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Role of Automated Systems for Geodata Collection and Processing in Reducing Labor Effort on Field Operations

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Abstract

This article examines the role of automated systems for geodata collection and processing in reducing labor effort during field operations, it aims to analyze the influence of modern LiDAR, photogrammetry, SLAM scanning and IoT monitoring technologies on the efficiency of field geodetic measurements, the objective is to identify the central reserves for reducing person-hours in data collection and initial processing, the relevance of the study is substantiated by the high cost and time expenditure associated with classical ground survey methods, when expenses for crew remuneration and logistics significantly exceed the possibilities for operational project management, the novelty of the work lies in the comprehensive comparison of traditional methods with the implementation of unmanned platforms and cloud pipelines, as well as in the quantitative assessment of person-hour savings based on data from Fujita Corporation, an Ohio quarry and practical examples of using the Leica BLK2GO mobile SLAM scanner, the analysis reveals that the shift from total stations and GNSS receivers to UAV-LiDAR and mobile mapping systems allows reduction in crew size and field exposure time by 40–60%, Structure from Motion photogrammetric algorithms provide processing of millions of points per minute with 70–80% time savings in office processing, and the integration of IoT sensors converts discrete inspections into continuous monitoring, reducing specialist dispatch frequency from quarterly to virtually seamless, additionally automation of post-processing via cloud services and geospatial AI ensures a twofold acceleration in generating orthophotos and dense point clouds while maintaining centimeter accuracy, which frees resources for analytical tasks and decision making based on ready digital twins, this article will be helpful to engineering and geodetic services, design organizations and researchers in the fields of remote sensing and infrastructure monitoring.

Keywords: *Geodata Collection Automation, LiDAR, Photogrammetry, SLAM Scanners, UAV Platforms, IoT Monitoring.*

INTRODUCTION

Field geodetic measurements remain a critical component of engineering, environmental protection and infrastructure projects, since they provide the initial coordinates for design, deformation monitoring and calculation of earthmoving volumes, without an accurate description of terrain and objects it is impossible to correctly position a bridge foundation, assess slope stability or forecast hydrological risk, in environmental studies detailed terrain models allow tracking of soil erosion, river channel dynamics and invasive vegetation spread, which directly influences the planning of protective measures and the rational use of natural resources.

The primary financial and temporal burden in classical methods falls on field crews: one or two pairs of surveyors with total stations, GNSS receivers and rods are forced to traverse each area of interest sequentially, such labor is highly paid: in the United States the hourly cost of a crew is estimated at USD 220–450 excluding transport and insurance expenses [1], additional costs arise from logistics of heavy equipment, repeat trips due to weather constraints, the need to install and remove temporary benchmarks, as well as manual verification and digitization of field notes in the office department, collectively these factors make ground surveying one of the most labor-intensive stages in an asset's life cycle.

Empirical data confirm the scale of the problem, on road construction Fujita Corporation recorded that the whole cycle "control survey – point cloud analysis" using the traditional approach took one and a half times longer than

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after implementation of unmanned platforms, meaning an extra 60% of person-hours were spent daily solely on measurements and primary processing [2], a similar ratio was shown at an Ohio quarry: inspection of stockpiles with an RTK receiver required ten person-hours, whereas data collection by drone reduced labor input to four person-hours while maintaining accuracy within two percent [3], such assessments demonstrate that manual field work rather than subsequent analysis is the central reserve for optimization and explain the industry's interest in automated systems that shift much of the workload from crew legs to server computing power.

MATERIALS AND METHODOLOGY

The study included 16 key sources, comprising statistical reports, industry cases, academic articles and technical documentation, practical data were based on estimates of cost and time expenditure of field crews using classical surveying methods [1], results of unmanned platform implementation in road construction and mining [2, 3], as well as manufacturers' and analysts' data on new LiDAR, SLAM and photogrammetry systems [5, 6, 7, 8], publications on Structure from Motion algorithms and comparisons of software pipelines for point cloud processing were also considered [9, 10, 13], reviews of IoT sensor applications and distributed analytics for facility monitoring [11, 12], and materials on integration of cloud pipelines and geospatial AI models with corporate BIM and GIS systems [14, 15, 16].

