LIFE-CYCLE COST ANALYSIS OF SOEKARNO-HATTA INTERNATIONAL AIRPORT RAIL LINK (SHIARL) USING VALUE-ENGINEERING METHOD

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Soekarno-Hatta Airport is the main gateway for international flights, particularly to Greater Jakarta. Currently, it serves more than 44 million passengers per year, which causes accessibility problems due to the high volume of vehicles. A toll road still remains the main access to the airport, and in peak hours there is congestion and time-travel uncertainty. Soekarno-Hatta International Airport Rail Link (SHIARL) is an alternative mass-transportation project to provide accessibility and mobility for people and goods to the airport. So far, the project is still unable to attract private investors due to a lack of technical and financial feasibility. This research aims to develop a conceptual design of SHIARL by using the value-engineering approach for a comprehensive study to realize this project. This research used quantitative and qualitative methods through questionnaire surveys distributed to various stakeholders related to the project, and focus group discussion (FGD). The results identified additional functions for innovation through the integration of Mass Rapid Transit (MRT), flood control, telecommunications, and development in the downtown area of the station. These functions were then analyzed by using life-cycle cost analysis to show the value for money of the project.

Keywords: Airport train, Innovation, Infrastructure, Project feasibility, Transportation, Value for money.

1 INTRODUCTION

Infrastructure plays a significant role in accelerating a nation's economic growth. The capability of a country to provide infrastructure becomes a prerequisite to stimulate and sustain targeted economic growth. Railway infrastructure has been claimed to contribute to national economic development as much as 41.20% of transportation-sector investment (Dikun 2010). The private sector is expected to contribute about 51.20% of the total financial of the railway project.

Greater Jakarta faces various hurdles to transportation development, including devastating annual floods during the rainy season, resulting in periodically-limited accessibility to the airport, which depends largely on the intercity and Sediyatmo highways. This dependency also leads to congestion and travel time uncertainty during peak morning and evening commuting hours. In 2011, the length of roads in Jakarta was about 6,866 km, which then increased to 6,955 km in 2012 (Ministry of Public Works 2013). With 1,000 new private vehicles sold every day in Jakarta (Directorate Traffic of Jakarta Metropolitan Police 2013), road infrastructure is soon overburdened. Thus rail-based mass transportation is required as an alternative solution to alleviate traffic jams and reduce carbon emissions from vehicles.

A recent railway project in Indonesia, particularly for urban development, is Mass Rapid Transit (MRT). Jakarta planned for 110.8 km, dividing the city into north and south corridors (MRT Jakarta, 2014), including the Soekarno–Hatta International Railway Link (SHIARL). The SHIARL project's feasibility was first investigated in 2002 by PT.RAILINK, and offered to investors in Infrastructure Summits in 2005 and 2006. However, due to failure in the financial feasibility, the project could not attract private investors. The status of SHIARL project has been downgraded from ready-to-offer to priority project.

Key success factors in mega-infrastructure projects depend on the feasibility of the offered project as determined by a significant "Value for Money" factor (Jin and Zhang 2010). Value for Money (VfM) is defined as an optimum utilization of public funds for infrastructure project by combining innovation in engineering, financial, and private investor involvement (Grimsey and Lewis 2007). VfM in this research was obtained through a Value Engineering (VE) approach, started by seeking additional functions that could be integrated into the project. VE is a proven method to generate an optimum outcome in terms of quality (Woodhead and Berawi 2007), efficiency (Berawi and Woodhead 2008) and innovation (Berawi and Susantono 2013). The result is expected to produce an innovative conceptual design to address problems in Greater Jakarta and also provide significant value for money for investors.

2 METHODOLOGY

This research employed a combination of quantitative and qualitative approaches. Quantitative approaches are characterized by the use of control variables and objectivity that in this case were conducted through a questionnaire survey and Life Cycle Cost (LCC) analysis. The questionnaires were distributed through online (softcopy) and offline (mail/hardcopy), with the objective of identifying the stakeholders' perception on the ideas generated by the value-engineering process. The offline questionnaire respondents were from government institutions and companies related to infrastructure development, including PT Kereta Api Indonesia (KAI), PT Railink, Ministry of Public Works, PT IIGF, Bappenas, and others. The online questionnaires were sent to the respondents via e-mail to 6 (six) mailing groups of practitioners from construction industries and value engineers in Indonesia.

