, needs assessment, disaster management, operations, and leadership in emergencies.

For more information, comments or queries please contact im@ifrc.org

About the IFRC

The International Federation of Red Cross and Red Crescent Societies is the world's largest volunteer-based humanitarian network. With member National Red Cross and Red Crescent Societies worldwide, we are in virtually every community reaching 160.7 million people annually through long-term services and development programmes, as well as 110 million people through disaster response and early recovery programmes. We act before, during and after disasters and health emergencies to meet the needs and improve the lives of vulnerable people. We do so with impartiality as to nationality, race, gender, religious beliefs, class and political opinions. Guided by Strategy 2030 – our collective plan of action to tackle the major humanitarian and development challenges of this decade – we are committed to saving lives and changing minds. Our strength lies in our volunteer network, our community-based expertise and our independence and neutrality. We work to improve humanitarian standards, as partners in development, and in response to disasters. We persuade decision-makers to act at all times in the interests of vulnerable people. The result: we enable healthy and safe communities, reduce vulnerabilities, strengthen resilience and foster a culture of peace around the world.

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- Jessica Letch, Manager, Emergency Operations and Coordination, IFRC Asia Pacific Regional Office
- Lucia Lasso, Head of Emergency Operations, IFRC
- Luke Caley, Information Management Lead, IFRC
- Steve McAndrew, Deputy Regional Director, IFRC Americas Regional Office

National Society stakeholders

- Charlotte McGlade, Director of Emergency Operations, Canadian Red Cross
- Dale Kunce, CEO Cascades Region, American Red Cross
- Jean-Pierre Taschereau, CEC, Leadership Development, Canadian Red Cross
- Laura Cardoso de Oliveira Avelino, Senior IM Advisor, Canadian Red Cross
- Paul Knight, GIS Officer, British Red Cross

Inter-agency stakeholders

- Alan Mills, Preparedness Coordinator, MapAction
- Andrea Porro, Afghanistan Country Representative, iMMAP
- Arie Claassens, Iraq Technical Advisor, iMMAP
- Christophe Bois, Director of Planning and Development, iMMAP
- Craig Von Hagen, MENA Regional Director, iMMAP
- Gabriel Clavijo, Communications and design officer, Colombia, iMMAP
- Issa Tingzon, Thinking Machines
- Ivan Contreras, Data Analyst, iMMAP
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- Jeffery Villaveces, Colombia Country Director, iMMAP
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- Joseph Muhlhausen, Head of Drones and Data Systems, WeRobotics
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- Peter Muller, Global Lead, UNDAC
- Phillip Frost, Geoinformatics Lead, MENA, iMMAP
- Sebastian Ancavil, GIS Officer, IOM

Related literature

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Congalton, R. G., & Green, K. (2019). *Assessing the accuracy of remotely sensed data: principles and practices*. CRC press.

Davill, R. (2015) The Future of Drones in Humanitarian Relief. MSc. Thesis, King's College, London

Ezequiel, C. A. F., Cua, M., Libatique, N. C., Tangonan, G. L., Alampay, R., Labuguen, R. T., ... & Loreto, A. B. (2014, May). UAV aerial imaging applications for post-disaster assessment, environmental management and infrastructure development. *In 2014 International Conference on Unmanned Aircraft Systems (ICUAS)* (pp. 274-283). IEEE.

Greenwood, F., Nelson, E. L., & Greenough, P. G. (2020). Flying into the hurricane: A case study of UAV use in damage assessment during the 2017 hurricanes in Texas and Florida. *PLoS one*, 15(2), e0227808.

Jensen, J. R. (2016). *Introductory digital image processing: a remote sensing perspective* (No. Ed. 4). Pearson Education, Inc.

Khaloo, A., Lattanzi, D., Jachimowicz, A., & Devaney, C. (2018). Utilizing UAV and 3D computer vision for visual inspection of a large gravity dam. *Frontiers in Built Environment*, 4, 31.

Kohli, D., Sliuzas, R., Kerle, N., & Stein, A. (2012). An ontology of slums for image-based classification. *Computers, Environment and Urban Systems*, 36(2), 154-163.

Loos, S., Lallemant. D., Baker, J., McCaughey, J., Yun, S., Budhathoki, N., Khan, F., Singh, R. (2019) G-DIF: A geospatial data integration framework to rapidly estimate post-earthquake damage.

Malpeli, K. C., & Chirico, P. G. (2015). Testing a small UAS for mapping artisanal diamond mining sites in Africa. *Photogrammetric Engineering and Remote Sensing*, 81(4), 257-263.

Notti, D., Giordan, D., Caló, F., Pepe, A., Zucca, F., & Galve, J. P. (2018). Potential and limitations of open satellite data for flood mapping. *Remote sensing*, 10(11), 1673.

Oren, Camille, and Verity, Andrej. Artificial Intelligence (AI) Applied to Unmanned Aerial Vehicles (UAVs) And its Impact on Humanitarian Action. *DH Network.* May 2020.

Radjawali, I., & Pye, O. (2017). Drones for justice: inclusive technology and river-related action research along the Kapuas. *Geographica Helvetica*, 72(1), 17.

Soesilo, D., Meier, P., Lessard-Fontaine, A., Du Plessis, J., Stuhlberger, C., & Fabbroni, V. (2016). Drones in Humanitarian Action: A guide to the use of airborne systems in humanitarian crises. *FSD Report*, 1-60.

Stehman, S. V. (1999). Basic probability sampling designs for thematic map accuracy assessment. *International Journal of remote sensing*, 20(12), 2423-2441.