The theoretical foundation comprised studies on comparative analysis of traditional and automated survey methods, the comparison of total station and RTK-GNSS showed comparable accuracy with significant reduction in exposure time using satellite technology [4], analysis of UAV LiDAR clouds confirmed the ability to create dense terrain models without installing ground benchmarks [7], studies of mobile SLAM scanners and static TLS illustrate the shift from field stops to traversal speed and automatic post-processing [6, 8]. At the same time, photogrammetry works demonstrate million-point-per-minute streams with partial optimization of cloud density without quality loss [9, 10].

Methodologically the study relied on comparative analysis of labor effort and accuracy metrics for different surveying technologies, first data were collected on person-hours and costs of field operations using total stations, GNSS receivers and UAV platforms [1–3], second a content analysis of unmanned vehicle and mobile scanner case studies was conducted, including evaluation of reduction in trips, logistics costs and risk in hazardous zones [2, 3, 6, 8].

RESULTS AND DISCUSSION

Since the emergence of electronic total stations field measurements have evolved from multi-hour procedures requiring four to six people and multiple instrument relocations to operations that today can be performed by a single operator, in the classical late-20th-century scheme linear visibility between points was mandatory, therefore a significant share of time was spent deploying rods and manually transferring observation logs, these tasks defined the main portion of labor effort.

The advent of satellite positioning systems changed work order: the need for intervisibility disappeared and point exposure time was reduced to tens of seconds, in a comparative study of 20 control points measured simultaneously by total station and RTK-GNSS authors recorded that satellite technology provided the same centimeter-level accuracy with substantially lower time expenditure per point and for overall network establishment [4], thus the practice "one instrument – one operator" was introduced, paving the way for automation of subsequent stages.

The next qualitative leap was ensured by unmanned aerial vehicles and mobile mapping systems, on quarries and construction sites drones generate point clouds and orthophoto maps in one or two flights, eliminating personnel work in hazardous zones, field trials of volumetric survey methodology showed that UAV photogrammetry yields comparable accuracy results while being more economical and less labor-intensive than traditional total station surveying [5].

Simultaneously portable SLAM scanners with reflector-free navigation technology have advanced, in comparison of static TLS and the handheld Leica BLK2GO system traversal speed proved to be the main advantage of the mobile method while maintaining centimeter accuracy of the model [6], therefore data that previously required several static setups over a full day are now captured by one specialist in minutes, shifting the primary workload from the field to office post-processing.

Thus, each new stage of equipment evolution systematically eliminates manual repetitive operations: first, line-of-sight requirements between points disappeared, then direct human work on the object was reduced, and finally lengthy instrument relocation cycles were removed, the combined result is crew size reduction, shortened field exposure and increased safety, which underpins further cost reduction in surveying projects.

The current stage of geodata collection automation relies on three technical branches, each addressing specific bottlenecks identified in traditional field work, firstly LiDAR on UAVs, vehicles and backpack systems converts surveying from point-wise to continuous point streams, at a 50 m flight altitude UAV LiDAR forms a cloud with horizontal and vertical dispersion of approximately 5–6 cm without ground benchmark installation (Figure 1), providing noticeably shorter crew field time than ground scanners or total stations [7].

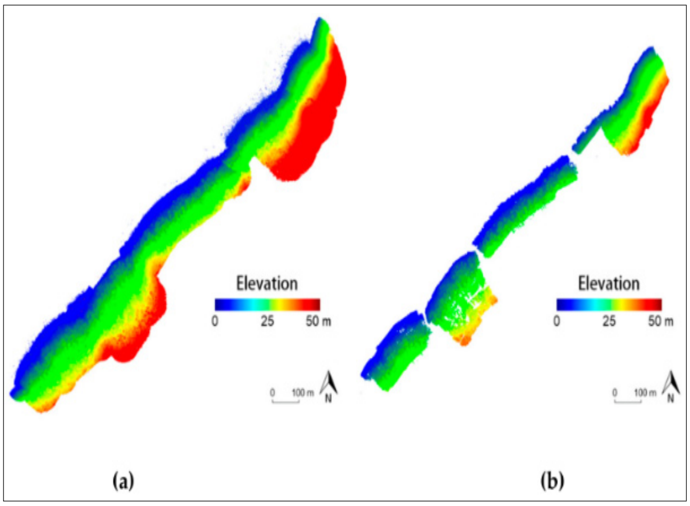

Fig. 1. Dense point cloud: (a) reconstructed from LiDAR data, and (b) generated using an image-based technique [7]

