

**2018**

**PROJECT ASSESSMENT REPORT FOR SITAMARHI**  
**PROJECT**

**T**his is a project assessment report for a recent assignment successfully executed at SATPALDA Geospatial Services. It has been drafted with the assistance of the internal project manager of the photogrammetry division at SATPALDA. This report collectively demonstrate the methodology adopted, all technical aspects, output analysis and finally what we achieved in this project.

**Prepared by:**

**SATPALDA.**

*(Dept. of Photogrammetry )*

## About the organization

**SATPALDA**, an ISO 9001:2008 company is a privately owned organization and a leading provider of satellite imagery and geospatial services to the user community. Established in 2002, SATPALDA has successfully completed wide range of photogrammetric and remote sensing projects. Our cost effective solutions are catered to broad spectrum of government and private users. The USP of SATPALDA's services is the unique blend of experience and cost effectiveness. Presently, SATPALDA is actively engaged with the customers spreading over South-East Asia, Africa and Europe.

Our approach to geospatial solutions is to align with the business needs of clients, to design solutions that integrate commercially available imagery and GIS data themes to assist in decision making, data interrogation, data publishing and dissemination.

Services
Orthorectification
Aerial Triangulation
Terrain Modelling (DTM)
3D Modelling
LIDAR
Topographic Mapping
DGPS Survey
Land cover mapping
Specialized Process (Pan- Sharpening, Landsat ETTM+Gap- Filled)
Software(SpaceEyes 3D, Correlator 3D, ScanEx Image Processor)

## Products

Satellite Imageries- Up to 1m Resolution (WorldView-4,3,2,1, GeoEye-1, Pleades 1A, 1B, QuickBird, Ikonos)

Satellite Imageries- 1m -2.5 m Resolution (SPOT 6 & 7, SPOTMaps, ALOS)

Satellite Imageries with Low Resolution (DMC, ASTER)

Satellite Imageries - TerraSAR-X (microwave images)

3D Landscape

60cm	DSM/DTM
1m	DSM/DTM
3m	DSM/DTM
5m	DSM/DTM

Elevation Data (AW3D, WorldDEM, Vricon)

Aerodrome Mapping Database (AMDB)

Drone Services



## Our Esteemed Associates



## Purpose of the project:

The purpose of this project is to carry out hydrological studies over the area of interest. Prime focus was on the hydrological features like River, Streams, Canals and Ponds. This helped in study of the movement, distribution, resources and environmental watershed sustainability in the area.

## Report in a nutshell

This report is for our quality assessment of the data and SATPALDA review its process, methodology, quality check procedures, time bounded delivery and what we achieved and learn from the project. The report consists a detailed description about the project requirement, work flow adopted, various steps and task involved, complete methodology and output product delivered as per the scope of the work.

## Client

Domestic (Indian client)

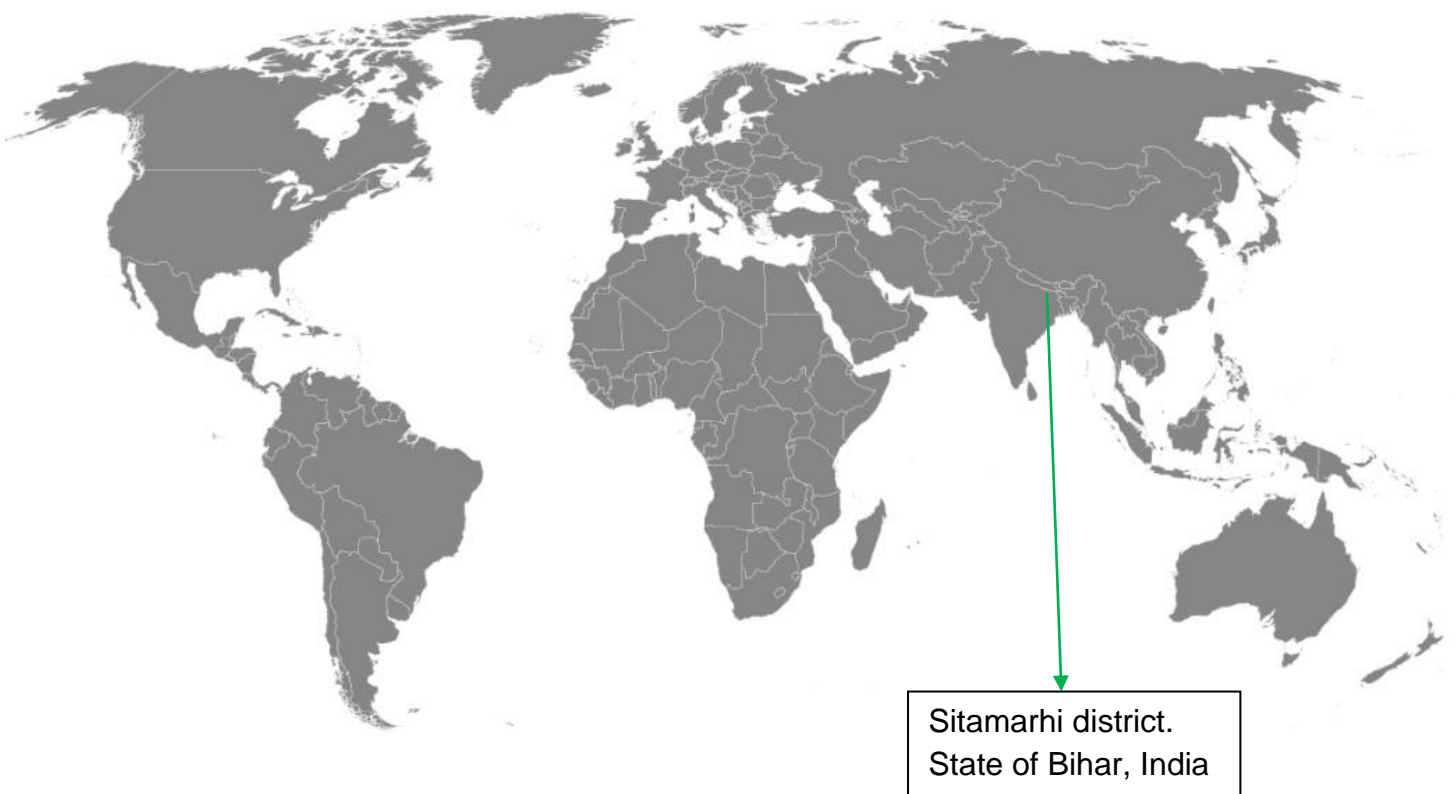
## Scope of the work

- 50cm Imagery acquisition from WorldView-2 satellite
- DGPS Survey
- DTM (1m grid spacing)
- Contour map (1m interval)

