

# USER INTERFACE FOR PROJECT BASED SPATIAL INFORMATION ACCESSION

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### ABSTRACT:

A subset of spatial information that many people deal with is "geographical" information. It is related to location on the earth's surface. Our most common encounter with this type of information is through topographic and tourist maps, nautical charts etc. With the advent of remote sensing, the maps generation has taken a new turn in addition to topology. The remote sensing data is being used for updating existing maps. Remote sensing data has various applications in many fields from planning to implementation and management of projects. With the advances in Sensor technology, resolution of remote sensing data improved rapidly. With the availability of commercial image processing packages, most of the processing and analysis of remote sensing data is being done at the user end as per their requirements. In case of application projects like Urban planning, layout survey etc, the polygon of the Area of interest will be provided for optimal data procurement rather than using satellite reference for data procurement. There is no tool for Spatial Verification of the data received from the satellite operator against the order. A database along with simple GIS support utility can be maintained for the supplied data along with metadata. As the data supply will be in stages, the updation also will be in similar fashion. The GIS utility provides tools for metadata insertion into database, accession of database with varied combinational queries and visual evaluation of the data procured. The coverage can be evaluated against requirement. Data pertaining to many projects can be archived into the single database and can be retrieved with respect to project particular reference. The software is developed using Java as front end to make it platform independent and web based and MS-Access as backend to cater the small-scale user requirements. This paper discusses about various aspects of package design, development and the mathematics usage and software tools used. The suitability of the package for various application projects in detail.

## 1. INTRODUCTION

Spatial Information can be defined as any information that has a location in space. A subset of spatial information that many people deal with is "geographical" information, which is related to location on the earth's surface. This can be acquired using maps like topographic and tourists guide maps, nautical charts etc., where the location of interest can be identified on map. With the advent of remote sensing, the map generation has taken a new turn and in addition to topology, remote sensing data is being used to upgrade an additional layer, as it aids for a better visual interpretation. This additional set of spatial information, which has several applications from planning to implementation for management of natural resources. With the advances in Optical Sensor technology, the spatial resolution of remote sensing data improved rapidly. Also, with the increased awareness and availability of advanced off the shelf Image Processing and Analysis software to the user community, most of the processing and analysis is being carried out at their end. So, the user is always working for an optimised method to avoid the procurement of surplus data to minimize his project cost. Area of Interest procurement method is the best way of optimising the data procurement cost because it addresses the both the problems of ordering and verification. To aid the above process, the user requires a

simple and friendly GIS based utility software, which generates AOI for his requirement and evaluate the received data according to his AOI with data accession and visual evaluation facility. Both user and supplier of the data develop a software package for this purpose, which can be used. This software eliminates the need to procure high cost GIS systems, which is a constraint for small-scale users. The facility of archiving Meta data and thumb nail image pertaining to many projects is provided in the software package, which makes an ideal solution to the users. The package is an OOPS based application.

### 1.1 Design & Development Aspects

The following aspects are considered for the design of the software:-

1. Incorporate major input and output elements like data requirement and verification.
2. Meta data creation as per user AOI.
3. Thumbnail image generation and archival for future visual evaluation of AOI data.
4. Layout of Partial / Full data procured
5. An efficient database design for handling multiple projects.

6. Accessing the database through user friendly GUI with platform independent software.
7. A minimum usage of Disk space.
8. Future requirements accommodation.

In order to satisfy all these above requirements, the software is developed using platform independent 'Java' and Oracle/Ms Access. The disk space requirement for the software is maximum of 4MB. The additional disk space required for image database handling varies on number of thumbnail image of data products. To optimize disk space requirement further, the thumbnail images are stored in compressed form using customized compression technique for data security. The user can allocate a maximum of 50MB for this software for mid-segment users. Keeping present and future user requirements the software is caters for different sensor types and various formats like super structure, Fast format and Geotif etc.

The database is designed in 3NF(third normal form) to avoid inconsistencies and redundancies. For better security and faster retrieval, metadata is created as database using Oracle/Ms- Access.