A field comparison of the Leica BLK2GO mobile SLAM scanner and static TLS revealed that for a 2400 m^2 area, a manual traverse by a single operator required 20 minutes. In contrast, a traditional laser scanner required 3.5 hours of work by two people, involving 27 setups and target deployments [8]. Although the MLS point cloud exhibits a higher noise level, it is important to emphasize that MLS can detect more trees in a shorter scan time than TLS and thereby capture the complete shape of their trunks, as shown in Figure 2.

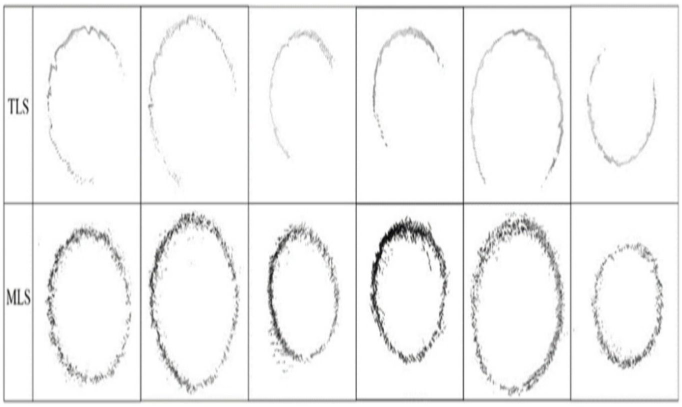

Fig. 2. Horizontal sections of the trees on the periphery area obtained by TLS and MLS [8]

The shift from hourly to minute-scale acquisition directly reduces labor costs and eliminates the risks associated with personnel presence in hazardous zones.

Secondly, photogrammetry and Structure from Motion algorithms have expanded the capabilities of both UAVs and terrestrial cameras. An experimental comparison revealed that the DJI Air 2S photogrammetric kit records over 10.7 million points per minute. In contrast, an RTK receiver collects approximately five points in the same interval [9], optimization of point-cloud density parameters further saves 70–80% of machine time in post-processing without loss of object-extraction accuracy [10], thus even if flight duration is limited by weather, the total person-hours remain orders of magnitude lower compared to traditional step-by-step traversing.

Finally, an IoT sensor network transforms structure-condition monitoring from discrete inspections into a continuous telemetry stream. A 2024 review highlights that continuous recording of vibrations, tilts and temperatures allows optimization of visual-inspection budgets and reduces the need for specialist dispatches [11], a field experiment on a road bridge in Italy demonstrated that edge-computing analytics reduced transmitted data volume from 780 kB to less than 10 bytes per hour, i.e. by a factor of 8×10^5, making round-the-clock monitoring economically comparable to infrequent inspections [12], in practice this implies replacing quarterly field visits by one team with remote monitoring of multiple assets simultaneously.

The cumulative effect of these three technologies manifests in the systematic elimination of repetitive manual operations—such as tripod repositioning, reflector placement, and field-log completion—the workplace shifts from a quarry or Arctic coastline to a cloud-based processing environment, where the engineer focuses on analysis and decision-making rather than physical measurement of each terrain point.

Ongoing automation moves the bottleneck from the field to the server: distributed cloud pipelines ingest raw imagery and return orthophotos and dense point clouds in a few clicks, in a comparative test Agisoft Metashape and DJI Terra generated a complete product suite in approximately half the time required by Pix4DMapper while preserving centimeter-level accuracy and thereby immediately saving office processing time [13], on Google Earth Engine a task requiring ten EECU-hours often completes in minutes thanks to automatic resource scaling, eliminating the need for an in-house compute cluster and its associated operational costs [14].

