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by Herawati Zetha Rahman

Submission date: 05-Nov-2019 01:32PM (UTC+0700)

Submission ID: 1207394408

File name: f_the_Soekarno_Hatta_International_Airport_Rail_Link_Project.pdf (356.53K)

Word count: 3447

Character count: 19213

Development of the Soekarno–Hatta International Airport Rail Link Project Using the Value Engineering Method: Creating Value for Money

Mohammed Ali Berawi^{1*}, Bambang Susantono¹, Suyono Dikun¹, Tommy Ilyas¹, Herawati Zetha Rahman^{1,3}, Abdur Rohim Boy Berawi¹, Teuku Yuri Zagloel², Perdana Miraj¹,
and Jade Sjafrecia Petroceany¹

1. Department of Civil Engineering, Faculty of Engineering, Universitas Indonesia, Depok 16424, Indonesia
2. Department of Industrial Engineering, Faculty of Engineering, Universitas Indonesia, Depok 16424, Indonesia
3. Department of Civil Engineering, Faculty of Engineering, Universitas Pancasila, Jakarta Selatan 12640, Indonesia

*e-mail: maberawi@eng.ui.ac.id

Abstract

Soekarno–Hatta Airport is the main gateway for international flights to Greater Jakarta. Its accessibility depends on the inter-city and Sedyatmo toll roads, which causes congestion in peak hours, leading to uncertainty about travel times. The Soekarno–Hatta International Airport Rail Link (SHIARL) is proposed as an alternative mass transportation project, which is expected to provide accessibility and mobility for people and goods to and from the airport. Previously, the project was unattractive to private investors as it was technically and financially unfeasible. Therefore, this research aims to improve the feasibility of the Soekarno–Hatta International Airport Rail Link (SHIARL) by using a value-engineering approach to create maximum value for money for the project. This research combines quantitative and qualitative methods. Questionnaire surveys are distributed to various stakeholders in the project, and a focus-group discussion (FGD) is conducted. The results identified additional, innovative functions through the integration of the Mass Rapid Transit (MRT), flood control, telecommunications, and development in the downtown area around the station. The life-cycle cost analysis confirmed the increased value for money because of the project's additional functions, including a positive Net Present Value (NPV). Moreover, the findings showed that the internal rate of return (IRR) was 3% higher than the original single-function project.

Abstrak

Pembangunan Proyek Kereta Api Bandara Internasional Soekarno-Hatta Menggunakan Metode Value Engineering: Menciptakan Nilai Tambah dan Inovasi. Bandara Soekarno-Hatta merupakan pintu gerbang utama penerbangan internasional ke Jakarta, dimana aksesibilitas perjalanannya sangat tergantung pada jalan tol antarkota Sedyatmo dengan tingkat kemacetan pada jam sibuk dan ketidakpastian waktu tempuh. Pembangunan Soekarno-Hatta International Airport Rail Link (SHIARL) diusulkan sebagai proyek alternatif transportasi massal yang diharapkan dapat memberikan aksesibilitas dan mobilitas orang dan barang dari dan ke bandara dengan lebih baik. Namun demikian, proyek ini kurang menarik investor swasta karena kelayakan teknis dan finansial. Oleh karena itu, penelitian ini bertujuan untuk meningkatkan kelayakan proyek SHIARL dengan menggunakan pendekatan rekayasa nilai untuk menghasilkan nilai dan manfaat yang optimum bagi investasi. Penelitian ini menggunakan metode kuantitatif dan kualitatif melalui survei kuesioner dan fokus group discussion (FGD). Hasil survey menunjukkan bahwa fungsi-fungsi tambahan sebagai inovasi meliputi penggabungan dengan Mass Rapid Transit (MRT), pengendalian banjir, pembangunan jalur utilitas telekomunikasi dan pusat komersil bawah tanah pada stasiun. Hasil analisis biaya siklus hidup menunjukkan peningkatan kelayakan proyek dengan NPV positif dan peningkatan nilai keuntungan (IRR) dari manfaat tambahan sebesar 3% dibandingkan dengan rencana awal proyek.

