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Operational Planning of *X-ray* Screening Detection System: Feasibility Analysis, Capacity, and Service Process Analysis Approach

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Abstrak

Studi ini menganalisis kerangka operasional PT. CKK dalam menyediakan layanan perbaikan dan pemeliharaan peralatan keamanan yang akurat dan andal melalui integrasi desain proses, teknologi, dan manajemen rantai pasok. Dengan menggunakan pendekatan gabungan yang melibatkan studi kasus, analisis dokumen, wawancara pemangku kepentingan, observasi lapangan, dan simulasi alur layanan, studi ini mengembangkan cetak biru layanan yang mencakup proses perbaikan, pemeliharaan preventif, dan penerapan teknologi seperti AI/Analytics untuk prediksi kerusakan, CRM terintegrasi GPS, blockchain untuk transparansi rantai pasok, dan alat pengujian khusus. Hasil penelitian menunjukkan bahwa strategi ini mampu mengoptimalkan efisiensi layanan, meminimalkan waktu henti operasional, dan memastikan kepatuhan terhadap standar internasional (TSA dan ECAC). Namun, keterbatasan seperti sifat teoretis penerapan teknologi canggih, ketergantungan pada kualitas data historis, dan beban investasi yang tinggi perlu diatasi. Implikasi manajerial merekomendasikan penguatan infrastruktur data, adopsi teknologi secara bertahap, pelatihan SDM berbasis e-learning, diversifikasi pemasok, dan perluasan ke sistem keamanan generasi terbaru. Penelitian ini memberikan panduan praktis bagi perusahaan jasa pemeliharaan peralatan keamanan untuk meningkatkan keandalan layanan sekaligus mendukung penetrasi pasar di Indonesia melalui kombinasi inovasi teknis dan manajemen operasional yang terukur. Temuan validasi melalui simulasi terbatas dan diskusi kelompok terfokus juga menekankan pentingnya keseimbangan antara inovasi teknologi dan adaptasi terhadap keterbatasan operasional di lapangan.

Kata Kunci: *Cetak Biru Layanan, Pemeliharaan Prediktif Sinar-X, Teknologi Blockchain, Pemeliharaan Peralatan Keamanan, Manajemen Rantai Pasok.*

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Abstract

This study analyzes the operational framework of PT. CKK in providing accurate and reliable security equipment repair and maintenance services through the integration of process design, technology, and supply chain management. Using a mixed approach involving case studies, document analysis, stakeholder interviews, field observations, and service flow simulations, the study developed a service blueprint that includes repair processes, preventive maintenance, and the application of technologies such as AI/Analytics for damage prediction, GPS-integrated CRM, blockchain for supply chain transparency, and custom testing tools. The results show that this strategy is able to optimize service efficiency, minimize operational downtime, and ensure compliance with international standards (TSA and ECAC). However, limitations such as the theoretical nature of the implementation of advanced technologies, reliance on the quality of historical data, and high investment burden need to be addressed. Managerial implications recommend strengthening data infrastructure, gradual technology adoption, e-learning-based HR training, supplier diversification, and expansion to the latest generation of security systems. This research provides practical guidance for security equipment maintenance service companies to improve service reliability while supporting market penetration in Indonesia through a combination of technical innovation and measurable operational management. The validation findings through limited simulations and focus group discussions also emphasized the importance of a balance between technological innovation and adaptation to operational limitations in the field.
Keywords: *Service Blueprint, Predictive Maintenance Xray, Blockchain Technology, Security Equipment Maintenance, Supply Chain Management.*

INTRODUCTION

The use of X-ray systems at airports is a critical component in maintaining flight security and safety, especially in the digital age that demands high efficiency and accuracy (Kierzkowski et al., 2025). In Indonesia, the significant growth in passenger and freight traffic, especially post-pandemic, has put pressure on airport security systems to increase capacity and responsiveness to current threats (Pivac et al., 2025). X-ray screening systems, particularly for baggage and luggage checks, play a central role in detecting prohibited objects such as weapons, explosives, or other dangerous substances. However, key challenges still remain, such as the overlap of objects in X-ray images that make identification difficult, the reliance on human operators who are prone to fatigue, and the need to integrate cutting-edge technologies to speed up the examination process without sacrificing accuracy (Teng et al., 2024).

