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GOVERNMENT OF INDIA

Ministry of Jal Shakti

Dept. of Water Resources, RD & GR

Central Water Commission

DETAILED PROJECT REPORT

Volume - I

-: Name Of Project : -

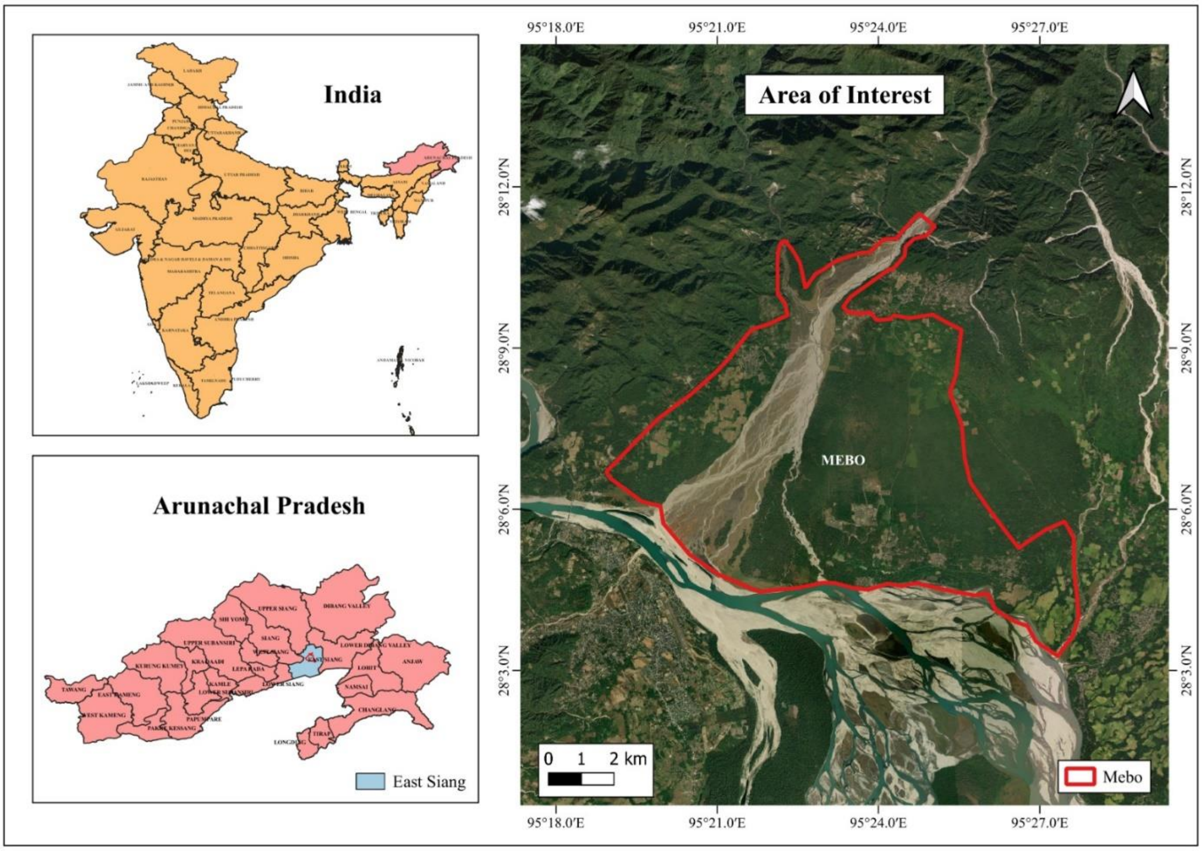
Detailed Topographical Survey (Surface and Bathymetry) for Reservoir Area, River Area, Command Area and Canal / Pipe Alignment Survey (0.5 m Contour interval) including the establishment of Permanent Bench Mark, etc. all complete of Mebo Irrigation Project in East Siang District, Arunachal Pradesh using a combination of DGPS, LiDAR, Unmanned Aerial Vehicle (UAV), and Echo Sounder etc.

LOCATION: Mebo Irrigation Project in East Siang District, Arunachal Pradesh

-: Prepared By: -

AM DATA LAB PRIVATE LIMITED

Index Map :- Mebo Irrigation Project in East Siang District, Arunachal Pradesh



AM DATA LAB PRIVATE LIMITED

Flat No. 101, Amrapali Apartments, Bhusari Colony,

Kothrud, Pune- 411038, Maharashtra.

Site Location :- Mebo Irrigation Project in East Siang District, Arunachal Pradesh

Detailed Project Report

AM DATA LAB PVT. LTD.
AERIAL MAPPERS

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Area of Intrest / Site Map

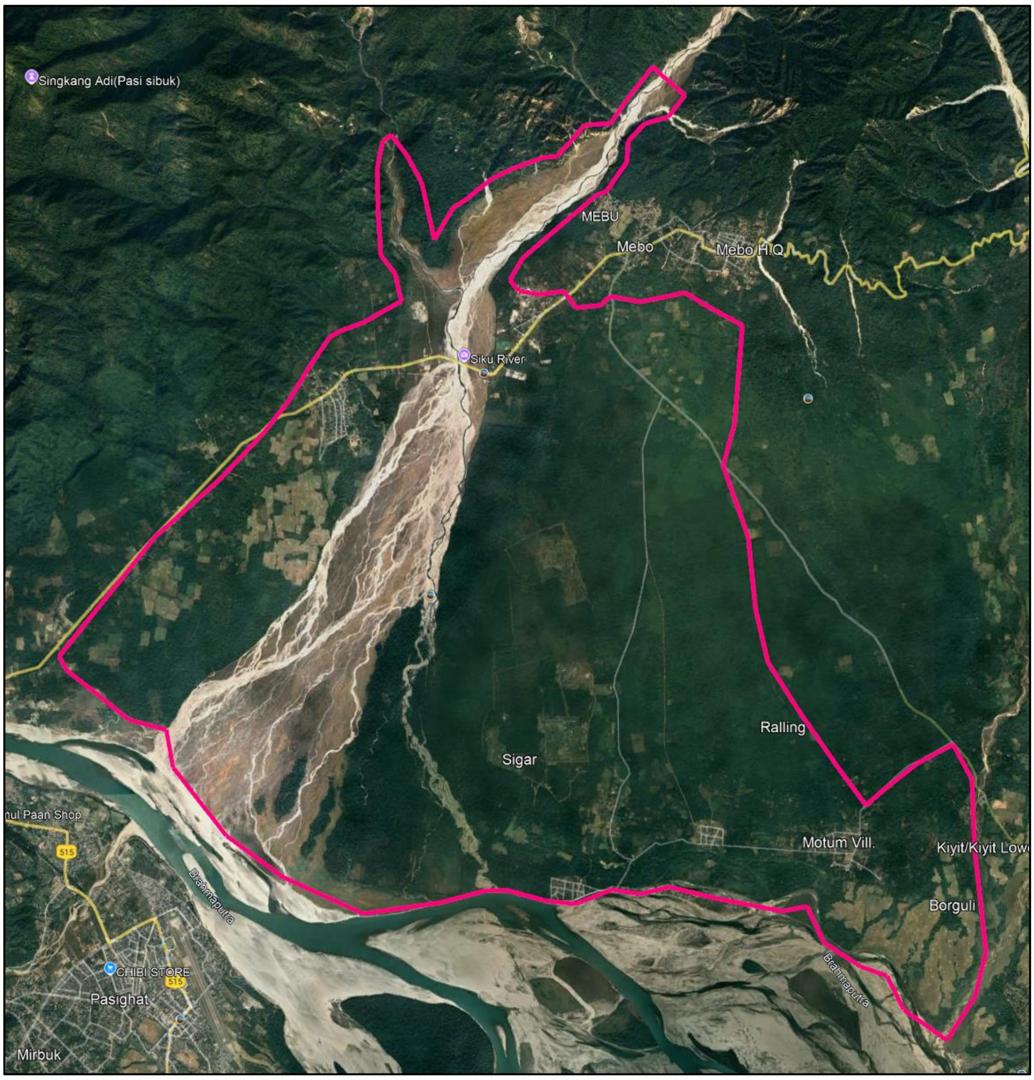


Fig. Area of Intrest / Site Map

Preface

The sustainable development and management of water resources is one of the most critical challenges in a rapidly developing country like India. The Ministry of Jal Shakti, through its Department of Water Resources, River Development, and Ganga Rejuvenation, emphasizes the need for comprehensive planning to optimize water resource utilization. Water is a vital resource for sustaining life and promoting economic development, and its proper management has become increasingly significant due to population growth and escalating water demand.

To address these challenges, the Central Water Commission (CWC) has entrusted AM Data Lab Pvt. Ltd. with the responsibility of conducting a "Detailed Topographical and Bathymetric Survey for the Mebo Irrigation Project" in the East Siang District of Arunachal Pradesh. This initiative reflects the government’s commitment to implementing rigorous adaptation policies to mitigate water scarcity and ensure equitable distribution on a regional basis.

The Mebo Irrigation Project aims to contribute significantly to enhancing agricultural productivity and addressing irrigation gaps in the region. The DPR is prepared with a dual focus: providing a robust technical framework for water resource planning and ensuring that it aligns with the regional objectives of sustainable irrigation practices. By incorporating advanced methodologies and modern surveying technologies, this project will help in building efficient irrigation infrastructure and addressing challenges such as sedimentation, slope stability, and water distribution efficiency.

Through this endeavor, AM Data Lab Pvt. Ltd. aims to deliver a comprehensive report that fulfills the technical and operational requirements laid out by the CWC and contributes to the socio-economic upliftment of the local communities by improving water resource management and agricultural outcomes.

About Central Water Commission (CWC)

The Central Water Commission (CWC) is a premier technical organization in India under the Ministry of Jal Shakti, Department of Water Resources, River Development, and Ganga Rejuvenation. It plays a pivotal role in the field of water resources development and management.

CWC is tasked with planning, coordinating, and supporting schemes related to the control, conservation, and utilization of water resources across the country. Its focus areas include flood control, irrigation, navigation, drinking water supply, and hydropower development. Additionally, the Commission undertakes investigations, construction, and execution of projects as required to fulfil these objectives.

The organizational structure of CWC comprises three main wings:

1. **Designs and Research (D&R) Wing** - Responsible for planning, technical designs, and conducting research to ensure the efficient execution of water-related projects.
2. **River Management (RM) Wing** - Focuses on hydrological and flood management, along with river basin planning.
3. **Water Planning and Projects (WP&P) Wing** - Dedicated to water planning, project formulation, and policy development for sustainable water management.

Each wing is headed by a member with the status of Ex-Officio Additional Secretary to the Government of India, while the CWC is led by a chairman with the status of Ex-Officio Secretary to the Government of India.

CWC's mission aligns with India’s long-term water resource management strategies, ensuring optimal use of this critical resource while addressing regional and national demands. The Commission’s expertise is integral to the successful execution of initiatives like the Mebo Irrigation Project, which aim to enhance water resource utilization and promote sustainable agricultural practices.

Table of Content

1. Introduction

Arunachal Pradesh is endowed with immense land and water resources, with approximately 30% of its total geographical area (83,743 sq. km) considered cultivable. However, current utilization is limited, with only 14% of the cultivable area under agriculture and 4% of the land irrigated. This underutilization contributes to a rice production deficit of 25%, equating to approximately 0.87 lakh metric tons annually, as reported by the Agriculture Department in 2017.

The Mebo Irrigation Project is a key initiative aimed at addressing these gaps by enhancing irrigated area coverage and improving water resource management. Leveraging advanced surveying technologies, this project employs tools such as Differential Global Positioning System (DGPS), Light Detection and Ranging (LiDAR), and Unmanned Aerial Vehicles (UAVs) to ensure precision in data acquisition and planning.

This project focuses on generating detailed topographical and bathymetric maps, developing Digital Terrain Models (DTMs), and conducting cross-sectional surveys. These deliverables are critical for expanding irrigation infrastructure, optimizing canal and pipe alignment, and addressing challenges like sedimentation and slope stability.

The Mebo Irrigation Project aligns with the state's mission to plug the rice production deficit and bring an additional 0.47 lakh hectares under irrigation. By integrating cutting-edge technology and skilled expertise, this Survey DPR provides a solid framework for sustainable irrigation development in the region.

Water resources are a critical component for sustaining agricultural and domestic needs, particularly in regions like East Siang District, Arunachal Pradesh, where the Mebo Irrigation Project is envisioned. The project aims to leverage modern surveying technologies to ensure accurate data acquisition for planning and implementation. Similar to the approach undertaken in the Mebo Irrigation Project DPR, this project integrates advanced methodologies, including Differential Global Positioning System (DGPS), Light Detection and Ranging (LiDAR), and Unmanned Aerial Vehicles (UAVs), to achieve a high level of precision in mapping.

The Mebo Irrigation Project emphasizes the generation of topographical and bathymetric maps, as well as the creation of Digital Terrain Models (DTMs) and cross-sectional and L- Section profiles, to ensure comprehensive coverage of the reservoir and command areas.

The survey plays a pivotal role in establishing benchmarks, determining canal and pipe alignments, and ensuring sustainable irrigation practices. It also focuses on addressing challenges such as sedimentation, slope stability, and efficient water distribution systems. The integration of cutting-edge equipment and specialized personnel underscores the commitment to delivering a robust and detailed project report that supports the long-term goals of the Mebo Irrigation Project.

We are submitting this Detailed Project Report (DPR) in two volumes:

- **Volume 1:** The Detailed Project Report
- **Volume 2:** All Deliverables Submission

2. Project Background

AM Data Lab Pvt. Ltd. has been awarded this work under Contract Agreement No. GEMC-511687716001905. dated 23- Nov- 2024 to carry out the Detailed Topographical and Bathymetric Survey for the Mebo Irrigation Project. The work involves conducting advanced surveys to meet the technical requirements outlined by the Central Water Commission (CWC) and delivering high-quality data for effective planning and implementation of the project.

The Mebo Irrigation Project has been envisioned as a critical initiative under the Government's efforts to enhance agricultural productivity and water resource management in the East Siang District, Arunachal Pradesh. The project, developed in alignment with national objectives for sustainable irrigation infrastructure, encompasses detailed studies and surveys for effective planning and execution.

The Employers earlier had carried out reconnaissance surveys where 3 cross-sections were taken on the Sirum River and 5 cross-sections on the Siku River. They also studied the catchment and command areas and tentatively identified the locations and types of various project components, summarized as follows:

S.No.	Component	Type of Structure	Remarks
1	Reservoir	Barrage	
		Width of the structure: 182.90 m	
		Number of gates: 12	
		Piers (Single: 9, Double: 2)	
		R.B.L: 297.500	
		Bed EL: 299.000	
		Pond Level: 304.500	
		Crest Level (Spillway/Under Sluice): 299.000	Storage Capacity: 29.566 MCM + losses.
		One location out of the proposed 3 to be finalized.	
2	Major CD Work	Aqueduct across Siku River	Bed level as per gradient w.r.t crest level of offtake at RL

			299.000 m
		Canal Flow: 2.45 Cum/Sec	Length of structure: ~1.00 km
		Based on Google Earth and confirmed by survey.	
3	Other Structures incl. CD	To be identified based on survey and minimized.	
4	Distribution System	Mixed (Gravity flow channels and piped network)	Two canals proposed from the barrage: RBC (0.66 Cum/Sec, GCA: 1379.78 ha) and GCA: 4199.16 ha (2.45 Cum/Sec).

The project site spans the Sirum River basin, a tributary of the Siku River, and integrates the latest engineering practices to manage water resources efficiently. The catchment area of 116.52 square kilometers provides an extensive platform for irrigating approximately 5,587 hectares under the Gross Command Area (GCA) and 4,000 hectares of Culturable Command Area (CCA). The intervention seeks to address water scarcity issues and improve crop yields for the benefit of over 2,500 local households.

Key Features and Justifications

- Strategic Location:
  - The Sirum River basin's geographic and hydrological characteristics make it a suitable candidate for an irrigation project.
- Sustainable Objectives:
  - The project is aligned with government policies promoting water conservation and sustainable agricultural practices.
- Community Benefits:
  - Beyond irrigation, the project will contribute to socio-economic upliftment through increased agricultural output and livelihood opportunities.

Salient Features of the Project

- Location: Mebo, Pasighat, Arunachal Pradesh
- Catchment Area: 116.52 sq. km
- Full Reservoir Level (FRL): 304.5 m
- Irrigation Intensity: 155%
- Beneficiary Population: 2,520

3. Objective of the Work

The primary objective of this survey is to provide scientifically validated dataset that will serve as the foundation for the planning, design, and execution of the Mebo Irrigation Project. Drawing from methodologies outlined in the work order and relevant tender documents, the specific goals include:

1. **Detailed Topographical Mapping:**
   - To create accurate topographical maps of the reservoir, river, and command areas using advanced technologies such as DGPS, LiDAR, and UAVs.
   - Generate contour maps with a 0.5 m interval to ensure high spatial accuracy and resolution.
2. **Bathymetric Survey:**
   - To conduct precise bathymetric surveys of the reservoir and river areas using echo-sounder technology, aiding in the assessment of underwater topography and sedimentation patterns.
3. **Benchmark Establishment:**
   - To establish primary and secondary control points and benchmarks that ensure spatial and vertical accuracy for all survey and alignment activities.
4. **Canal and Pipe Alignment:**
   - To provide precise data for the alignment of canals and pipelines, ensuring optimal water conveyance and minimal construction disruption.
5. **Reservoir Capacity Analysis:**
   - To support calculations for reservoir capacity and sediment management by providing high-accuracy Digital Terrain Models (DTMs) and 3D models.
6. **GIS Integration:**
   - To develop deliverables compatible with GIS software, such as KMZ/KML files, enabling efficient integration into planning and management systems.
7. **Support for DPR Preparation:**
   - To ensure that all data generated contributes directly to the Detailed Project Report (DPR), including maps, alignment designs, and capacity evaluations.

These objectives align with the requirements specified in the work order, ensuring that all deliverables meet the technical and operational needs of the Central Water Commission (CWC). By addressing these goals, the project aims to enhance water resource management and ensure sustainable agricultural productivity in theregion.

4. Scope of Work

The scope of work for the Detailed Topographical and Bathymetric Survey of the Mebo Irrigation Project involves the following components:

4.1 Reservoir Area Survey

1. **Topographical Mapping:**
   - Conduct detailed topographical surveys using advanced UAVs equipped with LiDAR and DGPS technology. The goal is to ensure high spatial accuracy and generate comprehensive terrain models. These models will enable precise understanding of the reservoir's topography.
   - Develop Digital Terrain Models (DTMs) and produce contour maps with an exceptionally detailed 0.5 m contour interval. These contour maps are crucial for understanding variations in elevation and planning infrastructure placement.
   - Extend the survey coverage to include the entire reservoir area up to MWL/HFL + 5 meters. This extension ensures a buffer zone is included for future design adaptations and flood management strategies.
   - The survey will also incorporate upstream and downstream areas within a 3 km radius from the barrage axis, capturing all hydrological and topographical features that could influence reservoir functionality or construction.
   - Conduct detailed topographical surveys using UAV and DGPS to capture terrain features.
   - Develop Digital Terrain Models (DTMs) and contour maps with a 0.5 m contour interval.
   - Ensure coverage of the reservoir area up to MWL/HFL + 5 meters and extending 3 km upstream and downstream from the barrage axis.
2. **Control Point Establishment:**
   - Establish master and secondary control points using DGPS equipment with specified accuracies.
   - Construct RCC pillars with appropriate markings and validate benchmarks against Survey of India standards.

