

# MAPPING ZANZIBAR





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WITH MORE THAN 1,200KM<sup>2</sup> TO COVER, MAPPING THE LARGEST ISLAND OF THE ARCHIPELAGO OF ZANZIBAR WAS GOING TO BE CHALLENGING. **DAVID ROVIRA** EXPLAINS HOW COLLABORATION, REAL-TIME TRAINING AND UAVS ALL HELPED CONTRIBUTE TO THE SUCCESS OF ONE OF THE LARGEST MAPPING PROJECTS EVER UNDERTAKEN

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Since 2004, the Revolutionary Government of Zanzibar has relied heavily on a single geographic resource – a map created following a manned aircraft mapping project – to make key decisions on infrastructure and environmental policy. However, due to significant urban developments, the map of the archipelago is now outdated, and a scarcity of land and population boom further highlighted the need to refresh the resource both accurately and efficiently. As a result, the Zanzibar Mapping Initiative (ZMI) was launched in August 2016, bringing together collaborators and experts from The World Bank, the Zanzibar Commission of Lands, the State University of Zanzibar, and Drone Adventures – a non-profit organisation comprised of employees from senseFly, a provider of professional UAVs. Founded in 2013, Drone Adventures aims to bring UAV technology to communities and countries that may need it, but are either unaware of the benefits it can offer or cannot afford to invest in a UAV. To date, the team has mainly worked on projects designed to tackle disaster management, humanitarian aid and resilience.

For the ZMI, five surveyors from the Commission of Lands and 20 students from the university joined the Drone Adventures team to develop a detailed digital map of the entire land mass of Zanzibar, as well as create a sustainable programme for future land management and environmental monitoring.

#### **Looking at logistics**

To manage the large-scale project, the team drew on its experience in using GIS. The land was divided into 9km<sup>2</sup> zones to ensure the entire island was split into equal areas, with QGIS used to digitise the land boundaries. With two huge areas to map, the team decided to first survey Unguja, Zanzibar's largest island of the archipelago,

## SURVEYING

with this sectioned into 239 zones, while its neighbouring island, Pemba, was divided into 182, ready to be mapped at a later date.

Thanks to their ability to cover a large area accurately and in a relatively short period of time compared to more traditional ground-based surveying methods, UAVs logistically were found to be the most effective tool for the sustainability of future mapping initiatives in the region. Fixed-wing UAVs were selected ahead of rotary drones, as the former's more efficient aerodynamics enabled longer flights at higher speed – a significant advantage when tackling such a vast land mass. Capturing high-resolution, detailed imagery was vital to the mission; however, this had to be balanced with ease-of-use due to the inexperience of some

local operators. To achieve the accuracy required to map the zones, the team used 10 light-weight UAVs in total, with senseFly's eBee professional mapping UAV chosen to meet the demands of the mission. Able to cover up to 1.2km<sup>2</sup> in a single automated flight, the eBee provided operators with a time and cost-efficient solution, which delivered high-resolution, accurate results.

True-colour RGB payloads of 18.2-megapixel resolution were used. Selected thanks to its lightweight design and high-resolution, the Sony WX was the primary sensor, with images geotagged by the eBee's on-board GPS. While real time kinematic (RTK) satellite navigation was explored, it was

operators and mitigate the need for, and cost of, additional equipment such as a base station.

As well as being an efficient tool, senseFly UAVs also offered a complete, end-to-end solution, to improve ease-of-use and support new users of the technology. The drones were operated through senseFly's accompanying eMotion flight planning software, enabling the team to quickly define the region to map, specify the ground resolution and set the required image overlap. From this information, eMotion automatically generated a full flight plan based on GPS waypoints. Pix4D photogrammetry software was then used to process the imagery for each 3x3km area. Geotags recorded X, Y and Z data,

### THE POWER OF UAVS

"We have a scarcity of land and very high urban growth, which means it is important for us to know the status of the area so we can better manage it. By using drones to map the entire region we have been able to obtain more accurate data and detect the changes that have occurred over the past 12 years, including how cities have developed and the impact of climate change. Having this resource really is a golden opportunity and will be a crucial tool in the future development of Zanzibar."

