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Banjak Timer: A Web-Based Real-Time Timing and Performance Monitoring System for Competitive Racing Events

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Abstract

Precision and timeliness are crucial in competitive sports, yet many local events still depend on manual timekeeping methods that often lead to delays and inaccuracies. This study introduces Banjak Timer, a responsive web-based system designed to automate race timing, consolidate results, and monitor performance in real time for downhill biking events. Drawing on edge computing and sensor-based monitoring concepts (Tang et al., 2024), the platform enables immediate start/stop timing, real-time leaderboards, and comprehensive post-race reporting. To assess system quality, a structured evaluation was conducted with live event participants using the ISO/IEC 25010 Software Quality Model. Results showed strong performance across all dimensions—including functional suitability, efficiency, usability, and reliability—confirming that Banjak Timer delivers a robust, user-centered solution that significantly improves operational efficiency and credibility of grassroots race events.

Keywords: Real-Time Timing System, Web-Based Application, Racing Event Management, Performance Monitoring, Sports Technology

Introduction:

In recent years, the integration of digital systems into sports management has transformed how athletic competitions are organized, monitored, and evaluated. As events grow in scale and complexity, especially in time-critical sports such as downhill racing, the need for accurate, real-time timing and performance monitoring systems becomes increasingly essential. Traditional methods involving manual recording and timekeeping often result in inconsistencies, delays, and administrative challenges. To address these issues, this study introduces Banjak Timer, a web-based real-time timing and performance monitoring system tailored for competitive racing events. Real-time platforms using wireless sensors and IoT-optimized architectures have demonstrated substantial improvements in latency and data accuracy, reducing delays to as little as 50 milliseconds in practical trials (Smith et al., 2023; Liu et al., 2024).

The conceptualization of this system is deeply rooted in the experience of the Banjak Organization of Carrascal, Surigao del Sur. During the height of the COVID-19 pandemic, when social interactions were limited and organized events came to a halt, a group of local professionals and students found a creative outlet through mountain biking. Gathering in the hills of Manag-as Gamuton, these enthusiasts began hosting informal downhill races as a form of recreational escape and physical activity. Over time, what began as a small gathering evolved into a vibrant community driven by passion and sportsmanship. This

grassroots movement laid the foundation for a more organized approach to racing, highlighting the need for a reliable system to manage rider data, monitor performance, and produce timely results.

Banjak Timer was developed to meet this growing demand, offering a comprehensive platform that supports event creation, rider registration, live timing, and detailed performance analytics. The system's interface was designed with accessibility and ease of use in mind, ensuring that both organizers and participants can navigate its features with minimal technical background. Through the implementation of this system, the study aims to contribute to the ongoing digital transformation of community-based sports, demonstrating how localized innovation can address operational challenges while promoting athletic engagement (Shen et al., 2024).

