

Site Mapping Guide

International Organisation for Migration (IOM)

Table of contents

| | |
|--|-----------|
| Introduction | 4 |
| What is a Site Map? | 5 |
| Audience | 5 |
| When and how can site maps be used | 5 |
| Acknowledgments | 6 |
| Feedback | 7 |
| | |
| I Part 1 - Preparation | 8 |
| 1 Identifying requirements | 9 |
| 1.1 Stakeholders | 9 |
| 1.2 General Requirements | 10 |
| 1.2.1 Personnel | 10 |
| 1.2.2 Time | 10 |
| 1.2.3 Hardware and Software | 10 |
| 1.2.4 Connectivity | 10 |
| 1.2.5 Funding | 11 |
| 1.2.6 Context | 11 |
| | |
| 2 Deciding on an approach | 12 |
| 2.0.1 Information needs | 13 |
| 2.0.2 Conflict and Data Sensitivity | 13 |
| 2.0.3 Data security/responsibility | 14 |
| 2.0.4 Regulatory environment | 14 |
| 2.0.5 Organizational requirements | 14 |
| | |
| II Part 2 - Obtaining imagery | 16 |
| 3 Using satellite imagery | 17 |
| 3.1 Types of satellite imagery | 17 |
| 3.2 Cloud cover | 17 |
| 3.3 Understanding spatial resolution | 17 |
| | |
| 4 Colour Bands | 18 |
| | |
| 5 Existing imagery | 19 |

| | |
|--|-----------|
| 6 Using UAV imagery | 20 |
| 6.1 Obtaining a drone kit | 20 |
| 6.2 Pre-flight | 20 |
| 6.2.1 Flight plan, nadir vs oblique images | 20 |
| 6.2.2 Ground control points | 22 |
| 6.2.3 Community engagement | 22 |
| 6.2.4 Path and image overlap | 22 |
| 6.2.5 Altitude Ground sampling distance | 22 |
| 6.3 Flight | 22 |
| 6.4 Post-Flight | 22 |
| 6.5 Post-Flight processing | 22 |
| 6.5.1 Orthomosaics with WebODM | 22 |
| III Part 3 - Developing Maps | 23 |
| 7 Tracing and labelling | 24 |
| 7.1 Manual tracing | 24 |
| 7.2 Automatic tracing | 25 |
| 8 Composing site maps | 26 |
| 8.0.1 Examples | 27 |
| 8.1 GIS | 27 |
| 8.1.1 Creating a Geodatabase | 27 |
| 9 Collaboration | 28 |
| 9.1 Generating geoPDFs | 28 |
| 9.2 Gathering feedback and map iteration. | 28 |
| IV Annexes | 29 |
| Acknowledgements | 30 |
| Glossary | 31 |
| Further reading | 32 |

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 responses 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.

Warning

This guidance is in draft-stage, much of the content is missing and its structure may be subject to change.

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.



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

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

i 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.

When and how can site maps be used

Site maps can illustrate camp settings in both sudden-onset disasters as well as protracted emergencies. They can be 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: Rehabilitation 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

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 will be required to develop site maps in your context? Regardless of the chosen approach, the development of site maps requires personnel, time, hardware, software, connectivity and funding. 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 may affect the overall feasibility or appropriateness their development?

1.1 Stakeholders

Whilst the development of site maps is somewhat 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 how many and which sites need to be mapped. Humanitarian actors, especially those on the ground, can also feed into the iteration process of the site maps, to validate information and keep the maps and underlying data up to date.
- **Authorities.** The authorities are a crucial interlocutor for approvals as well as the use of the maps and handover of expertise and equipment in the case of capacity development 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, as well as support staff such as drivers and procurement support will 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 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 or updating their content. These are important factors to consider when looking at the time frame of their intended use.

1.2.3 Hardware and Software

Depending on the chosen approach, not all items in the below table will be required. Highlighted are items which are required regardless of the chosen approach:

| Hardware | Software |
|----------------|------------------------------|
| Laptop | QGIS (or other GIS software) |
| Drone kit | WedODM |
| Android Tablet | Avenza maps |

1.2.4 Connectivity

While connectivity requirements vary depending on the chosen approach, some degree of connectivity should be assumed as needed. In situations of sudden onset disasters, connectivity can be very challenging and quite often can lead to bottlenecks and delays.

1.2.5 Funding

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

1.2.6 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 these challenges and risks is best done as early as possible to avoid wasting resources or to allow sufficient time to mitigate them.