3. **Deliverables:**
    - Geo-referenced maps and ortho-images in CAD/GIS-compatible formats.
    - Cross-sectional profiles and sedimentation analysis data.

4.2 River Area Survey

1. **Hydrographic and Longitudinal Surveys:**
    - Perform surveys along the Sirum River using echo-sounders, UAVs, and DGPS.
    - Capture riverbed profiles at 10 m intervals to evaluate hydraulic characteristics.
2. **Cross-Sections:**
    - Plot cross-sections from left high bank to right high bank, depicting natural and man-made features.
3. **Water Level Documentation:**
    - Record minimum and maximum water levels and historical high flood levels.
    -

4.3 Command Area Survey

1. **Land Use and Terrain Analysis:**
    - Conduct UAV-based LiDAR surveys to generate high-resolution maps covering land use and terrain.
    - Capture land use patterns and integrate them into irrigation planning.
2. **Contour and Alignment Surveys:**
    - Generate contour maps with 0.5 m intervals for accurate irrigation network design.
    - Prepare strip surveys and longitudinal profiles along canal alignments at 50 m intervals.
3. **Deliverables:**
    - Detailed maps showing command area features, land use classification, and proposed irrigation layouts.

4.4 Canal/Pipe Alignment Survey

1. **Alignment Optimization:**
    - Conduct surveys to align canals and pipelines efficiently, ensuring minimal disruption to inhabited areas and infrastructure.
    - Optimize routes to avoid excessive cuttings, fillings, or waterlogged zones.
2. **Cross-Drainage Structures:**
    - Survey locations for cross-drainage structures, ensuring compatibility with proposed canal alignments.
3. **Design and Compliance:**
    - Ensure designs adhere to BIS codes (e.g., IS 5968-1987) and CWC guidelines.
4. **Deliverables:**
    - Maps and profiles compatible with CAD/GIS, detailing canal alignments and cross-drainage features.

5. Brief Workflow and Approach for Execution

The execution of the Detailed Topographical and Bathymetric Survey for the Mebo Irrigation Project involves the following structured workflow and approach:

1. Pre-Execution Planning

Project Initiation: Organize initial meetings with NEID-3 to understand project objectives, timelines, and deliverables. We organized a meeting with the Executive Engineer of the CWC department and their engineering team. During the meeting, we presented a detailed workflow and methodology of our work, highlighting the use of advanced surveying technologies. The presentation aimed to provide a clear understanding of how these technologies would enhance accuracy and efficiency throughout the project. We also outlined the specific steps and processes involved, ensuring all parties were aligned on expectations. In addition, we discussed the tentative timeline required for project completion, taking into consideration all phases of work. We provided a breakdown of the deliverables to be submitted at each key milestone to ensure transparency and effective tracking of progress. This collaborative session allowed us to address any concerns and fine-tune our approach. By the end of the meeting, all parties had a mutual understanding of the project’s direction, timeline, and deliverables.

- **Site Reconnaissance:** Conduct preliminary visits to the project area to identify survey challenges and finalize locations for equipment deployment. Before commencing the site work, a thorough site visit was conducted by our team along with the Executive Engineer of the CWC department and their engineering team. During this visit, we closely examined the site and assessed the various challenges it presents. Together, we identified potential obstacles, including logistical issues, site accessibility, and any environmental factors that could affect progress. Detailed discussions were held to ensure a clear understanding of the project's scope and requirements. We also evaluated the resources needed and the manpower necessary to tackle the challenges effectively. Through this collaborative effort, we were able to estimate the time span required to complete the project. The team worked together to align on a realistic and efficient timeline that accounts for potential delays and other uncertainties. With this comprehensive assessment, we are confident that we can move forward with the project smoothly.

Site Visit in the presence of Executive sir & Engineers of NEID-3 CWC Department

- **Survey Design:** Prepare detailed survey plans, including control network design, equipment requirements, and manpower allocation. we prepared the tentative drone survey flight plans to cover the entire area, including the barrage section that is to be constructed. The flight plans were designed to ensure comprehensive coverage, as per the details specified in the tender documents. We carefully mapped out the flight paths to capture accurate data across all key areas of the site. Additionally, we developed a tentative DGPS points plan, which included the placement of Master Control Points (MCP) and Primary Control Points (PCP). These control points were strategically located to ensure precise georeferencing throughout the survey process. The plan was designed to align with the technical requirements of the project and provide reliable data for further stages of the work. By preparing these detailed plans in advance, we ensured that the surveying process would be efficient and accurate. This preparation allowed us to address any potential challenges upfront and streamline the execution of the site work.

2. Establishment of Control Network

- **GTS Benchmark Connection:** Connect the entire survey to the Survey of India GTS benchmark at the J.N. College Auditorium cum Students Centre, Pasighat. Before starting the DGPS survey on site, it was essential to first shift the GTS benchmark to a designated MCP point on the site. To ensure accurate georeferencing for the survey, we transferred the GTS benchmark from its original location at JN College, Pasighat, to MCP1 on the site. This transfer was carried out meticulously to maintain the integrity of the survey's data. The GTS benchmark, provided by the

Survey of India, serves as the reference point for all further measurements and survey work. By relocating it to MCP1, we ensured that all subsequent DGPS data would be aligned and consistent with the national geodetic system. This step was crucial for establishing a reliable and accurate foundation for the survey. Once the GTS benchmark was successfully shifted, we were able to proceed with the DGPS survey across the site. The process ensured that the survey would be carried out with the highest level of precision.

- **Master Control Points (MCPs):** Conduct static observations for at least 6 hours for MCPs to ensure high precision.

Master Control Point

- **Primary Control Points (PCPs):** Establish PCPs using DGPS with a minimum observation period of 1 hour.

Primary Control Point

3. Data Acquisition

- **Topographical Survey:** Use UAVs equipped with LiDAR sensors to capture high-resolution 3D terrain data.
- **Bathymetric Survey:** Deploy echo sounders to map underwater profiles; where depth is insufficient, conduct physical level pickups using DGPS.
- **Ground Control Verification:** Validate survey accuracy by comparing collected data against established benchmarks.

4. Data Processing and Analysis

- **Digital Terrain Models (DTMs):** Generate DTMs and contour maps with a 0.5 m interval for detailed analysis.
- **Integration of Bathymetric Data:** Combine underwater and surface data for a comprehensive hydrological model.
- **Error Correction:** Apply rigorous quality control measures to rectify anomalies in raw data.

5. Reporting and Deliverables

- **Volume 1 - DPR:** Compile findings into a comprehensive DPR, including methodology, results, and recommendations.
- **Volume 2 -** Deliverables Submission: Provide georeferenced maps, cross-sectional profiles, and GIS-compatible files.

6. Department Coordination and Review

- Present interim findings to stakeholders for feedback.
- Incorporate suggestions and finalize the report.

7. Submission and Handover

- Submit finalized deliverables to the Central Water Commission (CWC).
- Ensure all data is provided in both hard and soft copy formats as per project specifications.
- This systematic workflow ensures precision, efficiency, and alignment with the technical requirements of the Mebo Irrigation Project.

6. Mebo Irrigation Project Survey Work in East Siang District

6.1 DGPS Survey

DGPS Survey and Its Technical Details

Differential Global Positioning System (DGPS) is a technique used to improve the accuracy of standard GPS. It works by using additional reference stations, known as base stations, which are located at known positions. These stations calculate the error in GPS signals caused by various factors such as atmospheric interference, satellite positioning errors, and clock discrepancies. The errors are then transmitted to roving GPS receivers, which apply the corrections to their position calculations, significantly improving the accuracy.

This methodology focuses on the process of using DGPS for establishing precise control points, marking Ground Control Points (GCPs), and performing both static and kinematic observations. Below, we provide detailed explanations of DGPS, its working principles, and the specific techniques used in the project.

DGPS (Differential Global Positioning System) is an enhancement to the regular GPS system. While standard GPS provides position data based on satellite signals, DGPS uses a network of ground-based reference stations to correct errors in these signals, enhancing the accuracy of GPS positioning. DGPS works by comparing the GPS signal at a known reference location (base station) to the signal at the mobile unit (rover), thus identifying and correcting errors.

How DGPS Works:

1. **Base Station:**
    - The base station is placed at a known location and receives GPS signals. It then calculates the discrepancies between the GPS signal it receives and its known position.
    - The base station computes the error (like satellite clock errors or ionospheric delays) and sends correction signals to the rover in real-time

2. **Rover:**

    - The rover, which is the mobile GPS receiver, receives both the standard GPS signal from the satellites and the corrected signal from the base station.
    - The rover applies these corrections in real-time, improving its accuracy from several meters to centimeters.

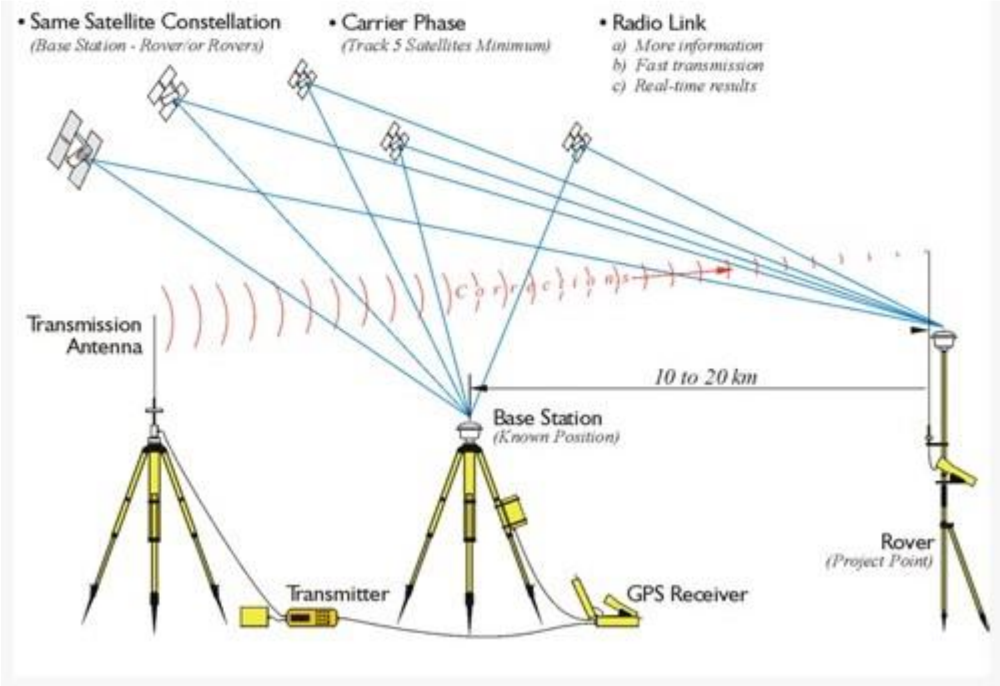
3. **Error Sources:**

    - Satellite Clock Errors: Slight inaccuracies in the atomic clocks on GPS satellites.
    - Ionospheric Delays: The ionosphere can delay GPS signals, especially during solar activity.
    - Multipath Errors: Signals reflected off large buildings or natural features can cause inaccurate readings.

DGPS Processing Methods:

Baseline Error Distribution:

Baseline error refers to the difference in positions calculated by the base and rover units over a given distance, known as the baseline. When the rover and base stations are far apart, errors may increase, and the baseline error distribution becomes important in understanding the magnitude of errors along the baseline.



1. **Short Baselines:**
   - When the base station and rover are located close to each other (typically within 10-15 km), the error due to ionospheric and satellite clock discrepancies is minimized. Shorter baselines offer higher positional accuracy because the signal correction is applied with minimal delay.
2. **Long Baselines:**
   - When the baseline is long, the corrections may not be as accurate, leading to increased error. However, DGPS correction techniques allow for error correction even over longer distances by using dual-frequency GPS systems or employing differential processing after data collection.
3. **Error Propagation:**
   - Errors are distributed across the baseline. As baseline length increases, errors can propagate, requiring more intensive correction algorithms. These algorithms ensure the rover's position is adjusted for any discrepancies, maintaining high accuracy.

Kinematic DGPS for Marking Ground Control Points (GCPs):

Kinematic DGPS is a method used to establish precise control points while the rover is moving. Unlike static DGPS, where the rover stays in a fixed position, kinematic DGPS allows for real-time corrections while the rover is in motion. This technique is particularly useful for marking Ground Control Points (GCPs) across large areas.

- **Real-Time Corrections:** The rover receives corrections from the base station continuously, ensuring the positions of control points are highly accurate.
- **Continuous Measurement:** The rover constantly measures its position while moving, making it ideal for large-scale surveys and marking multiple GCPs quickly.
- **Accuracy:** Kinematic DGPS provides high positional accuracy (centimeter-level) and is commonly used for dynamic surveys, where the area needs to be surveyed in real-time, such as for canal alignments or reservoir areas in irrigation projects.

Advantages of DGPS and GPS Observation Techniques:

1. **Increased Accuracy:**
    - DGPS offers much higher accuracy compared to standard GPS. It can provide horizontal accuracy up to 10 mm ± 1 ppm and vertical accuracy up to 10 mm ± 1 ppm, far beyond the typical GPS accuracy of several meters.
2. **Real-Time Positioning:**
    - DGPS offers real-time corrections, particularly useful for dynamic applications, such as marking GCPs, surveying large areas, or creating topographical maps.
3. **Reduced Errors:**
    - DGPS effectively reduces errors from ionospheric delays, multipath effects, and satellite clock discrepancies. It ensures the rover's position is corrected with high precision.

4. Improved Survey Speed:

- With kinematic DGPS, surveys can be completed much faster since the rover is continuously correcting its position, allowing for rapid and accurate georeferencing of large areas, such as in irrigation projects.

5. Flexibility:

- DGPS can be used for both static and kinematic observation methods, making it versatile for various types of surveys, including topographical, bathymetric, and alignment surveys.

Static Observation and Other Technical Details:

Static Observation:

Static DGPS observation is a method where both the base and rover stations are kept stationary at specific points for an extended period. This allows for more precise data collection as the system accumulates data over time, reducing the influence of errors.

- **Duration:** Static observation at control points like MCPs and PCPs typically lasts from 1 hour to several hours (e.g., 6 hours for MCPs). Longer observation times improve accuracy.
- **Accuracy:** The longer the observation, the higher the accuracy, especially in areas with challenging satellite geometry or atmospheric conditions.
- **Data Processing:** The data from static observations is later processed, applying corrections from the base station's reference position to the rover's data, ensuring high precision.

Post-Processing DGPS:

After collecting the GPS data from both the rover and the base station, the data can be post-processed to refine positions even further. Post-processing involves applying additional corrections based on the collected data, improving overall accuracy.

- **Software:** Specialized software (e.g., Hi-Target Business Centre, Global Mapper) is used to process the raw data and generate precise georeferenced coordinates for control points.

Advantages of Static Observations:

- Higher Precision: Static observation provides the most precise results, as it allows for accumulation of data over a period of time.
- Ideal for Benchmarking: Static DGPS is often used for setting permanent benchmarks and master control points in a project, ensuring accurate georeferencing for further surveys.

Dynamic Observation with RTK:

For real-time surveying where both the base and rover are mobile, Real-Time Kinematic (RTK) DGPS is used. RTK offers near-instantaneous corrections, and data can be collected on the move, making it ideal for large-scale dynamic surveys.

- **Real-Time Feedback:** RTK provides real-time feedback, allowing surveyors to monitor and adjust their measurements during the survey process, ensuring continuous accuracy.
- **Higher Speed:** RTK DGPS is faster than traditional static observations, making it ideal for large-scale projects like mapping irrigation canals or reservoir alignments.

Part 1: Requirements as per TOR for DGPS Control Points and Survey Methodology

The Terms of Reference (TOR) for the Mebo Irrigation Project outline specific requirements for establishing control points and conducting the DGPS survey. The key components are as follows:

1. **Establishment of Control Points:**

Master Control Points (MCPs):

- **Requirement:** The MCPs should be established using known Survey of India (SOI) Permanent Benchmarks (BM) for both horizontal and vertical control. The base station for DGPS should be referenced from these SOI benchmarks. A closed loop network of triangles connecting these MCPs should be formed, ensuring proper spacing and angles between them, neither too acute nor obtuse, to cover the survey area uniformly.

- **Pillar Construction:** The MCPs are to be established on RCC pillars (size: 45 cm x 45 cm x 60 cm) with proper reinforcement (at least four 6mm bars with stirrups). The pillars should be embedded 15 cm into the ground and compacted with CC M10 around the base. They should be painted yellow and marked with black paint for identification.

- **Observation:** A static observation of minimum 6 hours should be conducted using DGPS instruments for precise positioning of the MCPs.

