

From Ballpark to Society: Understanding Stakeholders' Adaptation to Automated Judgment via ABS in Baseball

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Abstract

Artificial Intelligence (AI) is increasingly automating expert judgments across diverse domains. However, the practical dynamics of adaptation among diverse stakeholders remain underexplored. We investigated the Korea Baseball Organization's adoption of the Automated Ball-Strike System (ABS), the first league-wide deployment of an AI adjudicator. Interviews with 38 stakeholders—umpires, players, coaches, and fans—revealed that adoption was driven by demands for fairness and frustration with human limitations, and was viewed as an inevitable trajectory. Acceptance depended less on accuracy than on verifiable consistency, which reduced interpersonal conflict by shifting judgment to technology. However, adaptive burdens were redistributed: players faced pressure to recalibrate strategies for survival, while umpires grappled with diminished authority. Systemic legitimacy hinged on procedural transparency and visible feedback mechanisms. Based on these findings, we propose governance principles emphasizing transparency and adaptive role reconfiguration for sustainable human-AI coexistence.

CCS Concepts

- **Human-centered computing** → **Empirical studies in HCI**;
- **Social and professional topics** → *Socio-technical systems; Automation.*

Keywords

Human-AI Interaction, Automated Judgment, Stakeholder Dynamics, Procedural Fairness, Role Reconfiguration, Sociotechnical Adaptation, Sports

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1 Introduction

Artificial intelligence (AI) systems increasingly assume responsibility for tasks that previously required human judgment. We define judgment-task automation as the delegation of evaluative judgments to AI systems. Specifically, these judgments require interpretation of criteria, assessment of evidence, and the rendering of consequential rulings. This trend spans diverse domains: AI now conducts clinical assessments in healthcare [64], reviews legal documents [103], screens job applicants [2], and guides autonomous vehicles [8, 50]. These deployments fundamentally redistribute expertise, accountability, and legitimacy within organizational systems [122].

The Human Computer Interaction (HCI) community has begun examining these shifts, yet our understanding of large-scale judgment automation remains incomplete [80, 96, 100, 105, 113]. Current research predominantly investigates limited-scope pilots or isolated deployments within single organizations [53]. High-stakes domains such as medicine and law remain in early adoption phases, constraining opportunities to observe sustained, ecosystem-wide adaptation. We lack empirical accounts of how multiple stakeholder groups navigate the transition when AI systems shift from supporting human judgment to routinely substituting for it. This research gap necessitates identifying settings in which judgment-task automation operates at scale over extended periods.

Professional baseball's Automated Ball-Strike System (ABS) provides such a setting. Baseball offers several methodological advantages for studying judgment automation: codified rules that enable consistent AI implementation [58], high-frequency judgment events that generate substantial data, and a visible network of interdependent stakeholders whose adaptations are immediately observable. The domain presents manageable risks compared to



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healthcare or legal systems, while maintaining governance flexibility that permits rapid policy adjustments. Nevertheless, the stakes remain substantial, as ABS calls directly influence competitive outcomes, economic incentives, and professional reputations across the sport's ecosystem.

ABS automates ball-strike calls, a foundational judgment task that occurs on every pitch and influences all subsequent strategic decisions. The system employs multi-camera tracking and radar technology to construct a three-dimensional strike zone, delivering real-time rulings that replace traditional umpire calls. We conducted our investigation within South Korea's baseball ecosystem, where the sport serves as both the dominant form of professional entertainment and a significant cultural institution. The Korea Baseball Organization (KBO) implemented ABS across all league games in 2024, establishing the world's first and only top-tier league to employ automated ball-strike calls universally. This comprehensive deployment contrasts with other major leagues, which remain in limited pilot phases. The system's continuous operation across an entire professional season creates unprecedented opportunities to examine sustained stakeholder adaptation to judgment automation.

Rather than focusing primarily on technical accuracy metrics [3, 18, 109], we investigated how large-scale judgment automation transforms legitimacy structures, professional identities, and strategic practices across stakeholder groups. This approach addresses a critical gap in HCI research, which has yet to examine the ecosystem-wide social implications of AI systems that routinely substitute for human judgment. We pursue three research questions that capture the temporal arc of automation adoption and its multifaceted consequences:

- RQ1: What expectations, concerns, and motivations shaped stakeholder positions toward ABS adoption prior to implementation?
- RQ2: How did continuous ABS operation affect interactional patterns and organizational dynamics across different stakeholder roles?
- RQ3: What design and governance principles emerged from stakeholder adaptation processes, and how might these inform responsible judgment automation in other domains?

To investigate these questions, we conducted interviews with 38 stakeholders across the KBO ecosystem during the 2025 season. We categorized participants based on their relationship to ABS and the nature of the system's impact on their roles. Our sample comprised four groups: (1) fans ($n = 15$) who experience ABS effects indirectly through game outcomes and viewing experiences; (2) players ($n = 10$), whose on-field performance and strategic decisions are directly shaped by automated calls; (3) coaches ($n = 5$), who support and guide players through strategy and decision-making, thereby encountering ABS impacts in a more indirect but still meaningful way; and (4) umpires ($n = 8$), whose primary judgment responsibilities were automated by the system. This sampling strategy enables examination of adaptation dynamics across different levels of proximity to the automated judgment process.

Our analysis reveals three cross-cutting dynamics that characterize stakeholder adaptation. First, system acceptance depended more on consistency and verifiability than on perceived accuracy alone; shared real-time pitch data enabled stakeholders to understand

calls even when unfavorable. Second, adaptation was pragmatic and role-differentiated: players absorbed adjustment costs through modified strategies, umpires experienced relief alongside diminished authority, and fans discovered new forms of engagement despite calmer atmospheres. Third, legitimacy derived from procedural transparency via clear parameters, recalibration protocols, and feedback channels, while ongoing debates over strike zone definitions sustained governance negotiations. These findings suggest judgment automation functions as a complex redistribution of responsibilities and authority rather than as simple human replacement.

This research contributes three insights for the HCI community and practice. First, we provide an ecosystem-level empirical account demonstrating that acceptance of judgment automation relies primarily on consistency and verifiability rather than on accuracy metrics alone. Second, we develop a conceptual framework of impact redistribution, revealing how automation shifts burdens from adjudicators to strategic actors while redistributing authority across organizational roles. Third, we derive design principles for responsible judgment automation: transparent and revisable parameters, accessible verification mechanisms, and cross-venue calibration protocols that maintain stable standards. While grounded in professional baseball, these findings inform AI deployment in domains requiring repeated, consequential judgments under public accountability.

2 Background

Our study is situated in the context of baseball, a sport whose cultural significance and complex rules are prominent in certain regions but not universally familiar [63, 67]. To ensure accessibility for all readers, we outline the sport, its social importance, ABS, and its current adoption status.

Baseball is a bat-and-ball sport organized around the pitcher-batter contest [33, 116]. While popular in regions like North America and East Asia, it is the most-watched professional sport in South Korea [20]. Its long season of near-daily games fosters deep community engagement, with 10,887,705 in-park entries recorded in 2024, surpassing 20% of the country's population [70]. Here, the sport functions as a major cultural platform for communal activities [5, 36] and digital content consumption [62, 84]. This high-frequency, consequential officiating environment provides a rich naturalistic setting to study the large-scale adoption of a judgment-automation system.

The foundational judgment at the heart of baseball is classifying each pitch as either a strike or a ball, a decision that dictates the outcome of every at-bat. This call is governed by the strike zone: an area over home plate vertically defined from the midpoint of the batter's torso to the bottom of the kneecaps [85].

However, the zone is not fixed; it is dynamically determined by each batter's stance. Applying this complex, dynamic rule to a high-speed pitch makes human judgment exceptionally challenging and prone to error [38, 49, 127]. Numerous studies document this fallibility, linking incorrect calls to factors such as implicit biases [52, 66, 82], fatigue, and deceptive pitch framing by catchers [31, 45]. Like many professional sports [24, 92, 111], baseball adopted video review systems to correct certain officiating errors,

but the frequency and immediacy of ball–strike calls made them unsuitable for such correction. Consequently, ball–strike adjudication remained a persistent source of controversy and one of the few remaining domains of unaided human judgment in the game, fueling a long-standing pursuit of a technological solution.

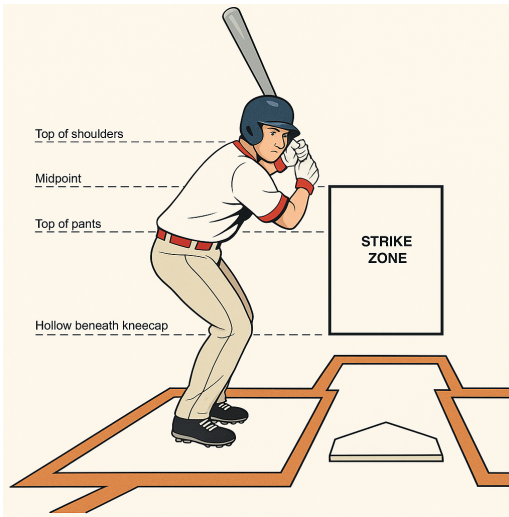


Figure 1: The baseball strike zone, defined from the midpoint of the batter’s torso to the bottom of the kneecaps, dynamically determined by stance.

This long-standing pressure led to the development of ABS. Technologically, the system relies on two primary tracking mechanisms: the Pitch Tracking System (PTS), which uses optical cameras to triangulate ball position [112], and TrackMan, which employs Doppler radar for trajectory analysis [120]. Advances in computer vision [19, 75] and machine learning [114, 117] allow both systems to determine in real time whether a ball intersects the three-dimensional strike zone. By calibrating the zone for each batter, the system aims to deliver more consistent and less biased calls than human officiating [58, 74].

