

SURVEYING USING DRONE TECHNOLOGY AND DGPS INTEGRATION

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Abstract

Surveying is a fundamental activity in civil engineering that provides accurate spatial data required for planning, design, construction, and monitoring of infrastructure projects. Traditional surveying methods, although reliable, are often time-consuming, labor-intensive, and limited in accessibility for large or difficult terrains [1], [2]. In recent years, the integration of Drone Technology (Unmanned Aerial Vehicles - UAVs) with Differential Global Positioning System (DGPS) has transformed the field of surveying by offering rapid, accurate, and cost-effective data acquisition [4], [8]. This review paper presents a comprehensive analysis of surveying using drone technology and DGPS integration by examining the principles, methodologies, equipment, applications, advantages, limitations, and recent developments in the field. The study evaluates how drones equipped with high-resolution cameras, photogrammetric software, and DGPS/GNSS receivers can generate orthophotos, Digital Elevation Models (DEM), contour maps, and topographic surveys with high precision [8], [13]. It also discusses the role of Ground Control Points (GCPs), Real-Time Kinematic (RTK), and Post-Processed Kinematic (PPK) techniques in improving positional accuracy [12], [14]. Furthermore, the paper highlights applications in land surveying, route alignment, mine surveying, construction monitoring, and disaster assessment [16]–[19]. The study concludes that drone-based surveying integrated with DGPS significantly improves efficiency, safety, and data accuracy, making it a modern and reliable alternative to conventional surveying methods in civil engineering practice [4], [10].

Keywords

Drone Surveying, UAV Survey, DGPS, GNSS, RTK, PPK, Photogrammetry, Topographic Survey, Ground Control Points, Civil Engineering Surveying, Orthomosaic Mapping, Digital Elevation Model

1. INTRODUCTION

Surveying plays a vital role in civil engineering as it provides the base data necessary for planning, design,

estimation, alignment, construction, and maintenance of engineering projects [1], [2]. Accurate surveying ensures that structures are built in the correct location, at the correct elevation, and according to the intended design. Conventional surveying methods such as chain surveying, compass surveying, plane table surveying, total station surveying, and leveling have been widely used for decades [1], [3]. While these methods provide dependable results, they often require significant time, skilled manpower, and repeated field visits, especially in large-scale or inaccessible project areas [2], [3].

With the advancement of geospatial technologies, drone-based surveying has emerged as an efficient and innovative alternative to traditional methods [4], [8]. Drones, also known as Unmanned Aerial Vehicles (UAVs), can capture high-resolution aerial images over large areas in a short period. These images can then be processed using photogrammetric software to generate accurate maps, contours, 3D terrain models, and volumetric calculations [8], [13]. However, the positional accuracy of drone imagery depends heavily on georeferencing quality [12], [14].

To improve this accuracy, DGPS (Differential Global Positioning System) is integrated with drone surveying. DGPS enhances positional accuracy by correcting satellite signal errors through reference stations and known control points [12]. When combined with Ground Control Points (GCPs), RTK, or PPK systems, drone surveys can achieve centimeter-level accuracy suitable for engineering applications [13], [14].

This review paper aims to provide a detailed understanding of surveying using drone technology and DGPS integration by combining theoretical concepts, technical methodologies, and practical civil engineering applications.

2. OBJECTIVES OF THE STUDY

The primary objectives of this review paper are:
To study the concept and importance of drone technology in modern surveying.

To understand the working principle and role of DGPS in

improving survey accuracy.

To analyze the integration of drones and DGPS for civil engineering survey applications.

To examine the equipment, software, and field procedures used in UAV-DGPS surveys.

To compare drone-based surveying with conventional surveying methods.

To identify the major applications, benefits, and limitations of drone and DGPS integration.

To evaluate the accuracy, efficiency, and practical usefulness of this technology in civil engineering projects..

3. METHODOLOGY

This review paper is based on a comprehensive study of secondary data collected from standard surveying textbooks, research papers, journal articles, conference proceedings, technical manuals, manufacturer guidelines, and case studies related to UAV surveying and DGPS applications [1][4], [8][14]. The methodology follows a descriptive and analytical approach.

