



PBG GEOPHYSICAL EXPLORATION LTD.

The technology brochure

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1. Description of the work.

PBG Geophysical Exploration Ltd. offers to carry out High Resolution Land Gravity, Magnetic and Gradiometry Surveys and the necessary adequate Geodesy Work in India. This undertaking includes data acquisition, field data processing and conceiving survey report after the completion of field work. Also processing and interpretation of gravity & magnetic data are proposed.

Contractor will provide a qualified and experienced staff for a ground gravity and magnetic, necessary geodesy survey at the highest industry level. Our experienced and well-trained specialists guarantee the best performance of field work as well as data processing, survey report preparation and final report including results of advanced data processing and interpretation.

Our company use high technology instruments at field work and modern hardware and software for data processing and interpretation which enable us to offer the services on the highest quality worldwide level.

2. Scope of work.

The Contractor will carry out the following main activities in the geophysical investigation:

- Measurement station positioning and coordinates measurements
- land gravity and magnetic field survey,
- on site data processing & data reduction,
- survey report preparation,
- advanced gravity & magnetic data processing for interpretation requirements,
- Final Report preparation with results of reduction density analyses, qualitative and quantitative interpretations. Maps and graphs attachments will be included and the final conclusions presented.

All the above purposed kinds of activities excluding advanced data processing, interpretation and final report preparation will be carried out simultaneously by the same field party. Advanced data processing and interpretation will be performed by independent interpretative team.

Geodetic crew obtains coordinates of the measurement stations and stations elevation above sea level. The precision of the leveling and station positioning will be better than ± 0.10 m, to protect the final accuracy of Bouguer anomaly determination in accordance to Client's requirements.

Gravity work will be tied to absolute gravity stations from Indian gravity network located within survey areas or surrounding this areas. Depending on requirements, the Contractor will establish new local gravity base stations closely to operational base. New base stations will be tied by double run loops to the nearest two gravity base points from Indian gravity network.

Magnetic survey will be in reference to magnetic base station recordings for define diurnal magnetic field variations. Magnetic base station will be established within survey areas in location where not exists magnetic noise variations produced by industry and human sites electrical and magnetic installation.

- New gravity base stations established within survey areas will be described in details. The description will contain:
- a station identifier (name/symbol/code),
- a topographical sketch of the point location,
- values of geodetic coordinates obtained using GPS measurements,
- the absolute, measured and adjusted value of gravity,
- the value of the station elevation.

Measured values of the gravity at the base stations will be adjusted using the least square method.

The activity in geophysical program will include:

Field survey:

- instrument calibration before the work,
- establishing, surveying and adjusting control points as geodetic GPS reference station network within survey area, for GPS survey in RTK and Rapid Static modes ,
- establishing base points and gravity measurement performance at network legs, adjusting gravity net,
- measurement of diurnal magnetic field variations at magnetic base station,
- gravity and magnetic measurements at the stations with two series of observations on each station (minimum 2% of the gravity and magnetic measurements will be repeated),
- measurements for estimation terrain undulations in the inner zone around gravity station up to 100 m radius (if necessary),
- data processing and reduction,
- survey report preparation.

Interpretation:

- analysis of the available, archival, geophysical and geological data,
 - advanced G&M data processing for qualitative and quantitative interpretation,
 - interpretation of results of advanced gravity and magnetic data processing.
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3. Work progress.

The gravity and magnetic survey will be performed simultaneously by the same crews. The work progress shown below is strictly defined of the time need for the gravity and magnetic data acquisition, data processing and interpretation. Excluding time for camp shifting the survey crews will carry out all routine gravity and magnetic field activities listed above.

Brief schedule of the is shown in the table given below:

Table no. 1.

Item	Description
1.	Mobilization (in the country of the Contractor origin) - 2 survey parties (4 survey crews), 1 interpretative team
2.	Acquisition of gravity and magnetic data (with geodetic support) including: • instrument tests and calibrations, • local base stations measurements and adjustment, • station positioning and coordinates determination, • field procedures (including terrain corrections estimation in the inner zone up to 100 m radius (if necessary), • data processing and reduction, measurements corrections and adjustments, • quality control and tests, • terrain model development for external terrain corrections computation (if necessary), • survey report preparation (up to 7 days after the field work completion)
3.	Demobilization of survey parties
4.	Advanced data processing
5.	Interpretation
6.	Final demobilization (in the country of the Client's origin)

The field parties will start demobilization immediately after the field work finishing. The survey report will be delivered to the Client in the seven days after the end of the data acquisition.