Keywords: airport railway, life cycle cost, transportation, value engineering, value for money

1. Introduction

According to Business Monitor International in 2012, the infrastructure industry has stimulated Indonesia

economic growth by contributing 5.5% to the country's GDP, with real growth of 9.3%. In particular, railway infrastructure has contributed about 41.20% or nearly 262.917 trillion rupiah of the total investment in the

transportation sector [1]. Because of the limited amount of financial support by the government, private sector involvement is encouraged for financing railway projects.

As one of the busiest airports in the world, Soekarno-Hatta Airport has experienced significant growth in the number of passengers that use the facility. It now serves 44 million passengers per year. The Soekarno-Hatta Airport Rail Link (SHIARL) has been proposed as a solution to the problems caused by this phenomenon. Access to the airport relies on inter-city and Sedyatmo toll roads, which causes congestion and uncertainty about travel time during peak hours. The SHIARL project is expected to increase punctuality, improve airport accessibility, and provide better mass transportation for the public.

Since it has been financially unfeasible, previous attempts to realize this project were unable to attract private investors. The SHIARL feasibility project was firstly proposed in 2002 by PT Railink and then offered in 2005-2006 at the Infrastructure Summit. Accordingly, in 2014, the Public Private Partnership (PPP) Book down-graded the status of the SHIARL project from "ready to offer" to "priority," which indicated the decreasing worthiness of the project. Therefore, this research aims to improve the feasibility of the proposed SHIARL by creating maximum value for money in the project.

The realization of a successful mega-project infrastructure depends on the quality of the project's feasibility, which is measured by significant value for money (VfM) [2,3]. VfM is evolved through a combination of innovations, including engineering, financial, and private investor involvement in managing public funds for the project's infrastructure [4]. In this study, the value-engineering (VE) method is used to increase value for money by proposing that additional functions be integrated into the project.

Several infrastructure projects around the world have used VE to generate optimal outcomes in terms of quality [5], efficiency [6,7], and innovation [8,9]. Hence, in this study, VE was used to create an innovative conceptual design to solve the problem of airport accessibility by increasing investors' value for money.

2. Methods

This research combined quantitative and qualitative methods. The quantitative method used a questionnaire survey and life cycle cost (LCC) analysis to control variables and objectivity. In the qualitative method [10], a participatory action research (participative action) was conducted, which criticized the assumptions and allowed for the learning process [11] and the development of a

"grounded theory" [12] through focus group discussions (FGD).

Both online (softcopy) and offline (mail/hardcopy) questionnaires were distributed to the stakeholders to gather data on their perceptions of the ideas produced in the value-engineering process. The respondents to the offline questionnaires were ministries, state-owned enterprises, and companies related to infrastructure development, including PT Kereta Api Indonesia (KAI), PT Railink, PT INKA, the Ministry of Transportation, the Ministry of Public Works, PT Jasa Marga, PT Wijaya Karya, Bappenas, Indonesia Infrastructure Guarantee Fund (PT IIGF), PT Sarana Multi Infrastruktur (SMI), the Special Committee for the Acceleration of Infrastructure Indonesia, and the Investment Coordinating Board. Online survey questionnaires were sent via e-mail to six groups of practitioners in the construction industry and value engineers in Indonesia. The data were analyzed by using inferential statistics, Cronbach's Alpha, and one sample t-test to determine the proportions of the responses. The reliability of the responses to the questionnaires was based on a confidence level of 95%.

Life cycle cost (LCC) evaluation was conducted using the discounted payback method to compare current and future values of money, which were represented by net present value (NPV) and internal rate of return (IRR).

3. Results and Discussion

Thirty-two questionnaires were returned during one month. When the analysis of the responses to the questionnaire survey was completed, FGDs were conducted to validate and verify the quantitative findings, as well as gain additional input from various stakeholders of SHIARL project.

Questionnaire survey. Most respondents worked at private companies (43%), while the second largest portion of respondents (63%) worked at government agencies. More than 50% of respondents had post-graduate degrees, and 26% held managerial and general director positions.