### 1.2 Database Details

It consists of two tables for storing data corresponding to projects and data. Fields of each table are given below:

**Project-table:** project-code, project-name

**Data-table:** project-code, orbit, scene, segment, strip, DOP, NE-coorinates,NW-coorinates, SW-coordinates, SE-coorinates,CN-coorinates, Projection, datum, ellipsoid, orgPar, orgMeridian, stdPar1, stdPar2, zone, tlx, tly, resolution, falseE, falseN. Request-year, request-number, product number, satellite, sensor, mode, sat-value, maps covered, GelFlag.

The relationship between project-table and data-table table is shown in Figure 2. The project record can have multiple data records. As the input data can be either raw or geocoded, both corner coordinates as well as projection parameters are archived. Based on the flag corresponding parameters will be used in display process.

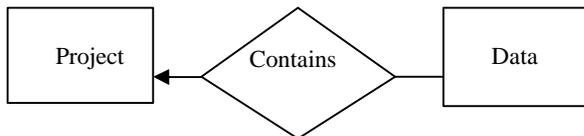


Figure 1 : Database ER Diagram

## 2. SOFTWARE DESCRIPTION

This software has five functional modules (Fig-2) namely AOI Creation, Insert Information, Supplied Data Verification, Export Database, Data Browse. It is a single option selection process i.e., only one option can be selected at a time. Data verification module is the key element of the whole package. This requires modules to insert Metadata into database, visual verification of the data for cloud cover estimation and exporting the AOI to third party compatible format.

**AOI Creation** module allows user to draw the polygon on the geocoded sample image or on the map displayed and exports the polygon as shapefile compatible to commercially available GIS packages (Fig-3) or generating AOI layer from known geographical co-ordinates. An additional facility is provided to see the polygon co-ordinates either in geographic or file co-ordinates for users who can perceive better his AOI.



Figure 2 : Main menu

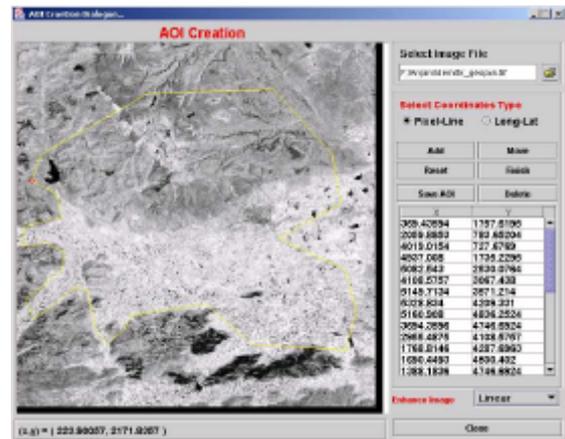


Figure 3: AOI Creation menu

**Data updation module** can be used to insert metadata into the database and to create thumbnail image from the received dataset. If more than one project is being handled, different project codes can be created or selected from the available list. Data updation process handles directly CD media instead of downloading to reduce disk space requirement and improves operations. The selected image file will be validated and the metadata of the image will be displayed for verification against the label content (Fig 4) . If the user opts to view toposheet layout over the selected product, it can be viewed by selecting "Layout" button (Fig-5) and the browse image of the same will be displayed by selecting the "Overview" button (Fig-6). Data insertion into database can be done using "Update" button.



Figure-4: Database Updation Menu

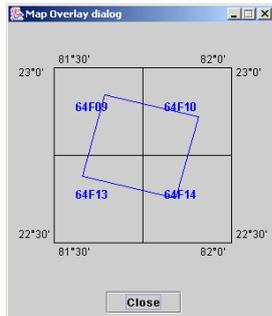


Figure 5: Map Overlay

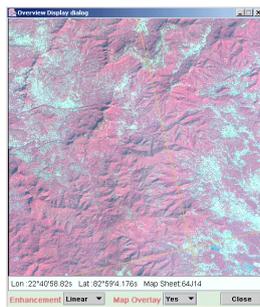


Figure 6: Browse Image Display

**Data Export module** enables the user to exchange the metadata between PDAS and commercial packages. The database can be exported to text format compatible to commercial GIS packages like ARC View etc. All fields or selected fields of the database can be exported (Fig-7).

