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# Geotagged Stop Work Authority Reporting and Hazard Mapping System for Electricity Distribution Safety

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## ABSTRACT

Occupational safety in electricity distribution depends on how quickly unsafe acts and unsafe conditions in the field are stopped, recorded, and followed up. Stop work authority gives every worker the right to halt hazardous work, yet in the studied customer service unit of the Indonesian state electricity company the process still relied on paper forms that were not always completed, required the signature of a supervisor who was often away from the site, carried no location data, and were difficult to recapitulate. This study aimed to design and evaluate a web information system that digitizes stop work authority hazard reporting and adds geotagging to every finding. The system was developed with the waterfall model, specified with use case, class, sequence, and activity diagrams and an entity relationship model, and implemented as a role-based web application in which browser geolocation and an interactive map supply the latitude and longitude of each finding. The digital record mirrors the paper form, including eight work requirement checks, stop and resume times, unsafe act and unsafe condition entries, protective equipment, photographs, and corrective recommendations. Fourteen black-box test cases covering authentication, finding management, and master data all passed, and a user acceptance test with the unit's safety team leader as process owner reached the maximum score on all fifteen statements. The results show that geotagged hazard reporting turns isolated paper forms into searchable and mappable records that support follow-up and contractor monitoring, although a wider evaluation with field officers and contractors is still required.

## INTRODUCTION

Electricity distribution work exposes field personnel to electric shock, falls from height, and falling objects, and live work on overhead lines carries a high fatality rate (Jiang et al., 2026; Ramirez-Bettoni, Eblen, & Nemeth, 2024). Analyses of utility accidents attribute them not only to individual errors but also to safety climate and management deficiencies (Baby, Madhu, & Renjith, 2021; Waugh, Newnam, & Rodwell, 2026). In Indonesia, the state electricity company PT PLN (Persero) pursues a zero harm and zero loss target through its Life Saving Rules, one of which is stop work authority (SWA): every employee and contractor is entitled, and expected, to stop work when a potential hazard is found until the hazard has been controlled (Murtasiyah & Halim, 2025; Sihombing, 2022; Yasseen et al., 2024). Stop work authority is therefore a frontline barrier, but its value depends on whether each stop decision is recorded, followed up, and learned from.

Research on safety voice shows that speaking up about hazards is associated with lower safety risk and fewer injuries, and that it depends on leader support and empowering supervision (Curcuruto & Griffin, 2023; Mathisen, Tjora, & Bergh, 2022). At the Gambut customer service unit (ULP) of PT PLN (Persero) in South Kalimantan, SWA was still documented on a paper form. Interviews with the unit's occupational health, safety, and environment (K3L) team leader revealed four problems: the form was not always completed in the field, approval waited for the signature of a supervisor who was often away from the site, the form recorded no position of the finding, and paper records could not be recapitulated per contractor or period. Hazards that were stopped informally therefore left no trace for evaluation.

Digital tools have begun to replace paper inspections and hazard reports in construction and manufacturing (Forteza, Carretero-Gómez, Estudillo, & Sesé, 2023; Pedrosa, Salazar, Cardoso, & Guedes, 2025), and location-aware reporting with geotags or web maps has been applied to unsafe acts at port terminals, to customer complaints in a water utility, and to community disaster reports (Iqbal, Febriyanto, & Irsyada, 2025; Lesmana, 2021; Mulyana & Purwita, 2026). Studies on SWA, in contrast, remain organizational, examining culture, training, and drills rather than the information system that records each stop decision (Murtasiyah & Halim, 2025; Yasseen et al., 2024). A structured SWA record that mirrors the official form, including its work requirement checks and stop and resume times, and binds every

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stop decision to a coordinate has not been reported for electricity distribution units.

This study therefore designs, implements, and evaluates a geotagged SWA reporting and hazard mapping system for an electricity distribution unit. Its contributions are (1) a data model that maps the paper SWA form one-to-one into structured fields, (2) a geotagging workflow that combines browser geolocation with manual marker correction, (3) role-based monitoring views, namely a findings map, a recapitulation per contractor, and a printable SWA form, for administrators, safety officers, employees, and contractor companies, and (4) a functional and acceptance evaluation with the process owner. The rest of the paper reviews related work, describes the method, reports the results, and discusses their implications and limitations.

