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Service Quality Improvement for Radio Frequency Spectrum Usage Monitoring at Balai Monitor Class I Surabaya Using SERVQUAL and AHP Methods

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Abstract.
Technological advancements have increased quality demands for frequency spectrum monitoring services. Balmon Surabaya, a UPT under *Permenkominfo* No. 1 of 2022, supervises the radio frequency spectrum in East Java. However, challenges such as declining monitoring results, numerous complaints, and ineffective disturbance handling have emerged. This study evaluates service quality gaps and proposes improvement strategies for radio frequency spectrum monitoring at Balai Monitor Class I Surabaya using integrated *SERVQUAL* and *AHP* methodologies. A quantitative survey collected data from 81 non-major user service recipients through structured questionnaires covering five service dimensions: tangibles, reliability, responsiveness, assurance, and empathy. Data analysis employed *SERVQUAL* gap analysis, Importance-Performance Analysis (IPA), and Analytical Hierarchy Process (*AHP*), integrated via Quality Function Deployment (QFD). Results revealed negative gaps between user perceptions and expectations across all dimensions, notably tangibles (-0.60), responsiveness (-0.60), reliability (-0.56), and assurance (-0.52). IPA identified six critical attributes in Quadrant I needing urgent attention. *AHP* prioritized these, with "information on disturbance handling timing" receiving the highest weight (41%). The study recommends five priorities for improvement: enhancing digital and interactive service media; strengthening monitoring and maintenance infrastructure; finalizing operational standards for procedures and service times; digitizing complaint systems with automatic progress updates; and visualizing disturbance handling progress on the user dashboard. These findings provide practical guidance to improve public service quality in frequency spectrum management, supporting more effective wireless communication supervision and lowering interference incidents in East Java.
Keywords: AHP; Monitor Station; Radio Frequency Spectrum; Service; Service Quality

INTRODUCTION

The Surabaya Radio Frequency Spectrum Monitor Center (Balmon) plays an essential role in supervising frequency spectrum use in the East Java region (Suryanto et al., 2021). The radio frequency spectrum is part of the electromagnetic spectrum utilized for wireless communication and is a limited resource requiring careful management (Zhang & Zhang, 2019). Based on Permenkominfo No. 1 of 2022, Class I Balmon Surabaya's main tasks include supervision of spectrum use, monitoring and handling disturbances, technical measurements, and public services related to frequency permits (Hidayat et al., 2022). Balmon's existence is crucial to ensure that

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frequency use complies with regulations, enabling smooth communication (Wang & Zhao, 2020; Kumar et al., 2020). Furthermore, frequency spectrum monitoring is vital in preventing interference and ensuring that wireless networks operate efficiently (Nguyen et al., 2021). Through these efforts, Balmon ensures optimal spectrum management in East Java (Rinaldi & Santoso, 2020), which supports the regional telecommunications infrastructure (Sari & Suryani, 2019).

Despite its strategic role, Balmon Surabaya faces several challenges in fulfilling its duties (Maroe Beni, 2018). Major issues include a high volume of public complaints about frequency disturbances, declining monitoring results, and reported user dissatisfaction (Li et al., 2020; Park & Kim, 2021). This is corroborated by SIMS data and inputs from service users, revealing a gap between expectations and Balmon's service performance (Chung et al., 2019; Zainal & Haryanto, 2022). Factors such as unclear complaint procedures and slow complaint handling were particularly noted (Zhang et al., 2021; Wong & Lee, 2020). These issues highlight the need for process improvements and greater transparency in handling public concerns (Chang et al., 2020). Furthermore, a more efficient complaint resolution system is necessary to enhance public satisfaction with frequency spectrum services (Xu & Zhou, 2021).

Recent data from the Balai Monitor Class I Surabaya Annual Report (2024) highlights significant service quality challenges, with user complaints rising 23% from 2022 to 2023, totaling 1,247 issues. SIMS data shows only 67% of disturbance cases were resolved within the regulatory timeframe, below the 85% target set by *Permenkominfo*. User satisfaction surveys at the end of 2023 recorded an average score of 3.2 out of 5.0, indicating ample room for improvement. Additionally, 15% of monitoring stations operate with outdated equipment, affecting detection accuracy and response times.

The equipment limitations hinder Balmon in maintaining supervision quality, causing delays in detecting and mitigating frequency interference. In today's fast-evolving communication landscape, optimal monitoring capabilities are demanded to prevent spectrum interference, and these device limitations must be urgently addressed through service improvement strategies.

