NAME OF WORK : FINAL LOCATION SURVEY FOR VARIOUS PROJECTS

SCOPE OF WORK

A. OBJECTIVE OF THE WORK

The primary objective of the work is for the Final Location survey of new line/Doubling/ 3rd and 4th line and in Ernakulam Construction jurisdiction including collection of data, Development of optimized feasible alignments, LiDAR survey, topographical survey, geotechnical investigation, hydraulic waterway analysis, traffic study and projection, estimation of works, rate of return calculations, submission of alignment and associated drawings, detailed estimate, Detailed Project Report, EPC tender documents, Land acquisition details, Design of Structures.

B. BROAD SCOPE OF WORK

(a) Final Location Survey for new line/Doubling/ 3rd and 4th line and detailed survey of new lines/Doubling in Ernakulam Construction jurisdiction.

(b) Collection of topographical data including contours, geophysical data, catchment area and other available reports and details.

(c) Assessment of the project area with high quality satellite images, topographical maps, contour data and other geographical features such as rivers, hills etc for identifying feasible alignments for the project and submission to authority for approval.

(d) Analysis of the alignments approved by Railways for the projects and submission of details like but not limited to land requirement (with details of Forest land), habitation, earthwork involved, obligatory points considered, critical locations, important structures, site constraints, approximate cost of work etc to authority for finalisation of the alignment for the new line.

(e) Survey of the project alignment

i) Collection & paper study of existing reports, data, drawing, documents, setting up of ground control points, HFL details etc. with respect to the selected alignment.

ii) Getting all clearance such as DGCA etc. as required for Aerial LiDAR survey along the proposed corridor

iii) Mobilization of Aircraft/Helicopter with required LiDAR and Camera equipment.

iv) Field measurements are to be carried out for collecting and submission of bed levels, Vertical clearances, span etc. for Road / Rail Bridges within the Area of Interest.

v) Aerial LiDAR data capture

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vi) Aerial Imagery capture

vii) Pre-processing and post processing of data

viii) Survey using DGPS equipments in the proposed alignment as instructed by Railways.

ix) Submission of data and deliverables

(f) Geotechnical investigation at major and important bridge locations, tunnel locations, ROB/RUB locations, other critical locations as instructed by Railway in the alignment.

(g) Hydraulic waterway analysis and calculations for the bridges based on catchment area and HFL details.

(h) Technical analysis for Final Location Survey based on the approved Terms of Reference and other technical parameters mentioned IRPWM and other Indian Railway Manuals and codes (all manuals and codes updated to the latest correction slip) are to be considered. Relevant European codes and other codes can be adopted when they are not superseding Indian Manual or codes.

(i) Traffic study and projection including projection of earnings, assessment of working expenses, FIRR and EIRR calculations.

(j) Preparation and Submission of Final alignment, other drawings and Reports.

(k) Preparation and Submission of detailed estimate of the final alignment.

(l) Preparation and Submission of Detailed Project Report as given in Railway Board letter No. 2022/W-I/Genl/DPR proforma (E office 3404238) dt 13.12.2023.

(m) Conducting utility survey and submission of cost of utility shifting will all details as per the requirement of Railway.

(n) Conducting OHE requirement, plans, Signal requirement, interlocking details, with plans and cost estimate.

(o) Preparation and submission of EPC documents, Design of structures, for the specified projects as instructed by the Engineer in Charge.

(p) Preparation and submission of plans, designs, BOQ, Rate analysis for the specified projects as instructed by the Engineer in charge.

(q) Procurement/collection of standard RDSO/Railway drawings, Revenue Maps, other approved drawings and its utilisatiion in the project shall be the responsibility of the contractor.

(r) Drawings submitted by the contractor require approval of various departments. The contractor shall deploy experienced Engineers to explain and get approval of all concerned for which no additional payment will be paid by Railway.

C. DETAILED SCOPE OF Work

LiDAR Survey - The detailed Scope of work covered in the Final Location Survey with LiDAR Survey and associated works includes collection of topographical data geophysical data and other geographical features, submission of feasible alignments for approval of Railway. On approval of the alignment, control points are to be established for conducting Aerial LiDAR Survey along the center line of approved alignment between TVC-NCJ (3rd line) and other New line/Doubling/Future projects, Angamaly-Sabari new line and Thuravur - Ambalapuzha Double line, collection of other relevant data, processing of data, DGPS survey, submission of details and drawings and Detailed Project Report.

The detailed scope of work for the consultant/contractor is detailed below.

1. Assessment of the Project area and identification of feasible alignments

Optimal feasible alignments are to be developed by the contractor. The alignments developed are to be submitted to authority. The basic details of the alignments such as total length, Identification of critical areas /sections such as Bridges/ Viaduct/ RE Walls, deep cuttings, viaduct length, tunnel length, land required, no of major/important bridges, linear waterway length etc are to be submitted for each alignment in .kml format. The alignments identified are to be submitted to Railways for approval of 3 alignments for further study.

The three selected alignments are to be further analyzed further and details such as but not limited to gradient, land requirement (with details of Forest land), habitation, earthwork involved, obligatory points considered, critical locations, important structures, site constraints, constructability consideration, approximate cost of work etc clearly bringing out the advantages and disadvantages of each option. Any additional detail required for finalisation of the alignment by Railway is required to be submitted. The detailed survey is to be carried out for the **approved alignment** by the Railway.

A comparison of the proposed three alignment options should be submitted in a tabular format along with abstract estimate of each alignment and the drawing showing of the proposed alignment so as to arrive at most optimal/economical.

For the approved alignment, a detailed engineering survey report should be submitted and the same should contain the following details:

- Salient features
- List of curves and gradients
- List of stations with yard length, gradient and curve, maximum cut/bank details
- List of ROBs/RUBs with proposed span and clearance.

- Location of major and minor bridges with proposed span, clearance, width of actual stream.
- Map showing the extent of agricultural, urban, forest land required to be acquired for permanent way and yards. This can be prepared by consulting topographic sheets and satellite images from Google Earth.
- List of tunnels indicating their length, location, gradients, overburden
- List of chainage wise stretches falling in restricted forest area, wild life sanctuaries, national parts etc.
- Earth work quantities

The details generated in this stage such as TOPOGRAPHOVAL MAPS/ ORTHO-PHOTOS/ COST ESTIMATION are solely for the purpose for finalizing the alignment. Accurate details with higher accuracy shall be generated from detailed studies using Aerial Lidar survey done later.

2. Detailed Survey of the project.

1. Establishing Ground Control Points and LiDAR survey

Aerial LiDAR Survey **using Aircraft/ Helicopter** complemented with Aerial Photography and videography shall be carried out for the proposed Area of Interest (AOI) along the **approved alignment** between Shoranur and Coimbatore.

Agency have to submit details of Survey of India control points which it intends to traverse to locations within 10km of the approved alignment. The primary control points are to be provided within Government land as far as possible. The locations identified for setting up the primary control points with inter distance of 20km along the project alignment are to be submitted to the Railway for approval. Agency have to identify the locations of secondary control points within 5 km inter distance along the approved alignment. Data shall be captured with reference to above Control points. The network is to be established along the approved alignment. Permanent structures or concrete pillars are to be established for control points.
(To achieve required accuracy, the contractor will have to establish additional ground control points as required, prior to flying. No additional payment will be made for this)

Broadly, the contractor would need to provide the following services:

i) Establishing Ground Control Points within Government land, wherever required, to achieve required accuracy. (Primary Control Points not exceeding 20 km intervals and Secondary Control Points not exceeding 5 Km intervals).
ii) Procuring necessary clearances from DGCA & Ministry of Defense, Government of India,

and other agencies for flying over the AOI to acquire raw LiDAR data, Imagery etc.

iii) Preparation of flight plan

iv) Acquiring and pre-processing LiDAR data and digital imagery

v) Post-processing of LiDAR data to produce the following:

   a. DSM

   b. DEM

   c. DTM

   d. Topographical map

   e. Ortho photos

vi) Conducting Quality Control/ Quality Assurance (QC/QA) to establish correctness of flight operations

vii) Validating horizontal and vertical accuracy has to be done by the agency in the presence of Railway representative. The Contractor will provide required Survey Equipment-DGPS or advanced and Surveyors on his own cost including all other required assistances incidental to above validation check.

viii) Compliance with other product requirements such as file naming, datum and projection, units etc.

ix) Delivery of raw data on the end of each day of survey, other products and supporting reports.

x) Supply of 3 Nos of All in one Desktop PC (HP, DELL, ASUS) – i9/i7, 12th generation processor with minimum 32 GB DDR4 RAM, 1 TB SSD, Intel UHD 770/NVIDIA graphics card or higher along with windows latest operating system, MS office, with 3 years onsite warranty, to suit the verification and utilization of all LiDAR processed data and outputs along with all licensed softwares (3 Nos of 3D Civil and Two nos of Autocad, ~~Open Rail, Global mapper~~, Five nos of Adobe Professional, and any other software required for the project) (except required for processing of LiDAR raw data) required for the project with validity for 1 year from the actual date of completion of the project.

xi) Supply of Printers – (1) Color A3 all in one ink tank re-fill system printer with Wi-fi, Ethernet, USB connections, Auto Duplex printing, similar to Brother MFC T4500 DW. (2) Color All in one A4 printer ink tank system with Wi-fi, Ethernet, USB connections, Auto Duplex printing, similar to HP 6075.

Note: The payment for all items covered in the SN 2 – Detailed Survey of the project will be made as per payment schedule - SN 2.14 for the Item No 1 of Schedule B. Separate payment will not be made for the items covered in the scope mentioned in SN 2.1-2.14, except for additional processing of captured data as per

requirement, which will be made as per Item No 2 of Schedule B.