**Data Browse** is an essential tool for visual verification of the data to estimate cloud cover. It can be invoked project wise as well as with other queries like toposheet or geographic location coverage. In case of project based, all image records pertaining to that project will be shown and image can be viewed with mouse click on the record and metadata of it will be displayed as well. Simple enhancements like linear, root and histogram based options are provided for better interpretation and toposheet overlay option is selectable (Fig-8).

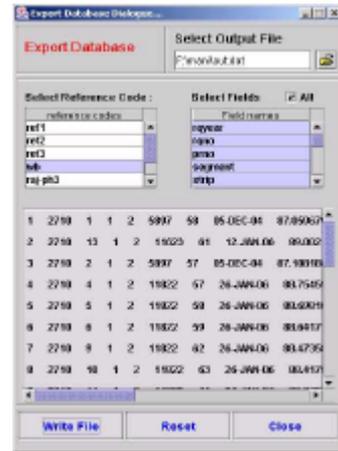


Figure 7 : Database Export Menu

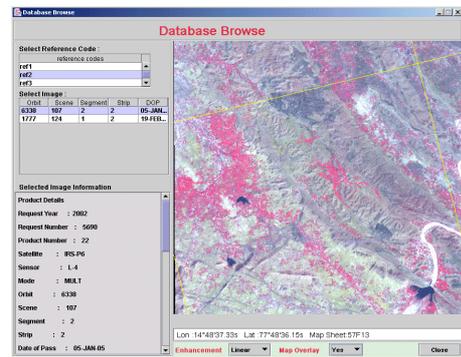


Figure 8 : Data Browse Menu

For the verification of supplied data against data ordered, user provided AOI shape file is used as reference. The perforations of the shape file (in case exists) are well marked and are considered while area under coverage estimation. Once a valid shape file and corresponding project code are selected, the boundary of each data product over user shape file is shown (Fig 8). Facility is provided for changing color codes used for shape file and data boundaries. The Meta data of the individual dataset can be viewed by using mouse click within the boundary.

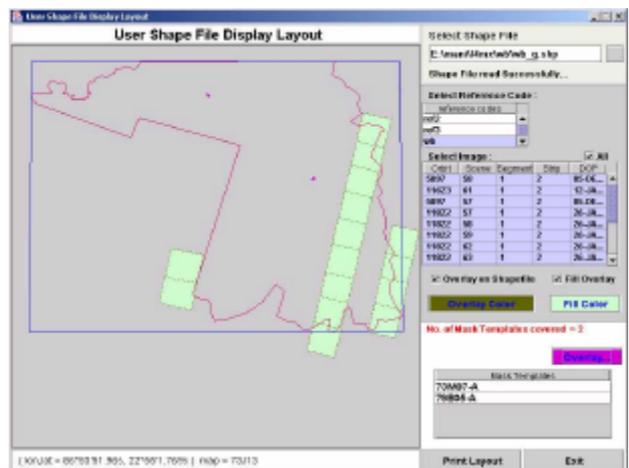


Figure 9 : User Shape file & Data Verification Menu

### 3. ALGORITHMS USED

Following are the important algorithms developed for better design of the package.

- For validation of toposheet number, geographic location, Shape file and image file formats
- A customized compression technique is developed using DCT, which includes minimum metadata corresponding to image on hand for better data security. The main feature is optimized quantification table generation. Though the compression ratio achieved is less compared to established compression techniques, it is almost loss less hence the quality of the browse images is better maintained.
- “Inside and outside test” algorithm is used for the estimation of data records coverage with in the user given shape file.
- Online geographic coordinate information was provided from the cursor coordinates using spatial transformations like affine, bilinear and perspective in case of super structure data.
- Various projection transformation algorithms are used for coordinates conversion between map and file coordinate systems. Algorithms for Polyconic, UTM and LCC projections and datums like Everest and WGS84 are implemented.
- Raster based Active area estimation of an image