**Dr Muhammad Juma, director of planning, Zanzibar government**

### EASE OF USE

"The drones are really easy to use – you basically shake the eBee three times, hold it so it becomes stable and simply flick it up in the air to launch it. The camera we used has taken hundreds of photographs, overlapping these and recording the exact geolocation of each image. When we returned to the office, we married the geolocation with the images and stitched these all together using Pix4DMapper."

**Frederick Mbuya, managing director, Uhurulabs**

## UAVS LOGISTICALLY WERE FOUND TO BE THE MOST EFFECTIVE TOOL FOR THE SUSTAINABILITY OF FUTURE MAPPING INITIATIVES IN THE REGION

ultimately deemed impractical for the project – Zanzibar doesn't have the infrastructure to support RTK/PPK, with no local reference stations or continuously operating reference station network. Due to the anticipated far-reaching use of the final orthomosaic, accuracy was important, but with such a large area to map, there was a need to balance this with time and cost efficiencies. The eBee's built-in GNSS was able to adapt to the logistical limitations, while meeting the demands for detail. In addition, the integrated nature of the GNSS helped streamline the training of local

to provide height measurements for the eventual orthomosaic and ultimately help support decision-making in the region.

### Testing times

While the drones were ready for deployment in March 2016, there was delay in receiving approval from the government of Zanzibar to fly drones in its airspace. With no specific legislation in place and proposed missions assessed case by case, senseFly and Drone Adventures volunteers worked with local project operators to facilitate the processing of a regulatory framework, and it was in August 2016 when the missions were



Aerial view of unplanted fields in Zanzibar captured by a senseFly eBee



An aerial view of the Zanzibar coastline



Aerial view of a community outside Stone Town

underway following approval by the military and civil aviation authorities. Thanks to this groundwork, regulations in the region became effective from September last year. As part of its compliance programme, the team needed to remain particularly vigilant when flying near urban areas where other aircraft were in operation, to ensure all clearance was secured before any missions commenced.

### In flight

Following regulatory approval, full-time mapping was carried out between August 2016 and July 2017. Operators were divided into teams of between three and five members, with two groups covering different

areas in a single day, five days a week. Each flight lasted between 30 and 45 minutes, with total flying time taking an average of four to five hours over the five-day period.

The flight duration depended, in part, on the capacity of the battery used. To meet the in-flight demands of the eBee, senseFly 2150mAh batteries were selected; however, the Lipo technology presented some challenges, as operating so intensively caused the batteries to, on occasion, lose capacity. To mitigate the risk of this, batteries were fully charged by the students ahead of each flight and then recharged overnight. The data collected was stored on hard drives in the field, before being transferred to a

large network attached storage system in the University of Zanzibar prior to processing.

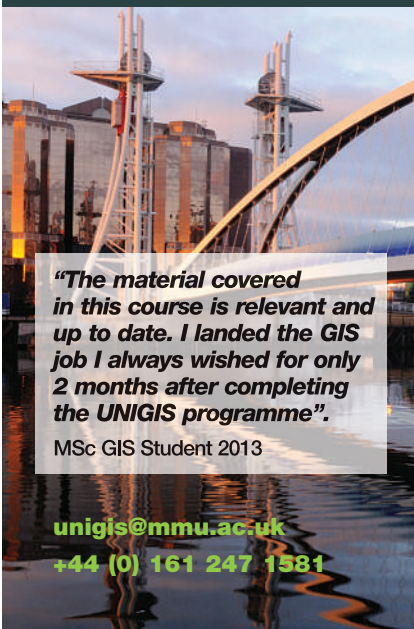
Ongoing challenges were met on the ground due to weather conditions, such as humidity and dust that affected the visibility, and high wind speeds achieving up to 29 knots. In more extreme instances, these environments delayed operations and caused general wear and tear, which resulted in drones occasionally needing to be repaired before flights could continue.

