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Feasibility Study Of Wireless Sensor Nodes On Bridges

Studi Kelayakan Node Sensor Nirkabel Pada Jembatan

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ABSTRACT
Bridges are important infrastructure in the transportation system that supports the acceleration of regional development and have significant social and economic benefits. However, bridge construction can also have risks, for this reason, it is necessary to carry out supervision from the early stages of construction to identify damage and intervene early. Based on the Directorate of Road and Bridge Engineering Development Directorate General of Highways, Ministry of PUPR, Indonesia has only seven SHMS, of which three are active, namely the Suramadu Bridge (Surabaya), Fisabilillah Bridge (Batam), and the repair stage, namely Soekarno Bridge (Manado), Bridge Merah Putih (Ambon), Musi IV Bridge (Palembang), as well as two that are not active, namely the Pasupati Bridge (Bandung) and the Rumpiang Bridge (South Kalimantan). Therefore, early warning is needed with a wireless sensor node sensor mitigation system. So, the purpose of this study is to identify and analyze opportunities to create a wireless sensor node sensor business for bridges. Feasibility studies are very important to avoid problems and loss of time, funds, and human resources in the wireless sensor node design process. The results of the research show that the investment made in the development of wireless sensor nodes is feasible and can provide benefits for the owner who implements it.
Keywords : *Wireless sensor node; Feasibility study; Bridges*

Introduction

Bridges are connecting infrastructure that provides easy access to roads and increase inter-regional connectivity that supports the acceleration of regional development. (Balasubramanian, 2017) describes a bridge as a man-made structure constructed to circumvent physical barriers without blocking the passages beneath them, such as bodies of water, valleys, or roads, which are constructed to provide passage over these barriers. (Wan et al., 2019) stated that along with the rapid economic development and rate of urbanization, bridges play an important role in the transportation system by supporting economic and social development so that their existence as infrastructure is deemed indispensable. Research conducted by (Husein et al., 2019) describes the construction of bridges as providing benefits to superior social criteria with community accessibility which makes it easier to carry out daily activities, and relations between communities are getting better. The construction of the bridge also has a positive economic impact which creates new business opportunities for the surrounding community and access to more effective and efficient modes of transportation.

Bridge construction is carried out using technology appropriate to the construction site, materials available in the vicinity, and designs that reflect regional characteristics. The bridge planning process considers basic principles such as structural strength and stability, long-term durability and reliability, ease of inspection and maintenance, user convenience, economy, ease of implementation, and aesthetics, and takes into account reasonable and minimal environmental impacts. This was carried out following the Circular of the Minister of Public Works and Public Housing Number 07/SE/M/2015 concerning Guidelines for General Requirements for Bridge Planning (Kementerian Pekerjaan Umum dan Perumahan Rakyat, 2015). Bridges are designed to support the burden of passing transportation equipment as well

as structures resulting from construction which are inseparable from the risk of endangering safety, starting from the construction stage up to the time of use. During the construction process stage, the potential hazards that arise are related to Work Accidents and Safety (K3) in the workforce and the impact on the community and the environment around the construction site. While in use, the potential hazard is caused by damage.

This risk factor can be mitigated by implementing a monitoring system from the construction stage. One of the key targets that must be met is the identification of damage to the structure from the early stages of development, if deemed appropriate, intervention is carried out as early as possible (Neves, 2020). In addition, maintenance and repair costs are generally lower than those of new construction. Indonesia's first bridge was built in 1682 named Engelse Brug. This bridge has been reconstructed in a permanent form to become the Kota Diamond Suspension Bridge (Dinas Pariwisata & Kebudayaan DKI Jakarta, 2021). Based on the Center for Data and Information Technology Secretariat General of the Ministry of PUPR. 2021 shows that there are 19,135 National Bridges with a total length of 539,477 m, as well as 201 Suspension Bridges with a total length of 14,424 m and 48 Special Bridges with a total length of 20,246 m (Pusat Data dan Teknologi Informasi Sekretariat Jenderal Kementerian PUPR, 2021). Based on data from the PUPR Ministry, in 2021 there were 536 cases of bridges that were heavily damaged in the province of Central Sulawesi and 39 cases of bridge collapses in the province of Papua (Kementerian Pekerjaan Umum dan Perumahan Rakyat, 2021). Damage to bridges can be anticipated through mitigation measures by installing SHMS or Wireless Sensor Nodes on the bridge structure, along with SHMS implementation data installed throughout Indonesia.

