

Next-Gen Site Surveys: Evaluating the Efficiency of RTK-GNSS, LiDAR, and Drone Photogrammetry in Asset Management

SIMAB KHAN

Lecturer, Civil Engineering Department, Anjuman Polytechnic, Nagpur, simabkhan91@gmail.com

MOHD. AAQUIB

Student, Civil Engineering Department, Anjuman Polytechnic, Nagpur, aaquib44896@gmail.com

MUHAMMAD AHMED

Student, Civil Engineering Department, Anjuman Polytechnic, Nagpur, maa09092009@gmail.com

MOHD. JAHAN

Student, Civil Engineering Department, Anjuman Polytechnic, Nagpur, mdjahan153@gmail.com

MOHD. AFNAN KHAN

Student, Civil Engineering Department, Anjuman Polytechnic, Nagpur, afnankhan24102006@gmail.com

FARHAN IRFAN KHAN

Student, Civil Engineering Department, Anjuman Polytechnic, Nagpur, farhankhan942047@gmail.com

Abstract

Modern asset management requires rapid, accurate, and economical collection of geospatial information. This paper evaluates three next-generation site-survey technologies—Real-Time Kinematic Global Navigation Satellite System (RTK-GNSS), Light Detection and Ranging (LiDAR), and unmanned aerial vehicle (UAV) photogrammetry—for asset-management applications. The technologies are compared using horizontal and vertical accuracy, field coverage rate, processing time, equipment cost, cost per hectare, and suitability for different terrain and asset types. RTK-GNSS provides high-accuracy positioning for individual assets and ground-control establishment. UAV LiDAR is particularly effective in vegetated and complex terrain because laser pulses can reach the ground through partial canopy cover. UAV photogrammetry provides low-cost orthomosaics, digital surface models, and three-dimensional visual models for open construction sites, stockpiles, and infrastructure inspection. The results show that no single technology is best for every asset-management task. A hybrid workflow using RTK-GNSS for control and discrete assets, UAV LiDAR for terrain and vegetation, and photogrammetry for visual documentation provides the most complete and cost-effective solution.

Index Terms—RTK-GNSS, UAV LiDAR, drone photogrammetry, asset management, site survey, geospatial accuracy, construction monitoring.

I. INTRODUCTION

Asset management in civil infrastructure, utilities, transportation, mining, and construction depends on reliable spatial data. Engineers require accurate information about the location, condition, quantity, and change over time of assets such as roads, pipelines, drainage systems, buildings, power lines, stockpiles, and construction sites. Conventional surveying methods, including total stations and static GNSS observations, provide dependable results but can be slow when large

areas must be covered. They also require direct access to the survey area, which may be difficult in forests, steep slopes, industrial sites, or active construction zones.

Next-generation survey systems improve productivity by combining satellite positioning, aerial imaging, laser scanning, and automated data processing. RTK-GNSS delivers real-time centimetre-level positions. UAV LiDAR produces dense three-dimensional point clouds. UAV photogrammetry converts overlapping aerial images into orthomosaics and 3D models. This paper compares these methods and identifies the

most suitable workflow for different asset-management applications.

II. LITERATURE REVIEW

Recent research shows that UAV photogrammetry can achieve approximately 1–3 cm horizontal accuracy in open terrain when RTK/PPK positioning and ground control points are used. However, its vertical accuracy reduces in vegetated areas because image-matching algorithms cannot identify the ground surface beneath dense canopy.

UAV LiDAR systems use laser pulses to measure distances to the ground and objects. Because LiDAR can record multiple returns from vegetation, it can generate a digital terrain model even in partially vegetated areas. Field studies report approximately 3–5 cm vertical accuracy on bare earth and approximately 5–10 cm under moderate to dense vegetation.

RTK-GNSS is widely used for utility asset mapping, boundary work, construction stakeout, and ground-control establishment. Dual-frequency, multi-constellation RTK receivers can generally achieve 1–3 cm horizontal accuracy and 2–5 cm vertical accuracy under favourable satellite conditions.