Conceptual Framework

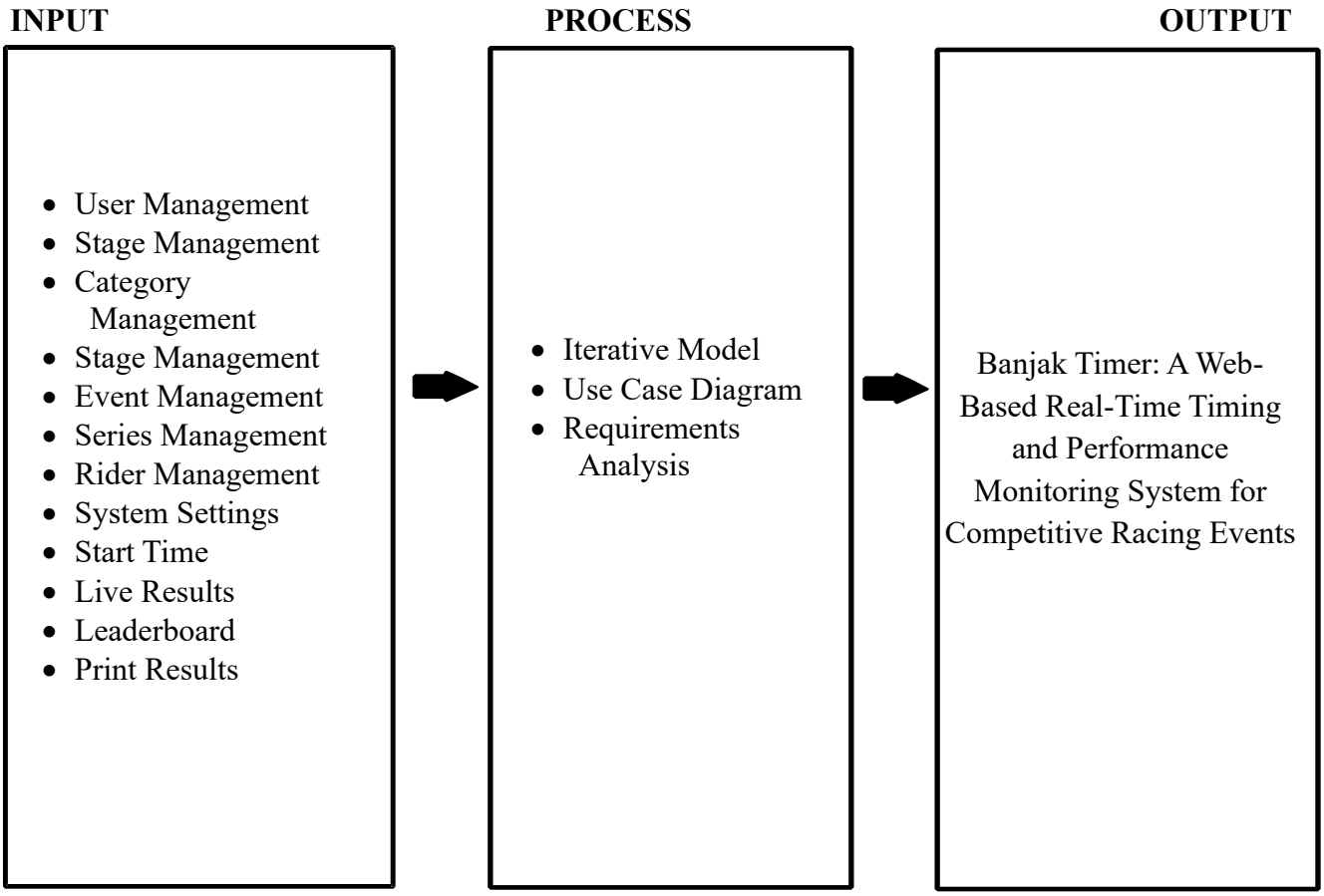

Figure 1.0 IPO Diagram of the Study

The Figure 1.0 Input–Process–Output (IPO) diagram encapsulates a well-structured workflow that drives the development of Banjak Timer: A Web-Based Real-Time Timing and Performance Monitoring System for Competitive Racing Events. This framework illustrates how discrete system modules and development stages combine to deliver a user-centric solution optimized for grassroots sporting events.

Input represents the essential modules needed for effective system operation. These include administrative controls (user, event, stage, and rider management) and dynamic features (system settings, start-time configuration, live result display, leaderboard tracking, and printable reports). Such modular input design aligns with established IPO methodologies commonly used in software engineering and sports analytics,

which emphasize clearly defined system inputs to ensure optimized output generation (Ye, 2024; Pappalardo et al., 2024).

Process reflects the iterative development activities that transformed these inputs into a functioning system. Guided by an incremental model, each development cycle was informed by actual stakeholder feedback and usage requirements. The integration of use-case diagrams provided a visual representation of how end-users interact with the system, enabling a more intuitive and responsive architecture. This approach mirrors the principles of agile development and scenario-based modeling widely adopted in system design (Tang et al., 2024).

Output is embodied in the responsive, web-based Banjak Timer platform. The system supports real-time timing, automated result logging, and dynamic performance tracking, all accessible through a user-friendly dashboard. This output is consistent with trends in sports telemetry and real-time data processing, which stress the value of instantaneous feedback for performance evaluation and operational coordination (Pappalardo et al., 2024; Tang et al., 2024).