Most respondents agreed that punctuality was the major factor in public transportation, particularly railway transport. Additional functions that could be integrated into SHIARL project were residential areas, a business center, and a city check-in facility for the airport. These additional functions of the SHIARL project would require an investment 30% higher than that of the previous SHIARL project. The responses also showed that the private sector would be expected to be much more involved in financial support, at 60%. Hence, government funding would amount to 40%. The results of the FGDs, which included representatives of the

expertise required by the project, confirmed the quantitative results of the questionnaire, regarding the potential additional functions of the project.

Creating value in SHIARL. The data used to create ideas about additional functions of the project were integrated through a Function Analysis System Technique (FAST) diagram. Innovative ideas for the SHIARL project were generated by the various problems in the Jakarta region, including the targeted development set by the government in a period of 20 years and the potential transportation development to be integrated in the project.

One of Jakarta's devastating problems is annual flooding in the rainy season, which causes periodic disruptions in the accessibility to the airport as users highly depend on the inter-city and Sedyatmo toll roads. This dependency also leads to congestion and uncertain travel time during peak hours. Moreover, the increasing number of commuters using private vehicles and the limited availability of land in Jakarta to serve city functions are also considered due to poor public transportation.

Considering road sector growth that below 1% per year compared to over 1,000 new vehicles are sold every day, the roads are predicted to be permanently congested in 2020. Therefore, rail-based project development is arguably the best solution to solve the transportation problems in the Jakarta region.

The several transportation problems in Jakarta and the potency of development served to provoke innovative ideas for the project. Underground infrastructure is proposed as a solution to compensate the limited land in Jakarta by integrating a Mass Rapid Transit (MRT) line and a flood tunnel that will be used to solve the problems of Jakarta's shortage of public transportation and annual flooding. The economic aspect is also considered in the proposal for the inclusion of a commercial area and fiber optic integration, both of which would generate regional income.

Furthermore, the consideration of natural resources in the project is expected to increase the efficiency and quality of the environment. These ideas led to the development of the FAST diagram shown in Figure 1.

Table 1. Innovative Ideas for SHIARL

Reference	Innovative Ideas
Limited land	Underground Infrastructure
Lack of public transportation	MRT integration
Floods	Floods tunnel integration
A needs of communication	Fiber optics integration
Renewable energy	Utilize natural resources (solar, kinetic energy)
Increase regional economy	Develop commercial areas (residences, business center)