## LITERATURE REVIEW

Stop work authority gives every worker the right and the duty to halt work that is unsafe. Sihombing (2022) positioned SWA as a means of reducing first aid cases toward zero lost time injury based on the accident pyramid. Murtasiyah and Halim (2025) found that combining weekly safety talks with an SWA programme at an oil and gas contractor raised employee participation, reduced unsafe acts during 2024, and made the use of SWA consistent. Yasseen et al. (2024) proposed stop work drills in which leaders rehearse real operational scenarios with frontline crews so that stop-work triggers are discussed before they occur. The broader safety voice literature links speaking up with lower safety risk and fewer injuries and identifies leader support, job control, and empowering as well as monitoring supervision as its drivers (Curcuruto & Griffin, 2023; Mathisen et al., 2022). These studies treat SWA as a matter of culture and leadership; none describes how stop decisions are recorded or followed up.

Digital tools have started to replace paper in safety management. Forteza et al. (2023) deployed a mobile application that replaced paper construction site inspections with digital records based on a risk model. Pedrosa et al. (2025) found that introducing a near-miss management system improved management commitment, investigation, meetings, and training as dimensions of safety culture. Irhandi, Coyanda, and Saluza (2024) built a web health, safety, security, and environment performance system modeled in UML that replaced semi-manual data handling with a management dashboard. Closest to the present work, Mulyana and Purwita (2026) replaced an unintegrated online form for unsafe act and unsafe condition reports at port terminals with a web system that maps GPS coordinates, sends real-time notifications, and adds a points leaderboard; all eleven black-box scenarios passed. A mapping review nevertheless found that most digital safety studies are technology development with limited evidence of injury reduction (Trask & Linderoth, 2023).

Location is the second building block. Teguh, Lestari, Louhenapessy, Hayasaka, and Wibowo (2021) used geotagged smartphone photos and a web application to support investigation and reporting of peatland fires, and Lesmana (2021) used the geotags embedded in customer photos to map service complaints in a water utility. Rexline and Shameema Nazrin (2024) used the Google Maps API to geotag the attendance of field workers. In this journal, web and mobile geographic information systems have been built for restaurant search (Fuad et al., 2021), language and literature mapping (Hutabarat et al., 2025; Putra et al., 2025), and community disaster reports with heatmap analytics (Iqbal et al., 2025). The accuracy of such geotags is limited: positions from mobile devices deviated by 4 m to almost 50 m from a high-precision receiver (Szafarczyk et al., 2025). Table 1 compares the most closely related studies with the present work. Location-aware reporting is established, but the SWA procedure itself, with its work requirement checks and its stop and resume decision, has not been digitized and geotagged for electricity distribution.

Table 1. Comparison of Related Studies and the Present Study

| Study | Context | Location handling | Evaluation | Gap addressed here |
|---|---|---|---|---|
| Mulyana and Purwita (2026) | Unsafe act and unsafe condition reports, port terminals | GPS coordinates on a GIS map | Black-box, 11 scenarios | General hazard report; no requirement checks or stop and resume record |
| Lesmana (2021) | Customer complaints, water utility | Geotags embedded in uploaded photos | System implementation | Service complaints rather than safety interventions |
| Irhandi et al. (2024) | Safety performance data, company | Not addressed | Prototype modeled in UML | No location; performance indicators rather than field stops |
| Forteza et al. (2023) | Site safety inspection, construction | Not addressed | Design and deployment of a mobile app | Inspection checklist not linked to a stop-work decision |
| Teguh et al. (2021) | Peatland fire investigation | Geotagged smartphone photos | Field application | Environmental events rather than work permits |
| Iqbal et al. (2025) | Community disaster reports | Reported events shown as a heatmap | Agile development | Public reporting rather than workplace SWA |
| This study | SWA in electricity distribution | Browser geolocation with | Black-box, 14 cases; UAT | Form-to-record mapping of SWA with geotagged |

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| | | |
|---|---|---|
| | manual marker correction | findings |

## METHOD

The study followed the waterfall model, a linear sequence of requirements analysis, design, coding, and testing that is commonly used for web information systems with stable requirements (Hanifah et al., 2025; Mintarsih, 2023). Figure 1 shows the stages and the feedback loop used to fix defects found during testing.