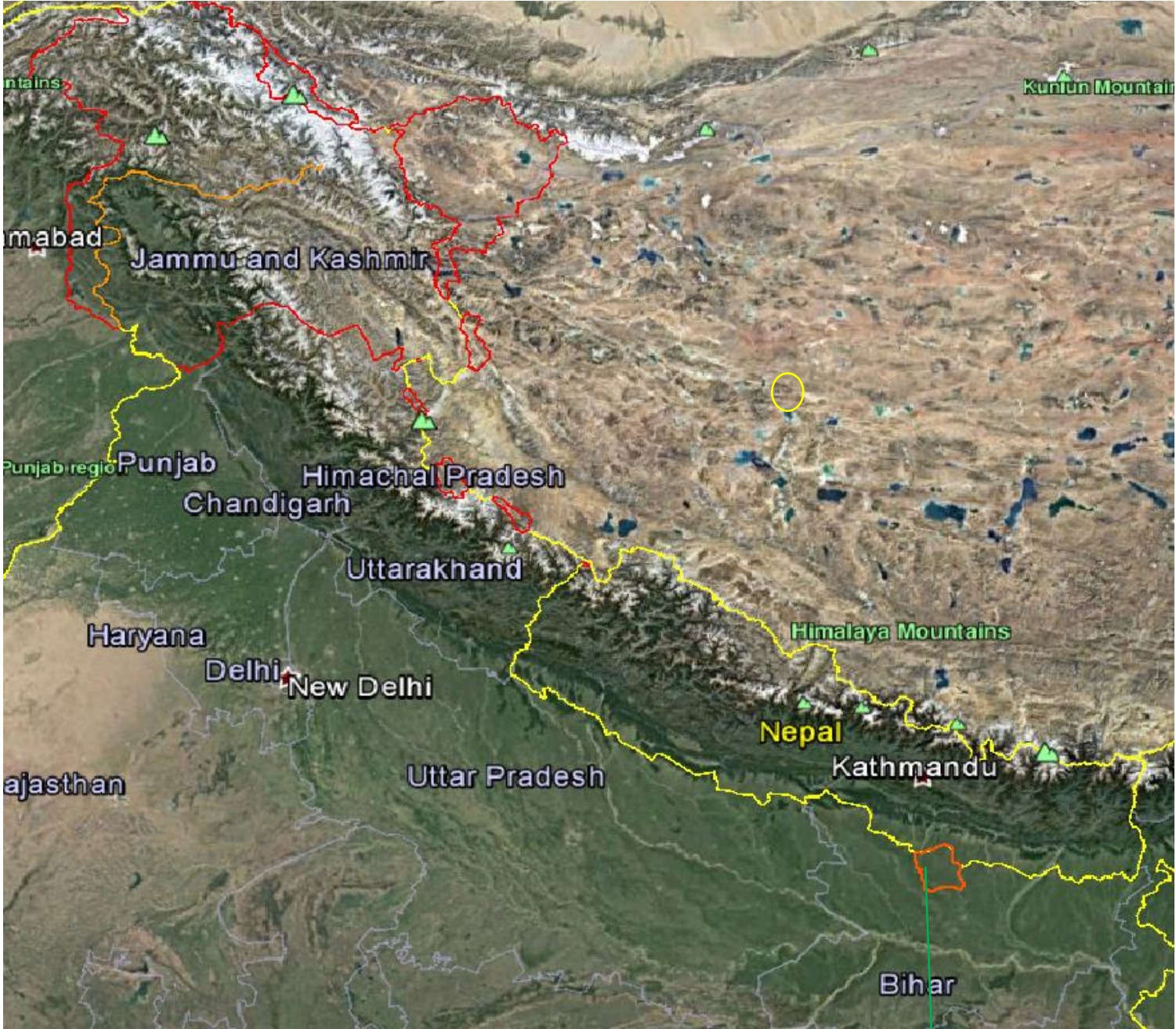
## Sitamarhi District

This place is considered as birthplace of Sita, the main character of the epic Ramayana and a temple dedicated to Sita lies near Sitamarhi town. Sitamarhi is located at **26.6°N and 85.48°E**. Sitamarhi is one of the districts of the **State of Bihar, India**. Sitamarhi town is the administrative headquarters of this district. The district is a part of the Tirhut Division and is **located along the border of Nepal**. District is drained by rivers such as Baghmati, Aghwara, Lakhandei (Lakshman Rekha), Manusmara & few other minor streams. the northern portion of Sitamarhi falls in foothills of Himalaya. Here elevation increases as one goes from south to north. The ground is not rocky and there are no mountains. Land is suitable for growing crops.