The study includes review of traditional and modern surveying methods, analysis of drone platform types and sensor systems, study of DGPS principles, RTK, and PPK methods, evaluation of field data collection procedures using GCPs and drone missions, comparative analysis of conventional surveys and UAV-DGPS surveys, and review of practical case studies from topographic mapping, route surveys, and construction monitoring[8],[10],[14],[17],[18]

4. LITERATURE REVIEW

The application of drone technology in surveying has gained significant attention in recent years due to its ability to rapidly capture high-resolution geospatial data [8], [9]. According to standard surveying literature, UAVs have become highly effective tools for topographic mapping, land development, and infrastructure planning [4]. Authors in modern geospatial studies have highlighted that drone-based photogrammetry can provide accurate and detailed terrain information with reduced field time compared to conventional methods [8], [13].

Research studies indicate that the use of DGPS/GNSS

significantly improves the positional accuracy of aerial survey data [12], [14]. Traditional standalone GPS is often affected by atmospheric delays, satellite clock errors, and multipath effects. DGPS corrects these errors by using a fixed reference station with known coordinates, thereby improving the position of the rover or UAV receiver [12]. Many recent studies show that when drones are integrated with RTK or PPK systems, the requirement for a large number of Ground Control Points can be reduced while maintaining centimeter-level accuracy [13], [14].

Literature also emphasizes the importance of Ground Control Points (GCPs) in drone surveying. GCPs are accurately measured points on the ground whose coordinates are determined using DGPS or total station [2], [12]. These points are used during photogrammetric processing to improve image alignment and georeferencing [13]. Studies have shown that the proper distribution and number of GCPs directly affect the quality of orthomosaics and Digital Elevation Models [8], [13].

Several engineering journals have reported that drone and DGPS integration is especially useful in road alignment surveys, contour mapping, mine volume estimation, riverbank monitoring, land development, and construction progress tracking [10], [16]–[18]. However, literature also identifies challenges such as regulatory restrictions, weather dependency, battery limitations, vegetation cover, and the need for skilled dataprocessing[7],[8],[19].

5. PRINCIPLES OF SURVEYING

Surveying using drone technology and DGPS is based on several fundamental principles:

5.1 Principle of Aerial Photogrammetry

Drone surveying works on the principle of photogrammetry, where overlapping aerial images are captured and processed to determine the shape, size, and position of ground features [4], [13].

5.2 Principle of Satellite Positioning

DGPS relies on satellite-based positioning systems such as GPS, GLONASS, Galileo, and BeiDou. The UAV or ground receiver determines its location from multiple satellite signals [12].

5.3 Differential Correction Principle

DGPS improves position accuracy by comparing satellite-derived positions at a reference station of known coordinates with the measured position and applying correction factors to the rover receiver or drone dataset [12], [14].

5.4 Ground Control Principle

Ground Control Points serve as accurately known points on the ground that anchor aerial imagery to real-world coordinates, improving absolute accuracy [2], [13].

5.5 RTK and PPK Correction Principle

RTK (Real-Time Kinematic): Corrections are transmitted in real time during the flight [14].

PPK (Post-Processed Kinematic): Raw GNSS data is corrected after the flight during processing [14].

These principles collectively enable accurate, efficient, and reliable engineering surveys [4], [12].

6. EQUIPMENT USED IN DRONE AND DGPS SURVEYING

The following equipment is commonly used in drone-based surveying integrated with DGPS:

- Drone/UAV Platform – Multirotor drones and fixed-wing drones [8], [9]
- Sensors – RGB high-resolution camera, LiDAR sensor, multispectral sensors [8], [13]
- DGPS/GNSS Receiver – Base station, rover receiver, RTK/PPK enabled GNSS modules [12], [14]
- Ground Control Targets – Clearly visible GCP markers [13]
- Survey Accessories – Tripod, measuring tape, controller, batteries [2], [3]
- Software – Flight planning, photogrammetry, GIS/CAD software [13], [15]