2.2 Coverage of the Survey work

The agency needs to work to cover all the scope work and details given here under. The survey is to be carried out with reference to the approved alignment between TVC-NCJ (3rd line) and other New line/Doubling/Future projects, Angamaly-Sabari new line and Thuravur - Ambalapuzha Double line. The work will involve carrying out a data capturing for detailed Topographic Survey along alignment for 300m width in each side of the CL of the existing track corridor showing all building details and other ground features as per project requirement or as instructed by Engineer. The processing of data will be for 100m width i.e. 50m either sides of the approved alignment. For additional requirements of processing raw data already captured due to the final alignment away from approved alignment, during alignment design, Design of ROBs and Major Bridges, additional areas as per instructions of Engineer will be processed and submitted covering all other outputs in CAD format. It will be paid as per item no. 1 of the Annexure A in the schedule of the works.

2.3 The survey shall cover following features:-

a) Built up line line (and show setback as well) inclusive of all roads, road/rail track showing important structures with their height and story based upon local inquiry, all bye lanes, footpaths, dividers/central verges, roads, Railway /Metro Railway tracks, details of stations, trees, manholes & other structures, nallahs/canal, storm water drains, H.T., L.T. Transmission lines, vertical clearance of OH utilities etc. Bridges, ROBs/RUBs/FOBs with type and spans, ponds, HFL, Bed Levels (to be collected manually/physically), level X-ings with their type, traction masts, signal posts, location box etc; except stated otherwise, elsewhere in the contract.

b) Marking outer dimension of all built up area along the corridor, and ownership such as private, Govt., residential and commercial etc. within survey limits. The secondary data shall be complied from open source (Google Earth etc;)

c) The Auto CAD drawings shall have different layers for different entities like Road, Rail, Spot/Ground levels, Drain, Building, Boundary Wall, Over Ground Utility and Under Ground Utility, Tree, Traverse Station, ROB/RUB etc. as instructed by Engineer-in-charge. X, Y, Z co-ordinates of all spot/ground points shall be provided in **CSV file** as directed by Engineer-in-charge with point numbers and feature coding as per list of codes given by Engineer-in-charge. Z co-ordinates are to be taken with due care and indicated accordingly.

d) Location of approach roads, main roads, lanes etc. showing road / lane name, carriageway, footpaths, central verge, drains and the widths of all the main and approach roads.

e) Details of land along the route and their uses such as residential areas, commercial areas, religious, parks, green areas, vacant lands etc and ownership private or government. Land acquisition plan to be prepared by the contractor, duly collecting the revenue maps from concerned State Government offices. No extra payment will be made for the same.

f) HFL of nearby existing bridges/ railway stations will be collected correctly by the agency and submitted to client shall be collected and provided by site inspection.

g) Details of level crossings with their, manned or unmanned, Road-Over-Bridges (ROBs) Road-Under-Bridges (RUBs) and Foot-Over Bridges (FOBs), Railway Bridges, Culverts etc. with their structural details, angle of crossing and road & rail levels shall be provided as per LiDAR imagery.

h) Details of railway tracks along the existing alignment including take off points, curves, transitions, crossings, switches and other details including electrical and signal structures with their distances from the existing railway tracks shall be provided as per LiDAR imagery.

i) Details of Religious structures such as Temple, Gurudwara, Mosque, Church, Monuments, Tombs, etc. clearly marking the Proposed Railway Centerline all along the corridor and giving cross reference of these structures with reference to the Proposed Railway boundary. The secondary data shall be complied from open source (Google Earth etc;)

j) Traffic signals, light posts, bus stops, junction boxes (telephone and power), fire and water hydrants and others), transformers etc shall be provided as per LiDAR imagery.

k) Spot levels of terrain in minimum 20m grid and in addition at the change of the topography, critical levels including vertical clearances of Road-over-Rail and Road-under-Rail bridges, railway OHE facilities, top levels of (a) railway station buildings, (b) platforms and (c) both rails of each track shall be provided as per LiDAR imagery. Rail levels shall be recorded at 20m intervals.

l) Vertical clearances to power line or telephone/telegraph lines at crossings of roads/railway line with in the Corridor (AOI)

m) Any other structure or details which the Agency may feel important and or as instructed by Engineer should also be added.

n) Contours at 0.5 m interval to be developed for entire corridor. The output shall be delivered in DWG format.

o) Necessary jungle clearance for proper execution of the work, wherever required, shall have to be done by the contractor at no extra cost and client will provide the support in getting permissions for the same.

p) The following documents shall be maintained at site by the contractor and submitted to client and will be considered as property of client.

i) **Traverse Register** - Details of Ground Control Points traverse stations with location map by using DGPS.

ii) Report of the DGPS survey shall be provided with all easting, northing and elevation (connected to GTS) along with monogram and calculation reports.

q) Contractor shall prepare one set of AutoCAD drawings with approved legend on a suitable scale to print out on A0 size drawing with 5Km length per sheet showing all man-made and natural features. Soft copies will also be supplied by the agency. The plan should have enough description of features and annotation so as to suffice the purpose of design of alignment. The contractor shall carryout physical verification of the plan prepared above with the help of hard copies using his own surveyors at site with the representatives of Railways.

r) After making necessary corrections, as may be required, corrected hard copies of the plan shall be (Client's representative and Contractor's surveyor) test checked and verified at site. Corrections, if any shall be carried out by the contractor and final drawings in hard copy (duly signed) and soft copy shall be submitted to Client for design of alignment. The sample template for above drawing has to approved Railways.

The contractor should collect all the relevant land plans from State revenue officials. The authority will provide assistance to the contractor for collection of the details.

2.4 General requirements

a. Clearances for Flying

The contractor is responsible to obtain necessary clearances from Director General of Civil Aviation, Ministry of Defense, Government of India, and other agencies as may be required to complete the job of flying over the AoI, acquire LiDAR and digital camera data etc. The client would provide necessary documentation; however, getting clearance would be the entirely the responsibility of the contractor.

b. Flight Planning

The flight path shall cover the study area completely including enough cross flight lines to eliminate shadowing and allow for proper quality control. Flight line overlap should be 30% or greater, as required, to ensure that there are no data gaps between the usable portions of the swaths. Data collections in high relief terrain should have greater overlap. Any data with gaps between the geometrically usable portions of the swaths will be rejected.

The contractor shall generally avoid missions during inclement weather which have been known to degrade the accuracy of laser return data. The contractor must document mission date, time, flight altitude, air speed, scan angle, scan rate, laser pulse rates, and other information deemed pertinent.

2.5 **Sensor Calibration**

The contractor must provide calibration certificate of sensor issued by the manufacturer. In addition, the contractor must submit evidence that the total LiDAR system was calibrated prior to current project initiation, for the purposes of identifying and correcting systematic errors. **Proper system calibration requires repetitive over-flight of terrain features of**

known and documented size and elevation using flight paths similar to those that will be used in the AOI.

2.6 Ground Control Survey

Agency have to collect details of bench marks/control points of known X, Y, Z coordinates which it plans for setting up of primary control points in Government land. The contractor must establish control network by using DGPS with reference to above Ground Control points. DGPS used for this exercise should be dual frequency (L1 and L2) and multi-channel capability with on-the-fly ambiguity resolution and be able to log GPS data at 1-second epochs or better. For the purpose of the aerial LiDAR survey, DGPS Control Pair Points will be minimum at every 5km and transferred to the area of interest or data pre-processing and quality control purposes. However, DGPS control points should be fixed not exceeding 20 km intervals to achieve stipulated accuracy of LiDAR survey. Such a point would be transferred on a flat surface and clearly marked out for visibility from the aerial LiDAR platform. The horizontal accuracy of the above work after processing of data and network adjustment will be 1:100,000 or better. The vertical accuracy during Transfer of 'Z' coordinates from nearest Control point shall have a minimum accuracy of $6\sqrt{K}$. Fixing of DGPS control points will be carried out as per specification mentioned in **Annex-GG.** During data collection, two DGPS base stations will simultaneously be used during the mission. Inter-distance between two base stations should not exceed 25 km. The density of ground control point shall vary as per the field condition subject to above to achieve the desired accuracy and have to be carried out by the agency. Additional cost will not be given for this purpose.

2.7 Pre-**Processing**

The raw LiDAR data should be assembled for clipping, filtering and Geo-tagging processing. The elevation data may then be examined and compared to the values and control. Because of the reflective nature of light, it is common for errors to be recorded because of the reflectivity, or lack thereof, from surfaces within the project area. Though a few points within each mission are indeed identified as discrepant, it is an insignificant percentage (usually less than 5%) that should be removed from the data.

2.8 **Post-Processing**

The contractor will provide un compressed high-resolution, high-accuracy, "bare-earth" ground elevation data at regular spacing (DEM), irregular spacing with mass points and break-lines (DTM), and the elevation data of all top surfaces (DSM). To restrict data to ground elevations only, the contractor must remove elevation points on bridges, buildings, and other structures and on vegetation, from the LIDAR- derived data. In addition to randomly spaced LIDAR points, before and after removal of data associated with structures and vegetation, the contractor must produce a bare-earth DEM. The contractor must use Triangular Irregular Network (TIN) linear interpolation procedures, including break lines, when validating the vertical accuracy of the data models.

Post Processing will be done for 100m wide corridor i.e.50m on either side of center line of the alignment. If there is requirement of additional data, the contractor shall do additional post processing to provide the stipulated outputs mentioned in the Bill of Quantities.

