Site Mapping Guide

International Organisation for Migration

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Introduction

Welcome to *SiteMapping.Guide*, an online guidance for the production of site maps in humanitarian response. Site maps are a key resource at all stages of a camp lifecycle; from the site planning of empty or partially settled land; the coordination and management of services on a site; the development and improvement of a sites' infrastructure; to the site closure/handover/decommissioning stage.

The aim of this guidance is fourfold:

1. **Broaden the development of site maps to more humanitarian actors** and profiles, mainstreaming the skills required and reducing reliance on a limited pool of specialized profiles.
2. **Increase the speed at which site maps are developed.** The shorter the lead time for creating site maps, the more useful they are for planning activities and coordinating partners in site, especially in sudden onset contexts.
3. **Scale the availability of site maps** to increase their benefit to reponses in a wider number of sites as well as in a wider number of countries.
4. Encourage the creation of **consistent site map products**, in terms of visuals, quality and process that are affected population-centric and that adhere to data responsibility and safeguarding standards.

The Site Mapping Guide provides a full step-by-step workflow to develop site maps. It also outlines key considerations and data protection risks associated with the management of drone captured imagery, as well as the responsible dissemination of related information products produced in the process.

This guide presents two different approaches to developing site maps. The first approach uses existing satellite imagery and the second uses drones to capture aerial imagery of sites when and where satellite imagery is not available or not suitable.

What is a Site Map?

While no strict definition of a site map exists, this guidance considers site maps to be physical or electronic maps of IDP displacement sites that use imagery

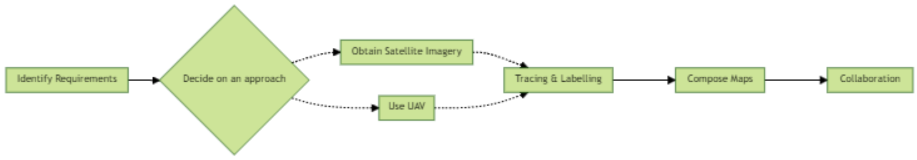


Figure 1: The Site Mapping Workflow *Source: IOM*

(aerial or satellite), along with the tracing and labelling of infrastructure (current or planned) as a tool for planning, coordination and risk analysis.

> **Note**
>
> Infographics or maps, which focus on needs or activity/output-level indicators are, for the purpose of this document, considered as Site Profiles rather than Site Maps and are beyond the scope of this guide.

Audience

This guide is for any Camp Coordination Camp Management, Shelter, or assessment actor, working in humanitarian contexts, requiring site maps to do site planning, camp coordination or risk analysis and working at either agency or inter-agency level.

While some prior knowledge of GIS software is beneficial for those who plan to use this guide, it is not a prerequisite. We hope that the steps documented in the below chapters are sufficient in detail and clarity for first-time users and will accompany new and experienced site mappers through the process of making site maps, from creating and visualising spatial data to exporting and disseminating standardized site maps.

While the guidance is relevant for all humanitarian staff, section that are specifc to IOM can be found in blue boxes like the following:

> **Note for IOM staff**
>
> Sections in the guidance that are specific to IOM staff will appear in boxes like this.

When and how to use site maps

Site maps can illustrate camp settings in both sudden-onset disasters as well as protracted emergencies. Site maps are relevant throughout the camp lifecycle and support the set-up, care and maintenance, closure and post-closure or recovery stages of a camp by being used to support the following activities:

- **Site planning** during sudden-onset emergencies or protracted crises.
- **Site improvements** - using site maps to plan improvements to infrastructure and site layout for disability and inclusion, GBV and fire hazard risk mitigation.
- **Site-level camp coordination** amongst service providers and ensuring coordination in the establishment of essential site infrastructure and camp services.
- CCCM coordination at the Cluster-level.
- GBV/ Protection **Safety Audits** conducted through direct observation, key informant interviews, focus group discussions.

Figure 2: Rehabilation of Wau PoC site *Source: IOM*

Acknowledgments

This guide was developed by IOM, with considerable inputs, support and feedback by many experts in fields such as site planning, GIS, CCCM and GBV. Financial support for this guide was generously provided by United States Bureau of Population, Refugees, and Migration (BPRM) through the Safe From the Start Initiative. A full list of names of those who contributed or support to this guide can be found in the acknowledgements annex.

Feedback

Many of the approaches and software/hardware tools are quickly evolving and improving. As such, we consider this guide to be a living document. If you have any suggestions on how we can improve this guide, please reach out to majones@iom.int and bmcdonald@iom.int.

Part I

Part 1 - Preparation

Chapter 1

Identifying requirements

Producing site maps requires a significant investment of personnel, time, software and hardware. In addition to these, the political/security/conflict context of the area, as well community acceptance and regulatory framework are factors to consider in whether or not site maps can be developed in your context and if so, which approach is most feasible.

Before jumping into **how** to develop site maps, it is important to first assess **if they can or should** be developed:

1. **Are site maps needed** in your context and what activities or decisions will they inform?
2. What **stakeholders** need to be involved, both in the development of the site maps (affected population, local and national authorities, staff, etc) and in their use (CCCM actors, local authorities, etc)? *How will buy in from these stakeholders be ensured?*
3. **What is required** to develop site maps in your context? Regardless of the chosen approach, the development of site maps requires funding, personnel, time, hardware, software, and connectivity. A shortcoming on any of these may affect the feasibility or timeline of the development of site maps.
4. What red-line **contextual challenges*, risks and sensitivities exist or may arise during the development of the site maps that could affect the overall feasibility or appropriateness of their development?