4. Personnel.

At all scopes of gravity activities to be carried out within the Project, the Contractor's technical staff will create two gravity & magnetic parties each consists of two survey crews, which will conduct the work according to the highest industrial level and state-of-art.

The composition of survey parties is shown in the Appendix B and C (survey parties and interpretative team respectively).

For gravity and magnetic investigation the Contractor will assign experienced personnel in geophysical and geodetic surveying. They will be graduated engineers geophysicists and surveyors and will have adequate experience in geophysical surveys carried out in adverse terrain.

The Contractor's personnel will be medically examined, trained in first aid (standard Contractor's HSE procedures), and properly skilled due to the work in specific menaces.

CVs of the Contractor's key personnel proposed for the work is attached in Appendix D and E (survey parties and interpretative team respectively).

5. Equipment.

For performance of the gravity & magnetic survey the Contractor will use modern geophysical equipment. Similarly, modern and sophisticated processing software will be used which can secure high accuracy of all measurements and the best final results. Main survey equipment shall include following units:

- gravity meters: SCINTREX CG-5 Autograv (equipped with seismic filter) - 3 pcs.,
- SCINTREX ENVI-MAG proton magnetometer - 4 pcs.,
- dual frequency geodetic GPS receiver Leica GP1230 or equivalent (working in RTK, Stop & Go, Static and Fast Static Modes) - 3 pcs.,
- automated total station - 2 pcs.,
- automated leveling instrument - 2 pcs.,
- computer and peripheral equipment:
 - notebook PC computer - 6 pcs.,
 - A-3 format color printer - 2 pcs.,
 - A-4 format LaserJet printer - 2 pcs.,
 - A-4 format scanner - 2 pcs.,
- for managing and processing acquired data in the field suitable software shall be deployed including SCINTREX firmware instrumental preprocessing software, gravity & magnetic data processing software, GPS data processing (Leica GeoOffice, South GPS Processor), mapping, geophysical and office software (design by SCINTREX, Golden Software, GEOSOFT, Microsoft and Contractor's design geophysical software),
- for advanced gravity data processing GEOSOFT G&M OasisMontaj G&M interpretative system will be deployed, as well another mapping and office software,
- for transportation of the equipment and survey crew in the field, 4 x WD vehicle will be used - 8 pcs.,
- wide range of accessories and additional equipment such as inclinometer, geodetic measurement tapes, batteries, chargers, first aid kits, safety equipment etc.

The detail list of equipment intended to the work is listed in Appendix F.

Technical specifications of main measurement equipment are listed in Appendix G up to E.

6. Geodetic survey for station positioning.

6.1. General Proposal.

Necessary geodetic measurements: position and heights of gravity & magnetic stations will be measured using DGPS technique. In cases when DGPS surveying not be possible due to satellite visibility obstruction, traditional, optical geodetic technique will be applied, based on total station measurements. This allows performing survey in proper time with the highest accuracy.

The Contractor proposes dual frequency GPS system for work conducting. The Contractor' crew introduces in surveying procedures Rapid Static method of survey at primary geodetic control points and for reference station network establishing. Ordinary gravity & magnetic stations will be surveyed in RTK mode. In difficult field conditions due to topographical features which don't let establish transmission between rover and reference station, gravity and magnetic stations will be surveyed using Rapid Static method also. The traditional geodesy technique based on total station observations or level measurements will be used, if in any cases local measurement conditions makes GPS surveying impossible to apply.

As mentioned above, PBG provide for a work GPS system Leica GP1230 and equivalent Stonex S9 GNSS, which will be equipped with necessary accessories, controllers, firmware and processing software to perform survey using any geodetic method. Leica GeoOffice processing system proposed for a work, let merge geodetic data in one coherent project even the data would be acquired using different measurement instruments and different technique of survey.

