TECHNOLOGY SELECTION IN AIRPORT RAILWAY PROJECT USING VALUE ENGINEEREING APPROACH

by Herawati Zetha Rahman

Submission date: 17-Oct-2019 04:26PM (UTC+0700)
Submission ID: 1194648620
File name: 2013-Int_Conf_2013_Hera.pdf (680.14K)
Word count: 3081
Character count: 17025

ISSN : 2354-6905

TECHNOLOGY SELECTION IN AIRPORT RAILWAY PROJECT USING VALUE ENGINEEREING APPROACH

M. Ali Berawi[1], Herawati Zetha Rahman[2], Zulkarnaen Mohammad[1]
[1] ID-Tech, Faculty of Engineering, University of Indonesia
[2] Faculty of Engineering, Pancasila University.
Email: herazetha@gmail.com

Abstract

Soekarno Hatta airport's express railway construction project using PPP scheme needs a very high investment cost. Therefore, requires innovative and creative efforts in the construction design to achieve an attracktive result to investors in the project financing stage. One of the efforts is to select the railway technologies to get an optimal design concept.
This research purposed to identify varies range of technology that will be selected in Soekarno Hatta International airport express railway construction. This research applies value engineering with life cycle cost analysis to determine the impact of technology selection in investment through cost optimization as its methodology.

***Keywords**: Value Engineering, Airport Railway, Technology Selection*

1. INTRODUCTION

In 2011, Soekarno-Hatta International Airports is noted as 12th airport in the world with busiest passenger traffic (4th busiest in Asia). It has surpassed Singapore's Changi Airport, which has 14% increases in passenger traffic with domestic passengers as the largest, also recognized as the only airport that has single access toll road, Prof. Dr. Ir. Sediyatmo Toll Road [1]. On 1977, the airport capacity was estimated to accommodate 22 million passengers per year, however in 2011, has reached 51 million passengers per year [2]. With the increasing passengers, so accessibility will be the main problem for Soekarno Hatta Airport.
Therefore, on 2003 the government has planned Soekarno Hatta railway project. This project proposed in 2005, 2006, and in 2009 PPP Book, but until now still has not reach its construction phase. The feasibility study of airport railway was re-evaluated on 2010 and re-proposed on 2013 PPP Book with the changed project's status, from *ready to offer* to *priority project*.

Table 1. SHIARL's Proposed Project in PPP Book [3,4]

PPP Book	Status	Estimated Cost
2009	Ready to offer	US$ 700 Million
2013	Priority	US$ 2.570 Million

This large investment cost required in the Soekarno Hatta airport's express railway project causes this project not attractive to be offered to private sectors. Thus need an innovative

ISSN : 2354-6905

and creative effort in the construction design to achieve a result that attract investors to participate in the project financing. One of the efforts is to do railway's technology selection to achieve optimal design concept. The technology that will be implemented in airport express railway infrastructure will give impacts to process and costs in the construction itself or simplifying process and operational & maintenance costs that is required in the complishion phase and thereafter.

2. THEORETICAL BACKGROUND

2.1. Value Engineering

Value Engineering (VE) is a decision making process based on team which is systematic and structured. Value Engineering (VE) is a team approach that oriented in functions, organized and directed to analyze functions in products, system, or supply process, intended to increase value with identifying and remove unnecessary costs to achieve needed performance in lowest project's life cycle cost [5].

VE method has been implemented in many infrastructure projects in developed countries, especially for projects with high costs and has been accepted as a best tool to manage project effectively [6-8]. VE method has been tested systematically that able to analyze a system's functions to produce optimal output for a project, in quality, technology, efficiency, and innovation [9-13]. VE process (is also called VE study) is a sequence of activities in a value study for an object (project, process, product) that includes functions definitions, idea developments and evaluations that will result VE proposal and hold as a workshop [14]. Generally, VE study consists of three steps, which are pre-workshop (preparation), workshop (six phases Job Plan execution), and post-workshop (documentation and execution).