Table 1. Data on the Implementation of SHMS in Indonesia

No	Bridge Name	Location	SHMS Status
1	Suramadu	Surabaya, Jawa Timur	Active
2	Soekarno	Manado, Sulawesi Utara	In repair
3	Merah Putih	Ambon, Maluku	In repair
4	The Fisabilillah Bridge	Batam, Kepulauan Riau	Active
5	Musi IV Bridge	Palembang, Sumatera Selatan	In repair
6	Pasupati Bridge	Bandung, Jawa Barat	Not active
7	Rumpiang Bridge	Kalimantan Selatan	Not active

Source: Directorate of Road and Bridge Engineering, Directorate General of Highways

Based on data collection directly from the Directorate of Road and Bridge Engineering, Directorate General of Highways, Ministry of PUPR. Indonesia only has seven structured health monitoring systems (SHMS), namely among the three active, namely the Suramadu Bridge (Surabaya), and the Fisabilillah Bridge (Batam). Then the repair stages are the Soekarno Bridge (Manado), the Red and White Bridge (Ambon), the Musi IV Bridge (Palembang), as well as those that are not active, namely the Pasupati Bridge (Bandung), the Rumpiang Bridge (South Kalimantan) (Bina Teknik Jalan dan Jembatan, 2022). With the increasing number of damaged bridges and the lack of a bridge structure health monitoring system, there is an opportunity to establish a wireless sensor node business, but in implementing this business a feasibility study is needed to ensure that the Wireless Sensor Node business project can run smoothly without any problems until it reaches the product reaches the customer and this WSN is needed because of the lack of implementation in Indonesia. a business feasibility study covering several aspects including market aspects, technical operational aspects, legal aspects, and financial aspects. This

feasibility study is very important to avoid problems and loss of time, funds, and human resources in the design process of the Wireless Sensor Node.

2. Literature Review

Feasibility study

According to (Sobana, 2018) a business or project feasibility study is a form of research that aims to evaluate whether a project or business can be successfully carried out or not. The project concept here can refer to the establishment of a new business or the introduction of a new product or service into an existing market. However, project success can be interpreted in different ways by for-profit and non-profit-oriented parties. For profit-oriented parties, project success is measured by how much profit is generated. On the other hand, non-profit parties such as the government or social institutions will measure project success by factors such as employment, resource utilization, and benefits provided to the wider community. A business or business feasibility study is research conducted to evaluate a business plan in depth. The goal is not only to determine whether a business is feasible or not to be established, but also to ensure that the business can be operated regularly to achieve optimal profits in an unspecified time, such as in a new product launch plan.

Company feasibility study, several stages need to be done. These stages include finding ideas, conducting research, evaluating, sequencing, planning implementation, and implementing plans. The research stage must begin with collecting data, processing data, analyzing data with appropriate analytical tools, and concluding results up to reporting. The evaluation phase involves considering existing business options. The sequencing stage involves prioritizing some of the company's proposals that have been assessed. The stages of the implementation plan involve determining the nature of the work, the time required, the number and qualifications of personnel, the availability of funds and other resources, and the conditions of operation and performance. The implementation stage involves realizing business development using the guidelines that have been made before (Purnomo et al., 2017).

Aspects of Business Feasibility Study

Several aspects of business feasibility that must be examined in depth include:

a. Legal Aspect

The legal aspect of a business feasibility analysis relates to the ability of economic actors to meet the legal requirements and permits required to operate in certain sectors. It is important to ensure that companies can comply with legal regulations and meet local registration requirements before operating. In this analysis, we can assess the legality of the company's legal form and business ideas to be implemented, as well as the company's ability to meet the required permit requirements. This legal aspect includes the legal documents needed to establish a new company, so it is very important to pay attention to this in a business feasibility study (Herijanto & Fiernaningsih, 2020).

b. Market Aspect

The market aspect is to see conditions in the large number of requests for products to be produced and see product functionality that is useful for potential customers in terms of quality and price. Marketing Strategy is to attract customers from competitors, where companies must analyze what customers need, this aims to meet customer needs and desires because companies cannot serve consumers in the same market and consumers have different desires. Therefore, companies must choose the right segmentation by dividing the overall market and planning strategies to meet the selected segmentation to make profits in a company. Marketing Mix is a tactical marketing tool used by companies to achieve desired objectives in the target market. The marketing mix includes all efforts made by the company to interact with consumers and provide value to customers in a product

that is produced. In the marketing mix, four marketing elements are used to provide value to customers consisting of 4p (product, price, place, and promotion) (Kotler & Armstrong, 2018).

c. SWOT analysis

SWOT analysis is an identification method used in systematically formulating strategies for making important decisions in the context of government and companies. The purpose of SWOT analysis is to maximize performance and achieve targets which are the main focus, including the vision and mission of both government agencies and private agencies. In strategic planning, SWOT analysis is used to analyze the factors that become strengths, weaknesses, opportunities, and threats to institutions or the organization. SWOT stands for (Strengths, Weaknesses, Opportunities, Threats), where SWOT is used to maximize strengths and opportunities, while simultaneously reducing weaknesses and threats. In the strategic decision-making process, SWOT analysis is closely related to the development of an organization's or company's mission, goals, strategies, and policies. Therefore, in analyzing these factors, the company's strategy must be in line with the overall strategic planning (Nggini, 2019).