1.1 Stakeholders

Whilst the development of site maps should be approach and context dependent, typically the following stakeholders will be involved:

- **Affected population in sites.** These need to be consulted before collecting drone-captured imagery to make sure they are informed and consent to the activity in order to minimize risks associated with this approach and prevent any misunderstandings.
- **Humanitarian actors.** These can help inform which and how many sites need to be mapped. Humanitarian actors, especially those on the ground, will also feed into the iteration process of the site maps, in order to validate geographic information and keep the maps and the underlying data layers up to date.
- **Authorities.** The authorities are a crucial interlocutor for approvals. In addition, their engagement can promote the use of the site maps in decision making processes. The participation of authorities in the site mapping process will also facilitate the handover and long term management of information, expertise and equipment, as well as support capacity development initiatives for future scenarios.
- **Legal team.** IOM Legal colleagues will provide any additional guidance on data collection, processing and sharing related to your specific context and are responsible for providing the final approval on the use of drones.

1.2 General Requirements

Developing site maps typically requires the following:

1.2.1 Personnel

Staff with relevant skills and expertise. Support staff such as drivers and procurement support will also be needed. Depending on the number of sites and how quickly the site maps are needed, the site mapping team may need to be scaled up.

1.2.2 Context

The security, political and regulatory environment play a large role in determining the approach to site mapping in a country but also whether or not the process is feasible at all. Identification of such challenges and potential risks is best done as early as possible to avoid wasting resources or to allow sufficient time to mitigate them.

1.2.3 Time

Developing site maps can be a time-intensive process, requiring prior consultations with various stakeholders, lead-time for procurement of equipment, travel time for site visits, time for collecting and processing the imagery, composing the site maps and collaboratively iterating and updating their content. These are important factors to consider when looking at the time frame of their intended use.

1.2.4 Funding

There are a series of finanical costs involved in the development of site maps that need to be taken into account. Annex 4 provides a table with indicative figures for the purpose of costing a site mapping exercise.

1.2.5 Hardware and Software

Hardware requirements must include: a laptop (with sufficent processing power, RAM and storage); the drone kit (drone, remote, batteries etc.); a smartphone (for use as a controller); ground-control points (printout or spray paint). It is optional but advised to also have tablets, to support usage of the maps and any connected data collection exercised.

Software requirements include: QGIS (or similar such as ArcGIS); WebODM (or similar such as PIX4D); DJI Fly mobile app; Dronelink mobile app (or similar for flight planning); Avenza Maps (or similar, for geoPDF usage) [1]

1.2.6 Connectivity

In situations of sudden onset disasters, connectivity can be very challenging and quite often can lead to bottlenecks and delays. While connectivity requirements vary depending on the chosen approach, a minimum degree of connectivity should be assumed for the initial gathering the required geographic information and data layers.

If using satellite imagery sufficent connectivity to download the imagery is required, or alternatively all map development can be done remotely with feedback from within country. Connectivity also affects the UAV imagery workflow as limited connectivity will require the use of offline tools only and for all processing of the imagery to be done locally. In areas with good connectivity, the imagery can be transferred to remote tools and computers for processing, allowing for a higher degree of remote support.

[1] Where possible free and open source software is used in the process, in-line with the UN Secretary General's Roadmap for Digital Cooperation An exeption for this are the Dronlink app which is commercial and Avenza Maps which is free but with paid features.

Chapter 2

Deciding on an approach

There are two approaches to making sites maps presented in this guide. The main differerence between the two is in how aerial imagery is obtained:

1. Using high-resolution satellite imagery.
2. Using drones to capture aerial images of the site.

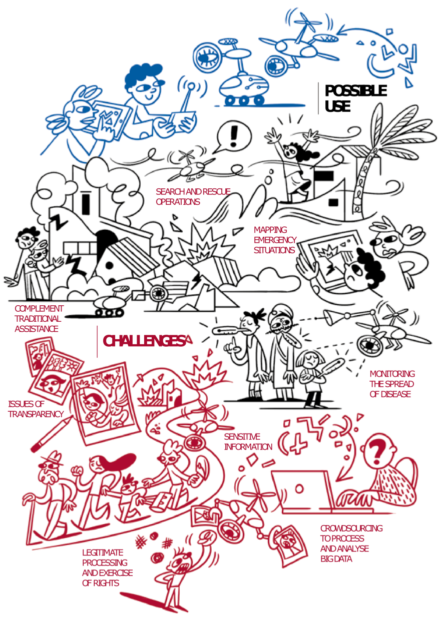


Figure 2.1: Uses and challenges of drone use *Source: ICRC*

Each of these approaches have pros and cons and it is important to evaluate each approach against the following criteria before assessing which approach to take in your context:

2.1 Information Needs

It is important to be clear on what images you want to collect and for which specific purpose. Consider whether you need only an image/orthomosaic or whether you are look to create a Digital Elevation Model, a 3D model, a NDVI index etc. as this will affect your flight plan. Think about whether there are others applications outside of site mapping that you are in need of, such as drainage analysis, slope analysis, landslide risk analysis or vegetation cover analysis. Consider what area needs to be covered whilst bearing in mind that larger areas require longer flight times, more storage etc.