Cloud pipelines process not only geometry but also semantics: geospatial AI extracts roads, buildings and utility networks directly from orthophotos and LiDAR point clouds, the PolyR-CNN model raised the mean average precision for building-outline extraction on the CrowdAI dataset to 79.2 AP, improving the baseline system by 15.9 points and operating 2.5 times faster with four times lower memory consumption than the previous solution, thereby both enhancing quality and reducing machine processing time [15], such architectures enable near real-time generation of classified maps, leaving only selective validation to the human operator.

The economic impact becomes apparent once results are automatically ingested into BIM, ERP and GIS: according to an Autodesk industry report, 52% of rework in construction is associated with poor data exchange and 35% of weekly working hours are spent resolving resulting conflicts [16], after transition to an integrated GeoBIM repository 59% of companies reported reduced project risk and 63% reported significant reduction in data-search and verification time due to direct exchange between platforms, as shown in Figure 3.

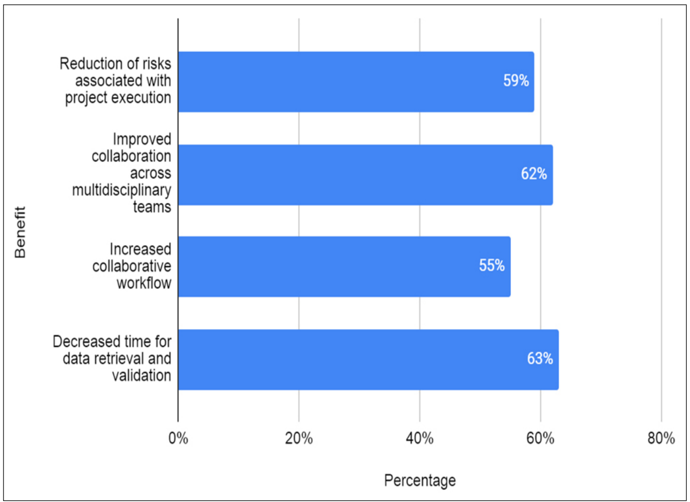

Fig. 3. Effects of GIS and BIM Integration on Project Performance Metrics [16]

Thus, automated processing closes the digital loop: sensors generate a data stream, the cloud transforms it into geometry and semantics, and corporate systems immediately utilize the result, finally eliminating repeat site visits and duplicate data entry. Automated methods of geodata collection and subsequent processing transfer the bulk of measurements from inaccessible terrain to the computing center, thereby sharply reducing specialists' field presence time. Unmanned platforms and mobile scanners simultaneously capture both surface geometry and semantics, and cloud pipelines complete model generation before the team returns to the office. The field phase becomes a brief mission for flight plan verification and quality control, rather than prolonged cycles of point targeting and recording.

Reduction of site-visit duration automatically lowers expenses for wages, per diems, fuel, and depreciation of heavy equipment. Where previously a multi-day shift with support vehicles was required, a single engineer trip with a drone or light scanner now suffices. Freed resources are redirected to analytical tasks rather than routine measurement, enhancing overall project profitability without additional capital investment.

Safety levels also improve, since personnel spend less time near operating machinery, on quarry slopes, or close to power lines. Accident risk decreases, and the company's insurance premiums fall along with the number of potentially hazardous operations. Concurrently, data quality improves, as dense point clouds and geospatial analysis algorithms ensure measurement consistency, thereby eliminating subjective factors and manual log transfer errors. Combined, these effects constitute a sustainable competitive advantage, where labor-effort savings are paired with a more reliable informational basis for further engineering decisions.

Automated systems for geodata collection and processing have already moved beyond pilot trials and are established in key economic sectors where any information delay leads to direct losses. In construction, aerial and terrestrial scanners enable daily verification of earthwork volumes, comparison with the project's digital model, and schedule adjustment on the same day; consequently, survey crews no longer revisit the site multiple times, and engineers make decisions based on an updated digital twin accessible to the entire team via a browser.

In the energy sector, LiDAR- and thermal-imaging–equipped UAVs inspect power-line corridors or pipelines in a time comparable to one working day, automatically flagging potential overheating, corrosion, or hazardous vegetation encroachment; the operator needs only review the report and issue a maintenance work order, eliminating lengthy ground patrols and improving overall network reliability.