d. Business Model Canvas (BMC)

The following is the business model canvas there are nine factors:

1) Customer segment is a business to understand customer needs to achieve revenue and profitability
2) A value proposition is a product or service advantage that differentiates the business from competitors
3) Channels are a means used to reach the target market and maintain relationships with customers and sellers
4) Customer Relationship is an interaction with new customers as well as old customers by maintaining customer trust
5) Revenue streams are income generated from customers that are regulated to increase business revenue
6) Key Resources are key factors needed to maintain and support business activities, such as production, availability of raw materials, and other supporting activities
7) Key Partnership is an important partnership relationship in carrying out business processes from start to finish
8) Key Activities are activities that are the focus of the business, including production, distribution, and service processes
9) Cost Structure is expenditure incurred to support all business activities and efforts to save costs (Natallia et al., 2022)

e. Technical and technological aspects

Technical aspects are analyzed to check whether project development and business execution can be technically implemented successfully. In addition, it is also analyzed whether the technical aspects used meet the required standards. Technical analysis includes several things, namely: (a) location readiness and production land area, (b) capability in preparing production equipment, (c) understanding of the production process, and (d) level of mastery of technology (Herijanto & Fiernaningsih, 2020). Business location refers to the place where goods and services are produced. This location has a major influence on operational costs and business investment. The determination of business location is influenced by several primary and secondary variables. Some of the main variables that are important in choosing a business location include the availability of raw materials, target

markets, and infrastructure such as electricity, water, telecommunications, labor, and transportation (Hanggita, 2018).

f. Financial Aspect

Financial aspects to estimate sources of funding and cash flows from business projects, to determine the feasibility of a budgeted business plan. In addition, planning investments by calculating costs and comparing expenses and income, such as the initial capital required and the ability of the project to return the capital within a certain period, and assessing the project's growth potential in the future (Adnyana, 2020).

Net Present Value

$$NPV = \frac{\text{Kas Bersih 1}}{(1+r)} + \frac{\text{Kas Bersih 2}}{(1+r)^2} + \frac{Kas\ Bersih}{(1+r)^2} - \text{Investasi}$$

The above criteria are based on the NPV assessment:

a. If the NPV = 0, the investment will equal the breakeven interest rate
b. If NPV = -1 (negative), then the investment will lose or yield below the interest rate
c. If NPV = + (positive), then the investment is profitable

Internal Rate of Return

$$0 = -\text{I0} + \sum_{t=n}^{n-1} \frac{CF_t}{(1+IRR)^n}$$

In obtaining a decision whether the project is feasible or not feasible from the investment based on the following assessment criteria:

a. If investment IRR > Cost of Capital indicates that the investment project is feasible to run
b. If the investment IRR < Cost of Capital indicates that the investment project is not feasible

Profitability Index

$$\text{PI} = \sum_{t=n}^{n=1} \frac{CF_t}{\frac{(1+r)^t}{\text{I0}}}$$

Payback Period (PBP)

$$\text{PP} = \frac{\text{NP}}{\text{P}}$$

3. Research Methods

This study uses a qualitative method, which is designed to directly identify problems and analyze gaps in the Wireless Sensor Node project business. After identifying and analyzing the problems, an analysis of the realization of technical data was carried out including the cost of raw materials, equipment, production processes, production time, labor, and distribution of questionnaires to the public works and spatial planning offices, contractors and consultants to support the Feasibility Study in the Wireless business. Sensor Nodes. The data is then tested using IBM SPSS software. Primary data is the main data obtained directly from data sources. Retrieval of data sources is done through the process of observation, interviews, and documentation. In the feasibility analysis of the Wireless Sensor Node, it is necessary to collect data which includes the results of the realization of technical data such as the cost of raw

materials, equipment, production processes, production time, and labor, as well as direct observation regarding the actual implementation of the Wireless Sensor Node production. In addition, supporting data collection was also carried out to the Directorate of Road and Bridge Engineering Development regarding the installation of the SHMS sensor system in Indonesia and distributing questionnaires regarding the SHMS Sensor Feasibility Study specifically for public works and spatial planning services, contractors, consultants, and infrastructure business owners. This is done to design a Feasibility Study from market, technical, and operational aspects, legality, and financial aspects. Secondary data is obtained indirectly from previous research documents called literature reviews. This data can help in carrying out the Feasibility Study of the Wireless Sensor Node.

4. Results and Discussions

Business Profile

Infra Sensor Multindo (ISM) is engaged in the production of health monitoring systems for bridge structures using special sensor products. This company operates in the Banten Province area but remains open to expanding throughout Indonesia. SHMS sensors are expected to improve infrastructure following SDGs number 9, namely Industry, Innovation, and Infrastructure. The vibration detection system on the bridge uses sensors to measure the bridge's dynamic response to vehicle load and speed. The Weight in Motion (WIM) sensor is used to measure the vehicle's load and speed, while the Accelerometer sensor is installed to measure the peak amplitude and frequency of the correct incident. Pre-processing is carried out at each Sensor Node using the Fast Fourier Transform (FFT) or Hilbert Huang Transform method to minimize data traffic on the Wireless Sensor Network (WSN) network. Parameters of load, vehicle speed, and dynamic response of the bridge (frequency and peak amplitude) are also measured when measuring the bridge rating. In addition, this system is also supported by Closed Circuit Television which can monitor the number of vehicles passing on the bridge.