2.9 Pre-processing and post processing of data to give the final outputs as below:

i. Classified Point Cloud in LAS (.las) format (Soft Copy format)

ii. Three dimensional topographic survey drawing of 50m corridor on either side of railway center line on a scale of **1:1000**

iii. Contour map at 0.5 m interval for 50 m corridor width on either side of alignment

iv. Digital Surface Model (DSM)/ Digital Elevation Model (DEM)/Digital Terrain Model from topographic survey data

v. Longitudinal and Cross Sections at 5m interval in undulated terrain and 10m interval in plain terrain, which is to be displayed in.dwg, xls format as per sample profile supplied to the contractor.

vi. Digital Ortho photos of 10cm GSD resolution (In tiles and seamlessly mosaicked over the survey area)

vii. 3 sets of all deliverables to be provided in Hard Copy.

viii. Soft copy of all deliverables to be provided.

ix. Digital Elevation Model (DEM)/Digital Terrain Model (DTM) in ESRI ASCII file format (*.asc) of the entire stretch of alignment should be divided into 1 KM size tiles during delivery to Railways.

x. Uncompressed Digital Orth photos of 10cm GSD resolution should also

be of the same divided area in ECW Format (.ecw) and delivered against each DTM.

2.10 Quality Control/Quality Assurance

Quality Control/Quality Assurance (QC/QA) of the LIDAR and/or LiDAR derived data will be the responsibility of the contractor. This QC/QA process shall include reviews of flight alignments and completeness of supporting data (e.g., cross sections, profiles).The client may perform additional QC/QA testing.

2.11 Flow Chart

A flow chart showing activities is placed as figure-1 below.

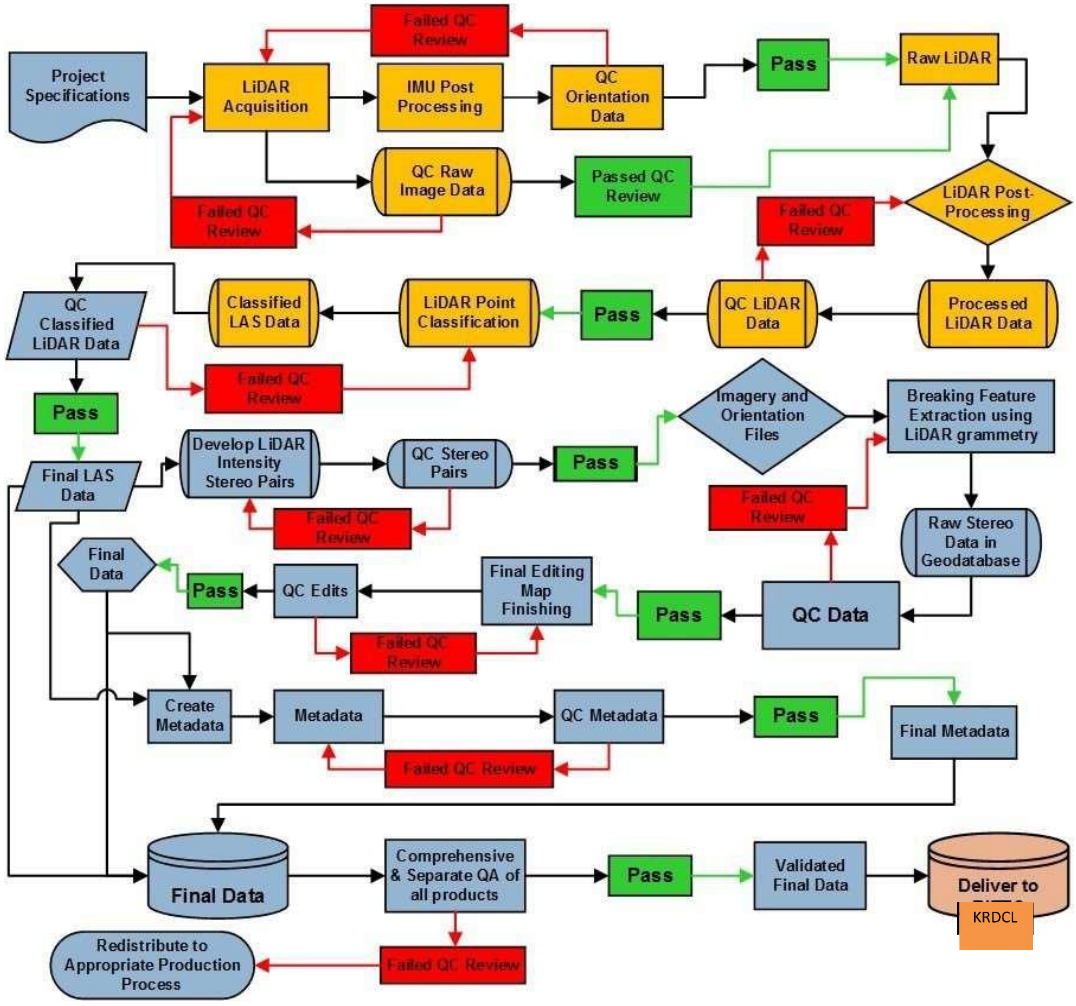

Figure 1 **LiDAR Mapping Flow Chart**

2.12 Detailed Specification of Aerial LiDAR Survey

(a) Data Capture Specifications

Items	Specifications
Aircraft Considerations	Single/Twin engine aircraft may be used for airborne LiDAR remote sensing. However, Twin engine aircraft
Data Density	provide efficient operations for sensors up to 6000m above sea level; they are equipped with power sources to handle a suite of modern sensors ;they offer work space and comfort to the pilot and camera operator; and the twin engines provide additional safety in the event a single engine should stall. Agency/ contractor will be fully responsible for safety using Single/Twin engine aircraft /helicopter. 10 Points/m2, (minimum, after discarding unusable points)
Operating Altitude	150m−900m
Fundamental Spatial Accuracy Requirements using LiDAR-Specific ground targets as defined below: LiDAR-specific ground target of 1m circle radius(two concentric circle design with different	Fundamental spatial accuracy must conform to the following standard: • Fundamental Horizontal Accuracy(FHA) <= **+/- 15cm**, 95% confidence interval (1.96 x RMSE) • Fundamental Vertical Accuracy(FVA) <= **+/- 10cm**, 95% confidence interval (1.96 x RMSE)

coatings) needs to be erected before commencement of flying. Density of these targets needs tobe finalized by contractor to achieve stipulated accuracy of LiDAR survey. Image of target is placed by side.	
Horizontal Datum	The World Geodetic Datum 84 (WGS-84)
Map Projection	The coordinate system for all deliverables is Universal Transverse Mercator (UTM).
Vertical Datum	**Orthometric** All deliverables will be referenced to the Survey of India Vertical Datum (MSL).
	Ellipsoid In addition, all deliverables will be referenced to the WGS- 84 reference frame. The source of the ellipsoidal height control shall be explained in the 'Post-Survey Spatial Accuracy Report'.
Collection Requirements	1. Recording a minimum Nominal Post Spacing (NPS) of0.25 m outbound pulses per square meter 2. A scan angle not exceeding 40˚ Total FOV (+/- 20˚ from nadir) 3. An across/along track point spacing ratio not exceeding 2/3. 4. Flight line overlap must be 30% or greater, as

	required to ensure that there are no data gaps between the usable portions of the swaths. 5. Data Voids (with void are as more than and equal to 4xNPS), measured using 1st-returns only within a single swath are not acceptable, except: a) Where caused by water bodies b) Where caused by areas of low near infra-red (NIR) reflectivity c) Where appropriately filled-in by an other swath 6. The spatial distribution of geometrically usable points should be uniform and free from clustering. 7. Environmental conditions for data capture are: a) Cloud and fog free between aircraft and ground. b) Flights would not be undertaken during periods of heavy smoke, haze & rain. c) Preferably, during leaf-offseason 8. Every effort shall be made to avoid breaks within individual flight lines. Where breaks within a flight line are necessary, the entire flight line composed of the resulting segments shall meet all of the requirements set forth in specifications

(b) Aerial Imagery Specifications

Items	**Specifications**
Ground Sampling Distance (GSD)	10cm
Bands	RGB (Three band natural colour imagery)
End overlap	30% minimum

Side overlap	20% minimum
Collection Condition	Same as LiDAR with following additional conditions: • Sun angle no less than 30 degrees to minimize shadows • Cloud free (at least 95% cloud free) with minimal smoke, smog and dust • Every effort shall be made to avoid breaks within individual flight lines. Where necessary, the entire flight line composed of the resulting segments shall meet all of the requirements set forth in these specifications. Where breaks occur, these shall have an overlap of at least four frames to ensure a stereo model of overlap or tie.
Image format	Uncompressed GeoTiff Uncompressed ECW Format
Imagery product	Seamless mosaic covering the project area and non-overlapping, edge-matched tiles.
Radiometric resolution	Minimum 8 bit in accordance with chosen image format
Horizontal Accuracy	10 cm GSD or better for the ortho-photo generated.
Radiometric Resolution	Minimum 8 bit per band in accordance with chosen image format
Horizontal Datum	The World Geodetic Datum 84 (WGS- 84).

Vertical Datum	**Orthometric** All deliverables will be referenced to the Survey of India Vertical Datum (MSL) **Ellipsoid** In addition, all deliverables will be referenced to the WGS- 84 reference frame. The source of the ellipsoidal height control shall be explained in the 'Post-Survey Spatial Accuracy Report'.
Map Projection	The coordinate system for all deliverables is the Universal Transverse Mercator (UTM).