The adoption of ABS in South Korea followed a phased trajectory. Experimental testing began in the KBO Futures league in 2020, followed by the Korea Baseball Softball Association (KBSA) adopting the system for select amateur tournaments in 2022. In 2023, the KBO Futures league conducted a final validation test specifically to prepare for top-tier deployment. This led to the official league-wide implementation of ABS in the KBO 1st league in 2024, marking the world’s first full-scale professional adoption. Currently in its second season (2025), the system continues to operate across all games, incorporating strike zone adjustments based on feedback. Regarding technical infrastructure, the KBO and KBSA utilized the exact same vendor and PTS mechanism for the 2023 and 2024 seasons. In 2025, while the KBO 1st league maintained the PTS framework, the KBSA and KBO Futures league both switched to TrackMan technology to evaluate sensor precision. To date, this full-scale adoption establishes South Korea as a critical precedent for other leagues that remain in pilot phases [69, 71].

3 Related Work

3.1 Automating Expert Judgment Across Domains

To clarify the scope of automation, we distinguish between judgment and decision-making. We define judgment as the evaluative act of expert discernment: classifying a state based on available evidence and codified criteria to determine “what is the case” (e.g., compliant/non-compliant, strike/ball). It is fundamentally a classification task constrained by rules [23, 93]. In contrast, decision-making involves selecting a future course of action among alternatives to optimize an outcome, often integrating multiple judgments with values, risks, and trade-offs to determine “what should be done” [11, 34, 99]. Systems like ABS automate judgment itself, assuming the expert’s role of classification and reshaping the context for strategic decision-making. We examine the sociotechnical ripple effects of this substitution: how it reconfigures umpire expertise, alters player strategies, and transforms the broader ecosystem.

High-stakes judgments have traditionally been performed by trained experts, yet concerns about cost, error, and bias have long motivated automation. Advances in sensing and data-driven AI have accelerated these efforts, embedding automated judgment in a growing number of critical domains [64, 103].

A large body of work arises in closed industrial and corporate ecosystems where performance is paramount. In manufacturing, computer vision pipelines render pass/fail rulings to minimize defects, with evaluations focused on accuracy [7, 102, 131]. In finance, machine learning for credit scoring and fraud detection issues approve/decline rulings under tight regulatory constraints [3, 18, 109]. However, due to restricted access to these internal environments, it is difficult to observe how the shift to automation actually changes the nature of the task and affects the people who depend on it.

Other domains are publicly visible and often contested, though research access remains challenging. In content moderation, platforms adjudicate policy violations at global scale using ML classifiers [135] and, more recently, LLM assistance [39, 59, 134]. Audits probe these models for errors, biases, and vulnerabilities [12, 47, 48, 110]; recent work also documents over- and under-moderation for group-targeted hate and dialectal variants, highlighting the need for procedural safeguards for consistency and recourse [54]. Because platforms rarely disclose operational models and data, audits are often constrained to standardized benchmarks or lab settings [44, 59, 86]. Thus, even with growing insight into model flaws in isolation, systematic view of real-world, cross-party dynamics among creators, moderators, and affected communities remains difficult.

In healthcare and law, adjudicative use appears primarily in autonomous screening/alerting and technology-assisted review (TAR), while strict ethical and privacy barriers constrain open deployment [43, 83, 90]. Field and simulation studies show that clinical decision support can reconfigure team communication and diagnostic routines, and that second-opinion scenarios yield nuanced trust–reliance patterns; task uncertainty also modulates reliance [32, 104, 130]. In legal practice, public defenders report obstacles to scrutinizing and contesting AI-mediated evidence, while survey work in legal judgment prediction remains largely dataset- and metric-driven [25, 60]. As a result, much of this literature skews

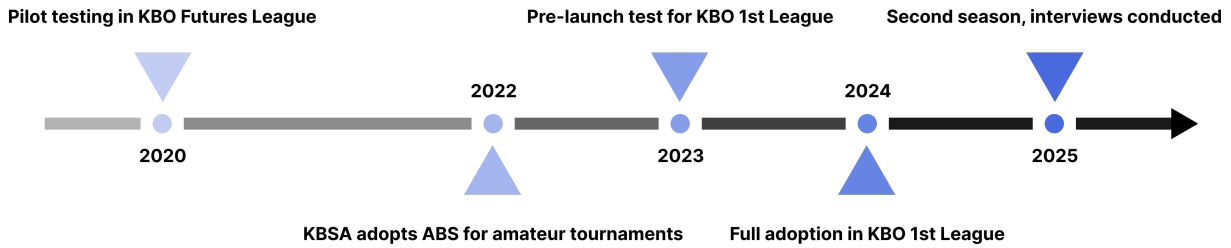


Figure 2: Timeline of ABS adoption in South Korean baseball (2020–2025), from initial pilot testing to full professional implementation.

toward offline metrics or small pilots, with limited multi-party perspectives [68, 98, 133].

Sports officiating offers a public and legible arena for studying these dynamics. Video review [53, 65, 106, 129], Hawk-Eye in tennis [4, 10, 22], goal-line technology [128], and semi-automated offside [125] demonstrate adjudication at scale and have generated empirical work on stakeholder reactions. ABS in baseball is distinctive in frequency (about 300 pitches per game) and centrality (each ruling is binding and immediate), offering a rare naturalistic setting to observe adaptation and contestation over time.

Across domains, technical feasibility is well established. However, rich accounts of the lived, sociotechnical impact of automated judgment in large-scale, multi-stakeholder ecosystems remain scarce, in part due to the structural barriers above. We address this by examining ABS in professional baseball. It serves as a league-wide, publicly observable system where AI acts as the definitive, high-frequency adjudicator. This enables analysis of how roles are reconfigured and how adaptation and legitimacy are negotiated when expert judgment is automated at scale.

3.2 Theoretical Lenses for Technology Acceptance & Governance

Research on technology acceptance has progressively refined psychological constructs to explain why individuals adopt or reject new systems. Attitude, defined as an individual’s evaluative disposition toward a behavior, represents a core construct in early models including the Theory of Reasoned Action (TRA) [37, 56], the Motivational Model [28], and the Theory of Planned Behavior (TPB) [1]. Subjective Norm, present in both TRA and TPB, captures how social expectations shape behavioral intentions, highlighting the inherently social nature of acceptance. The Technology Acceptance Model (TAM) [27] operationalized these abstractions through Perceived Usefulness and Perceived Ease of Use, emphasizing that users accept technology when they believe it enhances job performance with minimal effort. This utilitarian focus extends to Job-fit [118], which assesses whether a system aligns with professional capabilities, a critical metric for skilled practitioners. Barriers to adoption were formalized as Complexity [118] and Perceived Behavioral Control [1], while Facilitating Conditions [118] account for the organizational resources necessary for implementation. Expanding beyond individual cognition, Compatibility [89] examines whether technology aligns with existing values, while Image [89] links adoption to social status. Finally, the Unified Theory of Acceptance and Use of Technology (UTAUT) [123, 124] synthesized these

factors into four core dimensions: performance expectancy, effort expectancy, social influence, and facilitating conditions. Taken together, these models generally assume that individuals retain some discretion over whether and how they adopt a technology.

Moving beyond individual constructs, HCI research has explored the situated conditions that facilitate or hinder AI adoption. A critical prerequisite is Understandability, referring to the extent to which stakeholders can form an accurate mental model of system behavior. While explainability can enhance fairness perceptions, it paradoxically increases compliance with erroneous recommendations [30, 107, 132]. Studies highlight that the generative variability of AI [126] and probabilistic outputs create friction for stakeholders expecting deterministic control [61], suggesting that grasping system logic is a new barrier to adoption. Trust Calibration emerges as another challenge heavily shaped by domain expertise. Systematic reviews indicate that under-trust leads to disuse while over-trust risks over-reliance [57, 77, 94]. Crucially, experienced professionals often view AI as an auxiliary tool [79], whereas broadcasting experts express skepticism due to fragmented workflows [21]. Adoption is further contingent on Controllability, specifically mechanisms for recourse. Acceptance relies on who reviews decisions and how, with remediation perceived as reasonable only when criteria are clear [81, 101, 119]. However, a gap often persists between technology-centric development and user reality, limiting adoption despite comprehensive features [21]. Finally, Organizational Context fundamentally shapes adoption. Successful integration depends on workflow fit, often requiring the appropriation of routines [80, 100, 113]. Power dynamics also play a pivotal role; systems perceived as surveillance tools provoke resistance where insights are automatically reported to management [26].

Beyond adoption factors, automation fundamentally impacts task allocation and professional identity. Sociotechnical Systems theory frames this transition not as substitution but as a reconfiguration of roles [6]. Automation shifts the operator’s focus from execution to monitoring, altering their responsibility and self-image [9]. Recent HCI studies in high-stakes domains support this view, suggesting that successful automation requires flexible task allocation where humans and AI dynamically trade control based on context [46, 95]. For instance, research on clinical decision support demonstrates that automation reconfigures diagnostic routines, creating new forms of repair work to bridge algorithmic logic and real-world nuance [130]. In such settings, a system that is highly consistent yet misaligned with domain norms can become a stable source of procedural unfairness, even as it reduces visible disagreement.

This implies that even in full-automation contexts like ABS, the human role is transformed rather than eliminated, necessitating a renegotiation of authority and labor division to maintain system legitimacy.

Synthesizing these perspectives, we approach the introduction of ABS as a complex sociotechnical intervention. We derive three axes from the literature to serve as sensitizing concepts [13, 14] guiding our inquiry. First, drawing from foundational acceptance models, we define Professional and Contextual Fit, synthesizing constructs of Job-fit [118] and Compatibility [89] to examine alignment with expert capabilities and traditional values. Second, from AI-specific HCI research, we identify Trust and Controllability, encompassing Understandability, Recourse, and Organizational Governance [61, 80] to analyze how stakeholders negotiate agency against the “black box.” Third, grounded in sociotechnical theory, we focus on Role Reconfiguration, leveraging concepts of Task Allocation and Professional Identity [9, 130] to explore structural shifts in authority. While our coding and theme development were structured around the research questions, these lenses informed how we interpreted and organized patterns within and across stakeholder accounts. This theoretical framing allows us to unpack how KBO stakeholders navigate the tensions between the unprecedented, full-scale automation of judgment and the preservation of professional values.