Market Overview

Tangerang Regency is the region with the highest number of construction companies in Banten Province with 1,794 companies, followed by South Tangerang Regency with 1,379 companies, and Serang City with 804 companies. This shows that the construction sector in these areas is quite developed and has great potential in supporting the development and economic growth of Banten Province (Badan Pusat Statistik, 2023).

Questionnaire

Based on BPS Banten data, the average population growth in Banten province over the last three years (2020-2022) has reached 12,072,674 people, or around 2.92% overall. In 2022, there are several areas in Banten which are the areas with the most population, namely Tangerang Regency, Tangerang City, and Lebak Regency, which are the three areas with the most population, namely 3,352,472 people (Tangerang Regency), 1,930,556 people (Tangerang City), and 1,433,853 people (Lebak Regency) (Badan Pusat Statistik, 2021; (Badan Pusat Statistik, 2022b). The population density in Banten is also different, where Tangerang City is the area with the highest population density, reaching 10,825 people/km2. Then, it is followed by South Tangerang City with 8,361 people/km2 and Tangerang Regency with 3,262 people/km2 which also have a fairly competitive population density (Badan Pusat Statistik, 2022a). Therefore, information on population growth and population density can assist in regional development planning in Banten, especially in terms of the availability of infrastructure and public services for the community. Realization of the Operation of Roads and Bridges aims to see the expenditure funds of the Banten province public works and spatial planning services in the realization of the construction and maintenance of roads and bridges. The following is data on the realization of the Banten Province DPUPR APBD in 2021:

Table 2. Realization of DPUPR APBD Banten Provincial Government

Realization of the 2021 Banten Province DPUPR APBN		
No	**Activity description**	**Cost**
1	Provincial Road Management Program	Rp393.387.033.467
2	Development of Construction Services	Rp 1.294.368.500
3	Provincial Road Management Program	Rp41.028.995.779
4	Provincial Road Management Program	Rp23.652.578.511
5	Provincial Government Affairs Support Program	Rp35.549.649.793
6	Provincial Road Management Program	Rp30.543.267.680
7	Provincial Road Management Program	Rp19.719.991.227
	Total Realization of APBN Dpupr Banten Province	**Rp 545.175.884.957**

Source: Government Agency Performance Report (GAPR)

Based on the Government Agency Performance Report (GAPR), the Public Works and Spatial Planning Office of Banten Province in 2021 allocates funds for road and bridge construction, including programs for the implementation of provincial roads, development of construction services, and the Provincial Government Affairs Support Program. In the realization of the State Budget for the program for implementing roads and bridges, the Public Works and Spatial Planning Office of Banten Province spent Rp. 545,175,884,957 billion rupiah (Penataan, 2022). To improve supervision and monitoring of road and bridge construction, it is necessary to take effective actions in the maintenance and maintenance of infrastructure. Along with the large funding allocated for development, it is important to carry out continuous supervision and monitoring so that the quality of infrastructure is maintained and can be used optimally by the community. Monitoring and supervision require a Wireless Sensor Node for real-time monitoring so that before severe damage occurs the bridge can be repaired because the cost of building a new bridge based on the above data is more expensive than the cost of monitoring and routine maintenance regularly. This will reduce expensive development costs and also ensure the safety and comfort of road and bridge users because if the bridge is damaged, it will hamper the operational activities of the general public in carrying out their daily activities.

The Wireless Sensor Node Feasibility Study Questionnaire was used to evaluate interest in the use of wireless sensor nodes in Banten Province. This questionnaire will be distributed to the Office of Public Works and Spatial Planning of the Province of Banten, as well as consultants and contractors in collaboration with the Office of Public Works and Spatial Planning of the Province of Banten. The purpose of this questionnaire is to collect information about the number of projects carried out during one year, especially bridge projects, as well as to assess interest in applying sensors to bridges. The results of the validity test on the research questionnaire showed that all items with a scale of 1-5 had an r count value that was greater than the r table value (0.361). Following the provisions of the validity test, it can be concluded that the 5 items of the questionnaire tested were declared valid and suitable for use as research data collection instruments. The Cronbach's Alpha value obtained from the entire questionnaire is 0.850 > 0.60. Considering that Cronbach's Alpha value for all items is greater than 0.60, it can be concluded that the questionnaire used in this study is reliable and reliable.