Primary Control Points (PCPs):

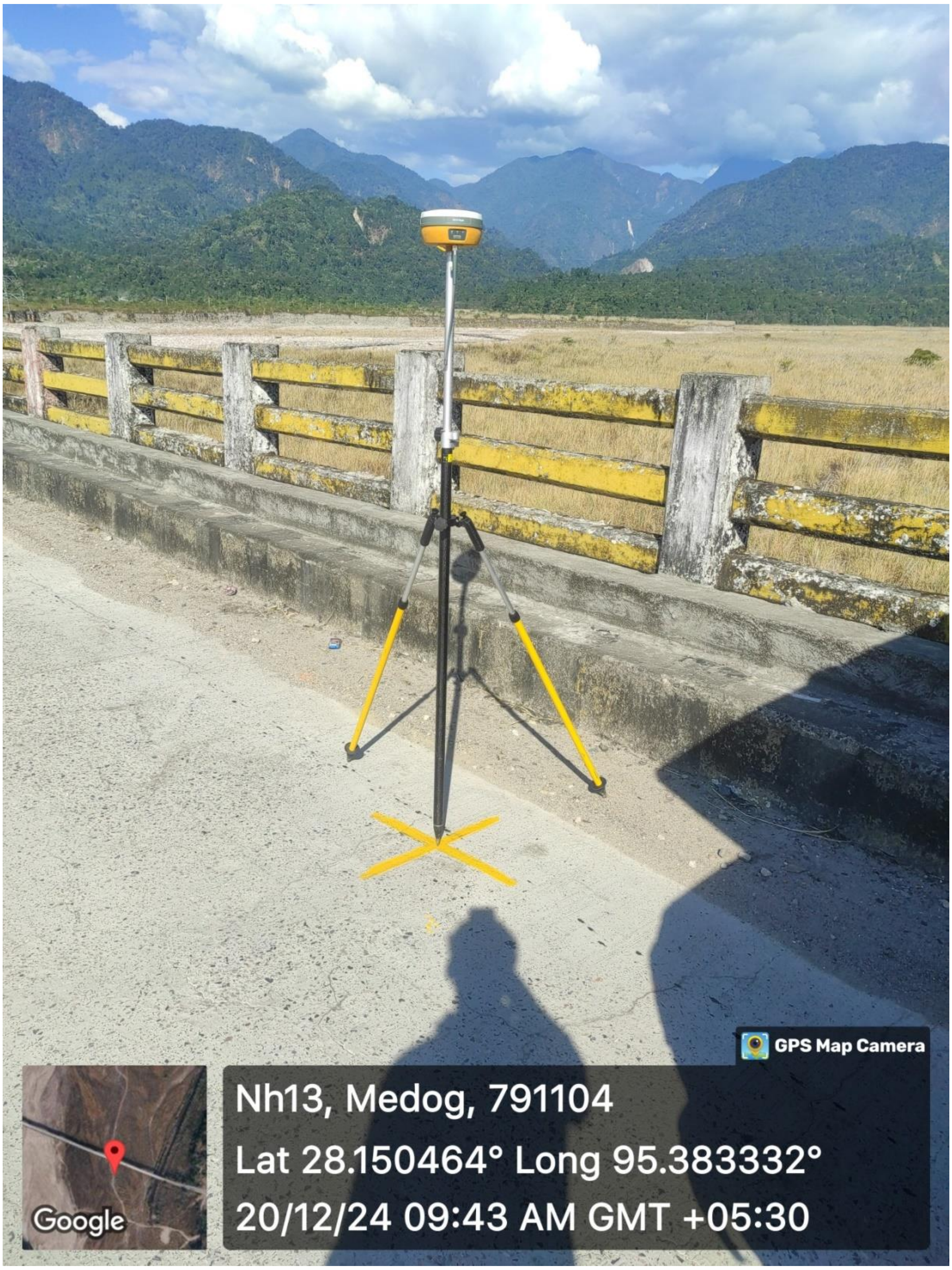
- **Requirement:** PCPs should be established using the same construction specifications as MCPs, but these points can be spaced up to 3 km apart for the reservoir areas. The primary control points should be placed at intervals with a maximum distance of 3 km.

- **Pillar Construction:** The PCPs must be installed on RCC pillars (size: 15 cm x 15 cm x 60 cm) reinforced with four 6mm bars, embedded 45 cm in the ground and compacted with CC M10. The pillars must be painted yellow and identified with black paint.

- **Observation:** A minimum of 1 hour of static DGPS observation is required for establishing the accuracy of PCPs.

Secondary Control Points (SCPs):

- Requirement: SCPs should be established using RTK or Electronic Total Station (ETS) at approximately 500 meters apart for the reservoir areas and adequate spacing for canal alignments. These control points should be marked on permanent structures like rocks, culverts, or bridges.

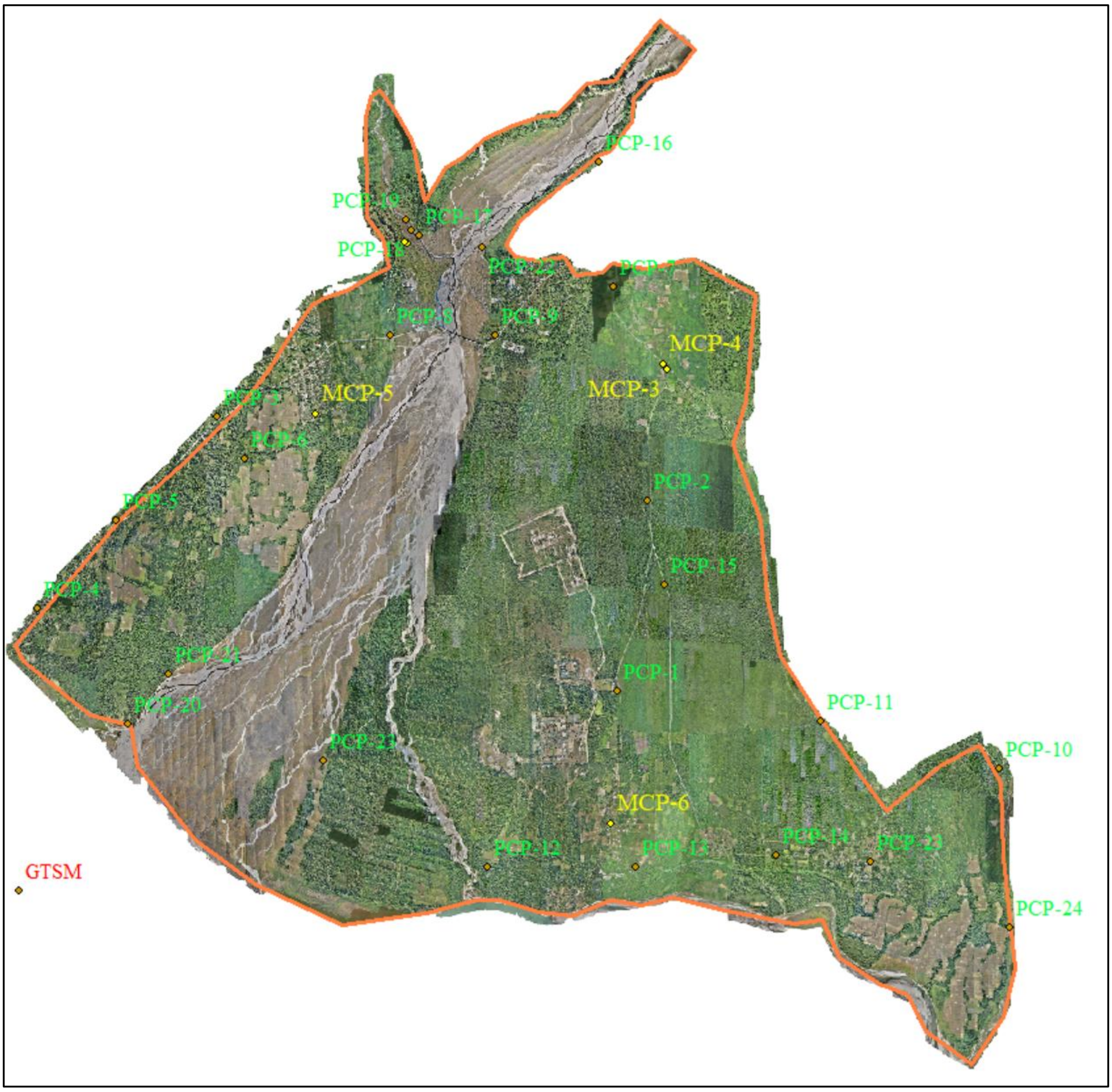


Ground Control Points (GCPs):

- Requirement: A minimum of 8 GCPs per square kilometer should be established. 50% of these GCPs should have a center-to-center spacing of 300 meters minimum, and the remaining 50% should be placed as directed by the Engineer-in-Charge (EIC).

Survey Area and Control Points:

- Strip Survey: A strip survey of the barrage site is required, using a grid of 10m x 10m intervals to ensure precise data capture of the area.



2. Accuracy and Observations:

- Horizontal Accuracy: Sufficient DGPS observations must be done for a minimum 1-hour uninterrupted observation on each control point using dual-frequency DGPS instruments. The horizontal accuracy should meet the post-processed differential accuracy of ±(5mm, +0.5 ppm length).
- Vertical Accuracy: Vertical control should be referenced against known Survey of India Permanent Benchmarks, with local geoid corrections using SOI GTS or CORS (Continuously Operating Reference Stations) to achieve an accuracy limit of 5 cm.

3. Data Processing and Deliverables:

- Raw Data Download: The surveyor should download the raw GPS data on-site and process it to generate grid coordinates (Northing, Easting, Elevation) referenced to Survey of India Mean Sea Level (MSL).
- Final Deliverables: The final deliverable should include a list of all control points, benchmarks, and reference points with coordinates in Universal Transverse Mercator (UTM) system. Photographs of each MCP pillar should be submitted, showing proper indexing and labeling for easy identification.

4. Site Requirements:

- Control Point Location: The control points must be located in areas clear of HT/LT lines, free from multipath problems, and open to the sky with a clear view of the horizon for uninterrupted satellite visibility.

Part 2: On-Site Implementation as per TOR for Control Points and DGPS Survey

In line with the Terms of Reference (TOR), the on-site implementation of the DGPS survey was carried out as follows:

1. Establishment of Control Points:

Master Control Points (MCPs):

- **Implementation:** The Master Control Points were established using the Survey of India (SOI) Permanent Benchmarks as references for both horizontal and vertical control. We connected these MCPs ensuring the spacing between control points was adequate to cover the survey area uniformly. We used Hi-Target V30 Plus GNSS RTK systems to ensure high-accuracy data collection.

- **Pillar Construction:** The MCP pillars were constructed on RCC pillars with the prescribed size of 45 cm x 45 cm x 60 cm with four 6mm bars and compacted with CC M10. The pillars were embedded 15 cm in the ground for stability, and they were painted yellow and marked with black paint for easy identification.

- **Observation:** Static DGPS observations were conducted for a minimum of 6 hours to achieve precise positioning of each MCP. This allowed for high accuracy in establishing control points for further surveys.

Primary Control Points (PCPs):

- Implementation: The Primary Control Points were placed within 3 km of each other in the reservoir areas. The construction followed the TOR specifications of 15 cm x 15 cm x 60 cm RCC pillars, reinforced with four 6mm bars and compacted with CC M10 around the base.
- Observation: A minimum of 1 hour of static DGPS observation was conducted at each PCP using dual-frequency GPS systems, ensuring the required horizontal and vertical accuracy.

Secondary Control Points (SCPs):

- Implementation: Secondary Control Points were placed using RTK and ETS techniques. These points were located approximately 500 meters apart in the reservoir areas and along canal alignments to ensure proper survey coverage. The SCPs were marked on permanent structures such as bridges, culverts, and rocks for visibility and durability.

Ground Control Points (GCPs):

- Implementation: We established 8 GCPs per square kilometer. 50% of the GCPs maintained a 300-meter center-to-center spacing, and the remaining GCPs were placed under the direction of the Engineer-in-Charge. The GCPs were marked and documented, and photographs were taken for accurate referencing.

2. Accuracy and Observations:

- Horizontal and Vertical Accuracy: The horizontal accuracy was maintained to ±(10mm, +1 ppm length), and vertical accuracy was ensured through geoid corrections using SOI GTS or CORS. Static DGPS observations of at least 1 hour were performed at each control point to achieve the necessary precision.

3. Data Processing and Deliverables:

- Data Download and Processing: The raw GPS data was downloaded on-site and processed to generate accurate grid coordinates, referenced to Survey of India Mean Sea Level (MSL). The coordinates were converted into the UTM system for consistency with international geospatial standards.
- Final Deliverables: A comprehensive list of all control points, benchmarks, and reference points was compiled. Photographs of each

MCP pillar were provided, ensuring proper indexing and easy identification.

4. Site Requirements:

- Control Point Location: The control points were carefully selected to be clear of HT/LT lines, free from multipath interference, and open to the sky to ensure proper satellite visibility and reliable data collection.

5. Benchmark Connection:

- Implementation: The entire survey was connected to the Survey of India GTS benchmark at the J.N. College Auditorium cum Students Centre in Pasighat, ensuring consistent and accurate reference to national benchmarks.

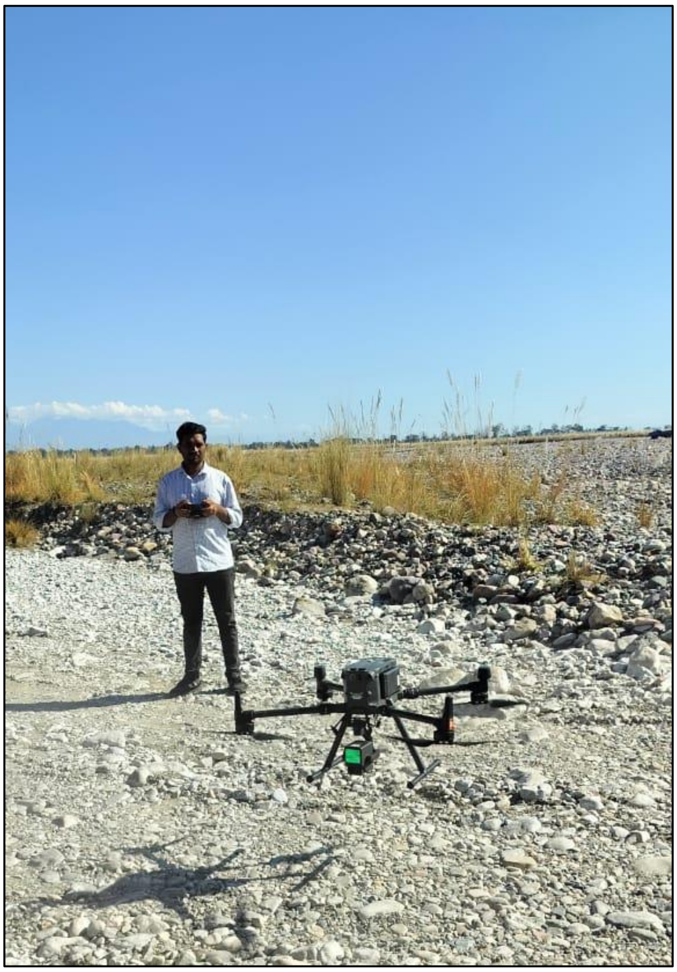
GTS Benchmark J.N. College Auditorium cum Students Centre, Pasighat

6.2 LiDAR Survey

Part 1: Requirements as per TOR for LiDAR Survey

LiDAR technology was utilized to meet the following requirements outlined in the Terms of Reference (TOR):

1. **Aerial Topographical Survey:**
    - Conducted using drones or UAVs equipped with calibrated LiDAR systems for high-accuracy terrain mapping.



On Site Drone Flying Operations

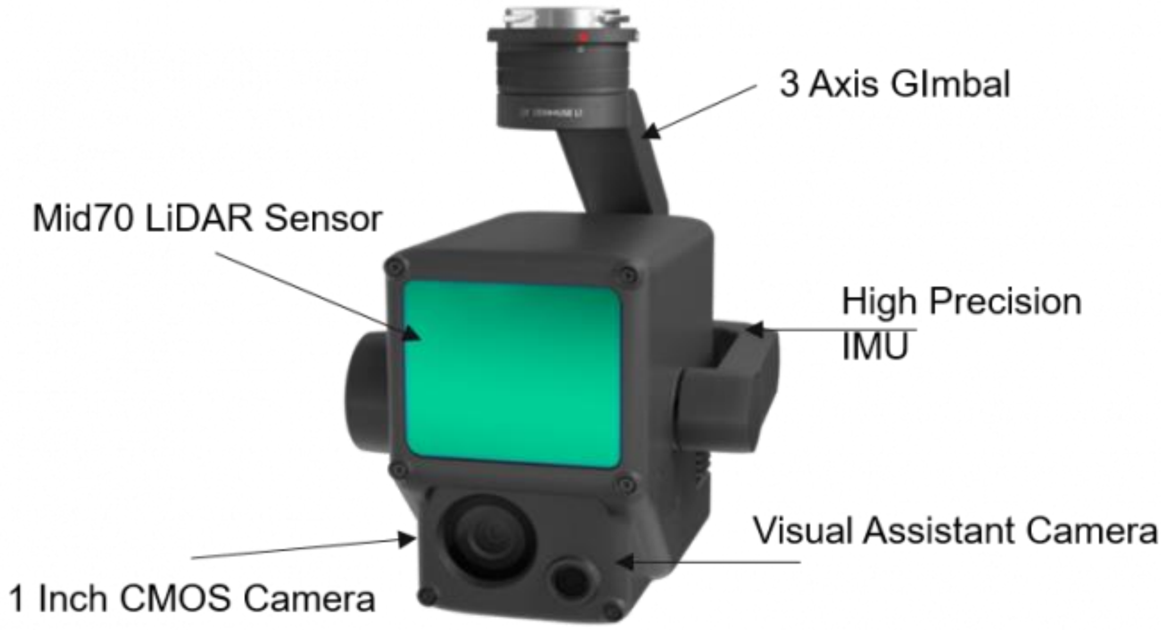
2. **LiDAR Specifications:**
   - Data density: Minimum 10 points per square meter.
   - Vertical Accuracy (FVA): ≤ ±10 cm at 95% confidence interval (1.96 x RMSE).
   - Horizontal Accuracy (FHA): ≤ ±15 cm at 95% confidence interval (1.96 x RMSE).
3. **Coordinate Systems and Datums:**
   - Horizontal Datum: WGS-84.
   - Map Projection: Universal Transverse Mercator (UTM).
   - Vertical Datum:
     - Orthometric: Referenced to Survey of India Vertical Datum (MSL).
     - Ellipsoidal: Based on WGS-84.
4. **Deliverables:**
   - Raw survey control data and classified data in LAS/DWG/DGN/TIF formats.
   - Processed data to include Digital Terrain Models (DTMs) and contour maps with a 0.5 m interval.
   - Layers and features properly labeled as per naming conventions.
5. **Imagery and Videography:**
   - Orthophotos and Topo plans generated using PPK technology-based aerial survey.
   - Fly-through videos created with DEMs/DTMs, highlighting structures and chainage.

Part 2: On-Site Implementation as per TOR for LiDAR Survey

The on-site implementation of the LiDAR survey adhered to the following processes:

1. **Deployment of Equipment:**
    - **Drone Operations:**
        - DJI Matrice 300 RTK drone equipped with Zenmuse L1 LiDAR sensor was deployed for capturing high-resolution point clouds and RGB imagery.

        - Missions were planned with optimal overlaps (End overlap: 70%, Side overlap: 60%) to ensure complete coverage.



- **Calibration:**
  - LiDAR sensors were calibrated prior to deployment to ensure data accuracy and consistency.

6.3 Bathymetric Survey

Bathymetric surveys were originally planned using Dual-frequency echo sounders to map underwater topography. However, due to limitations in water depth and the presence of stones in the river, conducting traditional bathymetric surveys was not feasible. The water depth in certain sections of the river was less than 0.5 meter, making it unsuitable for echo sounder operations.

Sirum River

On-Site Adjustments:

- To overcome these challenges, physical level pickups were conducted using DGPS equipment under wet conditions.
- This alternative method ensured complete coverage of the required survey areas, providing data equivalent to that of traditional bathymetry.

Key Features:

- Profiling of the reservoir and riverbed was achieved by direct measurement
- Integration of level pickup data with topographical data to assess sedimentation patterns and reservoir capacity.

On-Site Implementation:

- GNSS receivers were used for precise level measurements.