6.2. Geodetic network.

For gravity and magnetic surveys the new local geodetic networks will be established within survey areas. These network will consist of control points deployed as reference stations for RTK mode surveying, in a course of gravity and magnetic investigation. The network will be designed, measured and adjusted before gravity work commencement.

New local geodetic network of reference stations will be tied to existing controls of Indian Geodetic Network which can be found within survey areas or at the closest surrounding. The distance between reference station won't exceed 20 km. Reference stations will be fully described and temporary marked in the field.

Transformation parameters between local datum (Everest 1830) and GPS (WGS84) datum will be computed after reference stations network be tied to Indian official control points network. Parameters of transformation will be computed using modern geodetic software designed by Leica.

6.3. Setting out gravity and magnetic stations.

All gravity and magnetic station will be identified temporary in the field with a pin flag. Markers will contain a unique point number. Each gravity & magnetic point coordinate will be defined on a base upon established GPS control station. The maximum distance between reference station and rover working in Rapid Static mode won't exceed 20 km (15 km respectively in RTK mode).

All survey field observations and quality control indicators will be recorded in GPS controllers in the field and transferred to GPS data base project on notebook computer's hard disc. They also will be immediately backed up on CD-ROM media after the end of each day of work for eventual further using. This procedure will be strictly applied to raw and processed data as well.

6.4. Quality control and procedures.

GPS survey will be carried out in accordance to manufacturer's instructions and Contractor's experiences in GPS surveying. In this case GPS observations be controlled by firmware software running on controllers. Mentioned software can show operator any information need for observation including optimal time, which can protect high accuracy results obtained with processing procedures.

As a standard Contractor's measurement procedures DGPS survey will be performed when at least 5 healthy satellites and GDOP less (better) then 6. For RTK mode – minimum 6 satellites must appear over horizontal mask set to 20 degrees. Follow satellites configuration changes in a time, surveyor will keep attention on measurement system indicators (PDOP, GDOP) values and respectively will adapt parameters of survey (method and time of satellite data collection).

On a base of Contractor's experience, this procedure for RTK and Rapid Static modes can protect final results of coordinates determination with accuracy better then 10 cm in a position and an elevation as well.

For prediction of satellite configuration, processing of geodetic data Leica GeoOffice system is proposed.

For quality control in the field the Contractor proposes to repeat GPS observations at surveyed stations (no less than 2% of repetition).

6.5. Instrument maintenance.

For performing DGPS survey with required accuracy GPS equipment will be strictly maintained in accordance to manufacturer's instruction.

All GPS receivers utilized for work will be checked on an ultra short base 2 m long before survey. This test line established in an open area close to the work site. The difference of a line length measured by purposed for survey methods must not exceed 0.05 m in relation to the length defined by measurement tape.

Results of instrument checks will be stored in project database. On the Client request instrument checks will be repeated.

6.6. Accuracy of the station positioning.

To achieve required accuracy optimum sufficient parameters for Rapid Static GPS observations need to be set as follow:

- rover distance to reference station – less then 20 km (Rapid Static) and 15 km (RTK),
- GDOP value – not high then 5,
- number of common healthy satellites – no less then 5 (Rapid Static) and 6 (RTK),
- angle mask – 20 degrees above horizon,
- occupation time on station – no less then 7 min (defined by controller analysis + minimum 10%) for Rapid Static mode,
- data sampling – 5 sek (min. 90 epoch of phase and code stored).

On a base of Contractor's experience we expect to achieve significantly better accuracy then 0.1 m in a position and height as well.

7. Gravity/ magnetic/gradiometry data acquisition.

7.1. Instrument calibration.

For performing gravity survey SCINTREX CG-5 Autograv gravity meter will be used. All Contractors' instruments are checked every year and calibrated at a gravity meters test stand in Institute of Geodesy and Geodetic Astronomy of Warsaw Technical University. Performed test allows defining and comparing its parameters with those in the manufacturer technical specification.

After transportation, warm-up period and performed cycling standard manufacturer tests, a pre-survey instrument standard calibration over two base station from Indian gravity base network can be done.

Each magnetometer proposed for work will be synchronized in a time and checked due to instrumental levels shift of readings. It will be performed before work commencement at two points located about 50 m apart on area where not magnetic noise exists. On each point magnetic readings will be collected in 5 minutes period. After then instruments location will be replaced and next series of readings will be repeated. This procedure lets to obtain correction for level shift of readings as a reference to one unit admitted as a standard meter.