The qualitative approach (Creswell 1998) was conducted by using a participatory action research (participative action), critiquing implicit assumptions, and allowing for the learning process (Carr and Kemmis 1986) combined with "grounded theory" (Strauss and Corbin 1998) through Focus Group Discussion (FGD). FGD was conducted as a validation and verification method in order to gain more inputs from various stakeholders of SHIARL project on the findings. FGD involved various stakeholders related to the project, e.g., Directorate of Renewable Energy of the Ministry of Energy and Mineral Resources, PT Rail Link, Society of the Indonesian

Value Engineers (HAVE-I) and others. Furthermore, the evaluation of LCC was conducted using the discounted payback method, considering the comparison between current and future value of money represented by NPV and IRR values.

3 RESULT AND DISCUSSION

The questionnaire survey process took a month with 32 returned questionnaires. The largest percentage of respondents (43%) works for private companies, and the second-largest for government agencies.

Table 1. Additional functions from questionnaire survey.

Additional Functions for SHIARL Project	Respondent Replies	%
Electricity Generation (solar, kinetic energy)	16	18%
Area Development (residential, business center)	28	32%
City Check–In	23	26%
Cargo Services	18	21%

More than 50% of the respondents were post-graduate degree holders, and 26% of them held managerial and general-director positions.

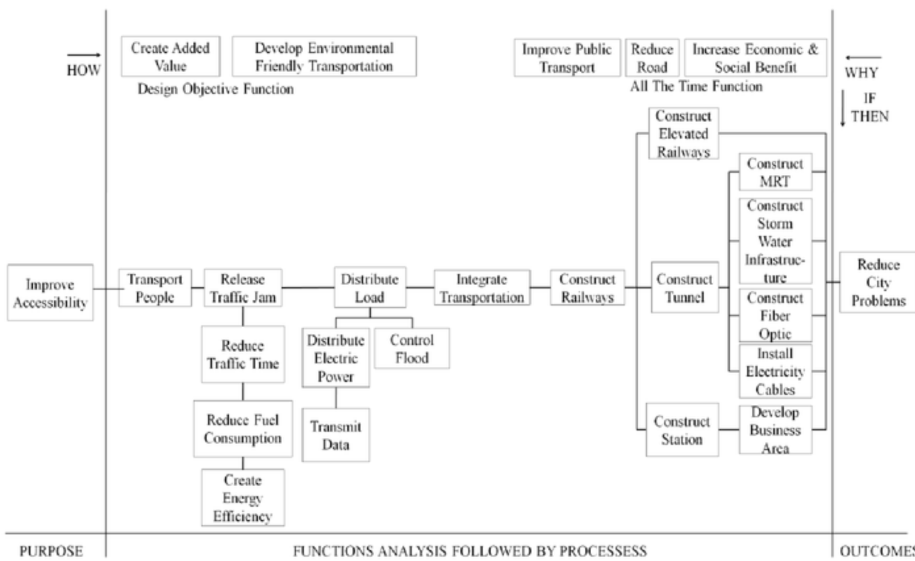

Figure 1. FAST diagram of SHIARL.

These functions were then developed into a conceptual design for a multi–function tunnel, called the Public Railways and Storm-water Infrastructure (PRASTI) Tunnel. The PRASTI Tunnel is designed to deal with congestion and flood problems in Greater Jakarta and improve accessibility to the airport. The tunnel itself would be divided into three levels: the first level serves as flood control, the second serves as airport accessibility through SHIARL, and the third is expected to increase public transport through MRT lane. The concept of cross-section visualization of PRASTI Tunnel is shown in Figure 2.

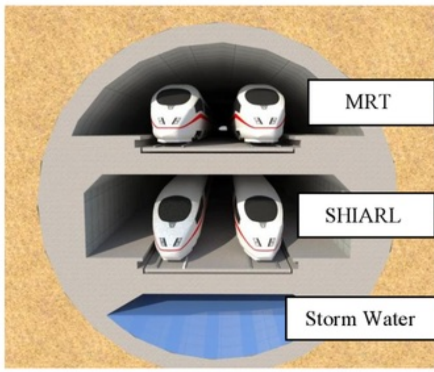

Figure 2. Cross-section of PRASTI tunnel.

Figure 3. Route concept of the project.

The SHIARL route will span 38.5 kilometers and connect Halim Airport in eastern Jakarta with Soekarno–Hatta Airport by using the median of the intercity toll road. The route would be divided into three sections: The first would be Halim Airport to Dukuh Atas, with elevated lanes for 12 kilometers. The second would be Dukuh Atas to toll road Sedyatmo, near Pluit, built as the PRASTI Tunnel stretching 9 kilometers, with an estimated depth of around 25–40 meters underground. The third would be toll road Sedyatmo, near Pluit, to Soekarno–Hatta Airport, with elevated lanes for 17.5 kilometers. The route selection also considers flood-area mapping in Jakarta, and links the West Flood Canal to Pluit Reservoir. Details of the route can be seen in Figure 3.