Depending on the purpose and audience of the map, it is important to capture the site's surroundings in order to situate it within its wider context. You should not map only within the boundaries of the site and where possible, you should try to include neighbouring host community settlements, transport linkages and other key infrastructure facilities, potential hazards or environental vulnerabilities in the area.

You should not be flying the drone above as many areas as possible to collect as many images as possible and then decide what to do with them. The data collection must be adequate, relevant and not excessive in relation to its purpose (only collect data which is needed).

2.2 Conflict and Data Sensitivity

Due to protection risks, the humanitarian use of drones in conflict settings is strongly discouraged. The term "dual-use technology" is commonly used to describe a technology with both civilian and military applications. With the rise of the use of drones for military use, there is a risk that the use of drones for humanitarian purposes in sites may be perceived as a security threat by the site population or cause trauma due to an association of drones with their military uses. In conflict settings armed actors or authorities are likely to perceive the flying of drones as both a security and informational risk. This means that the importation of drone equipment and/ or the request for flight approvals will likely be denied, or that their use in a site risk being perceived as a security threat. [^footnote]

There are **key considerations to take into account when collecting, processing and sharing any type of data**. These considerations determine the degree of sensitivity applied throughout the data life cycle and include:

- The potential to harm data subjects and others;
- The potential to discriminate;
- The potential to harm IOM staff and individuals representing authorized third parties.

In addition to the data risks and concerns outlined in the IOM Data Protection Manual, there are additional specific concerns and risks associated with the use of drones.[1]

[1] IOM Data Protection Manual

Once your flight area is identified, a risk-benefit assessment should be conducted prior to using drones. The assessment will evaluate the risks and benefits associated with collecting and processing drone captured imagery and determine whether flying a drone for the collection of aerial imagery is the best approach in your context.

2.3 Data Security and Responsibility

The use of drones to capture aerial images for site mapping does not require the collection of personal data. **Individuals must not be identifiable** from captured images. Ensure that the flight settings (altitude, angle etc.) eliminates or reduces as much as possible the likelihood that the captured imagery may directly or indirectly identify an individual. If, by mistake, you collect images in which people can be identified, you should immediately delete them. However, if the image taken must really be used, you can either crop the image or blur the faces of people who could be identified. While collecting the data or shortly thereafter, check whether any of the images captured contains sensitive data and therefore should be deleted or otherwise removed from/made unrecognizable in the image (for example, a group of individuals that could be identified as part of a specific group, image of illegal crops or settlement).

2.4 Community Engagement

Creating Site Maps requires buy-in from the community in and around the sites area of interest, in which they are informed of the planned activity, understand how its planned to be used and why its needed and to be able to accept or reject the activity or provide inputs into how the activity is conducted or how its outputs are used.

2.5 Regulatory Environment

It is crucial to be aware of and fully understand the laws at both national and local-levels, as well the regulatory procedures and norms related to the use of UAVs, as these can vary significantly between contexts. The regulatory environment can refer to import procedures and restrictions; limitations on size and types on drones; pilot qualification requirements; and geographic limitations for UAV flight.

The Global Drone Regulations Database keeps an updated collection of country-specific regulations. It can be used to better understand the source of legal information, find relevant contact information, operating rules, as well as licensing and approval procedures. [2]

[2] DroneRegulations.info launched by the UAVatiors network in 2014, is a database of national-level UAV regulationsi

2.6 Organizational Requirements

Many organizations have internal rules and guidance governing the use of technologies such as Drones. Donors may also have their own rules around their uses and the use of data resulting from the exercise. During the planning stage, it is important to contact the relevant organisation focal-point to ensure compliance with these rules.

> **Note for IOM staff**
>
> During the planning phase, it is important that IOM staff reach out to IOM's Office of Legal Affairs (LEG) leg@iom.int. They will provide legal and compliance guidance, as well as the latest version of the *Drone usage checklist* and *Risk-benefit analysis template*.

2.7 Level of Accuracy

In emergency contexts, the use of drones or acquiring high resolution satellite imagery of the site and its surrounding environment may not be feasible. Additionally, in the first days of an emergency, exisiting maps or preliminary spatial data on a site may not be digital (for example only photocopies of printed documents from local authorities or hand drawn maps may be available). In such cases, producing site maps with a high level of accuracy can be very challenging.

Whilst there are some issues and limitations to translating and integrating hand drawn maps into GIS environments, existing printed or hand drawn maps should be digitize by redrawing them in a GIS environment.

Once in possession of the printed or hand drawn map, collect the GPS coordinates of key locations in the site, such as existing buildings. Georeference a map in a GIS environmen. Create new layers bearing in mind any potential distortions, incorrect scales and degree of accuracy of the original map as well as how updated the original map is to current conditions in the site. The data layers produced need to be verified and validated by field colleagues. Verifying the resulting data layers in the field can help mitigate these limitations and improve the accuracy of the digital map. One approach is to coordinate a walk-around the site where participants check and annote the map using Avenza maps and a geoPDF draft map (more of this in 7.2)

However, low accuracy maps can still be used as supporting evidence to support decision making and programming. Whilst low accuracy maps should not be used to conduct risk analysis such as flooding or fire hazards and cannot be used for activities such as site planning, they can still be used for coordination purposes or as tools for focus group discussions. Depending on the intended use of the site map and the level of accuracy required for that activity, maps of the site can be hand drawn onto large surfaces by either experienced site planners or members of the affected population.