On mining sites, mobile platforms collect point clouds without interrupting excavators, and algorithms immediately compute pit and spoil-pile volumes. Thus, open-pit management recalculates the extraction coefficient each evening, rather than waiting for surveyors to finish their shift. Equipment continues to operate without downtime, and reserve estimation becomes a continuous process.

In agriculture, multispectral photogrammetry enables the diagnosis of leaf chlorophyll content and moisture before visual stress symptoms appear. Agronomists can identify disease foci on an index map and dispatch sprayers precisely, thereby saving herbicides and fuel. As a result, seasonal field inspections are reduced to infrequent control visits, and yields increase thanks to early problem response.

For environmental monitoring, satellite imagery with artificial intelligence analysis detects deforestation or erosion almost immediately after it occurs, and ground sensors also transmit data on soil moisture and air quality. Thus, protected area monitoring shifts to a continuous mode, allowing for faster implementation of restoration measures and avoiding costly expeditions. All these examples demonstrate how shifting routine measurements from the field to the digital domain simultaneously reduces manual labor and accelerates management decision-making.

Thus, end-to-end automation of geodata collection and processing has proven that it shifts the focus of surveying work from labor-intensive field activities to cloud-based analytics; it reduces field-crew staffing, minimizes on-site time, enhances safety and source-data quality, and establishes a new economic balance in which an engineer's ability to analyze and interpret data is valued more highly than manual coordinate measurement.

CONCLUSION

Based on the presented data and analysis, the following conclusions can be drawn regarding the role of automated systems in reducing labor effort during geodata collection and processing in field operations. First, the evolution of equipment from classical total stations and GNSS receivers to unmanned aerial vehicles, mobile SLAM scanners, and portable LiDAR devices has sequentially eliminated key manual operations, including the need for inter-point targeting, deployment of tripods with reflectors, and completion of field logs. Each technological stage has minimized field-crew size and substantially reduced field exposure time, as confirmed by data from Fujita, the Ohio Quarry, and Leica BLK2GO. The use of automated platforms has reduced person-hours by 40–60% or more, with static TLS being ten times slower than mobile scanning at comparable accuracy.

Second, integration of photogrammetry and Structure from Motion algorithms into unmanned systems has replaced tens of point-wise measurements with millions of photogrammetric points per minute, thereby reducing not only field-specialist effort but also office-processing time by 70–80% while maintaining the required level of detail. At the same time, the deployment of IoT sensors on infrastructure assets has converted discrete inspections into continuous monitoring, reducing data transmission volume by orders of magnitude and decreasing specialist site-visit frequency from quarterly to virtually seamless remote checks.

The third significant aspect is the transformation of geodata post-processing: cloud pipelines and geospatial AI enable the automatic generation of orthophotography maps, dense point clouds, and classified maps in minutes, rather than hours or days. Comparative tests of Agisoft Metashape, DJI Terra, and Pix4D Mapper demonstrate a twofold acceleration of processing pipelines while preserving centimeter-level accuracy. PolyR-CNN models improve the semantic segmentation quality of buildings and utility networks by 15.9 AP, reduce computational overhead, and accelerate processing by an average of 2.5 times.

The economic impact of automated system adoption is manifested in resource reallocation: liberated human hours are directed toward data analysis and project decision-making tasks rather than routine field measurements, thereby increasing overall project profitability without additional capital outlay. Reduced field visits lower expenses for wages, transportation, and equipment depreciation, while simultaneously improving personnel safety and source data quality by decreasing subjective manual-entry errors. As a result, companies gain a sustainable competitive advantage by having immediate access to an up-to-date digital model of the asset.

In conclusion, automated methods of geodata collection and processing radically transform the format of field operations by transferring the primary workload from physical point measurement to the computing center, where engineers concentrate on decision-making using ready digital twins. This shift ensures a significant reduction in labor effort, increases surveying speed and accuracy, and delivers economic and safety benefits, making automation an indispensable tool in modern engineering and environmental practices.

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