Several prior studies have successfully utilized *SERVQUAL*, IPA, and related methodologies to measure and enhance service quality in similar contexts. For instance, Cera et al. (2020) demonstrated the effectiveness of integrating *SERVQUAL* and IPA in improving public sector service quality, highlighting how gap analysis identifies specific areas for governmental service enhancements. Kusonwattana and Liangrokapart (2020) applied *SERVQUAL* to improve rail freight service efficiency in Thailand, showing that systematic service quality assessment leads to targeted infrastructure improvements. In telecommunications, Pribadi (2020) conducted a

comprehensive study on public service quality at Balai Monitor Class I Surabaya using integrated *SERVQUAL*, IPA, and House of Quality approaches, establishing a baseline for spectrum monitoring service quality measurement. Liu et al. (2023) advanced this by applying QFD and *AHP*-based methodologies to optimize system design via structured selection processes, providing frameworks applicable to technical service improvements.

This study aims to analyze the gap between expectations and perceptions of non-major user groups in Surabaya, Sidoarjo, and Malang, employing the *SERVQUAL* method developed by Parasuraman et al. (1988). *SERVQUAL* assesses service quality across five key dimensions: tangibles, reliability, responsiveness, assurance, and empathy, measuring differences between users' perceptions and expectations.

The *SERVQUAL* model offers an overview of service quality through gap values calculated as Perception minus Expectation. Averaging the gap per dimension allows identification of the weakest aspects, prioritizing areas for improvement. This enables Balmon to focus resources on dimensions with the largest gaps to enhance user satisfaction effectively.

This research's urgency stems from Balmon Surabaya's critical role in East Java's communications infrastructure, a major economic hub with dense industrial and telecommunications activity. Service quality shortcomings at Balmon can disrupt essential communications—including emergency, broadcast, and commercial networks—impacting regional economic activities, public safety, and compliance with international telecommunications standards. Moreover, as East Java expands digital economy initiatives and deploys 5G networks, demand for advanced spectrum monitoring grows, making service quality enhancements imperative to maintain the region's competitive edge.

The innovation of this study lies in its comprehensive integration of *SERVQUAL*, IPA, *AHP*, and QFD methodologies to analyze and improve public service quality in frequency spectrum management. This unified framework uniquely translates user perceptions into prioritized technical interventions, bridging subjective experiences with objective technical requirements through systematic analysis. This integrated approach is particularly novel within spectrum monitoring, where technical complexity often gaps user needs and solutions. The methodology provides a structured pathway from quality assessment to implementable technical improvements, offering a replicable model for public service organizations facing complex technical service demands.

The *SERVQUAL* and IPA results will inform strategies to improve Balmon Surabaya services. Using the House of Quality (HoQ) approach, strategies will be translated into relevant technical responses to enhance monitoring and disturbance complaint

handling. The HoQ will map user needs to effective technical solutions.

This study aims to: (1) evaluate current service quality gaps using *SERVQUAL*; (2) identify and prioritize critical attributes via IPA and *AHP*; (3) develop service improvement strategies using the QFD framework; and (4) provide actionable recommendations for enhancing spectrum monitoring service delivery. Benefits extend to Balmon Surabaya (evidence-based improvements), the public service sector (replicable quality enhancement methodologies), researchers (integrated framework contributions), and service users (improved experiences through targeted interventions).

The study focuses on monitoring and noise complaint services, targeting non-major users. Its findings are expected to offer a comprehensive picture of user satisfaction with Balmon Surabaya and produce practical recommendations to improve public service quality in frequency spectrum management—supporting more effective, interference-free wireless communications.

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MATERIALS AND METHODS

This research employed a quantitative approach using survey methods and multi-criteria analysis to evaluate radio frequency spectrum monitoring services. The study incorporated SERVQUAL and Analytical Hierarchy Process (AHP) methodologies to measure service quality gaps and prioritize improvements across five key dimensions: tangibles, reliability, responsiveness, assurance, and empathy. Data were collected through questionnaires distributed to 81 non-major user service recipients in Surabaya, Sidoarjo, and Malang, using a 1–5 Likert scale during January–May 2025 at the Surabaya Class I Radio Frequency Spectrum Monitor Center.

The analysis involved multiple stages to ensure robust findings, starting with validity and reliability tests to verify the measurement instruments. SERVQUAL analysis quantified gaps between user expectations and perceptions, while AHP systematically determined improvement priorities through paired comparison matrices, priority weight calculations, and consistency ratio validation ($CR \leq 0.1$). These weighted attributes were integrated into a Quality Function Deployment (QFD) framework, constructing a House of Quality to translate user needs into actionable technical responses.

The study provided concrete managerial recommendations for enhancing spectrum monitoring services with a structured approach to service quality improvement. By combining SERVQUAL gap analysis, AHP prioritization, and QFD technical translation, the research delivered a comprehensive strategy to address service deficiencies and align technical solutions with user expectations, ultimately aiming to optimize radio frequency spectrum monitoring operations in the region.