### CONCLUSION

This package caters not only to the user community to verify received data, but also at the data provider end to evaluate the missing / pending data to be supplied to the user. It aids both the communities for handling; maintaining and accession of AOI based project requirements. The chances of information mismatch between user and supplier can be avoided with the usage of this package at both ends. The package is developed in JAVA, to incorporate newer features as and when required. Features like data filling in the AOI area and individual thumb nail image display for mouse click options can be provided. The AOI creation module also can be further extended to create AOI shape file by accepting coordinates by keyboard entry or by extent of the area instead of interactive polygon selection.

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# ESTABLISHING PRECISE GROUND CONTROL POINTS USING DGPS MEASUREMENTS AND DIFFERENT PROCESSING PARAMETERS

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**KEY WORDS:** Ground Control Point, GPS data Processing, IGS, Precise orbits, Accuracy assessment.

## ABSTRACT:

The most traditional source of ground control point's (GCP) geodetic coordinates has been the topographic maps. However, with the advent of the Global Positioning System (GPS), it has become very easy to establish the GCP's coordinate in the field using a geodetic GPS receiver. This source of GCP's give the coordinates in a fixed datum (say, WGS84) whereas the topographic maps in our country are in a different datum i.e. Modified Everest. Once the data is collected using GPS, it has to be processed with few reference stations (IGS) so as to generate the final coordinates. Many softwares, both freeware as well as commercial, are available for its processing, but the problem of phase ambiguity resolution over large baselines and the various ionospheric and tropospheric correction modules becomes deciding when one wants to choose among them. In this study we have tried to compare the results of two campaigns processed using two different GPS post-processing softwares, carried out in a hilly and another over a plain terrain. It has been observed that in the positional coordinates the deviations are not much but in the height the difference found was as high as 4-5m. The difference is attributed to the detailed ionospheric and tropospheric corrections as well as the use of various earth rotation parameters taken in the standard software as compared to the freeware. Also the difference of datum and use of various tectonic plates for the computation of station velocities as considered in the standard package has contributed to this difference.

## 1. INTRODUCTION

Use of Ground Control points for the rectification of satellite imagery with respect to a reference map in a specified projection and datum asks for a number of considerations or issues. Few of these issues are like the accuracy of GCPs, their identification and distribution on the image and source of GCPs. The most traditional source of ground control point's (GCP) geodetic coordinates has been the topographic maps. However, with the advent of the Global Positioning System (GPS), it is not uncommon to determine a GCP's coordinate in the field using a geodetic GPS receiver. In order to get the coordinates using a GPS receiver one has to process the GPS data taken over a period of time, depending on the mode in which it has been acquired. The processing depends on a number of parameters like the computation of atmospheric interactions of the signal (basically the delay), earth rotation parameters and most importantly the resolving of ambiguity resolution especially in the case of long baselines. The data processing task is complicated because of the large number of unknowns that must be resolved. These parameters vary on time scales longer than the processing interval required for near-real time meteorological processing, so the risk of undetected biases exists. The methodology for handling this processing varies among the processing software packages that are available and refinements are topics of ongoing research.

The choice of the software and technique to be used for such processing would depend primarily on the level of accuracy

desired, and other factors such as the hardware available, surveying technique used to collect the data, etc (Supriya Likhari et al, 2002).

In this study, it has been tried to compare the results in the form of geodetic coordinates using one COTS and other commercial but scientific GPS data processing software. The software, Bernese 5.0, developed by Astronomical Institute, University of Bern, Switzerland (Hugentobler, U, et.al., 2005) is a very detailed and comprehensive software meant for mainly rapid processing of small-size single and dual frequency surveys, permanent network processing, ambiguity resolution on long baselines (up to 2000 km using high accuracy orbits), ionosphere and troposphere modeling, combination of different receiver types (antenna phase center calibrations), simulation studies, orbit determination and earth rotation parameter estimation, generation of free network solutions etc. The other software used in the study is Ski-PRO 2.1 (User manual), receiver-specific software. This software is relatively easier in use as compared to Bernese, but is unable to solve phase ambiguities for baselines more than 20kms. Also it uses few standard Ionospheric and tropospheric models for their correction and also doesn't require specific files for earth-rotation and orientation corrections. This software is mainly suitable for processing small baselines and for other kinematic, stop and go type of surveys which require relatively lesser accuracies in comparison to establishing GCPs in standalone mode.