- Physical observations were supplemented with digital data processing to ensure accuracy and alignment with project requirements.
- Data was processed using specialized hydrographic software to produce underwater bed profiles.

2. High-Resolution Point Cloud Generation

A **point cloud** is a collection of 3D coordinates (x, y, z) that represent the surface of the Earth, captured by LiDAR sensors. The high-resolution point cloud generated during the survey is used to create accurate Digital Terrain Models (DTMs) and contour maps.

Point Cloud Generation Process:

1. **Laser Pulse Emission**: The Zenmuse L1 sensor emits laser pulses towards the ground. These pulses bounce back after hitting the surface, and the time it takes for the pulse to return is used to calculate the distance to the surface.
2. **Point Cloud Density**: The density of the point cloud refers to the number of points collected per unit area. For high-resolution surveys, the point cloud density is typically high, capturing millions of points per square meter. This allows for a detailed representation of the terrain, including small variations in surface features.
3. **Georeferencing**: The RTK system on the DJI Matrice 300 RTK ensures that the point cloud is accurately georeferenced, meaning that each point in the cloud has a precise geographic location (latitude, longitude, and elevation).
4. **Data Processing**: The raw LiDAR data is processed using specialized software (e.g., **LiDAR360**, **Global Mapper**, or **ArcGIS**) to filter out noise and unwanted points (e.g., from vegetation or buildings) and create a clean, accurate point cloud representing the bare-earth surface.

Part 2: On-Site Implementation as per TOR for High-Resolution Point Cloud Generation

The on-site implementation of the LiDAR survey adhered to the following processes:

2. **Deployment of Equipment:**
   - **Drone Operations:**
     - DJI Matrice 300 RTK drone equipped with Zenmuse L1 LiDAR sensor was deployed for capturing high-resolution point clouds and RGB imagery.
     - Missions were planned with optimal overlaps (End overlap: 70%, Side overlap: 60%) to ensure complete coverage.
   - **Calibration:**
     - LiDAR sensors were calibrated prior to deployment to ensure data accuracy and consistency.
3. **Survey Process:**
   - **Terrain Coverage:**
     - The survey covered 57 km², including the reservoir area, command area, and canal alignments, adjusted during execution based on field conditions.
   - **Canopy Correction:**
     - Data was processed to remove vegetation effects, ensuring accurate ground representation.
   - **Flight Conditions:**
     - Flights were conducted under clear weather conditions, avoiding shadows, smog, and high soil moisture levels.
4. **Point Cloud Generation and Processing:**
   - **Point Cloud Creation:**

    - Laser pulses emitted by the Zenmuse L1 LiDAR sensor were used to generate high-density point clouds, representing the terrain with precision.
    - Each point was georeferenced with RTK-enabled positioning, ensuring spatial accuracy.
  - **Data Filtering:**
    - Specialized software such as LiDAR360 and Global Mapper was used to classify data into bare-earth and other categories.

5. **Imagery and Orthophotos:**
   - High-resolution orthophotos were created with a Ground Sampling Distance (GSD) of 5 cm or better.
   - Orthomosaics and georeferenced images were delivered in TIFF and ECW formats.
6. **Deliverables:**
   - Digital Terrain Models (DTMs) and contour maps with a 0.5 m interval.
   - Fly-through videos with tagged locations and relevant details.
   - Final processed data in CAD/GIS-compatible formats.

4. Creation of Digital Terrain Models (DTMs)

A **Digital Terrain Model (DTM)** is a 3D representation of the bare-earth surface, created from the point cloud data. It excludes non-ground features like buildings, trees, and other obstructions, providing an accurate representation of the terrain itself.

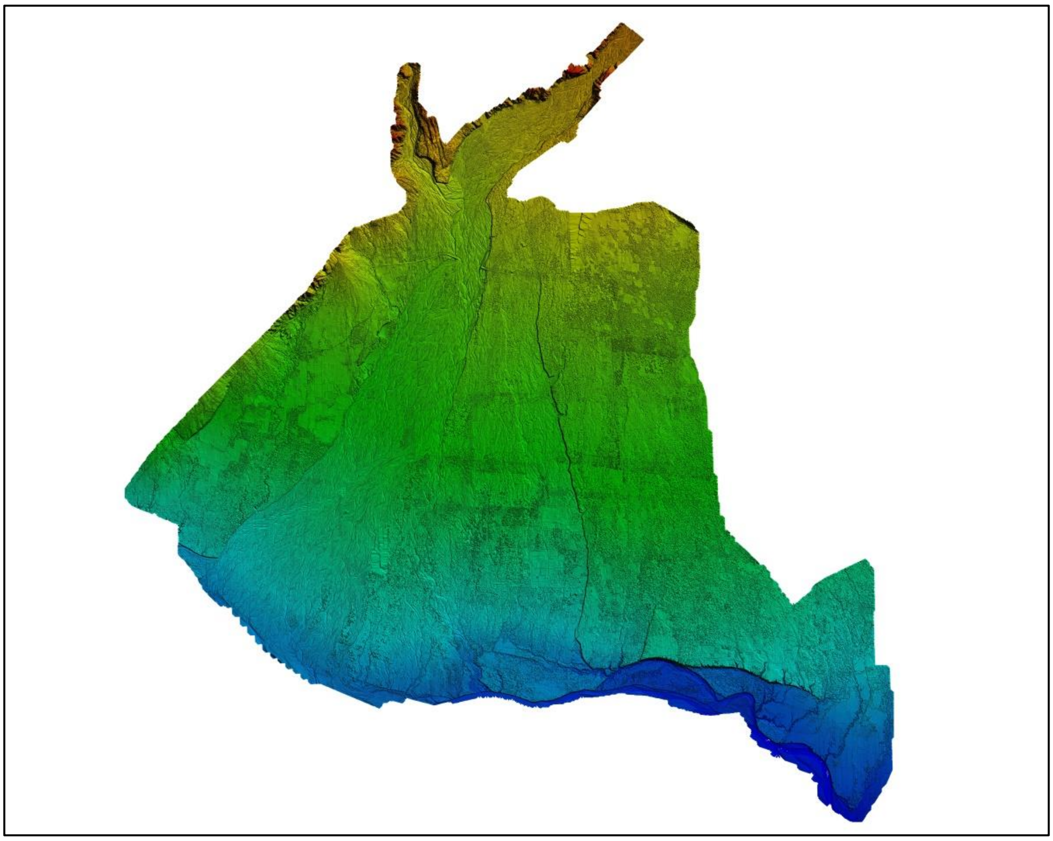
Part 1: Requirements as per TOR for Digital Terrain Models (DTMs)

1. **Ground Classification:**
    - LiDAR data must distinguish between ground and non-ground objects (e.g., buildings, vegetation, and other obstructions).
    - Sophisticated algorithms must be employed to classify points accurately as ground or non-ground. Only ground points are used for generating the DTM.
2. **Denoising:**
    - Noise and erroneous data points must be removed to ensure clean and accurate DTMs.
3. **Surface Modeling:**
    - The classified ground points should be used to create a seamless surface model of the terrain.
4. **Interpolation:**
    - Techniques like triangulated irregular networks (TIN) or gridding must be applied to interpolate ground points into a continuous surface model.
5. **Resolution:**
    - The DTM resolution must align with the density of the LiDAR point cloud. For this project, high-resolution DTMs with grid sizes of 0.5 meters or smaller were required to provide detailed elevation data.
6. **Accuracy Standards:**
    - Vertical Accuracy: ≤ ±10 cm at a 95% confidence interval (1.96 x RMSE).
    - Horizontal Accuracy: ≤ ±15 cm at a 95% confidence interval (1.96 x RMSE).

Part 2: Project Implementation as per TOR for Digital Terrain Models (DTMs)

The on-site implementation for generating DTMs adhered to the TOR guidelines and involved the following steps:

1. **Point Cloud Filtering:**
    - Ground points were extracted from the full point cloud using advanced classification algorithms. This ensured that only relevant data points representing the bare-earth surface were retained for further processing.
2. **Interpolation:**
    - Filtered ground points were interpolated to create a continuous surface. Techniques such as triangulated irregular networks (TIN) or gridding were used to produce an accurate and seamless terrain model.
3. **Denoising:**
    - Noise and errors in the point cloud were identified and removed using specialized software such as LiDAR360, Global Mapper, and ArcGIS. This step ensured that the resulting DTM was free from distortions.
4. **Resolution:**
    - The DTMs were generated at a high resolution, with grid sizes of 0.5 meters or smaller, allowing for detailed analysis of the terrain.
5. **Accuracy Validation:**
    - The DTMs were validated against control points established during the DGPS survey to ensure compliance with vertical and horizontal accuracy standards outlined in the TOR.
6. **Deliverables:**
    - Final DTMs were provided in CAD/GIS-compatible formats, including LAS, DWG, and TIF files.
    - Contour maps with a 0.5 m interval were included as part of the deliverables to support project planning and execution.



Digital Elevation Model

5. Contour Map Generation with a 0.5 m Interval.

Part 1: Requirements as per TOR for Contour Map Generation with a 0.5 m Interval

1. **Definition and Objective:**
   - A contour map is a 2D representation of terrain, where each line connects points of equal elevation. It provides a clear understanding of terrain shapes, slopes, valleys, and ridges, aiding in engineering design and flood modelling.
2. **Contour Interval Specification:**
   - The TOR specifies a contour interval of 0.5 meters to ensure high precision suitable for applications like irrigation planning and structural designs.

3. **Data Source:**
    - Contour maps must be generated using the Digital Terrain Model (DTM) created from LiDAR survey data, ensuring consistency and accuracy.
4. **Accuracy Standards:**
    - Vertical Accuracy: ≤ ±10 cm at a 95% confidence interval (1.96 x RMSE).
    - Horizontal Accuracy: ≤ ±15 cm at a 95% confidence interval (1.96 x RMSE).
5. **Visualization and Deliverables:**
    - Contour maps must be GIS-compatible and delivered in formats such as DWG, SHP, and TIFF.
    - Layers must include terrain features like slopes, streams, and valleys, as specified in the TOR.

Part 2: Project Implementation as per TOR for Contour Map Generation with a 0.5 m Interval

1. **Elevation Data Interpolation:**
    - The DTM, derived from high-density LiDAR point clouds, was used to interpolate a continuous surface of elevation values.
    - Contour lines were drawn at 0.5-meter intervals to accurately depict elevation changes across the project area.
2. **Processing Workflow:**
    - Advanced GIS software, including ArcGIS and Global Mapper, was used to process the DTM and generate the contour maps.
    - The software ensured precise interpolation of elevation data and alignment with established survey benchmarks.
3. **Visualization and Analysis:**
    - Contour maps were visualized to highlight critical terrain features such as slopes, valleys, and ridges.

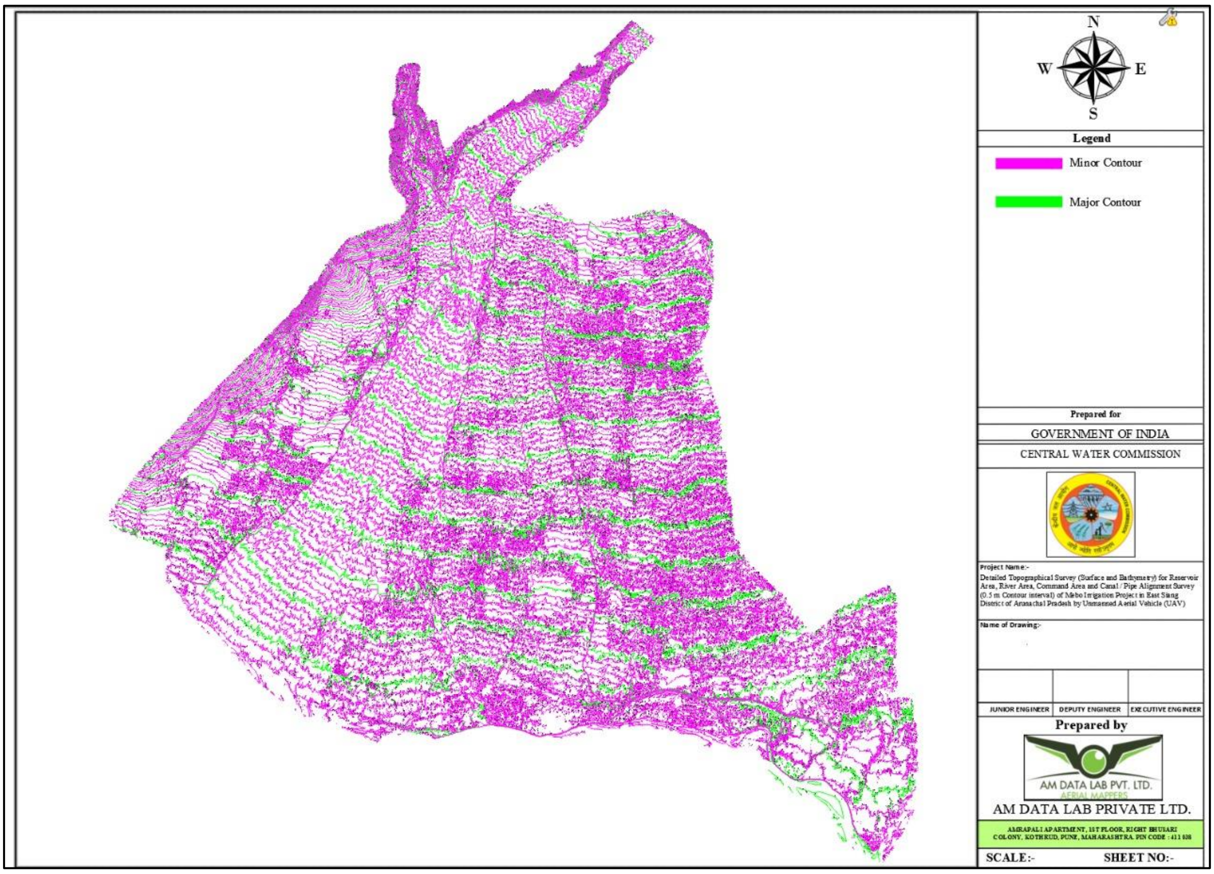
- These maps underwent thorough review and validation to ensure accuracy and adherence to TOR requirements.

4. **Quality Assurance:**

    - Each contour map was cross-verified against DGPS control points to ensure compliance with accuracy standards.
    - The maps were validated for consistency with field measurements and project specifications.

5. **Deliverables:**

    - Contour maps were delivered in raster and vector formats, including SHP, DWG, and TIFF files.
    - Processed data were organized into clearly labeled layers, detailing terrain features essential for planning and execution.

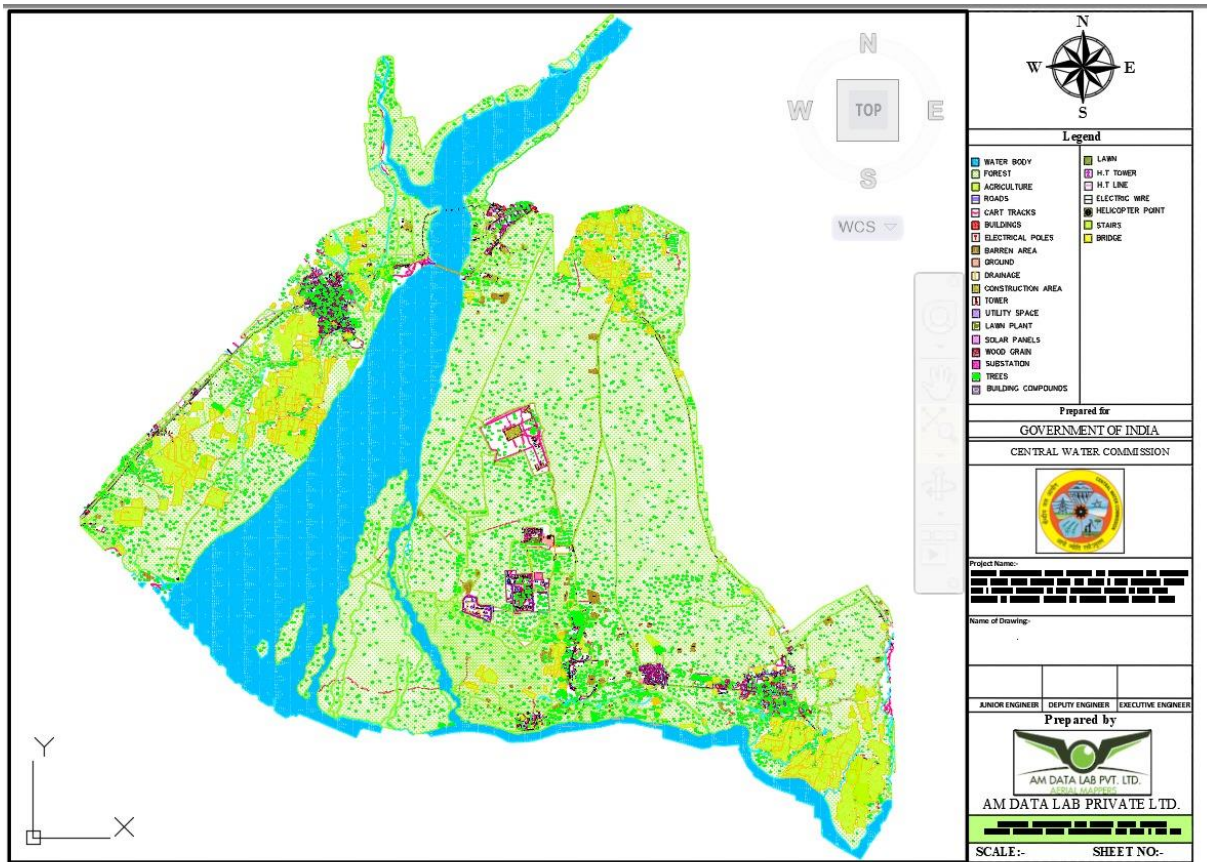


Contour Map

Topographical Map Generation

The topographical map includes all essential terrain and infrastructure details required for planning and design. Key features captured in the survey include:

• Roads and trails. • Telephone and electric poles. • Houses and huts. • Important land markings and landmarks. • Forest cover and vegetation. • Streams, slopes, and valleys.



Topographical Map

6. Coverage of the Entire Command Area, Reservoir, and Canal Alignments

The LiDAR survey was conducted over a large area, including the **command area**, **reservoir**, and **canal alignments**. This comprehensive coverage is essential for understanding the topography and planning infrastructure.

Command Area:

- The **command area** refers to the area served by a particular irrigation system. LiDAR data provides detailed information on the terrain to optimize irrigation planning, water flow analysis, and land development.

Reservoir:

- LiDAR data is critical for modeling the terrain around the **reservoir**, including the shoreline, slopes, and potential flood zones. The high-resolution DTM and contour maps help in reservoir design, flood risk assessment, and water storage capacity analysis.

Canal Alignments:

- For **canal alignments**, LiDAR data helps in planning the route and slope of the canal. Accurate elevation data ensures that the canal follows the optimal path and maintains the necessary gradient for efficient water flow.