2.8 Decision Matrix

Scenario	*Satellite Imagery*	*UAV imagery*
A site map is needed in the fastest time possible		
The site is in a conflict affected area		
The location of the site is inaccessible		
There is persistent cloud-cover over the site		
Very detailed imagery is required		
A DSM or 3D model is required		

Part II

Part 2 - Obtaining imagery

Chapter 3

Satellite imagery

The choice of using satellite imagery, instead of capturing aerial imagery using drones, may be due to the need for rapid mapping turnaround time, lack of direct access to the area of interest or limitations to flying a drone listed in the previous chapter.

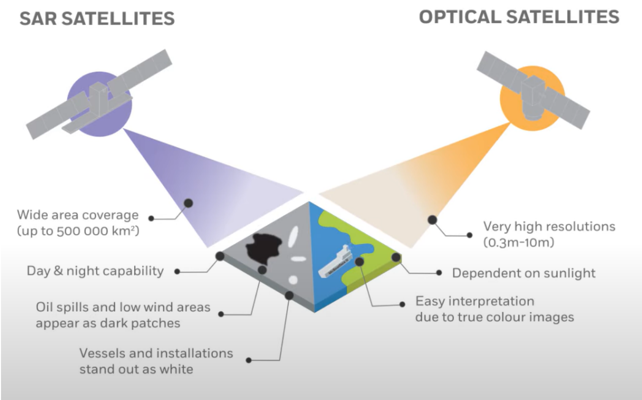
This section introduces the different types of satellite imagery, what to consider when choosing imagery most appropriate for your use case and where to source the imagery.

3.1 Types of satellite imagery

There are different types of satellite imagery. The types of imagery generated from a satellite depends on the kind of image-capturing method (remote sensing technology) it uses: active or passive sensors. Active sensors emit radiation towards the Earth's surface and collect the reflected radiation. Lidar and Synthetic Aperture Radar (SAR) are both example of active sensors. SAR emits electromagnetic pulses whereas Lidar emits light pulses towards the Earth surface, both measuring the reflection. Passive (or Optical) sensors detect radiation naturally reflected from the Earth's surface and are dependent on the day-night cycle.

For the purpose of site mapping, **satellite imagery sourced using Optical satellites is most prevalent and useful** (as these typically produce imagery with colour similar to how the human eye preceives color).

> ⚠ Note on Colour bands
>
> Satellites produce a range of different visual outputs. These visual outputs differ in their color combinations. Wavelengths detected by the satellites are translated into color bands then can combined to form an Index. This allows further analysis to be conducted. **True-color images**, as produced by Optical satellites and often used for mapping purposes, are a



Synthetic Aperature Radar(active) vs Optical(passive) sensors *Source: ESMA Lisbon*

combination of the red, green and blue bands which results in an visual output similar to how we see color with our eyes. Other types of outputs include the **Normalized Difference Vegetation Index** (NVDI), which can be used to monitor changes in vegetation, or the **False Color Infrared** combination, which can be used in water detection during the heavy rain seasons or in the event of flooding.

3.2 Cloud cover

Passive satellites are not able to capture through clouds and therefore can be limited when observing certain areas with dense cloud coverage, posing a challenge to rapid response to hazards such as cyclones or floding.

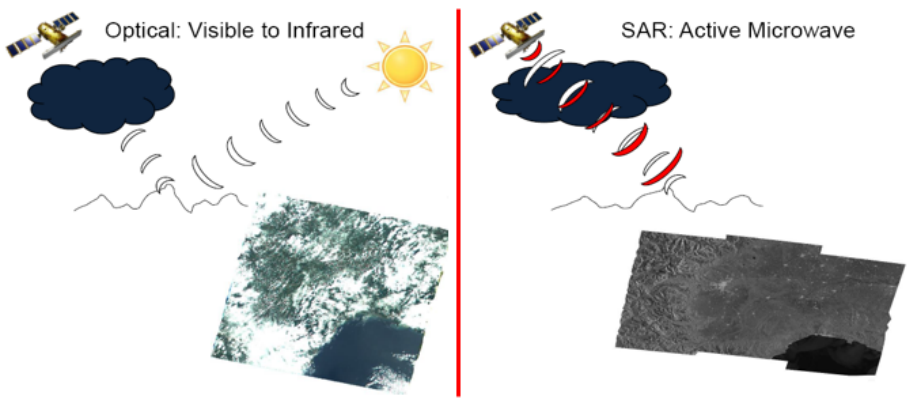
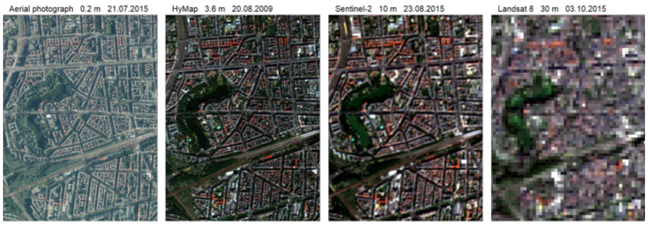


Figure 3.1: Optical imagery sources are affected by cloud cover *Source: Harris Geospatial*

3.3 Spatial resolution

The resolution of a satellite image is categorized as follows:

- High resolution: 30cm-5m/pixel
- Medium resolution: 10-30m/pixel
- Low resolution: over 60m/pixel



Comparison of different spatial resolutions *Source: X. Yao*

A 10m resolution means that each pixel represents a 10m x 10m area on the ground.The smaller the spatial resolution, the higher the level of detail.