## 2. OBJECTIVES

The prime objective of the study is to:

Establish geodetic coordinates of well-distributed Ground control points, taken using dual frequency GPS receivers in DGPS mode using different COTS packages and their accuracy assessment.

### 3. STUDY AREA AND DATA USED

For this study, Dehradun city in Uttaranchal and Jaipur in Rajasthan have been selected. For Dehradun city one reference point with continuous four days observation and other surrounding 29 points (rovers) distributed in an area of 30 \* 30km with one hour continuous observation at each location were taken.

For Jaipur test site, one reference with continuous three days observation and other 21 rover points with each one-hour observation were taken.

For processing and establishing the coordinates, for both the study sites, 6-7 IGS station coordinates and the other necessary associated files for the corresponding dates were downloaded from net (<ftp://lox.ucsd.edu/pub/>).

The most important input for the GPS data processing is the orbits of GPS satellites. IGS posts the precise orbits of all the GPS satellites in a delayed mode on the Net. The web address used to access the precise orbits was

<ftp://igsb.jpl.nasa.gov/igsb/product/>

For the processing in Bernese one has to download several other files that are specific to the Bernese GPS Software. These files can be downloaded from the link:

<http://www.aiub.unibe.ch/download/BSWUSER50/>

Once the files are downloaded they have to be copied to specific directories for further processing in Bernese.

## 4. METHODOLOGY

### 4.1 Field Campaign

Using four Leica SR520 series dual frequency GPS receivers Dehradun City and surrounding area was surveyed from 17 - 20 Nov'05 and Jaipur city from 27 - 29 Dec'05. In order to achieve mm-level accuracy at the reference point continuous 3-4 days observations were taken and using nearby 5-6 IGS stations they were established in differential mode.

### 4.2 Bernese processing

The Bernese GPS Software contains about 70 programs, which are ordered logically into four parts.

#### 4.2.1 RINEX

The Transfer Part includes all programs related to the transfer of RINEX files (observations, navigation messages, meteorological files) into Bernese format or vice versa, or to manipulate RINEX files such as cutting to a specific time window or concatenation of files. RINEX tools allow to extract header information, generate statistical information, or preprocess observations at the RINEX level.

#### 4.2.2 Orbits/EOP

The Orbit Part contains all programs related to satellite orbits or Earth Orientation Parameters (EOPs). This includes the generation of an internal orbit representation (so-called

standard orbit) starting from precise ephemerides or broadcast information, update orbit information, creation of precise orbit files, concatenation of precise files, comparison of orbits, conversion of EOP information from IERS format to Bernese format, extraction of pole information.

#### 4.2.3 Processing

The Processing Part contains the main processing programs. This includes code processing and receiver synchronization (program CODSPP), generation of baseline files (program SNGDIF), dual frequency code and phase pre-processing (program MAUPRP), parameter estimation based on GPS and/or GLONASS observations (program GPSEST) and on the superposition of normal equation systems (program ADDNEQ2).

#### 4.2.4 Service

The Service Part contains a simulator (program GPSSIM) as well as a number of tools to browse binary observation files, check residuals, compare and manipulate coordinates, and many more. This menu item also provides the possibility to browse program output or error message files.

Conversion:

The conversion programs are part of the Service Part. They allow to convert binary files into ASCII format and vice versa. Additional programs allow to convert SINEX files into normal equation files, extract station information from SINEX, to manipulate troposphere SINEX files. Finally programs are provided to convert files from the old Version 4.2 format to the new format used in Version 5.0 of the Bernese GPS Software.