## Location:

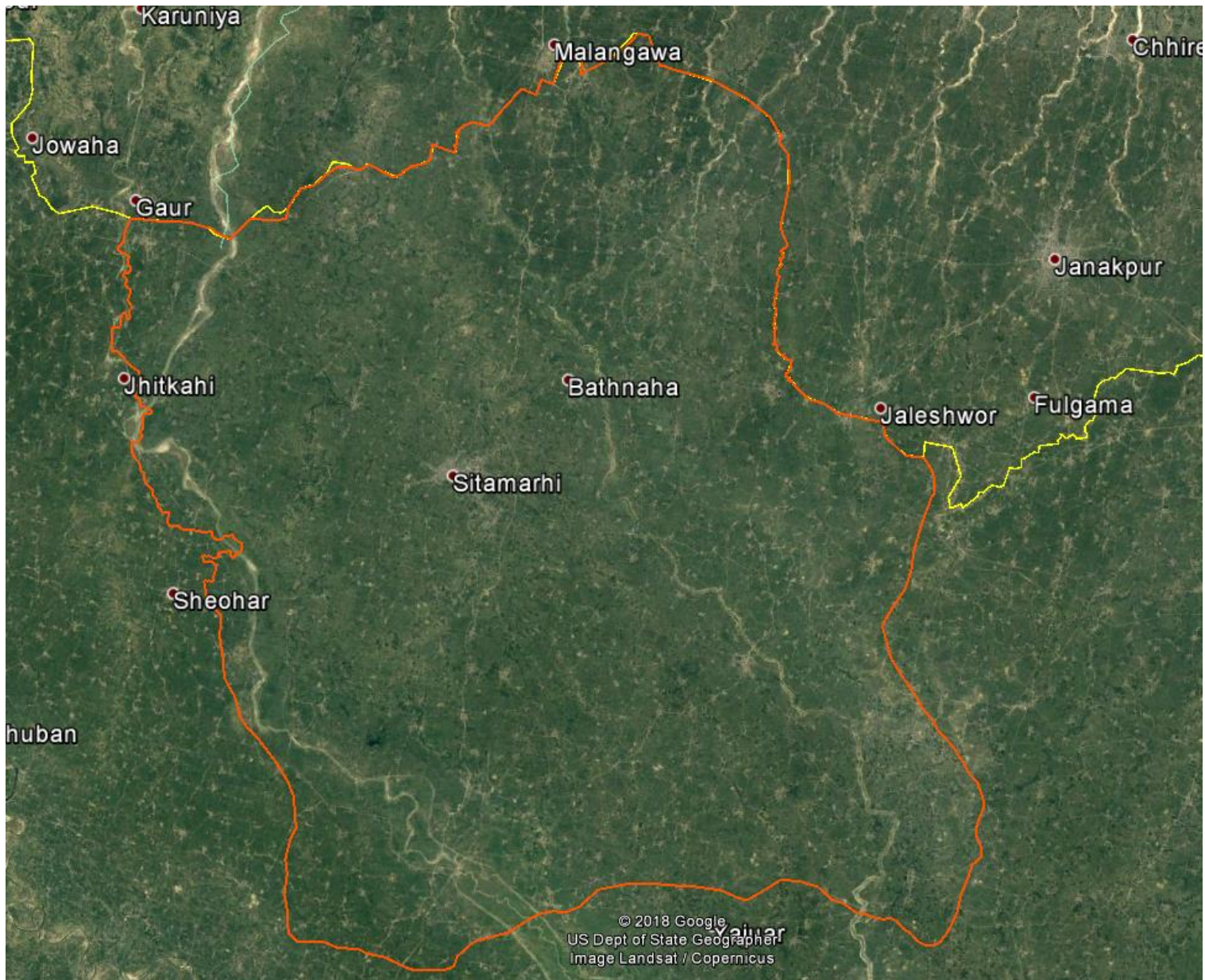






**Area of Interest**

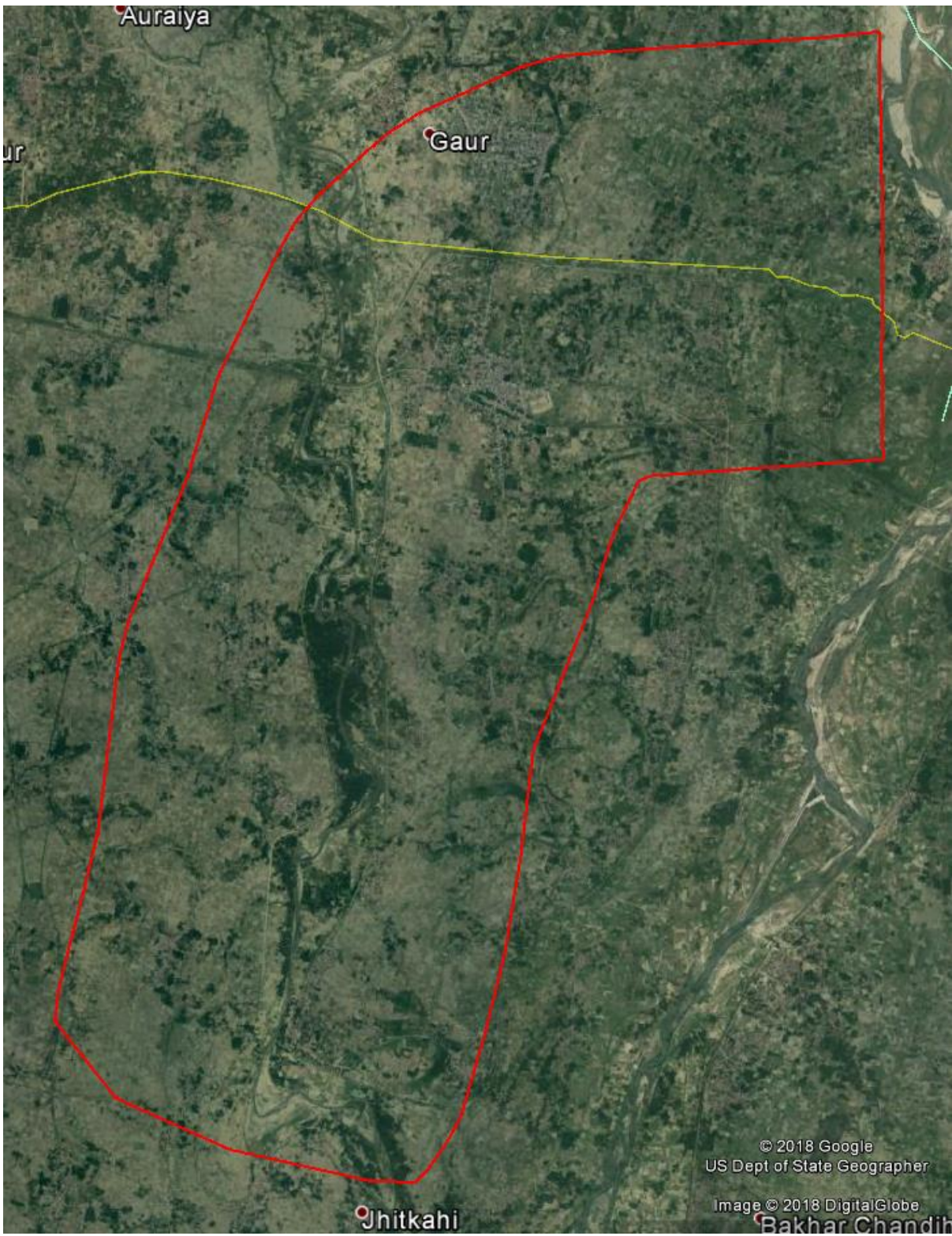




### Total Area of Interest

Perimeter : 257.64 km  
Area : 2704.3 sq km



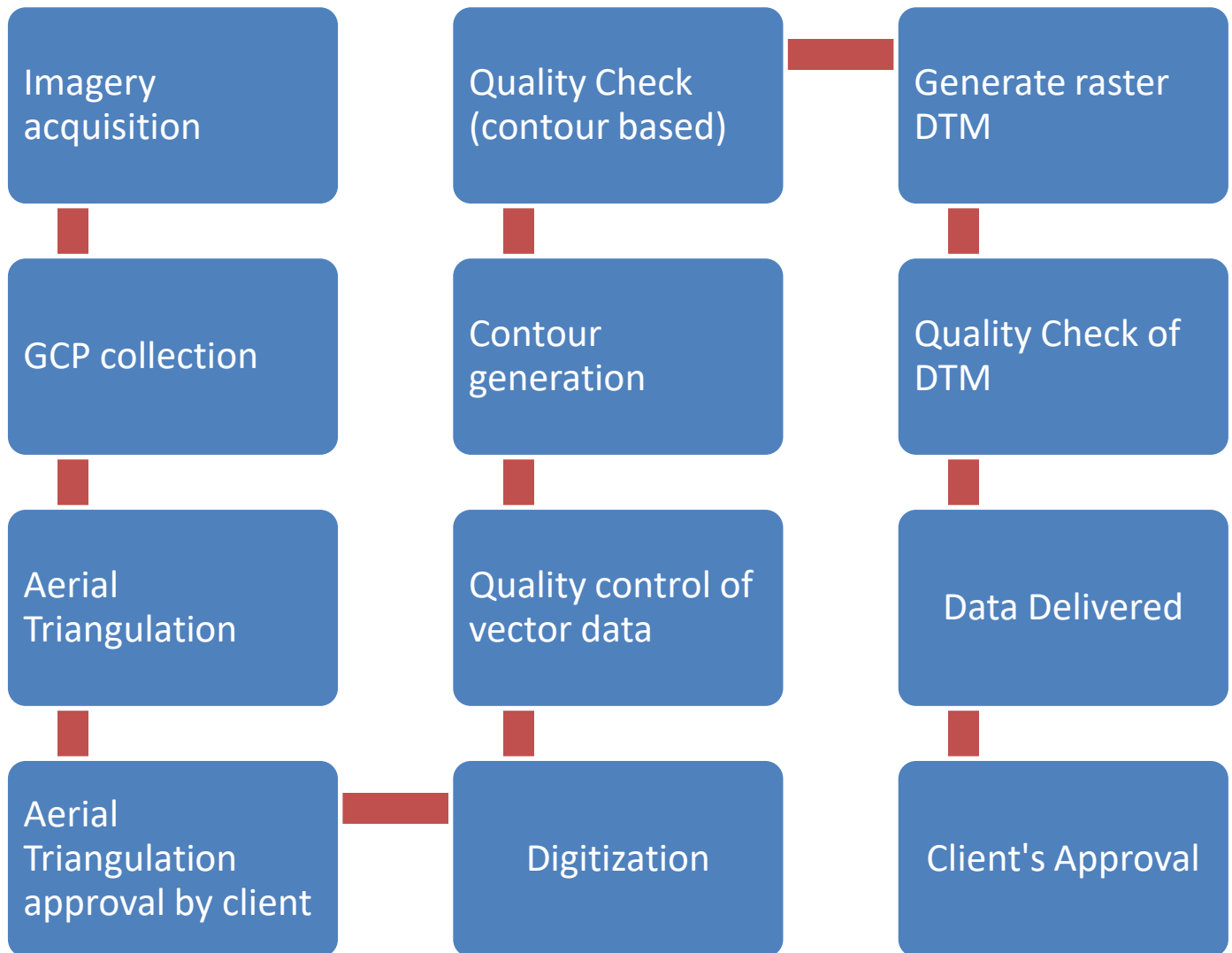


**Area considered for assessment purpose**

Perimeter : 38.778 km  
Area : 73.554 sq km



## Workflow of the project



## 50cm stereo imagery acquisition (WorldView-2)

WorldView-2 satellite sensor from DigitalGlobe provides 8-band multispectral imagery. It was launched on October 8, 2009 from Vandenberg Air Force Base on a Delta II rocket to become DigitalGlobe's third satellite in orbit, joining WorldView-1 which was launched in 2007 and QuickBird which was launched in 2001. It takes a new photograph of any place on Earth every 1.1 days. The overall objective was to meet the growing commercial demand for high-resolution satellite imagery.

<b>Launch Information:</b>	Date	:	October 8, 2009
	Launch Vehicle	:	Delta 7920 (9 strap-ons)
	Launch Site	:	Vandenberg Air Force Base, California



## GCP Collection (DGPS Survey)

Ground control points are large marked targets on the ground, spaced strategically throughout the area of interest. When used correctly, ground control points greatly improve the global accuracy of the image. They help ensure that the latitude and longitude of any point on our image corresponds accurately with actual GPS coordinates. This is important in situations where precision mapping and true global accuracy are needed.



Differential Global Positioning Systems (DGPS) are enhancements to the Global Positioning System (GPSs) which provide improved location accuracy, in the range of operations of each system, from the 15-meter nominal GPS accuracy to about 1cm in case of the best implementations. The system has three major components: space, earth control, and end user.

### **Basic Definitions**

**Base station:** Base station receives signals from the satellite and create correction factor. These corrections are further sent via radio to rovers.

**Rover:** A Rover is a survey tool used to receive signals from the satellite and a base station to calculate grade.

**PDOP:** Position Dilution of Precision (PDOP) is the measure of geometrical strength of GPS satellite configuration. As the PDOP value increases both the horizontal and vertical precision of your data point increase.