7.2. Base Network.

For the best results of survey the program on each survey area must be tied to minimum two permanent gravity base stations of Indian gravity network. To make it possible, the Client should provide a complete description of permanent gravity base stations of Indian network located within the survey area or near this area. The description will contain:

- gravity station identifier (name/symbol/code),
- a sketch of the gravity station location,
- co-ordinates,
- the elevation of the gravity station (above sea level),
- the absolute value of gravity.

The Contractor's staff will establish new base stations located near operational bases within the survey area. New base stations will be tied to the nearest existing absolute base points of Indian network. Local base stations will be surveyed, and fully described. Description will contain the full information listed above.

Standard measurement scheme for gravity tie observation is as follows:

ABBAABBCC.....

where: A, B, C, ..., means the identifier of a network station.

This kind of measurements makes possible independent twofold determination of the instrumental residual drift and fourfold calculation of the differences of gravity at base points.

Magnetic base stations will be established within survey area not far then 30 km distance to the most remote gravity & magnetic station within survey areas. If more than one magnetic base

station will be established these stations be tied together by long term (up to 2 hours) simultaneously measurements on each base station. The difference of magnetic total field level at each station position will be obtained using statistical analyze and finally introduced to the magnetometers readings to lead up readings to one common reference level.

Magnetic survey may be executed in reference to the arbitrary taken local reference datum or may be tied to the reference level obtained for magnetic epoch in one of geophysical observatories in India.

If Client requires, magnetic measurements on survey area may be tied to the absolute magnetic value obtained for given epoch by magnetic observatory at the observatory magnetic station. In this case the Client shall to deliver to the survey crew copies of magnetic registration made in the nearest observatory station.

At least magnetic total field anomaly will be computed using IGRF formula on epoch required by Client.

7.3. Field Procedures.

SCINTREX CG-5 Autograv gravity meter is proposed for gravity measurements course. Due to electronically drift compensating system, ensuring low, linear residual drift in a time is observed. This instrument allows performing measurements with ties to base gravity stations at the beginning and the end of working day. It allows to control residual drift rate and keeps high accuracy of measurements.

Gravity meter will be placed and leveled on tripod in the time of readings acquisition. Elevation of system sensor above the ground surface (marker) will be measured and stored in the meter memory for further processing as well as another gravity data. At each gravity station two 60 seconds series of readings will be made with 1 s sampling. It gives up to 120 gravity readings at each observation point done in two series. If some readings from measurement series exceed standard deviation value then they will be automatically rejected. If a difference between averaged value obtained from two series exceeds 0.01 mGal, then the readings will be repeated until the result of repetition will be satisfied and shows stable condition of working meter.

Gravity value will be stored in instrument memory together with unique identifier of the station, time of reading, height of tripod, calculated values of the tidal and tilt corrections.

All series of readings will be done with seismic filter usually turned on to eliminate microseism errors and to reduce errors caused by wind.

The similar pattern of magnetic measurement will be carried out on survey stations in a reference to the registration of control magnetometer (with 30 sec. sampling readings) located on magnetic base station.

At every working day gravity measurements at gravity stations will be carried out in the following manner:

- measurement at the gravity base station before the start of the survey for the day,
 - control measurement at magnetic control point located near operational base, remote from magnetic noise sources,
 - measurement at the station established along survey lines,
 - repetition at stations measured in the different day of survey,
-

- if necessary, terrain undulation estimation for inner zone terrain correction calculation,
- gravity measurements at the base station at the end of the survey for the day and magnetic measurements at magnetic control point,
- data dump to PC computer, drift checking and measurement loops control, data reduction.

Each measurement station will be checked before magnetic survey due to presence of magnetic noise at the position. This procedure will be executed in a pattern as 3 points magnetic readings in the circle of 5 m radius from measurement's station location. If the readings not be coincident in 5 nT, then magnetic station will be shifted to the new position, which will guarantee not disturbed magnetic reading. If so, the offset from gravity station position will be measured and finally introduced to magnetic catalogue. Also shifting of magnetic station position be done if any potentially magnetic sources will be seeing by observer near point location or if differences between successive readings exceeds 3 nT in a 20 sec. measurement period.