(c) Project Planning and Reporting Specification

ITEMS	SPECIFICATIONS
Project Plan	Complete project plan detailing work break down structure, agreed data capture plans, project milestones, delivery schedules, progress reporting schedules etc. shall be submitted within 7 days of issue of LOA.
Pre-Survey Quality Assurance Plan	The Contractor shall prepare and submit a Quality Assurance Plan that conforms to an identified management system and generally complies with ISO9001. The plan must address the organization and management of the project, work procedures, environmental considerations, safety and risk control and test procedures. The Plan must also detail the procedures to be used in verifying that the deliverables meet the required specification including:

	• The procedures and methodologies to be used to validate the deliverables meet the required specifications. • Details of proposed sensor calibration checks and methodology to be used to establish both reference stations and ground test sites. The Project Plan must be submitted at least 7 days prior to commencement of the survey.
Post-Survey Spatial Accuracy Report	• Acceptance of the Post-Survey Spatial Accuracy Report and related information is required before point classification, ortho generation and other product derivation are to proceed. • The absolute and relative accuracy of the data, both horizontal and vertical, and relative to known controls, shall be validated prior to classification and subsequent product development. • This validation is limited to the Fundamental Spatial Accuracy (defined below), measured in clear, open areas. A detailed report of this validation is a required deliverable. The report will include the following: • Flight trajectories • Details of system calibration checks • Results of relative (flight run) matching and details of any adjustments made • Source of primary ellipsoidal height control • Details of ellipsoid to orthometric corrections

	Applied including any final adjustment to local SOI vertical datum supplemental to the standard Geoid correction • Results of vertical and horizontal accuracy validation using statistical approach • All survey control coordinates, site id and check point comparisons in both Excel spreadsheet and KMZ/CAD file formats • Digital photographs of all survey and check sites, with the site ID included in the filename. The bearing of the photo direction will also be included • Other related information
Flight Trajectories	• All flight trajectories used for the capture of the delivered LiDAR and photograph data will be supplied in KMZ/CAD files. The KMZ/CAD file table's must include the date of capture, local start time, local end time and which reference station was used for each trajectory. The KMZ/CAD file will show photo footprint and its center.
Metadata	• Project level metadata for each deliverable product must be created. Metadata must be delivered that fully comply with FGDC metadata format standard in extensible Markup Language (XML) format .Metadata must contain the following information: • Collection Report detailing mission planning and flight logs • Survey Report detailing the collection of ground control and reference points used for both data

	calibration and QA/QC accuracy assessments. • Processing Report detailing LiDAR calibration, LiDAR classification, and product generation procedures including methodology used for break line collection and hydro-flattening. • QA/QC Reports detailing the analysis, accuracy assessment and validation of the point data (absolute, within swath, and between swath); the bare-earth surface (absolute); and other optional deliverables as appropriate Control and Calibration points: All control and reference points used to calibrate, control, process and validate the LiDAR point data or any derivative products will be delivered. Geo-referenced, digital spatial representation of the precise extents of each delivered dataset. This should reflect the extents of the actual LiDAR source or derived product data, exclusive of Triangular Irregular Network (TIN) artifacts or raster NODATA areas. All metadata files must contain sufficient content to fully detail all procedures used for data processing, QAQC, and finalization.
Project Report	The Project Report will comprise a technical discussion addressing how each of the contract specifications has been met, a statement of consistency with any specified standards, results of independent accuracy and validation tests, metadata statements and extra-ordinary issues that may have affected the nature or delivery of the project. All aspects of the project operations must be adequately reported.

d) Quality Assurance Specifications

Items	Specifications
Fundamental Spatial Accuracy Validation (FSA)	The onus for reaching the required accuracy i.e.±10cm) lies with the contractor. Independent accuracy assessments will also be carried out. The number of check points (locations) will be at least 10 per 5 km of length. **A separate DGPS (preferably in static mode) survey will be carried out with reference to same control network by contractor for this purpose. To save time, this activity may be carried out in advance i.e. during densification of DGPS control for LiDAR survey.** **Vertical Accuracy Validation** 1. The vertical accuracy of the point cloud dataset is to be tested using a TIN surface constructed from bare-earth LiDAR points compared against ground survey check points. 2. Check points are to be surveyed independently of any LiDAR GPS operations. Check points must adequately cover the full extent of the survey area, and be representative of the project area landscape. **Horizontal Accuracy Validation** 1. Contractor is required to report horizontal accuracy achieved. 2. The contractor will use feature based horizontal accuracy measures to report horizontal accuracy and will notify the approach in post-survey spatial accuracy report. **FSA will be reported in the format attached as Annex-AA. Independent validation will also be carried out by Railway and/or any other agency. The contractor would be required to resolve issues, if any, found in independent validation**

(e) Validation Check:

After completing LiDAR Survey, the contractor will supply the final data and drawings as per technical specification to Railway. For validation by DGPS/Total Station of drawings created using LiDAR data, the entire corridor will be divided into stretches of 10 km each. Each 10 km stretch will be validated independently in the manner explained below:

a) During staking of alignment and topographical survey, a team arranged by Agency will carry out verification/validation survey of drawing created using Aerial LiDAR output (at least **25** points/ km) of permanent structures like buildings/ bridges/ temples/ wells etc. This has to be done in the supervision of Railway.

b) The difference in coordinates (x,y,z) of these points should not be more than+/-**15** cm, when compared with the coordinates obtained through DGPS/Total Station (by LiDAR Contractor through approved Independent Agency).

c) Payment for the entire stretch will be released, if linear error is within permissible limits for less than 10% points of total points checked within 10km stretch.

d) In case, the difference is more than the permissible limits for 10% and above of total points checked within 10km stretch, the payment for entire stretch of 10 km will not be released till further checking.

e) In case of error found beyond permissible limits, the LiDAR contractor will have to carryout joint verification with the agency team in the presence of Railway representative. During this process, if the LiDAR contractor's work is found faulty for more than 10% of the checked points of 10 km stretch, the contractor has to redo the defective stretch of the work at his own cost.

f) In addition, he would be liable to a penalty of 100% of total cost of that particular 10 km stretch against item-1 of the Schedule of Rates. This will be over and above liquidated damages imposed, if any.

The work will be carried out to the required level of accuracy specified in "Scope of Services & Objectives" Section. In case, the required level of accuracy is not achieved, the Contractor will have to repeat the work and payment will be made only after satisfactory level of accuracy is achieved.

2.13 Deliverables of LiDAR Survey

The following are the deliverables for the LiDAR survey:

a. One set of un classified LAS files- for specifications refer **Annex-BB.**

b. One set of classified LAS files in accordance with the tiling schema (to be decided in consultation with Railway) - for specifications refer Annex-BB

c. One set of raster DEM's (hydro flattened bare earth) delivered in the specified grid format (for e.g., GeoTIFF). The DEM's must also be delivered in the project tiling and required naming schema.

d. One set of 1-meter intensity imagery in Geo TIFF file format.

e. One set of Metadata for each data deliverable.

f. Digital Ortho photos of 10cm GSD resolution (in tiles and seamlessly mosaicked over the AOI) in Geotiff format as per detailed specification mentioned in **Annex-CC.**

g. Three dimensional topographic survey drawing including contours (0.5m interval) of AOI, on a scale of **1:1000** as per detailed Specification mentioned in **Annex-DD.** A sample drawing shall be got approved from Engineer in charge before taking up drawing preparation for AoI.

h. DSM/DEM as per detailed specifications mentioned in **Annex-EE.**

i. Break lines in dwg format as per specifications mentioned in **Annex-FF.**

j. Longitudinal plan with all details in the Area of Interest for the project section in dwg format as per sample profile (will be decided during project execution) for the existing tracks.

k. Cross section at 20 m interval in dwg/xls format as per sample profile.

l. Supply of 3 Nos of All in one Desktop PC (HP, DELL, ASUS) – i9/i7, 12th generation processor with minimum 32 GB DDR4 RAM, 1 TB SSD, Intel UHD 770/NVIDIA graphics card or higher along with windows latest operating system, MS office, with 3 years onsite warranty, to suit the verification and utilization of all LiDAR processed data and outputs along with all licensed softwares (3 Nos of 3D Civil and Two nos of Autocad, ~~Open Rail, Global mapper~~, Five nos of Adobe Professional, and any other software required for the project) (except required for processing of LiDAR raw data) required for the project with validity for 1 year from the actual date of completion of the project.

m. Supply of Printers – (1) Color A3 all in one ink tank re-fill system printer with Wi-fi, Ethernet, USB connections, Auto Duplex printing, similar to Brother

MFC T4500 DW. (2) Color All in one A4 printer ink tank system with Wi-fi, Ethernet, USB connections, Auto Duplex printing, similar to HP 6075.

n. **Collection Report** : A collection report detailing mission planning and flight logs will be submitted.

o. **Survey Report:** A survey report detailing the collection of all ground control, HFL including the following will be submitted.

- Control points used to calibrate and process the LiDAR and derivative data
- Check points used to validate the LiDAR point data or any derivative product

p. **Processing Report**: A processing report detailing calibration, classification and product generation procedures including methodology used for break line collection and hydro- flattening will be submitted.

q. **QA/QC Report:** A QA/QC report, detailing procedures for analysis, accuracy assessment and validation of the following will be submitted.

- Point data (Absolute vertical accuracy / relative vertical accuracy)
- Bare earth surface (absolute vertical accuracy)

r. **LIDAR Project Report:** LiDAR project report must be delivered at the end of the processing along with the final delivered products. The project report serves as the primary report for the LiDAR survey carried out and includes detailed explanation on the processing and qualitative assessment performed on the data. The quantitative analysis and the accuracy results should be clearly demonstrated and information on all survey points used for the accuracy analysis must be included. Break line production procedures should be well defined including the production methodology, qualitative assessment and topology rules used for the project. A data dictionary defining the horizontal and vertical datum, coordinate system and projection used for this project and all break line feature definitions for streams and rivers, and inland lakes and ponds should be clearly defined. The DEM production methodology and QA/QC assessment on the DEMs must be clearly explained.