4 Methodology

4.1 Research Design

This study employed a qualitative research design to examine how the ABS system has been received and adapted within leagues, including the KBO, where it is currently in operation. Observing ABS in real league games allows us to see not only how the system functions in practice but also how the roles and expectations of umpires, players, coaches, and fans are reconfigured. In this sense, the ABS case provides a lens for understanding the broader implications of judgment automation in sports and beyond.

Our focus was on four key stakeholder groups. First, umpires are the direct recipients of ABS support, experiencing changes in their authority and role. Second, players directly confront shifts in strike zone consistency and the burden of strategic adjustments. Third, coaches encounter ABS through team management and game flow. Fourth, fans experience the indirect consequences of changes in officiating and perceptions of fairness. Together, these groups occupy different positions and perspectives in the baseball ecosystem, and examining them side by side highlights the layered effects of ABS adoption.

To capture these perspectives, we conducted semi-structured interviews [72]. The interview protocol was constructed based on our research questions and sensitizing concepts derived from related work: trust, role reconfiguration, and contextual fit. The questions were designed to elicit both prior expectations regarding ABS and lived experiences following its implementation (see Appendix B for the full interview guideline). This approach enabled us to examine not only the practical effects of the system but also how an AI-based judgment technology becomes embedded in the cultural and social fabric of sport.

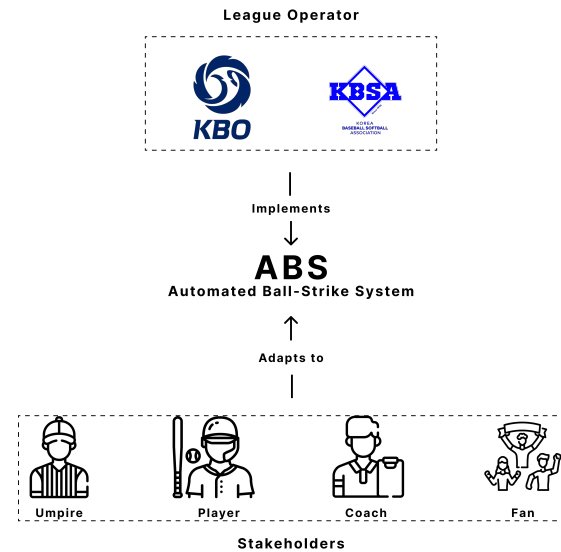


Figure 3: Overview of the research context: ABS implementation by league operators and stakeholder adaptation.

4.2 Recruitment

We aimed to capture the voices of people who had sufficient experience with ABS in actual games. Eligibility was restricted to individuals who had engaged with the system for at least one year after its introduction. This criterion was set to move beyond first impressions or early reactions and to examine how adaptation experiences and strategic adjustments developed over time as the system was applied and operated in practice [97]. Specifically, we included players who had competed in ABS games for more than one year, coaches who had coached under ABS for more than one year, umpires who had officiated games with ABS for more than one year, and fans who had consistently experienced ABS through live attendance or broadcasts for at least one year.

Interviews were conducted between June and August 2025. This period was chosen because the system had already been fully implemented for one complete season and was in its second season with ongoing modifications and recalibrations. We expected that participants could reflect not only on their initial impressions but also on how the system stabilized and evolved through adjustments over time.

Recruitment was carried out primarily through personal networks and snowball sampling, but the approach varied by group [91]. Umpires were the most challenging participants to secure. The KBO Umpire Committee is small in size, and because all members are under the league’s direct authority, many expressed concerns that participating in ABS-related interviews might become controversial. We sent official letters and contacted individuals through personal connections, but most declined. To address this challenge, we expanded recruitment to the KBSA. For the 2023 and 2024 seasons, KBSA umpires operated under the exact same vendor and PTS mechanism as the KBO. Even with the pilot testing of new sensors in 2025, the fundamental mechanism of automated judgment remains consistent across the ecosystem. Crucially, this technical

consistency is reinforced by a shared professional pipeline; the KBSA serves as the primary training ground for professional umpires, sharing educational curricula and career pathways with the KBO. Consequently, KBSA umpires possess a professional identity and operational experience that are practically indistinguishable from their KBO counterparts, making them a high-fidelity proxy for understanding adaptation to automated officiating.

Players and coaches were somewhat easier to access compared to umpires, although many were still hesitant because ABS remained a sensitive topic on the field. Through repeated persuasion and referrals, we eventually recruited five pitchers, five batters, and five coaches. These groups were often recruited together through overlapping networks. Fans were the most straightforward to recruit. Starting with acquaintances, participation expanded through referrals, and we were able to include individuals who had consistently experienced ABS through live attendance and broadcast viewing.

Across all groups, we emphasized voluntary participation, confidentiality, and anonymity so that participants could share their views without fear of repercussion.

4.3 Participants

A total of 38 individuals participated in this study, consisting of eight umpires (U1-U8), ten players (P1-P10), five coaches (C1-C5), and fifteen fans (F1-F15). All participants had at least one year of firsthand experience with ABS in live games after its introduction.

The umpire group consisted of professionals from the KBSA. As detailed in the recruitment section, KBO umpires were reluctant to participate, leading us to this alternative. These umpires had been involved since the pilot phase of ABS, offering professional perspectives on both the system's initial adaptation and its current operation.

The player group included a mix of rookies and veterans. We recruited five pitchers and five batters with diverse playing styles, which allowed us to compare how ABS created opportunities or burdens for different types of athletes. All participants had accumulated sufficient experience with ABS to reflect on how game strategies and training routines had shifted over time.

Coaches ranged from those who had only recently transitioned from playing to long-serving veterans with decades of experience. Positioned to both support player adaptation and coordinate team operations, they provided insight into how ABS influenced not only individual performance but also training, strategy, and team management. Specific coaching roles are not disclosed to protect anonymity.

Fans were comparatively easier to recruit. Many had followed baseball for over a decade, offering long-term perspectives on how ABS shaped their experience of fairness and enjoyment. Because they had engaged with ABS both through live attendance and televised games, their accounts revealed how the system was perceived both inside and outside the stadium. Compared to other groups, gender distribution was more balanced.

By including these four groups, the study was able to examine how ABS was experienced across different stakeholders and roles, capturing a range of perspectives both on and off the field. Table 1 summarizes participant demographics. Note that reported ABS experience includes participation in pilot testing phases in the Futures

League (since 2020), predating the official 2024 adoption. Complete demographic tables by group are provided in the Appendix A.

Table 1: Summary of participants by group (N=38). Ages of players, coaches, and umpires are grouped; fans' ages are reported as collected.

Group	N	Age Range	Baseball Exp. (yrs)	ABS Exp. (yrs)
Players	10	20s–30s	9–28	2–3
Coaches	5	30s–50s	13–44	2–5
Umpires	8	20s–50s	14–46	3
Fans	15	22–30	2–19	2–3
Total	38	20s–50s / 22–30	2–46	2–5

4.4 Data Collection

Data collection was conducted between June and August 2025 through semi-structured interviews. All interviews were conducted with participants active in baseball leagues in Korea. With participants' consent, sessions were audio-recorded and later fully transcribed for analysis. An interview guide with open-ended questions was prepared in advance, but the format remained flexible, allowing the interviewer to pursue follow-up questions that arose from the conversation.

The setting of interviews varied by participant group. Fans were primarily interviewed face-to-face in seminar rooms at the university, though in some cases the research team visited participants to conduct the sessions. Players and coaches were interviewed in person at their respective ballparks. One coach, due to scheduling conflicts during game operations, was first contacted at the stadium and later completed the interview via phone. Umpires were interviewed at stadiums where they were officiating, with the research team visiting in person to facilitate trust and access.

Each session lasted about an hour. Example questions included:

- "What were your initial thoughts when you first heard about the introduction of ABS?"
- "How did your experience with ABS compare to traditional umpire-based officiating?"
- "If similar technologies were to be applied to other sports, what considerations should be taken into account?"

These examples illustrate the types of prompts that guided discussion while leaving space for participants to elaborate on issues of personal relevance. A complete list of interview questions is provided in the Appendix B.

4.5 Data Analysis

We analyzed the interview data using a codebook thematic analysis (TA) approach [15, 51]. This method was chosen for its suitability in systematically identifying and comparing recurring patterns across our four distinct stakeholder groups. Our process followed a structured 'coding reliability' TA model to ensure rigor and consistency [16, 17].

All interviews were transcribed in full. One researcher produced the initial transcripts, and another cross-checked them to ensure accuracy.

We first developed an initial codebook based on our research questions. This codebook was structured around three sensitizing axes: (1) the perceived necessity of ABS, (2) experiences and adaptations after its introduction, and (3) the broader applicability of AI-assisted officiating.

Three researchers then analyzed the transcripts. Each transcript was independently coded by two researchers using the initial codebook while also inductively adding new codes as they emerged. The coders then met to compare codes, discuss discrepancies, and reach a consensus, refining the codebook iteratively. All codes were collated on a shared Miro board [87], where the team grouped similar items into broader categories.

While the sensitizing axes provided an initial structure, the final themes and sub-themes were refined inductively from the patterns identified in the data. This process resulted in three higher-level themes and eleven sub-themes. A table summarizing the final thematic structure is presented in the Findings section.

4.6 Ethical Considerations

This study received approval from the authors' Institutional Review Board (IRB) prior to data collection (Protocol No. 2506/004-006). All participants were provided with the official IRB-approved information sheet, which explained the study's aims, procedures, and their rights. Written consent was obtained for participation, audio recording, and transcription. Participation was entirely voluntary, and participants were informed that they could withdraw at any time without penalty.