Survey magnetometers will be working in 2 sec sampling rate (the sensitivity ± 0.1 nT).

7.4. Drift correction.

Microprocessor based system in the gravity meter CG-5 Autograv can to correct automatically changes of the instrument readings caused by most internal factors. These factors produce long term system drift that is compensated by system software during field measurements. Long term drift compensation is setting and controlled by operator, depends on results of cycle observation in the time of periodical controls (every week). Procedures to set correct settings follow a manufacturer's instruction.

Software compensation doesn't completely remove the effect of instrumental drift. After compensation linear residual drift is observed.

Any residual drift will compensated by a procedure on base station readings – at least at the beginning and the end of survey day. On a base points readings corrected for tidal attractions and tripod height a residual drift will be defined. A value of the drift will be apportioned proportionally to the interval of the time between base point and gravity field station readings.

Maximum acceptable value of daily, linear drift must be less then 0.5 mGal/day. If an anomalous drift will be observed, the gravity meter's settings will be checked and gravity readings will be repeated next day at each gravity station from anomalous drift measurement loop.

Magnetic instruments not need introducing this kind of correction. They make absolute values of magnetic total vector which is observed on a station. However these are changing with a time. Magnetic variations will be simply rejected in a reference to daily recordings at the base magnetic station.

7.5. Tidal correction.

This correction is needed due to Sun and Moon gravity effect which produce tides in Earth surface and can contribute up to 0.3 mGal difference to the measurements in the whole day.

Correction for Earth tides may be made in various ways depending on circumstances. In our case, calculations of tidal correction will be based on analytical formula given by Longman, 1959 which is included in instrumental firmware. This correction will be calculated and introduced to gravity readings automatically after the end of measurement cycle at each gravity station.

Earth's surface tides not influent on magnetic data.

7.6. Terrain correction.

Due to the topography configuration terrain correction needs to be introduced to gravity measurements. This effect is caused by gravity influence of masses surrounding gravity stations. The value of the effect depends on magnitude of topography undulations, their distance to the measurement station and rock densities.

To correct this effect the standard Contractor's technique is proposed which is based on theory of gravity and practice. The technique gives optimal topography estimation and protects requirements of accurate and high sensitive measurements.

The area surrounding each gravity point will be divided onto three main zones. The first zone (inner zone) is the area within the circle of radius 100 m. The second zone is defined as a concentric zone surrounding gravity stations from 100 m up to 20 km (intermediate zone). The last zone exceeding 22 km calculations of the terrain correction be up to 200 km range. The last zone is taken into gravity data processing in a regional investigation. The computation of terrain effect produced by topography undulations within all zones bases on an elevation data obtained different ways.

Proposed technique to use for determining the terrain correction for inner zone (up to 100 m radius) bases on calculations a sum of gravity attraction of cylinder segments approximating terrain undulations within a circle of a 100 m radius around the gravity station. The circle area is divided onto 8 sectors. Terrain undulations within each sector are estimated by measurement of angles and distances of terrain undulation along the 8 lines running from gravity station out of the circle. Angles and distances define cylindrical segments are approximating topography.

Simply instruments will measure terrain undulations: inclinometers and measurement tapes. Results of measurements will be stored in a surveyor log.

Terrain estimation in inner zone will be introduced if at least in one direction within a zone terrain undulation with a slope exceeds 60 inclination.

Intermediate topography attraction (over 100 m radius up to 22 km) will be calculated from the digital elevation model of topography obtained from topography maps or satellite origin data. In Contractor's opinion gravity attraction given by masses located in intermediate zone can be omitted due to small surface undulation within the block with values less than meter accuracy.

Earth's surface undulation of magnetic attraction is usually not adapted into magnetic data processing. In case of magnetic anomalies computation using IGRF formula the elevation of magnetic station is taken into account to correct the value of anomaly due to magnetic vertical gradient.

7.7. Subsurface densities determination.

Distribution of subsurface rock densities reflects in gravity data. If no data are available, subsurface densities will be obtained from gravity survey. The best method was worked out by Parasnis, 1952. This method is using by Contractor as a standard in such cases. This method needs to do some gravity measurements along line running through an inclined terrain surface. This method is proposed for determination subsurface rock densities as a better and more accurate than Nettleton's estimation.

