BIO-DATA

Paper Reference Number	:	**PN-135**
Title	:	High Resolution satellite data for Canal Alignment Surveys
Name of the Author/ Presenter	:	Harikumar P.S., Manager
Organization	:	Rolta India Limited
Mailing Address	:	Rolta Technology Park, MIDC, Marol Andheri East Mumbai - 4000093 Maharashtra India
Telephone	:	+91(22) 2926 6666, 3087 6543 Extn:1757
Fax	:	+91(22) 2836 5992
E-mail	:	harikumar.ps@rolta.com

The Author is Manager of the Business Development (Photogrammetry & Image Processing) group of Rolta India Limited. Mr. Harikumar obtained his Bachelor of Engineering from the University of Kerala, and his Master of Technology with specialization in Remote Sensing from College of Engineering, Anna University. Prior to joining Rolta, he was working with Geofiny Technologies Pvt.Ltd, SGS Infotech and Fugro Survey Limited. He has worked and lead many projects in photogrammetry, Lidar mapping, marine 3D mapping and GIS.

High Resolution satellite data for Canal Alignment Surveys

Harikumar P.S and Dr.C.D.Murthy
Rolta India Limited, Mumbai

Introduction

In order to study the technical and economic viability of a canal alignment, authorities will be conducting a pre-feasibility study followed by survey and investigation of the selected route. During the pre-feasibility study, various alternative alignments for the canal will be investigated. The topography of the terrain is the most crucial factor that is taken into account during the pre-feasibility stage. At present, in India we use toposheets for topographic studies. The use of toposheets of scale 1:50000 will help the users in getting terrain representation at 20m contour interval. Most of the cases, 20m interval contour representation may not represent the terrain for constructing canals. More over, the toposheets are outdated by atleast 20 to 30 years. All further studies, construction activities are depended upon pre-feasibility report, it is important to generate the best possible alternative canal routes using the best terrain representation. 3Dimensional Terrain generation using high resolution satellite stereo data sets can be proposed as an alternative cost effective solution. Our understanding and experience shows that terrain representation upto 1m contour interval is possible using the present day high resolution stereo satellite data using Photogrammetry techniques. As the current available high resolution satellite data , with the 0.5 to 1 m pixel resolutions, will help the users creating fine resolution terrain and locating the features with good accuracy, the cost and time for the survey and investigation stage can be reduced considerably.

Canal Alignment Surveys

Canals are man-made channels for water. There are two types of canal:

A. **Water Conveyance canals**: Canals that are used for the conveyance and delivery of fresh water, for human consumption, agriculture, etc.

B. **Waterway canals**: Canals that are navigable transportation canals used for carrying ships and boats loaded with goods and people, often connected to existing lakes, rivers, or oceans. Included here are inter-ocean canals such as the Suez Canal and the Panama Canal.

This paper is discussing about water conveyance canals that are mainly used for irrigation activities.

The main canal of an irrigation canal system, in general, will be positioned for irrigation of largest possible command area. In most cases, the canal will closely follow the land contours, losing only minimum elevation to maintain the slope needed for suitable flow velocity. The land commanded by the main canal will be subdivided into irrigation units

of about 10 ha each. From the main canal, secondary canals will be laid out to each irrigation unit, following the line of highest elevation in each unit so as to maximize the area served by each secondary canal. Tertiary canals, or field channels, will then be laid out from the secondary to deliver water throughout the unit.

On flat sloping, non-undulating lands, canals will generally have the same slope as the terrain. In steeply sloping lands, canals will be given a slope which is less than the terrain to avoid high flow velocities. Whatever be the slope of the canal, abrupt changes in the slope should be avoided. If the bed slope changes suddenly the flow velocity in the canal will also change, and such a change in flow velocity can cause erosion or may lead to siltation in the canal bed.

Thus the most important factor in all canal systems in deciding the alignment is the relief or three dimensional quality of the terrain. The relief of the earth is called as topography of the terrain which is very much useful in planning and locating natural/artificial structures. The most common method of representing the topography of an area is to use contour lines**.** We, in India, use Survey of India toposheets for understanding the topography of the terrain. Survey of India toposheets of scale 1:50,000 contain contours at 20m interval.