The description of the results of the Feasibility Study Wireless Sensor Node questionnaire with 32 respondents involved, shows if question 1 is related to "Do you emphasize the importance of monitoring the robustness of your structure in various construction projects?" as much as 78.1% of respondents answered that they strongly agreed, then 21.9% of respondents answered that they agreed. Question 2 is related to "Do you think that the construction structure health monitoring tool will help you?" as many as 68.8% of respondents

answered strongly agreed, and 31.3% answered that they agreed. Question 3 about “Are you interested in applying monitoring tools to your infrastructure development project?” as many as 65.6% answered strongly agree, and 34.4% answered agree. Question 4 "How much do you understand or are familiar with the features and uses of structural health monitoring system (SHMS) sensors?" 65.6% of respondents answered strongly agree, and 31.3% of respondents answered yes. This shows if the respondent has understood SHMS. Question 5 is related to "In your opinion, monthly data maintenance costs are burdensome for you?" 62.5% of respondents answered that they strongly agreed, 25% of respondents answered that they agreed, and some respondents chose neutral, namely 12.5%.

Potential market

Based on forecasting as well as the potential market that has been carried out, there are large growth projections indicating high interest in installing wireless sensor nodes on bridges. In this projection, it is estimated that by 2023, there are potentially as many as 216 bridges interested, increasing to 246 bridges in 2024, 279 bridges in 2025, 317 bridges in 2026, and 361 bridges in 2027. This data was obtained through a survey against 30 valid respondents, where the approval level is very high the wireless sensor node sensor reaches 100% approval. Thus, based on these projections, it is hoped that every year all bridges that are in accordance with the projection data above will be installed with wireless sensor node sensors.

Marketing strategy

The marketing Strategy aims to market and promote wireless sensor node products in Banten Province. In this case, segmentation is used to identify and divide the market for wireless sensor node products into smaller groups, and select segments that have the potential to purchase these products. Furthermore, targeting is used to determine which market is the main target in selling wireless sensor node products. Lastly, positioning is used to determine the appropriate market with quality product functions in wireless sensor nodes for consumers.

a. Segmentation of Multindo's Infra Sensor based on:
    1) Geographic: local markets spread across Banten province. We started producing sensors for the first year in Banten Province. Then, it extends to DKI Jakarta and so on
    2) Demographics: old bridge infrastructure companies as well as new bridges with sensor installations. Our target market is private contractor companies, bridge construction consultants, toll road services, PUPR (Public Works and Spatial Planning)
    3) Psychological: these companies need a long time to supervise and monitor the condition of the bridge using wireless sensors connected to the dashboard monitoring system. If the condition of the bridge is not stable or there is damage or other things that threaten the safety of the bridge around the road and toll roads, it is necessary to take preventive or corrective measures

b. Multindo Infra Sensor Targeting:

    The product target is Bina Marga Public Works and Spatial Planning Office of Banten Province, then spread to DKI Jakarta and so on

c. Positioning Infrared Sensor Multindo:

    Providing a Wireless Sensor Node (Sensor) bridge in real-time monitoring system and equipped with computer vision which can detect visual areas in the bridge area.