Particular attention was paid to safeguarding confidentiality. Many participants expressed concern that their remarks might be identified and lead to unwanted repercussions, which made them cautious about joining the interviews. To address this, all personally identifiable details such as names, team affiliations, and specific positions were removed from the transcripts. Demographic information such as age was reported in categorical ranges rather than exact values to minimize the risk of re-identification. In reporting the findings, participants were referred to only by anonymized role-based codes, ensuring their identities remained fully protected.

5 Findings

This section presents how the introduction of ABS reshaped and preserved adjudication, drawing on interviews with players, coaches, umpires, and fans. We highlight recurring patterns and group differences, using representative quotations to illustrate their perspectives. The findings move from pre-adoption motivations and concerns to post-adoption adaptations, then broaden to issues of consistency, human–technology role division, and conditions for sustainable operation.

5.1 Motivations, Expectations, and Concerns about ABS

Before ABS was introduced, umpires, players, coaches, and fans held mixed and sometimes conflicting views about ball–strike adjudication. Long-standing frustrations with human calls coexisted with expectations that automation could bring greater consistency,

alongside worries about technical maturity and unintended consequences. This section details how motivations, expectations, and concerns shaped stakeholders' orientations toward ABS.

5.1.1 Negative Experiences with Human Umpiring. Many participants (n=34) described long-standing frustrations with human umpires, which became an important backdrop for welcoming technological intervention. A recurring theme was the belief that umpire judgments varied depending on a player's status or the game situation. Players and coaches (n=11) repeatedly emphasized that rookies and less-known athletes were disadvantaged compared to veteran stars. One player (P5) recalled:

“When a famous veteran threw a borderline pitch, everyone assumed it would be called a strike. But if a rookie threw the same ball, it was almost always a ball.”

Fans (n=14) echoed these accounts, pointing to controversial calls that eroded their expectation that professional sports should be decided by skill rather than officiating errors. Consequently, these accumulated negative experiences fueled a strong desire for ABS, as stakeholders hoped technology would deliver the consistency that human officiating struggled to provide.

However, participants distinguished these frustrations from simple accusations of incompetence. Many (n=9) emphasized that calling balls and strikes is inherently difficult due to the speed and volume of pitches. As one umpire (U3) explained:

“It's not that we are careless. The strike zone is incredibly hard to judge perfectly, pitch after pitch, for an entire game.”

Some umpires (n=4) further argued that ball–strike calls reflect broader game management and context, not just mechanical measurement. This perspective framed ABS not merely as a remedy for mistakes, but as a technological supplement to a task that is physically demanding and contextually complex.

Taken together, these accounts illustrate how negative experiences with umpire calls shaped participants' openness to ABS. Frustrations with inconsistency and perceived bias fueled expectations that technology could restore fairness, while simultaneous recognition of the difficulty of umpiring framed ABS as a tool to supplement, rather than simply replace, human judgment.

5.1.2 Expectations of Greater Consistency. All participants expressed strong expectations that ABS would above all ensure consistency. While human umpires were perceived as sometimes calling the same pitch differently depending on game context or their momentary judgment, the system was expected to apply a uniform standard that would yield fair outcomes for both teams.

Players in particular emphasized the reassurance of having “the same pitch always called the same way.” One player (P9) explained:

“I thought the machine would treat everyone the same. That seemed like the biggest advantage.”

Fans echoed this view, with one fan (F3) noting:

“What frustrated me most was that the zone changed with every umpire, sometimes even every game. With ABS, at least both teams get the same calls, so I thought the controversies would decrease.”

Table 2: Thematic structure derived from the analysis, outlining 3 major themes and 11 sub-themes.

Themes	Sub-themes and Descriptions
Motivations, Expectations, and Concerns about ABS (Pre-Adoption)	Negative Experiences with Human Umpiring Long-standing frustrations with inconsistency and bias fueled the demand for technological intervention.
	Expectations of Greater Consistency Stakeholders anticipated that AI would be more objective and less error-prone than human judgment.
	Concerns about Technical Completeness Fears that rigid algorithms might miss the flow and drama of the game.
After the Introduction of ABS (Post-Adoption)	Conflict Reduction via Technology Real-time data verification and the shift to non-human authority removed targets for argumentation, minimizing emotional conflict.
	Consistency, Consistency, and Consistency Acceptance was driven more by the system's consistency than by the belief in its accuracy.
	Players as the Most Impacted Stakeholders The burden of adaptation weighed more heavily on the roles receiving the judgment than on the roles being automated.
	Reduced Burden and Shifting Roles of Umpires Umpires experienced psychological relief from decision pressure but a simultaneous loss of professional agency.
	Divergent Perspectives and Complexity Across Stakeholders The same system parameters created distinct advantages or disadvantages depending on player position and style.
Broader Implications and Governance (Governance & Expansion)	Calls for Transparency and Communication Participants expressed a need for accessible channels to provide feedback and voice concerns.
	Balancing Human and Technological Roles The introduction of technology prompted a shift in professional roles and responsibilities within the game.
	ABS as Part of an Inevitable Adoption Trajectory Automation was perceived as an unavoidable societal trajectory, leading to pragmatic adaptation rather than resistance.

Coaches also valued this aspect, highlighting that identical pitches at identical locations would always receive identical rulings. One coach (C4) explained:

“Before, the same course could be called differently depending on the umpire. With the machine, I believed the same pitch would always give the same result.”

Umpires themselves acknowledged the human limits of consistently judging fast-moving pitches over an entire game, expressing optimism that the machine could maintain a steady and impartial standard.

Taken together, expectations for consistency emerged as a shared belief across players, coaches, fans, and umpires, positioning ABS as the most convincing solution to long-standing frustrations with human variability.

5.1.3 Concerns about Technical Completeness. Alongside expectations for greater fairness and consistency, many participants repeatedly raised concerns about the technical completeness of ABS.

Although the strike zone is formally defined as the space above home plate, extending from the midpoint between a batter's shoulders and the top of their pants down to the hollow of the knee, applying this rule in practice was seen as far more complex.

Umpires, coaches, and players emphasized that real-world ball-strike calls are not based on the written rule alone, but on a layered interpretation that incorporates multiple subtle factors: the batter's height and stance, their swing form, the type and trajectory of the pitch, and even the last-moment movement of the ball. Many (n=12) questioned whether ABS could adequately capture this complexity. As one coach (C2) explained:

“The zone isn't just a box in the rulebook—it's interpreted through all these moving factors. I'm not sure a machine can account for them all.”

Concerns also extended to the possibility of mechanical or software errors. Several participants (n=7) noted that while human mistakes might be tolerated as part of the game, a malfunctioning

system could create disruption on a larger scale. One player (P7) observed:

“Machines aren't perfect either. If it glitches or makes a mistake, the confusion could be even worse than with a human.”

For these participants, technological errors posed a unique problem: unlike human calls, they could not be easily explained, negotiated, or contextualized within the flow of the game.

A further layer of concern focused less on accuracy itself and more on the cultural and experiential qualities of baseball. For some, the appeal of the sport lies not only in correct or incorrect outcomes but also in the drama, tension, and rhythm that officiating calls bring to the game. One umpire (U7) reflected:

“Baseball isn't only about right or wrong calls. It's about the flow and the tension. I don't know if machines alone can preserve that.”

Overall, while ABS was expected to enhance the consistency and objectivity of ball–strike calls, participants simultaneously worried that it might fail to capture the complexity of real play, introduce new risks of technical failure, and diminish the unique contextual drama that defines baseball. For many, the success of ABS was not simply a matter of technical precision but also of whether the system could coexist with, rather than erode, the cultural and experiential values of the sport.

5.2 After the Introduction of ABS

Once ABS was implemented in live games, stakeholders reported a variety of changes in how umpire calls were accepted and how games were experienced. Before its adoption, expectations and concerns had coexisted; but once the system was in operation, concrete patterns began to emerge in how calls were received, how consistency was evaluated, how players and umpires adapted, and how different groups perceived advantages and disadvantages. This section examines how ABS shaped the acceptance of ball–strike calls, what benefits and complaints were raised in parallel, and how the roles and experiences of stakeholders were reconfigured in practice.

5.2.1 Conflict Reduction via Technology. After the introduction of ABS, many participants (n=28) reported that accepting calls became easier than before. A significant factor facilitating this shift was the ability to check results instantly. Each dugout was equipped with a tablet displaying ABS pitch data in real time, allowing players and coaches to verify the basis for calls on the spot. One coach (C2) noted:

“Before, with borderline pitches, we would argue with the umpire. Now we can check it right away on the tablet, so those arguments have basically disappeared. It cuts out a lot of pointless disputes.”

Players similarly emphasized that they no longer had to rely on an “invisible authority” but could treat calls as data they could immediately confirm, which fostered trust and reduced frustration.

Consequently, both players and umpires (n=14) stressed that emotional strain was reduced. Under human officiating, players often carried lingering resentment throughout the game, but now they recognized that “arguing won't change anything and only

wastes energy.” This shift allowed them to accept outcomes with less emotional conflict. Umpires, for their part, described relief in no longer bearing sole responsibility for every ball–strike call. Fans (n=9) experienced these changes indirectly. With fewer confrontations between players and umpires, they reported being able to immerse themselves in games more easily. As one fan (F9) put it:

“There's no one to argue with anymore, it just comes out as data, so you accept it. It really cuts down on all the unnecessary drama.”

In sum, the introduction of verifiable data through ABS reduced unnecessary disputes and emotional strain, fundamentally reshaping the acceptance process from reliance on invisible authority to verification of objective data.