6. Root Mean Square Error (RMSE) of +-10 cm

The **Root Mean Square Error (RMSE)** is a measure of the accuracy of the LiDAR data. An RMSE of **10 cm** indicates that the vertical accuracy of the LiDAR data is within 10 centimeters of the true elevation values. This is an excellent level of accuracy for topographical surveys, ensuring that the generated DTMs and contour maps are highly reliable for engineering and planning purposes.

Importance of RMSE:

- **Accuracy Assurance**: The RMSE provides a quantitative measure of how well the LiDAR data matches the true surface. An RMSE of 10 cm means that the data is highly accurate, which is critical for applications like flood modeling, infrastructure design, and environmental monitoring.
- **Quality Control**: The RMSE is used to assess the quality of the survey and ensure that the data meets the required specifications for the project.

On-Site Implementation:

- Data acquisition was performed under optimal weather conditions to minimize distortions.

- Overlapping flight paths ensured seamless data integration and coverage.

5.4 Quality Control

Rigorous quality control measures were implemented at every stage to ensure data accuracy and reliability. These included:

1. Real-time data verification during acquisition using onboard monitoring systems.
2. Post-processing of raw data using CORS Survey of India, Hi-target Business centre HBC, DJI Tera, Lidar 360 Global Mapper and AutoCAD.
3. Cross-referencing datasets with established benchmarks and known control points.
4. Generation of error correction reports to identify and rectify discrepancies.

Deliverables Adhering to Specifications:

- Orthoimages and georeferenced maps compatible with CAD/GIS systems.
- Digital Elevation Models (DEMs) and cross-sectional and L sectional profiles.
- KMZ/KML files for GIS applications.

This comprehensive methodology ensures the delivery of accurate and actionable data for the Mebo Irrigation Project, meeting the technical and operational requirements specified in the tender documents.

7. Resources for Survey

7.1.1 Personnel

The survey team primarily focused on ensuring the highest data quality with minimal on-site personnel. The roles included:

- Project Manager: Oversaw all survey activities, ensuring adherence to project requirements and timelines.
- Survey Engineers: Specialized in DGPS and LiDAR surveys to acquire accurate spatial data.
- Drone Pilots: Operated UAVs for aerial surveys, focusing on high-resolution data capture.
- Data Analysts: Played a critical role in processing, verifying, and analysing survey data to produce deliverables, ensuring all outputs met GIS and CAD standards.

The emphasis on data analysis ensured that all collected data were accurately processed, leading to high-quality results compatible with project needs.

7.1.2 Equipment and Software

The survey utilized state-of-the-art equipment and software to achieve precision and adhere to project requirements:

- **GNSS Receivers:** Hi-Target V30 Plus Static and RTK Systems for high-accuracy positioning and control point establishment.

- **UAVs (Unmanned Aerial Vehicles):** DJI Matrices 300 RTK drones integrated with Zenmuse L1 LiDAR sensors for capturing topographical data with exceptional accuracy.

- **LiDAR Sensors:** Advanced light detection sensors for generating high-resolution Digital Terrain Models (DTMs) and contour maps with a 0.5 m interval.

- **Echo Sounders**: High-frequency bathymetric sensors mounted on custom survey boats for profiling underwater features (limited by site conditions).

Software:

Use of Survey of India CORS and GTS Benchmark

For northing and easting coordinates, we utilized the Survey of India Continuous Operating Reference Stations (CORS) network, ensuring precise geospatial referencing. For elevation data, we referenced the GTS benchmark located at J.N. College, Pasighat. This combination ensured high accuracy and alignment with national geodetic standards.

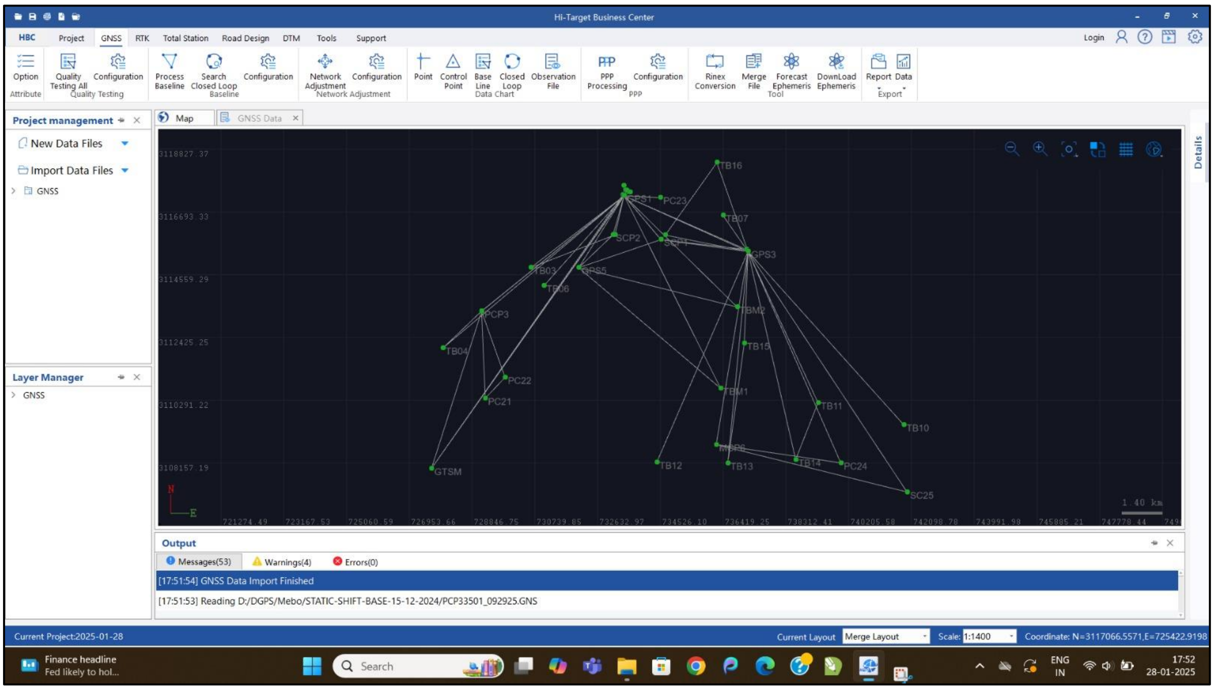
By adhering to these requirements and implementing the outlined process, the contour maps provided detailed and reliable data for the successful planning and execution of the Mebo Irrigation Project.

Hi-Target Business Centre (HBC): For GNSS data management and processing.

The **Hi-Target Business Centre (HBC)** is a comprehensive software solution designed for managing and processing GNSS data. It is developed by **Hi-Target**, a global provider of high-precision surveying and mapping equipment. HBC serves as a centralized platform for data storage, post-processing, and management, primarily aimed at GNSS-based projects. Here's a detailed explanation of its features and functions:

Overview of Hi-Target Business Centre (HBC)

1. **Purpose**:
    - Manage GNSS data from various sources, including static and kinematic observations.
    - Perform post-processing to achieve high-accuracy results.
    - Centralize project data for streamlined workflows and efficient project management.
2. **Target Users**:
    - Surveyors and geospatial professionals.
    - Engineers working on cadastral, infrastructure, and geodetic projects.
    - Organizations managing large-scale GNSS data.
3. **Compatibility**:
    - Works seamlessly with Hi-Target GNSS receivers and other standard GNSS equipment.
    - Supports multiple data formats, such as RINEX, for interoperability.



Key Features of HBC

1. **Data Management**:
    - Centralized storage of raw GNSS data, processed data, and project files.
    - Easy organization of files by project, date, or location.
    - Data import/export in standard formats (e.g., RINEX, CSV).

2. **GNSS Post-Processing**:
    - **Static Processing**: Refines static GNSS observations to achieve high-precision coordinates.
    - **PPK (Post-Processed Kinematic)**: Enhances kinematic data accuracy by processing rover and base station data.
    - **Network Adjustment**: Adjusts data from multiple stations to ensure consistency across the network.

3. **Coordinate System Support**:

   - Built-in library of global and regional coordinate systems, including custom datum definitions.
   - Transformation tools to convert between coordinate systems.

4. **Baseline Processing**:
   - Calculates baselines between GNSS stations for geodetic and control surveys.
   - Provides detailed quality reports, including precision and reliability metrics.

5. **Real-Time Data Integration**:
   - Connects to real-time GNSS correction services (e.g., CORS, NTRIP).
   - Supports RTK data processing for real-time applications.

6. **Quality Control and Reporting**:
   - Tools for analyzing data quality, including satellite geometry, signal strength, and observation time.
   - Generates detailed reports for documentation and client deliverables.

7. **Visualization and Mapping**:
   - Integrated mapping interface for viewing survey data.
   - Supports importing background maps and geospatial layers.
   - 3D visualization of GNSS points and baselines.

8. **Customizable Workflows**:
   - User-defined templates for repetitive tasks.
   - Automated processing options to save time and reduce errors.

Workflow in HBC

1. **Data Import**:
   - Collect GNSS data using Hi-Target receivers or other compatible devices.
   - Import raw data files (e.g., .GNSS .dat, .rinex) into HBC.
2. **Data Processing**:
   - Process static or kinematic data to refine positions.
   - Perform baseline calculations and network adjustments.
   - Transform results into the desired coordinate system.
3. **Quality Assurance**:
   - Review quality indicators such as precision, RMS errors, and satellite geometry.
   - Correct any discrepancies or outliers in the data.
4. **Data Export**:
   - Export processed coordinates and results in formats compatible with CAD/GIS software.
   - Generate reports for project documentation.
5. **Data Management**:
   - Archive projects for future reference.
   - Organize data by project name, survey type, or date.

Benefits of Using HBC

1. **High Accuracy**:
   - Achieves sub-centimeter precision through advanced post-processing algorithms.
   - Ensures data consistency with network adjustments.

2. **Efficiency**:
   - Streamlines GNSS workflows with centralized management and automated tools.
   - Reduces the time required for data processing and reporting.
3. **Flexibility**:
   - Supports a wide range of GNSS data formats and coordinate systems.
   - Adapts to various survey types, including geodetic, cadastral, and engineering surveys.
4. **Professional Reporting**:
   - Provides detailed, customizable reports suitable for client submissions and regulatory compliance.
5. **Cost-Effectiveness**:
   - Reduces reliance on third-party software by offering an all-in-one solution.
   - Minimizes errors and rework, saving time and resources.

DJI Terra

DJI Terra is a comprehensive mapping and data processing software developed by DJI, designed specifically for UAV (drone) data. It supports the processing of LiDAR and photogrammetry data to generate high-resolution outputs for surveying, mapping, and modeling. Here's a detailed explanation of its functionality and applications:

Overview of DJI Terra

1. **Purpose**:
   - Process UAV-collected data, including LiDAR and photogrammetry.
   - Generate high-resolution maps, 3D models, and point clouds.
   - Streamline workflows for surveying, construction, and geospatial analysis.
2. **Compatibility**:
   - Optimized for DJI drones equipped with LiDAR payloads (e.g., Zenmuse L1).
   - Supports photogrammetry data from DJI drones with RGB cameras (e.g., Phantom 4 RTK, Matrice series).
3. **Applications**:
   - Surveying and mapping.

- Infrastructure development.
- Forestry and environmental monitoring.
- Mining and resource management.
- Landslide and terrain analysis.

Key Features of DJI Terra for LiDAR Data

1. **LiDAR Data Processing**:
   - Processes raw LiDAR point cloud data collected by UAVs.
   - Automatically removes noise and filters redundant points.
   - Generates accurate, high-density 3D point clouds for detailed analysis.
2. **High-Resolution Outputs**:
   - **Point Clouds**: Captures fine details of terrain, structures, and vegetation.
   - **Digital Surface Models (DSM)**: Includes all surface features like trees and buildings.
   - **Digital Terrain Models (DTM)**: Provides bare-earth elevation models by removing surface features.
   - **Orthomosaics**: Creates georeferenced, high-resolution images by stitching drone-captured photos.
3. **Real-Time Processing**:
   - Supports real-time LiDAR point cloud generation for immediate insights during field operations (with Zenmuse L1).
   - Enables on-site validation of data quality.
4. **Coordinate System Support**:
   - Offers built-in support for global and local coordinate systems.

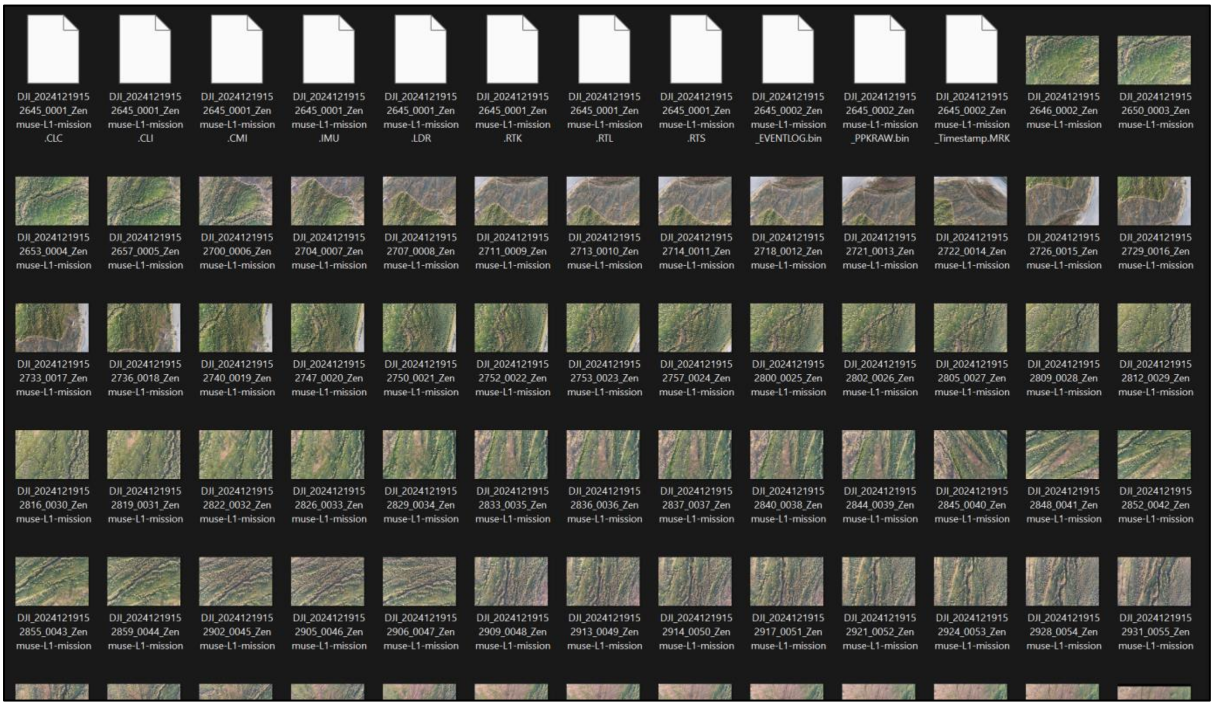
- Allows custom coordinate transformations for project-specific needs.

5. **Seamless Integration**:
   - Works directly with DJI drones, minimizing compatibility issues.
   - Supports mission planning, data capture, and processing within a single platform.
6. **Terrain Awareness**:
   - Handles complex terrains with high accuracy, even in areas with dense vegetation or challenging topography.
   - Automatically detects and processes ground points to create DTMs.
7. **Data Analysis and Visualization**:
   - Provides tools for measuring distances, areas, and volumes.
   - Visualizes point clouds in 3D for detailed inspection.
   - Supports classification of LiDAR data for different object types (e.g., ground, vegetation, structures).

Workflow for Processing UAV LiDAR Data in DJI Terra

1. **Data Collection**:
   - Plan and execute a drone mission using DJI Terra’s mission planning tools.
   - Use a DJI drone equipped with a LiDAR payload (e.g., Zenmuse L1) to capture data.
2. **Data Import**:
   - Import raw LiDAR data (point clouds) and GNSS/IMU data from the drone.

- Add any supplementary data like GCPs (Ground Control Points) for georeferencing.



3. **Data Processing**:
   - Pre-process LiDAR data to clean noise and refine point clouds.
   - Generate 3D point clouds, DSMs, DTMs, and orthomosaics.
   - Perform real-time or post-mission processing based on project requirements.
4. **Analysis**:
   - Analyze terrain features, measure distances, and calculate volumes.
   - Classify LiDAR data into different categories for specific applications.
5. **Export**:
   - Export processed data in standard formats (e.g., LAS, TIFF, OBJ) for use in GIS, CAD, or modeling software.

Advantages of DJI Terra for LiDAR Data

1. **High Accuracy**:
   - Processes data with centimeter-level precision when combined with RTK/PPK positioning.
   - Generates detailed outputs suitable for professional surveying and engineering.
2. **Efficiency**:
   - Automates data processing workflows, reducing manual effort and processing time.
   - Real-time capabilities allow on-site validation, minimizing rework.
3. **Versatility**:
   - Handles various terrain types, including forests, urban areas, and open fields.
   - Supports multiple output formats for diverse applications.
4. **User-Friendly**:
   - Intuitive interface simplifies data processing for users of all experience levels.
   - Integrated tools for mission planning, processing, and analysis.
5. **Cost-Effective**:
   - Reduces dependency on multiple software tools by offering an all-in-one solution.
   - Enhances productivity and minimizes operational costs.

Outputs Generated by DJI Terra

1. **Point Clouds**:
   - High-density, georeferenced 3D point clouds.

