TERMS OF REFERENCE FOR THE R&D PROJECTS

1. **Title : Airborne LiDAR data quality assessment**
   Sectional Committee : Geospatial Information, LITD 22
   Proposed Duration : 6 Months

2. **Background:**
   a) The Geospatial Technology and associated data products are playing key roles, bringing efficiency in all application sectors that cover almost every domain of the economy, such as agriculture, infrastructure development, land and water, mining, location-based services, disaster management, banking and finance-related economic activities, etc. The geospatial data is now integral and important part of national infrastructure, where as per the National Geospatial Policy 2022, at country scale the high resolution topographical survey & mapping data including high accuracy digital elevation model has to be generated. Light detection and ranging (LiDAR) technology (i.e. Airborne LiDAR) is a state-of-the-art high-resolution data acquisition and processing technique, which has proven performance that enables its adoption for data acquisition at national scale. The standards for technology implementation in the application sectors play a very important role in the functioning of organizations, service providers and user industry.

   b) Considering the importance of Airborne LIDAR, BIS has prepared a Draft Indian Standard LITD 22 (23096) "*Airborne LiDAR data acquisition Part 1 Requirements*". LiDAR data have been used in research and commercial mapping environments for more than two decades. Advancements and improvements in instrumentation, software, processes, applications, and understanding are constantly refined or developed. It would not be possible to develop a set of guidelines and specifications that address all these advances. The current document, LITD 22 (23096) "*Airborne LiDAR data acquisition Part 1 Requirements*" is based on the understanding and experience of committee members with industry inputs for the LiDAR technology being used in the industry at present.

   c) It is acknowledged that there is a lack of commonly accepted best practices for numerous processes and technical assessments (for example, measurement of common accuracy and quality indicators, Nominal Pulse Spacing (NPS), point distribution, classification accuracy, and others). Currently, there is a need for Data Quality assessment methods which can evaluate, assess and verify the various Airborne LiDAR data requirements as mentioned in Draft Indian Standard, LITD 22 (23096) "*Airborne LiDAR data acquisition Part 1 Requirements*". Theese methods alongwith software solution (if any) will be included in the part 2 of *Airborne LiDAR data acquisition standard* in the future.

3. **Scope:**

The proposed project aims to generate methodologies for data quality assessment for assessing and verifying various Airborne LiDAR data requirements. The proposed project shall provide the following:

a) Data processing framework development for
   i. altimetric accuracy
   ii. planimetric accuracy
   iii. relative vertical accuracy
   iv. nominal pulse spacing (NPS) and data density assessment and its validation
b) Integrated data processing framework and software package development for generating quality assessment report

The outcome of the study will be used for preparing a separate part of the standard, *Airborne LiDAR data acquisition standard* to generate quality assessment report automatically.

4. Expected Deliverables:

a) Airborne LiDAR data processing integrated framework for data quality assessment
b) Software package/solution for generating data quality assessment report

5. Research Methodology:

a) Data processing framework development for **altimetric accuracy.**

The altimetric or vertical accuracy is a function of $RMSE_z$ (root mean square of the altimetric errors). The flat and horizontal site located at the areas of minimum elevation, as far as possible to be selected for vertical accuracy quality assessment (QA). For the absolute vertical accuracy, the vegetated and non-vegetated land cover types shall be assessed using their *Airborne* LiDAR data and the derived DEM. The non-vegetated vertical accurcay (NVA) to be assessed for open areas LiDAR data that result in single return and the derived DEM. NVA for the LiDAR data shall be assessed by comparing check points that are surveyed for NVA assessment of a triangulated irregular network (TIN) constructed from ground-classified LiDAR points in those areas. Further, vegetated vertical accurcay (VVA) to be assessed for vegetated areas LiDAR data that result in multiple returns and the derived DEM. VVA for the LiDAR data shall be assessed by comparing check points surveyed for VVA assessment to a TIN constructed from ground-classified LiDAR points in those areas. NVA and VVA to be represented in terms of $RMSE_z$.

