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Technical and Operational Evaluation of SRT-Based IP Contribution for Live Television Broadcasting

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Abstract. Secure Reliable Transport (SRT) is increasingly used for IP-based live-broadcast contribution because it enables low-latency delivery, packet recovery, and encrypted transport over public networks. However, its practical value depends on measurable performance under real operating conditions and disciplined operational control. This study evaluates the implementation of SRT in live football league and volleyball broadcasts using bounded case evidence from operational records, questionnaires, and focused interviews. The analysis links event-level Quality of Service (QoS) behavior with operational deployment indicators and compares SRT-based contribution with conventional IP transport and satellite contribution. The evaluated indicators include latency, effective packet loss after recovery, service interruption events, recovery time, bitrate stability, setup time, onsite staffing, and operational expenditure. The findings show that SRT provides a practical latency-reliability trade-off relative to regular best-effort IP transport and a lower deployment-cost profile than satellite contribution under the observed conditions. Stable implementation depends on consistent parameter settings, redundancy planning, monitoring ownership, and incident escalation discipline. This study offers a reproducible, engineering-oriented case-evaluation structure for assessing SRT deployment and improving reliability and operational efficiency in IP-based live broadcasting.

Keywords: IP contribution, live broadcasting, Quality of Service, remote production, Secure Reliable Transport

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1. Introduction

The transition from legacy contribution infrastructure to IP-based live production has increased demand for contribution systems that are reliable, low-latency, and operationally efficient. Live television links must remain resilient to jitter, packet loss, bandwidth variation, and service instability on public networks. Secure Reliable Transport (SRT) has therefore gained attention because it runs over UDP and combines low-latency transmission, retransmission, congestion control, and payload encryption [1]–[3]. Recent broadcast-to-cloud and latency-measurement studies similarly show that synchronization, delay control, and continuity remain central to IP-native live workflows [4], [5].

Prior studies have mainly examined SRT behavior, low-latency delivery, testbed architecture, redundancy, and packet-loss sensitivity under controlled or semi-controlled settings [6]–[9]. These works clarify technical capability, but they do not fully explain how SRT performs within live broadcast operations, where production deadlines, venue connectivity, monitoring responsibility, staffing, recovery procedures, and cost exposure also shape contribution success [10], [11]. Therefore, this paper does not evaluate whether SRT is universally superior; rather, it examines how SRT-related QoS behavior is translated into deployment efficiency and incident-control practice in a bounded live television case.

The study is framed at the intersection of QoS/QoE-based live video evaluation and socio-technical operational reliability. Latency, residual packet loss, recovery time, freeze events, and bitrate stability represent the technical QoS layer, whereas setup time, staffing, monitoring ownership, redundancy preparation, and escalation readiness represent operational controls that sustain live production [10], [12], [13]. This framing is consistent with low-latency streaming and QoE studies that emphasize the relationship among latency, buffering, adaptive delivery, and user-perceived continuity [14], [15].

This study addresses the gap through a bounded case-based evaluation of SRT implementation in live football league and volleyball television broadcasts. It compares SRT with conventional IP transport and satellite contribution using latency, residual packet loss after recovery, service continuity, setup requirements, onsite staffing, and operating expenditure. The analysis draws on event-level records from an anonymized broadcaster and focused clarification from engineering, NOC, and production personnel. Because the case is limited to one broadcaster and two production contexts, the findings are presented as analytically useful case evidence rather than universal protocol benchmarks.

The paper aims to present engineering-oriented case evidence on SRT trade-offs in real deployment and to identify implementation factors associated with stable field deployment, including parameter-setting discipline, redundancy planning, monitoring ownership, and incident response readiness. The case boundary, evidence sources, measurement definitions, and interpretation limits are made explicit to strengthen methodological transparency.

2. Method

2.1. Broadcast contribution architecture

The case involves live sports contribution from an outside broadcast location to a television control room through an IP-based transport chain. The analysis covers live football league and volleyball broadcasts. Field video and audio are encoded, transmitted across public IP connectivity, received by a gateway or decoder, and integrated into control-room workflows. SRT is used as the primary protocol because it supports packet recovery, configurable latency buffering, and encrypted UDP transport [1], [2], [11].