## Methodology

1

- **Place the Base station at a known point (*make sure without the known point we cannot place the base station*)** \*The base station should be leveled and centering accurately

2

- **Measure the slant height with tap and start the receiver of the base station.**

3

- **Check the number of satellite and PDOP value in a controller display. Now in a controller type, we enter the name of the point and the height of the controller and then we click on ' Start base station'.**

4

- **According to AOI (Area Of interest), surveyor go to the point approximately 1 km from the base station and mark the static point by using Rower .**

5

- **Now surveyor placed the point for 10- 15 min (Time is according to the range of base station). The more surveyor go far from the base station, the time for placing the static point will be more.**

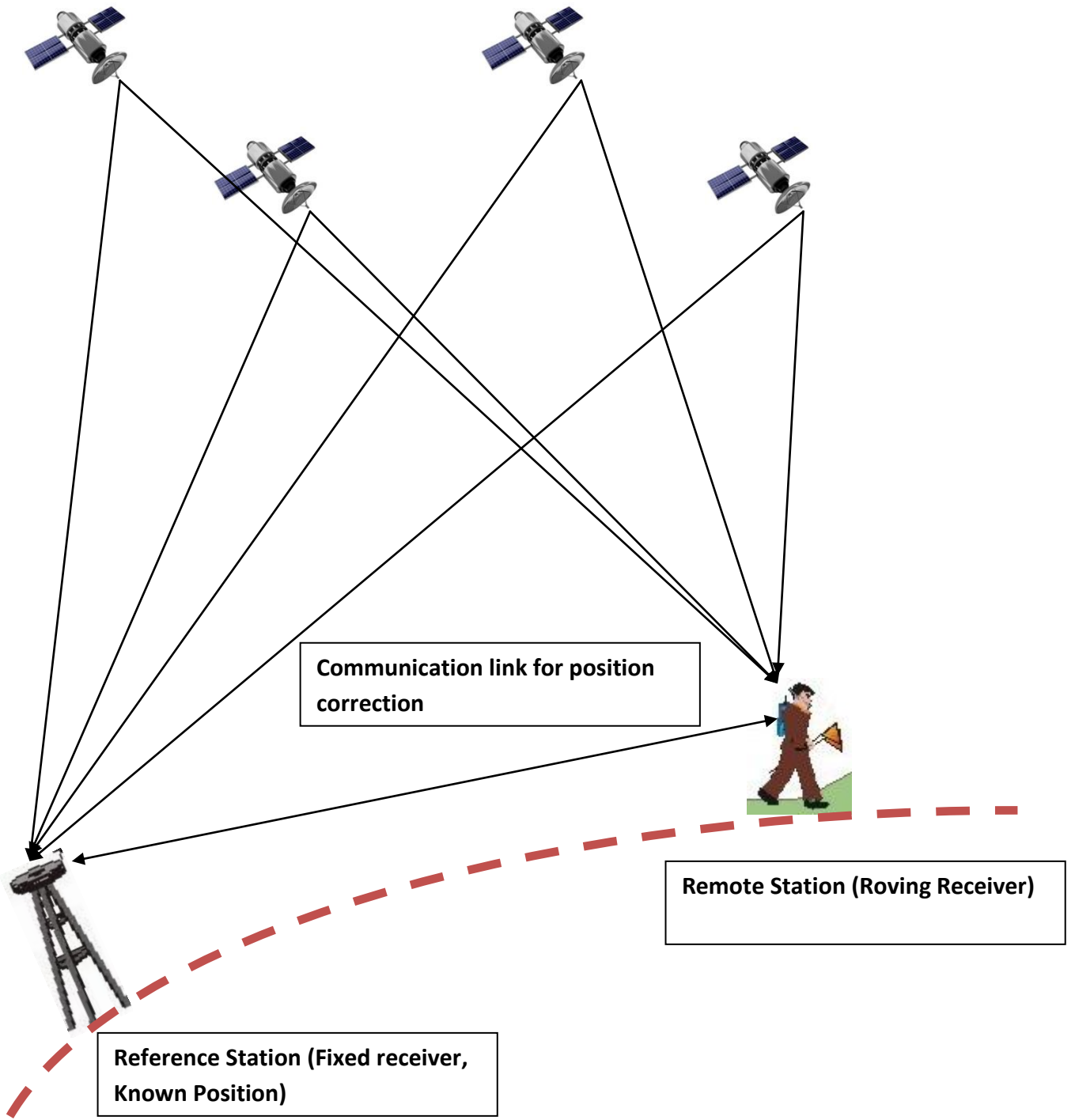
6

- **Surveyor placed the point for 10- 15 min (Time is according to the range of base station). The more surveyor go far from the base station, the time of placing the static point will be more.**

7

- **If the surveyor wants to go beyond the range of the base station, he must place the base station where he take static point and the survey (i.e shown in pictorial diagram).This method is called Leap frog Method.**

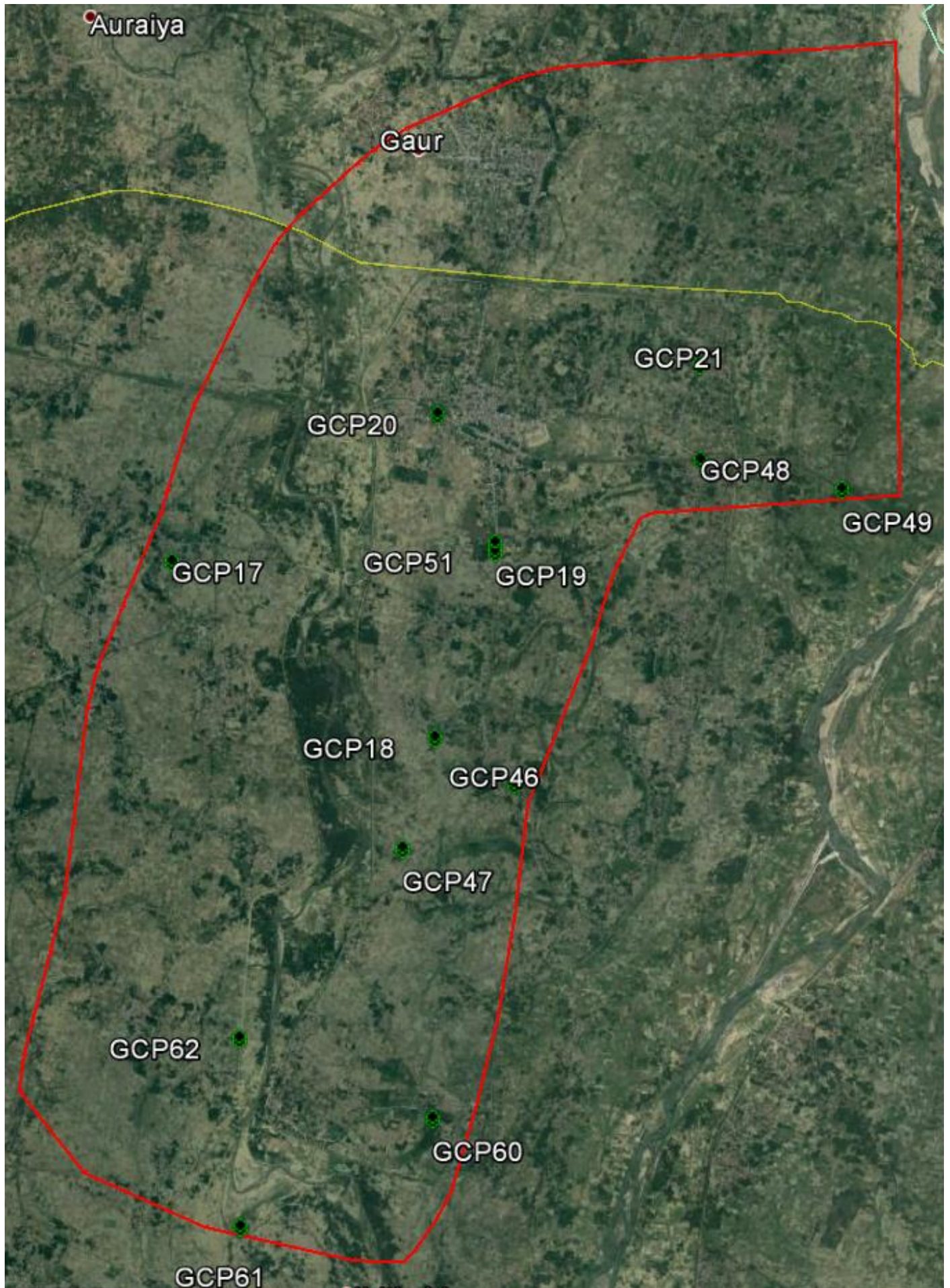
**Satellite Constellation**



**Communication link for position correction**

**Remote Station (Roving Receiver)**

**Reference Station (Fixed receiver, Known Position)**



*Distribution of the GCPs collected over the area.*



GCP ID	X	Y	Z
GCP60	327666.1	2951066	67.93
GCP61	325515.5	2949895	68.31
GCP62	325534.6	2951983	68.18
GCP46	328622	2954757	70.48
GCP47	327374.9	2954059	68.69
GCP17	324858.1	2957267	71.04
GCP18	327749.4	2955279	69.39
GCP19	328448.9	2957427	69.71
GCP20	327828.3	2958858	72.2
GCP21	330743.4	2959368	72.67
GCP48	330737.2	2958314	74.75
GCP49	332303.6	2957964	76.09
GCP51	328445.8	2957327	70.6

*GCPs with their IDs and corresponding values (in meter).*



GCP 18



GCP 19



GCP 17

*Few pictures of surveyors collecting GCPs*

# Aerial Triangulation

Aerial Triangulation (AT) represents the mathematical process of establishing precise and accurate relationships between the individual image coordinate systems and a defined datum and projection (ground).