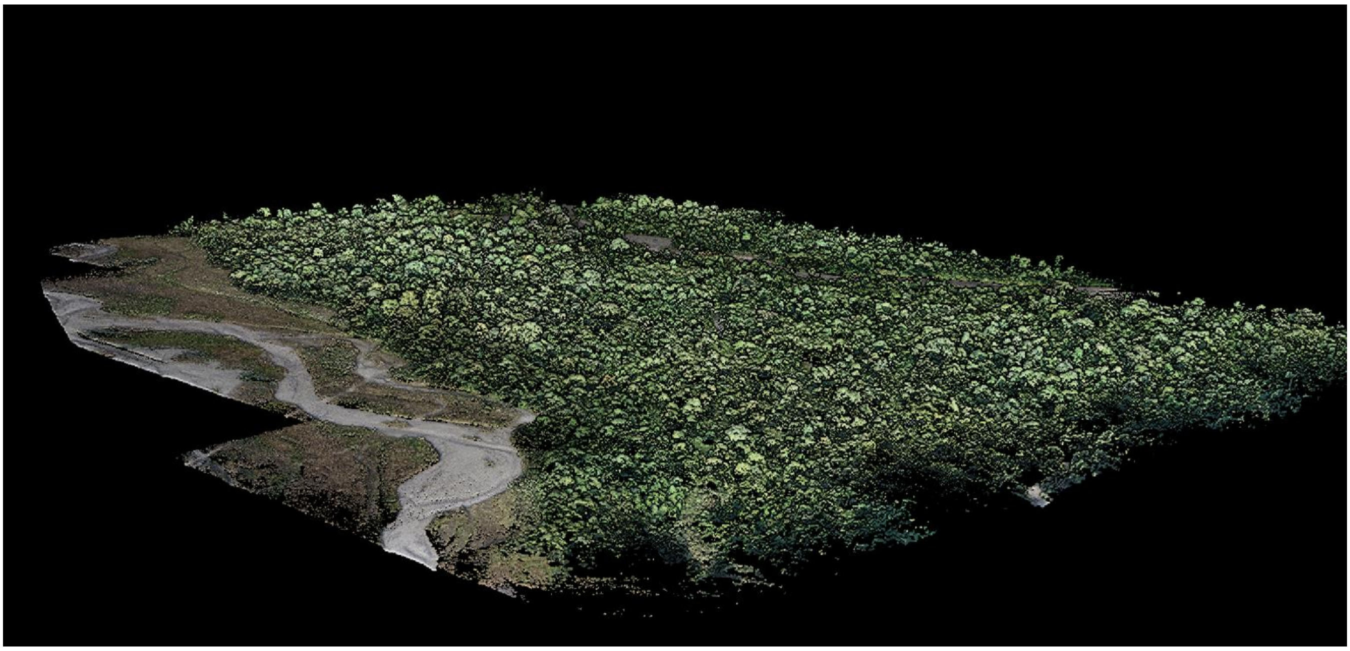
  - Compatible with software like AutoCAD, ArcGIS, and CloudCompare.

2. **Digital Surface Models (DSM)**:
   - Includes all surface features for applications like urban planning and flood modeling.
3. **Digital Terrain Models (DTM)**:
   - Provides accurate ground-level elevation data for hydrological and geological studies.
4. **Orthomosaics**:
   - High-resolution, georeferenced aerial imagery for mapping and visualization.
5. **3D Models**:
   - Textured models for visualizing structures and landscapes.

Applications of DJI Terra in Different Industries

1. **Surveying and Mapping**:
   - Create precise topographic maps and elevation models.
   - Identify and map boundaries with high accuracy.
2. **Forestry**:
   - Measure tree heights, canopy cover, and biomass.
   - Monitor deforestation and forest health.
3. **Construction and Infrastructure**:
   - Monitor site progress and calculate material volumes.
   - Design and plan infrastructure projects with accurate terrain data.
4. **Mining**:
   - Map and monitor excavation sites.
   - Calculate stockpile volumes and optimize resource extraction.

5. **Landslide Analysis**:
   - Identify unstable slopes and loose materials.
   - Monitor changes over time to mitigate risk



Generated Point Cloud Data

- **LiDAR 360: For analyzing and visualizing LiDAR point cloud data**.

LiDAR 360 is a professional software suite designed for analyzing, visualizing, and processing LiDAR point cloud data. It is developed by **GreenValley International** and is widely used in various industries for managing large-scale point cloud datasets. The software provides specialized tools for geospatial analysis, terrain modeling, forestry applications, and more, making it a versatile solution for LiDAR data workflows. Below is a detailed explanation of its features and applications:

Overview of LiDAR 360

1. **Purpose**:
   - Analyze and visualize massive LiDAR point cloud datasets efficiently.

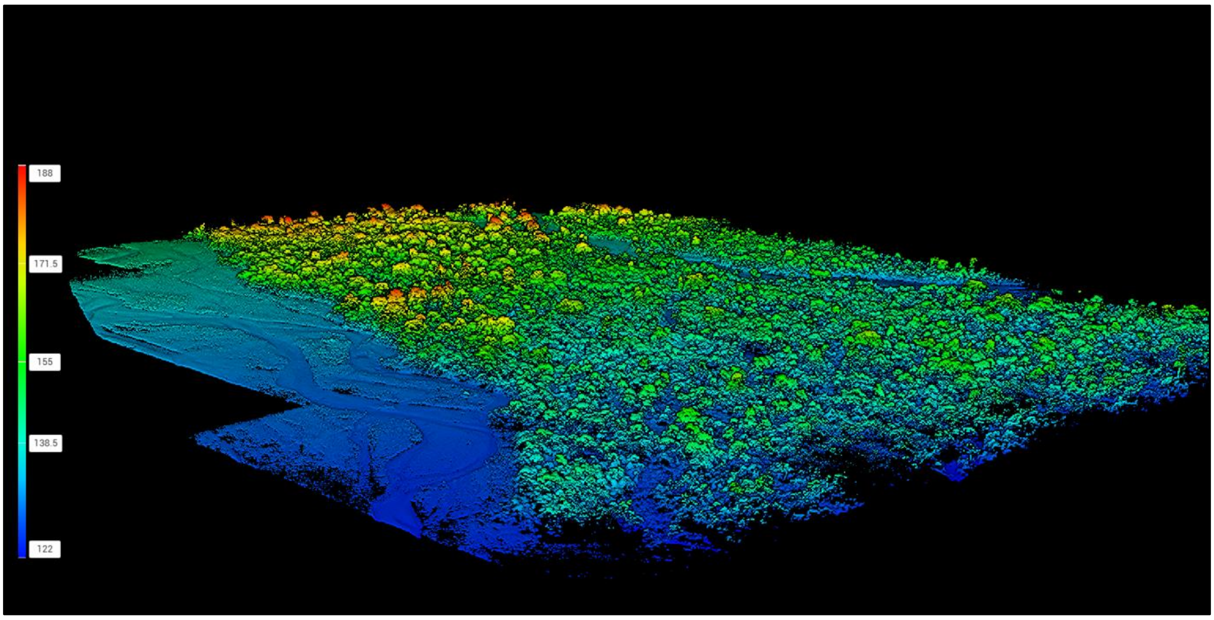
   - Perform advanced geospatial analysis, terrain modeling, and feature extraction.
   - Create actionable outputs for industries like forestry, surveying, and infrastructure.

2. **Compatibility**:
   - Supports LiDAR data in standard formats like LAS, LAZ, and ASCII.
   - Integrates seamlessly with other GIS and CAD software.

3. **Applications**:
   - Forestry management and canopy analysis.
   - Terrain and hydrological modeling.
   - Urban planning and infrastructure development.
   - Geological and landslide analysis.

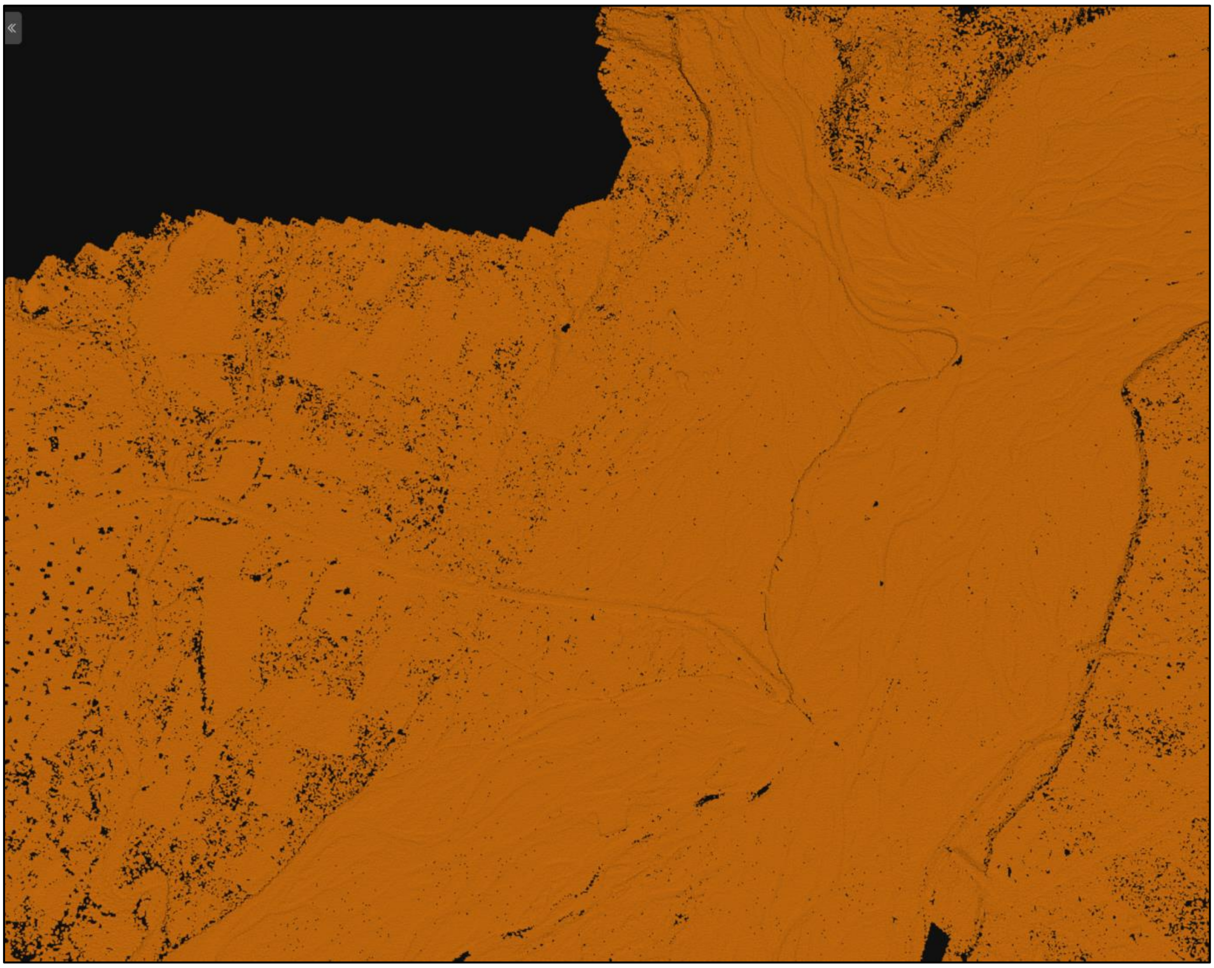
Key Features of LiDAR 360

1. **Point Cloud Visualization**:
   - Efficiently handles large-scale point cloud datasets with billions of points.
   - Provides tools for 3D visualization, allowing users to explore and inspect data interactively.
   - Supports colorization by elevation, intensity, classification, or custom attributes.



Point Cloud by height

2. **Terrain Analysis**:
    - Generates **Digital Terrain Models (DTM)** and **Digital Surface Models (DSM)** from point clouds.
    - Extracts contour lines and slope maps for detailed topographic analysis.
    - Identifies terrain features such as ridges, valleys, and breaklines.
3. **Point Cloud Classification**:
    - Automatically classifies points into categories like ground, vegetation, buildings, and water.
    - Custom classification tools allow manual refinement of results.



Ground Classification

4. **Forestry Tools**:
   - Measures tree height, canopy density, and biomass.
   - Identifies individual trees and calculates metrics such as Diameter at Breast Height (DBH).
   - Assesses forest health and growth over time.
5. **Volume and Change Detection**:
   - Calculates volumes of stockpiles, pits, and other features.
   - Detects changes in terrain or structures over time by comparing datasets.

6. **Hydrological Analysis**:
    - Extracts drainage networks, watersheds, and flow paths.
    - Identifies flood-prone areas and models water flow.
7. **Advanced Data Processing**:
    - Noise filtering to clean raw LiDAR data.
    - Point thinning and decimation to optimize data for specific applications.
    - Batch processing for handling multiple datasets efficiently.
8. **Geospatial Integration**:
    - Supports global and local coordinate systems for georeferencing.
    - Exports processed data in formats compatible with GIS and CAD software.
9. **Plugins and Modules**:
    - Offers specialized modules for forestry, terrain, powerline analysis, and more.
    - Modular design allows users to tailor the software to their specific needs.

Workflow in LiDAR 360

1. **Data Import**:
    - Load LiDAR point cloud data in supported formats (e.g., LAS, LAZ).
    - Import supplementary data like DEMs, orthophotos, or vector layers for context.
2. **Data Visualization**:
    - Visualize point clouds in 3D to inspect data quality and coverage.
    - Apply filters to focus on specific attributes or areas of interest.

3. **Pre-Processing**:
    - Clean the dataset by removing noise and outliers.
    - Classify points into ground, vegetation, and other categories.
4. **Analysis**:
    - Perform terrain modeling, forestry analysis, or hydrological studies based on project needs.
    - Extract features like trees, buildings, or water bodies.
5. **Output Generation**:
    - Create DTMs, DSMs, contour maps, or volume calculations.
    - Export processed data for use in GIS, CAD, or other analysis software.
6. **Reporting**:
    - Generate detailed reports with metrics and visualizations for stakeholders.

Advantages of LiDAR 360

1. **Scalability**:
    - Handles large datasets efficiently, making it suitable for regional and national-scale projects.
2. **Versatility**:
    - Supports a wide range of applications, from forestry to urban planning.
3. **User-Friendly Interface**:
    - Intuitive tools and workflows reduce the learning curve for new users.
4. **Customizable Workflows**:
    - Modular design allows users to focus on specific tasks or industries.

5. **High Accuracy**:
    - Advanced algorithms ensure precise classification, modeling, and analysis.
6. **Cost-Effectiveness**:
    - Provides a comprehensive suite of tools, reducing the need for multiple software packages.

Outputs Generated by LiDAR 360

1. **3D Point Clouds**:
    - Cleaned and classified point clouds ready for further analysis or visualization.
2. **Digital Elevation Models**:
    - DTMs for ground-level elevation and DSMs for surface features.
3. **Canopy Metrics**:
    - Tree height, canopy density, and biomass estimates.
4. **Hydrological Models**:
    - Drainage networks, flow paths, and watershed boundaries.
5. **Contour Maps**:
    - Extracted from terrain models for topographic mapping.
6. **Volume Calculations**:
    - Accurate measurements for stockpiles, excavations, and other features.

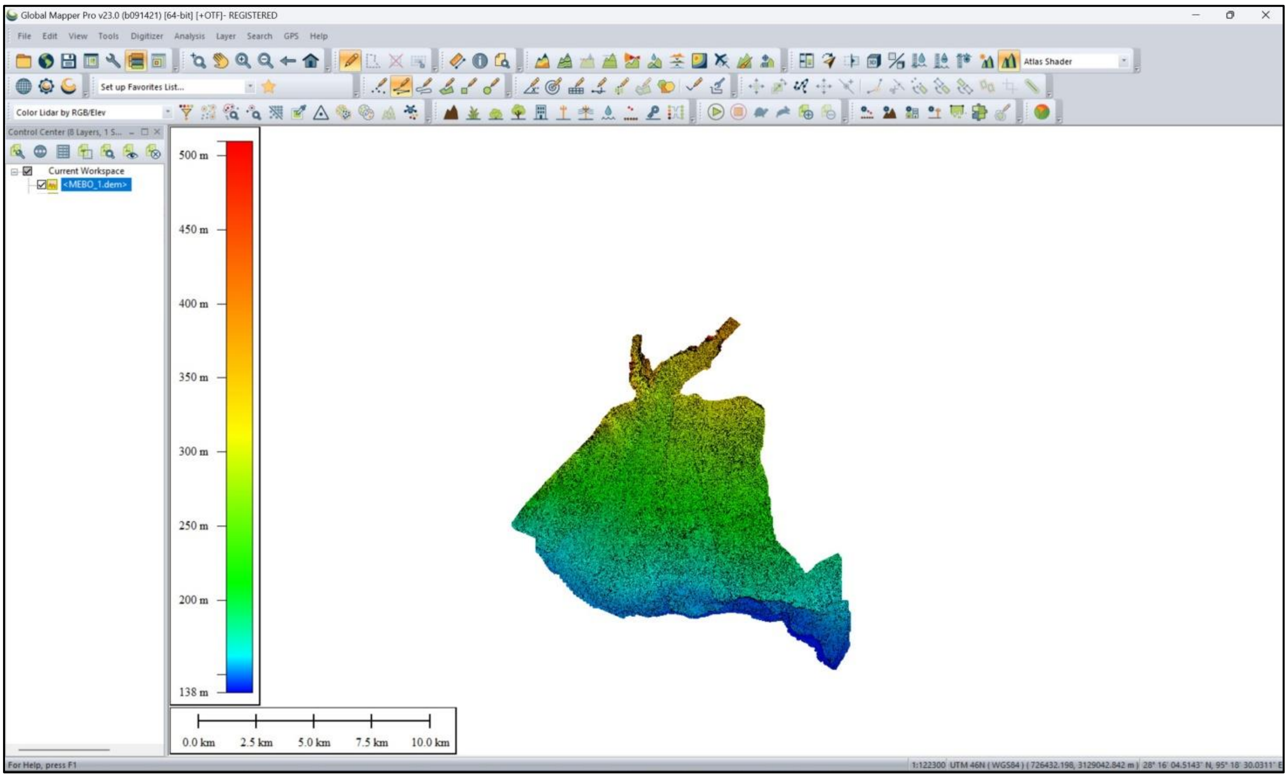
Applications of LiDAR 360 in Various Industries

1. **Forestry**:
    - Monitor forest health, growth, and biomass.
    - Assess carbon sequestration and tree inventory.

2. **Surveying and Mapping**:
    - Generate accurate topographic maps for engineering and construction.
3. **Urban Planning**:
    - Model cityscapes and assess infrastructure.
4. **Geology and Landslide Analysis**:
    - Identify unstable slopes and monitor terrain changes.
5. **Flood Risk Assessment**:
    - Model water flow and identify flood-prone areas.

- **Global Mapper: For terrain data processing and analysis**.

Global Mapper is a powerful, versatile GIS (Geographic Information System) software developed by **Blue Marble Geographics**. It is widely used for terrain data processing, analysis, and visualization, supporting a wide range of data formats and offering extensive tools for geospatial analysis. Its user-friendly interface and robust functionality make it a popular choice among professionals in surveying, mapping, and engineering fields. Below is a detailed explanation of its features and applications:



Overview of Global Mapper

1. **Purpose**:
    - Process and analyze terrain data, including elevation models, LiDAR point clouds, and raster imagery.
    - Create and edit geospatial data for mapping and analysis.
    - Perform advanced geospatial calculations and visualizations.

2. **Compatibility**:
   - Supports over 300 file formats, including LAS/LAZ, GeoTIFF, SHP, DXF, and more.
   - Compatible with various GIS, CAD, and geospatial data systems.
3. **Applications**:
   - Terrain modeling and analysis.
   - Infrastructure planning and development.
   - Natural resource management.
   - Environmental and geological studies.