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In Indonesia, X-ray systems at airports generally still rely on manual procedures, where operators can only trigger alarms without providing a specific visual designation of the location of prohibited objects in the imagery (Kierzkowski et al., 2025). This has the potential to cause confusion and delays, especially when passenger volumes increase. Studies on the use of eye-tracking suggest that analysis of operator attention patterns can improve detection accuracy by mapping the areas most frequently observed during examinations (Kierzkowski et al., 2025). In addition, the development of deep learning-based algorithms, such as LightRay and YOLOv7 modifications, has proven its effectiveness in detecting prohibited objects in complex X-ray images, including in overlapping scenarios (Tao et al., 2021; Zhao et al., 2022). This technology opens up opportunities for Indonesia to adopt automated systems that are able to reduce human workload while minimizing detection errors (Teng et al., 2024).

Airport infrastructure in Indonesia also needs to adapt to technological developments. Modifications of security control areas, such as the use of X-ray machines optimized based on the airline's business model (low-cost carrier vs. full-service carrier), are important to keep pace with the surge in passenger numbers (Pivac et al., 2025). The integration of the Internet of Things (IoT) in X-ray monitoring systems such as real-time dashboards to track device health and operational uptime can improve efficiency and ensure compliance with national and international regulations (Wang et al., 2024). Although challenges such as physical capacity limitations and modernization budgets still exist, the implementation of innovative AI-based solutions, data augmentation with Generative Adversarial Networks (GANs), and increased operator training are strategic steps to strengthen airport security systems in Indonesia (Tao et al., 2021; Zhao et al., 2022). By combining technology, adaptive infrastructure design, and humanist approaches such as eye-tracking, Indonesia has the potential to become a model for developing countries in optimizing aviation safety in the digital era.

The need for a rapid diagnostic service, Predictive Maintenance xray, continues to increase in line with the demands of security screening at airports, the need for goods detection, and awareness of the threat of narcotics and prohibited goods dangers. The *X-ray* Screening System clinic is here to offer faster and more efficient services than large hospitals. However, the establishment of this service requires careful operational planning because it involves high-value investments, strict regulations related to radiation, and the need for certified technical personnel. Therefore, this study aims to design an end-to-end

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X-ray clinic operational system, including service process mapping, capacity calculation, and technical and operational business feasibility projections.

RESEARCH METHOD

This research uses a mixed approach that combines qualitative methods and applied science design to develop the operational framework of PT. CKK which focuses on security equipment repair and maintenance services. The research process begins with an in-depth case study through the analysis of the company's internal documents, including service blueprints, repair process flows, supply chain structures, and a planned list of technology inventories, to map the operational needs and specific challenges in the security equipment repair services industry. Data collection was carried out through structured interviews with operational management, field technicians, and the marketing team of PT. CKK, as well as direct observation at workshops and customer sites to validate the designed workflow. In addition, this study utilizes secondary analysis in the form of international standards such as TSA and ECAC, academic literature on service supply chain management, and case studies of similar companies to ensure the suitability of service design with industry best practices. Process design validation is carried out through service flow simulation using tools such as service blueprints and testing of supporting technologies (such as IoT and CRM integration) on a limited scale, followed by focus group discussions with technical experts and customer representatives to assess the feasibility of implementation. This research was carried out for eight months with a primary data collection period from January to April 2025, followed by analysis and preparation of recommendations until May 2025, thus ensuring that the findings are not only theoretical but also have high practical relevance in the operational context of PT. CKK in Indonesia.

RESULTS AND DISCUSSION

In line with the business goals and objectives of PT. CKK, which is engaged in the repair and maintenance of security equipment services that are obliged to ensure that the results of the work are really accurate and reliable, then PT. CKK makes process and service design planning, *service blueprints* and technology that will be used for repair and testing purposes.