The main objective of aerial triangulation is to produce from ground control, sufficient points in the photogrammetric models to ensure that each model can be oriented accurately as required for stereo compilation in either orthophoto or line mapping.

There are mainly three stages of aerial triangulation:

## **Preparation**

- Point identification of ground control
- Numbering settings for points, images and strips
- Input data: flight details (photo coordinates plus omega, phi and kappa rotation), camera calibration and scanned or digital images

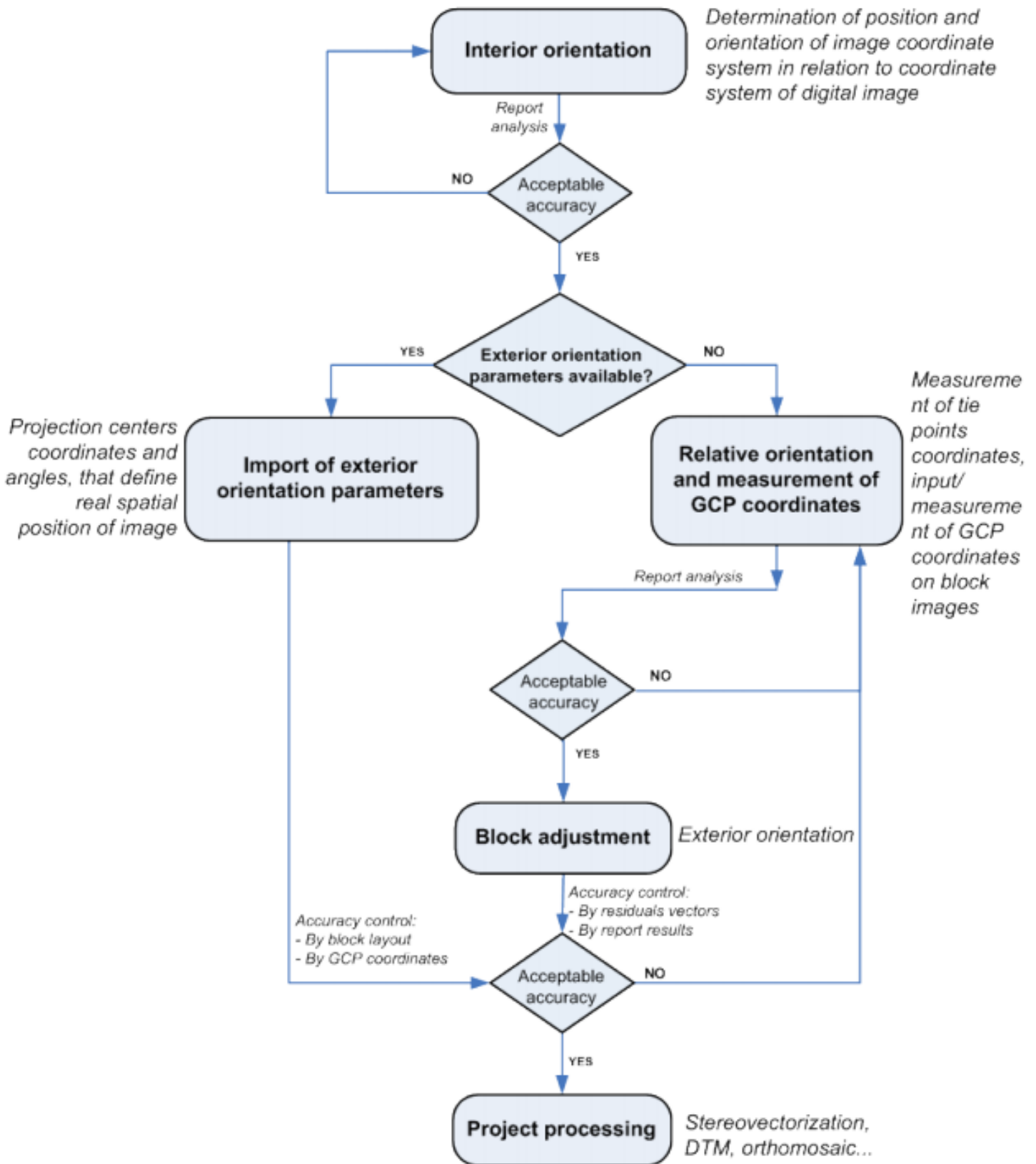
## **Image Measurement**

- Interior orientation (fiducial marks measurement for analogue cameras)
- Automatic tie points determination using images pyramid levels
- Ground control points measurement
- Manual tie points measurement if necessary (in cases where automatic measurement could not determine an acceptable number of tie points per image or in failure situations)

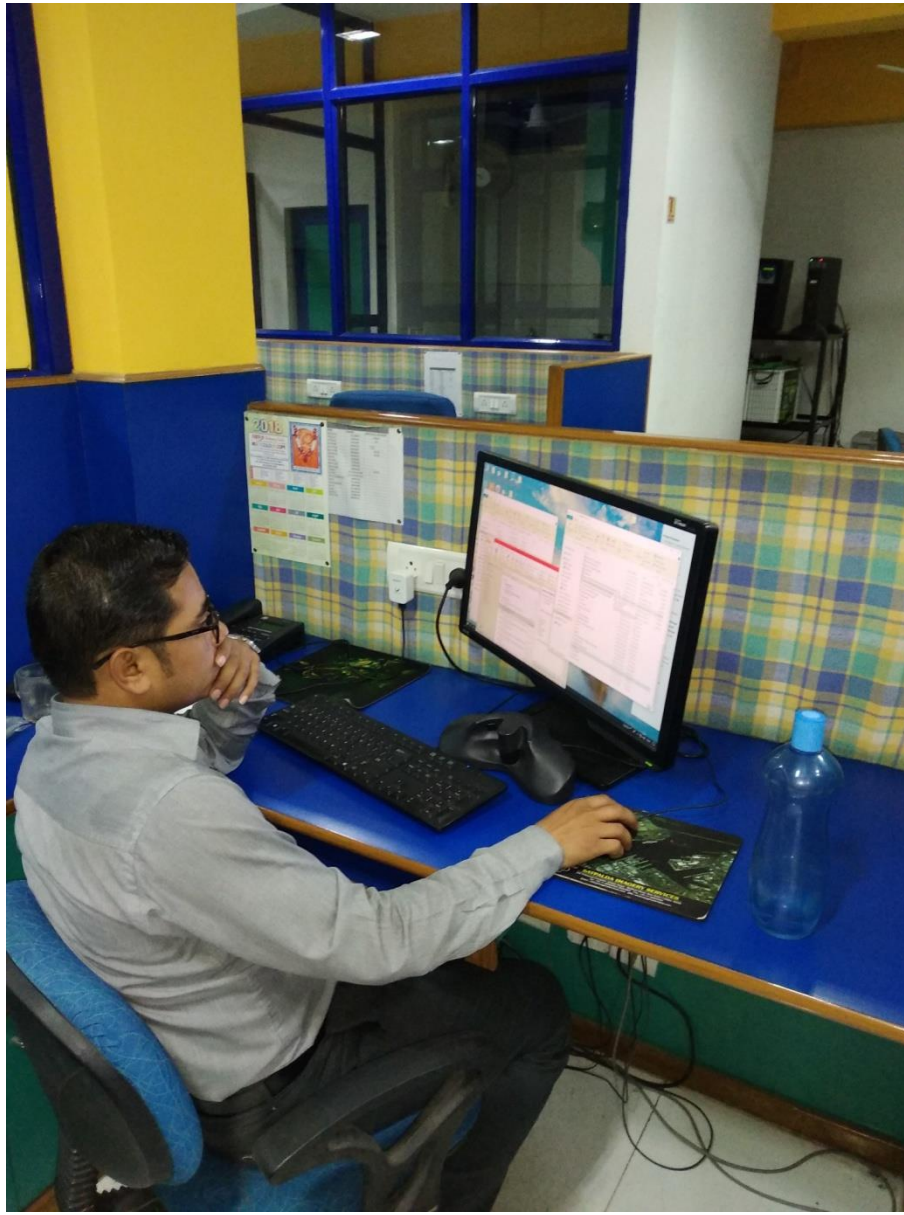
## **Block Adjustment**

- Input of observations (x, y, z coordinates or GPS/IMU, ground control) and initial parameter values.
- Preliminary data processing, including generation of initial values for bundle adjustment parameters.
- Iterative solution (including special algorithms for determination of blunders and error propagation).
- Acceptance of results (after accuracy and reliability assessment).
- Final output of results (EO data).

