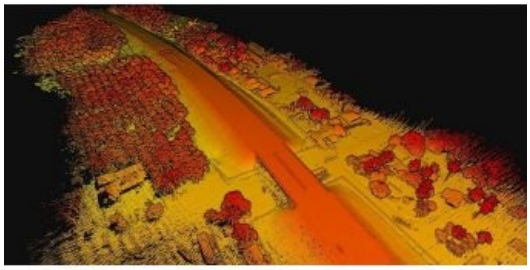
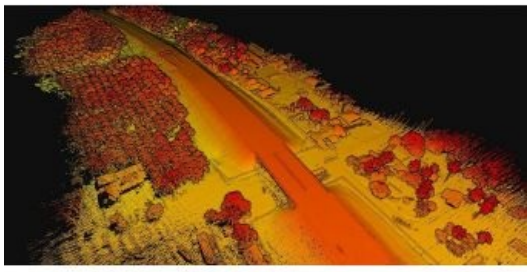
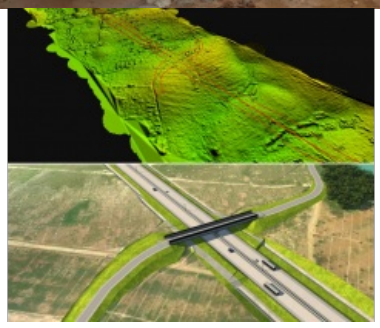
KEEPING THE TRANS-SUMATRA TOLL ROAD ON TRACK

Large-scale UAV-Lidar Survey in the Tropics







With a total length of 2,789km, the Trans-Sumatra Toll Road Project is one of Indonesia's National Strategic Projects and the longest toll road project in Southeast Asia. In order to keep the project on track for the scheduled completion date of 2024, UAV-Lidar was chosen as the topographic data acquisition method, combined with building information modelling (BIM), to optimize the time planning and costs. Read on to learn more about this challenging project, which has included several obstacles.

The Trans-Sumatra Toll Road Project will connect cities in the north, south, east and west of Sumatra, the second most populated island of Indonesia. The Indonesian Government assigned this mega project to PT Hutama Karya as a state-owned enterprise company. The company has been tasked with not only constructing the Trans-Sumatra Toll Road, but also with financing, planning the construction work and ultimately operating it.

UAV-Lidar mapping: the right choice

In the search for the right mapping solution to carry out this immense project, Hutama Karya considered various options. Airborne Lidar was rapidly dismissed since the team concluded that the approach would meet neither accuracy expectations nor cost targets. Additionally, the use of aircraft would not allow the small-scale partial data acquisition needed for this project. Hutama Karya therefore opted for UAV-Lidar mapping to offer the flexibility to adapt to the project size, dense vegetation and terrain as well as the accuracy, budget and scheduling requirements. From a survey perspective, using UAV-Lidar can reduce the acquisition time by an average of 13-15km/day compared with traditional land survey methods. The work can also be done by a single team. This results in 80-85% time efficiency, and the reduced manpower translates into lower overall survey costs. Additionally, Hutama Karya has used other survey methods based on the map scale requirements and work specifications. For example, land surveys were carried out to capture details for structural calculations and also in areas with a dense tree canopy. During the project, bathymetric surveying was also performed for rivers and dams because of Lidar limitations.

Map of the Trans-Sumatra Toll Road Project. (Courtesy: Hutama Karya)

Careful planning

The island of Sumatra has a large mountain range. Corridor mapping in these circumstances is challenging because the flight planning

has to take the capability of the unmanned aerial vehicle (UAV or 'drone') in the terrain into consideration without sacrificing the data quality. The company therefore always conducts a detailed pre-survey and discusses the flight plan with their UAV specialists and also with the UAV manufacturer to ensure a safe and optimal flight plan. In this case, to map the planned toll road, Hutama Karya used the fixed-wing eVTOL Tron UAV from Quantum Systems. It was equipped with the YellowScan Surveyor Ultra UAV Lidar sensor payload.

Because the toll road project mostly crosses through isolated non-populated areas, another challenge is posed by the condition of the existing roads. Due to poor accessibility, 4x4 cars are essential workhorses for the Lidar survey, and the route options required careful planning.

The corridor mapping process was divided into 10km sections. In a best-case scenario this translated into 220 flight missions. The worst-case scenario plan – which took account of realistic threats due to factors such as poor weather conditions, potential damage to the UAV or sensors, and the need for repairs – envisaged 350 flight missions.