Table 1. Service *Design* of PT. CKK

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No.	Equipment Industry	Service applications	Service and Services
1	X-Ray Scanning System *Machine*	Radiation *Scanning System* Repair	X-Ray Tank Generator *Repair*. Cascade Block *Repair* LVDS, ADC and board components Computer Rack *Repair*
		Radiation *Scanning* Testing	*Testing Anode* – *Catode Current* *Kv and mA* testing *Testing Line Scope* and *Array Response* EWSTP and STP test
		Preventive and Maintenance	Wire *and* computer rack *inspection* Line *scope* inspection and scanning results Regular radiation testing Certification
2	Walk Through Metal Detector *Machine*	System Detector *Repair*	Detector module *repair* Sensitivity testing Object sensor inspection
		Preventive Maintenance	Detector Sensitivity Inspection and Testing Testing with OTP Certification
3	*Explosive Trace Detector*	System Detector *Repair*	Test kit *module repair* Replacement *of consumable parts* Test *kit testing*
		Preventive and Maintenance	Check on *the water purification catridge* (APC). Membrane checking Dopant check Drying *Check* Calibration
4	*Medical X-Ray*	X-Ray Generator *Repair*	Cascade Repair Replacement *of anode* parts – *cathodes* Cathode tube *replacement*

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Service Process Design

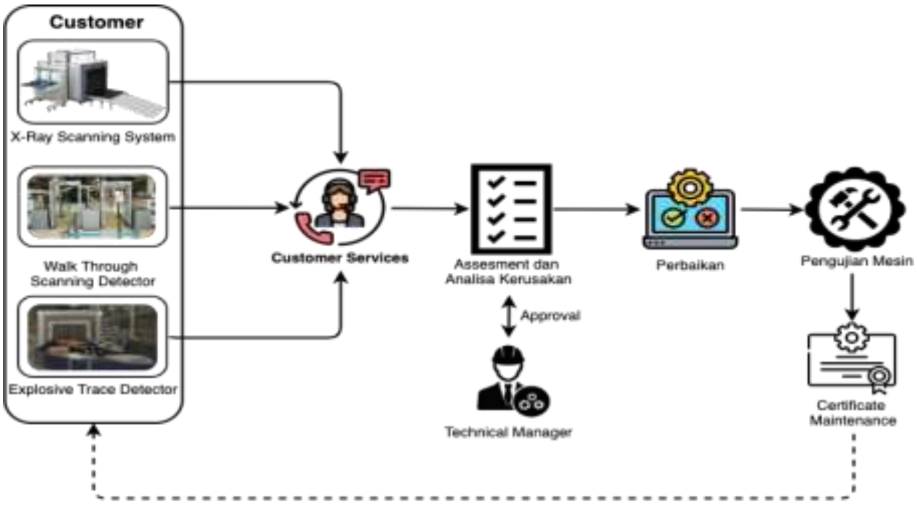

Figure 1. Repair and Testing Process Flow