Depending on the user's needs, different image resolutions can be used:

- High resolution images are used in scale analysis or monitoring since a smaller area is often covered. The level of detail at such spatial resolution allows for small and individual objects to be identified. High resolution images are ideal for humanitarian aid applications, detailed mapping, urban planning, as well as infrastructure, forestry and agriculture monitoring. However, high-resolution imagery is expensive and as a result, less of it is openly accessible. **For the purposes of creating site maps, high resolution imagery is preferable**.

- Low to Medium resolution images are useful for understanding the bigger picture, whether that is looking at historical trends or deriving insights from spectral analysis. For example, ESA's Sentinel and NASA/USGS Landsat data provide historical data at this resolution.

3.4 Imagery sources

Some free data sources for low to medium resolution imagery include USGS/NASA's Landsat and ESA's Sentinel series.

High-resolution imagery can be sourced from UNOSAT. Some satellite image providers also provide imagery for certain select disasters. An example of this is Maxar's Open Data Program. OpenAerialMap can also be a useful source, where open licenced aerial imagery is made available for download.

Note for IOM staff

For IOM staff, subject to availability, high-resolution Satellite imagery can be requested from IOM DTM GIS unit dtmgis@iom.int

Chapter 4

UAV imagery

Once you have understood what is required to collect aerial imagery using drones, the site mapping exercise and the use of drones has been discussed with the various affected stakeholders, a risk-benefit assessment has been conducted and approvals and permissions has been received from relevant actors, you are ready to start planning the flight.

4.1 Obtaining a drone kit

> **Note for IOM staff**
>
> On request, the Global CCCM team in Geneva can coordinate, with the support of the site mapping team, the deployment of a drone kit located at IOM HQ. IOM staff can reach out to CCCM Support globalcccm@iom.int with a brief description of the site mapping exercise and the intended use of the site maps, as well as the risk-benefit assessment and approval from IOM LEG colleagues. If and when available, the drone kit will then be sent with staff deployments or shipped to the requesting mission.

4.2 Pre-flight

Prior to the flight, consider the following: [1]

- **Weather:** Most drones are not waterproof and therefor it is important to check precipitation forecasts in the flight area of interest. Wind speed also has an adverse effect on drone flight. Both type and size influence the susceptibility of drones to wind. Smaller drones, such as the DJI Mavic Mini for instance, have a windspeed operating ceiling of approximately

[1] A comprehensive checklist was created by the Humanitarian UAV Network]

18km/h. Clouds, if above the flight altitude can have a positive affect as they act as a giant soft-box scattering sunlight, but if they are rolling may cause inconsistencies with light exposure. If possible, it's best to fly around the middle of the day, when the sun is overhead, to limit shadows in the imagery.

- **Stakeholder engagement:** Assuming regulatory processes have already been followed. Its important that the population in the site area of interest is fully informed and understands the plannedactivity, that there is acceptance of the activity and that theres a communication channel in place for the community to voice any complaints or feedback.
- **Hardware checks:** Make sure that all batteries are charged and that all required equiments is functioning.
- **Pre-identify takeoff and landing sites:** A suitable area will be free of obstructions such as trees or overhead wires and away from move foot or road traffic.
- **Create a flight plan:** This includes the planned route, with altitude, overlap and takeoff/landing areas pre-programmed.

4.2.1 Nadir vs oblique images

The image captured when a drones camera faces directly down is called a *nadir* image. For creating an orthomosaic of a site, nadir images are preferred to oblique images which are more suited to tasks such as 3D modelling.

Figure 4.1: An example of an *oblique* angle image of Bakassi Camp, northeastern Nigeria *Source: IOM*

4.2.2 Ground control points

Ground control points are marks created on the site as reference points to match specific points on the image to specific coordinates within the site. They provide

Figure 4.2: An example of a *nadir* angle image of Wau PoC, in South Sudan *Source: IOM*

a great degree of accuracy for the image that relying on the GPS of the drone by itself.

Use a minimum of 3 GCPs and capture the coordinates of each GCP centrepoint with a Phone or handheld GPS for an accuracy level of 1-3 metres. For accuracy of 1cm a specialised Real-time kinematic positioning (RTK) kit is required.

Figure 4.3: An example Ground Control Point *Source: Pix4d*

4.2.3 Path and image overlap

A minimum of 16-31 images are needed to create an orthophoto from drone captured imagery with WebODM. Images should averlap by 70-72%.

- Minimum number of images captured: 16-32
- Minimum image overlap: 70-72%
- Minimum image overlap for 3D: 83%

4.2.4 Flight altitude

Ground Sampling Distance (GSD) refers to geographic area represented by one pixel of an image. It reflects the resolution of the image, with flight height and image sensor resolution being the two biggest determining factors. For site mapping a GSD of 2.5cm2 - 1cm2 is the range most suitable. Most flight planning software automatically calculate the GSD based on an entered flight altitude. The flight altitude should also consider potential flight obstructions such as trees or overhead power lines, noise and also privacy as having a flight altitude and GSD that is too low could result in the unintended consequence of capturing information that could be personally identifiable.