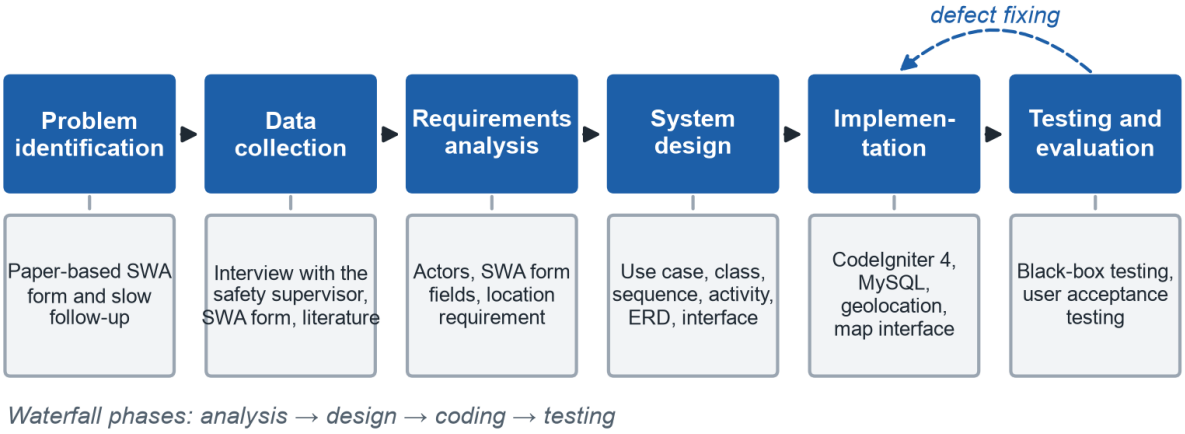



Figure 1. Research stages following the waterfall model

### Research Site and Data Collection

The research was conducted at the Gambut customer service unit (ULP) of PT PLN (Persero), Jl. A. Yani Km. 21, Landasan Ulin Barat, Banjarbaru, South Kalimantan, which serves electricity customers in Gambut District and its surroundings, between August 2024 and July 2025. Three sources were used. First, a semi-structured interview with the K3L team leader, who supervises field safety and acts as the process owner of SWA, captured the current procedure, its problems, and the expected functions. Second, the official paper SWA form was analyzed section by section to derive the data fields. Third, a literature study on SWA, digital hazard reporting, and web mapping informed the design choices.

### Analysis and Design

Requirements were expressed as actors and use cases. The design was specified with the Unified Modeling Language, as in comparable web safety information systems (Irhandi et al., 2024): one use case diagram, one class diagram, 17 sequence diagrams, and 18 activity diagrams. The database was modeled with an entity relationship diagram and a relational schema, and 21 interface mock-ups were drawn for the four user roles before coding.

### Implementation

The system was implemented as a web application with the CodeIgniter 4 framework in PHP, which separates models, views, and controllers, and a MySQL database. The interface uses the AdminLTE template. Location capture uses the browser Geolocation API and the Maps JavaScript API. Development ran on a Laragon local server and Visual Studio Code on a laptop with an AMD Ryzen 3 7320U processor, 8 GB of memory, and Windows 11.

### Evaluation

Functional correctness was assessed with black-box testing, which compares the observed output with the expected output for given inputs without inspecting the source code (Mintarsih, 2023; Sholeh, Gisfas, Cahiman, & Fauzi, 2021). Test cases were derived from the use case scenarios and covered valid and invalid inputs. The success rate is computed with (1), where $n_{\text{pass}}$ is the number of test cases whose observed result matched the expected result and $n_{\text{total}}$ is the number of test cases.

$$SR = \frac{n_{\text{pass}}}{n_{\text{total}}} \times 100\% \qquad (1)$$

Acceptance was assessed with a user acceptance test (UAT) of the contract acceptance type, which checks whether the delivered system meets the requirements agreed with the client (Budisaputro et al., 2024; Chamida, Susanto, & Latubessy, 2021). The questionnaire contained 15 statements on the functions and interface of the system, each rated on a five-point Likert scale: strongly agree (5), agree (4), neutral (3), disagree (2), and strongly disagree (1). The respondent was the K3L team leader as client and process owner, and the test was held on 18 April 2025. The acceptance index is computed with (2), where $S$ is the sum of the frequency of each answer multiplied by its weight and

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$S_{max}$ is the highest weight multiplied by the number of statements and respondents.

$$P = \frac{S}{S_{max}} \times 100\% \quad (2)$$

## RESULT

### Requirements and Process Analysis

In the current process, a supervisor who sees unsafe work in the field writes an SWA letter, hands it to the worker or contractor, and the work is stopped. Because the letter needs the signature of a supervisor who may not be on site, issuance is delayed, and minor interventions are often not written at all. Table 2 contrasts this procedure with the proposed system on seven aspects identified in the interview.