The Contractor expects that values of subsurface rock density are known from earlier geophysical & geological surveys and can be given by Client. Especially due the reason of fact that survey area is plain and suitable terrain undulation may be not exist for Nettleton's or Parasnis estimation.

7.8. Quality control.

The quality control will be performed due to following parameters. Individual loops with greater than 0.1 mGal post-drift misclosure will be repeated. Inter-meter repeat measurement tolerance won't exceed 0.05 mGal.

Minimum 2% of stations shall be repeated. For rigorous control the Contractor propose to perform each repetitions at different days. A full statistical analysis from the repetitions will be attached to the technical survey report. The acceptable tolerance of repetition shall be better than 0.05 mGal. Continuous gravity meter behavior will be monitored via daily and long-term drift at the operational base station.

Magnetic survey instrument before daily work commencement will be controlled on the same magnetic control point located in a neighborhood of operational base location.

7.9. Instrument maintenance

The SCINTREX CG-5 Autograv gravity meter and SCINTREX Envi-Mag magnetometers will be strictly maintained in accordance to manufacturer's instructions given in technical documentation attached to instrument.

Gravity meter calibration, weekly gravity meter checks and necessary adjustments will be performed to protect accurate, high sensitivity and reliable gravity observations.

In any case when gravity staff finds some anomalies which can be produced by instruments (follow drift value in gravity or find exceed values of repetitions) additional tests will be performed immediately to correct the problem.

7.10. Accuracy

The final accuracy of Bouguer anomaly determination will be calculated using following formula:

$$e_{rms} = \pm (e_{g_{rms}}^2 + (0.3086 - 2\pi G * \rho)^2 * e_{h_{rms}}^2 + e_{\gamma_{rms}}^2 + e_{t_{rms}}^2)^{(1/2)}$$

where:

$e_{g_{rms}}$	- error of absolute gravity determination,
$e_{h_{rms}}$	- error of elevation determination,
$e_{\gamma_{rms}}$	- error of latitude correction,
$e_{t_{rms}}$	- error of terrain correction determination,
0.3086	- value of a mean vertical gravity gradient,
$2, \pi, G$	- constants,
ρ	- value of subsurface rock density.

7.11. Setting out Gravity & Magnetic Stations

All gravity & magnetic station will be identified in the field with temporary markers. Markers will contain a unique point number related to seismic station identifier. Each gravity point

coordinates in a position and height will be defined on a base upon established geodetic control station.

7.12. Gradiometry data acquisition

Vertical gradient of gravity is determined by the measurement made at two points situated vertically one above the other.

To measure the vertical gradient of gravity portable towers used measurement to a gravity meter to measure changes in the force of gravity in the vertical interval of a certain height. Gravimetric measurements of the tower consists of a series of readings on the positions: lower - upper - lower - upper - lower.

8. Gravity/ magnetic/ gradiometry data processing on site

Gravity and magnetic data surveyed and acquired in the field work will be immediately stored on PC computer memory media and the same or next day will be processed.

For data processing suitable software will be utilized. In field procedures data will be preprocessed using firmware software written to the meters system.

For processing data the Contractor proposes to apply software listed as a part of equipment specification.

Follow Contractor's standards processing procedures will contain:

- preprocessed SCINTREX CG-5 instrumental corrections: tidal correction, tilts correction,
- preprocessed SCINTREX ENVI-MAG correction for diurnal magnetic field variations,
- post processed corrections:
 - drift correction,
 - latitude correction,
 - terrain correction,
 - free air correction,
 - Bouguer correction,
 - IGRF correction,
- for quality control statistical analysis will be every day currently performed and results updated.

The drift rate obtained from gravity measurements performed on base stations at the beginning and at the end of the day will be proportionally to the time of measurement introduced to gravity readings.