Phases in Canal Alignment survey

Pre-feasibility study

Alternative routes will be prepared with the help of toposheet contours during pre-feasibility study. The routes will be placed in such a way that it will closely follow the land contour to ensure the retention of the water velocity to its maximum speed. The best alternate route that require minimum cut and fill activity will be taken for further survey and investigation.

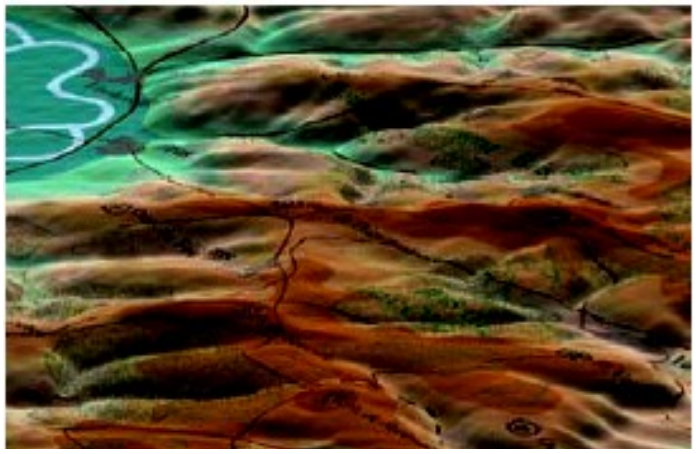

Fig 1. Possible Alignments of canals

Survey and Investigation

One need to carryout additional surveys and investigations for finalizing the best alternate canal route. Various studies during this stage include

- Archaeological survey
- Mineral Survey
- Communication Survey
- Drainage Survey
- Hydrological and meteorological investigation
- Construction Material Survey
- Soil Survey
- Environmental, Ecological and socio-economic Survey

These activities are followed by

- Alignment Survey of Canal System
- Establishing Bench Marks
- Fixing of Center Line Stones
- Strip Survey along Alignment of Canal
- Fixing of Boundary Stones
- Preparation of Land Acquisition Plan

Design and construction of Canal

Canals may be constructed in cut or in fill depending on local circumstances. Canals in fill are constructed above ground level by building embankments with soil brought from other locations or scraped from the adjacent field. For small canals, sometimes only one large embankment is constructed, and then the canal cross-section is excavated in the middle.

In all these phases, it is important to identify the location of natural and manmade features, understand the topography of the terrain. High resolution stereo images can be used for creating the topography of the study area as well as for locating manmade and natural features.

Remote Sensing Technology

Remote sensing technology can be used in many applications, with considerable advantages both in terms of cost and time, with acceptable standards of reliability. Whatever information is required to be generated about the ground conditions on the Earth's surface, which we normally do extensive time consuming ground surveys utilizing number of human resources, is now possible by using remotely sensed data. The high resolutions satellite data study through remote sensing interpretation methods will provide the correct terrain conditions. One can simulate the actual terrain ,as captured by the satellite sensor on a given date, through Photogrammetry techniques sitting in the

with minimum visits to the ground for only verification purposes. Investigation activities in many projects such as road alignment, railway alignment, canal alignment or inter-basin river water transfer and pipeline alignment takes considerable time if we have to depend on traditional methods, by studying the topographical maps and several visits to the site.

Fig 2. Sample Geoeye1 imagery (Courtesy: Satellite Imaging Corporation)

Satellite remote sensing has made enormous progress over the last decades and a variety of sensors now deliver medium and high resolution data on a need basis.

High resolution satellite imageries can be used for various applications in Engineering and Construction, Defence and intelligence, Government, LBS, Natural Resources, Oil and gas, telecoms and utility mapping and corridor mapping . Stereo capabilities of these satellites will help in DEM generation, 3D terrain modeling and visualization. Our experience on Geoeye1 stereo data shows that one can achieve an RMSE accuracy of 0.1. m in plan and 0.25 m in height by utilizing the RPC data ,which comes with satellite data, and with minimum GCPs.