5.2.2 Consistency, Consistency, and Consistency. The most (n=36) strongly emphasized change after the introduction of ABS was the consistency of calls. Participants noted that while calls sometimes felt different from their expectations, they could accept them because “the same standard applies to everyone.” As one player (P3) put it:

“Even if I feel the call is strange, I can accept it because it's applied equally. At least our team isn't the only one at a disadvantage.”

Players and coaches (n=8) also noted that the experience of the ABS zone varied across ballparks. However, since both teams in a given game were subject to the same zone, they still regarded the outcomes as fair. One coach (C5) remarked:

“Each stadium does feel a bit different, but in the end, both sides get the same calls on that field that day, so I thought it was fair.”

This perception was linked to expectations of fairness for rookies as well, with some noting that “talented rookies stood out more under the same conditions.”

Fans (n=11) echoed these sentiments, observing that consistency reduced frustration with calls and made it easier to focus on the game. One fan (F5) explained:

“It used to be frustrating when the strike zone changed with each umpire, but now, no matter what the zone is, both teams get the same calls, so it feels fair.”

Umpires likewise acknowledged that reduced disputes around calls eased some of their burden.

Yet, some umpires (n=4) questioned whether the zone enforced by ABS represented the “right kind of consistency.” One umpire (U8) reflected:

“Yes, it's consistent. But we still need to ask whether it's actually the correct zone.”

Ultimately, consistency provided by ABS became the main reason stakeholders evaluated it positively: even if the calls were not perfect, they could still be accepted as fair. Yet, several participants emphasized that the very consistency praised as ABS's strength was also a point requiring improvement. They argued that true consistency means not only making the same call in the same situation but also ensuring that the standard remains uniform across stadiums and contexts.

5.2.3 *Players as the Most Impacted Stakeholders.* The introduction of ABS brought technological intervention into umpire judgment, reshaping the dynamics of game management. Yet the group that experienced these changes most directly was the players. Because they were the ones who had to accept each call and adjust their strategies and techniques accordingly, players bore the most immediate consequences. Umpires and coaches alike agreed that “ABS had the greatest impact on players.”

Still, many players (n=7) emphasized that ABS had not fundamentally altered their training routines or preparation. One player (P2) explained:

“Our preparation is the same. Batting practice and pitching routines haven’t changed, and ABS didn’t suddenly transform how we play baseball. We just do what we’ve always done, while gradually adjusting to the new standard.”

However, strategic and technical adjustments during games were more visible. With ABS redefining the effective strike zone, the value of certain pitches was recalibrated. Pitches that once fell outside the zone, such as breaking balls in the dirt or fastballs diving sharply inside, were now called strikes if they touched the boundary. Pitchers found that targeting the corners could yield favorable calls, while batters faced the burden of responding to pitches they would previously have let pass. One batter (P6) shared:

“What I used to think of as a ball is now called a strike. It’s tough because the strike zone I practiced for feels different, and I’m forced to handle more difficult pitches.”

Catchers (n=2) also saw their role change. Pitch framing had long been a prized defensive skill, but it lost much of its relevance under ABS. Some coaches (n=2) even noted that teams reconsidered the types of foreign pitchers they recruited, reflecting new performance priorities under ABS.

This shift was accompanied by players’ passive acceptance. With ABS firmly institutionalized, open resistance was virtually impossible, and the fear of being left behind or losing one’s position was significant. One player (P3) admitted:

“Honestly, I don’t like it, but the system has changed. I have to adapt, or I’ll fall behind in competition.”

Rather than voicing strong opposition, players (n=8) leaned toward quick adaptation and compliance with the new regime.

ABS also contributed to perceptions of fairness and expanded opportunities. With the same criteria applied to both veterans and rookies, hierarchical biases diminished. A coach (C1) noted:

“Before, less-known players often got squeezed on borderline calls. Now, whether you’re a starter or from the second squad, the calls are the same. It feels like opportunities have opened up.”

As a result, talented rookies had greater chances to stand out, while non-starters felt they were evaluated under fairer conditions.

Some fans argued that umpires, having lost authority, were the ones most profoundly affected. Yet the prevailing consensus among participants was that players, who had to directly respond to calls, rethink their strategies, and adjust their preparation, were the group most significantly impacted by ABS.

While ABS undeniably altered the authority of umpires, its deeper and broader effects were felt by players. From strategic adjustments, defensive techniques, and batting approaches to shifts in opportunities for rookies and reserves, the system restructured players’ competitive environment. ABS thus represented not merely a change in how calls were made, but a technological intervention that reshaped the conditions under which players prepared, competed, and adapted.

5.2.4 *Reduced Burden and Shifting Roles of Umpires.* The introduction of ABS brought umpires a profound sense of psychological relief. Many (n=9) expressed that they no longer bore the sole responsibility for every ball–strike call, a burden that had been especially heavy during high-stakes games or for less experienced umpires. As one umpire (U1) explained:

“In the past, if I missed just one or two calls, arguments came right away. Now, that criticism doesn’t come to me, and it feels much easier.”

This relief was accompanied by a noticeable loss of authority. Several umpires (n=4) lamented that their professional expertise felt diminished and that their presence in the game had become less central. One umpire (U6) reflected:

“Before, calling balls and strikes was my authority. Now, I feel more like someone just following the system.”

Still, the role of the umpire did not disappear. While ABS reduced their authority over strike-zone judgments, umpires remained responsible for the broader management of the game. They continued to oversee player safety, regulate the pace of play, and handle unexpected disruptions. In fact, some felt that ABS allowed them to focus more fully on these essential duties.

Players and coaches (n=9) also viewed these changes positively. With fewer emotional clashes over disputed calls, relationships with umpires became smoother. A coach (C5) noted:

“Since there are no more arguments about strike calls, the game flows much more easily.”

Players similarly acknowledged that while umpires had lost some authority, they still carried the responsibility of managing the game, and they welcomed the reduced conflict.

Fans, however, showed more ambivalence. Some regretted that umpires no longer carried the same weight and instead appeared more like “administrators” or “facilitators.” One fan (F4) commented:

“Umpires don’t feel like figures of authority anymore; it’s more like they’re just managing things on the side.”

Others observed that ABS eliminated the drama and unpredictability that used to arise from contested calls, reducing the sense of excitement. Yet many also welcomed the calmer viewing experience, noting that games were easier to enjoy without constant flare-ups over officiating.

In sum, ABS reduced the authority of umpires while simultaneously relieving them of pressure and reinforcing their role as game managers. For umpires, this shift brought both comfort and a sense of loss; for players and coaches, it fostered smoother relationships

and greater stability; and for fans, it produced a mix of disappointment over lost drama and appreciation for a more stable and less contentious game.

5.2.5 Divergent Perspectives and Complexity Across Stakeholders. Across all interviews, stakeholders consistently acknowledged that ABS had brought greater consistency to strike and ball calls. Yet, they also emphasized that this improvement did not carry the same meaning for everyone, nor did it guarantee satisfaction across groups. In listening to their varied accounts, it became clear that no single system can satisfy everyone at once, and that the very same feature of ABS could be interpreted as either a benefit or a burden depending on one's role, situation, or playing style.

Among players, experiences were diverse. Some pitchers welcomed ABS because it rewarded precise corner targeting, while others, particularly those relying on specific pitch types, found themselves disadvantaged. Batters expressed similar ambivalence: some appreciated a clearer zone, while others struggled with pitches they had long expected to be called balls now landing as strikes. In this way, the same consistency could generate opportunity for one type of player while imposing greater pressure on another. Many players acknowledged that these trade-offs were inevitable and that adjusting to them would remain a difficult and ongoing process.

Coaches also framed their assessments through the lens of their teams' composition. Those guiding younger squads or players with certain physical traits such as height or hitting tendencies noted both advantages and disadvantages in how ABS shaped outcomes. While they often articulated desired adjustments or reforms, they simultaneously recognized that any such changes would likely disadvantage someone else. As a result, their expectations for large-scale revisions remained cautious.

Fans largely welcomed the reduction in controversies and the sense of stability ABS brought. Yet even among fans, ambivalence appeared. Some admitted they felt differently when ABS rulings favored their team compared to when it penalized them. Still, because the system applied consistently to both sides, they ultimately accepted it even if not always happily.

Umpires appreciated the reduction in personal burden but regretted the erosion of their authority and professional standing. Several emphasized that implementing ABS should not stop at installing the system itself; instead, ongoing dialogue about how the zone is defined and operationalized remained essential. Coaches echoed this need for iterative feedback loops, stressing that player adaptation and overall game management required continual communication between teams and league authorities. From a different angle, a few participants also questioned whether ABS should have been such a high priority at all, suggesting that the resources invested might have been more impactful if directed elsewhere in the sport.

Taken together, these accounts highlight that stakeholders recognized both the benefits and limitations of ABS. They understood that no innovation could please everyone, and that the very features praised by some would inevitably frustrate others. A recurring theme was the willingness to accept a system that did not fully align with their individual preferences, precisely because they knew such diversity of experience was unavoidable. At the same time, participants emphasized that the league must still provide visible

mechanisms for exchanging feedback and demonstrating responsiveness, even if complete consensus could never be achieved.

5.3 Broader Implications and Governance

Umpires, players, coaches, and fans reflected on their experiences with ABS not only as users but as stakeholders directly affected by its judgments. Building on these perspectives, participants shared broader reflections on what the adoption of technology in judgment tasks might mean across other sports and professional domains. Central themes included the importance of transparent operation and communication with stakeholders, evolving ideas about how responsibilities should be divided between humans and technology, and reflections on the broader societal meaning of such technological adoption. Accordingly, this section examines the ABS case as a lens to consider three broader implications: what conditions are necessary for automated judgment systems to operate successfully, how roles should be divided between humans and technology in judgment automation, and how people today (and potentially in the future) perceive such systems in society.

5.3.1 Calls for Transparency and Communication. Participants (n=21) consistently emphasized that for ABS to be stably integrated, the system's design and implementation process needed to be transparent and responsive to stakeholder input. However, many felt that such expectations were not adequately met in practice.