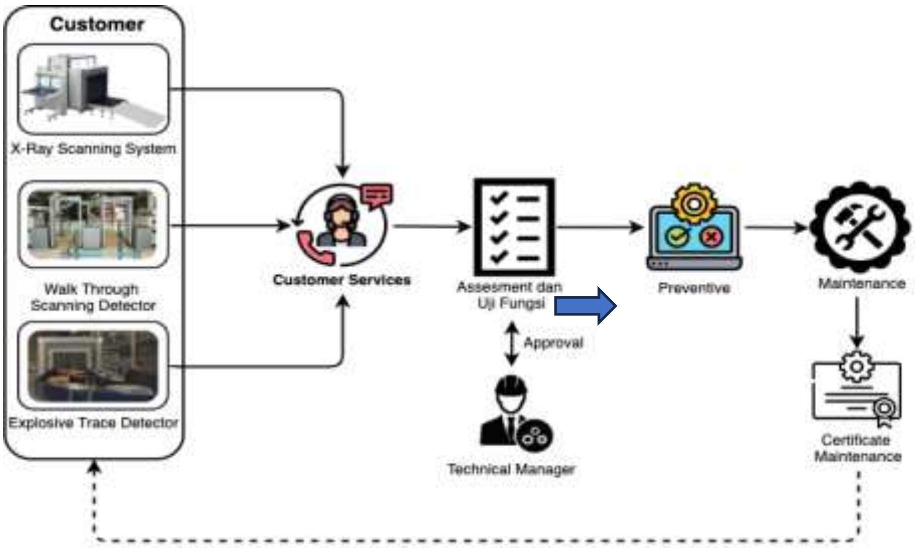

Figure 2. Preventive and Maintenance Process Flow

Layout and Service Flow

PT. Citra Klinik Seguridad provides certified maintenance and repair services to achieve peak performance in *X-Ray screening & detection systems* so that machine operating hours are maintained and operational activities are not disrupted. Providing *preventive and corrective maintenance* contract services at affordable prices for all types of *X-Ray scanning system* machines in all locations in Indonesia. Our service work system includes *spare parts* repair work, replacement *of spare parts* if they can no longer be

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repaired permanently, engine testing, certification services and machine removal. The following is the *layout* and flow of CKK services.

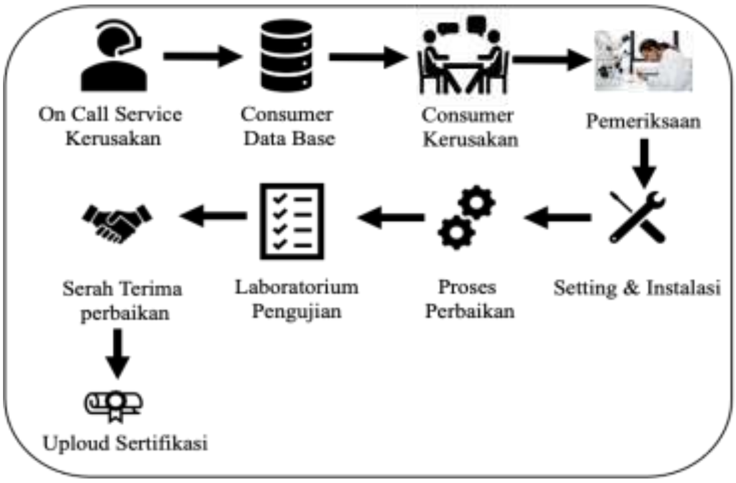

Figure 3. Service Stream

Service Stream

As a company in the field of Repair and Maintenance Services, we provide the best service for customers, for that in accordance with *the Lean Business Canvas*, which is *a unique value* proposition, namely a service application, for that we make *a Service Blue Print* that is tailored to customer needs. *Service Blueprint* is prepared for repair and maintenance services for Machinery and Spare Parts. The following is an illustration of the work process at PT. Security Clinic Image.