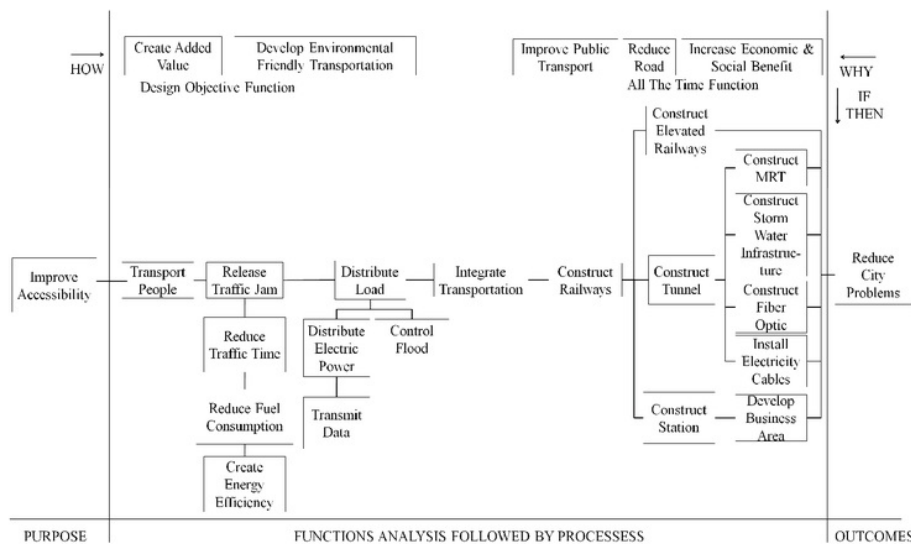


Figure 1. FAST Diagram of SHIARL

These functions were developed into the conceptual design of a multi-functional tunnel, a public railways and stormwater infrastructure (PRASTI) tunnel, to overcome congestion, reduce flooding in the Jabodetabek area and increase accessibility to and from Soekarno–Hatta Airport by integrating three main functions in one tunnel: MRT, the airport railway, and flood control. In the design, the tunnel is divided into three levels: the first level serves as flood control; the second level serves as airport accessibility through SHIARL; and the third level is expected to serve the MRT line. The cross-sectional image of the proposed multi-functional PRASTI Tunnel is shown in Figure 2.

The SHIARL route is planned to be 38.5 kilometers, using the inter-city toll road to connect Halim Airport in eastern Jakarta with Soekarno–Hatta Airport. This route is divided into three sections: the first section is from Halim airport to Dukuh Atas, with an elevated lane for 12 kilometers; the second section is from Dukuh Atas to the Sedyatmo toll near Pluit, which will use the PRASTI tunnel for nine kilometers; the third section from the Sedyatmo toll near Pluit to Soekarno–Hatta Airport, with an elevated lane for 17.5 kilometers. The selection of the route selection also considered the mapping of the flood area in Jakarta and linked the West flood canal to the Pluit reservoir. Details of the route are shown in Figure 3.

Life cycle cost analysis. The cost estimate of the construction of the SHIARL project was conducted

using two calculations: first, initial cost plus operational and maintenance cost of elevated SHIARL; second, initial cost plus operational and maintenance cost of the PRASTI tunnel. The construction cost of the PRASTI tunnel will be divided into four areas: 1) flooding; 2) transportation, which consists of the airport train and MRT; 3) telecommunications; and 4) commercial area development.

The construction costs of tunnels vary worldwide, depending on several factors. The initial cost of the PRASTI tunnel will be determined through benchmark comparisons of tunnel projects with similar diameters

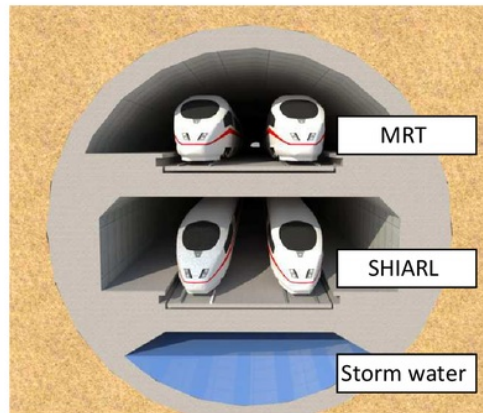


Figure 2. Cross Section of PRASTI Tunnel



Figure 3. Route of the SHIARL Project

and functions, such as the SMART Tunnel in Malaysia and the Channel Tunnel in the UK. The profile of the PRASTI tunnel (19 m) is much larger than the diameter of the Malaysian SMART Tunnel, which is 13.2 m.

Therefore, the initial cost of the PRASTI tunnel is calculated by interpolation. Conversely, the operational and maintenance costs of the tunnel are assumed to be within 0.5% of the initial cost [13], with increased annual inflation per year for the respective functions [14].

The initial cost of the elevated train will be 9.33 trillion rupiah, and operational and maintenance costs will be around 204.51 billion rupiah per year. The costs of the transportation function of the PRASTI tunnel will be as follows: the initial cost will be 894.89 billion rupiah, and the operational and maintenance costs will be around 12.89 billion rupiah per year. The initial cost of flood control will be about 15.71 trillion rupiah, and the operational and maintenance costs will be 78.55 billion rupiah per year.

PT Telkom, an Indonesian state-owned telecommunication enterprise, will be in charge of fiber optic construction, which will cost about 152.96 million rupiah/km. The 9 km of fiber optic construction in the PRASTI tunnel will cost around 1.38 billion rupiah. The operational and maintenance costs of fiber optics in the tunnel will be about 102.60 million rupiah per year. Furthermore, 5,600 m² of commercial development will be located at six MRT underground stations and at Dukuh Atas Station. Construction costs for the commercial area are

estimated at 3.6 trillion rupiah. The operational cost is assumed 2% of the initial cost or around 73.47 billion rupiah. Table 2 provides a summary of the cost analysis.