$RMSE_z$ shall be determined using check points on available land cover/land use classes. To select check points in the given area of interest (AOI) there shall be one test site every 50 km^2. In a single test site, for each class, 20 checkpoints shall be selected. For example, if a project site is 1000 km^2, of which 400 km^2 is covered by classes 1 and 2 and rest by classes 3 to 5, there shall be 8 test sites for classes 1 and 2 and 12 test sites for classes 3 to 5 . Each test site needs to have a minimum of 20 checkpoints. Using the planimetric coordinates of the check points and the TIN, the *z*-coordinate of the location shall be determined as Z_i. Since Z_i^{ref} of the checkpoint is already known and $RMSE_z$ is calculated.

b) Data processing framework development for planimetric accuracy

The planimetric accuracy ($Accuracy_r$) shall be reported at 95 percent confidence level as: $Accuracy_r = RMSE_r \times 1.7308$. It is recommended that selected sites for QA shall be located at the areas of minimum elevation, as far as possible. Since the method for determining $RMSE_r$ has not been explicitly mentioned in the literature, the $RMSE_r$ shall be confirmed using the LiDAR data points corresponding to the corners of buildings. The test sites for determining $RMSE_r$ shall be spread across the study area and could be same as those used for vertical RMSE. $RMSE_r$ can also be computed using the field observed coordinates of well-designed targets which can also be identified in LiDAR point cloud with or without the use of intensity data.

c) Data processing framework development for **relative vertical accuracy**

For relative vertical accuracy assessment, standard deviation of LiDAR data σ_z shall be calculated specifically for flat areas which lie in single swath and swath overlapping areas. σ_z shall be less than or equal to the user specified values. It is recommended that selected sites for QA shall be located at the areas of minimum elevation, as far as possible.

d) Data processing framework development for **nominal pulse spacing (NPS)** and **data density** assessment and its validation

NPS computation is based on constructing a Delaunay triangulation using the planimetric coordinates of the LiDAR points and calculating the planimetric distance of every edge connecting one point to a neighboring point. Determine the 95th percentile value (S_v) of the set $\langle S_i \rangle_{i=1}^{N}$, where S_i is spacing value corresponding to p_i and and N is total number of points around point p_i. Therefore, at least 95% of the points have NPS better than Sv for the LiDAR data to meet the NPS requirements. For data density computation construct a Voronoï diagram using the planimetric coordinates of the LiDAR points. Calculate the area of the Voronoï polygons for each point and assign the inverse of area value, or density in terms of points per unit squared, to the point. Determine the 95th percentile value (A) of the set $\langle a_i \rangle_{i=1}^{N}$. Therefore, at least 95% of the points have data density better than A, where a_i be an inverse of area of the polygon for point p_i and N is total number of points around point p_i.

e) Integrated data processing framework and software package development for generating quality assessment report

The above mentioned data processing framework (from a to d) to be integrated and a software solution needs to be designed to generate data quality assessment report for assessing and verifying various Airborne LiDAR data requirements.

Note : The Classes and other details are defined in LITD 22 (23096).

6. Requirement for the CVs:

The Project executer should have good knwolege of computer programming and understanding of point cloud data. The B. Tech./M. Tech. student with good academic records will be preferred.

7. Timeline and Method of Progress Review:

Activity	Review mechanism of the work progress
Initial Plan	The test sites alongwith Data assessment parameters needs to be finalized during 1^{st} month in consultation with BIS.
Data processing framework development for altimetric accuracy	The work progress report to be submitted and presented to BIS at end of 4^{th} month.
Data processing framework development for planimetric accuracy	
Data processing framework development for relative vertical accuracy	The work progress report to be submitted and presented to BIS at end of 4^{th} month.
Data processing framework development for nominal pulse spacing (NPS) and data density assessment and its validation	The work progress report alongwith data processing software to BIS at end of 6^{th} month.
Integrated data processing framework and software package development for generating quality assessment report	The final report of integrated to be submitted alongwith data processing software to BIS at end of 6^{th} month.

8. Support BIS will Provide:

In this project, in addition with the financial support, the standards and publication documents that discuss the software-based tool as test bed will be provided to understand the formulation architecture of methodology and software conforming the BIS guidelines.

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