Key implementation variables include encoder-gateway compatibility, latency-buffer settings, retransmission behavior, redundancy design, monitoring visibility, and security configuration. These variables affect both end-to-end delay and the ability to maintain service continuity under network variability. Figure 1 summarizes the SRT-based live contribution workflow used as the technical reference architecture.

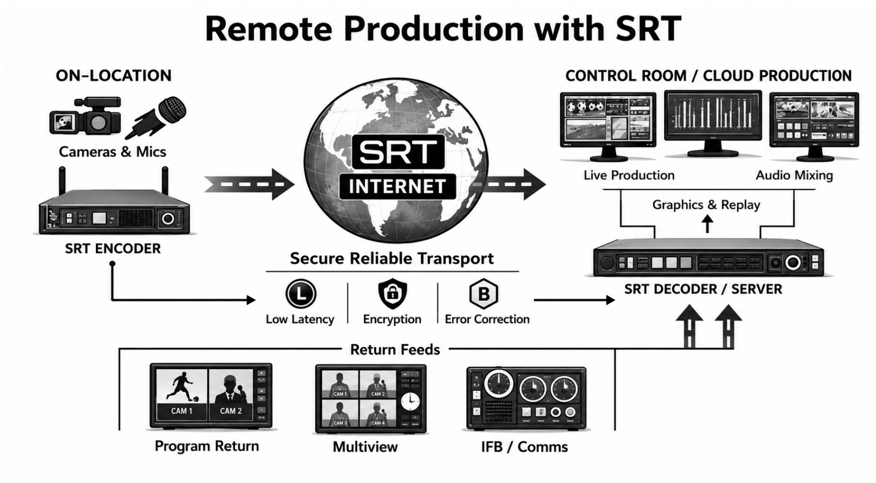

Figure 1. SRT-based live contribution workflow used as the technical reference architecture.

2.2. Case boundary, sampling strategy, and data sources

This study adopts a bounded single-case design focused on one anonymized Indonesian television broadcaster and the contribution chain connecting field acquisition, encoding, public-network transmission, gateway or decoder reception, and control-room integration. The empirical material was drawn from live sports operations outside Jakarta under routine broadcast conditions, with two focal contexts: live football league and live volleyball broadcasting. The broadcaster identity, event names, and raw operational identifiers are anonymized because the technical logs and cost records came from a live commercial environment.

Sampling was purposive and operational rather than random. A contribution operation was included when it belonged to one of the two focal sports contexts, involved field-to-control-room live contribution, and had sufficient technical and operational records to extract latency, residual packet loss, interruption, recovery, setup, staffing, and cost indicators. Records used only for standby monitoring or those with incomplete incident and cost documentation were excluded. This approach limits statistical generalization but clarifies the evidence boundary.

The evidence combines two streams. The first consists of event-level technical records, receiver or decoder monitoring outputs, engineering logs, and NOC incident notes. The second consists of operational records, cost summaries, setup reports, staffing notes, travel documentation, structured questionnaires, and focused clarification sessions with engineering, NOC, production, and management personnel. Combining these sources links observed QoS behavior with setup duration, crew demand, recovery, and cost exposure.

2.3. Questionnaire and interview design

Technical and operational records were supplemented by structured questionnaires and focused interviews for the football league and volleyball cases. The role-based design enabled the same implementation issue to be examined from managerial, production-operational, and engineering perspectives [11], [12], [16]. Detailed instruments are summarized in Appendix A.

The instrument was prepared for Production Managers, Program Producers or production operations representatives, and Technical Managers. It combined closed-ended Likert-scale items, open-ended questions, and optional quantitative prompts. The closed-ended items covered managerial efficiency, producer-operational impact, and engineering performance, while the open-ended items captured perceived SRT advantages, constraints, satellite-link relevance, and future deployment recommendations [12].

In both cases, the five-point Likert-scale questionnaire was paired with semi-structured interviews to clarify context and reduce ambiguity. Managers addressed cost, staffing, logistics, and remote-production strategy; production personnel addressed workflow, coordination, quality adequacy, and flexibility; and Technical Managers addressed packet-loss handling, latency, reliability, monitoring, infrastructure, and the comparative role of SRT versus satellite links [10], [17]. The material was used as structured case evidence to triangulate QoS logs and operational KPI records, not as a standalone statistical survey.