The simulation of the feasibility analysis of the PRASTI SHIARL project consisted of three scenarios (i.e. displacement ratios in percent), based on the assumed number of potential passengers: 1) optimistic scenario, with 40% of passengers transferring their mode of transportation to the Airport railway; 2) normal scenario, with 30% of passengers transferring their mode of transportation to the Airport railway; 3) pessimistic scenario, with 20% of passengers transferring their mode of transportation to the Airport railway. Based on the LCC analysis, additional functions in SHIARL and the PRASTI tunnel will contribute to the increased value of IRR. These results confirmed that the project is technically and financially feasible. Furthermore, the additional functions not only will improve the project in economic value but also will provide benefits to the community by reducing flooding events in the Jakarta area.

The comparison of NPV and IRR values between no additional functions in SHIARL and the SHIARL–PRASTI tunnel is shown in Table 3. Although the simulation showed the pessimistic result of 40%, in real terms, the train is still the preferred mode of public transportation. The 30% and 40% shown in the simulation are therefore acceptable figures.

Currently, separate projects with related functions in the PRASTI tunnel have been proposed for development in

Table 2. Summary of LCC Analysis

Function Components	Construction Cost (Rp)	Operational and Maintenance Cost (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

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%	14,178,000,000,000	10.56%
30%	5,670,741,614,402	9.11%	23,617,000,000,000	12.50%
40%	10,403,582,949,318	10.73%	33,440,000,000,000	14.24%

the Jakarta area. First, the MRT project was proposed by the Indonesian government to reduce congestion in the Jakarta would requires about 33 trillion rupiah for the 23.3 km linking Lebak Bulus in South Jakarta to Kampung Banda in North Jakarta. Second, the Ministry of Development and Planning (2013) proposed the construction of an airport train from Halim Airport in Eastern Jakarta to Soekarno–Hatta Airport in Western Jakarta. This 38.5 route would include three main stations and cost around 25 trillion rupiah. Finally, a flood control system to reduce the annual heavy flooding was proposed at a cost of about 17 trillion rupiah, which caused the loss of about 20 trillion in 2013. Compared to the cost of 76 trillion rupiah for the three separate proposed projects, the cost of 21 trillion rupiah for the PRASTI tunnel, which integrates all functions, is the most effective way to both overcome the numerous problems in Jakarta and provide an innovative solution for the financial feasibility of the project.

On top of that, the estimated revenue generated by transportation, commercial areas, utilities, and the amelioration of flooding enhances the feasibility of the PRASTI tunnel, in accordance with the PPP financial scheme.

4. Conclusions

Value engineering (VE) has been widely applied to produce optimal results in project development through the fulfilment of the required quality, application of advanced technology, and achievement of innovative ideas. The results showed that the application of VE in mega infrastructures, particularly the SHIARL project, produced added value for the project. Innovations for the SHIARL project were gained through the following additional functions: 1) passenger MRT; 2) airport passenger train; 3) potential commercial area underground; and 4) fiber optics. The life cycle cost analysis identified two components of calculation, the elevated SHIARL and the PRASTI tunnel. Construction costs of the elevated SHIARL are around 9,331.93 billion rupiah, and the cost of operation and maintenance was valued at 204.51 billion rupiah. The construction cost of the PRASTI tunnel is about 20,280.81 billion rupiah, and the cost of the O&M is around 165.02 billion rupiah. Subsequent to the life cycle cost analysis, this study produced a positive NPV and IRR of about 10.56% for a demand of 20%; 12.50% of IRR for a demand of 30%; and 14.24% of IRR for a demand of 40%.

Acknowledgments

The research was fully supported by research grants from the University of Indonesia and the Ministry of Education, Republic of Indonesia.

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