Follow Client requirements latitude correction of gravity values will be computed on a base of IGS 1971 formula given by Cassinis, 1930. The formula describes normal gravity shifts with latitude.

$$\gamma_0 = 978\,049 * (1 + 0.0052884 * \sin^2\Phi - 0.0000059 * \sin^22\Phi) \text{ [mGals]}$$

where:

- | | |
|------------|--|
| γ_0 | - value of latitude correction (normal gravity), |
| Φ | - latitude. |

Latitude correction of magnetic values will be computed on a base on IGRF (International Geomagnetic Reference Formula). The formula describes normal magnetic shifts with latitude and longitude, as well as estimation of elevation correction due to magnetic vertical gradient.

Terrain correction will be computed and introduced to gravity data in two steps. Separate computation will be performed for inner and intermediate zone (if required).

As was explained above, purposed technique to use for determining the terrain correction for inner zone basis on calculations of sum gravity attraction of cylinder segments approximating terrain undulations within a circle of a 100 m radius around the gravity station. Terrain correction in inner zone will be introduced on a base of surveyor data logs. Calculation will be performed using software designed for this technique by the Contractor.

The terrain correction for mass attraction surrounding gravity station from 100 m up to 22 km will be introduced if required. Purposed computation technique basis on approximation of terrain undulation by a sum of rectangular prism located on or below the plain surface running through the gravity station. The density of grid defining terrain undulation depends on digital model details and needs to be 100 meters spaced grid. For this proposal 3D gravity modeling software will be utilized, modified for terrain correction computation. The Contractor designed the adequate software to apply.

The free air correction (Fay'e correction) allows to reduce gravity value onto chosen reference level. This correction is calculated for each gravity station on a base of mean vertical gradient of gravity. The value of free air correction is given as:

$$\Delta g_F = (dg/dh) * h$$

where:

- Δg_F - free air correction,
- (dg/dh) - mean vertical gradient of g (-0.3086 mGals/m),
- h - gravity station elevation above reference level.

The Bouguer correction will be calculated as attraction given by masses distributed within horizontal, infinite slab of a thickness equal to difference between gravity station elevation and reference level. Bouguer correction is given as:

$$\Delta g_B = 2\pi G \rho h = 0.04192 * \rho * h$$

where:

- π - pi constant,
- G - gravity constant,
- ρ - slab density,
- h - difference between station elevation and reference level (obviously Mean Sea Level).

Bouguer anomaly at gravity stations will be calculated in reference to chosen level according the following formula:

$$\Delta g_{Bou} = \Delta g_p + \Delta g_F - \Delta g_B + \Delta g_T - \gamma_0$$

where:

- Δg_p – absolute gravity including tidal and drift correction,

Δg_F	– Faye correction,
Δg_B	– Bouguer correction,
Δg_T	– terrain correction (a sum of inner and external corrections),
γ_0	– latitude correction.

All gravity, magnetic and corresponding geodesy data will be collected together in a survey catalogue, which will include:

- gravity & magnetic station unique identifier,
- date & time of reading,
- measured values of gravity and magnetic field,
- value of diurnal magnetic variation,
- geodetic coordinates of the station in a reference to WGS84 ellipsoid and EGM96 level datum,
- geodetic coordinates in a reference to local datum (Everest 1830 spheroid),
- grid coordinates Easting, Northing in local datum in a reference to parameters of map projection (UTM projection),
- absolute gravity value,
- Free air gravity value,
- Bouguer anomaly ref. to defined subsurface rock density,
- total value of terrain correction,
- terrain correction in zone 0-100 m,
- terrain correction in zone 100 m up to 22 km (if required),
- IGRF value of correction,
- magnetic ΔT anomaly.

Processing procedures will include grid interpolation for data presentation and base graphs or map plots also.

Due to Contractor's standard procedures control graphs or maps will be plotted every week in A-4/A-3 size format in the field.

Proposed grid format for digital part of reports content can be chosen between GEOSOFT, USGS, Golden Software (Surfer) or any other specified by the Client. In such case Contractor can prepare tools for a conversion.

10. Advanced data processing and interpretation.

In a respect to the Client requirements PBG will carry out integrated interpretation using other geoscientific data (seismic, well and surface geological data) available or delivered by ONGC from survey areas.

Interpretative part of work will include advanced data processing for qualitative and quantitative interpretation. Qualitative interpretation techniques will be applied to gravity and magnetic data refer to methods may be used to obtain and understanding major geological tectonic features, i.e. to

outline geological-geophysical units ranges and boundaries. Quantitative techniques will be used to estimation of sedimentary thickness.