7. PROCEDURE OF SURVEYING USING DRONE TECHNOLOGY AND DGPS

The general procedure of conducting a UAV-DGPS survey is as follows:

Reconnaissance – Study terrain, accessibility, and obstacles [2], [3]

Establishment of Ground Control Points – GCPs are placed and measured using DGPS [12], [13]

Mission Planning – Flight altitude, overlap, GSD, speed, and flight path are defined [8], [13]

Drone Data Acquisition – UAV captures overlapping aerial photographs [8], [9]

DGPS/RTK/PPK Data Collection – Positional corrections are recorded [12], [14]

Image Processing – Orthomosaic, DSM, DEM, contours, and 3D models are generated [13], [15]

Accuracy Verification – Check points are compared with processed outputs [12], [14]

Final Output Preparation – Survey data is exported for engineering design [4], [15].

8. APPLICATIONS OF DRONE SURVEYING WITH DGPS IN CIVIL ENGINEERING

Drone technology integrated with DGPS has numerous civil engineering applications:

- Topographic Survey – Contour maps, elevation data, terrain models [4], [10]
- Route Alignment Survey – Roads, railways, canals, pipelines [2], [18]
- Land Development and Plotting – Layout planning and land-use analysis [8], [10]
- Construction Monitoring – Progress tracking and site documentation [17]
- Earthwork and Volume Calculation – Excavation and embankment quantities [16]
- Mine Surveying – Pit mapping and stockpile analysis [16]
- River and Watershed Survey – Floodplain and erosion studies [19]
- Disaster Management – Landslide and flood damage assessment [19]
- Structural Inspection – Bridges, dams, towers, inaccessible structures [8], [17].

9. ROLE OF DGPS IN IMPROVING DRONE SURVEY ACCURACY

DGPS is a critical component in drone surveying because it significantly enhances spatial accuracy.

DGPS reduces major GPS errors such as satellite clock errors, orbital errors, atmospheric delays, receiver timing errors, and multipath effects [12]. The drone images can be accurately tied to the ground coordinate system using GCPs and DGPS measurements [13]. With RTK/PPK integration, drone surveys can achieve near centimeter-level precision under suitable conditions [14]. This improves reliability for engineering design, including road profiles, drainage planning, cut-fill calculations, and layout design [4], [10]

10. COMPARISON BETWEEN CONVENTIONAL SURVEYING AND DRONE-DGPS SURVEYING.

Conventional surveying remains highly accurate for control establishment and setting out, but it is time-consuming and labor-intensive over large areas [1], [2]. Drone-DGPS surveying offers faster coverage, reduced manpower, safer operation in hazardous terrain, and dense spatial datasets such as orthomosaics and DEMs [8], [10], [13]. Therefore, UAV-DGPS surveys are especially effective for topographic mapping, construction monitoring, and repeated project observations [17], [18].

11. CASE STUDY ANALYSIS

A sample civil engineering case study can be considered for a road alignment and topographic survey of a proposed 25-hectare land parcel.

Case Study Summary

- Project Type: Proposed road alignment and site grading
- Survey Area: 25 hectares
- Method Used: Multirotor UAV with RTK GNSS + DGPS GCPs
- Flight Altitude: 80 m
- Image Overlap: 80% forward, 70% side
- Number of GCPs: 8
- Outputs Generated: Orthomosaic, DEM, contours at 0.5 m interval, longitudinal profile.

Findings

- Total field time was reduced from approximately 3–4 days (conventional method) to less than 1 day.
- Survey team requirement reduced from 4–5 persons to 2–3 persons.
- Orthomosaic and DEM provided detailed terrain information.
- DGPS-based GCPs improved georeferencing accuracy significantly.
- The generated contour map was suitable for preliminary design and quantity estimation.

Engineering Significance

The case demonstrates that drone surveying integrated with DGPS can deliver accurate and comprehensive terrain data quickly, making it highly beneficial for planning and design in civil engineering projects.