During the initial rollout, some umpires and players were able to participate in tests, but practice opportunities were unevenly distributed. Umpires recalled that although they had limited exposure to ABS, it was not sufficient to prepare them for real-game operations. Players similarly noted that the explanations they received were mostly confined to numerical standards rather than experiential practice. In most cases, tangible encounters with the system occurred only during exhibition games or a handful of training sessions. One player (P1) explained:

“All I got was a simple explanation of how ABS sets the zone, but I had to actually face it in games to really learn how it worked.”

Coaches, who often had to support players in adapting to the new system, examined ABS more closely in technical detail. They voiced concerns about the limited availability of system data, the lack of structured forums for discussion, the weak incorporation of feedback, and decision-making processes that seemed opaque. In their view, the mere installation of the technology was not sufficient without mechanisms for ongoing dialogue and refinement.

Several participants also pointed out that the introduction process was unusually fast and largely top-down in nature. While this approach enabled efficiency and rapid adoption, it also meant that the system was implemented without broad consensus. As a result, continual revisions and ad-hoc adjustments followed, leading some to describe the process as improvised rather than systematically planned.

Even after full adoption, feedback channels for strike zone settings remained underdeveloped. For example, when the zone was criticized as excessively high in media coverage during the 2024 season, adjustments were made in the following year. Yet participants stressed that such changes only occurred when controversies became highly visible, while day-to-day concerns raised by players

and coaches often went unheard. Issues such as the validity of the rectangular zone, the need for resizing, or interpretation of the zone relative to batting stances were frequently discussed informally but rarely incorporated into systematic revisions. Umpires shared similar frustrations. As one umpire (U8) remarked:

“We raise all kinds of feedback while working with the system, but it’s hard to feel like any of it is really acted upon.”

Fans, by contrast, expressed relatively lower demands for transparency and communication in the implementation process. Some said they sought out information when curious, but most described themselves as passively accepting the system, noting that the visual cues displayed during broadcasts were sufficient to ease their concerns.

Overall, participants highlighted that the strike zone is not a fixed construct but rather a continuing subject of interpretation and negotiation. While the rules formally exist, how they are operationalized in live games is ultimately shaped through consensus. For that reason, many stressed that sustained and systematic communication between governing authorities and field stakeholders was needed, yet they felt this infrastructure remained insufficient in the current operation of ABS.

5.3.2 Balancing Human and Technological Roles. From their experiences with ABS, and by extending their reflections to other sports and broader domains, participants raised another central issue: how roles should be divided between humans and technology. Many (n=29) agreed that technology could enhance the objectivity and consistency of judgments while reducing unnecessary disputes, yet they also emphasized that “technology cannot replace everything.”

Umpires (n=8) acknowledged that ABS relieved much of the burden of ball-strike calls, but they stressed that many aspects of game management remained squarely within human responsibility. Tasks such as player substitutions, managing the flow of the game, handling unexpected incidents, and communicating with players and coaches were described as areas where technology could not intervene. As one umpire (U7) explained:

“ABS makes the calls, but running the game is still our responsibility. Technology cannot handle everything.”

Players (n=7) also noted that while they welcomed more technology to improve fairness and accuracy, there were clear limits to what technology could replace. Several described the idea of a future without human umpires as both uncomfortable and difficult to imagine.

Looking beyond baseball, participants expressed similar views in other sports and wider domains. They highlighted the advantages of technology, including greater accuracy, reliability, and the ability to handle judgments that humans struggle to make. Conversely, they stressed the limitations of machines in interpreting context or intention. For instance, whether a baseball play counts as interference, or whether a foul in soccer or basketball is intentional, was seen as requiring human judgment. As one coach (C5) put it:

“Technology is good for applying the rules, but questions of intent should ultimately be left to people.”

Fans (n=11) echoed these concerns. They appreciated that technology reduced disputes and improved accuracy, but some worried

that it diminished the unpredictability and human element that make sports exciting. One fan noted, “If machines decide everything, the game loses some of its tension and unpredictability.” These concerns illustrate how participants saw the role of humans as essential not only in sports, but also in other social domains. While sports value unpredictability and drama, fields such as medicine and law emphasize contextual interpretation, intent, and ethical reasoning, areas that participants believed could not be fully replaced by technology.

Ultimately, participants repeatedly stressed that technology is strongest when providing consistency and objectivity, while humans remain essential for interpreting context, intention, and ethical nuance. The ABS case illustrates this balance: when each side focuses on what it does best, judgment automation becomes not a wholesale replacement but a means to strengthen trust and credibility in both games and institutions.

5.3.3 ABS as Part of an Inevitable Adoption Trajectory. Across discussions about ABS, participants (n=26) consistently emphasized that this change was not merely a choice confined to baseball, but rather part of a broader societal trajectory. They framed the integration of technology as an unavoidable process, deeply connected to a social climate that increasingly values fairness and objectivity. As one coach (C3) put it:

“Younger generations see even the smallest differences as unfair. In that atmosphere, ABS was bound to come in sooner or later.”

Some players and coaches (n=11) further noted that baseball does not need to remain static. Instead, they argued that it should evolve in tandem with technological and societal developments. For them, professional athletes are accustomed to constant adaptation, whether to new rules, strategies, or training methods, so adjusting to a new system of judgment was perceived as another step in that ongoing process.

In addition, several participants framed ABS adoption through an economic and pragmatic lens. They observed that minimizing controversial calls could enhance the credibility of the league, improve the fan experience, and ultimately strengthen the brand value and profitability of teams and the league as a whole. From this perspective, ABS was not only a reform to secure fairness, but also a rational investment with tangible economic benefits.

This momentum was intertwined with both shifts in social values and advances in technology. In earlier years, the idea of a “robot umpire” was occasionally discussed, but it remained impractical due to technological limitations. Recently, however, the availability of precise sensors, high-speed cameras, and AI-based tracking systems has made actual implementation feasible. As one umpire (U2) reflected:

“Back then, the technology just wasn’t there, so it was impossible. Now that it exists, it could finally be introduced.”

Participants (n=12) also pointed out that this trend is not unique to baseball. They cited other sports where technology has already reshaped officiating, such as VAR in soccer and Hawk-Eye in tennis, as well as growing expectations for technological support in broader domains like law and medicine. As one fan (F14) explained:

“Fairness is a big theme in society these days, and now that the technology is developed enough, systems like ABS were bound to come in eventually.”

Taken together, ABS adoption was perceived as the convergence of multiple forces: a societal push toward fairness and objectivity, a technological infrastructure mature enough to support automation, economic rationales tied to fan experience and league credibility, and parallel expansions of technology in other sectors. Participants accepted these changes as part of an irreversible flow, while simultaneously stressing that the real challenge lies in establishing sustainable operational principles and balance in the face of this transformation.

6 Discussion

The Discussion interprets our findings in relation to prior work and highlights four themes. First, automation redistributes effects to those who live with its outcomes. Second, acceptance depends less on accuracy alone than on the assurance of consistency. Third, sustainable operation requires visible structures for participation and feedback. Finally, humans and technology should coexist, with their balance flexibly adjusted to task and context. Together, these points reframe automated judgment as a reconfiguration of roles and responsibilities, with implications beyond baseball.

6.1 Who Is Most Affected: From Role Automation to Redistribution of Effects

Across interviews, automated judgment did more than swap who executes a task; it reshaped who ultimately bears the consequences of that task. Participants emphasized that ABS changed who must adjust and absorb its results, rather than merely who performs the call. Players described having to adapt their strategies and accept outcomes they cannot negotiate with, while umpires experienced a reduction in pressure and responsibility. Fans noted fewer disputes, but also a shift in how excitement is generated. Taken together, these reactions show that automated judgment reorganizes the distribution of burdens and benefits across the baseball ecosystem: players assume greater performance risk, umpires relinquish elements of agency, and spectators encounter a different narrative of fairness. This observation contrasts with prior work that views automation primarily as a technological transfer of tasks from humans to machines [40, 115]. ABS was not simply a replacement of the umpire's role, but a reallocation of who is exposed to outcomes and who must adapt. In this sense, automated judgment redistributes pathways of impact, a dynamic echoed in findings that automation can intensify pressures on those most dependent on its results [35].

This redistribution manifested as both change and continuity. While core training routines such as batting practice, pitch preparation, and recovery remained intact, the burden of strategic adjustment shifted unevenly across roles. Pitchers recalibrated how aggressively to attack the edges. Batters had to adapt to a zone where contact on the borderline may now be rewarded. Catchers experienced a decline in the value of framing that once defined a key component of their expertise. These shifts reveal that automation moved the primary weight of adaptation onto players, who must constantly respond to a standard they did not set and

cannot negotiate with. Umpires, meanwhile, reported reduced psychological pressure but also a tangible contraction of professional authority and visibility; their exposure to error decreased, yet so did their influence. Fans welcomed fewer disputes but noted that excitement was now driven less by contestation and more by predictability. In short, baseball changed without entirely changing: the embodied routines persisted, but the distribution of burdens and benefits across roles was redrawn.

These observations suggest that the design and governance of automated judgment must address who is newly burdened and how they can act. When players are the ones most exposed to shifting outcomes, and when umpires lose opportunities to intervene, the system cannot rely solely on technical correctness. Instead, mechanisms for participation, explanation, and recalibration should be built into everyday operations. Players and coaches need accessible channels to understand how the zone is set and to provide feedback when strategic demands escalate. Umpires should retain meaningful situational discretion and avenues to exercise their expertise. Fans, too, benefit from transparency that helps them track when and why adjustments occur. In this sense, automated judgment is sustainable not when it simply moves a task to a machine, but when it redistributes decision-making authority and responsibility in ways that people experience as legitimate and adaptable [35]. These principles extend to other algorithmic decision contexts where those who absorb the consequences must also have a voice in shaping how the standards are applied.