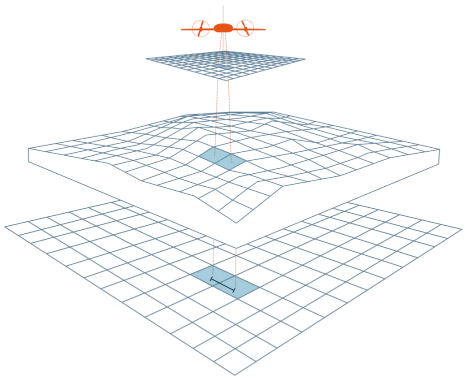


Figure 4.4: GSD is the amount of actual ground captured by the distance between the center point of two adjacent pixels. *Source: wintra.com*

4.3 Post-Flight

Following the flight, make sure to check the imagery quality and completeness, safely storge the equipment and ensure the data captured is securely stored.

4.4 Post-Flight processing: Creating Orthomosaic

Drone captured images then need to be stitched together into one image or *orthomosaic*.

WebODM is a free software that can be used to create orthomosaics from drone captured-imagery. To install WedODM manually, follow the steps outlined here. Once installed, create a new project.Upload the images to create a task. After the task has been successfully completed, the orthomosaic will be ready to download. Select *orthophoto.tif* in the list of available formats and the single image output will download.

In addition to creating orthomosaics, WebODM can also produce Digital Surface Models or 3D models of the site.

Part III

Part 3 - Developing Maps

Chapter 5

Tracing and labeling

Once the aerial imagery has been obtained, two primary post-processing approaches are involved to extract the geographic information of different site features from the imagery. The site mapper can either **manually** or **automatically** trace and label these features.The site features to be extracted from the aerial imagery will depend on the needs, objective and audience of the site map.

For instance, the site mapper may look to map the location and configuration of shelters in a site. Post-processing of the image will consist of generating a new data layer of shelter outlines.

It is important to be aware of the advantages and the disadvantages of choosing whether to manually or automatically trace and label site features in order to determine which option is most suited. The table below presents a summary of both.

Manual	Automatic
Advantages Extracting geographic information by manually tracing and labeling requires only basic GIS skills. It can be done offline in contexts with limited connectivity. Allows for medium to high accuracy of traced shelters and buildings that have irregular or non-rectangular geometry.	A high number of shelters and buildings can be traced and labelled in a small amount of time, relative to manual tracing.

Manual	Automatic
Disadvantages Time intensive, relative to automatic tracing.	Most open-source tools require some minimum understanding of machine learning principles. Most low-code tools are not open-source and may incur additional costs Depending on 1) how much data is available to train the machine learning model, 2) the type and accuracy of the tool used (amongst other factors), there may be errors or inaccuracies in the outlines and labels generated requiring the site mapper to manually verifying and edit outputs.

Note

If there is high cloud or tree coverage, some features may not be visible in the aerial imagery and thus will not be visible to the site mapper or detected by the machine learning model. Therefore, it is crucial to validate all extracted geographic information by consulting with and seeking inputs from stakeholders and colleagues in the field.

5.1 Manual tracing

Manual tracing can be done in GIS or AutoDesk software. QGIS can be downloaded for free here. Once the software download is complete, georeference the aerial imagery into a new workspace. Create a new vector layer and toggle edit to trace the required features and save the data layer.

5.2 Automatic tracing

Below are some tools which can assist you in creating a workflow for automatic shelter detection:

- Create a training data set from aerial imagery with Groundwork.azavea. When signing up with Groundwork, up to 10 campaigns (projects) can be created free of charge when creating an account. Upload orthomosaic image to Groundwork, label features and export the training data in .json format.
- Extract shelter outlines from aerial imagery using Mapflow.ai's built in deep learning and semantic segmentation models. After signing up, create a new project.

Tiff vs GeoTiff

In order to use your orthomosaic in Mapflow.ai, you may need to georeference your image in QGIS beforehand and export it as a GeoTiff with either web mercator, UTM or lat-lon coordinate systems.

Mapflow can also be used as a plugin in QGIS and can be downloaded from here. Further guidance on how to install the Mapflow QGIS plugin is available here.

Chapter 6

Composing site maps

Site maps are composed of layers of geographic information/ data. These data layers are loaded and manipulated in a Geographical Information System (GIS) such as QGIS, ArcGIS and others. After layers are correctly projected onto their corresponded geographic location and different visualization settings are applied, a layout is composed (either from scratch or from an existing site map template).The layout is then exported to PDF or geoPDF. Styled and raw data layers can can be saved into a Geopackge for a seamless transfer of geographical information between mappers and future mappers.

6.1 Examples of site maps

Below are some examples of site maps. More examples can be found here.

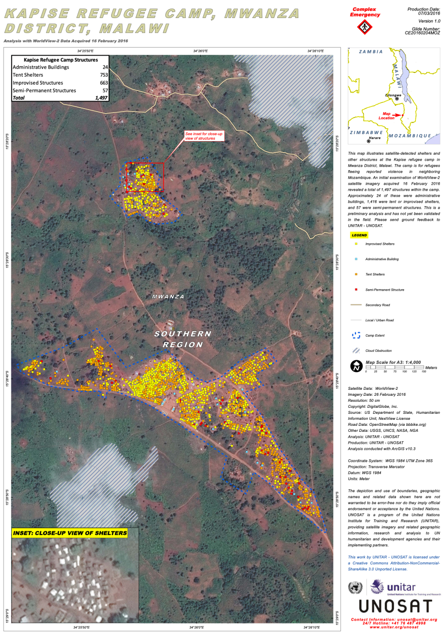
6.2 Working in GIS

GIS software can open different file types: Vector files (which use points, line segments and polygon objects to identify geographic information), Raster files/images (which use cells/ pixels to represent geographic information), and Delimited text files (such as .csv file types). For example:

Data Layer Example	File Type
Aerial Imagery	Raster file
Location of healthcare facilities or service providers	Vector file
Population per block	Delimited Text file

6.2.1 Loading data layers and veryfying projections

To prepare the site map, load the data layers into a GIS workspace, such as QGIS.