### 4.3 SKI-Pro Processing

Leica geosystems's SKI-Pro software is a comprehensive, automated suite of programs for GPS surveying including post processing and support of real-time measurements. Its functionality includes:

- Data import
- Data management
- Data processing
- Network adjustment
- Datum transformation
- Data export

Data processing allows to process GPS observations that have been recorded in the field to achieve WGS84 coordinates and their relative accuracy.

Static, Rapid-Static, Stop and Go, Kinematic, Kinematic on the fly, and single-point data can be processed. The computations during processing are completely hidden for the user. All selected data is processed automatically in a batch process without the need for any user interaction.

## 5. RESULTS AND DISCUSSIONS

The results for Dehradun and jaipur using Bernese and SKI-Pro are presented in tables 2 and 4 respectively.

**Table 1: Computation of coordinates using Bernese and SKI-Pro GPS data processing software for Dehradun area**

<b>Bernese</b>					
Point_ID	Parameter	A PRIORI VALUE	ESTIMATED	RESIDUAL	RMSERROR
		(m)	(m)	(m)	(m)
IISC	X	1337936.608	1337936.397	-0.211	0.0094
	Y	6070317.1101	6070316.984	-0.1264	0.0222
	Z	1427876.682	1427876.71	0.0288	0.0119
	U	843.7079	843.5498	-0.1581	0.0238
MALI	X	4865366.44	4865366.34	-0.0996	0.0086
	Y	4110737.495	4110737.448	-0.0465	0.0232
	Z	-331121.6601	-331121.6702	-0.0101	0.0125
	U	-23.3425	-23.448	-0.1054	0.0164
POL2	X	1239971.451	1239971.303	-0.1483	0.0094
	Y	4530790.088	4530789.934	-0.1534	0.0224
	Z	4302578.795	4302578.706	-0.0886	0.01
	U	1714.2043	1714.0066	-0.1976	0.0206
REFG	X	1141097.449	1141098.311	0.8621	0.0094
	Y	5390381.992	5390385.283	3.2902	0.0221
	Z	3203371.644	3203372.681	1.0362	0.0107
	U	660.8527	664.3082	3.4555	0.0227
<b>SKI-Pro</b>					
		A PRIORI VALUE	ESTIMATED	RESIDUAL	RMSERROR
IISC	X	1337936.608	1337931.532	-5.0752	0.0446
	Y	6070317.1101	6070311.886	-5.2241	0.0969
	Z	1427876.682	1427876.302	-0.3798	0.0396
	U	843.7079	837.5875	-6.1204	0.1011
MALI	X	4865366.44	4865366.501	0.0609	2.6172
	Y	4110737.495	4110737.458	-0.0369	1.1581
	Z	-331121.6601	-331121.7282	-0.0681	0.3622
	U	-23.3425	-23.3163	0.0262	1.426
POL2	X	1239971.451	1239968.562	-2.8887	0.0415
	Y	4530790.088	4530786.769	-3.3183	0.0764
	Z	4302578.795	4302576.636	-2.1594	0.0712
	U	1714.2043	1709.8268	-4.3775	0.0951
REFG	X	1141097.449	1141098.278	0.8289	0.3696
	Y	5390381.992	5390386.995	5.0023	0.1836
	Z	3203371.644	3203372.363	0.7183	0.1003
	U	660.8527	665.5872	4.7345	0.2451

**Table 2: Difference in estimated coordinates between Bernese and SKI-Pro softwares for Dehradun area**

Point	Para	Bernese generated Coordinates	SKI-Pro generated Coord.	EST.(Diff) in m
IISC	X	1337936.397	1337931.532	4.8642
	Y	6070316.984	6070311.886	5.0977
	Z	1427876.71	1427876.302	0.4086
	U	843.5498	837.5875	5.9623
MAL	X	4865366.34	4865366.501	-0.160499999
	Y	4110737.448	4110737.458	-0.0096
	Z	-331121.6702	-331121.7282	0.058
	U	-23.448	-23.3163	-0.1317
POL	X	1239971.303	1239968.562	2.7404
	Y	4530789.934	4530786.769	3.1649
	Z	4302578.706	4302576.636	2.0708
	U	1714.0066	1709.8268	4.1798
REF	X	1141098.311	1141098.278	0.0332
	Y	5390385.283	5390386.995	-1.7121
	Z	3203372.681	3203372.363	0.3179
	U	664.3082	665.5872	-1.279