III. METHODOLOGY

The study compares RTK-GNSS, UAV LiDAR, and UAV photogrammetry using four evaluation criteria:

- Horizontal and vertical accuracy, measured using root mean square error (RMSE).
- Field efficiency, measured in hectares covered per day.
- Cost, including equipment cost and approximate survey cost per hectare.
- Suitability for open sites, vegetation, urban infrastructure, linear corridors, utility assets, and stockpiles.

The comparison is based on published field studies, manufacturer specifications, and industry survey benchmarks. Values are presented as typical ranges because actual performance depends on satellite visibility, weather, terrain slope, vegetation density, flight altitude, image overlap, and data-processing workflow.

IV. TECHNOLOGY OVERVIEW

A. RTK-GNSS

RTK-GNSS uses carrier-phase observations from GNSS satellites and corrections from a base station or network RTK service. It provides real-time coordinates with centimetre-level accuracy. RTK-GNSS is most effective for locating individual assets, establishing survey control, and checking the position of constructed features.

B. UAV LiDAR

UAV LiDAR mounts a laser scanner on a drone. The scanner emits thousands of laser pulses per second and records the time required for each pulse to return. The result is a dense 3D point cloud that can be classified into ground, vegetation, buildings, and other objects.

C. UAV Photogrammetry

UAV photogrammetry uses overlapping aerial photographs and Structure-from-Motion processing to create orthomosaics, digital surface models, contour maps, and textured 3D models. RTK-enabled drones reduce the number of ground control points required, although several GCPs are still recommended for high-accuracy engineering surveys.

V. RESULTS AND DISCUSSION

A. Accuracy Comparison

Table I. Typical accuracy of survey technologies

Technology	Horizontal accuracy (cm)	Vertical accuracy (cm)	Performance in vegetation
RTK-GNSS	1–3	2–5	Point-based; no area coverage
UAV LiDAR	3–5	3–5 bare earth; 5–10 vegetation	Excellent ground penetration
UAV Photogrammetry	1–3	2–5 open terrain; unreliable in vegetation	Poor ground visibility under canopy

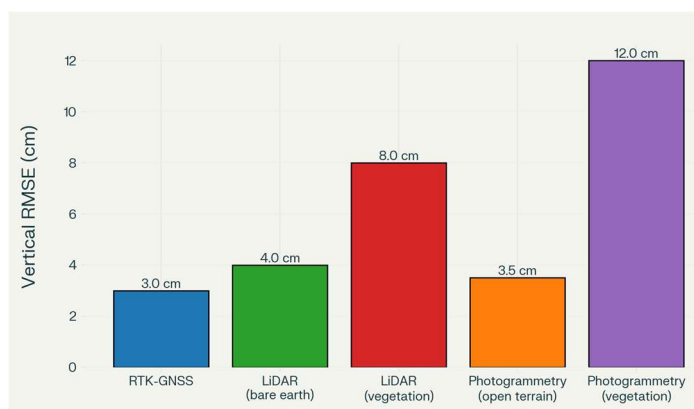


Fig. 1. Vertical accuracy comparison by terrain type.

Fig. 1 shows that RTK-GNSS and photogrammetry perform well in open areas, while LiDAR maintains useful vertical accuracy under vegetation. Photogrammetry should not be used as the only source of ground elevation in densely vegetated areas.

B. Efficiency and Cost

Table II. Efficiency and cost comparison

Metric	RTK-GNSS	UAV LiDAR	UAV Photogrammetry
Typical coverage rate	2–5 ha/day	50–100 ha/day	50–100 ha/day
Processing time for 50 ha	Low; mostly field data	6–12 hours	2–6 hours
Typical equipment cost	USD 15,000 – 40,000	USD 80,000 – 150,000	USD 20,000–50,000
Approximate cost per hectare	USD 200–500	USD 75–120	USD 45–75
Typical field crew	2 persons	2–3 persons	2 persons



Fig. 2. Estimated survey cost per hectare.