	GeoEye 1	IKONOS	QuickBird	WorldView1	WorldView2
Resolution	0.5 m for Panchromatic 2.0 m in Multispectral	0.8 m for Panchromatic 3.2 m in Multispectral	0.6 m Panchromatic 2.4 m in Multispectral	0.5 m for Panchromatic	0.5 m Panchromatic 2.0 m in Multispectral (8 band)
Positional Accuracy (CE90) (Without GCPs)	2.5 m	15 m	23 m	6.5 m	4.6 m to 10.7 predicted
Revisit Time	~ 3 days	~ 3.5 days	~ 3 days	~ 4.6 days	~ 3.7 days
Swath Width	15.2 Km at Nadir	11.3 Km at Nadir	16.5 Km at Nadir	17.6 Km at Nadir	16.7 Km at Nadir
Stereo Availability	Yes	Yes	Yes	Yes	Yes

Table 1. High Resolution Satellites

DEM and Contour Extraction from High Resolution data

Most of the present day high resolution satellites (Table.1) have the capability of producing stereo images. Using these stereo satellite imageries through digital photogrammetric techniques, we can create extremely detailed Digital Elevation Models (DEM) of approximately 3m – 5m resolution. Such a DEMs would be ideally suited for very precise site analysis and visualization. Its relative accuracy is high because of the precision of the source materials. The absolute accuracy is depended upon the availability of topographic maps or ground control points. As the elevation value is mainly used for cut and fill estimation, the relative accuracy will serve the purpose in canal alignment applications.

The spacing of the DEM grid can be established by requiring that no more than 1-foot contour elevation change in each grid cell. To compute that spacing, consider the slope along each edge of your site:

Assuming that the terrain is having moderate slope (5%), we can calculate the grid spacing by:

Slope = Change in elevation/length =5/100
Grid Spacing =1/slope =100/5 = 20 feet = 7 m

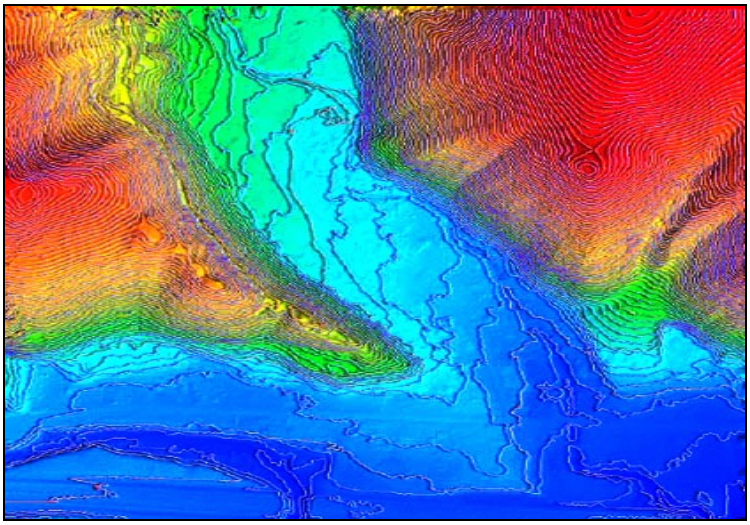

Fig 3. Terrain with Contours

Thus once the user knows the DEM grid interval, using the latest photogrammetry software's, necessary terrain can be generated (Fig3.). Using the TIN interpolation techniques, these DEM can be used for generating the necessary contours.

Methodology

Geoeye1 stereo imagery is utilized as an input in a project. Five to Six well distributed control points needs to be collected within the study area. Satellite triangulation process will be performed using **Rolta Photogrammetry Mapper**. Rolta Photogrammetry Mapper, indigenously developed software, has the capability of supporting all the latest satellite stereo sensors. Once the user, collects the control points in both the stereo images, triangulation process can be executed to generate epipolar stereo images (Fig4). For the test dataset, by giving 5 control points, we are able to achieve a planimetric RMS error less than 0.2m and height RMS error less than 0.25m.

This stereo data can be taken into Automatic DTM extraction module to generate 10m DEM. DEM interval can be fixed as per user requirement. For a moderately undulating terrain 10m grid will be sufficient. Automatic DTM points will give a reasonably accurate DEM in minimum time.