Statement of the Problem

In competitive racing events, precision and speed in timing systems are vital to ensuring fair competition and maintaining stakeholder confidence. Studies have shown that traditional manual methods—such as handwritten logs and handheld stopwatches—are often inconsistent, prone to human error, and difficult to scale during events with many participants (Altmann et al., 2018). In the case of the Banjak Organization of Carrascal, timing practices remain largely fragmented: timekeepers rely on handwritten logs, mobile stopwatches, or ad-hoc digital entries, all manually consolidated later. This cumbersome process is time-intensive, risks data loss, and delays result publication. Manual timers also introduce significant variability—research indicates that manual timing can be up to 6% faster than electronic timing systems, with nearly double the standard deviation of error (Altmann et al., 2018).

Such shortcomings undermine oversight, transparency, and real-time data availability. Participants and spectators increasingly demand live feedback, accurate rankings, and transparent stage-by-stage performance monitoring—capabilities that manual timing systems struggle to provide reliably (Berg et al., 2023). Moreover, the lack of an integrated platform for managing rider data, timing, tracking, and result dissemination hampers the organization's ability to scale its events and maintain operational consistency.

Given these challenges, a responsive and fully integrated system is essential. Recent advancements in edge computing and real-time monitoring technologies have shown promise in improving data latency, system responsiveness, and user accessibility in high-performance sports environments (Tang et al., 2024). In response, the Banjak Timer was developed—a web-based platform designed to automate timing operations, consolidate results, and provide real-time updates, leaderboard displays, and print-ready performance summaries. The system aims to elevate grassroots race management through improved accuracy, speed, and usability.

This study is guided by the following key questions:

1. What are the current practices of the Banjak Carrascal Organization in terms of:
   Recording rider timing;
   Consolidating race results?

2. What specific problems and challenges are encountered by the organization with respect to time recording, data management, and result processing?
3. What system features can be developed to address the identified operational gaps in timing accuracy, data consolidation, and real-time monitoring?
4. What enhancements can be introduced to further improve the performance, efficiency, and usability of the developed system?
5. System Assessment Based on ISO/IEC 25010 Software Quality Standards

Scope and Limitation

This study focuses on the design and development of Banjak Timer, a web-based application intended to automate rider timing, result consolidation, and performance monitoring during local downhill racing events organized by the Banjak Carrascal Organization. The system allows real-time tracking of start and finish times, live result displays, leaderboard generation, and the production of consolidated reports accessible via desktop or mobile devices (Tang et al., 2024).

However, the scope excludes integration with advanced timing hardware such as RFID or GPS-based systems, as well as external sensors or wearable devices. This limitation aligns with observations in similar real-time sports monitoring platforms, which highlight the need for additional infrastructure to achieve automatic identification and high-precision timing beyond 50 ms (Tang et al., 2024; Torres-Ronda et al., 2022). The system also does not include predictive analytics or AI-based performance forecasting, focusing instead on foundational timing and reporting functionality. Finally, Banjak Timer assumes stable internet connectivity for real-time updates and may experience delays or data loss in low-bandwidth settings, a challenge widely acknowledged in cloud-dependent sports systems (Torres-Ronda et al., 2022).

Methodology

The development of Banjak Timer followed a structured methodology to ensure that the system was aligned with user needs, technically sound, and compliant with quality software standards. The process included five main stages: Research Design, Requirements Collection, Software Requirements Specification (SRS), Requirements Validation, and the Implementation of the Iterative Development Model.

Research Design

This study employed a descriptive-developmental research design. The descriptive component involved gathering information about the current practices and challenges faced by the Banjak Carrascal Organization in managing race timings and consolidating results. The developmental aspect focused on creating a fully functional web-based system that addresses these issues. This design approach allowed the researchers to study actual use cases while developing a solution grounded in user context.

Requirements Collection

The initial phase of development began with direct observation and interviews with organizers and timekeepers of the Banjak Organization. Key activities included analyzing how race times were recorded manually, how results were computed and presented, and identifying pain points such as delays, inaccuracy, and data loss. The data gathered provided insight into the essential features that needed to be integrated, such as real-time timing input, automatic result generation, and live leaderboard display.