6.2 Consistency, Not Just Accuracy

In our study, ABS was widely accepted not only because of accuracy, but more importantly because of consistency. While many participants assumed that “machines are generally more accurate,” what actually lowered emotional pushback was the assurance that the same standard would be applied to everyone. Even when outcomes diverged from expectations, people accepted them because “I’m not the only one affected” and “both sides are treated equally.” These reactions show that procedural fairness, meaning the sense that rules are applied impartially to all, can sustain acceptance even when doubts about accuracy remain.

This finding qualifies and extends prior work on trust in automation, which has largely emphasized performance and accuracy as primary drivers [57, 77, 94]. Our results show that accuracy alone does not account for how acceptance continues over time. Instead, consistent application becomes a maintenance mechanism of trust: accuracy makes the system acceptable, but consistency keeps it accepted. This distinction highlights a shift from an accuracy-first model toward a model where ongoing legitimacy is grounded in stable, observable rules.

Consistency also intersects with longstanding debates about bias. Friedman and Nissenbaum [41] argue that systematic differences only constitute bias when they produce unfair outcomes. Our participants' willingness to accept minor strike-zone deviations across ballparks illustrates this logic: even when the zone was “a little off,” fairness was still perceived as long as everyone played under the same rule. In other words, equal application of an imperfect standard can still feel legitimate in practice.

Stakeholder Guidelines for Adaptive Judgment Automation: Insights from the ABS Case

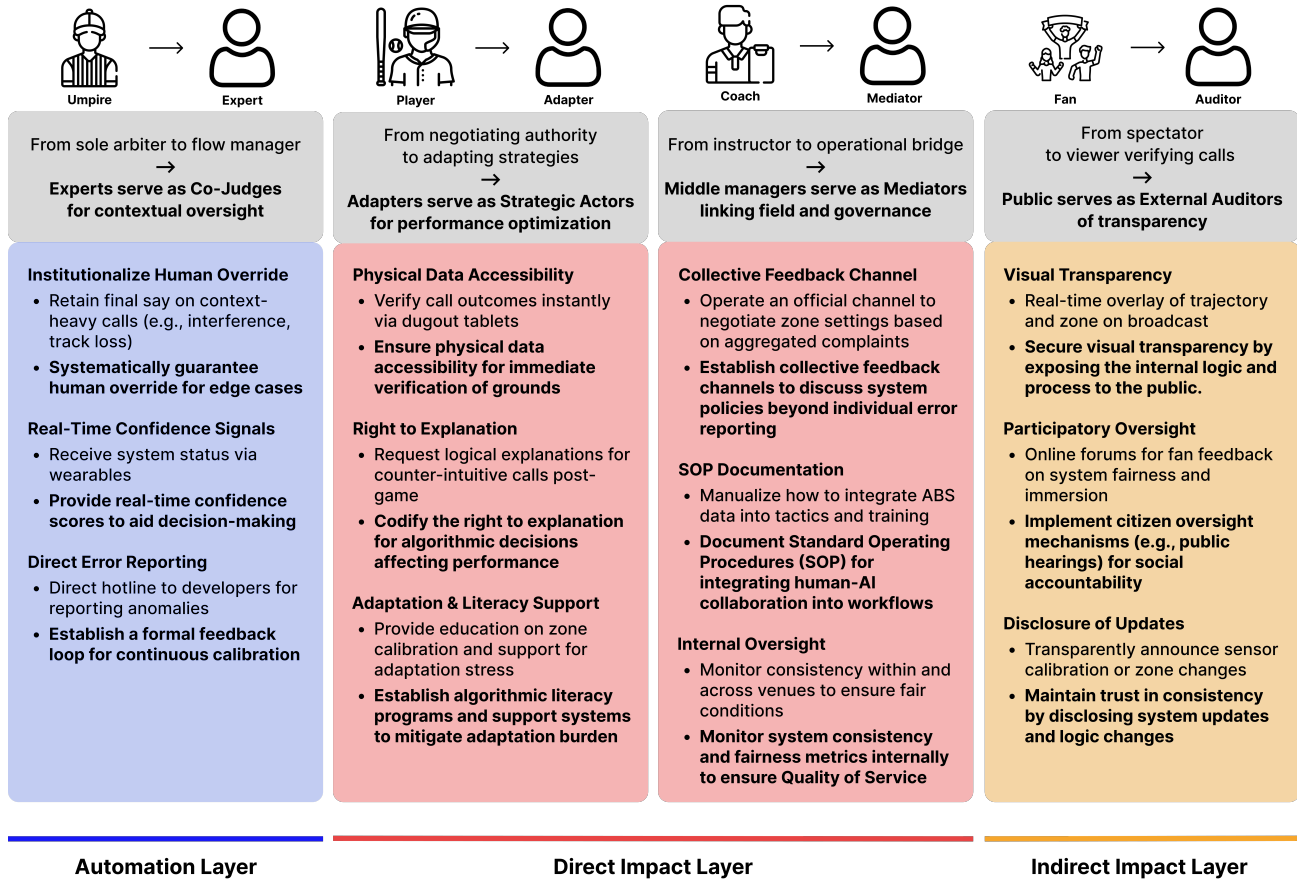


Figure 4: Stakeholder Guidelines for Adaptive Judgment Automation derived from the ABS Case.

However, consistency alone is not sufficient. As previous critiques of automation warn, a system can become consistently wrong if its benchmark drifts [9]. Because consistency amplifies whatever standard it enforces, the quality of the standard must be continuously examined and justified. The broader implication is that trust in automated judgment depends not only on outcomes, but also on whether stakeholders experience the standard as consistently applied in practice. When equal conditions are treated equally, people show greater willingness to regard unexpected results as fair. Thus, automated judgment should advance accuracy while actively managing consistency over time. With this approach, trust and acceptance can be sustained not only in baseball but also in other domains where automation reshapes judgment.

6.3 The Momentum of Adoption and the Need for Feedback Structures

Participants interpreted the adoption of ABS not merely as a technical upgrade but as an inevitable convergence of sociotechnical

forces. From the lens of traditional acceptance models [1, 27, 37, 124], this momentum was driven by a negative Attitude toward the inherent inconsistency of human judgment and a strong Subjective Norm prioritizing fairness, reflecting the intense societal discourse on equity in Korea [73, 76]. These factors collectively fueled a demand for objective adjudication. While early concerns about latency hindered Perceived Ease of Use, the eventual maturation of vision and sensing technologies satisfied the ecosystem's Performance Expectancy. This created a strong Contextual Fit between the system's capabilities and the league's desire to restore the Image of fair competition. However, unlike the voluntary adoption assumed in standard models, ABS was characterized by a powerful institutional mandate. For players and coaches, acceptance was driven less by personal utility than by the necessity of professional survival and competitive adaptation. Furthermore, while familiarity with existing tracking systems provided a baseline of trust, this was complicated by Professional Fit issues. Experts often detected conflicts between the rigid algorithmic zone and their embodied skills,

such as calls on physically "unhittable" pitches. In short, while the technical conditions to justify the technology had aligned, the sociotechnical infrastructure remained incomplete. During the rollout, explanations were confined to abstract principles, and access to the system was uneven. These gaps reveal that while Facilitating Conditions were technically present, the procedural mechanisms for Understandability and Recourse were initially insufficient. These mechanisms are critical for mitigating the friction between algorithmic logic and human expertise, and their absence surfaced later as communication difficulties around zone calibration and appeals.

Scholarship on procedural justice establishes that legitimacy rests not merely on accurate outcomes, but on the presence of "voice" and "correctability," which provide the structural assurance that decisions can be challenged and errors rectified [78, 121]. Our findings reveal a critical gap in this regard: while players accepted ABS's consistency as a form of fairness, they remained anxious because the mechanism for correctability was opaque. They accepted individual calls but doubted whether the system itself was responsive to their collective concerns. This observation nuances Molnar et al.'s argument on explainability [88]; in a continuously operating system like ABS, stakeholders need more than just a description of the system's logic; they require visible proof that their feedback triggers actual adjustments. Thus, legitimate governance requires more than just opening a communication channel; it demands what Fung describes as a visible "cycle of responsiveness," comprising clear stages of how feedback is submitted, reviewed, and acted upon [42].

Accordingly, communication should be designed as a connected flow, not a checklist of isolated features. Making this flow visible also helps sustain stakeholders' perception of procedural fairness as the system evolves. Before and during the season, stakeholders jointly inspect the zone and calibrate when needed. During and right after games, brief rationales and recent calibration history should be immediately accessible to provide a common basis for subsequent discussion. Field observations and telemetry should be tied to short review cycles so that small adjustments propagate quickly, and zone-variation metrics (for example, park- or period-level variation) should be shared regularly so everyone can reason from the same information. When submission, review, decision, response, and sharing run as a single loop, disagreements can be adjusted before they accumulate and the process naturally feeds learning for the next season. In other words, a communication channel should not be a one-off inbox but a continuously circulating circuit.

This logic extends beyond sport. In online exam proctoring, trust improves when students and instructors can observe why suspicion signals were triggered, offer contextual explanations, and see how these inputs inform periodic threshold updates [29]. In plagiarism detection, connecting similarity notices, context submissions, committee reviews, and routine revisions of policies into a single loop enables later decisions to evolve, not just the dispute at hand [55]. Across these settings, acceptance grows when stakeholders can see how rules are applied and how their feedback leads to concrete adjustments. Thus, the sustainability of automated judgment in any domain does not come from initial accuracy alone. It depends on whether the system's operation remains participatory, inspectable, and correctable over time.

Judgment automation such as ABS gains initial acceptance from broader momentum toward fairness and technological advancement. Its long-term legitimacy, however, depends on whether those affected can observe how their voices influence adjustments. When feedback flows are visible, traceable, and responsive, automated judgment becomes not a fixed replacement of human authority, but a system continually co-shaped with the field as circumstances evolve.