2 Deciding on an approach

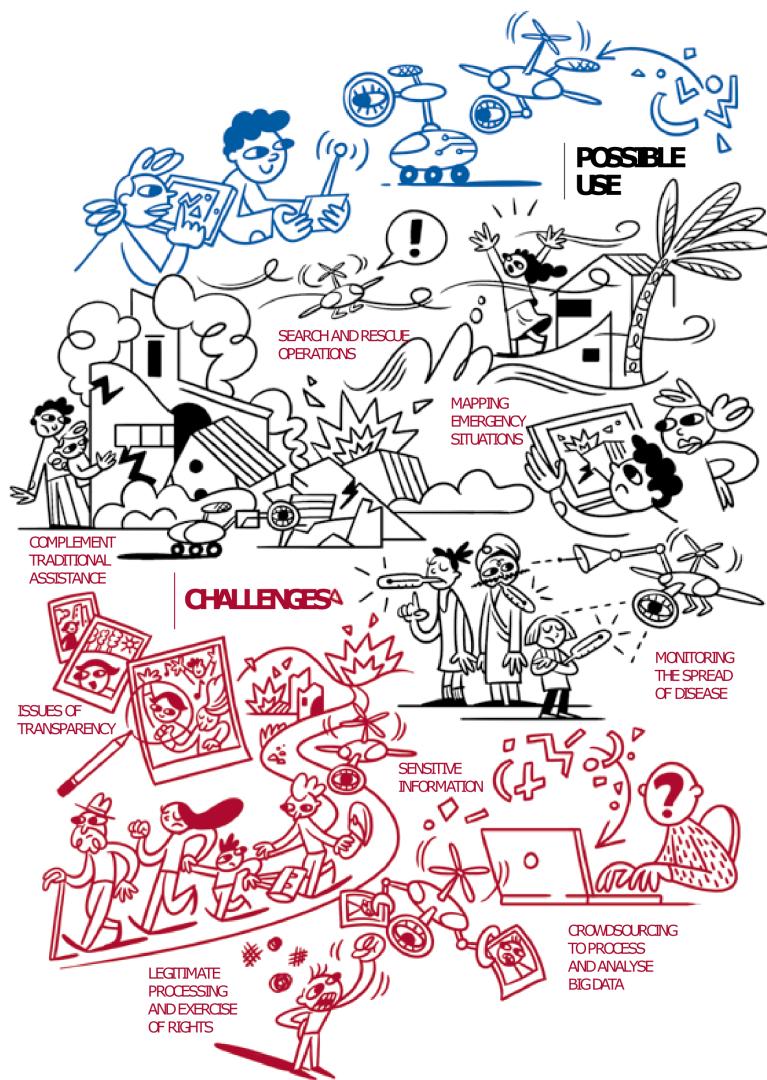


Figure 2.1: Uses and challenges of drone use *Source: ICRC*

There are two approaches to making sites maps presented in this guide. The main difference 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.**

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:

2.0.1 Information needs

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

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 the purpose (only the needed data is collected).

2.0.2 Conflict and Data Sensitivity

Due to protection risks, 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 may mean that importation of equipment or flight approvals are not likely to be granted, or that their use in a site risk being perceived as a security threat.¹

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.

¹Chapter 7 of [ICRCs Handbook on data protection in humanitarian action](#) examines the use of drones and remote sensing.

In addition to the data risks and concerns outlined in the [IOM Data Protection Manual](#),² there are additional specific concerns and risks associated with the use of drones.²

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

2.0.3 Data security/responsibility

The use of drones to capture aerial image for site mapping does not require the collection of personal data. Individuals must not be identifiable from captured images. Ensure that the flight (altitude, angle etc.) eliminates or reduces as much as possible the likelihood that imagery captured 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, you should check whether some of the data collected is particularly sensitive and should be deleted or otherwise made unrecognizable in the image (e.g. a group of individuals that could be identified as part of a specific group, image of illegal crops or settlement).

2.0.4 Regulatory environment

It is important to fully understand the national and local-level laws, procedures and norms related to the use of UAVs as it 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, and can be used to understand the sources of legal information, relevant contact information and regulations on operating rules, licensing and approval procedures.³

2.0.5 Organizational requirements

i 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 provide legal and compliance guidance as well as the latest version of the *Drone usage checklist* and *Risk-benefit analysis template*.

²[IOM Data Protection Manual](#)

³[DroneRegulations.info](#) launched by the UAViators network in 2014, is a database of national-level UAV regulations.

Many organization 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 its important to contact the relevant organisation focal-point to ensure compliance with these rules.

Part II

Part 2 - Obtaining imagery

3 Using satellite 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 emitting electromagnetic pulses and Lidar emitting light pulses towards the Earth surface and measuring the reflection. Passive (or Optical) sensors detect radiation naturally reflected from the Earth's surface and is dependent on the day-night cycle. For the purpose of site mapping optical sources, which typically produce imagery with colour reproduction similar to the human eye, are most prevalent and useful.

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.

3.3 Understanding spatial resolution

Resolution of an image is categorized as follows: - High resolution: 30cm-5m/pixel - Medium resolution: 10-30m/pixel - Low resolution: over 60m/pixel

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 users needs, different image resolutions are used.

Low to Medium resolution images are good 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.

High resolution images are ideal for small scale analysis or monitoring since often a smaller area is covered. The level of detail at such spatial resolution allows from small and individual objects to be identified which makes it 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.

4 Colour Bands

5 Existing imagery

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

High resolution Satellite imagery can be requested from IOM DTM.

Alternatively, OpenAerialMap provides access to openly licensed aerial imagery. Imagery can be downloaded as a .tiff image file for free. However, in some cases, imagery for your area of interest may not be available. In this case, you may need to capture your own imagery.