2.4. Evaluated indicators and analytical procedure

The technical assessment uses six QoS-oriented indicators: average latency, effective packet loss after recovery, freezes or dropped frames, service interruption events per hour, disruption recovery time, and bitrate stability expressed as the coefficient of variation (CV) [5], [18]–[20]. Effective packet loss after recovery refers to residual loss after transport-level recovery mechanisms. Service interruption events refer to disruptions that are operationally visible to engineering or production teams.

Operational evaluation uses contribution OPEX per event, setup time, onsite personnel, and trip or accommodation requirements. These measures indicate whether a technically feasible contribution method also supports efficient field deployment and repeatable live production. Figure 2 outlines the observed contribution chain and the data-collection points used for technical and operational evidence.

Each indicator was operationalized before comparison. Average latency was treated as the field-to-control-room delay; residual packet loss was calculated from post-recovery loss indications; freeze and dropped-frame events were taken from decoder, receiver, or NOC notes; the interruption rate was calculated per monitored hour; recovery time was measured from disruption detection to stable restoration; and bitrate stability was expressed as the standard deviation divided by the mean bitrate.

The analysis proceeded in three steps. First, records were summarized comparatively across SRT-based internet transport, conventional IP transport, and satellite contribution. Second, results were interpreted through mechanism-level reasoning involving latency buffers, retransmission, network variability, and recovery performance. Third, results were triangulated with questionnaire and interview clarification to identify factors associated with stable deployment. Figure 3 presents the methodology flow.

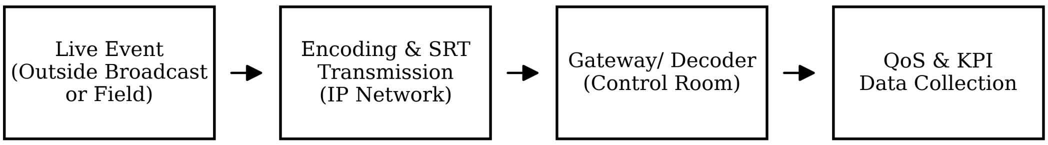

Figure 2. Observed contribution chain and data-collection points for QoS and operational evidence.

2.5. Measurement setup and data extraction

QoS and operational KPI ranges were extracted from event-level operational records, engineering reception logs, NOC incident summaries, cost summaries, setup reports, staffing notes, and travel documentation across the football league and volleyball contexts. Because the archive stored performance information as operational summaries rather than laboratory datasets, the study consolidated available observations into directional operating ranges for each contribution mode.

Technical values were derived from field-to-control-room monitoring and engineering logs. Data extraction followed a consistent coding procedure: identify the contribution window, check receiver or decoder monitoring records, record visible disruption and recovery notes, match the window with setup and staffing records, and consolidate comparable ranges. Confidentiality constraints prevent disclosure of raw event identifiers, packet traces, and vendor-specific device configurations.

Questionnaire and interview materials were used as triangulation support to verify whether the measured ranges were consistent with practitioner experience. Therefore, Tables 1 and 2 should be read as consolidated operating evidence from available live contribution records rather than as event-by-event inferential statistics. This approach avoids overstated causal or statistical claims in a single-case study.