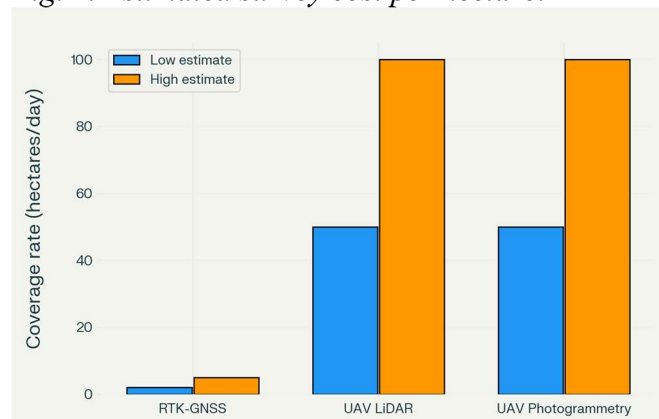


Fig. 3. Field coverage efficiency.

UAV photogrammetry generally has the lowest cost per hectare for large open sites. UAV LiDAR costs more but is justified where terrain modelling beneath vegetation, corridor mapping, or detailed 3D surface extraction is required. RTK-GNSS has the highest cost per hectare for large-area mapping but remains highly economical for small, targeted asset surveys.

C. Suitability for Asset Management

Table III. Technology suitability matrix

Asset or terrain type	RTK-GNSS	UAV LiDAR	UAV Photogrammetry	Recommended approach
Open construction site	★★	★★★	★★★★★	Photogrammetry with RTK control
Dense vegetation	★	★★★	★	LiDAR with RTK ground control

Urban infrastructure	★★ ★★	★★ ★★	★★★★	Photogrammetry, RTK, and selective LiDAR
Pipeline or powerline corridor	★★ ★	★★ ★★ ★	★★★★	LiDAR with photogrammetry
Utility assets: valves and manholes	★★ ★★ ★	★★	★★★	RTK-GNSS as primary method
Stockpile volume measurement	★★	★★ ★★	★★★★ ★	Photogrammetry for volume; LiDAR for base surface

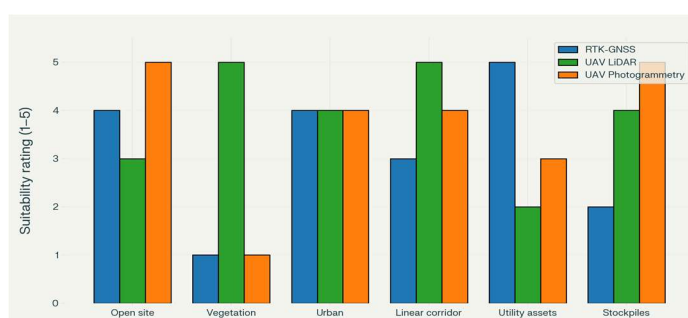


Fig. 4. Technology suitability by asset and terrain type.

VI. PROPOSED HYBRID WORKFLOW

A practical asset-management workflow should combine the strengths of all three technologies:

1. Use RTK-GNSS to establish ground-control points and locate discrete assets such as valves, manholes, poles, and drainage structures.
2. Use UAV LiDAR to produce an accurate ground surface model in vegetated, sloping, or complex terrain.
3. Use UAV photogrammetry to produce orthomosaics, visual inspection records,

stockpile volumes, and 3D models for project stakeholders.

4. Integrate all datasets in a GIS or BIM platform for asset registers, maintenance planning, change detection, and progress monitoring.

VII. LIMITATIONS

The results depend on site conditions and survey workflow. RTK-GNSS accuracy reduces near tall buildings, dense tree canopy, and other sources of multipath. LiDAR requires higher investment and specialist processing. Photogrammetry cannot reliably measure the ground beneath dense vegetation and requires adequate lighting and texture on the surface.

VIII. CONCLUSION

RTK-GNSS, UAV LiDAR, and drone photogrammetry each provide important benefits for modern asset management. RTK-GNSS is the preferred method for high-accuracy asset positioning and survey control. UAV LiDAR is the strongest option for terrain mapping in vegetation and linear infrastructure corridors. UAV photogrammetry is the most economical method for open-site mapping, visual documentation, and volumetric analysis.

The most effective solution is not a single technology but a hybrid workflow. By combining RTK-GNSS, LiDAR, and photogrammetry, asset managers can obtain accurate positions, reliable terrain models, and useful visual records while reducing survey time and cost.

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