Technical and operational aspects

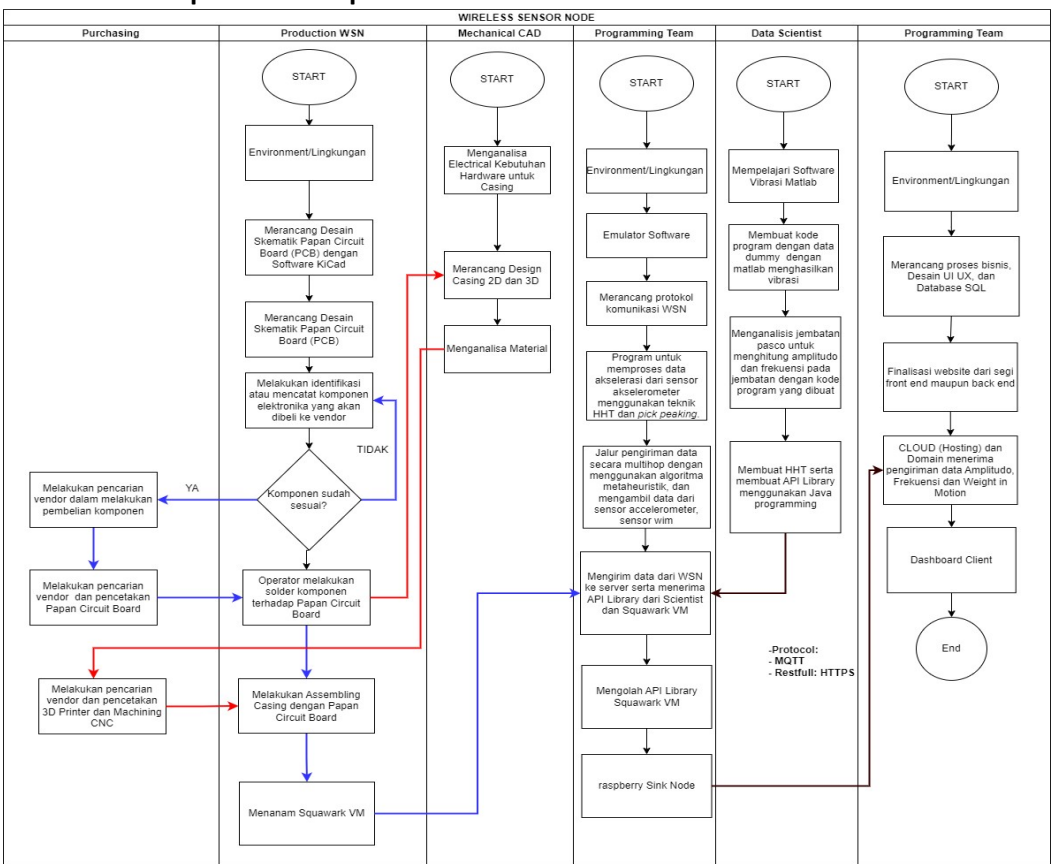

Figure 1. Wireless Sensor Node Business Process

Based on the above business processes, this business project focuses on the development of wireless sensor node hardware and intelligent software integrated into it. The method used is the engineering method, with the output divided into four stages of product transformation, namely requirements modeling, design modeling, architectural modeling, and solution modeling in the form of prototype products. In the process, the project manager, WSN Production, quality control, mechanical drafter, quality assurance, programming team, purchasing, and data scientist are involved.

Business Model Canvas

The Business Model Canvas is an analysis that describes, observes, and discusses business conditions by classifying them into nine effective factors in the Business Model Canvas (Wallin et al., 2013). In a wireless sensor node, nine factors affect business activity, this business activity is based on the implementation of store data and the evaluation of projects carried out, so that all business operations run well. The following is the business model canvas wireless sensor node:

a. Customer Segments: Customer Segments from the wireless sensor node business with a target market, namely the Public Works and Spatial Planning Office of Banten Province. Because the Office of Public Works and Spatial Planning is in charge of the construction of bridges and the routine maintenance of bridges. In its implementation, for example, the development of the Cipanas mega project to Banten stalls. Based on data collection from contractor Jaya Construction as the contractor for the Public Works and Spatial Planning Office of Banten Province, he has handled the construction of the Ciberang Bridge, attached in the attachment.

b. Value Propositions: The value proposition of the Wireless Sensor Node is to provide a sensor solution that continuously monitors the bridge 24 hours a day. This sensor is also able to determine the vibrational frequency of the element being reviewed in three directions, the speed, and weight of the vehicle that is running, and to know the visual condition of the area for object detection such as trucks. The Wireless Sensor Node is attached in the attachment.
c. Channel: In marketing by maintaining relationships and communication with customers, the Wireless Sensor Node will hold a technology socialization exhibition organized by the Public Works and Spatial Planning Office of Banten Province, as well as the next step is to carry out promotions through Instagram advertisements and events. In implementing the exhibition technology invitation is attached to the attachment section.
d. Customer Relationship: In a customer relationship, it has a relationship with the customer by providing loyalty, namely by providing free maintenance services to the wireless sensors installed on the bridge.
e. Revenue stream: Revenue Stream from the Wireless Sensor Node by carrying out a plan to sell sensor products in one package, namely manufacturing pcb sensors, manufacturing sink nodes, manufacturing solar road studs, and sensor installation services based on financial aspects calculations for IDR 46,911,405 / package.
f. Key Activities: Key Activities Wireless Sensor Node carries out the production process of PCB hardware design, Solar Road Stud, Artificial Intelligence Networking WSN, Vibration Data Analysis, Dashboard Monitoring System, and Artificial Intelligence Computer Vision then continues the product testing and exhibition process and sells products to public works and spatial planning services Banten province and private construction companies.
g. Key Resource: The resources needed in the wireless sensor node, based on the realization and evaluation of improvements in the tavern project, are project managers, PCB production operators, Quality Control, Drivers, CAD Mechanical Drafters, Quality Assurance, Programming Teams, Purchasing, and Data Scientists.
h. Key Partner: In carrying out all business activities, partners are needed, namely Road and Bridge Engineering Development as the one who regulates the standard operational provisions for roads and bridges, G-CAD Technology as (an offline vendor) for printing solar road stud casings, PT. Global Pratama Powerindo is (an offline vendor) of raw materials for making sink nodes, in PT. Kurnia Jaya Mukti (Offline vendor) as a vendor for purchasing postcode investment equipment, Spectra (Offline vendor), a PCB antenna manufacturer, component purchase (Mandiri Elektronik, Iwant Elektronik, Spectra, Abirawa Elektronik, Cipta Mandiri, CME Elektronik, Central Elektronik and WD Elektronik at Plaza Bandung Elektronik (Offline Vendors) then online (Shenzhen JDB Technology Co., Ltd, Tokopedia) purchases from the realization of the tokoeka project, attached in the attachment.
i. Cost Structure: In the analysis of the wireless sensor node business, the costs incurred consist of investment costs and operational costs consisting of raw material costs, initiation costs, shipping and packaging costs, depreciation costs, direct employee wage costs, electricity costs, security and cleaning costs, advertising, insurance costs, office wifi costs, bank administration fees, server and domain fees, and other costs.