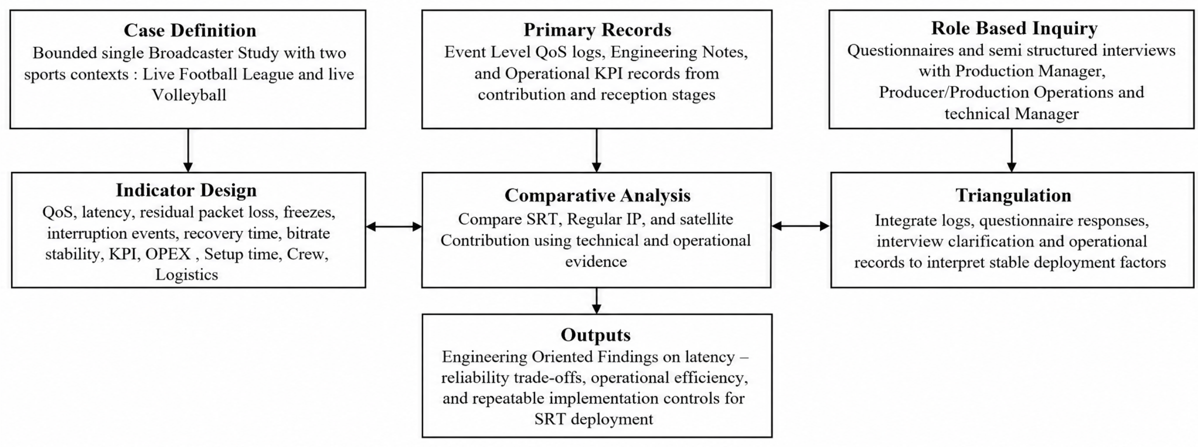

Figure 3. Research methodology flow integrating case definition, role-based inquiry, comparative analysis, and triangulation.

3. Results and Discussion

3.1. Comparative QoS performance

Table 1 compares contribution performance across SRT-based transport, conventional IP transport, and satellite contribution. No mode dominates every metric. SRT appears as a balanced compromise between latency, recoverability, and operational robustness for live television contribution; therefore, the table should be read as comparative case evidence rather than as a universal technology ranking.

Table 1. Comparative QoS evidence across SRT, conventional IP, and satellite contribution

No	Contribution metrics	SRT (internet ARQ)	Regular IP (UDP/TCP)	Satellite link
1	Average latency (ms)	180-320	120-250	550-800
2	Effective packet loss after recovery (%)	< 0.3	1.5-3.5	< 0.1
3	Number of freezes or dropped frames	1-3	8-15	0-1
4	Service interruption events (per hour)	2-5	10-25	20-40
5	Recovery time during disruption (s)	0.05-0.12	0.18-0.35	0.02-0.05

Note: Comparison based on observed live sports contribution events at one anonymized Indonesian television broadcaster.

The observed SRT profile is consistent with its ARQ-based design. SRT accepts a moderate latency-buffering cost so that retransmission can reduce residual packet loss and visible freeze events. Regular IP transport may show lower nominal delay, but it is more exposed to packet loss, bitrate instability, and longer visible disruption. Satellite contribution remains robust once the link is established, but its operational interruption counts reflect setup, weather sensitivity, coordination, and recovery logistics. Thus, packet-level reliability and operational continuity are related but not identical.

Compared with regular best-effort IP transport, SRT shows slightly higher delay because reliability is improved through latency buffering and retransmission. This delay is accompanied by lower residual packet loss, fewer freeze events, lower interruption frequency, and faster operational recovery. Under the observed conditions, this profile is more acceptable for live production because low nominal latency can be outweighed by unstable output and slower incident handling.

Compared with satellite contribution, SRT does not match the lowest residual packet loss or the fastest recovery when satellite transmission is stable. Nevertheless, it offers substantially lower latency and avoids some deployment constraints. This matters because live television workflows require a compromise among transmission certainty, production responsiveness, and field logistics. A similar protection-delay trade-off was reported in ASSET's Listen Before Talk study, where improved efficiency and lower collision rates were accompanied by higher delay [21].

3.2. Operational deployment efficiency

Table 2 shows the operational consequences of adopting SRT in the observed workflow. SRT is associated with improved deployment efficiency through lower dependence on leased contribution infrastructure, shorter setup time, and reduced onsite personnel and travel requirements. These gains are interpreted not as automatic protocol-based savings, but as outcomes of combining SRT transport with a centralized and lighter field-production model.

Table 2. Comparative operational KPI evidence before and after SRT implementation

No	Key performance indicator	Before SRT	After SRT	Change (%)
1	Contribution OPEX per event	IDR 120-150 million	IDR 55-70 million	Down 45-55%
2	Contribution setup time (minutes)	180-240	45-60	Down 70-75%
3	Number of onsite personnel	10-12 persons	4-6 persons	Down 50-60%
4	Trips and accommodation requirements	6-8 trips	1-2 trips	Down 65-80%

Note: Operational figures are presented as directional case evidence from the observed broadcaster rather than as universally transferable savings rates.

The dominant efficiency gains arise from reduced dependence on high-cost contribution links, greater provisioning flexibility, and the ability to centralize more production activities in the control room. Compared with the pre-SRT model, the after-SRT condition reduced cost exposure, shortened setup time, and lowered the field deployment footprint. Thus, contribution technology should be evaluated through both signal-delivery metrics and the workflow model it enables [22].