Table 2. Current Paper-Based Procedure and the Proposed Geotagged System

| Aspect | Paper-based SWA | Proposed system |
|---|---|---|
| Recording medium | Paper form filled in the field | Web form on a laptop or smartphone |
| Completeness | Fields often left blank | Required fields validated before saving |
| Location of finding | Not recorded | Latitude and longitude from geolocation or map click |
| Approval and follow-up | Waits for supervisor signature on paper | Status updated by the administrator and visible to all roles |
| Access by contractors and employees | Copy handed over on site | Read access to their own findings and the findings map |
| Recapitulation | Manual counting of paper forms | Recap chart per contractor with date filters |
| Document output | Handwritten form | SWA form generated as PDF from stored data |

Table 2 compares the current paper-based Stop Work Authority (SWA) procedure with the proposed geotagged system across seven aspects. The paper-based procedure relies on handwritten forms that are often incomplete, do not record where a hazard was found, and require a supervisor's signature that may be delayed when the supervisor is not on site. Recapitulation also depends on manually counting paper forms, and contractors and employees receive only a copy handed over on site. In contrast, the proposed system uses a web form accessible from a laptop or smartphone, validates required fields before saving, and captures latitude and longitude through geolocation or a map click. Report status is updated by the administrator and visible to all roles, while contractors and employees have read access to their own findings and the findings map. The system also provides a recap chart per contractor with date filters and generates the SWA form as a PDF from stored data. Together, these features address the main weaknesses of the paper-based procedure while keeping the SWA form as an official output.

### Mapping the SWA Form to Structured Data

Table 3 maps each section of the official SWA form to the fields of the finding record. Section A contains eight work requirement checks, from an approved work permit to the availability of personal protective equipment (PPE); each check is stored as available or not available, and a missing requirement is the formal reason to stop the work. Section B stores the time the work was stopped and resumed, and Section C stores any number of findings, each classified as an unsafe act or an unsafe condition. Location, finding date, and follow-up status complete the record.

Table 3. Mapping of the Paper SWA Form to the Finding Record

| SWA form section | Content | Stored fields | Input control |
|---|---|---|---|
| Header | SWA holder, arrival time at site, job type, work executor | officer, arrival_time, job_type, executor | Session user, time, text, contractor list |
| A. Activity | Work permit approved; SOP, work instruction or checklist; job safety analysis approved; competent supervisor; competent workers; proper tools; safety signs and lockout tagout; suitable PPE | k1 to k8 | Available or not available, with the rule that work stops if a requirement is missing |
| B. Action | Work stopped temporarily; work resumed | t1, t2 | Time |
| C. Field findings | Description of each finding and its type | finding_detail (description, unsafe_act, unsafe_condition) | Repeatable rows with check boxes |
| D. Photo | Evidence of the finding | photo | File upload |
| Follow-up | PPE in use, corrective recommendation | ppe_used, recommendation | Text |
| Location and status | Position, date, and progress of the finding | latitude, longitude, finding_date, status | Map picker, date, status update |

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The resulting logical data model is shown in Figure 2. A single login table authenticates all users and its level column determines the role. The finding table references the reporting officer, the employee concerned, and the executing contractor, so every finding can be traced to who reported it, who was involved, and which company carried out the work.