Financial Aspect

The financial aspect is all the costs involved in the Wireless Sensor Node business. This cost includes investment which consists of two parts, namely intangible fixed assets and tangible fixed assets. This investment is planned to be obtained through loan capital from Bank Rakyat Indonesia. Furthermore, there are operational costs which include direct and indirect costs. All of these costs are included in the income statement and cash flow to know the financials of the business over five years. In looking for business feasibility, the calculation of rate of return, present value, net present value, internal rate of return, profitability index, and payback period is calculated.

Income statement

The income statement provides a concise overview of the total expenses associated with the company's operations and the revenue generated during the operating period. Based on the profit and loss obtained from Excel calculations, it is found that the wireless sensor node business project earns significant profits every year. In the first year, profits reached IDR 2,651,389,715, in the second year it became IDR 3,372,422,948, in the third year it became IDR 4,192,123,886, in the fourth year IDR 6,150,573,760, and in the fifth year, it was IDR 7,209,963 .427. This increases the positive things for the project to be implemented because it is increasing from year to year.

Cash Flow

Cash flow is a report to check cash expenditures and receipts of a company in a certain period. Based on the cash flow obtained from Excel calculations, it is found that the wireless sensor node business project gets an increase every year. In 2023, this project managed to generate a cash income of IDR 2,786,208,709, in 2024 the amount of cash increased to IDR 3,507,241,942. In 2025 cash increased again to reach IDR 4,326,942,882. In 2026, the cash project will increase again to IDR 6,285,392,754 and in 2027, this project will succeed in achieving a cash inflow of IDR 7,344,782,421. In the cash flow projection above, there are principal installment loans and bank interest with a three-year tenor.

Present Value, Net Present Value and Internal Rate of Return

The present value is used to find the cost of capital in investment compared to the interest rate based on capital from bank loans in the Wireless Sensor Node business project. In the present value, there is an interest rate of 8% based on the Financial Services Authority at the interest rate of BRI bank loans. In proving the simple interest rate formula, an interest rate of 8% is obtained (Otoritas Jasa Keuangan, 2023). Where is this interest rate the cost of capital that will be compared with the value of the investment in the net present value and the internal rate of return. Net Present Value is a difference between the costs and benefits associated with an investment in a business or project in the form of cash flow and determines the feasibility of a business then the Internal Rate of Return is an investment valuation method to find the value of the interest rate, thus providing a net present value of investment cash flow. The following calculations are obtained from Excel.

Marketing Mix 4p

Marketing Mix is needed to plan a company's marketing strategy based on product, price, place, and promotion. The following is the 4p marketing mix in selling wireless sensor node products:

a. ***Product****:*

Product is a combination of goods and services offered by the company to the target market, wherein the wireless sensor node product is in the form of goods services in the form of sensors and installation services. The following is information on the Wireless Sensor Node as a monitoring system in real time with the following features:

1) Accelerometer (Three Axis) is used to determine the vibrational frequency of the elements being reviewed in three directions
2) WIM (Weight in Motion) is used to measure the speed and weight of the axle of a vehicle that is running
3) CCTV and Computer Vision are used to determine the visual condition of the area and can detect objects such as passing trucks
4) Field survey and sensor installation services for bridges

b. ***Place***

Place or distribution is a company activity that makes products available to target consumers, in the manufacture of Wireless Sensor Nodes located in factory companies located in South Tangerang.

c. ***Price***

Price is the cost that must be paid by consumers to buy a product, where sales with one package of Wireless Sensor Node, Sink Node, CCTV, and Solar Road Stud as well as installation and field survey services amount to IDR 46,911,405.

d. ***Promotion***

Promotion is an activity that communicates the superiority of a product and convinces target customers to buy it. In the promotion of wireless sensors, product introduction is carried out. Product introduction will be carried out through a socialization exhibition by the Public Works and Spatial Planning Office of Banten Province, then the promotion will be carried out through advertising media consisting of social media, brochures, and websites.