Table of Contents of a Lidar project report is placed below:

Table of Contents Executive Summary

The Project Team

Date of LiDAR Survey Datum Reference

Lidar Vertical Accuracy Project Deliverables Project Tiling Footprint

LiDAR Acquisition Report

LiDAR Acquisition Details

LiDAR Control Airborne GPS Kinematic

Generation and Calibration of Laser Points (raw data) Absolute and Relative accuracy

Preliminary Vertical Accuracy Assessment Final Swath Vertical Accuracy Assessment

LiDAR Processing & Qualitative assessment

Data Classification and Editing Qualitative Assessment
Analysis Derivative LiDAR Products Model Key Points
Bare-Earth
LiDAR First
Return LiDAR
Last Return
LiDAR
Survey Vertical Accuracy Checkpoints

LiDAR Horizontal & Vertical Accuracy Statistics & Analysis

Background

Horizontal Accuracy Test Procedures Horizontal Accuracy Testing Steps
Horizontal Accuracy Results
Vertical Accuracy Test Procedures Vertical Accuracy Testing Steps Vertical Accuracy Results
Break line Production & Qualitative Assessment Report

Break line Production Methodology

Break line Qualitative Assessment Break line Topology
Rules Break line QA/QC Checklist

Data Dictionary

Horizontal and Vertical Datum Coordinate System and Projection Inland Streams and Rivers
Description Table
Definition Feature
Definition
Inland Ponds and Lakes
Description Table
Definition Feature
Definition Tidal Waters
Description Table
Definition Feature
Definition

DEM Production & Qualitative Assessment

DEM Production Methodology DEM Qualitative Assessment DEM Vertical Accuracy Results

DEM QA/QC Checklist.

Appendix A: Survey Reports NOTE:

- Topographical Survey Plans in DWG format for the route alignments as per scope of work including CSV files
- The final CAD output should be compatible with AutoCAD Civil 3D Software and similar in hard and soft copies in desired numbers
- Video file merged for entire length of corridor in 4k quality in mp4 format with a Special Video player with 4K Monitor & Player for viewing the videos. The video file shall be based on DEM based Ortho.
- Similarly, survey reports with all drawings and data covering entire scope of work will be submitted in editable format (e.g.MS-Word, MS- Excel, AutoCAD etc., as may be applicable) in hard and soft copies in desired numbers
- Soft and hard copies in 4 sets will be submitted by the agency. One copy of draft and three copies of the final submissions.
- Daily, weekly and monthly reports shall be prepared and submitted by agency
- Method Statements and Work Schedule before start of work to be submitted.

2.14 HYDROLOGICAL STUDIES FOR SPAN CONFIGURATION OF BRIDGES

i. Hydrological Study of rivers/ nallas / khads crossings will be performed wherever new bridges are proposed by the Consultant. The study shall include:

ii. Calculation & finalization of hydraulic design parameters such as design discharge, design HFL, linear waterway etc.

iii. Study of drainage patterns for a feasibility study of bridges, slopes, deep cuttings, high embankment, landslide area etc.

iv. Finalization of span configuration of bridges based on linear waterway calculated on the basis of design discharge and other hydraulic design parameters, slope stability, geology, topography, type of bridge, launching scheme etc. will be performed by the consultant.

2.15 Scope of Detailed Survey and documents submission.

(i) Finalisation of span configuration of Bridges based on the hydrological study and other ground conditions, alignments etc. and design.
(ii) Finalisation of tunnel length, shape and design. It should cover tunnel working design, drawings, details of works involved, tunnel ventilation system, Fire detection, supervision system, Illumination scheme, Communication system for maintenance & emergencies, Evacuation system like escape tunnel design, surveillance system, Proposed execution scheme, removal of muck during execution, list equipment required for execution, Signalling system, Design of Railway Electrification.
(iii) Finalisation of span configuration of ROB/RUB and other crossing structures and design.
(iv) Preparation of land acquisition plans, land acquisition proposals and documents including obtaining the revenue maps and visiting the concerned offices. The land acquisition plan to be digitised by the contractor as directed. Calculation of area of land to be acquired along with details of plot and its owners, valuation of structures etc are to be carried out by the agency as per the direction.
(v) Visit of experts to the site for checking the feasibility and study for flinalising the Bridges, Tunnels and other structures.
(vi) Detailed formation design on the basis of slope stability design consideration.
(vii) The contractor should obtain forest clearances and no additional payment for the work.
(viii) Preparation and submission of Cost estimate, BOQ, Rate analysis, EPC/normal tender documents for the assigned projects as per the requirement of Railway and as directed by the Engineer in charge of the work.
(ix) The scope includes arrangements for approach roads, service roads, clearing of bushes/grass/shrubs as directed by the Engineer in charge.
(x) The scope includes conducting Environmental Impact Assessment (EIA) study.
(xI) Procurement/collection of standard RDSO/Railway drawings, Revenue Maps, other approved drawings and its utilisatiion in the project shall be the responsibility of the contractor.

2.16 Preparation of Land Plans:

The scheme will contain the following:

(i) The center line of proposed alignment and also the corridor of land acquisition shall be marked on the ground at each 100 M interval as well as at the change of land boundary or as directed by Engineer.

(ii) Revenue village map of the entire area shall be collected by the Contractor.

(iii) The center line of proposed Railway alignment & also the corridor of land acquisition shall be marked on revenue village map.

(iv) Record of Rights of all plots which are falling in the proposed land acquisition corridor shall be collected from Revenue department. Details of Govt. & forest land should also be collected.

(v) Plot wise area of land acquisition (Private/Govt./Forest) shall be calculated.

(vi) Ratio of area of plot proposed to be acquired to the total plot shall also be calculated. Details of buildings, water sources etc coming in way of proposed alignment shall also be submitted separately.

(vii) Collection of sale data of land transactions of last five years required for land acquisition on (Private Land).

(viii) Collection of all relevant details of government & forest lands separately to facilitate preparation of papers for their acquisition.

(ix) The scope of work will include plotting the land boundary on drawing.

(x) Preparation of Land acquisition proposal as per prevailing guide line/policy and practice in vogue. No any extra claim of agency will be entertained due to deviation in procedure or extra activities and documentation.

2.17 Other Deliverables in the Project Scope

Submission of drawings and reports as below.

Sl. No.	Particulars	Scale	No. Of copies to be submitted
1	Alignment plan (duly marking required existing details along the alignment and additional details for a minimum width of 50m on either side of track where proposed realignment of track is involved) (preferably 2 to 3km for each sheet and sheet width 50cm (approx.))The plan should include UP and DN line details. Payment for the item is inclusive of both the tracks.	20metre to 1cm	Check print:2 nos. on white paper. Final print in soft copy and hard copy (after approval)
2	Alignment section (preferably 5 to 7.5km for each sheet and sheet width 50cm (approx.) Horizontal Vertical	 50 m to 1cm 5 m to 1cm	Check print:2 nos. on white paper. Final print in soft copy and hard copy (after approval)
3	Working plan (duly marking required existing and proposed details for a minimum width of 50m on either side where realignment is involved and to the extent required at regrading locations) (preferably 2 to 3km for each sheet and sheet width 50cm (approx.)	20metre to 1cm	a) Check print:2 nos. in white paper. b) Final print in soft copy and hard copy (after approval)

4	Working section containing UP and DN line (preferably 5 to 7.5km for each sheet and sheet width 50cm (approx.) at curves where realignment is involved and at regrading location Horizontal Vertical	 50 m to 1cm 5 m to 1cm	a) Check print:2 nos. on white paper. b) Final print in soft copy and hard copy (after approval)
5	Cross section at 100m intervals(A3 size)	Horizontal & Vertical in same scale	a) Check print:2 nos. b) Final print: 2 copies
6	Index plan	0.5km to 1cm	a) Check print:2 nos. in white paper. b) Final print in soft copy and hard copy (after approval)
7	Index section Horizontal Vertical	 0.5km to1cm 10 m to 1cm	a) Check print:2 nos. on white paper. b) Final print in soft copy and hard copy (after approval)
8	General map (in A3 size)	Not to scale	2 copies
9	Index map	2.5km to 1cm	2 copies
10	Diagram for Important/Major bridges, ROB, RUB and Level crossings.	A3/A4 size	a) Check print:2 nos. on white paper. b) Final print in soft copy and hard copy (after approval)
11	Station yard plan.	1 : 1000	a) Check print:2 nos. on white paper. b) Final print in soft copy and hard copy (after approval)
12	OHE installation plan	1:100	a) Check print:2 nos. on white paper. b) Final print in soft copy and hard copy (after approval)

13	Interlocking plan	1:2000	a) Check print:2 nos. on white paper. b) Final print in soft copy and hard copy (after approval)
14	Detailed estimate and DPR as per Indian Railway Engineering code (Civil engineering, electrical engineering and Signal and telecommunication engineering) along with Traffic study and Rate of Return calculations as per latest Railway Board Circulars during submission.	Detailed estimate, DPR, Traffic study and RoR calculations are to be carried out as per latest Railway Board guidelines	a) 2 copies for approval. b) 5 copies (after approval) & soft copy
15	Hydrological Report		a) 2 copies for approval. b) 2 copies (after approval) & soft copy
16	EPC Tender Documents		a) 2 copies for approval. b) 2 copies (after approval) & soft copy
17	Design of structures		a) 2 copies for approval. b) 2 copies (after approval) & soft copy
18	Utility Survey details		a) 2 copies for approval. b) 2 copies (after approval) & soft copy
19	Land plans & land acquisition details		a) 2 copies for approval. b) 2 copies (after approval) & soft copy
20	Conceptual plans of proposed stations		a) 2 copies for approval.

			b) 2 copies (after approval) & soft copy
	Note: Autocad drawing of all plans and soft copy of all plans & documents to be submitted by the contractor as and when instructed by the Engineer in charge.		

2.18 Engagement of Personnel:

To render the above services effectively and efficiently, The Contractor should deploy the following personnel with minimum requisite qualification and experience as mentioned hereunder as per the scope of project. The below list of personnel is only indicative and the contractor should deploy all necessary personnel as required for satisfactory completion of the work and no additional payment is applicable for deployment of the personnel. Payment will be based on the completion of works as per the scope of the work.