Key Features of Global Mapper for Terrain Data

1. **Terrain Visualization**:
   - Displays terrain data in 2D and 3D views for detailed inspection.
   - Supports a variety of data formats, including DEMs, DTMs, DSMs, and LiDAR.
   - Offers hill shading, slope shading, and contour visualization.
2. **Terrain Analysis Tools**:
   - **Elevation Calculations**: Measure elevation values at specific points or across regions.
   - **Slope and Aspect Analysis**: Determine terrain steepness and direction for various applications.
   - **Contour Generation**: Create contour lines at customizable intervals.
   - **Volume Calculations**: Calculate cut-and-fill volumes for construction and excavation projects.
   - **Watershed and Drainage Analysis**: Identify drainage basins, flow paths, and flood-prone areas.
3. **LiDAR Point Cloud Processing**:

- Visualize, classify, and filter point cloud data.
- Generate DTMs, DSMs, and 3D models from LiDAR datasets.
- Perform noise removal and thinning to optimize data.

4. **Raster Data Processing**:
    - Mosaic, reproject, and resample raster datasets.
    - Extract elevation or terrain data from raster imagery.
    - Perform spectral analysis for environmental studies.
5. **3D Modeling and Visualization**:
    - Create 3D models of terrain and structures.
    - Export 3D data in formats like OBJ, 3DS, and STL.
    - Simulate viewsheds and line-of-sight analysis.
6. **Geospatial Calculations**:
    - Measure distances, areas, and perimeters.
    - Analyze spatial relationships between features.
    - Perform coordinate transformations and georeferencing.
7. **Hydrological Analysis**:
    - Identify water flow patterns, stream networks, and watersheds.
    - Model potential flood zones based on elevation data.
    - Analyze terrain for water retention and drainage capacity.
8. **Data Editing and Customization**:
    - Digitize features, edit vector data, and create new layers.
    - Style and label features for customized maps.
    - Add annotations, legends, and scale bars for professional outputs.
9. **Export and Integration**:

- Export processed data in various formats for use in other GIS and CAD software.
- Integrate with external GPS devices for field data collection.

Workflow for Terrain Data Processing in Global Mapper

1. **Data Import**:
    - Import terrain data (e.g., DEM, LiDAR, or raster imagery) in supported formats.
    - Load additional data layers, such as shapefiles or CAD drawings, for context.
2. **Data Visualization**:
    - View terrain data in 2D or 3D modes.
    - Apply hill shading, slope analysis, or color gradients to enhance visualization.
3. **Analysis**:
    - Perform elevation, slope, and aspect calculations.
    - Generate contours, calculate volumes, or conduct hydrological analysis.
    - Extract features such as ridges, valleys, or water bodies.
4. **Data Editing**:
    - Modify terrain data by removing noise, reclassifying points, or editing vector features.
    - Digitize new features or boundaries as needed.
5. **Output Generation**:
    - Export results as maps, 3D models, or raw data files.
    - Create high-quality visualizations and reports for stakeholders.

Advantages of Global Mapper

1. **Wide Format Support**:
    - Processes data from diverse sources without conversion, saving time and effort.
2. **User-Friendly Interface**:
    - Intuitive design enables quick learning and efficient workflows.
3. **Scalability**:
    - Handles large datasets, including nationwide terrain models and massive LiDAR point clouds.
4. **Versatility**:
    - Offers tools for multiple industries, from construction to environmental management.
5. **Cost-Effective**:
    - Provides extensive functionality at a fraction of the cost of other GIS software.
6. **Customizability**:
    - Supports scripting and custom workflows for advanced users.

Outputs Generated by Global Mapper

1. **Contour Maps**:
    - Visualize elevation changes with customizable intervals and styles.
2. **3D Models**:
    - Create realistic 3D representations of terrain and structures.
3. **DTMs and DSMs**:
    - Generate elevation models for bare-earth or surface analysis.
4. **Hydrological Models**:

- Identify watersheds, flow paths, and potential flood zones.

5. **Volume Reports**:
    - Provide detailed cut-and-fill calculations for construction projects.
6. **High-Quality Maps**:
    - Produce cartographic outputs with legends, labels, and annotations.

Applications of Global Mapper in Various Industries

1. **Surveying and Mapping**:
    - Generate topographic maps and elevation models for engineering projects.
2. **Construction and Infrastructure**:
    - Plan and monitor construction activities, including excavation and grading.
3. **Environmental Management**:
    - Analyze terrain for conservation, erosion control, and habitat studies.
4. **Geology and Mining**:
    - Map mineral deposits, monitor mine sites, and calculate resource volumes.
5. **Disaster Management**:
    - Model flood zones, landslides, and other hazards for risk assessment.
6. **Urban Planning**:
    - Design infrastructure and assess land suitability for development.

- **AutoCAD: For map generation and integration of survey outputs into engineering designs.**

AutoCAD is a widely used software application developed by **Autodesk** for computer-aided design (CAD) and drafting. It is extensively employed in engineering, architecture, surveying, and construction industries for creating detailed 2D and 3D designs, including maps and integration of survey outputs into engineering workflows. Below is a detailed explanation of how AutoCAD is used for map generation and survey data integration in engineering designs:

Overview of AutoCAD

1. **Purpose**:
   - Create and edit precise 2D and 3D drawings and designs.
   - Integrate survey outputs for accurate engineering and construction planning.
   - Generate maps, layouts, and technical documentation.
2. **Compatibility**:
   - Supports multiple file formats, including DWG, DXF, SHP, and more.
   - Integrates seamlessly with surveying and GIS tools like Total Stations, GNSS, and LiDAR.
3. **Applications**:
   - Map generation and geospatial visualization.
   - Civil engineering designs, including roads, bridges, and utilities.
   - Integration of survey data for accurate project execution.

Key Features of AutoCAD for Map Generation and Survey Integration

1. **2D and 3D Design Capabilities**:
   - Create detailed 2D maps with layers, annotations, and symbols.
   - Build 3D models for terrain visualization, structures, and infrastructure.

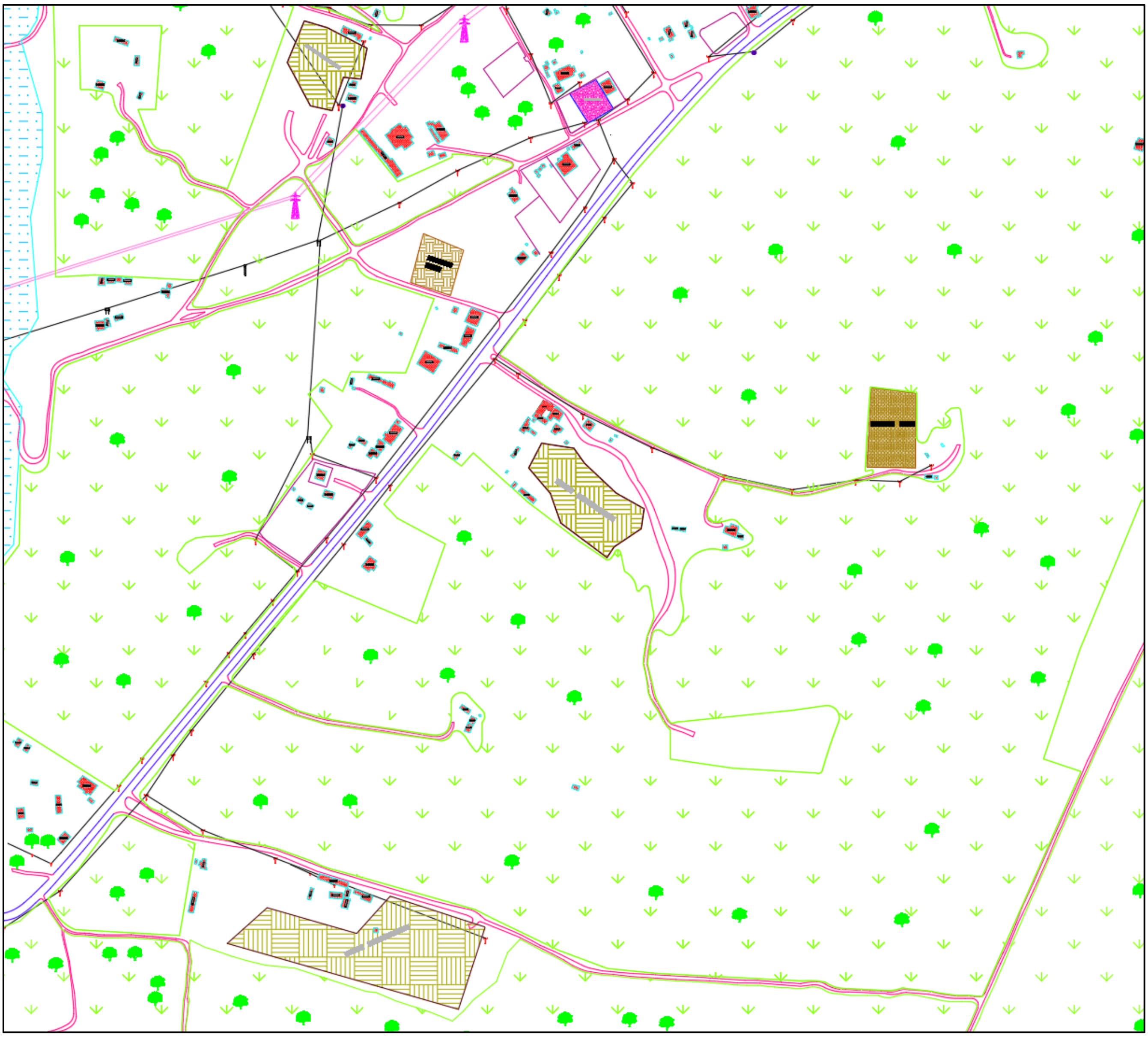
2. **Survey Data Import and Processing**:
    - Import survey data directly from Total Stations, GNSS devices, or other surveying tools.
    - Handle data in formats like CSV, SHP, and DXF for seamless integration.
    - Use point clouds from LiDAR surveys for terrain modeling and feature extraction.
3. **Coordinate System Support**:
    - Work with global and local coordinate systems for georeferenced maps.
    - Transform survey data into project-specific coordinate systems.
4. **Terrain Modeling and Analysis**:
    - Create contour maps, profiles, and cross-sections from survey data.
    - Model terrains using point clouds or elevation data for topographic analysis.
5. **Integration with Civil Engineering Tools**:
    - Combine survey outputs with engineering designs for roads, pipelines, and buildings.
    - Use Civil 3D (an AutoCAD extension) for advanced civil engineering workflows, such as corridor modeling and grading.
6. **Annotation and Documentation**:
    - Add labels, dimensions, and notes to maps for clarity and communication.
    - Create legends, scale bars, and north arrows for professional map outputs.
7. **Layer Management**:
    - Organize data into layers for efficient editing and visualization.

- Control the visibility and style of layers to focus on specific map elements.

8. **Data Export and Sharing**:
   - Export maps and designs in formats like DWG, PDF, or DGN for sharing and collaboration.
   - Share data with GIS software for further geospatial analysis.
9. **Customization and Automation**:
   - Use scripting (e.g., AutoLISP) to automate repetitive tasks.
   - Customize templates and tools for specific project requirements.

Workflow for Map Generation and Survey Integration in AutoCAD

1. **Data Collection**:
   - Gather survey data using Total Stations, GNSS devices, or LiDAR.
   - Export the data in compatible formats like CSV, DXF, or SHP.
2. **Data Import**:
   - Import survey data into AutoCAD.
   - Georeference the data to align with project coordinates.
3. **Map Creation**:
   - Generate base maps using survey points, contours, and boundary data.
   - Add layers for different features like roads, buildings, and utilities.



Digitized Map

4. **Terrain Modeling**:
   - Create elevation models, contours, and profiles from survey data.
   - Visualize terrain changes and plan grading or excavation.
5. **Integration with Designs**:
   - Overlay survey data with engineering designs for seamless integration.
   - Design infrastructure elements like roads, pipelines, or drainage systems.
6. **Annotation and Detailing**:
   - Add dimensions, labels, and notes to maps for clarity.
   - Include scale bars, legends, and north arrows for professional presentation.
7. **Output and Sharing**:
   - Export the final map or design in the desired format for stakeholders.
   - Share data with other software like GIS platforms or construction tools.

Advantages of AutoCAD for Map Generation and Survey Integration

1. **Precision and Accuracy**:
   - Ensures high levels of accuracy in mapping and design, critical for engineering projects.
2. **Versatility**:
   - Supports a wide range of applications, from simple 2D maps to complex 3D models.
3. **Compatibility**:

- Works seamlessly with survey data and integrates with other software and devices.

4. **Customization**:
   - Allows users to create custom tools, templates, and workflows for specific needs.
5. **User-Friendly Interface**:
   - Offers intuitive tools for efficient map creation and design.
6. **Cost-Effective**:
   - Reduces errors and rework by integrating accurate survey data into designs.

Outputs Generated by AutoCAD

1. **2D Maps**:
   - Detailed maps with annotations, symbols, and layers for different features.
2. **3D Models**:
   - Terrain models and infrastructure designs for visualization and analysis.
3. **Profiles and Cross-Sections**:
   - Visual representations of terrain and design elements along specific alignments.
4. **Construction Plans**:
   - Detailed layouts and plans for construction projects.
5. **Exported Data**:
   - DWG, DXF, and PDF files for sharing with clients and collaborators.

Applications of AutoCAD in Various Industries

1. **Surveying and Mapping**:
   - Create accurate base maps and integrate survey data for geospatial analysis.
2. **Civil Engineering**:
   - Design roads, bridges, pipelines, and other infrastructure using survey inputs.
3. **Construction**:
   - Generate detailed construction plans and manage site layouts.
4. **Urban Planning**:
   - Plan and visualize urban developments with precise mapping.
5. **Environmental Studies**:
   - Analyze terrain and create maps for conservation or disaster management.

Physical Infrastructure: RCC benchmarks and Ground control point markers constructed to ensure long-term reliability and consistency in measurements.

The deployment of these resources ensured adherence to the technical specifications outlined in the tender documents and enabled the successful completion of all survey activities, including adjustments for site-specific challenges.

The deployment of these resources ensured adherence to the technical specifications outlined in the tender documents and enabled the successful completion of all survey activities, including adjustments for site-specific challenges.

8. Milestones and Deliverables.

The deliverables for the project are structured as per the milestones outlined in the tender documents:

1. Milestone 1: Barrage Area Survey

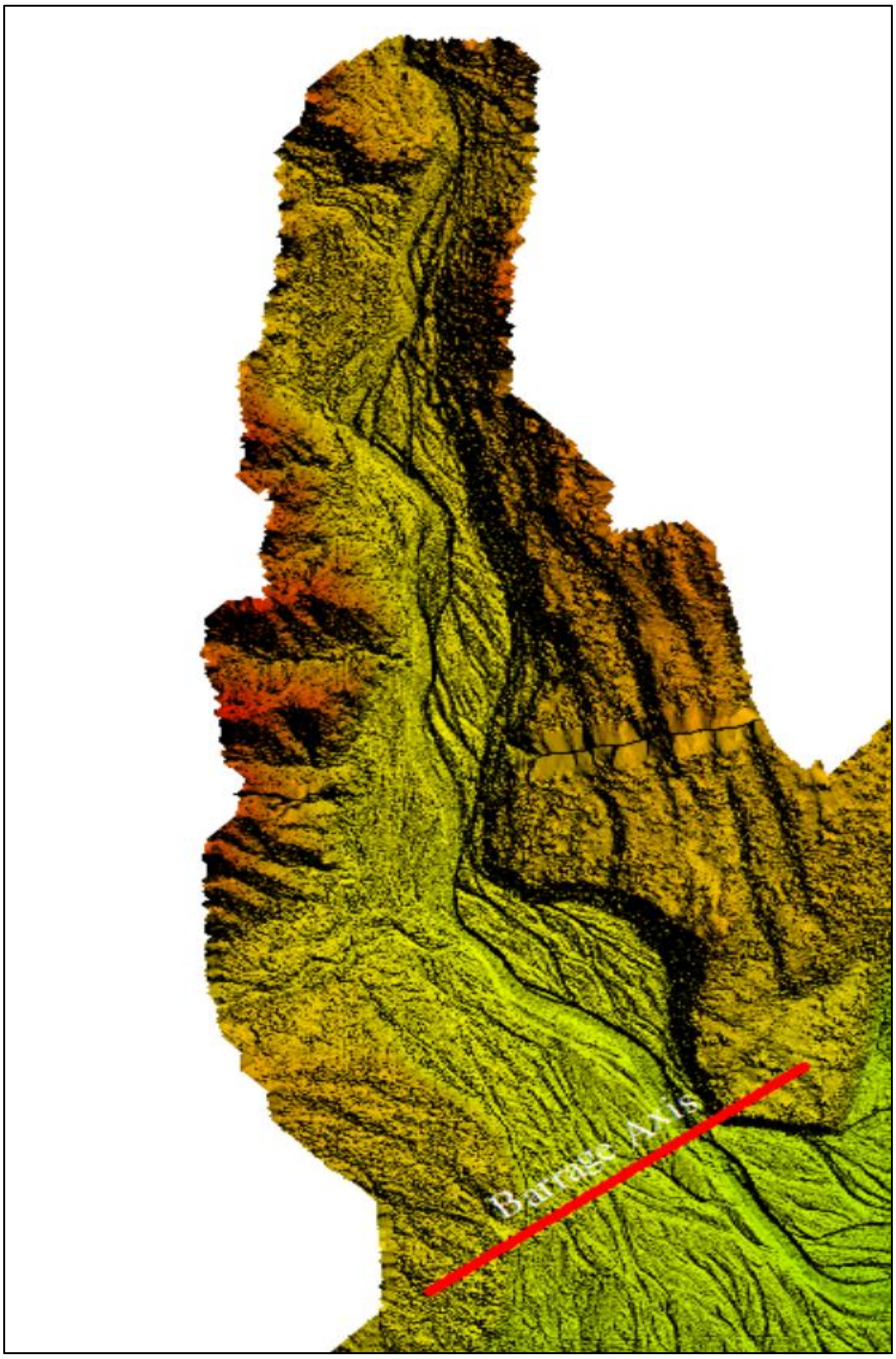
- Details of GCPs (Ground Control Points) established, including RLs of benchmarks.

AM DATA LAB PVT. LTD.

Detailed Topographical Survey Surface and Bathymetry for Reservoir Area River Area Command Area and Canal Pipe Alignment Survey 05 m Contour interval of Mebo Irrigation Project in East Siang District of Arunachal Pradesh..