4 LIFE-CYCLE COST ANALYSIS

Cost estimate for the construction project comprises two calculations: 1) initial costs plus operational and maintenance costs of the elevated SHIARL; 2) initial costs plus operational and maintenance costs of the PRASTI Tunnel. The calculation for the PRASTI Tunnel has been divided into four functions: transportation, flood control, telecommunications, and commercial area. Comparisons for unit prices for the tunnel projects were gathered from benchmarking various tunnels in the world, e.g., the SMART Tunnel in Malaysia and the Channel Tunnel in UK. Meanwhile, revenue from the project consists of four functions: Passenger MRT, Airport Passenger Train, Potential Commercial Area Underground, and Fiber Optics.

The result of calculation of the initial cost for the elevated train is 9.33 trillion rupiah, with operational and maintenance costs around 204.51 billion rupiah per year. Meanwhile, the transportation function in PRASTI Tunnel is comprised of 1) initial costs valued at 894.89 billion rupiah, and O&M costs of about 12.89 billion rupiah per year. On the other hand, the initial cost of flood control will be 15.71 trillion rupiah, with annual O&M costs of 78.55 billion rupiah.

Since fiber-optic construction is anticipated to be around 152.96 million rupiah/km, the 9 km fiber-optic construction in the PRASTI Tunnel will cost about 1.38 billion rupiah. Fiber-optic O&M costs require 11.4 million rupiah/km/cable/year, thus O&M costs for the PRASTI Tunnel fiber optics will be 102.60 million rupiah per year. Furthermore, there will be 5,600 m^2 of commercial area development located underground, divided into 6 MRT underground stations and the Dukuh Atas station. Considering that construction costs in Jakarta are around 24 million rupiah/m^2, the construction cost for commercial area is anticipated to be about 3.6 trillion rupiah. If operational costs are assumed to be about 2% of the initial cost, then the O&M cost will be around 73.47 billion rupiah. A summary of the analysis can be seen in Table 2.

Table 2. Summary of LCC analysis.

Function Components	Construction Cost (Rp)	O&M Cost for 27 years (Rp)
SHIARL, Elevated	9,331.93 Billion	204.51 Billion
PRASTI Tunnel		
a. Transportation Function		
• Airport Train	423.95 Billion	5.98 Billion
• MRT	470.93 Billion	6.92 Billion
b. Flood Control Function	15,710.84 Billion	78.55 Billion
c. Telecommunication function	1.38 Billion	0.10 Billion
d. Commercial Area Function	3,673.71 Billion	73.47 Billion
Total	29,612.74 Billion	369.53 Billion

The SHIARL-PRASTI feasibility analysis consists of three scenarios based on the assumption of its potential passenger use. Based on the LCC analysis, additional functions in SHIARL + PRASTI Tunnel contribute to the increased value of IRR. The project is thus confirmed to be technically and financially viable. Furthermore, these additional functions not only improve the feasibility of the project in terms of economic value, but also provide benefit to the community by reducing floods in Jakarta area. The comparison of NPV and IRR value between no–additional function of SHIARL and SHIARL–PRASTI Tunnel is shown in Table 3.

Table 3. NPV and IRR SHIARL vs. SHIARL-PRASTI.

DEMAND	SHIARL		SHIARL+PRASTI	
	NPV	IRR	NPV	IRR
20%	(2,700,253,187,341)	5.50%	58,607,581,574,941.90	7.536%
30%	5,670,741,614,402	9.11%	89,524,161,343,320.80	9.751%
40%	10,403,582,949,318	10.73%	122,114,189,296,626.00	11.617%

5 CONCLUSION

Value engineering (VE) has been widely applied to produce optimum result for projects development by proposing innovative ideas. Innovation for the SHIARL project is gained through additional functions comprised of the following items: 1) Passenger MRT, 2) Airport Passenger Train, 3) Potential Commercial Area Underground, and 4) Fiber Optics. Life-Cycle Cost analysis is divided into two components: SHIARL elevated and PRASTI Tunnel. Construction cost for the SHIARL elevated is around

9,331.93 billion rupiah, and the O&M cost is around 204.51 billion rupiah. The PRASTI Tunnel construction cost is about 20,280.81 billion rupiah, and the O&M cost around 165.02 billion rupiah. The analysis in this paper also produces a positive NPV, with 7.53% of IRR for 20% demand, 9.75% of IRR for 30% demand, and 11.61% of IRR for 40% demand.

Acknowledgments

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