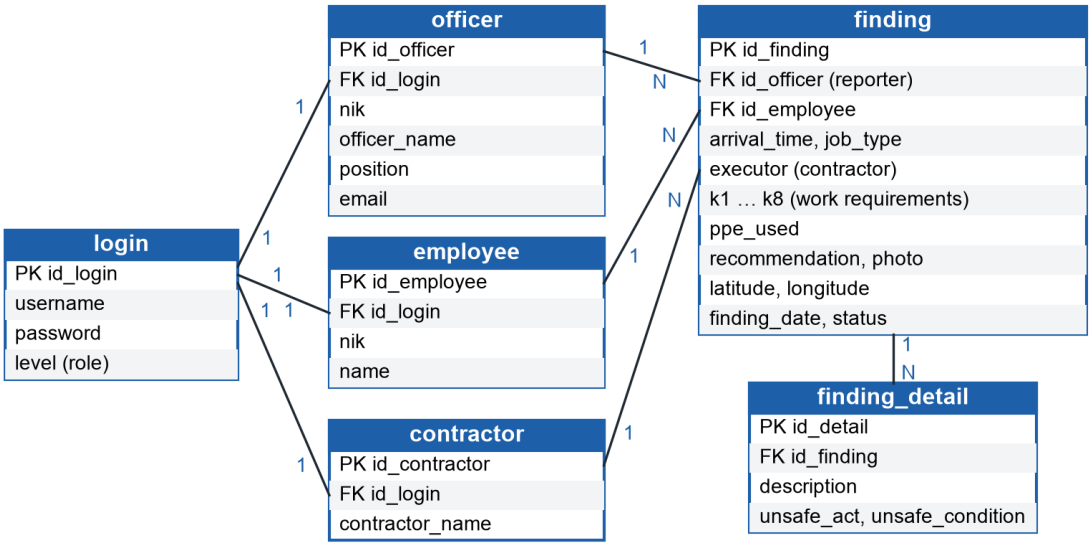



Figure 2. Logical data model of the finding record and user roles

**Roles and Functional Design**

Four roles were identified (Figure 3). The administrator manages master data on employees, officers, and contractors, updates finding status, prints the SWA form, and views the recapitulation. The safety officer records SWA findings in the field, and recording a finding always includes tagging its location. Employees and contractor companies have read access to the findings list, finding details, and the findings map, so the parties whose work was stopped can see the reason and the required correction. Because the administrator inherits all officer functions, the use cases form a strict hierarchy of privileges.

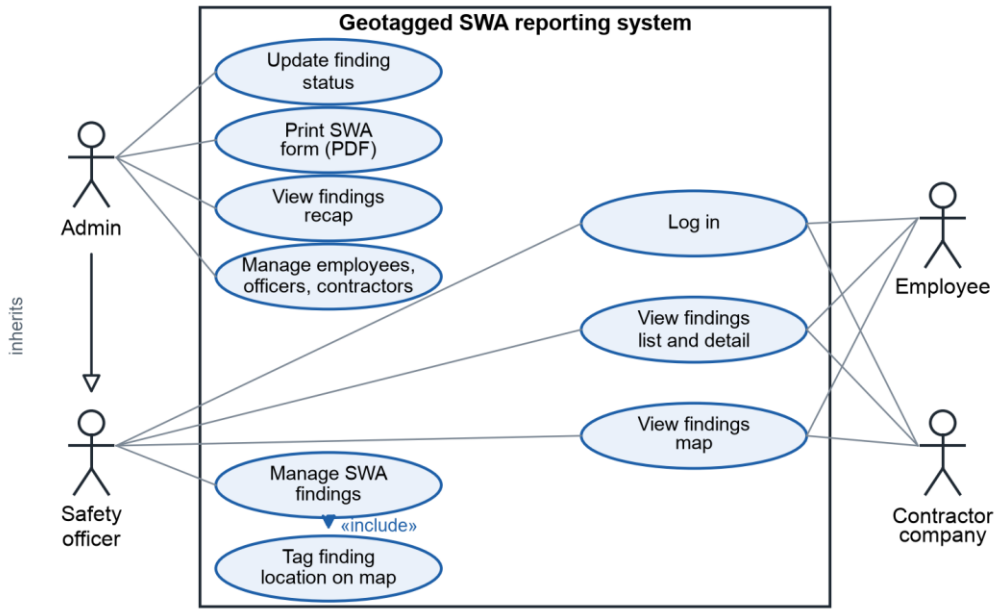



Figure 3. Use case diagram of the geotagged SWA reporting system

**Implementation and Geotagging Workflow**

Figure 4 summarizes the architecture. The presentation layer serves the finding form with its location picker, the findings list, the findings map, the recapitulation chart, and the PDF form; the application layer checks the role of every request before running the corresponding controller; the data layer stores the records and uploaded photographs.