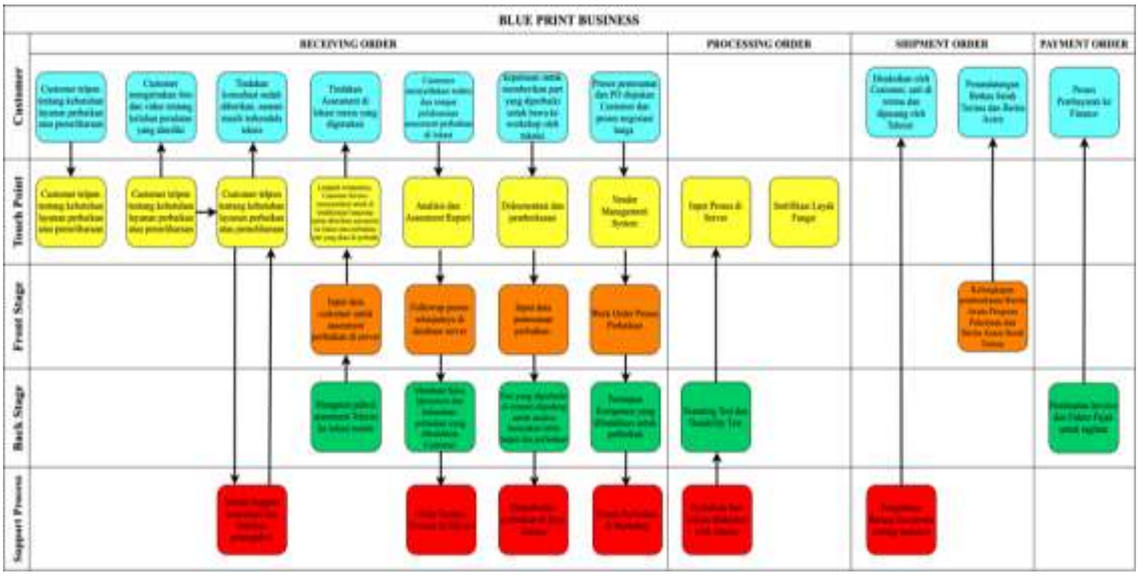

Figure 4. *Service Blueprint*

Source: Author Data (2025).

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Technology

The application of technology will be required in several aspects as follows:

Table 2. Service Technology of PT. CKK

Technology	Function	Advantages	Implementation	Goal
AI/*Analytics*	Data analysis for maintenance schedule optimization.	Prediction accuracy >95%, cost savings.	Machine learning algorithm + integration with *IoT dashboards.*	IoT adoption, customer satisfaction.
CRM	Service request management and customer feedback.	Fast response, customer retention.	*The CRM platform* integrates with IoT and GPS.	*Market Penetration*, Customer Satisfaction.
Blockchain	Supply chain transparency and compliance audits.	Reduce fraud, business legitimacy.	Record parts transactions and service history on *the blockchain*.	ASEAN Expansion, Financial Sustainability.
E-Learning	Training employees and customers on technology.	Technician competence is improved, customers are self-sufficient.	IoT/AI training module + video *tutorial*.	*Human Capital*, IoT Adoption.
GPS *Tracking*	Optimizing the Field Technician's Route.	Response time <2 hours, logistics costs are down.	GPS *tracker* on fleet + CRM integration.	Customer Satisfaction, ASEAN Expansion.
Cybersecurity	Protection of customer data and internal systems.	Reduce the risk of data leakage.	*Firewalls*, encryption, security audits.	Regulatory Compliance, Brand Reputation.
AR for Training	Simulation of engine repair through augmented reality.	More effective training, lower costs.	Partnerships with AR providers.	*Human Capital*, IoT Adoption.
Oscilloscope	Testing the high voltage frequencies generated from *the*	Speed of results	Service Process	Customer Satisfaction

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	Power generation Generator			
TLD *Badge*	Absorb radiation emitted by *generators* and avoid technicians being exposed to ionizing radiation	Technician safety	*Safety*	Employee Safety
Meter Survey	Measure the performance of the radiation emitted by the generator	Technician safety	*Safety*	Employee Safety
Mega Ohm Multimeter	Measure the components in the *Generator* and *Controller* that are responsible for providing radiation signals to the machine in order to scan objects perfectly.	Speed of results	Service Process	Customer Satisfaction
Mock Up Scanning	Testing the scanning stability of generator and *controller components*	Speed of results	Service Process	Customer Satisfaction

Source: Author Data (2025)

Operational Delivery

Supplier Chain Management

Operations delivery describes a complete and integrated approach to undertaking different types of specific projects or businesses. This operations delivery provides a complete end-to-end model of the company's workcycle and is used as a reference for running a business with the same characteristics. The delivery of these operations can be further elaborated in detail in the supply chain management framework. *Supply chain* is a system that integrates activities from the stages of making contracts or agreements, procurement *of spare parts*, procurement of *X-Ray* machine testing equipment, *storage of spare parts*, repair processes, and services, as well as sending repair reports to customers. A product or service can reach consumers after going through various stages in supply *chain management*. PT CKK has a supply chain from suppliers to customers as follows:

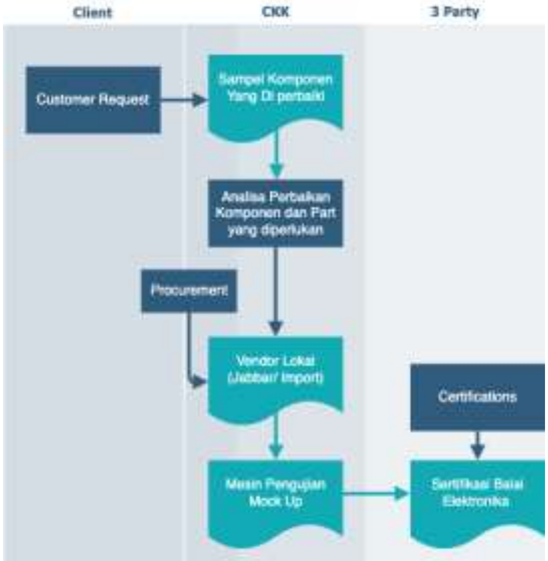

Figure 5. Supply Chain Management

Inventory Planning and Control

Inventory planning is related to determining the availability of spare parts, determining the time or schedule of repairs, and customers who will witness it. Meanwhile, inventory control or control includes controlling office and *workshop* operations within certain level limits according to planned, and protecting the quality, accuracy and speed of test results. In line with the strategy chosen in QSPM, namely market penetration. In terms of inventory control and control, the managers synergize with each other to do several things, including for the marketing division after compiling customer targets then the operational division prepares the repair process, ensuring repair equipment is in good condition and allocating repair time. In addition, it also records the receipt of repair or maintenance requests, stores *spare parts*, monitors the repair and maintenance process, and evaluates the results of repairs and the performance of technicians. And every month always checks goods, *spare parts* and equipment that support PT CKK's operations. The following is a list of *spare parts* and equipment that are owned and must be managed. Details of the PT CKK Inventory List can be found in the Appendix.

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Equipment Planning

Operational planning and the inventory of *required parts* relate to the type of radiation testing and radiation scanning. Meanwhile, inventory control or control includes operational control of *X-Ray scanning systems*, *Walkthrough Metal Detectors*, and *Explosive Trace Detectors* as planned, and protection of service quality, accuracy and speed of test results. In line with the strategy chosen in QSPM, namely market penetration. In terms of inventory control and control, the managers synergize with each other to do several things, including for the *marketing* division after compiling the target consumer and then the operational division preparing mock ups and scanners. In addition, it also records the receipt of repair modules, stores repaired modules, monitors the radiation testing process, and evaluates test results. And every month always checks the items that support the operation of the *X-Ray Clinic*. The following is a list of *scanning system* testing machine equipment that must be owned and must be managed.

Quality Management

Quality management is the act of supervising all activities and tasks necessary to maintain the expected level of excellence. The quality that is supervised is not only limited to the quality of the testing machine but also the quality of the *storage place*, the quality of the employees recruited and hired and the quality of service quality. Supervision and monitoring at every point during the technician testing process is important to carry out in order to maintain the quality of the test results produced in accordance with *applicable standards*. This is in line with Chapter IV Figure 4.5 *Lean Canvas* on *Key Activities*, there are SOPs, and support *the Value Proposition*, which is the results *of precise and accurate scanning tests and consulting services around mechanical testing procedures according to* TSA and ECAC international *standards*.