## Aerial Triangulation workflow







*Photogrammetry engineer at SATPALDA performing Aerial Triangulation*

### **Aerial Triangulation Report**

PROJECT COORDINATE SYSTEM	UTM_45N		
PROJECT ELLIPSOID	WGS_84		
PROJECT UNITS FOR SRG SYSTEM	Meters		
SRG ORIGIN(xyz)	X	Y	Z
	328580.837	2954631.263	0.000
SRG SCALARS(xyz)	X	Y	Z
	1.000	1.000	1.000

## CONVERGENCE TEST

THIS ITERATION'S WEIGHTED PROJECTED RESIDUAL RMS	0.308
PREVIOUS ITERATION'S WEIGHTED PROJECTED RESIDUAL RMS	0.308
PERCENTAGE DIFFERENCE BETWEEN THE ITERATIONS	0.002

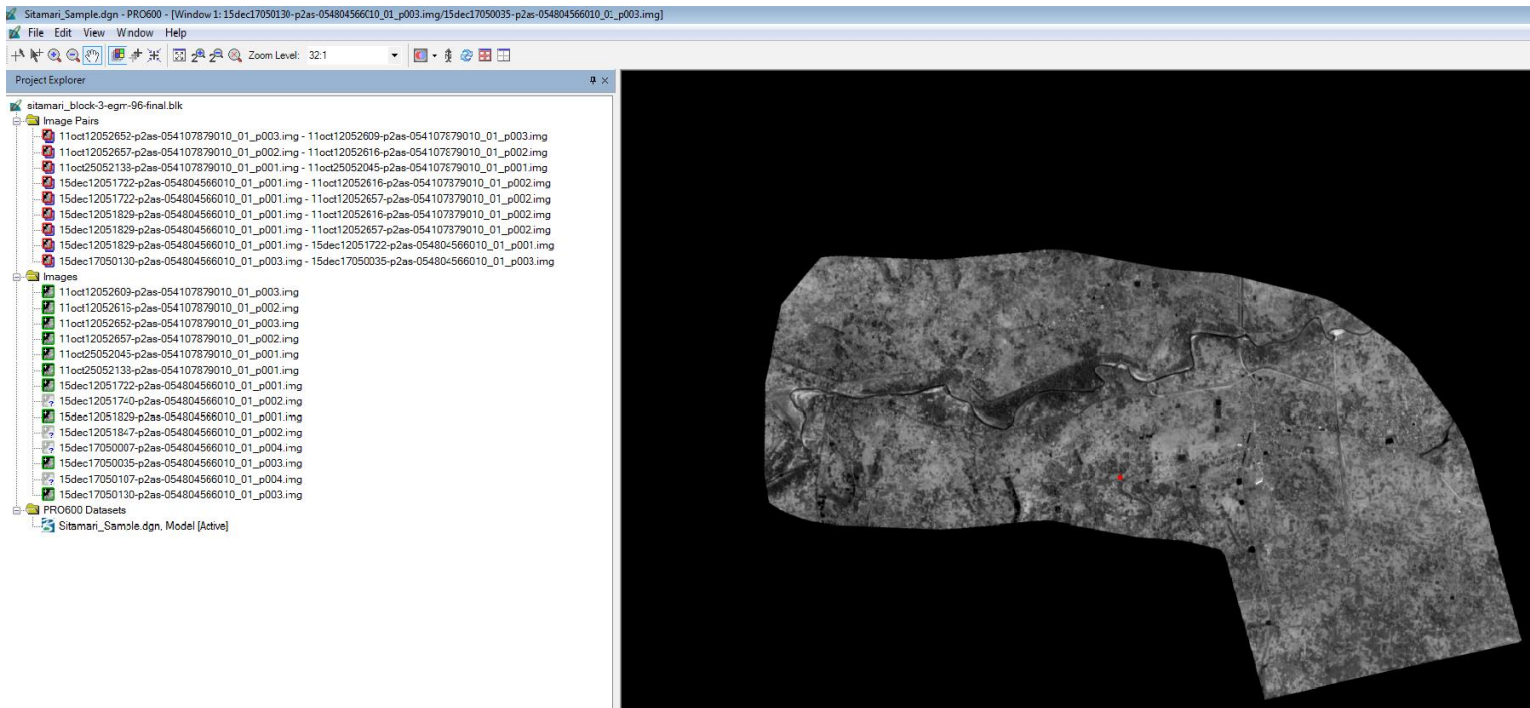
*Convergence detected!*

## SOLUTION DATA SUMMARY

PROJECT SOLUTION METHOD	Absolute
ITERATIONS	3
REDUNDANCY	109
EARTH CURVATURE USED	Yes

## RMS VALUES

RMS x	0.100
RMS y	0.095
RMS z	0.041
<b>Total RMSE</b>	<b>0.143</b>



*Stereo model of the AOI ready for Digitization after Aerial Triangulation*

## Digital Terrain Model (DTM) Creation

Digital Terrain Model (DTM) is a digital representation of a landscape. This is a combination of lines and points which collectively produce a vector data that represent the bare earth. Following some step by step methods and using this vector data the output is a bare-earth raster grid, referenced to a vertical datum.

After completion of Aerial Triangulation the stereo pair images are ready to create DTM.

- 1) DTM is created with X, Y and Z coordinates for each point. Seamless DTM is generated for entire area of interest.
- 2) Digital Terrain Model is interpolated from extremely dense 3D cloud points which were extracted from the images.
- 3) These points are further edited and corrected in 3D environment using photogrammetric software. During this process we need to perform online editing of contours which make sure the data on ground and a perfect cross check for all minor and major undulations of ground .Points over vegetation, buildings, closed water bodies and bridges are removed if there are any. Points are edited manually with keeping contours on and this is done at various intervals.
- 4) Now comes the breaklines in play. These are the vector lines an operator digitize manually using any photogrammetric software. These lines represent top and bottom of any sudden or gradual changes present on earth surface. They best support point data and a buffer around them is created by software so that there is no elevation conflict occur between points and lines.



- 5) After filling whole area with points and breaklines data is again checked with contour lines and once operator is satisfied , data is further moved to Quality Control team.
- 6) Stringent quality control system is applied to make sure the DTM is of the desired accuracy. If any issue found data is reverted back to operator for correction and delivered only after achieving quality standards set by client.



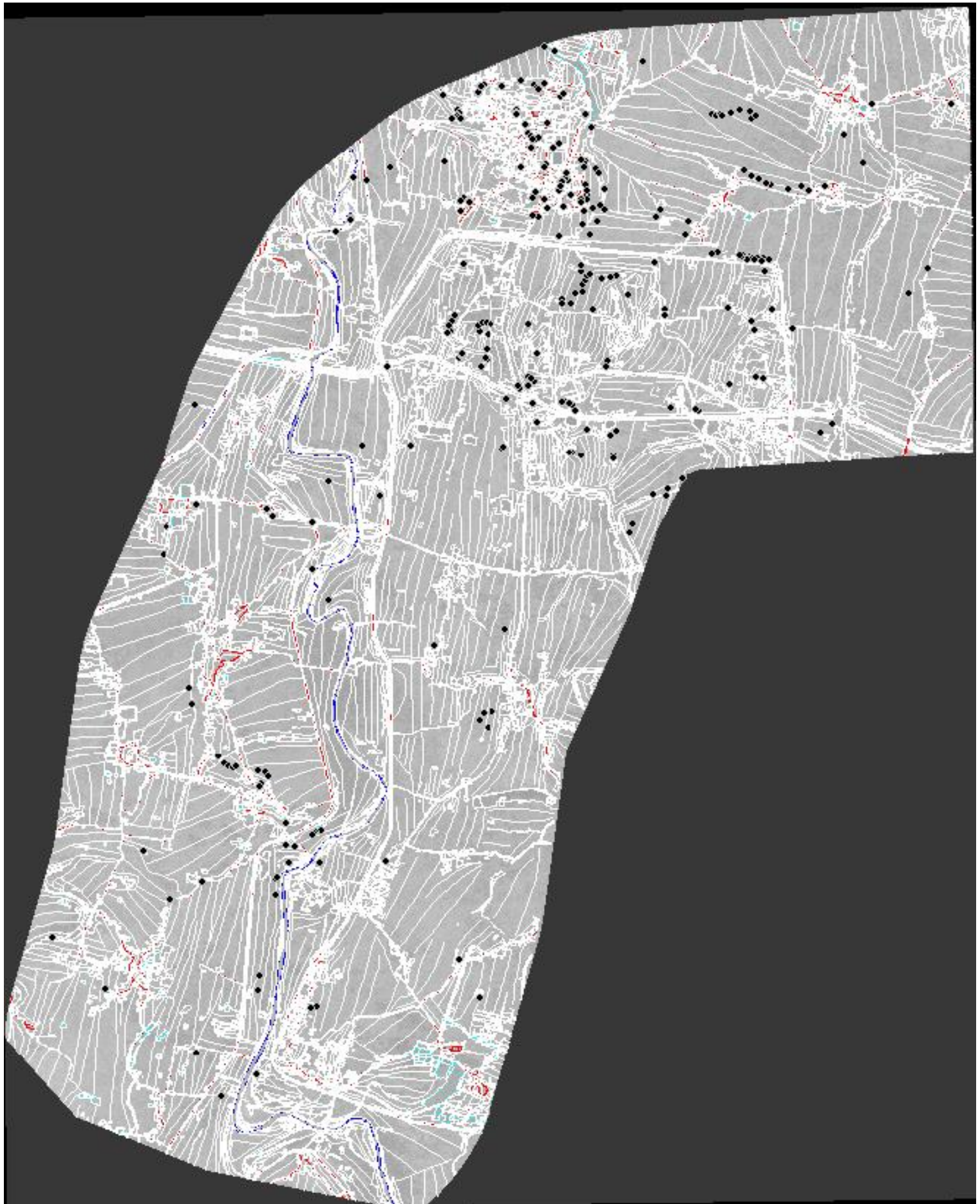
*(Photogrammetry engineers at SATPALDA creating DTM using photogrammetry workstations)*