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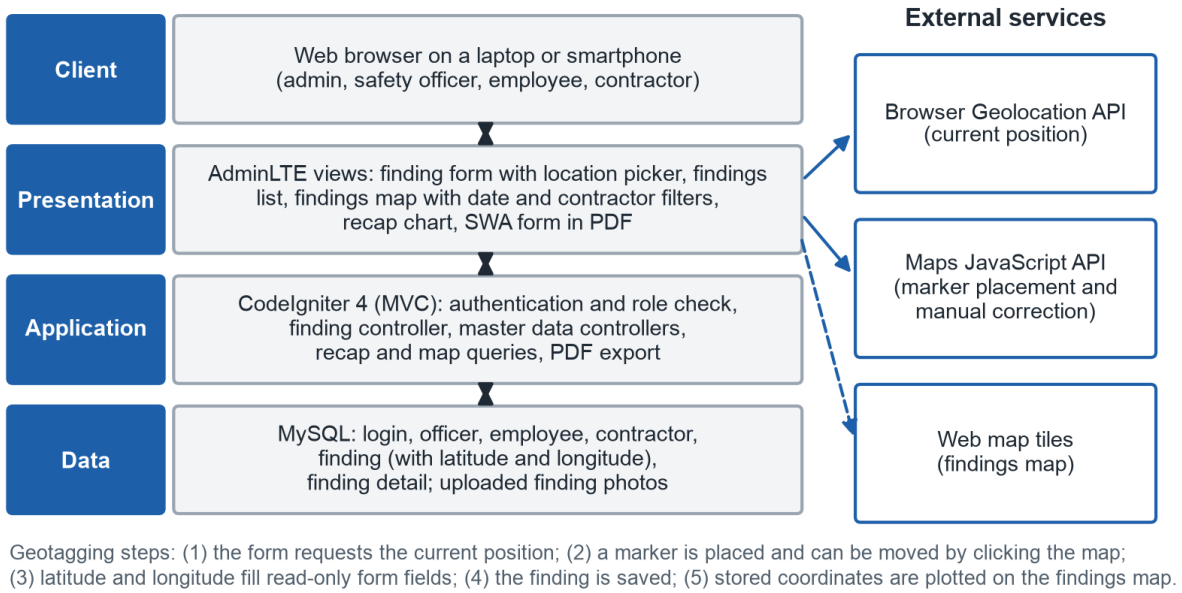
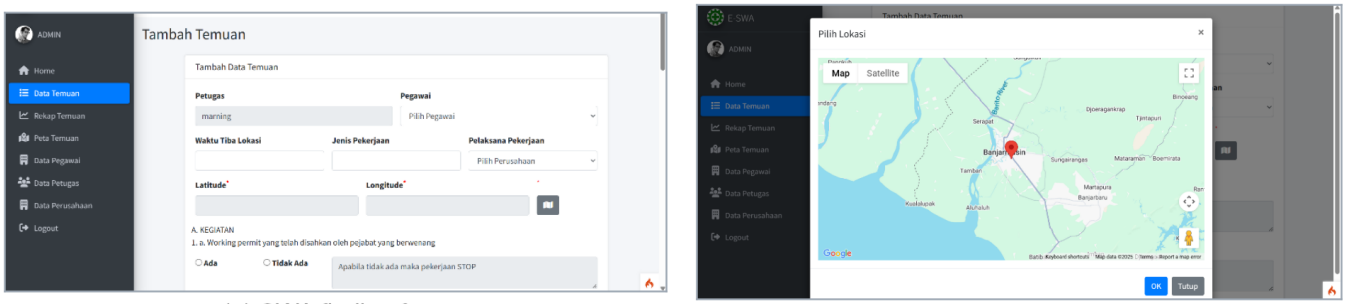



Figure 4. System architecture and geotagging workflow

Geotagging follows five steps. When the location picker opens, the map is centered on the service area at latitude -3.6055 and longitude 114.7065, and the form requests the current position from the browser. If the position is granted, a marker is placed there and its latitude and longitude are written to two read-only fields; if it is denied or unavailable, the map shows a message and keeps the default center. In both cases the officer can click the map to move the marker, which covers findings reported after leaving the site or positions distorted by weak satellite reception. The coordinates are then saved with the finding and plotted on the findings map. Figure 5 shows the finding form and the location picker.