Software Requirements Specification (SRS)

Based on the collected requirements, a detailed Software Requirements Specification document was created. This included functional requirements such as event creation, rider registration, category and stage configuration, start-stop timing controls, leaderboard generation, and print-ready result summaries. Non-functional requirements were also outlined, focusing on performance efficiency, ease of use, mobile responsiveness, and security of race data. The SRS served as the blueprint that guided the design and development process throughout the project.

Requirements Validation

To ensure that the system requirements reflected actual user needs, validation was conducted through prototype presentations to selected stakeholders—event marshals, timekeepers, and system testers. Their feedback helped refine the flow of functions, simplified certain interface elements, and clarified timing procedures. This step also led to adjustments in the timing mechanism to ensure that both manual and auto-generated inputs were accurately synchronized in real time.

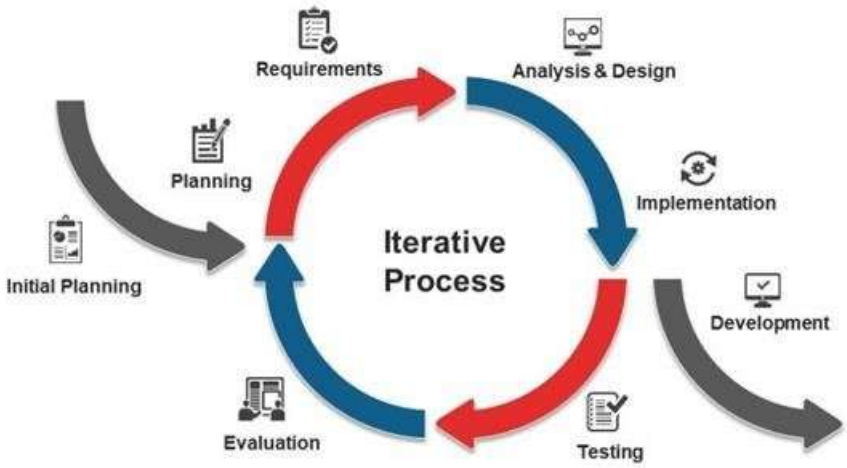

Figure 2.0 Iterative Development Model

The figure 2.0 Iterative software process model, enabling continuous improvement through repeated cycles of planning, building, testing, and evaluation. This approach ensured that the system evolved in alignment with user needs while reducing risk and maximizing functional accuracy. Below is a breakdown of each step as it was implemented in the project:

Initial Planning

The project began with defining its purpose—to resolve the issues faced by the Banjak Carrascal Organization in managing race timings and consolidating rider results. Key stakeholders were identified, including race organizers, technical timekeepers, and participants. The goal at this stage was to understand the environment and constraints in which the system would operate, particularly in outdoor, real-time events with limited infrastructure.

Requirements Gathering

Following the initial planning, in-depth discussions and interviews were conducted with local organizers to identify the exact pain points. Manual stopwatch timing, lack of centralized data, delayed result

announcements, and inconsistent formatting were common issues. Based on these insights, core requirements were outlined—such as live time entry, automated leaderboard, event and rider management, and printable result summaries.

Planning

With the requirements validated, the development process was divided into manageable modules, scheduled over development cycles. Prioritization was guided by functionality: the rider registration and stage management modules were developed first, followed by the timing logic and result display components.

Analysis and Design

This phase involved mapping out the logical flow of the system using use-case diagrams and process maps. The user interface was designed with simplicity in mind—ensuring usability across devices. The system architecture was structured to run on PHP and MySQL with XAMPP, hosted locally or over a LAN, ensuring flexibility during races.

Implementation

Each functional component was then translated into code. The rider registration form, stage timing control, leaderboard logic, and print module were implemented using PHP and MySQL. JavaScript was used for dynamic features, such as live countdown timers and update triggers.