6 Using UAV imagery

6.1 Obtaining a drone kit

6.2 Pre-flight

Go through the [Humanitarian UAV Network | Operational Check List](#).

6.2.1 Flight plan, nadir vs oblique images



Figure 6.1: An example of an *oblique* angle image of Bakassi Camp, northeastern Nigeria. *Source: IOM*



Figure 6.2: An example of a *nadir* angle image of Wau PoC, in South Sudan *Source: IOM*



Figure 6.3: An example Ground Control Point *Source: Pix4d*

6.2.2 Ground control points

6.2.3 Community engagement

6.2.4 Path and image overlap

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

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

6.2.5 Altitude Ground sampling distance

6.3 Flight

...

6.4 Post-Flight

...

6.5 Post-Flight processing

Drone captured images then need to be stitched together into one image or *orthomosaic*. Here we recommend using WedODM and take you through software installation, creating a new project, uploading the images, creating a task, and downloading the orthomosaic.

6.5.1 Orthomosaics with WebODM

To install WedODM manually, follow the steps outlined [here](#).

Create a new project, upload drone captured images to create a task and download the orthomosaic. After the task has been successfully processed, select orthophoto.tif in the list of available

Part III

Part 3 - Developing Maps

7 Tracing and labelling

Once the site mapper has the aerial imagery, a series of options exist to process that imagery according to your needs. One of these needs may include generating labelled shelter and/ or building outlines. The site mapper may chose to either manually or automatically trace and label these features. In order to determine which option to use, let's look at the advantages and disadvantages of both.

| Manual | Automatic |
|---|---|
| Advantages Tracing and labeling manually requires only basic GIS skills. Can be done offline in contexts with limited connectivity. Allows for medium to high accuracy tracing of shelters and buildings with irregular or non-rectangular geometry. | Advantages High number of shelters and buildings can be traced and labelled in a small amount of time, relative to manual tracing. |
| Disadvantages Time intensive, relative to automatic tracing. | Disadvantages Some tools may require basic to advanced understanding of machine learning principle. This is required with most open-source tools. Most low-code tools are not open source or free and may incur additional costs Depending on how much training data is available, the type and accuracy of the tool used,(amongst other factors), there may be errors or inaccuracies in the outlines and labels generated. |

Note: If there is high cloud or tree coverage, some features may not be visible in the aerial imagery and thus will not be detected by the site mapper or the machine learning model. Therefore, it is crucial to validate the generated outlines and labels with inputs from colleagues in the field.

7.1 Manual tracing

Manual tracing can be done in GIS or AutoDesk software. Quantum GIS can be downloaded for free [here](#). Once the software download is complete, import and georeference the aerial imagery in QGIS. Create a new shapefile layer and toggle edit to trace the features required. Untoggle edit to save your edits.

7.2 Automatic tracing

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

- Create a training data set from aerial imagery with [Groundwork.azavea](#). Upload orthophoto to Groundwork, label features and export training data in .json format.
- Extract shelter outlines from aerial imagery using Mapflow's built in deep learning and semantic segmentation models. Mapflow can 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](#).
- Analyse and conduct image segmentation on aerial or satellite imagery using the [UP42 platform](#).

8 Composing site maps

... ## Key elements of a site map

The following list of element should be included in the final output:

- Title and Subtitle
 - Country
 - State
 - Site Name
 - Thematic Title
 - Date
- Site map audience/ permission/ sharing restrictions
- Production date of site map
- Site map version
- Inset maps:
 - At Country/ Regional level
 - At Regional/ Area level
- Source notes:
 - Data sources
 - Satellite Imagery source
 - Coordinate system
 - Site GPS coordinate points
 - IOM CCCM Logo (or other)
 - Contact
 - Disclose limitations regarding accuracy of site map
- Map:
 - Base Map (satellite/ aerial imagery)
 - Scale bar
 - Orientation indicators
 - Legend
 - Camp Infrastructure:
 - * 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
- Other optional labelling and infrastructure:
 - Functioning/ non-functioning
 - Male/ female latrines
 - Unusable area
 - 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

8.0.1 Examples

8.1 GIS

8.1.1 Creating a Geodatabase

... ### Creating/ Importing Templates ...

9 Collaboration

Throughout the development cycle of site maps, involving the stakeholders identified earlier in this guide is key to producing high quality, user-centered site maps. However

The main outputs of this workflow is the physical and PDF site map. However, in the process of making these - it is important to recognise the following products are also created:

- Aerial/ Satellite imagery of sites in which CCCM, shelter or other humanitarian activities are being carried out.
- Geodatabase containing Vector layers of shelters and other camp infrastructure
- Site map Templates
- GeoPDFs

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 to:

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 stores, presented and shared is crucial to both allow for and promote the use of these products.

9.1 Generating geoPDFs

... ## Reading and annotating geoPDFs 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.

9.2 Gathering feedback and map iteration.

...

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:

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 effects of image perspective and relief effects by using camera model information and elevation data, creating a final 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](#)