**Table 3: Computation of coordinates using Bernese and SKI-Pro GPS data processing software for Jaipur area**

		<b>Bernese</b>		
Point_ID	Parameter	A PRIORI VALUE (m)	ESTIMATED (m)	RESIDUAL (m)
BAHR	X	3633908.96	3633908.703	-0.2574
	Y	4425275.496	4425275.302	-0.1942
	Z	2799861.349	2799861.454	0.1058
	U	-17.0826	-17.3171	-0.2345
DGAR	X	1916269.644	1916269.322	-0.3228
	Y	6029977.377	6029977.285	-0.0928
	Z	-801720.0828	-801719.9723	0.1105
	U	-64.9164	-65.1151	-0.1987
JAIP	X	1396411.618	1396412.557	0.9387
	Y	5520009.319	5520012.293	2.9742
	Z	2865243.602	2865243.3	-0.3019
	U	374.9446	377.5856	2.641
KIT3	X	1944945.275	1944945.033	-0.2419
	Y	4556652.212	4556651.994	-0.218
	Z	4004325.981	4004325.946	-0.035
	U	622.5009	622.2496	-0.2513
PIMO	X	-3186293.882	-3186293.959	-0.0773
	Y	5286624.222	5286623.952	-0.2699
	Z	1601158.266	1601158.214	-0.0521
	U	95.5133	95.315	-0.1982
		<b>SKI-Pro</b>		
Point_ID	PARAMETER	A PRIORI VALUE	ESTIMATED	RESIDUAL
BAHR	X	3633908.96	3633909.472	0.5118
	Y	4425275.496	4425279.172	3.6759
	Z	2799861.349	2799866.784	5.4346
	U	-17.0826	-11.8421	5.2405
DGAR	X	1916269.644	1916268.229	-1.415
	Y	6029977.377	6029982.399	5.0216
	Z	-801720.0828	-801721.9016	-1.8188
	U	-64.9164	-60.3646	4.5518
JAIP	X	1396411.618	1396412.618	0.9997
	Y	5520009.319	5520012.335	3.0155
	Z	2865243.602	2865243.272	-0.3297
	U	374.9446	377.6222	2.6776
KIT3	X	1944945.275	1944945.681	0.4061
	Y	4556652.212	4556656.916	4.704
	Z	4004325.981	4004331.831	5.8504
	U	622.5009	629.6728	7.1719
PIMO	X	-3186293.882	-3186299.485	-5.6033
	Y	5286624.222	5286635.254	11.0321
	Z	1601158.266	1601160.187	1.9213
	U	95.5133	107.9399	12.4266

**Table 4 : Difference in estimated coordinates between Bernese and SKI-Pro softwares for Jaipur area**

Point_ID	Parammmete r	Bernese generated Coordinates	SKI-Pro generated Coord.	EST.(Diff) in m Bernese - SKI- Pro(m)
BAHR	X	3633908.703	3633909.472	-0.7688
	Y	4425275.302	4425279.172	-3.8699
	Z	2799861.454	2799866.784	-5.3296
	U	-17.3171	-11.8421	-5.475
DGAR	X	1916269.322	1916268.229	1.093
	Y	6029977.285	6029982.399	-5.1136
	Z	-801719.9723	-801721.9016	1.9293
	U	-65.1151	-60.3646	-4.7505
JAIP	X	1396412.557	1396412.618	-0.0607
	Y	5520012.293	5520012.335	-0.0415
	Z	2865243.3	2865243.272	0.0277
	U	377.5856	377.6222	-0.0366
KIT3	X	1944945.033	1944945.681	-0.6481
	Y	4556651.994	4556656.916	-4.922
	Z	4004325.946	4004331.831	-5.8854
	U	622.2496	629.6728	-7.4232
PIMO	X	-3186293.959	-3186299.485	5.5263
	Y	5286623.952	5286635.254	-11.3021
	Z	1601158.214	1601160.187	-1.9733
	U	95.315	107.9399	-12.6249