To overcome this and reduce downtime, the Drone Adventures team assisted in integrating this new and advanced technology into workflows and educating students and operators who, at the

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## SURVEYING



A senseFly eBee drone

### TOP TIP

For massive mapping projects that involve huge volumes of data, it's important to stay organised. Break up large areas into zones to make flights more manageable and keep track of which flights correspond to each zone.

beginning, were unfamiliar with it. They were given real-time training in how to use the drones and flight planning software effectively, including relevant launch and landing procedures, guidance on how to generate sufficient overlap between images in the flight planning stage, and information on how best to organise, process and analyse the large amount of data.

While transferring the data to the processing computers took time, this investment in the students' training paid off, with data organised efficiently and labelled correctly to ensure a smooth and timely process. In addition to improving accuracy and efficiency in the field, the coaching helped upskill the community to a level where it will be able to manage on their own any future mapping projects when required – from monitoring environmental conditions to keeping track of the health of crops.

### Revolutionary results

The use of the eBees resulted in significant cost savings – compared to the original manned aircraft project in 2004, the ZMI mission came in 10 times cheaper. In addition, historically, if the government determined that the base map needed updating, it had to pay to rent a plane from Kenya, as well as operational and analysis costs. Following the ZMI's investment in UAVs and training, local communities in Zanzibar now have the capability to update data themselves on demand – dramatically reducing the amount of capital required for third-party geospatial data providers.

In total, more than 1,300 flights were conducted, with 932 flights between August and November 2016 and a further 436 taking place from January to July 2017. Throughout the mission, an average of 211 photos were captured per flight for each zone. This level of efficiency led to the project being completed in less than a year – a substantial achievement given the area covered.

UAVs also delivered benefits in terms of accuracy. For instance, the ground resolution improved from 25cm using a



Local operators and members of the community with the senseFly eBee ahead of its flight



A typical ground station set up for flight operations



A member of the Zanzibar Mapping Initiative demonstrating how to launch the eBee drone



Local operators and members of the community with the senseFly eBee



senseFly team members assisted the mission on behalf of Drone Adventures

manned aircraft in 2004 to 7cm on the new map, while the Pix4DMapper software enabled tens of thousands of images to be seamlessly stitched together to create a high-resolution, georeferenced orthomosaic. Processing took, on average, 12 hours per zone covered; however, the images acquired were not always perfect due to extreme conditions, such as high winds, or operational

making. Results from the initiative have already generated interest from other government agencies, including a US\$2m land tenure project, which will apply RTK/PPK-enabled eBee Plus drone technology to map smaller parcels and provide survey-grade absolute accuracy. In addition, mapping has started on the smaller island, Pemba, with data expected to be collected and available for use this year.

## ZANZIBAR DOESN'T HAVE THE INFRASTRUCTURE TO SUPPORT RTK/PPK, WITH NO LOCAL REFERENCE STATIONS OR CONTINUOUSLY OPERATING REFERENCE STATION NETWORK

issues with the camera. In instances where the output was blurry, the drones were flown again over important areas and data reprocessed to ensure the insights generated were reliable. Despite this element of trial and error, the resulting map is detailed, accurate and will be a vital resource for the communities in the years to come.

### What's next?

The digital map will now be used by a range of government departments and organisations to inform urban and environmental policy-

There is huge potential for UAVs to help with such land tenure decisions, as well as disaster risk management, coastal erosion monitoring and agriculture policy. By investing in capacity building and the integration of UAVs in land administration, public authorities in Zanzibar have the opportunity to make a significant difference to the local environment and the communities who live and work there.

*David Rovira is senseFly's regional manager for Africa and president of Drone Adventures*