SRT advantages remain conditional. Cost and staffing benefits may decline if settings vary between events, redundancy is absent, venue internet quality is unstable, or monitoring ownership is unclear. Operational efficiency should therefore be interpreted as a function of transport capability and implementation discipline, not merely as a before-and-after cost difference.

Table 3 summarizes descriptive results from questionnaires and focused interviews in the two sports contexts. The table provides triangulation evidence rather than inferential survey results. The lower engineering-feasibility score relative to managerial efficiency indicates that technical risk remains more sensitive to network readiness, fallback planning, and monitoring discipline.

Table 3. Descriptive summary of questionnaire and interview-based case ratings.

Dimension	Football league case	Volleyball case	Cross-case reading
Managerial efficiency mean score	4.7/5.0	4.6/5.0	Strong perceived gains in cost, logistics, setup efficiency, and support for remote production.
Producer-operational mean score	4.1/5.0	4.2/5.0	SRT is viewed as operationally adequate for coordination, workflow flexibility, and production continuity.
Engineering-feasibility mean score	3.9/5.0	3.9/5.0	Technical feasibility is positive, but performance remains dependent on network quality, monitoring, and fallback planning.
Dominant implementation constraint	Availability of stable internet infrastructure for live transmission.	Availability of stable internet infrastructure for live transmission.	Network readiness remains the main boundary condition for reliable deployment.
Indicative operational effect	OPEX down 40–60%; setup reduced 2–4 h; crew reduced 5–7; latency 300–400 ms; uptime 85%.	OPEX down 45–55%; setup reduced 2–3 h; crew reduced 5–7; latency 300–350 ms; uptime 80%.	Operational benefits are material, but bounded by infrastructure quality and venue connectivity.

Note: Mean scores are descriptive averages from the completed role-based instruments. Engineering-feasibility combines the engineering-performance, satellite-comparison, and infrastructure-implementation item groups. The table is triangulation support, not inferential statistics.

3.3. Implementation factors affecting stable deployment

The case evidence indicates that stable SRT contribution depends on repeatable implementation practices. Table 4 summarizes these controls. Configuration discipline reduces latency and retransmission inconsistency; redundancy planning reduces exposure to venue-network failure; monitoring ownership shortens detection time; and post-event review turns operational evidence into future parameter tuning.

Table 4. Key implementation factors associated with stable SRT deployment

Implementation factor	Technical implication	Operational effect
Parameter-setting discipline	Maintains consistent latency buffers, retransmission behaviour, and encoder-gateway compatibility across events.	Reduces avoidable instability and configuration drift between field and control room.
Redundancy planning	Uses dual connectivity or failover-ready path design where network variability is high.	Improves continuity and reduces recovery delay during disruption.
Monitoring ownership	Defines dashboard visibility, alerting, and escalation responsibility for NOC and engineering teams.	Accelerates disruption detection and response during live operation.

Security and vendor governance	Maintains access control, device compatibility, and repeatable technical procedures.	Lowers operational risk and reduces deployment uncertainty.
Post-event performance review	Links event-level QoS evidence with setup and cost outcomes for repeat tuning.	Supports continuous improvement and more predictable future deployments.

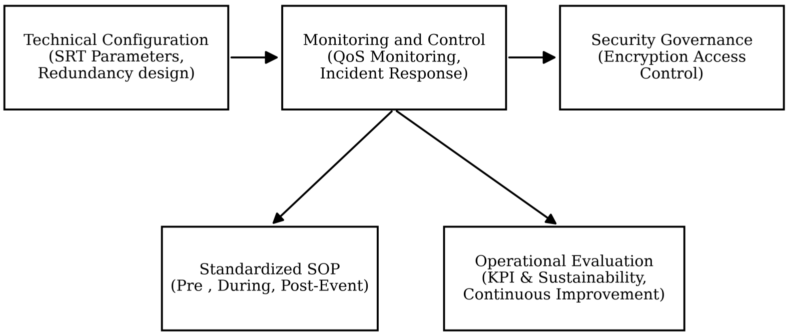

Figure 4. Control areas linking SRT configuration, monitoring, governance, and operational evaluation.

These factors show that SRT implementation cannot be reduced to protocol selection alone. Latency settings, retransmission thresholds, monitoring practices, security governance, and escalation ownership jointly shape the contribution outcome. Reasonable technical settings may still underperform when monitoring responsibility and escalation procedures are unclear.