(a) Source: UNOSAT

(b) Source: REACH Initiative

Figure 6.1: **Examples of Site maps**

Most publicly available geographic information datasets are projected in a world Coordinate Reference System (CRS) (WGS 84). When loading a layer projected in a whole world CRS, the layer will look slightly distorted in the workspace. Ensure that the Project CRS is set to the area of your site location. You can use the epsg.io database of coordinate systems to know the coordinate system you should be using for you context. All loaded data layers need to be checked and projected where needed, according to the project CRS.

6.2.2 Layers and elements of a site map

This guide is accompanied by a site map template which can be loaded into QGIS's Print Composer. Below is a dummy example of a site map produced using this template.

> **Note**
>
> For the purposes of supporting a **standardized approach to the production of static site maps**, and ensuring new **site maps can be compared and used alongside existing maps**, the template provided in this Site Mapping Guide is one approach to laying out a site map, however this can and should be adapted based on the context and it's audience.

The following list of layers and elements can be included in the final output:

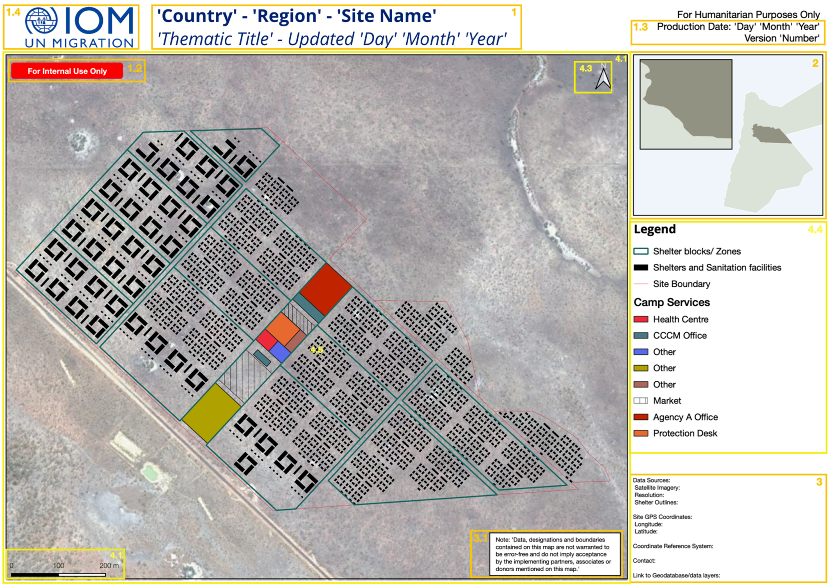


Figure 6.2: An example of a dummy site map composed in QGIS using the site map template included in this guide. *Source: IOM*

- **Title and Subtitle (1)**
  - Country
  - State
  - Site Name
  - Thematic Title
  - Date site map was last updated
- Site map audience/ permission/ sharing restrictions **(1.2)**
- Production date and version number of site map **(1.3)**
- Agency/ NGO Logos **(1.4)**
- **Inset maps (2)**
  - At Country/ Regional level
  - At Regional/ Area level
- **Notes (3)**
  - Data sources
  - Satellite Imagery source
  - Imagery Resolution
  - Coordinate system
  - Site GPS coordinate points
  - Agency/ NGO Logo
  - Contact
  - Link to Geodatabase/ corresponding data layers

  - Disclose limitations regarding accuracy of site map **(3.1)**

- **Map**
  - Base Map (satellite/ aerial imagery) **(4.1)**
  - Scale bar **(4.2)**
  - Orientation indicators **(4.3)**
  - Legend **(4.4)**
  - Camp Infrastructure **(4.5)** :
    * Shelters
    * Shelter blocks
    * Zones
    * WASH facilities
    * Water points
    * Education facilities
    * Health Facilities
    * Distribution points (Food/ NFI)
    * Markets(s)
    * Information desks
    * CFM desks
    * Other camp facilities
    * Movement network (Roads, pathways)
    * Community areas/ centre
    * Religious buildings/ spaces
    * Site Entrance(s)
    * Site boundary
    * Security facilities or guard points
    * Fences/ Camp Boundaries

- **Environment**
  - Host community
  - Green belt
  - Trees/ Vegetation
  - Agricultural land

- **Optional additional labels**:
  - Functioning/ non-functioning facilities
  - Male/ female latrines
  - Unusable area
  - Agency responsibility for each section of the site
  - Shelter numbers/ Addressing
  - Summary information/ figures
    * Site population (households and individuals)
    * Site area
    * Total no. of shelters
    * Shelter type and size
    * Quantity of sanitation blocks/ latrines/ showers
    * Type of water supply
    * Total no. of water points

6.2.3 Visualizing data layers

Once the files are opened in QGIS, they will appear as layers. These layers can be duplicated in order to show different visualisations of the same file.

6.2.4 Adding fields and editing attributes

Shapefiles (ESRI Shapefile format) are the most common type of vector file. This file format dataset consists of several files. Of these different files, there are two which you should be familiar with for the purposes of this site mapping exercise. First, the .shp file, which contains the geometries of the features in the layer and secondly, the .dbf file, which contains the feature **attributes**.