SR.NO.	NAME	EASTING	NORTHING	ELEVATION	DGPS IMAGES
1	GTSM	727548.4041	3108172.299	183.76	
2	MCP-1	733178.6919	3117552.715	301.49597	
3	MCP-2	733133.4755	3117575.335	301.81301	
4	MCP-3	736949.7297	3115733.373	282.6013	
5	MCP-4	736893.2622	3115797.028	283.7606	

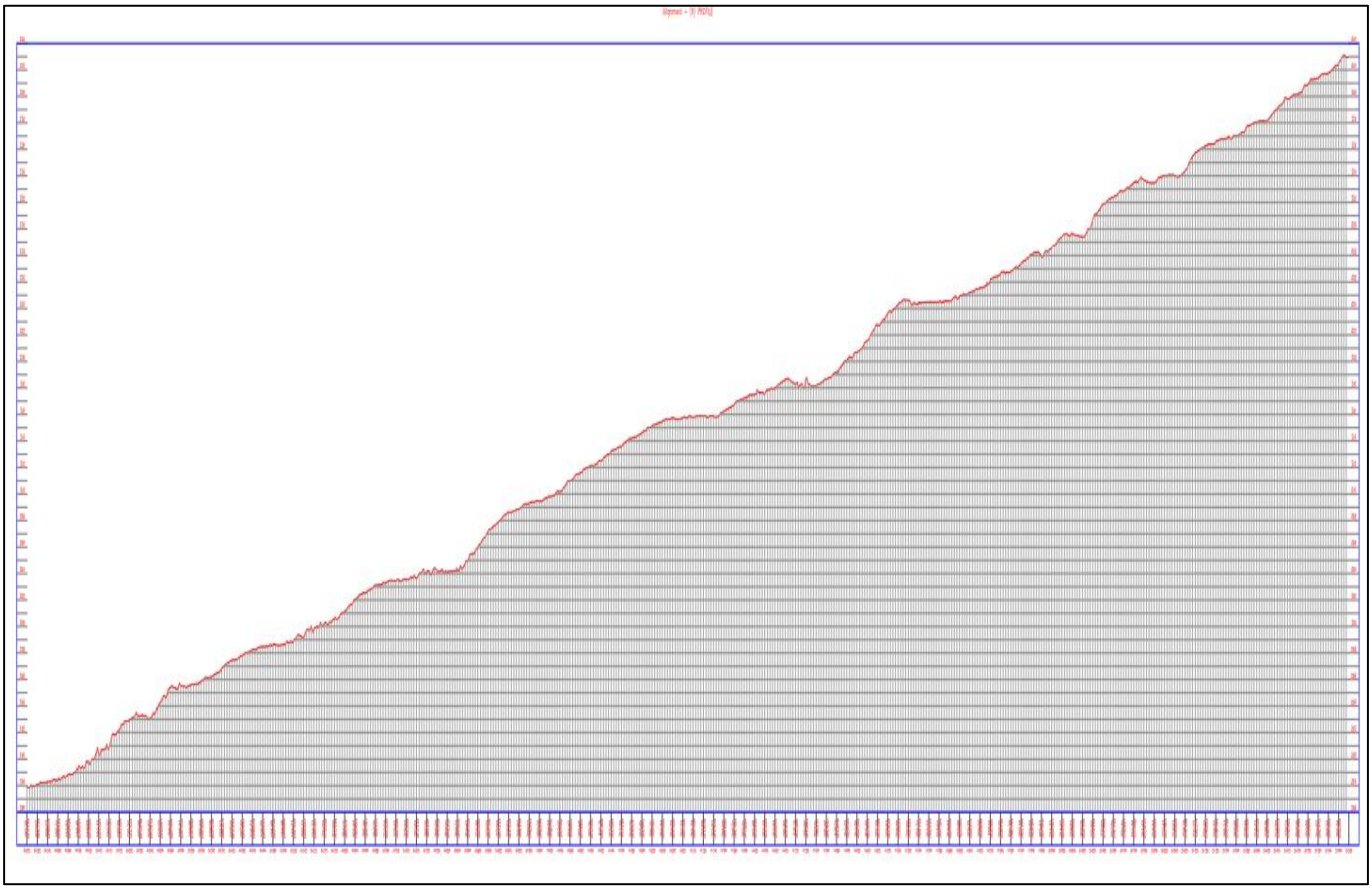
- Cross-sectional surveys at 50 m intervals for 500 m upstream and downstream of the barrage axis.
- Contour maps of the area up to HFL + 5 m.



Barrage Axis Survey DTM

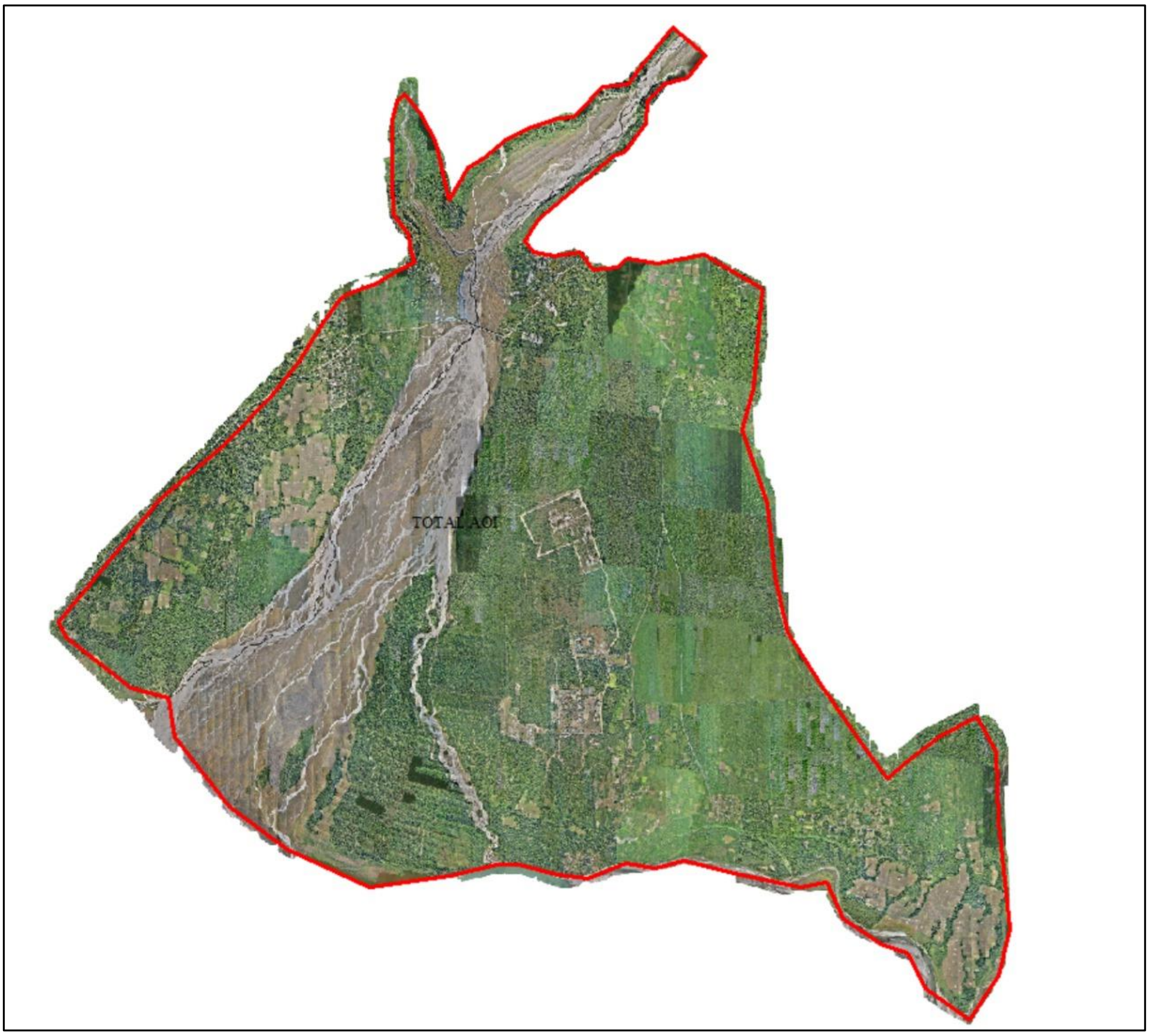
2. Milestone 2: Reservoir Area Survey

- 2D and 3D contour maps at a 0.5 m interval.
- Cross-sectional and longitudinal profiles of rivers and drainage systems.
- Property and settlement mapping, detailing land use classifications and prominent structures.



3. Milestone 3: Command Area and Canal Alignment Survey

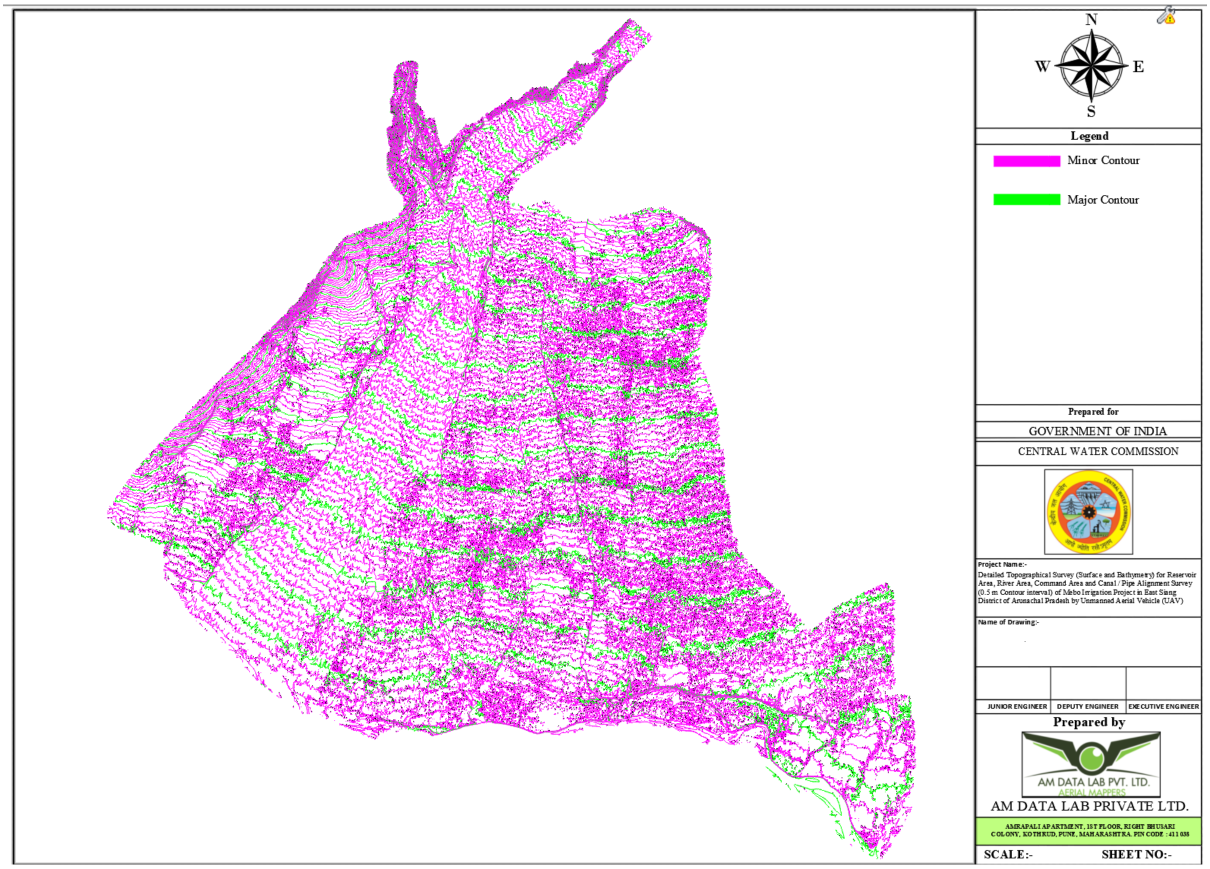
- Land use/land cover maps with 1 m contours.
- Strip surveys and longitudinal profiles along canal alignments.



Total AOI

4. Milestone 4: Cross Drainage Locations

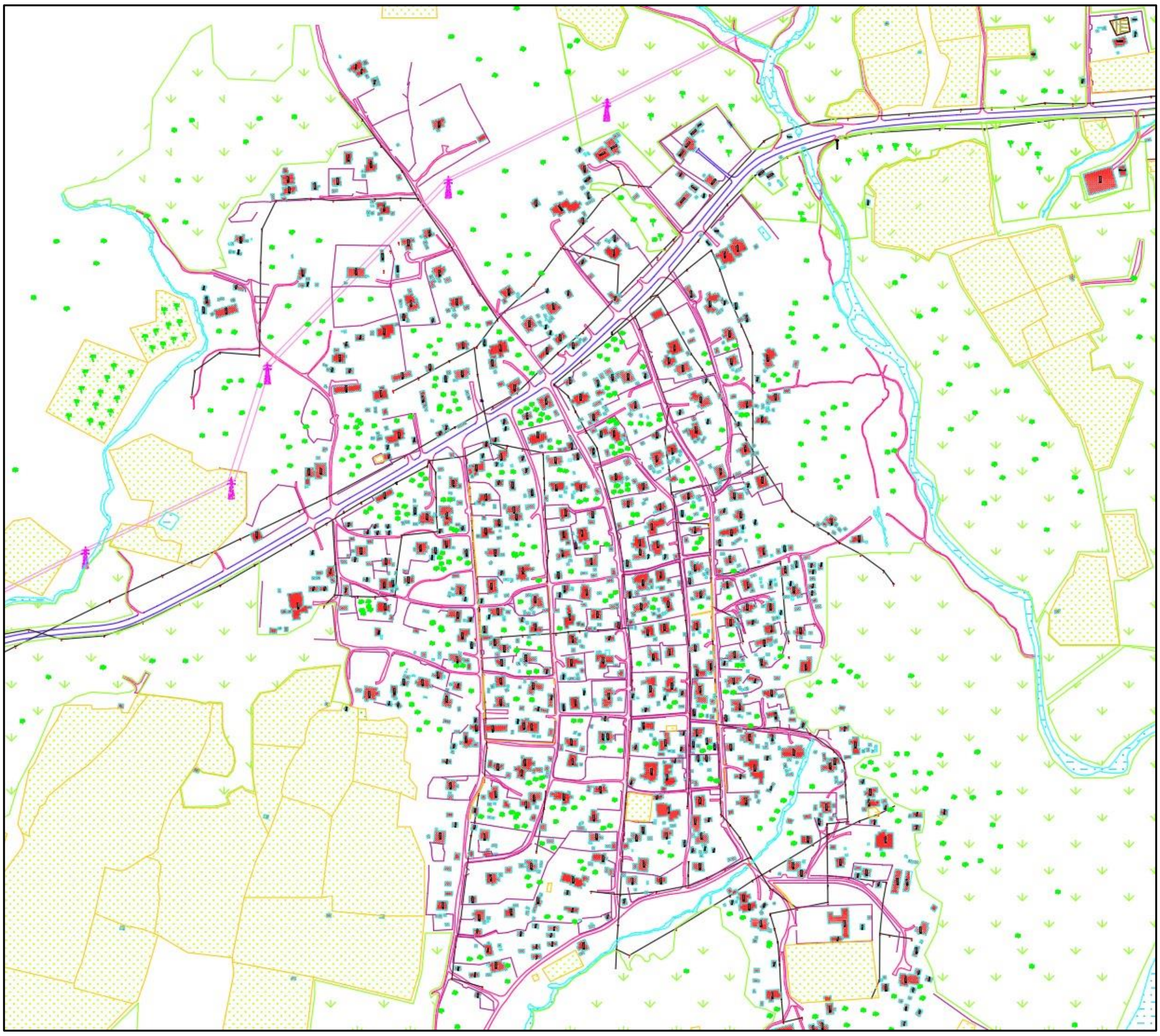
- Contour plans of drainage crossings at 0.5 m intervals.



- Cross-sections upstream and downstream of drainage crossings.

5. Milestone 5: Final Data and Report Submission

- Geo-referenced maps in CAD/GIS formats.



Georefrenced CAD Map

- Soft copies of DEMs, DTMs, and orthophotos.
- Five hard copies of the final report and data sets in editable formats.The milestones ensure structured progress and timely submission of all required data and reports to meet project specifications.

9. Conclusion and Recommendations

Conclusion

The Detailed Topographical and Bathymetric Survey for the Mebo Irrigation Project successfully achieved its objectives by leveraging advanced technologies such as DGPS, UAVs, LiDAR, and GIS tools. Despite challenges such as shallow water depths in the river, alternative methodologies ensured comprehensive data collection and adherence to the project's technical requirements.

The collected data has been meticulously processed and validated, providing an accurate foundation for planning and design. The results contribute significantly to improving water resource management, irrigation planning, and infrastructure development in the East Siang District.

Recommendations

1. **Periodic Updates:** It is recommended to conduct periodic surveys to monitor sedimentation, changes in topography, and infrastructure impact.
2. **Enhanced Water Resource Management:** Utilize survey data to develop advanced water distribution systems and improve irrigation efficiency.
3. **Local Authorities Collaboration:** Strengthen collaboration with local authorities and stakeholders for better implementation of project outcomes.
4. **Future Surveys:** Employ a combination of UAV-based LiDAR and hydrographic surveys to address any evolving project needs.

The recommendations aim to ensure the sustainable development and long-term success of the Mebo Irrigation Project.

Note:- Please Refer Volume 2 For All Deliverables

Date:-28/01/2025

To,
The Executive Engineer
NEID-III, CWC
Chimpu, Itanagar, Arunachal Pradesh – 791111

Subject: Submission of Data as per Milestone for "Detailed Topographical Survey (Surface and Bathymetry) for Reservoir Area, River Area, Command Area, and Canal/Pipe Alignment Survey (0.5 m Contour Interval) including the establishment of Permanent Bench Mark, etc., all complete for Mebo Irrigation Project in East Siang District, Arunachal Pradesh."

Dear Sir,

As per the Work Order and agreed project milestones, we, **AM Data Lab Pvt Ltd**, have successfully completed the following tasks and are submitting the corresponding data and reports:

Milestone 1: Establishment of Control Network

- Installation of **Permanent Bench Marks (PBMs)** using DGPS for accurate georeferencing.
- Establishment of **Ground Control Points (GCPs)** for UAV and LiDAR data correction.
- Submission of **control network report**, including coordinates, accuracy assessment, and methodology.

Milestone 2: Topographical Survey of Reservoir and River Area

- **UAV and LiDAR-based terrain mapping** for detailed elevation modeling.
- **Bathymetric survey using Echo Sounder** for underwater depth profiling.
- Generation of **contour maps at a 0.5 m interval** for the reservoir and river area.

Milestone 3: Command Area Survey

- **DGPS and UAV-based topographical survey** covering the entire command area.
- Preparation of **alignment plans, cross-sections, and elevation models**.
- Submission of **processed survey data, maps, and GIS-compatible files**.

Milestone 4: Canal and Pipe Alignment Survey

- **Detailed alignment survey** for proposed canals and pipelines.
- **Cross-section and longitudinal profiling** for hydraulic analysis.
- Submission of **alignment drawings, GIS layers, and survey reports**.

Milestone 5: Final Data Processing and Reporting

- Integration of **all surveyed data** into a single geospatial database.
- Preparation of **final maps, reports, and digital deliverables**.
- Submission of **comprehensive survey documentation and project summary report**.

All data has been compiled and submitted in the required format. We kindly request your review and feedback to proceed with the next steps.

Prepared by:

AM DATA LAB PVT. LTD.
AERIAL MAPPERS

AM Data Lab Pvt. Ltd. Pune,

Maharashtra.