The personnel engaged by the Contractor will be required to attend the Offices of CAO/Constriction/ERS, Division offices, Head Quarters/SR & Railway Board for attending meetings with various Railway Authorities required for the discussion & progress of the works. The additional payment on this account is not applicable for the same.

S. No	Designation	Nos.	Minimum required Educational qualifications and/or Experience
1	Team Leader cum Project Manager	1	Qualification: Graduate in Civil Engineering with minimum 15 years' experience (experience will be counted only after Graduation). (OR) At least 7 years' service in JAG & above in Civil Engineering Department or in equivalent grade in Indian Railways/RITES/ IRCON/RVNL or equivalent grades in Konkan Railway/MRVC/DFCCIL/any JVs/SPVs with Ministry of Railways, any Metro Rail Corporation either individually or combined.
2	Civil Engineer: Alignment Engineer	1	Qualification: Graduate in Civil Engineering with minimum 5 years' experience after Graduation or Diploma in Civil Engineering with minimum 7 years' experience. (OR) At least 4 years' service in JAG & above in Civil Engineering Department or 7 years' service in Senior Scale / Junior Scale or in equivalent grade in Indian Railways/RITES/IRCON/RVNL or equivalent grades in

			Konkan Railway/MRVC/DFCCIL/any JVs/SPVs with Ministry of Railways, any Metro Rail Corporation either individually or combined.
3	Traffic Expert	1	Qualification: Graduate in Civil Engineering with minimum 4 years experience in Transportation Planning & Economics (OR) At least 4 years' service in JAG & above in Operating Department or 7 years service in Senior Scale / Junior Scale or in equivalent grade in Indian Railways/RITES/IRCON/RVNL or equivalent grades in Konkan Railway/MRVC/DFCCIL/any JVs/SPVs with Ministry of Railways, any Metro Rail Corporation either individually or combined.
4	Electrical Expert (OHE/ TRD)	1	Qualification: Graduation in Electrical Engineering with minimum 4 years' experience in Railway assignment. (OR) At least 4 years' service in JAG & above in Electrical Department or 7 years service in Senior Scale / Junior Scale or in equivalent grade in Indian Railways/RITES/IRCON/RVNL or equivalent grades in Konkan Railway/MRVC/DFCCIL/any JVs/SPVs with Ministry of Railways, any Metro Rail Corporation either individually or combined.
5	Signal & Telecommunication Expert	1	Qualification: Graduation in Electronics and Telecommunication Engineering with minimum 4 years' experience in Railway assignment. (OR) At least 4 years' service in JAG & above in Signalling & Telecommunication Department or 7 years service in Senior Scale / Junior Scale or in equivalent grade in Indian Railways/RITES/IRCON/RVNL or equivalent grades in Konkan Railway/MRVC/DFCCIL/any JVs/SPVs with Ministry of Railways, any Metro Rail Corporation either individually or combined.
6	Civil Engineer: Estimator	1	Qualification: Graduate in Civil Engineering with minimum 4 years' experience after Graduation or Diploma in Civil/Survey Engineering with minimum 7 years' experience. (OR) At least 4 years' service in JAG & above in Civil Engineering Department or 7 years service in Senior

			Scale / Junior Scale or in equivalent grade in Indian Railways/RITES/IRCON/RVNL or equivalent grades in Konkan Railway/MRVC/DFCCIL/any JVs/SPVs with Ministry of Railways, any Metro Rail Corporation either individually or combined.

Sl No	Designation	Qualifications
1	Sr.Photogrammetry Expert	Post Graduate in Geomatics/Geo-Informatics/MSC. Geology/Surveying/ Remote sensing and Mapping with minimum of 5years'experience in Photogrammetry related works And iii. Relevant experience in at least one Linear project of Railways/Highways/Metro/Irrigation projects.
2	Estimation expert	1. Graduate/Diploma/in Civil Engg. Or With specialization in estimation having at least three years of experience in estimation of Railway/highway//Metro Projects. (OR) 2. Retired Railway SSE/W, AEN/XEN having minimum 3 years of Survey experience.
3	Sr.Geotechnical Expert	Graduate in Civil Engineering/ PG in Geo-technical Engineering/ MSc Geology with minimum of 5years'experience in geotechnical investigation and Geo-Technical designs of Railway/highway/Metro Projects.
4	Drawing Expert/CAD lead	Graduate/Diploma in Civil Engg. With specialization in AutoCAD/ Autodesk 3D Civil/Micro Station/Navis work or similar of Software and having Atleast three years' experience in Preparation of GADs/Lsection/ ESPs of Railway/Metro/highway Projects.
5	Land Acquisition Expert	Land Acquisition Expert shall have sufficient experience in Land acquisition and dealing with State Revenue Authorities.

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2.19 Payment Schedule for LiDAR Item of Schedule.

- 5% of accepted cost of work on completion, setting up of control points and submission of data of DGPS works and starting of LiDAR Survey.
- 10% of accepted cost of work on satisfactory completion of LiDAR survey and submission of LiDAR survey data, supply of computers, printers and installing all softwares as per deliverables.
- 25% of accepted cost of work on satisfactory completion and submission of draft of drawings, other documents as per deliverables of LiDAR survey and completion of Validation check of LiDAR data at site.
- 25% of accepted cost of work on satisfactory completion and submission of final drawings as per LiDAR deliverables and submission of draft drawings of all other plans including OHE and signal plans.
- 5% of accepted cost of work on submission of Draft Detailed Project Report and Draft Detailed Estimate.
- 20% of accepted cost of work on satisfactory completion and submission of final Detailed Project Report and all deliverables.
- Balance 10% of the amount on Acceptance of final survey report with all deliverables.

2.20 Time Schedule for the Final Location Survey and Detailed Survey

Following time schedule shall be adhered to by the agency strictly

(a) Time schedule for TVC-NCJ FLS

Main Activities	**Target** (D is the Date of issue of LOA)
1.Collection of data and submission of alignments	D+15 days
2. Submission of details for alignment approved by Railway	D+20 days
3. Statutory approvals	D+20 days
4. Completion of field work for setting up all control points by DGPS and Auto levels and finishing all preparatory works for doing LiDAR Survey for the selected alignment	D+30days
5.Aerial LiDAR Survey and data capturing, Drone survey, Traffic survey and collections of all other data as per scope of work	D+60 days
6. Submission of Hydrological report, Utility Survey details etc.	D+70 days

7. Processing, preparation, CAD work, and submitting the data and CAD survey plan (draft) including XYZ data and DTM etc.	D+90 days
8. Preliminary Survey Report, Plans, WS & WP, OHE, Interlocking plans etc.	D+110 days
8. Draft DPR, Detailed Estimate, Draft EPC documents.	D+120 days
9. Final Survey Report, deliverables, DPR and DE.	D+150 days
10. Submission of draft EPC documents, Land acquisition details, OHE, Signal details.	D+160 days
11. Submission of final EPC documents, Land acquisition details,OHE and Signal details.	D+180 days
Note:- Agency to put adequate independent teams for field Surveys, processing data, plotting works, reporting and final submission to achieve the above targets.	

(b) Time schedule for new FLS works

Main Activities	**Target** (L is the Date of issue letter by Railway regarding the details of new project)
1.Collection of data and submission of alignments	L+15 days
2. Submission of details for alignment approved by Railway	L+20 days
3. Statutory approvals	L+20 days
4. Completion of field work for setting up all control points by DGPS and Auto levels and finishing all preparatory works for doing LiDAR Survey for the selected alignment	L+30days
5.Aerial LiDAR Survey and data capturing, Drone survey, Traffic survey and collections of all other data as per scope of work	L+60 days
6. Submission of Hydrological report, Utility Survey details,	L+70 days
7. Processing, preparation, CAD work, and submitting the data and CAD survey plan (draft) including XYZ data and DTM etc.	L+90 days

8. Preliminary Survey Report, Plans, WS & WP, OHE, Interlocking plans etc.	L+110 days
8. Draft DPR, Detailed Estimate, Draft EPC documents.	L+120 days
9. Final Survey Report, deliverables, DPR and DE.	L+150 days
10. Submission of draft EPC documents, Land acquisition details,OHE, Signal details.	L+160 days
11. Submission of final EPC documents, Land acquisition details,OHE and Signal details.	L+180 days
Note:- Agency to put adequate independent teams for field Surveys, processing data, plotting works, reporting and final submission to achieve the above targets.	

(c) Time schedule for AFK-Erumeli (Sabarimala) new line - Detailed Survey.

Main Activities	**Target** (D is the Date of issue of LOA)
1.Collection of data and submission of alignments	D+15 days
2. Submission of details for alignment approved by Railway	D+20 days
3. Statutory approvals	D+20 days
4. Completion of field work for setting up all control points by DGPS and Auto levels and finishing all preparatory works for doing LiDAR Survey for the selected alignment	D+30days
5.Aerial LiDAR Survey and data capturing, Drone survey, Traffic survey and collections of all other data as per scope of work	D+60 days
6. Submission of Hydrological report, Utility Survey details, Land acquisition details, Land plans etc.	D+90 days
7. Processing, preparation, CAD work, and submitting the data and CAD survey plan (draft) including XYZ data and DTM etc.	D+100 days
8. Preliminary Survey Report, Plans, WS & WP, OHE, Interlocking plans etc.	D+120 days
9. Detailed Estimate, Draft EPC documents, Design details of tunnel & Bridges	D+150 days

10. Final Survey Report, deliverables, DE, EPC documents	D+180 days
Note:- Agency to put adequate independent teams for field Surveys, processing data, plotting works, reporting and final submission to achieve the above targets.	