Aerial photo of the Trans-Sumatra Toll Road under construction. (Image courtesy: Hutama Karya)

Challenges of mapping in the tropics

The biggest challenge for the team while on data acquisition duty was the weather; poor conditions significantly hindered the Lidar acquisition process. On one occasion they could not fly for a full week because of bad weather. Additionally, the weather caused disruption on the local roads, such as landslides, falling trees or large holes, forcing the survey team to take time-consuming detours from their originally planned routes. It is standard procedure to closely observe the weather conditions for one or two days to identify the pattern of the local weather behaviour. Based on these observations, the team could plan the flights, taking into account the mission duration, the flight length and the exact time when potentially good weather conditions were forecast.

Another project challenge was to meet the required LE90 accuracy of 0.25m for the 1:1,000 map scale (based on The Geospatial Information Agency Standard for Large-scale Maps). On the first three of the Lidar surveys for the sections Muara Enim to Bengkulu, Padang to Pekanbaru and Aceh to Sigli (611km), the team struggled to meet that accuracy tolerance for each of the survey points. To tackle these accuracy challenges, the project team conducted trial-and-error scenarios and practical research in-house, and exchanged knowledge with researchers and also with the YellowScan support team to discuss the acquisition, processing and post-processing strategy. After much discussion back and forth, the team have now found a successful formula and are continuing to adapt it for the entire project.


Preparing for the UAV-Lidar survey of the Betung of Jambi section. (Image courtesy: Hutama Karya)

A third challenge related to the hilly and forested terrain, especially around the areas of Muara Enim, Padang, Bengkulu and Pekanbaru. To overcome this, the project was flown at an altitude of 150m, even though YellowScan recommends a maximum flight altitude of 80m for its Surveyor Ultra. This pushed the boundaries of the Lidar system, but was deemed necessary to avoid the risks of flying at a low altitude over such extreme terrain. In fact, in a local first, the project took advantage of the regulations in Indonesia to conduct beyond-visual-line-of-sight (BVLOS) flights in the area around Muara Enim over each 30km-long survey section. This 30km corridor mapping was performed from three take-off and landing points, using a Leica GPS base station on the ground. Although the dense tropical forest (palm trees) made it difficult to identify the initial ground control point (GCP), the team succeeded in meeting the accuracy requirements.


Lidar point cloud of the existing Pekanbaru to Dumai toll road section. (Image courtesy: Hutama Karya)

Recommendations for further improvement

Now 18 months into this prestigious project, Hutama Karya has conducted 1,478km of corridor mapping with the UAV-Lidar system. In fact, this Lidar survey has become the fastest topographic survey with detailed engineering design (DED) accuracy in Indonesia. This achievement gives cause to be optimistic about the goal of finishing all corridor surveys by the end of 2021. Nevertheless, there still is some work to be done to achieve the LE90 accuracy tolerance for all sections of the project.

The project team are continuously fine-tuning their skills at operating and using the UAV-Lidar system, but their experiences also form the basis for suggestions for further improvements. Firstly, they would like VTOL fixed-wing UAVs to be made more weather-resistant so that they can be used in a wider variety of conditions. Secondly, the current UAV-Lidar system has a telemetry capability of ±5km. Further improvement of the system telemetry range, either with radio or 5G connectivity, would make UAV flights safer for everyone – especially for BVLOS. Moreover, the team members hope to see a better combination of laser, IMU and GNSS in the Lidar system to make it possible to capture more detailed survey data. Lastly, the team is looking forward to even lighter and more resilient Lidar systems in the future, with more endurance so that they can combine more payload. Ideally, it should be possible to combine UAV-Lidar and an RGB camera in a single fixed-wing UAV. All these improvements will produce better data quality when combined with a competent and experienced pilot.

Conclusions

Overall, the Trans-Sumatra Toll Road Project is on track for success, and the main obstacles during Lidar data acquisition have largely been overcome. The UAV-Lidar mapping method used by the project team proved to be capable of conducting very large-scale Lidar data acquisition missions for corridor mapping. The chosen mapping solution, YellowScan Surveyor Ultra, has been shown to work well in sometimes harsh conditions, including when operated above the recommended flight altitude, in high humidity and under other tropical constraints. UAV-Lidar systems can therefore optimize the time and cost involved in obtaining accurate topographic data as the basis for better decision-making in the project planning phase. This large-scale project is evidence of how UAV surveying has continued to evolve since becoming a standard tool for professional surveyors and is repeatedly opening up new opportunities.

Acknowledgements

Many thanks to PT Hutama Karya for being willing to share extensive details about this project, which can rightfully be described as prestigious. Additional thanks go to YellowScan for facilitating contact with the project leaders in Indonesia.

DTM of the Betung to Jambi section (top) and BIM in InfraWorks software using the Lidar DTM of the Betung to Jambi section (bottom). (Image courtesy: Hutama Karya)