6.4 Redefining Roles: Guidelines for Task Allocation in Automated Judgment

Across our study, judgment automation did not remove humans from the system; instead, it fundamentally reconfigured the responsibility, focus, and self-image of stakeholders. Rather than asking whether humans or technology should lead, the practical question became when and how their roles should shift. Umpires transitioned from sovereign arbiters to managers of game flow; players shifted from negotiating with authority to adapting to objective constraints. In this view, coexistence is not merely a philosophical stance but an operational necessity that evolves as automation matures. To effectively support these evolved roles and proactively prepare for the continued expansion of automated judgment, a structured framework for task allocation is essential. Consequently, the operational challenge lies in actively redesigning the division of labor to align with this new reality.

To address this, we propose actionable guidelines for adaptive task allocation, as illustrated in Figure 4. Drawing inspiration from established procedural justice theories [78, 121] and human supervisory control concepts [95, 108], these guidelines are designed not just to assign tasks, but to provide the necessary structural support and protocols to stabilize the three distinct layers of impact created by automation: the **Automation Layer**, the **Direct Impact Layer**, and the **Indirect Impact Layer**.

For the **Automation Layer**, the guidelines focus on restoring professional agency to the Expert acting as a supervisor. Aligning with the principles of supervisory control [95, 108], to prevent the paradox of authority where umpires feel disempowered yet responsible, the system must institutionalize human overrides for context-heavy exceptions and provide confidence signals that aid judgment.

For the **Direct Impact Layer**, the priority is mitigating the adaptation burden. Since players must adapt to a black box, providing physical accessibility to data is not merely a convenience but a prerequisite for procedural fairness [78, 121]. Similarly, for coaches acting as Mediators, establishing collective feedback channels ensures that field experience is not ignored but integrated into system governance [42].

Finally, for the **Indirect Impact Layer**, the guidelines target the maintenance of social legitimacy. By ensuring visual transparency and disclosing updates, the system transforms spectators into valid Social Auditors who reinforce the system's credibility through public verification [125].

Although grounded in the ecosystem of baseball officiating, these guidelines offer a transferable framework for other high-stakes judgment domains. This generalizability exists because the act of ball-strike adjudication is structurally isomorphic to legal risk

assessment in courts [25, 68], grading or proctoring in education [29, 55], and credit scoring in finance [18, 109]. Each of these fields involves applying codified rules to reality to render consequential rulings. Furthermore, each is increasingly adopting algorithms to enhance objectivity [64, 103].

Thus, the stakeholder dynamics we observed parallel the patterns within these broader contexts. At the **Automation Layer**, judges and teachers must transition into ‘contextual supervisors’ who intervene in edge cases, mirroring the evolved role of umpires [95]. In the **Direct Impact Layer**, the adaptive burden faced by students and loan applicants parallels that of players. They require data access and explanation rights to navigate the system [18, 60]. Simultaneously, lawyers and financial advisors must serve as mediators who translate algorithmic logic into actionable strategies. Finally, the **Indirect Impact Layer** identifies the ‘Fan’ and the general public as the foundational source of legitimacy.

A professional league cannot sustain itself without the trust of its fanbase. Similarly, legal and financial systems rely on the collective consent of the citizenry to function [42]. This structural alignment suggests that mechanisms like visible consistency and procedural feedback are likely transferable conditions for legitimacy in these broader societal domains [78, 121].

7 Limitations and Future Work

We offer a qualitative, ecosystem-level account of adaptation to judgment automation, but several limitations remain. Sampling breadth meant that some professional groups (players, coaches, umpires) were sparsely represented. This allowed us to trace cross-role interdependencies, yet single-group, longitudinal studies could reveal finer-grained mechanisms and heterogeneity. Recruiting top-tier KBO umpires proved difficult given topic sensitivity and organizational constraints, and we excluded system developers to keep focus on user-side adaptation. Future work should bring these actors, including developers, league officials, and media, into view to examine how design, governance, and public discourse co-produce legitimacy and trust. Finally, our findings are situated rather than statistically generalizable. Even so, the recurring patterns we observe, such as redistribution of effects and the primacy of consistency, motivate a transferable framing. Testing and refining this lens in adjacent settings where AI adjudicates repeated, consequential events can establish scope conditions and yield actionable guidance for building more equitable, transparent, and governable judgment-automation systems.

8 Conclusion

The stakeholders at the heart of baseball’s automated adjudication were not opposed to technology per se; they were deeply concerned with how it is governed and implemented. Their accounts show that trust in AI adjudication rests less on a promise of perfect accuracy than on the lived reality of verifiable consistency. Adaptation was pragmatic and role-specific, yet it revealed a redistribution of adaptive burden from umpires to players, who must act on the judgments. Ultimately, their collective message is that the system’s legitimacy hinges on transparent, participatory governance. By giving voice to their reasoning, we reframe judgment automation as a sociotechnical reconfiguration and outline a path forward that

centers procedural justice and role adaptation, so that AI systems are not only effective but also socially legitimate.

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A Full Participant Demographic Tables

For completeness, we provide the full demographic tables of all 38 participants. To protect anonymity, players, coaches, and umpires are reported by age group; fans' exact ages are retained.

A.1 Demographics of Players

Table 3: Demographics of players (N=10). Ages are grouped into categories (20s, 30s, 40s, 50s) to ensure anonymity.

No.	Age Group	Baseball Exp. (yrs)	ABS Exp. (yrs)
P1	20s	9	2
P2	30s	28	2
P3	20s	17	3
P4	20s	16	2
P5	30s	24	2
P6	20s	14	2
P7	30s	27	2
P8	20s	14	2
P9	20s	16	2
P10	30s	18	2

A.2 Demographics of Umpires

Table 4: Demographics of umpires (N=8). Ages are grouped into categories (20s, 30s, 40s, 50s) to ensure anonymity.

No.	Age Group	Baseball Exp. (yrs)	ABS Exp. (yrs)	Umpire Exp. (yrs)
U1	40s	33	3	15
U2	40s	18	3	12
U3	30s	14	3	14
U4	30s	22	3	9
U5	20s	20	3	6
U6	50s	46	3	31
U7	30s	16	3	4
U8	30s	20	3	4

A.3 Demographics of Coaches

Table 5: Demographics of coaches (N=5). Ages are grouped into categories (20s, 30s, 40s, 50s) to ensure anonymity.

No.	Age Group	Baseball Exp. (yrs)	ABS Exp. (yrs)	Coach Exp. (yrs)
C1	30s	25	3	1
C2	50s	44	4	26
C3	40s	32	5	8
C4	30s	26	2	5
C5	40s	13	2	8

A.4 Demographics of fans

Table 6: Demographics of fans (N=15). Ages are reported as collected.

No.	Gender	Age	Baseball Exp. (yrs)	ABS Exp. (yrs)
F1	F	25	19	2
F2	M	25	7	3
F3	F	23	5	3
F4	M	25	18	2
F5	M	25	18	2
F6	F	28	10	3
F7	M	28	19	2
F8	M	27	19	2
F9	F	27	13	2
F10	F	27	9	2
F11	M	26	18	2
F12	M	30	14	2
F13	F	28	2	2
F14	F	23	4	2
F15	F	22	3	2

B Interview Guideline

This section outlines our final semi-structured interview guide. The guide served as a flexible framework; actual conversations varied based on participants' responses. Core questions are denoted by bullets, with potential follow-up probes indented below.

B.1 Background & First Impressions

- **Initial Exposure:** When did you first hear about ABS, and what was your initial impression?
 - What images or associations came to mind?
 - How did you initially assess ABS's trustworthiness and why?
- **Stakeholder Voice:** To what extent do you think stakeholders' voices were reflected in ABS adoption?
 - Whose voice mattered most? What were you most uncertain about?
- **Umpire Reactions (Umpires only):** What were your first thoughts upon learning about ABS adoption?
 - Drivers of positive/negative sentiment?
 - Reactions from peers and fans?

B.2 Adoption & Adaptation

Common Questions (All Roles).

- **Concrete Situations:** Please recall specific situations experienced with ABS.
 - Key differences vs. traditional system (pros/cons)?
 - Adequacy of pre-rollout training/explanation?

Role-Specific Questions.

Players.

- **Strategy:** How did ABS affect pitch/zone targeting or in-game management?
- **Trust & Emotion:** Did trust in consistency change? Did emotional acceptance or post-call response change?

- **Routine:** Do you check ABS data in the dugout? Any changes to training routines?

Coaches.

- **Decision Making:** Influence on strategy and feedback to players?
- **Instruction:** Shifts in pitching/hitting instruction practices?
- **Impact:** Observed mental/performance impacts on players?

Umpires.

- **Role Shift:** How did your role, authority, or perceived expertise change?
- **Pros/Cons:** What improved or worsened more than expected?

B.3 Operation, Culture, and Governance

- **Current View:** What is your overall view of ABS now?
 - Any inconvenient experiences or frustrations remaining?
 - Discussions with team, community, or media?
- **System Reliability:** Do you feel there is a clear feedback and remediation pipeline for technical issues?

– Did league explanations help restore trust?

- **Trust Basis:** Do you trust ABS's technical accuracy? Is it based on experience or technical explanation?
- **Human vs. Machine:** Is it easier to accept machine calls vs. human calls?
 - Differences in emotional acceptance and justifiability?
- **Voicing Criticism:** Is it culturally easy to voice negative opinions about ABS?
 - Are criticism and debate welcomed? Have you felt constrained?

B.4 Future Directions & Impact

- **Improvements:** What aspects need improvement? How should human umpires and ABS collaborate?
- **Expansion:** Considerations for amateur leagues or other AI domains (law, medicine)?
- **Impact Ranking:** Rank how strongly ABS affects each stakeholder group (1–5) and why.
- **Satisfaction:** Overall satisfaction (1–10) and reasons.