For the processing of Dehradun GPS data three IGS stations viz., IISC, MALI and POL2 were used. REFG represents the reference point at Dehradun. It is observed that in the Bernese processed table, the difference between the a priori and estimated coordinates for the IGS stations is maximum of the order of 20cm. Hence it can be taken that while processing in Bernese the coordinates of the IGS stations (which have been taken continuously for many years generated through averaging) don't change appreciably. Whereas in the case of SKI-Pro, the maximum change in coordinates of IGS stations between a priori and estimated is 6.0m. Hence for all comparison purpose Bernese has been selected as the reference.

The maximum difference in SKI-Pro generated coordinates with respect to Bernese in X is 4.86m whereas the minimum is 0.033m. The maximum difference in Y is 5.097m and minimum is 0.009m. The Z coordinate shows a maximum difference of 2.07m and a minimum of 0.058m. In the case of geodetic height, the maximum difference is 5.96m and the minimum is 0.1317m.

As far as the computation of REFG (Reference point at Dehradun) is concerned, it is observed that with Bernese, the difference in the geodetic height coordinate is around 3.45m whereas the difference in cartesian X, Y and Z coordinates is 0.8621m, 3.290m, 1.036m respectively. Whereas the similar values from SKI-Pro are quite high (about an order of magnitude).

In the case of Jaipur, a plain terrain, we have again taken Bernese processed coordinates as the reference for comparison purpose. The logic behind taking them as reference is similar as in the case of Dehradun. Here four IGS stations viz., BAHR, DGAR, KIT3 and PIMO were used. The difference between the estimated and a priori coordinates for the reference station,

JAIP, is 0.938m in X, 2.97m in Y, 0.302m in Z and 2.64m in geodetic height. Whereas the corresponding differences using SKI-Pro are 0.999m, 3.015m, 0.329m and 2.67m. It can be observed that the coordinates computed using Bernese and SKI-Pro for the Jaipur reference point (JAIP) are almost same. The maximum difference is ~ 6cm (X coordinate) and minimum is ~ 2cm(Z coordinate).

## 6. CONCLUSIONS

In this study we have tried to compare the results from two GPS data processing softwares, Bernese and SKI-Pro for a plain and another undulating terrain. Bernese, a scientific and very detailed software, takes into account the detailed interaction of atmosphere (troposphere, ionosphere), earth orientation and rotation parameters, precise orbits, coordinates and velocities of the ground stations etc for the specific days of GPS data collection. Whereas SKI-Pro, relatively easier in use, takes standard inbuilt models for these corrections and also resolves phase ambiguity upto 20Km of baselines only.

The results of this study shows that for a hilly terrain like Dehradun the difference between the estimated coordinates of Bernese and SKI-Pro are quite significant (an order of magnitude difference) but for the plain terrain, Jaipur, the results are quite similar.

This is too early to say that in the case of plain terrains where the height variations are of the order of 20-40m detailed atmospheric and earth orientation related modeling for generating the coordinates is not required. Need of confirmation of such results over other variety of terrain and by considering various combination of parameters during processing is the part of future work.

## REFERENCES

Hugentobler, U., Dach, R. and Fridez, P., 2005. Bernese GPS software, Version 5.0, Astronomical Institute, University of Bern.

SKI-Pro Version 2.1, 2000. User manual/Getting started with SKI-Pro.

Supriya, L., Kulkarni M. N., Tomar, V.S. and Praveen, P., 2002. A comparative study of results from GPS data processing software. In: Asian GPS proceedings 24 - 25 October, India International Centre, New Delhi, India.

For downloading IGS station related files  
<ftp://lox.ucsd.edu/pub/>

For precise orbits <ftp://igsceb.jpl.nasa.gov/igsceb/product/>

For files related to Bernese processing  
<http://www.aiub.unibe.ch/download/BSWUSER50/>