(d) Time schedule for TUVR-AMPA Doubling - Detailed Survey

Main Activities	**Target** (D is the Date of issue of LOA)
1.Collection of data and submission of alignments	D+15 days
2. Submission of details for alignment approved by Railway	D+20 days
3. Statutory approvals	D+20 days
4. Completion of field work for setting up all control points by DGPS and Auto levels and finishing all preparatory works for doing LiDAR Survey for the selected alignment	D+30days
5.Aerial LiDAR Survey and data capturing, Drone survey, Traffic survey and collections of all other data as per scope of work	D+60 days
6. Submission of Hydrological report, Utility Survey details, Land acquisition details, Land plans etc.	D+90 days
7. Processing, preparation, CAD work, and submitting the data and CAD survey plan (draft) including XYZ data and DTM etc.	D+100 days
8. Preliminary Survey Report, Plans, WS & WP, OHE, Interlocking plans etc.	D+120 days
9. Detailed Estimate, Draft EPC documents, Design details of tunnel & Bridges	D+150 days
10. Final Survey Report, deliverables, DE, EPC documents	D+180 days
Note:- Agency to put adequate independent teams for field Surveys, processing data, plotting works, reporting and final submission to achieve the above targets.	

Validation of Accuracy **Annex-AA**

Sample for Reporting Validation of Accuracy

Check Point ID	Ground Control Points/Features from DGPS survey			Observed Test Points (LiDAR)			Difference (m)			RMSE (diff in)2			
	X (m)	Y (m)	Z (m)	X (m)	Y (m)	Z (m)	Dx (m)	Dy (m)	Dz (m)	$(\text{diff in x})^2$	$(\text{diff in y})^2$	$(\text{diff in z})^2$	$(\text{diff in x})^2 + (\text{diff in y})2$
105	294226.142	2310266.942	24.199	294225.758	2310267.536	24.324	0.384	-0.594	-0.125	0.148	0.352	0.016	0.500
106	289321.775	2312372.274	17.827	289322.264	2312372.169	17.827	-0.489	0.105	0.000	0.239	0.011	0.000	0.250
107	292984.760	2314625.737	21.073	292984.655	2314625.248	21.198	0.105	0.489	-0.125	0.011	0.239	0.016	0.250
108	288238.514	2317126.672	11.536	288238.951	2317126.323	11.536	-0.437	0.349	0.000	0.191	0.122	0.000	0.313
109	292060.929	2318911.930	17.379	292060.737	2318912.227	17.129	0.192	-0.297	0.250	0.037	0.088	0.063	0.125
112	289325.747	2324475.767	21.416	289326.044	2324475.959	21.541	-0.297	-0.192	-0.125	0.088	0.037	0.016	0.125
113	283377.779	2327073.562	12.018	283377.185	2327073.178	12.018	0.594	0.384	0.000	0.352	0.148	0.000	0.500
114	286686.102	2328218.890	8.988	286685.858	2328218.942	9.113	0.244	-0.052	-0.125	0.060	0.003	0.016	0.063
115	282454.312	2331582.318	11.448	282453.823	2331582.423	11.198	0.489	-0.105	0.250	0.239	0.011	0.063	0.250
116	286557.382	2333052.949	13.578	286557.330	2333052.705	13.703	0.052	0.244	-0.125	0.003	0.060	0.016	0.063
117	282901.823	2336131.645	16.133	282901.771	2336131.401	16.383	0.052	0.244	-0.250	0.003	0.060	0.063	0.063
118	287402.604	2338089.098	19.238	287402.901	2338089.290	19.363	-0.297	-0.192	-0.125	0.088	0.037	0.016	0.125
121	283637.945	2341647.138	18.900	283637.997	2341647.382	18.775	-0.052	-0.244	0.125	0.003	0.060	0.016	0.063
122	287502.736	2342922.841	29.961	287502.492	2342922.893	29.961	0.244	-0.052	0.000	0.060	0.003	0.000	0.062
123	283030.867	2346146.651	17.663	283031.059	2346146.354	17.538	-0.192	0.297	0.125	0.037	0.088	0.016	0.125
124	287274.629	2348356.243	22.638	287274.681	2348356.487	23.013	-0.052	-0.244	-0.375	0.003	0.060	0.141	0.063
125	282982.546	2350288.411	17.310	282982.005	2350288.271	17.060	0.541	0.140	0.250	0.293	0.020	0.063	0.313
126	288074.376	2353250.506	35.643	288074.184	2353250.803	35.518	0.192	-0.297	0.125	0.037	0.088	0.016	0.125
127	282355.427	2355790.537	20.440	282355.183	2355790.589	20.190	0.244	-0.052	0.250	0.060	0.003	0.063	0.063
129	282186.936	2362053.480	23.303	282187.128	2362053.183	23.428	-0.192	0.297	-0.125	0.037	0.088	0.016	0.125
130	286224.569	2363030.850	21.168	286225.058	2363030.745	21.043	-0.489	0.105	0.125	0.239	0.011	0.016	0.250
131	280856.196	2366533.494	17.265	280856.440	2366533.442	17.390	-0.244	0.052	-0.125	0.060	0.003	0.016	0.063
132	285192.722	2367981.603	22.964	285192.914	2367981.306	22.839	-0.192	0.297	0.125	0.037	0.088	0.016	0.125
134	287441.330	2373242.098	21.110	287441.278	2373241.854	20.735	0.052	0.244	0.375	0.003	0.060	0.141	0.063
135	283895.024	2375614.396	23.734	283895.268	2375614.344	23.859	-0.244	0.052	-0.125	0.060	0.003	0.016	0.062
136	288687.783	2377348.520	28.196	288687.294	2377348.625	27.821	0.489	-0.105	0.375	0.239	0.011	0.141	0.250
										Sum	0.953	4.375	
										Average	0.037	0.168	
										RMSE	0.191	0.410	
										NSSDA	0.375	0.710	

:

LiDAR Point Cloud (data) Specifications **Annex-BB**

Sl No	Deliverables	Specifications
1	**Data**	a. Each LiDAR LAS file (per tile) produced should contain the following elements, as a minimum, for each return: i. The return number for each signal ii. Horizontal and Vertical Position (x,y,z) in the specified horizontal and vertical datum iii. Intensity return values for each return signal iv. GPS Timestamp of capture for each point (the timestamp should be unique for each laser pulse) v. Geo-reference information included in the LAS header b. LiDAR data from different flight lines will be consistent across flight lines with a maximum 7-10 cm vertical offset between adjacent flight lines. This is referred to as the relative accuracy. c. No data voids due to system malfunctions or lack of overlap. d. Dense vegetation data voids minimized by automatic removal process. e. The lineage (metadata), positional, content (completeness), attribution, and logical consistency accuracies of all digital elevation data produced will conform to the specifications. f. Product Accuracy Information Reporting: Product accuracy information will be reported according to NSSDA guidelines. At a minimum, statements concerning source materials and g. Production processes used will be provided in the metadata sufficient to meet the requirement of the Accuracy Standards. h. LiDAR data will be classified correctly with limited artifacts or misclassifications remaining in the dataset. i. LiDAR processing and editing will be consistent. j. Statisticsrunon100%ofthedatawillverifyfileformatting, projection information, classes used, scan angles, returns per pulse, and nominal point density.
2	**Unclassified Point Cloud**	a. All returns, all collected points, fully calibrated and adjusted to specified vertical datum, by swath. (file size not to exceed 2GB). b. Fully compliant LAS v1.2 (or v1.3), point record format with all standard attributes including: c. Intensity values (native radiometric resolution). d. Return number. e. Geo-referencing information in all LAS file headers. f. GPS times recorded as adjusted GPS time, at a precision

<table>
<tr><td></td><td></td><td>sufficient to allow unique timestamps for each pulse.
g. Data is to be provided in the following:
i) Orthometric (Survey of India Vertical Datum)
ii) Ellipsoidal (WGS-84).</td></tr>
<tr><td>3</td><td>Classified Point Cloud</td><td>a. All returns, all collected points, fully calibrated and adjusted to specified vertical datum, and classified as specified below.
b. Fully compliant LASv1.2(orv1.3), point record format with all standard attributes including:
i) Intensity values (native radiometric resolution).
ii) Return number.
iii) Geo-referencing information in all LAS file headers.
iv) GPS times recorded as adjusted GPS time, at a precision sufficient to allow unique time stamps for each pulse.
v) ALL points not identified as “Withheld” are to be classified.
c. Data is to be provided in the following Vertical Datums:
i) Orthometric (Survey of India Vertical Datum)
ii) Ellipsoidal (WGS-84).
d. Tiled delivery</td></tr>
<tr><td></td><td>Required Point Cloud Classificatio n Level</td><td>a. All classified point cloud data must adhere to the following classification scheme. (The ASPRS scheme of classification can be seen for reference)
b. The minimum number of point classes to be delivered according to this scheme is defined by the Classification Level specified below
<table><tr><th>Number</th><th>Point Class</th><th>Description</th></tr><tr><td>0</td><td>Unclassified</td><td>Created, never classified</td></tr><tr><td>1</td><td>Default</td><td>Unclassified</td></tr><tr><td>2</td><td>Ground</td><td>Bare Ground</td></tr><tr><td>3</td><td>Low Vegetation</td><td>0-0.3m</td></tr><tr><td>4</td><td>Medium Vegetation</td><td>0.3-2m</td></tr><tr><td>5</td><td>High Vegetation</td><td>>2m</td></tr><tr><td>6</td><td>Building Structure</td><td>Buildings, sheds, houses and silos etc</td></tr><tr><td>7</td><td>Low/highpoints</td><td>Spurious high/low point returns (unusable)</td></tr><tr><td>8</td><td>Model Key Points</td><td>Reserved for model key points only</td></tr><tr><td>9</td><td>Water</td><td>Any point in water</td></tr><tr><td>10</td><td>Bridge</td><td>Any Bridge or over pass</td></tr><tr><td>11</td><td>Not used</td><td>Reserved for future definition</td></tr></table></td></tr>
</table>