(a) SWA finding form

(b) Location picker with a movable marker

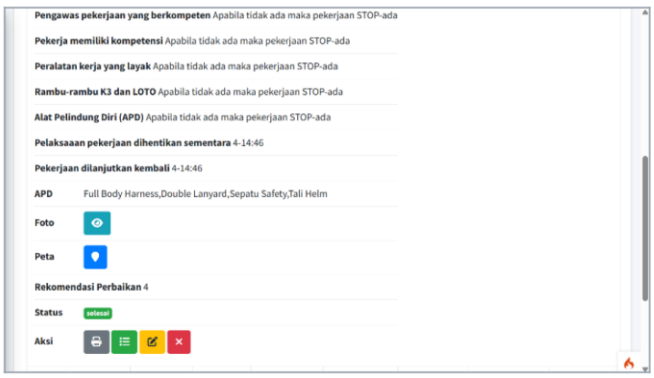
Figure 5. Recording an SWA finding: (a) finding form with the eight work requirement checks and (b) location picker

Figure 6 shows the monitoring outputs. The finding detail page lists every requirement check, the stop and resume times, the PPE in use, the photograph, a map link, the corrective recommendation, and the status, with actions to print, view, edit, and delete. The generated PDF reproduces the layout of the official SWA form, so the digital record can still be signed and archived. The recapitulation page counts findings per contractor within a selected date range, and the findings map filters markers by date range and contractor.

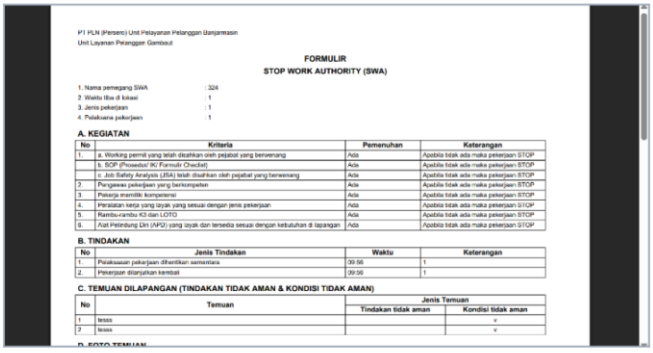
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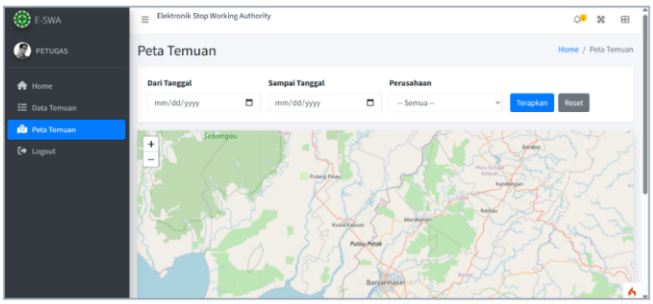

(a) Finding detail, status, and actions




(b) Generated SWA form (PDF)




(c) Findings recap per contractor




(d) Findings map with date and contractor filters

Figure 6. Monitoring outputs: (a) finding detail, (b) generated SWA form, (c) recapitulation per contractor, and (d) findings map

**Testing Results**

Fourteen black-box test cases were executed. Table 4 groups them by module and role. All 14 observed results matched the expected results, so the success rate from (1) is 14 divided by 14, or 100%.

Table 4. Black-Box Test Results by Module

| Module | Test scenarios | Role | Cases | Passed |
|---|---|---|---|---|
| Authentication | Login page displayed; error message for a wrong username or password; login redirects to the role dashboard | Admin, officer, employee | 5 | 5 |
| Finding management | Findings list displayed; new finding form opened from the add button | Admin, officer, employee | 5 | 5 |
| Master data | Employee and officer lists displayed; add forms opened | Admin | 4 | 4 |
| Total | | | 14 | 14 (100%) |

Table 5 summarizes the user acceptance test. The process owner chose strongly agree for all 15 statements, giving $S$ equal to 75 and $S_{max}$ equal to 5 multiplied by 15 statements and one respondent, or 75. The acceptance index from (2) is therefore 100%.