RESULTS AND DISCUSSION

This study aims to measure and improve the quality of radio frequency spectrum monitoring services at the Class I Monitor Center in Surabaya using the SERVQUAL method and the Analytical Hierarchy Process (AHP). Results of respondent distribution.

Table 1. Respondent Distribution Results Data

Category	Subcategories	Number of Respondents	Percentage (%)
Gender	Man	66	81,5%
	Woman	15	18,5%
Age	21–30 years old	15	18,5%
	31–40 years	28	34,6%
	41–50 years	27	33,3%
	>50 years old	11	13,6%
Types of Frequency Use	Land Mobile (Private)	51	63,0%
	Broadcast	30	37,0%
Location	Surabaya	50	61,7%
	Sidoarjo	13	16,0%
	Hapless	18	22,3%
Total		**81**	**100%**

Validity and Reliability Test Results

The results of the reliability test using SPSS version 29 showed a Cronbach's Alpha value of > 0.6 in terms of customer perception, expectations, and interest level, so that the data was declared reliable and suitable for SERVQUAL, IPA, AHP, and QFD analysis.

Table 2. Reliability Test Results

N of Items	Cronbach's Alpha		
	Reality	Expectation	Significance
22	0,952	0,953	0,953

Service Quality Analysis (Servqual)

Based on the results of questionnaire data processing from 81 respondents, all dimensions of SERVQUAL showed a negative gap value. The dimensions with the 4 largest gaps are Tangible: The interference reporting system is easy to use and accessible to service users (-0.60), Responsiveness: Information on the time of handling the disturbance is clearly provided (−0.6), Reability: Monitoring is carried out regularly and periodically (-0.56), Assurance: The use of reliable monitoring devices in handling the disturbance (−0.52). This indicates that there is a discrepancy between the services received and the user's expectations, especially in the aspects of responsiveness to

handling disturbances and the certainty of service information.

Importance-Performance Analysis (IPA)

After obtaining the SERVQUAL gap value, an IPA analysis was conducted to map service attributes based on performance and importance level into four priority quadrants.

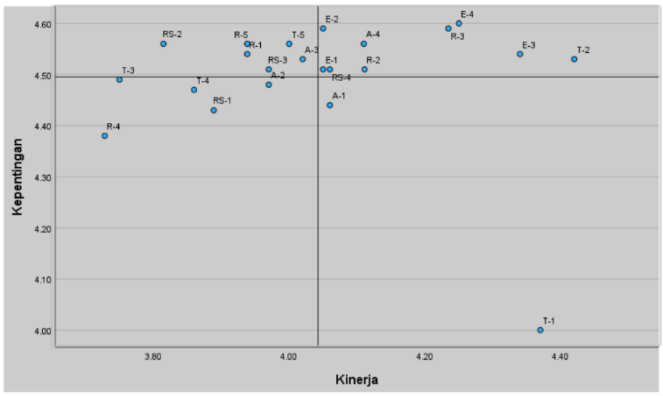

Figure 1. Scatterplot Importance Performance Analysis

In figure 1, It can be known that the priority service quality attributes to be improved are those included in Quadrant I with a high level of importance and low performance, namely as many as 6 (six) attributes, including:

1. Information on the time of handling the disturbance is clearly provided (RS2)
2. Officers handle frequency disturbances according to the type of problem reported (R-1)
3. Officers are able to effectively resolve nuisance complaints (R-5)
4. Delivery of technical information is provided when needed (RS3)
5. Service information media is provided visually and digitally providing complete and easily accessible information (T-5)
6. The use of reliable monitoring devices in Interference Handling (A3)

Analysis of Analytical Hierarchy Process (AHP)

Weighting of the results of service quality attributes that have been carried out using the Analytical Hierarchy Procedures (AHP) method:

Table 3. The Results of Service Quality Attributes

No.	Attribution	Value
1	Information on the timing of the disturbance is clearly provided (RS2)	41%
2	Use of reliable monitoring devices in handling disturbances (A3)	21%
3	Officers handle frequency disturbances according to the type of problem reported (R-1)	15%

No.	Attribution	Value
4	Officers are able to resolve nuisance complaints effectively	10%
5	Delivery of technical information is provided when needed (RS3)	7%
6	The information media service is provided visually and digitally providing complete and easily accessible information (T-5)	5%

Analysis of Quality Function Deployment (QFD)

After the results of AHP are used as a customer requirement, the next step is for AHP to be integrated with QFD which functions to connect customer needs with technical specifications as an operational action that needs to be done. This priority weight is obtained from the calculation of the priority vector as a result of pairwise comparison, which then produces a priority matrix of service quality attributes based on customer requirements, as shown in this matrix designated as Voice of Customer (VoC).