SWOT Analysis

SWOT analysis is an identification method used in formulating strategies for selling wireless sensor nodes systematically for decision-making and maximizing performance and achieving targets which are the main focus by paying attention to strengths, opportunities, weaknesses, and threats to achieve the company's vision and mission. The following is a swot analysis for selling wireless sensor nodes:

a. Strength: Digital Integrated Products so that data is easy to monitor practically; Products have critical and crucial uses for Bridge infrastructure; Products during the day use renewable energy from solar panels so they are more efficient.
b. Opportunity: Build awareness of the importance and efficiency of this product in monitoring bridge structures; Sustainable infrastructure development in the future and interconnectivity between regions; The increasing mobility of the people means that there are more bridge users which means the increasing demand for structural safety; Build more concrete UI and data; There are only seven monitoring and supervision sensors in Indonesia based on data collection for Road and Bridge Engineering Development.
c. Weakness: High capital and operational cost structure; The product is not known by many people/customers.
d. Threat: New competitors when awareness of the importance of SHMS sensors begins to grow; Competitors with more efficient information system designs.

Market Analysis

In market analysis, you can analyze market conditions and the needs of customers, competitors, and other things. The aim is to see market opportunities for selling wireless sensor nodes in the province of Banten because, with a large number of constructions, it can improve infrastructure and also in terms of the proportion of companies, so that the more infrastructure development the more the market for using wireless sensor nodes will expand.

Table 3. Present Value, Net Present Value dan Internal Rate of Return

Cost of Capitals	8%		
Initial Investment Cost	(3.500.000.000)	PV 0	(3.500.000.000)
FV 1	Rp 2.786.208.709,25	PV 1	Rp2.579.822.878,93
FV 2	Rp 6.293.450.651,39	PV 2	Rp5.395.619.557,09
FV 3	Rp 10.620.393.531,97	PV 3	Rp8.430.810.798,00
FV 4	Rp 16.905.786.285,63	PV 4	Rp12.426.257.604,93
FV 5	Rp 24.250.568.706,43	PV 5	Rp16.504.529.580,11
		TOTAL PV	Rp45.337.040.419,07
		NPV	Rp28.308.911.322,69
		IRR	131%

Based on the Internal Rate of Return obtained from excel calculations, it is found that the wireless sensor node business project is feasible, because the internal rate of return exceeds the cost of capital, with an IRR of 131% > 8%. Thus, the wireless sensor node project can be implemented.

Profitability Index and Payback Period

The profitability index is an investment that is calculated based on the level of the index by dividing the present value. Based on Excel calculations, the profitability index results from the net present value of the investment invested are 9.1, this value produces a positive value so that with a PI > 1, the investment made is a feasible investment to implement. The payback Period is the return on investment in calculating the amount of net cash flow that comes from the investment every year until the value of the investment returns.

Table 4. Payback Period

Payback Period				
Information	Calculation		PBP value	
Initial Investment	-Rp	7.213.170.242		
1st year Proceed	Rp	2.786.208.709	-Rp	4.426.961.533
2nd year Proceed	Rp	3.507.241.942	-Rp	919.719.591
3rd year Proceed	Rp	4.326.942.881	Rp	3.407.223.290
4th year Proceed	Rp	6.285.392.754	Rp	9.692.616.044
5th year Proceed	Rp	7.344.782.421	Rp	17.037.398.464

Based on the Excel calculation above, in PBP calculations the return on investment will be carried out by calculating the net cash flow value obtained from the investment every year until the investment value is covered or can be returned in full. Investments with a total value of IDR 7,213,170,242 in the first year of the investment can generate a net cash flow value of IDR 2,786,208,709 so that in year one the residual value of the investment that has not returned is IDR 4,426,961,533. in the second year the investment can generate a net cash flow value of IDR 3,507,241,942 so that in the second year the investment value that has not returned is IDR

919,719,591. Furthermore, in the third year, it generates a cash flow of IDR 4,326,942,881 with a profit of IDR 3,407,223,290 stating that the investment value has returned on investment in the third year. That the WSN Project takes 2 years to return all investment capital.

5. Conclusion

Based on data obtained from the Directorate of Road and Bridge Engineering, Directorate General of Highways, and Ministry of PUPR, there are seven wireless sensor nodes installed on several bridges in Indonesia. Of the seven bridges, three of them are active, namely the Suramadu Bridge in Surabaya and the Fisabilillah Bridge in Batam. Some bridges are currently under repair, namely the Soekarno Bridge in Manado, and the Musi IV Bridge in Palembang. Meanwhile, the Pasupati Bridge in Bandung and the Rumpiang Bridge in South Kalimantan are not active. This is an opportunity to conduct a wireless sensor business, based on investment calculations using the Net Present Value method with an investment value of IDR 28,308,911,322.69, positive results were obtained. This shows that the investment is worth it. In addition, an internal rate of return of 131% is obtained, with a Cost of Capital of 8%, so the WSN business project is feasible. Therefore, it can be concluded that the investment made in the development of wireless sensor nodes is feasible and can provide significant benefits for the owner who implements it. In the application of wireless sensor node technology, an effective socialization effort is needed to increase knowledge and understanding of the importance of wireless sensor node technology in the implementation of roads and bridges for public works and spatial planning services as well as private construction companies in Indonesia.

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