### **3D Feature Extraction**

While digitizing 3d features with the help of stereo pair on photogrammetric software as per the project specifications the following procedures are adopted for 3D features extraction:

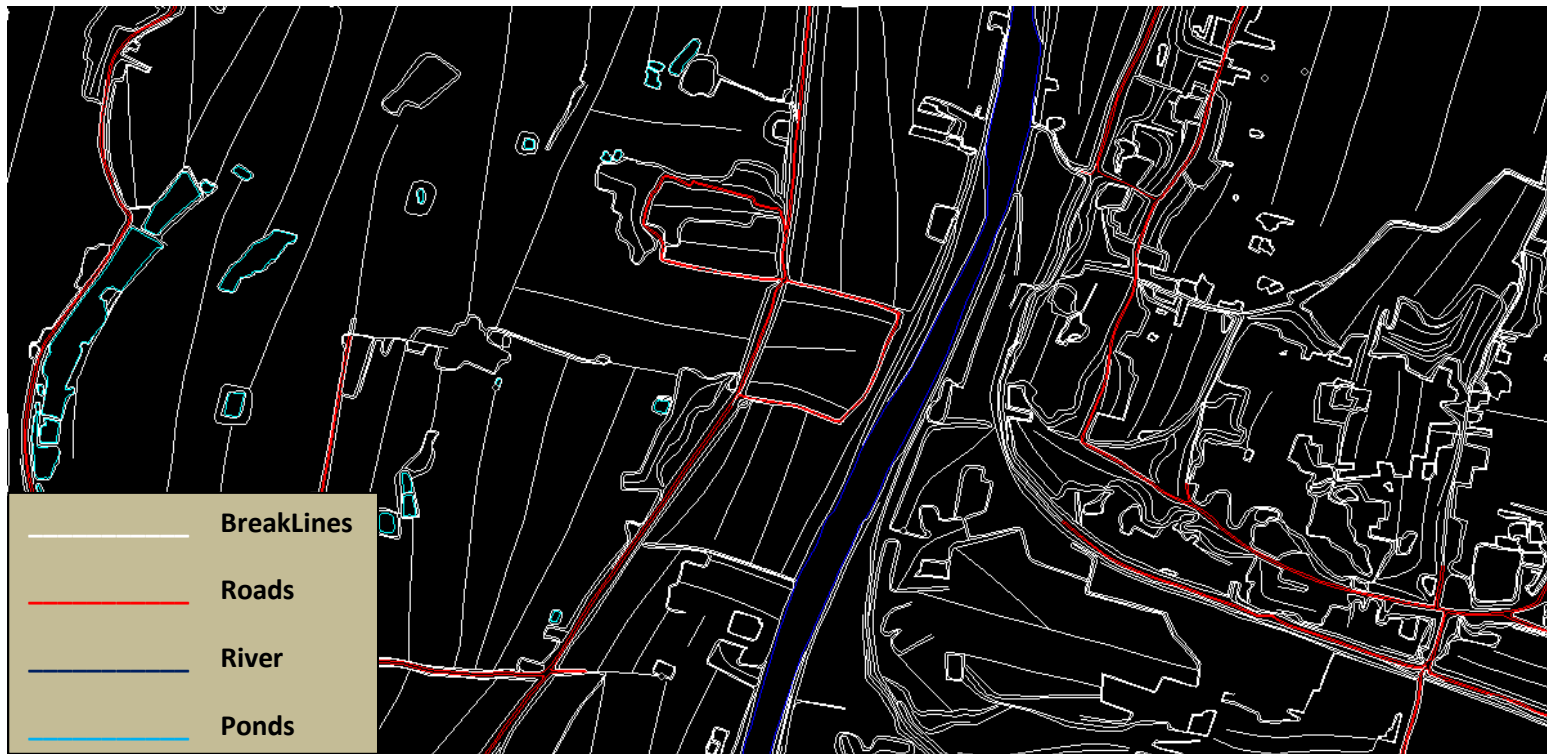
#### **1. Transportation features:**

- a. All transportation features are digitized at the travelling edge and embankment edge as well so that roads will be clearly seen and recognize in output DEM/DTM.
- b. All roads are discontinued at overpasses and bridges as we are concern about bare earth only. Mass points are deleted inside roads ensuring smoothness of output data and contour lines as well.
- c. If both sides of roads are at same elevation (as seen most of the time) we need to keep each opposite vertex at the same elevation to avoid any unwanted slope on roads sides which is genuinely not present on ground.



*Vector data extracted on the basis of stereo pair imagery*





*A zoomed portion of the vector data digitized and used for DTM*

## 2. Hydrography/Hydrological Features:

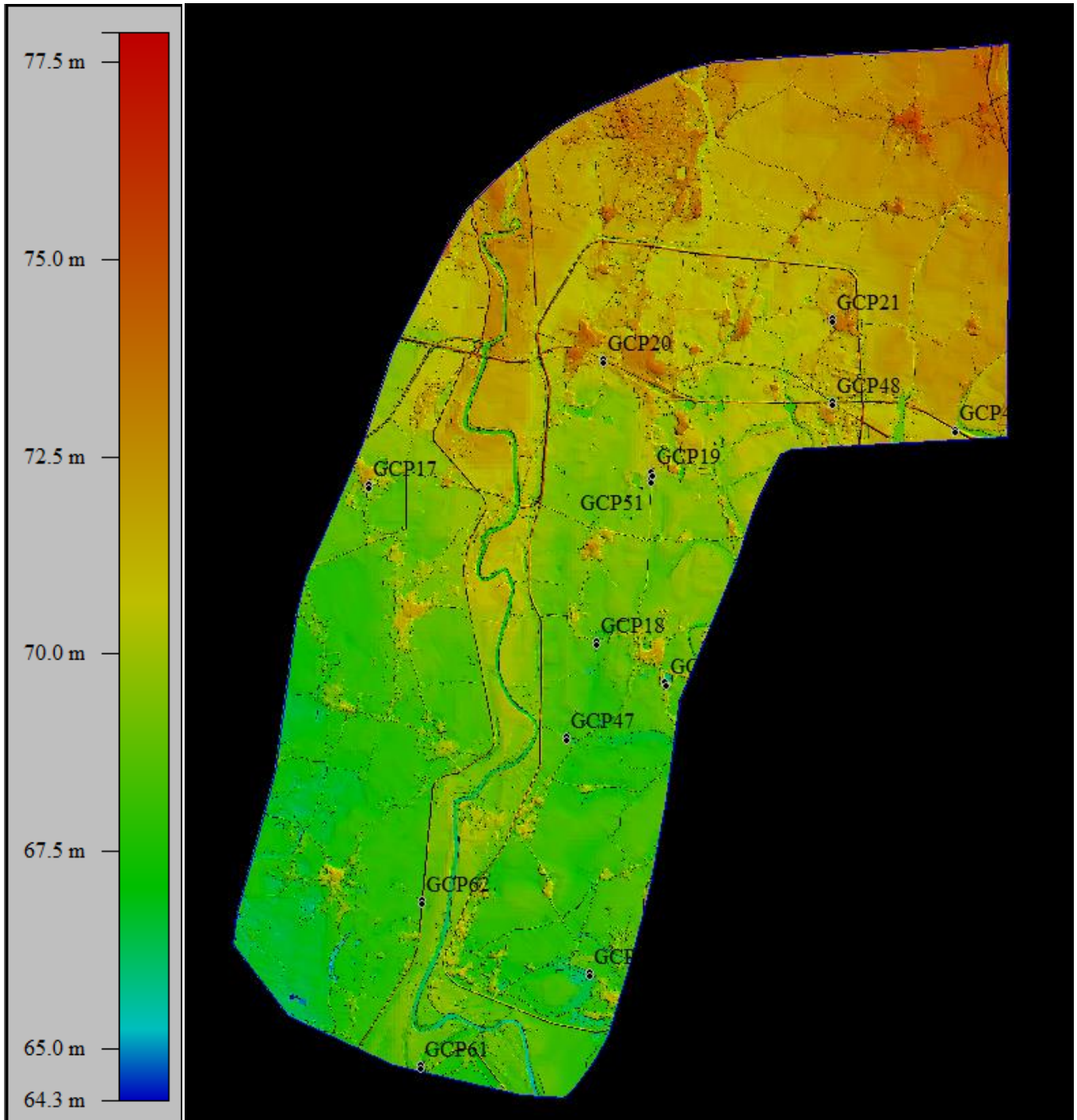
- a. All running water bodies captured from top to down (downhill flow – downstream).
- b. All double Line Rivers collected with a parallel elevation at both the banks of the river by following the downstream method.
- c. All hydro features continued through bridges to represent the natural flow of water.
- d. Water levels collected for Static water bodies (Ponds and Lakes) at the centre of the feature with water elevation.
- e. The mass points over the dead areas such as water bodies are deleted, as this need no height variation. A picture of the Hydrological features is given below:

All the still water features collected at a constant height.

## 3. Breaklines:

Breaklines are digitized at natural terrain breaks to support the contours with respect to the scale. It is important to collect top and bottom breaklines where there are vertical drops. Retaining walls collected with the break lines at top and bottom. Similarly all embankments collected with the breaklines.





*Raster DTM with 1m grid spacing verified with GCPs*

## DTM quality control and analysis

Quality control for a DTM is a multi level process. We focus to do the work right at first attempt and avoid any kind of rework or correction situation. Our experienced engineers put their best efforts in creating vector data as per above described guidelines. Online QC is done at the production level by QC manager and required feedback is given to the team. Final QC is done once data production is complete. Following is the check list we follow for the quality control of a DTM:

- ✓ Completeness of the Data (as per AOI).
- ✓ Edge match with the adjacent data set.
- ✓ Geometric correctness of the features (roads, streams, river etc.).
- ✓ Accuracy of the elevated (Z value) vector data (at 4x zoom level).
- ✓ Data cleaning to avoid undershoot, overshoot, line cross and data duplicity.
- ✓ Cross checking of DTM with respect to GCPs

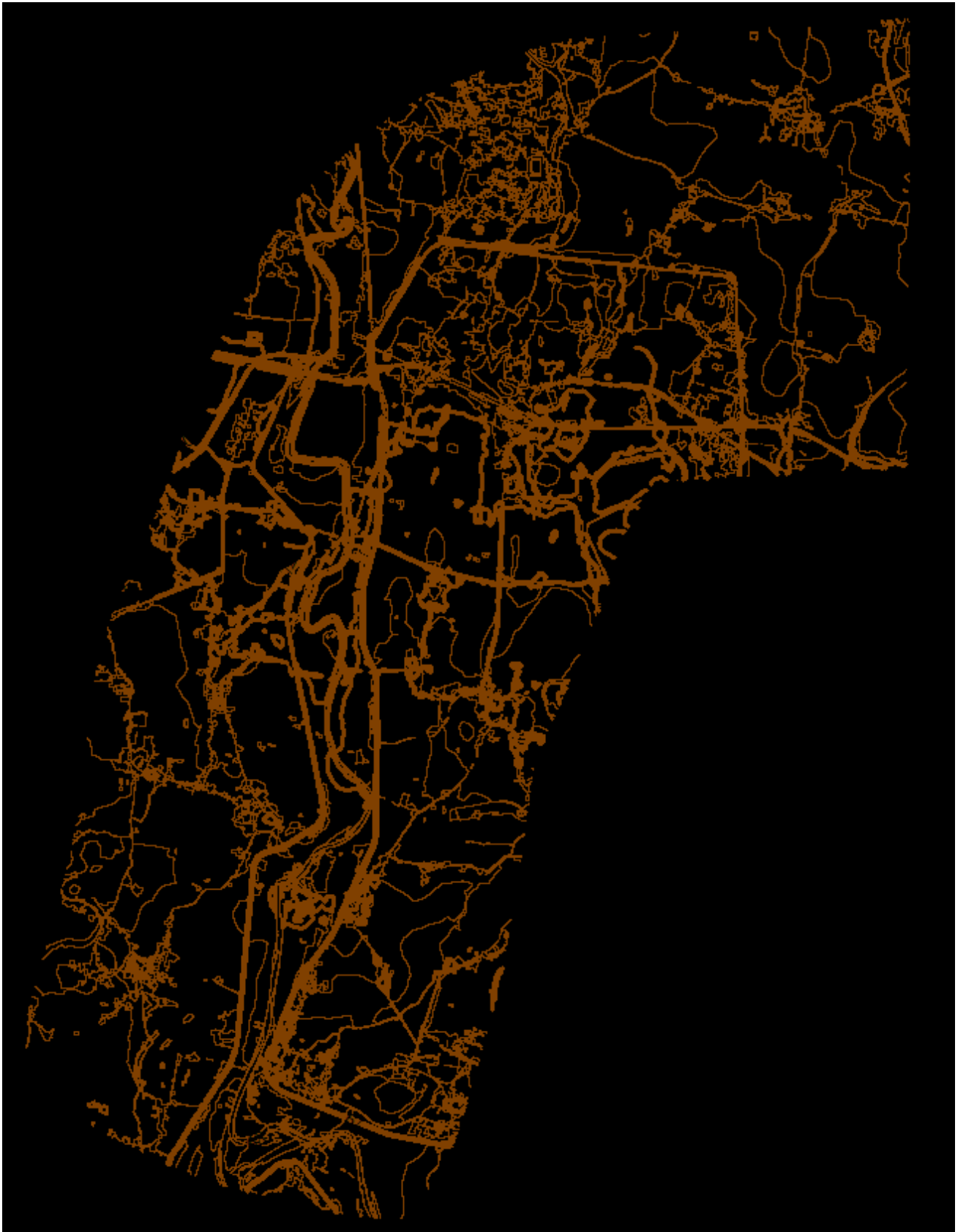
## Assessment of DTM with reference to GCP's

GCP ID	X	Y	Z	DEM Elevation	Diff. From DEM
GCP60	327666.1	2951066	67.93	68.3975	-0.467
GCP61	325515.5	2949895	68.31	68.7286	-0.419
GCP62	325534.6	2951983	68.18	68.4335	-0.253
GCP46	328622	2954757	70.48	70.43	0.050
GCP47	327374.9	2954059	68.69	68.8922	-0.202
GCP17	324858.1	2957267	71.04	71.3705	-0.331
GCP18	327749.4	2955279	69.39	69.469	-0.079
GCP19	328448.9	2957427	69.71	69.66	0.050
GCP20	327828.3	2958858	72.2	72.2085	-0.008
GCP21	330743.4	2959368	72.67	72.77	-0.100
GCP48	330737.2	2958314	74.75	74.6244	0.126
GCP49	332303.6	2957964	76.09	76.04	0.050
GCP51	328445.8	2957327	70.6	70.6981	-0.098

*Table validating DTM elevation with reference to GCPs*

## Contour map creation (1 m interval)

After the creation of DTM and its approval by the quality control manager, contour lines were generated as per client's requirement which is 1m in this case. The contour map is well checked and super imposed on same stereo pair used for DTM to check its quality.



*Contours with 1m interval*

## **Final data delivered**

- ✓ **50cm orthoready Imagery from WorldView-2 satellite.**
- ✓ **DGPS detailed survey report.**
- ✓ **DTM with 1m grid spacing raster data (TIFF).**
- ✓ **Contour map with 1m interval (DWG).**

## **Report conclusion**

This assessment report is prepared under the supervision of the project manager (Photogrammetry) and approved by the management thereafter. Like any other assessment report we frame out our methodology, quality assessment and figure out the areas where we can further enhance the quality. SATPALDA is proud to deliver such a huge and multi tasking project within stipulated time and highest level of quality which is accepted by our client with an appreciating note. This will further help us to make new strategies and implementation of some new ideas to our existing policies for the production house and marketing too.

Here we are not only concerned about our internal quality but at the same time we are providing a transparency to user community about our products, services and the way we execute our projects.