Automatic DEM will be edited in 3D environment to remove erroneous points and then contours are generated at 2m interval. Simultaneously, ortho photo can be generated for mapping the hydrographic, transportation and other land features.

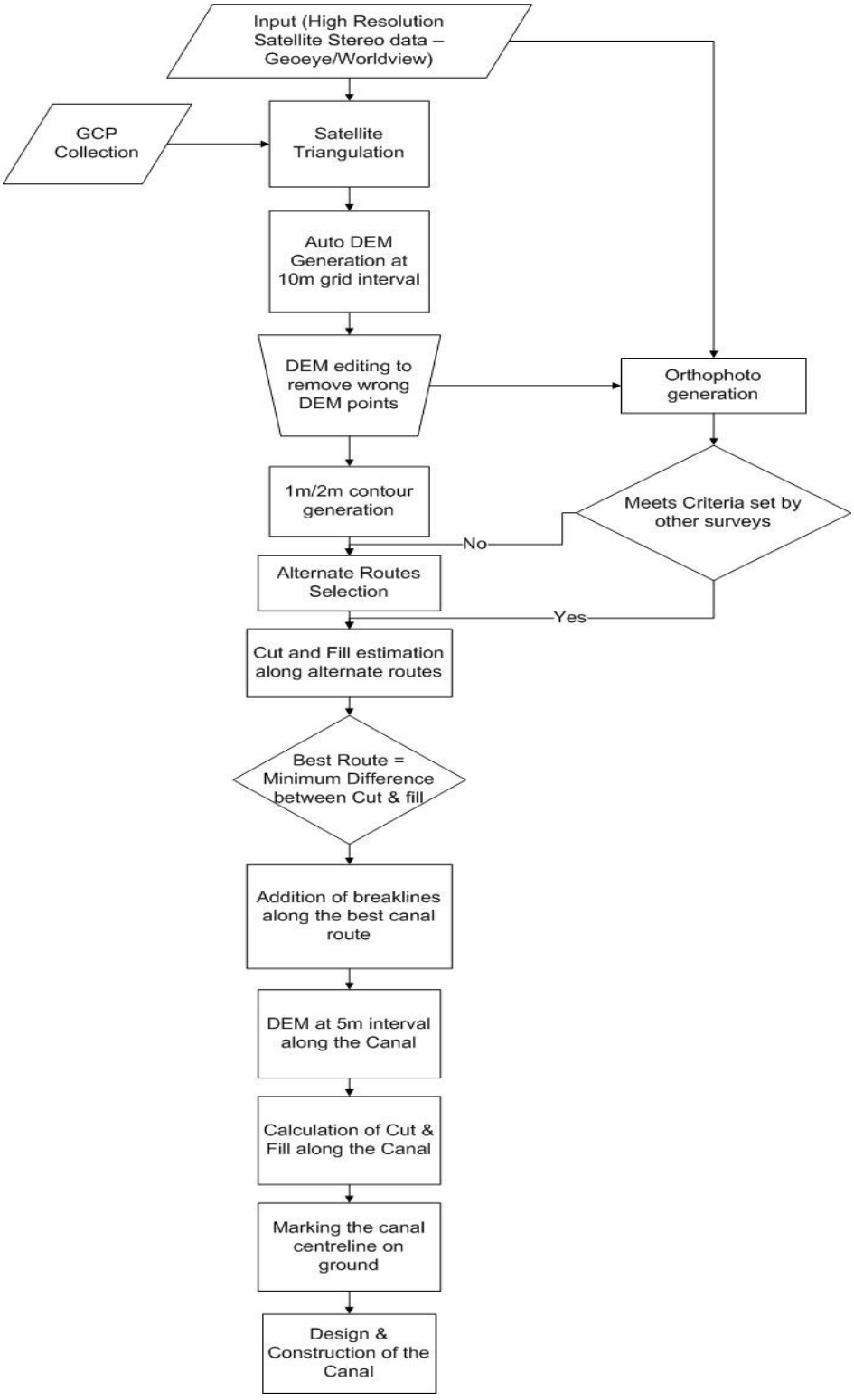

Fig.4. Process Flow Chart

Alternate canal alignments can be marked on the contour as per the criteria such as, it should have minimum cut and fill, should not have steep gradient etc. Once the alternate alignment is marked, the alignments can be overlaid over the terrain features that are collected with the help of ortho photo. Ortho photos of 0.5m resolution can be generated using Geoeye1 imagery. These images will help you in identifying the features in and around the alignment. Hydrographic features such as pond, rivers etc. can be clearly seen in the imagery that can be digitized. All types of roads can also be demarcated with the help of ortho photos. Other important features such as archaeological features, communication installations can also be digitized with the help of ortho photos. All these features may lead to deviations in the proposed alignments. If any modification is required on the alternate alignments, the alignment can be revised and cut and fill estimation can be done again.

Final alignment will be proposed based on the slope of the canal and cut and fill estimation. Alignment which has got the minimum cut and fill difference and minimum other costs such as Cross Drainage, minimum gradient change will be chosen as the best alignment for constructing the canal.

On the chosen final alignment corridor, more accurate DEM will be prepared with the help of photogrammetry techniques. Breaklines, if required will be placed within 1km on either side of the proposed corridor to enhance the DEM quality. This will help the user in generating a very high quality DEM.

As the final alignment is known and a 5m DEM within canal corridor can be generated using the proposed methodology, the final cut and fill volume estimation can be computed. The centerline of the alignment marked on digital environment can now be transferred to the ground. Survey bench markings can be done along the canal route and boundary can be placed for construction activities.

Advantages

Present methods for canal alignment studies require lot of field works from pre-feasibility stage till construction. Survey activities such as taking long and cross profiles require lot of manpower and time.