The attribute table interface allows you to view and [edit the attribute data] (https://docs.qgis.org/3.22/en/docs/user_manual/working_with_vector/attribute_table.html#editing-attribute-values) as well as interact with features in a layer (by selecting or filtering features for example). Fields are columns of attribute values and these can be added, deleted and edited through this interface.

> ⚠ Warning
>
> Any saved changes made to a data layer in QGIS will also change the source file. If you wish to edit/ delete or add features or attribute values to a layer but do not want to edit the original source file, save the layer as a separate file **before** making your edits. Additionally, removing a layer will remove it from the work space but will not delete it from your source folder.

6.2.5 Print Layouts and Using Templates

With QGIS's layout composer, you can create layouts or use existing layout templates. The template file can be downloaded here. Once the layout is complete, save and export the print layout as an image, an svg (for future editing in other software such as Adobe Illustrator or InkScape, select export as vectors), or as a PDF. If saving as a PDF, consider saving the layout as a GeoPDF by selecting 'Create Geospatial PDF (GeoPDF) in the export PDF settings (refer to Section 7: Collaboration for why you should export your site map alsp as a GeoPDFs)

6.2.6 Saving the data layers and styles into a Geopackage

Data layers are saved on your local computer. To facilitate sharing geographic information, data layers can be compressed into a **Geopackage**. The QGIS project and all the data used in the project can be saved using the Package Layers tool and easily shared and stored as such for future use.

Chapter 7

Collaboration

Throughout the development cycle of site maps, the contributions and participation of the different stakeholders identified earlier in this guide, is key to producing high quality, updated site maps. Static PDF site maps are the main output of this workflow. However, it is also important to recognise that other products are created in the process of making these maps, such as:

- Aerial/ Satellite imagery of sites in which CCCM, shelter or other humanitarian activities are being carried out,
- The geopackage which contains geographic information and data layers of the site infrastructure,
- GeoPDFs,
- Site map template

7.1 Information and knowledge management

These are valuable information products which can be used by colleagues and other humanitarian actors to conduct thematic analysis as well as serve as an evidence base for advocacy, planning and decision making. More importantly, these products are tools to collaborate with stakeholders and actors on the ground that in turn can:

1. Verify and validate the information,
2. Feedback and suggest modifications,
3. Update the data when changes occur on the ground.

Therefore, the manner in which this data is stored, presented and shared is crucial to both allow for and promote the use of site maps.

> **Note**
>
> IOM and partner agency/ NGO staff can and are encouraged to share these data products with the CCCM Global Cluster so there is continuity in the management of site data. The CCCM Global cluster can play a role in facilitating the storage, dissemination and use of site data whilst ensuring it is done so responsibly.

7.2 Generating, reading and annotating geoPDFs

In the previous section, we looked at exporting print layouts as GeoPDFs. GeoPDFs are PDFs with embedded georeferenced location information.

GeoPDFs can be imported into Avenza maps. The app uses the built in GPS in a tablet or smartphone to locate users when out of range of a network or internet connection. Users can mark points of interest, attach photos with exact location, and add annotations to existing features.

7.3 Gathering feedback and map iterations

Through Focus group discussions and site walks, the site maps can be annotated by different stakeholders to mark for example, errors in the map, changes in the layout of the site, the location of new or closed services etc. The site map can either be project or printed in large formats or imported in Avenza map to be used during site walks in order to determine the precise location of different features.

7.4 Using Site maps in Practice

Site maps can provide a spatial perspective on issues and risks within sites. They can be used as inputs to safety audits, identification of risk factors and support coordinated planning and coordination of response activities.

Part IV

Annexes

Acknowledgements

We would like to thank the following people for their support during all stages of the development of this guidance:

Glossary

A glossary of terms used throughout this guide:

DSM Digital Surface Model. A modelling of a an area that include foliage and structures.

DTM Digital Terrrain Model. Similar to DSM but excluding foliagge and other structures. Also Displacement Tracking Matrix, an IOM initiative that gathers data on mobility, vulnerability and needs.

Drone Common term for unmanned or remotely-piloted aircraft.

Georeferencing The act of aligning geographic data (such as a map) to a known coordinate system.

GIS Geographic information system. In general terms, a system that is designed to manipulate, store, analyze, and manage spatial and geographic data.

GSD Ground sample distance. The resolution of an aerial image

IOM International Organization for Migration.

Nadir In aerial photography, the point on the ground that lies directly below the perspective center of the camera lens; also, images taken from this perspective (i.e., straight down).

Orthomosaic A two-part process in which a number of images are combined together or "stitched" into a single image and also corrected for distortion.

Orthorectification A process of removing the efects of image perspective and relief efects by using camera model information and elevation data, creating a fnal image that has a constant scale.

RTK Real time kinematic. A technique used to extract more-precise-than-normal position data from global satellite navigation timing signals.

UAV Unmanned Aerial Vehicle, commonly known as a drone. Radio controlled fixed-wing or rotorcraft.

Further reading

DRONES AND AERIAL OBSERVATION: New Technologies for Property Rights, Human Rights, and Global Development

UNICEF Drones for Sustainable Development Goals Toolkit

HOT OSM UAV Mapping Guidelines

IASC Operational Guidance on Data Responsibility in Humanitarian Guidance

ICRC Handbook on Data Protection in Humanitarian Action