Technical Response

		Meningkatkan digitalisasi sistem pengaduan dan notifikasi progres otomatis	Melengkapi standar operasional prosedur teknis dan waktu layanan	Penguatan infrastruktur pemantauan teknis dan pemeliharaan sistem monitoring	Integrasi informasi layanan ke dalam portal publik	Meningkatkan kompetensi dan kapasitas petugas teknis	Membuat visualisasi progres penanganan gangguan di dashboard pengguna	Melakukan sosialisasi aktif kepada pengguna layanan	Menyesuaikan pelayanan berdasarkan segmentasi wilayah.	Melakukan evaluasi teknis berkala terhadap efektivitas penanganan gangguan	Meningkatkan efektivitas media layanan digital dan interaktif	Pengembangan sistem pengukuran kepuasan pengguna layanan gangguan
Informasi waktu penanganan gangguan diberikan secara jelas	41%	Θ	Θ	○	○	▲	Θ	▲	○	▲	Θ	○
Penggunaan perangkat monitoring yang handal dalam penanganan gangguan	21%	▲	▲	Θ			▲			○	Θ	
Petugas menangani gangguan frekuensi sesuai dengan jenis permasalahan yang dilaporkan	15%		Θ	Θ		Θ				Θ		
Petugas mampu menyelesaikan pengaduan gangguan dengan efektif	10%	▲	Θ	Θ		Θ				Θ		
Penyampaian informasi teknis diberikan saat diperlukan	7%	○	▲		Θ		○	Θ			Θ	
Media informasi layanan disediakan secara visual dan digital memberikan informasi yang lengkap dan mudah diakses	5%	Θ			Θ		Θ	Θ			Θ	
contribution		3,64	4,08	4,17	2.17	1,66	2,72	0,73	1,23	2,29	5,54	1,23
normalized contribution (%)		12,4	13,8	14,1	7,4	5,6	9,2	2,5	4,2	7,8	18,8	4,1
Priority		4	3	2	7	8	5	11	9	6	1	10

Figure 2. House of Quality Result

Discussion

The findings of this research align with and extend previous studies in service quality measurement and improvement. The negative gap values identified across all SERVQUAL dimensions are consistent with Cera et al. (2020)'s findings in public sector services, where perception-expectation gaps commonly indicate areas requiring systematic improvement. The identification of responsiveness and reliability as the most critical dimensions mirrors the patterns observed in Kusonwattana and Liangrokapart (2020)'s study of transportation services, suggesting that operational efficiency and communication transparency are universal concerns across public service sectors.

The effectiveness of the integrated SERVQUAL-IPA-AHP approach demonstrated in this study validates the methodological framework previously established by Pribadi (2020) in the same organizational context, while extending it through more comprehensive priority weighting. The 41% priority weight assigned to "information on disturbance handling timing" reflects the critical importance of communication transparency identified in Liu et al. (2023)'s work on system optimization, where information flow emerged as a key performance determinant.

The QFD integration successfully translates user requirements into technical specifications, supporting the theoretical framework proposed by Hauser et al. (2010) that emphasizes the importance of structured requirement translation in service improvement initiatives. The five priority improvement areas identified through this integrated approach—digital service media, infrastructure strengthening, operational standards, complaint system digitization, and progress visualization—align with contemporary trends in public service digitalization documented in recent literature.

The research extends previous work by demonstrating how multi-criteria decision analysis can be effectively applied to technical service environments, providing a structured pathway from user feedback to implementable solutions. The consistency ratios achieved in AHP analysis (CR ≤ 0.1) validate the reliability of priority assessments, supporting the framework's applicability to similar technical service contexts.

CONCLUSIONS

This research successfully identified significant service quality gaps in radio frequency spectrum monitoring services at Balmon Surabaya, with all 22 surveyed attributes showing negative *SERVQUAL* gaps—particularly in responsiveness and tangibles, both at -0.60—indicating user perceptions fell consistently below expectations. By integrating *SERVQUAL* gap analysis, Importance-Performance Analysis (IPA), and Analytical Hierarchy Process (*AHP*), the study pinpointed six critical attributes needing immediate attention, prioritizing “information on disturbance

handling timing" with a 41% weight. Consequently, five targeted improvement strategies were developed: enhancing the effectiveness of digital service media, strengthening monitoring infrastructure, formalizing operational standards, digitizing complaint systems with automatic notifications, and implementing user-accessible progress visualization dashboards. This work contributes to the literature by being the first to comprehensively apply the integrated *SERVQUAL*-IPA-*AHP*-QFD framework in spectrum monitoring, offering a replicable, structured approach for translating user needs into practical technical solutions with broader relevance to public technical services. Future research should focus on evaluating the real-world effectiveness of these improvement strategies through longitudinal studies, assessing the framework's applicability in other technical service contexts, and developing automated, real-time service quality monitoring systems to support continuous enhancement in dynamic environments.

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