		12	Overlap points	Flight line overlap points
		13-31	Not used	Reserved for future definition

Digital Ortho Photo Specifications **Annex-CC**

Sl No	Deliverables	Specifications
1	**Ortho-rectification**	a. The digital elevation data required for this process shall be provided by the LiDAR deliverables specified above. b. The rectification process shall use the polynomial resampling technique to ensure high accuracy and image quality. c. The mosaicking process shall minimize image distortions and smearing and produce a seamless edge-matched product. d. Ortho-rectified Image Chips shall be tonally balanced prior to generation of an image mosaic. Relative join(misalignment) of transportation features between adjacent image chips/tiles shall be within the tolerance defined by the horizontal positional accuracy requirement set out above. e. The rectification process shall involve a solution of the appropriate photogrammetric equations for each pixel in the output image. It is not preferable to solve photogrammetric equations at anchor points only and then warp the content of the original image between the anchor points. f. The Contractor will describe their approach for ortho-rectification.
2	**Radiometry**	a. All images will be clear and sharp in detail with no light streaks, static marks, scratches, or other noticeable blemishes. The imagery will be free from defects, such as out-of-focus imagery, and will not contain inconsistencies in tone and/or density between individual orthos and/or adjacent sheets. To ensure consistency, the imagery will be radiometrically and geometrically corrected to enable adjacent files to be displayed simultaneously without obvious distinctions between them. b. The Contractor will describe their technical approach to producing radiometry balance.
3	**Digital ortho images**	c. Seamless mosaic at 5cm pixel resolution. d. Edge-matched, non-overlapping tiles at anticipated 5cm pixel resolution

3D Topographic Survey Specifications **Annex–DD**

S. N.	Deliverables	Specifications
1	**Topographic Plan**	**1. Preparation of Topographic Map** This activity will include 3D digitization of all the features (natural and manmade) e.g. existing roads, extension of settlements, change in land use pattern, change in water bodies, etc. and capturing new features e.g. new roads/railways, new settlements, etc. The scale of topographic map will be standard 1:1 as available after ortho- rectification; however, font size for text matter should be suitable for a scale of 1: 2,500. The topographic map consisting of all the features shall be prepared in AutoCAD environment as one drawing and in blocks of suitable length along the alignment as may be decided during the execution of work. There will be separate layer for each feature. While drawing features, the precautions mentioned below needs to be adopted:- i) There should not be any topological errors; ii) Consistency should be maintained for symbology and attributes of features; iii) Consistency should be maintained for File naming conventions; iv) There should not be any missing feature; v) The entire data should have the required positional accuracy (+/-cm) vi) All the linear features need to be captured at the centre of the perceived casing; vii) All Point features should be captured as point feature at the centroid of the backdrop polygon; viii) Contours (smooth) generated from DEM shall be overlaid as a separate layer.

Digital Surface Model and Digital Elevation Model Specifications Annex-EE

S. N.	Deliverables	Specifications
1	**Digital Surface Model(DSM)**	a) Digital Surface Model (DSM) on 1.0m grid The DSM will be generated from the "first return" LiDAR mass point data. This will include ground and non-ground points such as vegetation and buildings. b) Void areas (i.e., areas outside the project boundary but within any tiling scheme) shall be coded using a unique "NODATA" value.
2	**Digital Elevation Model(DEM)**	a) Digital Elevation Model (DEM) on 1.0m grid bare earth b) The DEM will be generated from the LiDAR mass point data classified as "Ground" only, so that it defines the "bare earth" ground surface. c) The DEM generation will employ a Point to TIN and TIN to Raster process with Natural Nearest Neighbor interpolation. d) Hydro-flattening will be undertaken for natural and man- made water bodies and water courses as defined below: 1. Non-tidal water bodies with a surface area greater (>) than 25m2 2. Water courses greater than 5m nominal width. 3. Flat and level bank-to-bank with a gradient following the immediate terrain. 4. Water courses will break at road crossings and bridges. 5. The entire water surface edge must be at or immediately below the surrounding terrain. 6. Any additional data layers created for the purposes of hydro-flattening such a masks or break- lines must be provided as KMZ/CAD files. e) Void areas (i.e., areas outside the project boundary but within any tiling scheme) shall be coded using a unique "NODATA" value

Break lines Specifications **Annex -FF**

S.N.	Deliverables	Specifications
1	Break lines	LiDAR intensity images in combination with the elevation data will be used to create a pseudo stereo pair which then allows a photogrammetric system operator to "see" in 3D and use this technique to better determine the location of ground features. This technique is often defined as lidar grammetry, and is used extensively in the creation of break lines. The first step is to create synthetic LiDAR stereo-pairs using a software such as the Terra solid/GeoCue or any other industry standard software. These synthetic LiDAR stereo pairs will then be stereoscopically compiled to create break line features. Industry standard soft wares may be used for this compilation. This ultimately means there is no CAD to GIS file translation required and that the resultant photo interpreted data is topologically correct and GIS ready upon completion. Break lines will be created for the following features: a) **Streams and Rivers** The banks or land/water interface shall be depicted for all linear hydrographic features. Islands will be excluded as "holes" in the Streams and Rivers features. Each vertex placed needs to maintain vertical integrity, including monotonicity and connectivity. Exemptions to monotonicity may occur due to complex branch networks. b) **Ponds and Lakes** The land/water interface is depicted for all water bodies, such as lakes, ponds, and reservoirs, at a constant elevation. Every vertex on each feature must be placed at the same elevation and all elevation is set at or slightly below the surrounding terrain. Islands will be excluded as "holes" in the Ponds and Lakes features. c) **Hydro Flattened DEM Production** The processed and classified LiDAR point cloud may be used to create Digital Elevation Models.

		Bare-earth DEMs with 1- meter pixel resolution will be created for the project area. These DEMs will be hydro-flattened, using the break lines collected as described above.

Specifications for fixing of DGPS control points **Annex-GG**

S.N.	Deliverables	Specifications
1	**DGPS Control Points**	**1. Installation of Control Points for LiDAR Survey** Establishing ground control points for conducting the above survey, using DGPS with Survey of India (SOI) control points as reference duly observing for minimum 24 hrs. for base station from nearest SOI control point. (In case SOI controls are not available, base station is to be established with 72 hours observations) to be done for 20 km primary static point with permanent structure establishment pillars, every 5 km secondary points to be established with existing structures. The ground control network should be established and using the established ground control network, extension of horizontal and vertical controls in the form of Newly established Survey Control Points (NSCP) shall be established. **Densities of these control points will at least 1 control points at every 5km**. However, it needs to be finalized by contractor to achieve stipulated accuracy of LiDAR survey. The following points shall be kept in mind while selecting NSCP locations: • Clear of HT/LT lines, radio / mobile towers, high frequency dish antennas, radar etc. • Free from multipath problems associated with tall features in the vicinity. • Free from foliage • Free from major obstructions /obstacles • Easily accessible to the survey team. • Open to sky with a clear view towards sky at15- degree angle with horizontal plain. • NSCP must be located on pillars/permanent structures, which should be easily identifiable in data procured through LiDAR Survey. • Marker numbering scheme shall be finalized in consultation with Railway before start of work.

		2. Scheme and schedule of observation The contractor shall prepare a scheme i.e. network of NSCPs in advance and get it approved from Railway representative. The network shall be presented either on satellite imagery or on Google images. This should also contain description of proposed NSCPs. When observation scheme containing location of NSCPs which is adequately connecting Existing ground control points forming a network is approved by Railway representative, the contractor shall submit schedule of observation indicating tentative date and time of observation at NSCPs specifying their locations. **3. Observation of NSCPs** Necessary jungle clearance and approach to site for proper execution of work wherever required shall have to done by the contractor at no extra cost. A minimum of 34 healthy satellites should be available during entire duration of observation. Dual frequency DGPS receivers with the required accessories and software are to be used for observations. The DGPS receivers should not be older than three years from the date of award of contract. Compatible DGPS instrument and accessories of LEICA /Trimble/ASTECH/Spectra- precision/Topcon/Hemisphere or of any other reputed brand having similar specifications only shall be used so as to achieve the required accuracy. Chinese models of any brand shall not be allowed to use. The DGPS sets used shall be multi channels. The horizontal accuracy of the above work after processing of data and network adjustment will be 1:100,000 or better. Observations taken with Geometric Dilution of Precision (GDOP) exceeding 4 should not be considered. During observations, satellite mask angle should be above 15degree.

		Establishment of NSCPs 4.12 Utilizing established DGPS Control Points fixed along the route adjusted coordinates are to be made available. DGPS team will be deployed to make observations on smaller interconnected triangles i.e. NSCPs. 4.13 NSCPs shall be engraved neatly for their identification as directed by engineer-in-charge. Base painting covering engraved text shall be done followed by filling of engraving with contrast color paint as decided by the engineer-in-charge. Information to be engraved would contain the following text: To be engraved Name of Project:FLS-…..-….. UniqueID:CNERS-001 Date:DD-MM-YYYY Engraving, painting and writing work on NSCPs shall be carried out neatly and distinctly by engaging a professional. In any case, it should not be done by unskilled labour /surveyor/engineer in a scribbled manner. Using digital camera of at least 10 mega pixels, contractor shall take photograph of each NSCPs after finalizing writing etc. and submit it to Railway in digital form with proper indexing and labeling. Wherever the alignment / pier point is fixed on road, a Mild Steel rod of 10 mm dia and 350mm long shall be used / fixed. At the centre of the rod, the location of pillar etc. shall be punched as per instruction of engineer. The quoted cost should be inclusive of all expenses on this account too.

Shabin Asaf
Digitally signed by Shabin Asaf
Date: 2026.06.25 13:34:37 +05'30'