Testing

After each development iteration, the modules underwent unit and integration testing. Several mock races were simulated to validate the accuracy of the recorded times and the synchronization of results across devices. Bugs in timing lapses and misaligned rankings were identified and corrected through focused adjustments.

Evaluation

Post-testing, the system was deployed in an actual community race conducted by the Banjak group. Feedback from organizers and marshals revealed areas of improvement, such as streamlining the live result display and adding visual cues for time status (e.g., race started, in progress, completed). These refinements led to improved usability and enhanced the overall event experience.

Participants of the Study

The following are the participants of the study.

Table 1. Participants of the Study

Participants	Frequency	Percentage
Riders	96	82.76
Banjak Representative	5	4.31
Marshalls	5	4.31
IT Experts	10	8.62
Total	116	100.00

Table 1. shows participant of the study the success of this research largely depended on the input of participants who were directly involved in or affected by the system being developed. A total of 116 individuals took part in the study, representing various roles essential to the operation and evaluation of the *Banjak Timer* system.

The majority of the participants were riders, accounting for 82.76% of the total population. As the primary users of the system, their feedback was critical in assessing the accuracy, speed, and user-friendliness of the timing and result monitoring features. Their hands-on experience during live test events provided realistic insights into the system's performance under actual race conditions.

Banjak Representatives and Marshalls, each comprising 4.31% of the participants, played a key role in overseeing event flow and validating the system's relevance to local race operations. Their participation ensured that the system aligned with the organizational standards and logistical routines of Banjak-managed events. Their observations contributed to refining system modules such as stage control and timing notifications.

Additionally, 10 IT Experts (8.62%) were involved to examine the technical integrity of the platform. Their role was crucial in evaluating the system's backend structure, database handling, and overall performance efficiency. Their recommendations helped optimize code execution, improve page load speed, and enhance the system's security features.

This diverse set of participants ensured that the evaluation process was both comprehensive and grounded in actual user experience. The balanced representation of users, administrators, and technical professionals allowed for a thorough assessment of the system's functionality, usability, and reliability—resulting in a more refined and applicable digital solution for competitive racing events.

Instrumentation

To ensure the integrity and relevance of the findings, two primary instruments were employed in this study: a semi-structured Interview Guide and a Standardized ISO 25010-based Questionnaire. The interview guide captured detailed insights from riders, Banjak organizers, marshalls, and IT professionals about current timing practices, existing challenges, and user expectations. Their responses directly informed the system's design and refinement.

To assess the developed system's quality, the researcher used a standardized questionnaire grounded in the ISO 25010 Software Quality Model. The tool measured the system's performance across eight critical dimensions, including functionality, efficiency, usability, and security. Each item was rated using a 5-point Likert scale. The results provided a comprehensive view of the system's compliance with international software standards and highlighted areas for improvement.

Data Gathering Procedure

The process was meticulously planned and executed to ensure that the findings genuinely reflected the needs, expectations, and experiences of the individuals involved in competitive racing events managed by the Banjak Carrascal Organization.

The procedure began with the identification and selection of key participants, including riders, marshalls, Banjak representatives, and IT experts. These individuals were purposively chosen based on their direct involvement in race operations, system development, or technical evaluation. Prior to data collection, the purpose and scope of the study were clearly explained to all participants, and informed consent was secured.

Following the system's development and deployment, participants were asked to evaluate its performance using a standardized questionnaire based on the ISO 25010 Software Quality Standards. This tool measured the system's quality across eight dimensions: functional suitability, performance efficiency, compatibility, usability, reliability, security, maintainability, and portability. Participants rated each criterion using a 5-point Likert scale, and their responses were encoded and statistically analyzed to determine the overall compliance of the system with international software quality benchmarks.

Additionally, the system was tested in a live race event organized by the Banjak group, where real-time performance, user interactions, and system responsiveness were observed and documented. This allowed the researcher to validate the system under actual field conditions and further refine the features based on empirical data.

Through this multi-step data gathering process—grounded in both qualitative insight and quantitative evaluation—the study ensured that the development of Banjak Timer was driven by evidence, responsive to its users, and grounded in the real-world challenges of race management.

Data Analysis

The following tools were used to analyze the data to be gathered.