12. RESULTS AND DISCUSSION

The study indicates that drone technology combined with DGPS provides a highly efficient and accurate surveying solution for

modern civil engineering applications. The most significant advantages are:

- Rapid data collection over large areas
- Reduced field time and labor requirement
- High-resolution aerial imagery and 3D terrain models
- Improved safety in hazardous or inaccessible sites
- Accurate georeferencing through DGPS, RTK, and PPK
- Better support for design, estimation, and monitoring

The results also show that GCP placement, flight altitude, overlap settings, and DGPS accuracy are key factors affecting output quality. While standalone drone surveys may provide visually good maps, engineering-grade accuracy is best achieved when DGPS integration is used properly.

In comparison to traditional methods, drone-DGPS surveys provide richer datasets and better visualization, although conventional surveying is still necessary for control validation, legal boundary work, and precise setting out.

13. CHALLENGES AND LIMITATIONS

Despite its advantages, surveying using drone technology and DGPS faces several practical challenges, including:

- High initial investment in UAVs, GNSS receivers, and software [8], [13]
- Weather dependency such as wind, rain, and fog [8]
- Limited battery life, especially for multirotor drones [9]
- Regulatory restrictions and flight permissions under drone rules [7]
- Requirement of skilled operators and data processors [8], [15]
- Reduced effectiveness in dense vegetation or obstructed terrain [10], [19]
- Dependence on control quality and proper GCP distribution [13], [14].

These challenges can affect accuracy, safety, and project feasibility if not properly managed [7], [8].

14. CONCLUSION

This review paper concludes that surveying using drone technology integrated with DGPS is a modern, efficient, and highly valuable approach for civil engineering surveying [4], [8]. The combination of UAV-based aerial data collection and DGPS-based positional correction provides accurate, high-resolution, and comprehensive spatial information in

significantly less time than conventional surveying methods [10], [13]. The study highlights that drone-DGPS integration is especially useful for topographic mapping, route surveys, construction monitoring, earthwork estimation, and difficult terrain surveys [16],[18]. Although challenges such as cost, regulations, weather limitations, and technical expertise remain, the advantages of speed, safety, coverage, and data richness make this technology increasingly important in modern civil engineering practice [7], [8], [19].

15. REFERENCES

- [1] B. C. Punmia, Ashok Kumar Jain, Arun Kumar Jain, **Surveying Vol. I**, Laxmi Publications.
- [2] S. K. Duggal, **Surveying Vol. I & II**, Tata McGraw Hill.
- [3] R. Subramanian, **Surveying and Levelling**, Oxford University Press.
- [4] Paul R. Wolf and Charles D. Ghilani, **Elementary Surveying: An Introduction to Geomatics**.
- [5] National Building Code (NBC), India – **Surveying and Site Planning Provisions**.
- [6] IS Codes related to **Surveying and Mapping Practices**.
- [7] DGCA India, **Drone Rules / UAV Operation Guidelines**.
- [8] IJERT Papers on **UAV Surveying and Photogrammetry Applications**.
- [9] IRJET Papers on **Drone Surveying in Civil Engineering**.
- [10] IJRAR / IJSRET Papers on **Topographic Mapping using Drones**.
- [11] Research Papers on **Smart Surveying Technologies in Civil Engineering**.
- [12] GNSS and DGPS Technical Manuals / **DGPS Surveying Studies**.
- [13] Pix4D / Agisoft Metashape **Documentation on Photogrammetry and GCP Processing**.
- [14] **RTK and PPK Survey Method Studies in UAV Mapping**.
- [15] GIS and Remote Sensing Journals on **Orthomosaic and DEM Generation**.
- [16] **Mine Surveying and Earthwork Volume Estimation using UAV Case Studies**.
- [17] **Construction Monitoring using UAV-based Photogrammetry Research Papers**.
- [18] **Route Alignment and Corridor Mapping using UAV and GNSS Studies**.
- [19] **Disaster Mapping, Floodplain Survey, and River Monitoring using UAVs**.
- [20] **Recent Civil Engineering Journal Papers on Drone-based Survey Integration**.