The main implication is that SRT is most useful when embedded in a disciplined deployment routine rather than treated as a one-time protocol substitution. For broadcast engineering organizations, the practical unit of improvement is the contribution system as deployed, monitored, and reviewed, not the transport stack alone.

3.4. Discussion and limitations

Taken together, the findings support three observations. First, SRT offers a useful latency-reliability compromise under public-network conditions. It does not outperform satellite contribution on every resilience metric and does not match the lowest delay of regular IP transport, but it reduces the operational disadvantages of both alternatives by providing sufficiently low delay with improved recoverability.

Second, SRT strengths are associated with deployment efficiency only when the contribution architecture is supported by consistent parameter templates, redundancy preparation, and clear monitoring ownership. Third, the observed relationship between SRT settings and performance should be interpreted as a mechanism-level association, not statistical causality, because the study uses bounded operational evidence rather than controlled experimentation. Case evidence can therefore complement laboratory and testbed studies by showing how transport choices affect real production behavior [1], [10], [13]. Similar findings in low-latency video streaming show that adaptive control, error recovery, and network-aware delivery can improve continuity, although they may introduce trade-offs in delay, stability, and perceived quality [23]–[25].

This study is limited to one broadcaster, one operational environment, and two sports-production contexts. The technical records are operational rather than laboratory-generated; therefore, the analysis emphasizes practical engineering interpretation instead of statistical generalization. Confidentiality constraints also limit disclosure of event identifiers, raw-log counts, packet traces, and equipment details. Future work should examine larger multi-event and multi-station datasets and controlled network impairment conditions.

4. Conclusion

This study evaluated SRT-based contribution in live television broadcasting using bounded case evidence from live sports operations. The results indicate that SRT offers a practical latency-reliability compromise for IP-based contribution: it is more robust than conventional best-effort IP transport in terms of residual packet loss, service continuity, and recovery behavior, while remaining more deployment-efficient than satellite contribution in setup time, staffing, and operating expenditure under the observed conditions.

Stable implementation depends not only on protocol capability but also on consistent parameter settings, redundancy preparation, monitoring procedures, and incident escalation readiness. These factors should be treated as part of the engineering deployment problem. The study contributes a reproducible case-evaluation approach for relating SRT QoS behavior to operational deployment efficiency. Because it is a single bounded case, the results should be interpreted as case-based engineering evidence rather than universally generalizable performance claims.

Declaration of AI and AI assisted technologies in the writing process

During the preparation of this work, the author(s) used ChatGPT to support language editing, conciseness improvement, formatting refinement, and manuscript clarity. After using this tool, the author(s) reviewed and edited the content as needed and assume full responsibility for the content of the publication.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Questionnaire and interview design for the football league and volleyball case studies

Both instruments addressed the use of Secure Reliable Transport (SRT) in television broadcasting and were structured for role-based inquiry involving Production Managers, Program Producers or production operations representatives, and Technical Managers. The appendix therefore serves as supporting triangulation material for the bounded case design and mixed-method interpretation adopted in the paper [12], [16].

Each instrument contained four substantive components. First, a respondent profile section captured role, industry experience, and prior exposure to SRT. Second, a managerial-efficiency section asked respondents to assess the effect of SRT on operating cost, logistics, field staffing, setup time, business flexibility, remote-production strategy, competitiveness, and CAPEX or OPEX reduction. Third, a producer-operational section examined workflow simplification, coordination, location flexibility, audio-video adequacy, multi-location support, multiplatform distribution, production efficiency, usability, creativity, and live stability. Fourth, an engineering section examined packet-loss handling, network robustness, acceptable latency, reliability, security, comparison with satellite links, implementation complexity, multi-ISP requirements, integration with existing systems, monitoring, and troubleshooting.

The instruments also included open-ended questions covering the main advantages of SRT, the largest implementation constraints, the conditions under which satellite contribution remains necessary, the perceived effect of SRT on overall operating efficiency, and suggestions for future development. Optional quantitative fields were used to document estimated cost savings, reduction in field crew, reduction in setup time, indicative SRT latency, and system uptime. The questionnaires were administered together with semi-structured interviews so that the responses could be clarified against event-level technical logs and operational KPI records from the two sports-broadcast case contexts.