Thematic Analysis. This method was employed to identify the problems and challenges encountered by the participants.

Weighted Mean. This was used to determine the developed system's extent of compliance with ISO 25010 software quality standards as assessed by the participants.

Table 2. Likert Scale Used in Determining the Developed System's Extent of Compliance with the ISO/IEC 25010 Software Quality Standards

Weight	Mean	Descriptive Interpretation
5	4.20 - 5.00	Very Great Extent
4	3.40 - 4.19	Great Extent
3	2.60 - 3.39	Moderate Extent
2	1.80 - 2.59	Little Extent
1	1.00 - 1.79	Very Little Extent

Results and Discussion

The core of this study was to identify the practical gaps in the traditional race timing operations of the Banjak Carrascal Organization and to develop a responsive system that would directly address those issues. Through interviews, field observations, and live system testing, data was gathered to assess both the problems encountered and the improvements brought by the Banjak Timer system. The findings below summarize the significant outcomes in relation to each research question.

1. Current Practices in Recording Rider Timing and Consolidating Race Results

- The organization used manual stopwatches and handwritten logs for recording rider times, with each stage timed on separate devices.
- Consolidation was done manually, usually through spreadsheets—resulting in inconsistent data, misalignment in rankings, and processing delays.

- The absence of a centralized and synchronized platform made real-time validation of race outcomes nearly impossible.
- These manual practices introduced avoidable human errors and eroded confidence in result accuracy, particularly during high-participation events.

2. Problems and Challenges Encountered

- Delayed result announcements were a recurring issue, largely due to the manual collation process.
- Organizers reported frequent data loss, misentries, and formatting errors due to the lack of a digital backup system.
- No live performance tracking meant riders and spectators had limited engagement during ongoing races.
- Marshalls experienced difficulty coordinating across race stages, which often led to confusion in start times, sequence, and data logging.
- These operational gaps limited the organization's ability to grow and manage larger, more competitive events.

3. System Features Developed to Address Operational Gaps

- Banjak Timer introduced real-time start/stop control, linked to automatic time logging and ranking computations.
- A live leaderboard provided instant visibility of results to riders, marshalls, and organizers.
- Features such as event setup, rider registration, stage management, and category grouping simplified administrative workflows.
- The system was built for mobile and desktop access, ensuring flexibility even in remote race locations.
- Centralized data handling eliminated the need for post-race consolidation, boosting efficiency and data integrity.

4. Enhancements Introduced to Improve Performance, Efficiency, and Usability

- Interface design was streamlined based on user feedback to allow faster navigation and simplified operations.
- The result display layout was modified to emphasize visibility, with color cues and live updates.
- A confirmation prompt was added before final submission of times to prevent accidental overwriting.
- Backend improvements led to faster page loads, especially on mobile devices, enhancing overall responsiveness.

5. System Assessment Based on ISO/IEC 25010 Software Quality Standards

Based on the evaluation conducted by the IT experts, the developed system was found compliant with the ISO/IEC 25010 Software Quality Standards to a very great extent in terms of functional suitability, performance efficiency, compatibility, availability, reliability, security, maintainability, and portability.

Table 31. Summary of the Evaluation Conducted by the IT Experts of the Developed System's Extent of Compliance with the ISO 25010 Software Quality Standards

ISO/IEC 25010 Characteristics Criteria	Criteria Mean	Descriptive Rating
A. Functional Suitability	4.72	Very Great Extent
B. Performance Efficiency	4.75	Very Great Extent

C. Compatibility	4.67	Very Great Extent
D. Usability	4.66	Very Great Extent
E. Reliability	4.73	Very Great Extent
F. Security	4.60	Very Great Extent
G. Maintainability	4.70	Very Great Extent
H. Portability	4.55	Very Great Extent
Overall Mean	4.67	Very Great Extent