Utilizing the Remote Sensing and Photogrammetry techniques the total project duration can be reduced to a great extent, without compromising on quality. Contour generation for 100 sq.km area can be done within a week to fortnight depending upon the terrain condtions. Once the DEM / Contour is ready, the calculation of cut and fill within the DEM area can be done within no time.

Ortho photos of the study area minimizes the field visits for other surveys. Natural and manmade features can be digitized from the ortho photo and overlaid on the proposed alignment for alterations of the alignment if required.

Conclusion

We have observed that GeoEye-1 ,0.5 m resolution, stereo imagery is capable of producing unprecedented levels of ground point determination accuracy. We are able to achieved the Geo-positioning accuracy of 0.1m (0.2 pixels) in planimetry and 0.25m (0.5 pixel) in height with addition of limited ground control points during the triangulation stages performed in Rolta Photogrammetry Mapper software. This level of quality is well suited for the generation of both digital surface models to around 1-2m height accuracy and 0.5m GSD ortho imagery.

For canal alignment surveys, the pre-feasibility study is conducted by using Survey Of India toposheet and a topographic survey is conducted by taking cross profiles at 50 meter interval along the canal route. Using the proposed methodology, users are getting elevation points at an interval of 10m with very good relative accuracy thus leading to a better cut and fill estimation and the best alignment for canals.

As the ortho satellite images will help in identifying the locations of present transportation network, hydrographic features, other natural and man made features, field survey for identifying those objects can also be reduced to a great extent.

Thus overall, high resolution satellite stereo is a cost-effective solution for canal alignment surveys over conventional practices.

Acknowledgements

The authors are extremely thankful to Rolta higher management for allowing us to participate and present our paper in MapIndia-2010.

References

- Application of high-resolution stereo satellite images to detailed landslide hazard assessment- Janet E. Nichol , Ahmed Shaker, Man-Sing Wong
  Department of Land Surveying and Geo-Informatics, The Hong Kong Polytechnic University, Hong Kong
- GeoEye Update Technical Specification Overview -Andrey Shumakov, The IXth International Scientific and Technical Conference " From imagery to map: digital photogrammetric technologies" October 5-9, Greece
- Elevation extraction from satellite data using PCI software - Dr. Jehad Hijaz, Remote Sensing Manager, PCI Geomatics
- Webpage: www.nwda.gov.in/writereaddata/sublink2images/169.pdf