Final processing of obtained datasets of CBA (Complete Bouguer Anomaly) and magnetic ΔT anomaly will include but not be limited to:

- magnetic anomalies transformation to the pole,
- residual gravity and magnetic anomalies determination by removal of regional trend, approximated by low-order polynomial trend surface and FFT low pass approach,
- horizontal and vertical gradient anomalies distribution computation,
- determination of anomaly sources location using Euler deconvolution method or similar,
- gravity and magnetic anomalies inversion and forward gravity and magnetic modelling along profiles running over survey areas.

Parameters of anomalies transformations, i.e. grid density, chosen algorithms and others will be adapted in reference to the density of survey grid, the magnitude and estimated depths to structures and will be described for Client approval.

Maps and plots of modeling section will be plotted as color contour maps and plots in scales required by Client.

11. Reporting.

The Contractor will work out two kinds of reports from gravity and magnetic survey. The first will be prepared within 7 days after finishing field work (Survey Report describing all aspects of field data acquisition, onsite data processing and adjusting up to gravity & magnetic anomalies computations and presentation).

The second, Final Report will be submitted after interpretation finishing. This report will include wide description of interpretation techniques, results of data processing and transformations, geophysical modeling, relations potential field features to geological forms and structures, etc. Final report will include attachments in a form of graphs and maps with interpretation results presentation to the respect of the aim of survey.

In a reference to standard requirements the Contractor feels obligated in daily, weekly and monthly reporting in a time of data acquisition and interpretation, independently to the Survey Report after finishing field work and Final Report as well.

Daily reports will include information about work statistic and any events and reasons, which can influent on survey or interpretation progress and can have important meaning for data processing and interpretation.

Weekly and monthly reports will include summarized statistic of work progress and partial information acquired and processed in a report's period. These reports will contain:

- list of identifiers of repeated station,
 - list of identifiers of station with terrain correction applied in an inner zone (up to 100 m)
 - actual statistical accuracy analysis,
 - hardcopy and ASCII file of raw geodetic data,
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- hardcopy and ASCII file of raw gravity and magnetic,
- hardcopy and ASCII file with processed gravity data,
- map of the measured station locations
- color graphs with gravity and magnetic anomaly distribution along survey profiles at A-3/A-4 size sheets.

Survey Report will be worked out within 7 days of the end of acquisition. It will be delivered in agreed number of copies.

The Survey report will describe all aspects of the data acquisition with details. It will include but not be limited to:

- general description of survey area,
- list of personnel and equipment utilized for project performing,
- description of field survey procedures for data acquiring follow a scope of work,
- description of data processing procedures utilized for determination gravity and magnetic anomalies,
- full statistical analysis of accuracy of measurements and achieved final preciseness of survey,
- sketches with complete description of local gravity network station location,
- conclusions obtained in work conducting.

In a form of attachments to the report:

- gravity and magnetic catalogue,
- surveyor logs with terrain undulation estimation up to 100 m, if any,
- graphs and gravity Bouguer anomaly maps at a scale agreed with Client's representative.

The Final Report will describe all aspects of the data advanced processing features and results of the interpretation, with details. It will include but not be limited to:

- description of interpretative procedures and techniques applied to the gravity and magnetic data follow the aim of work,
- general description of gravity and magnetic anomalies distribution,
- description of relationships between results of processed gravity & magnetic data to other geophysical and geological data,
- description of results obtained by interpretative procedures and computations,
- conclusions in respect to the aim of survey,

In a form of attachments to the report:

- gravity and magnetic maps,
- sections with gravity and magnetic modeling,
- maps of tectonic features.

Survey Report and Final Report from performed survey will be prepared in two forms. One is a paper form, the second is digital form. Follow this standard the Contractor attaches in digital form (MS Office format) the text of reports, statistical analysis of measurements and formatted catalogue (database) of gravity and magnetic station (MS Excel, MS Access formats), as well as in free ASCII

format. Graphs, maps and section plots in digital format (GS Grapher, GS Surfer or Geosoft and another agreed formats) and their conversions to bitmaps picture format, which can be acceptable by the Client. Any data (raw or processed) will be stored on CD-ROM disks.