The evaluation of the Banjak Timer system using the ISO/IEC 25010 Software Quality Standards revealed consistently high ratings across all assessed criteria, with an overall mean of 4.67, interpreted as "To a Very Great Extent." This strong result confirms the system's quality, stability, and suitability for deployment in competitive racing events. Among the eight quality characteristics, Performance Efficiency received the highest score of 4.75, reflecting the system's ability to process real-time data without lag, even under simultaneous operations. Functional Suitability followed with a mean score of 4.72, indicating that the system reliably delivered its intended features such as start-stop timing, leaderboard generation, and report printing. The system also demonstrated strong Usability and Reliability, earning scores of 4.73 and 4.66, respectively. Users—many of whom lacked technical expertise—were able to navigate the interface intuitively, while the system maintained consistent performance during actual event deployment. Further, the system scored 4.70 in Maintainability, confirming that its modular code structure allowed easy updates and quick issue resolution. Compatibility and Portability also received favorable ratings of 4.67 and 4.55, respectively, proving the system's effectiveness across various devices and operating environments. Even Security, though implemented with basic access control measures suitable for a localized setup, achieved a strong score of 4.60, assuring data protection during usage. Taken together, these results affirm that the Banjak Timer system meets internationally recognized standards of software quality. Its strong performance in all dimensions of the ISO/IEC 25010 model demonstrates not only its technical soundness but also its practical value in addressing the operational challenges of race timing and performance monitoring in real-world event scenarios.

Conclusion

This study set out to address the operational limitations experienced by the Banjak Carrascal Organization in managing competitive racing events, particularly in the areas of rider timing, result consolidation, and performance monitoring. Through a methodical process of observation, requirements gathering, system development, and evaluation, the *Banjak Timer* system was conceptualized, built, and tested to respond to the specific challenges identified in traditional race management practices.

The findings of the study confirm that the current manual methods of recording times and processing results were not only inefficient but also prone to errors and delays. By introducing an automated, web-based platform, the system successfully streamlined race operations, eliminated redundant manual tasks, and enhanced the overall accuracy and transparency of competition outcomes. Real-time timing, dynamic leaderboard updates, and printable summaries significantly improved the race experience for organizers and participants alike.

Moreover, the system's performance—measured against the ISO/IEC 25010 Software Quality Standards—demonstrated strong compliance across all eight quality characteristics, particularly in

functional suitability, performance efficiency, usability, and reliability. These results affirm the system's robustness, user-friendliness, and adaptability for use in grassroots and community-based racing environments.

In conclusion, the *Banjak Timer* system stands as a reliable and scalable solution for race management, offering a timely response to the evolving needs of event organizers in the digital age. It not only modernizes local sports coordination but also sets a foundation for further innovation in real-time performance tracking and digital event systems.

Recommendations

Based on the findings and successful deployment of the Banjak Timer system, the following recommendations are proposed to sustain and further improve its implementation:

1. **Wider Adoption in Local and Regional Events**

Event organizers in other municipalities or regions conducting similar race formats are encouraged to adopt the Banjak Timer system. Its user-friendly design and accurate timing features make it suitable not only for downhill biking but also for other time-sensitive competitions.

2. **Integration with GPS and RFID Technologies**

While the current system performs efficiently, integrating advanced tracking tools such as GPS modules or RFID chips may enhance timing precision and allow for more detailed performance analytics, especially in large-scale or multi-stage races.

3. **Mobile Application Development**

To improve accessibility and usability during field operations, it is recommended that a dedicated mobile application be developed. This would allow marshalls and coordinators to operate and monitor races entirely through handheld devices without relying on desktop or browser-based tools.

4. **Cloud-Based Data Storage and Backup**

Incorporating cloud-based services can ensure real-time data synchronization and secure storage, particularly beneficial for events held in multiple locations or where connectivity is inconsistent. This would also support future data analytics for training and performance reviews.

5. **Continuous User Training and Feedback Loop**

Regular orientation sessions for new users and a feedback mechanism embedded into the system can help capture ongoing user insights, ensuring continuous system improvement and community ownership.

6. **Further Research and Customization**

Researchers and developers are encouraged to explore the adaptability of the Banjak Timer system to other sports or event types. With proper customization, the core functionalities could be repurposed for athletics, triathlons, or academic competitions requiring precise time tracking.

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