CONCLUSION

PT. CKK has designed a comprehensive operational system to ensure accurate, reliable, and international standard security equipment repair and maintenance services according to its business objectives. Through structured process design planning including service blueprints, repair workflows, preventive maintenance, and integration of cutting-edge technologies such as AI/Analytics for maintenance prediction, integrated CRM, blockchain for supply chain transparency, GPS tracking systems, and special testing tools

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(Oscilloscope, TLD Badge, and Meter Survey), the company is able to optimize service efficiency, technician safety, and customer satisfaction. This approach is strengthened by measurable supply chain management, SOP-based quality control, and preventive maintenance strategies that include periodic testing, calibration, and certification to TSA and ECAC standards. By combining technological innovation, precision of testing procedures, and commitment to service reliability, PT. CKK not only supports market expansion through continuous penetration but also minimizes customer operational downtime, strengthening its reputation as a trusted partner in maintaining optimal performance of security systems throughout Indonesia.

This research has several limitations that need to be considered in further application and development. First, the design of proposed services and technologies, such as the integration of AI/Analytics, blockchain, and AR, is still theoretical and has not been empirically tested on a broad scale, so its effectiveness under real operational conditions—especially in locations with limited technology infrastructure—needs to be verified. Second, reliance on historical data for AI-based maintenance predictions has the potential to reduce accuracy if data availability or quality is inadequate, given that not all customers may have a consistent record-keeping system. Third, the implementation of advanced technologies such as blockchain and AR requires high investment and trained human resources, which may be an obstacle for companies with limited financial or technical capacity, especially in expansion into rural areas in Indonesia. Fourth, the focus of the research only covers three types of security equipment (X-Ray Scanning System, Walk Through Metal Detector, and Explosive Trace Detector), so the process design does not cover the challenges of maintaining the latest generation of security equipment or emerging technologies. Fifth, assumptions about customer compliance with preventive maintenance schedules and the availability of spare parts from suppliers have not taken into account the risk of global supply chain disruptions or logistics delays that can disrupt service reliability. Finally, the study has not quantitatively measured the long-term impact of the proposed strategies on customer satisfaction, such as customer retention or increased market share, so further studies with actual data are needed to validate claims of improved service efficiency and reliability.

Clinical *X-ray* Screening System operational planning requires integration between process efficiency, optimal capacity, and compliance with radiation regulations. Operations managers need to manage HR rotation based on peak hours, as well as perform regular

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equipment maintenance to maintain *service uptime*. Digitizing results can speed up throughput and reduce the need for physical storage space.

The managerial application of the results of this study includes a number of strategic recommendations that need to be adopted by the management of PT. CKK to strengthen service reliability, operational efficiency, and long-term competitiveness. First, strengthening data management infrastructure is a priority to support AI-based maintenance predictions, given the reliance on quality historical data. Management needs to develop a centralized digital recording system that integrates with IoT to ensure prediction accuracy and reduce the risk of errors due to incomplete or inconsistent data. Second, gradual and focused implementation of technology is needed to avoid the burden of excessive investment, especially in areas with limited infrastructure. For example, prioritizing the adoption of GPS-integrated CRM and testing tools such as Oscilloscope before moving to complex solutions such as blockchain or AR, so that resource allocation is more effective and within the company's financial capacity. Third, human resource capacity development through technology-based training should be a routine agenda, including e-learning modules and AR simulations, to ensure technicians are able to operate advanced equipment while minimizing the risk of procedural errors due to lack of competence. Fourth, supply chain diversification and risk mitigation strategies need to be implemented by establishing partnerships with more than one critical spare parts supplier and compiling strategic stock reserves, in order to anticipate logistics disruptions or delivery delays that have the potential to hinder service reliability. Fifth, the expansion of services to the latest generation of security technologies—such as AI-based detection systems or IoT devices—needs to be urgently considered to expand market coverage and accommodate increasingly dynamic customer demands, given the limitations of the current research focus on just three types of equipment. Finally, the implementation of quantitative metrics to measure long-term customer satisfaction such as customer retention, increase in repeat orders, and structured post-maintenance feedback should be integrated into the CRM system, so that management can evaluate the real impact of service innovations on business growth and company reputation. By implementing these steps, PT. CKK was not only able to overcome existing operational limitations but also strengthen its position as a reliable and sustainable security maintenance service provider at the regional level.

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