Table 5. User Acceptance Test Summary

| Respondent | Statements | SD (1) | D (2) | N (3) | A (4) | SA (5) | S | $S_{max}$ | Index |
|---|---|---|---|---|---|---|---|---|---|
| K3L team leader (process owner) | 15 | 0 | 0 | 0 | 0 | 15 | 75 | 75 | 100% |

## DISCUSSION

The main change introduced by the system is structural. Each stop decision becomes a complete record with a time, a location, a reporting officer, the employee and contractor involved, the eight requirement checks, and a follow-up status. Validation of required fields addresses the incomplete forms reported in the interview, and the status field replaces the wait for a signature on paper with a state that every role can see. This agrees with the shift from paper to digital records reported for construction inspections and near-miss management, where the digital system was also perceived as a sign of management commitment (Forteza et al., 2023; Pedrosa et al., 2025). Compared with the port terminal system of Mulyana and Purwita (2026), which also maps unsafe act and unsafe condition reports, the present system adds the requirement checklist and the stop and resume record of the SWA form but does not yet offer real-time

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notifications or participation incentives. Like most digital safety studies reviewed by Trask and Linderoth (2023), it has not yet measured reporting volume, follow-up time, or injury outcomes, so the benefit is shown as a capability rather than an observed effect.

Geotagging turns SWA from a document into spatial data. Web geographic information systems published in this journal mostly map static objects such as restaurants or languages and literature (Fuad et al., 2021; Hutabarat et al., 2025; Putra et al., 2025), whereas the findings map here shows events that can be filtered by period and contractor, which allows supervisors to see where and with which contractor unsafe work recurs. Accident analyses in power grid enterprises show that such events cluster by region, month, and time of day (Jiang et al., 2026), which is the pattern the map is meant to reveal. The accuracy of mobile geolocation varies from a few meters to tens of meters (Szafarczyk et al., 2025), so the design allows manual correction of the marker. The same freedom can introduce wrong positions, so storing the reported accuracy radius and capture time together with the coordinates is a simple improvement.

The data model favors fidelity to the official form. Storing the eight requirement checks as fixed columns keeps the PDF output identical to the paper form and keeps queries simple, but any revision of the form requires a schema change. A normalized checklist table, numeric or spatial column types for the coordinates, and a referrer restriction on the map key embedded in the browser code would make the system easier to maintain and safer to deploy beyond a single unit.

Several limitations constrain the conclusions. The acceptance test involved one respondent, the process owner who also defined the requirements, so the maximum score reflects agreement with the agreed scope and may contain a ceiling effect; it cannot be generalized to field officers or contractors. The 15 statements were developed for this study and are not a standardized instrument such as the System Usability Scale, for which benchmark scores by system type are available (Vlachogianni & Tselios, 2022). Comparable acceptance studies also involved more users, for example 30 users in Budisaputro et al. (2024). The black-box cases covered authentication, finding management, and master data for three roles, but did not include the contractor role, status updates, PDF generation, or map filtering. Finally, the system was evaluated in one unit before a field deployment period. The results therefore demonstrate functional readiness and acceptance by the process owner, not effectiveness in reducing incidents. A multi-user evaluation with a standardized usability scale, a before and after comparison of reporting and follow-up time, and a wider test suite are needed. Once enough geotagged records accumulate, they can also serve as training data for spatial hotspot detection and prediction of recurring unsafe conditions, as heatmap analytics already do for community disaster reports (Iqbal et al., 2025), which links this work to intelligent safety analytics.

## CONCLUSION

This study digitized stop work authority for an electricity distribution unit as a geotagged web information system. The paper SWA form was mapped into a structured finding record with eight work requirement checks, stop and resume times, unsafe act and unsafe condition entries, PPE, photographs, recommendations, status, and coordinates, and four roles were given access that matches their responsibility. Geotagging combines browser geolocation with manual marker correction, so each stop decision can be placed on a map and recapitulated per contractor and period. All 14 black-box test cases passed and the process owner accepted the system with the maximum score on all 15 statements. The main contribution is a reusable pattern, consisting of the form-to-record mapping, the geotagging workflow, and role-based monitoring views, that turns isolated paper SWA forms into auditable and mappable safety data. Future work should evaluate the system with field officers, employees, and contractors using a standard usability instrument, measure reporting and follow-up time before and after adoption, add instant notifications to supervisors, and use the accumulated geotagged records for spatial hotspot analysis and prediction of recurring unsafe conditions.

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