2.2. Soekarno-Hatta Airport Express Railway Conceptual Design

Airport express railway route will connect two airports in Jakarta, namely: Halim Perdanakusuma aiport and Soekarno Hatta airport. This route is proposed to privates with PPP scheme. Railway routes will pass through Inner Ring Road Toll Road in parallel with elevated construction in toll road median, then via MH Thamrin road to Mangga Dua with underground construction, which then turn in parallel with harbor toll with elevated construction in airport toll road's median towards Soekarno-Hatta airport. Airport express railway is integrated with Jakarta's MRT route in Dukuh Atas Station. This Dukuh Atas integration is purposed to provide passengers from North Jakarta and South Jakarta using Jakarta's MRT. This route selection has considered several aspects, including business area development, land availability, Jakarta's rail transportation plan, and Jakarta's flood distribution map, to add flood control function to underground rail route along MH Thamrin road to Mangga Dua area.

ISSN : 2354-6905

Figure 1. Soekarno Hatta Airport Express Railway Route
Source: ID Tech UI

Second option airport railway route's length is 38,5 kilometer, consists of 12 kilometer elevated route from Halim to Dukuh Atas; 9 kilometer underground route; and 17,5 kilometer elevated route to Soekarno Hatta airport. Airport train consists of 8 cars per train set; with total passengers are 480 passengers per train set. The train will operate from 05.00 AM to 10.00 PM (17 hours daily). The planned headway is 15 minutes, but can be reduced to increase daily trips if it reaches passengers escalation.

Table 2. Train Frequency and Total Passengers Scenario

ops hour	headway	Jumlah Trip		pass/trainset	pass/day	pass/year
17	15	72	144	480	69,120	25,228,800
17	12	85	170	480	81,600	29,784,000
17	10	102	204	480	97,920	35,740,800
17	7.5	136	272	480	130,560	47,654,400
17	6	204	408	480	195,840	71,481,600

2.3. Train Technology

Train infrastructure construction technology is advanced developed technology in the world until through every components. Each of those components have its own functions and work that related to safety, security, and comfort of the passengers. Thus, railway technology selection process needs innovative and creative steps without reduce functions in those components. Understanding function concept of a project is an important step to be able to innovate creatively [15]. Value Engineering (VE) is a application of a systematic process through functions analysis [14]. With value engineering approach, those processes is expected to be done so an efficient result is achieved. Developed railway technology are track, signaling, ad electricity process.

Generally, there are two kind of track, which are ballasted track and ballastless/slab track. All track in Indonesia are using ballasted track. Slab track design has already used in European countries, Japan, Malaysia, China, and Singapore. Ballasted track is a rail that is

ISSN : 2354-6905

place on a mounting that using ballast below it with certain thickness to distribute load to the ground. In slab track, the ballast is replaced with concrete that has same function to distributed load. The benefit of slab track are reducing structure height, lower maintenance and high availability, service life improvement, high lateral track resistance which allow speed increase with tilting technilogy, unaffected with ballast particle impact in high speed [16].

There are two kind of electricity system for train, which are Alternating Current (AC) and Direct Current (DC). The generally used AC system is 25 kV AC, while DC system is 1500 V DC and 750 V DC. Electricity system that is used in Indonesia is 1500 V DC system. AC system has higher voltage, with same load, produces lower current than DC system, so AC system needs conductor cables with smaller diameter that DC system. The optimal distance between relay station is 30 km to 50 km for 25 kV AC and 5 km to 7 km for 1500 V DC, so AC system need fewer relay station than DC system. This become important in designing the railway infrastructure, to chose what electricity system that will be used.

Traditional signaling system is based on *fixed block* utilization. In signaling with fixed block, train movement is limited by the designed blocks with constant distance and fixed location. Train is not allowed to move to the front block if signal lamp has indicated red light, even with very low speed. In modern signaling system with *moving block* system, train will be controlled with by control system and not limited to fixed blocks. Train can move up to very small distance to the train in front of him, but with speed controlled from the system. Train movement in moving block system is based on braking distance which is affected by speed. Moving block system can increase traffic capacity and traffic fluidity. Signaling in Indonesia still using fixed block, while moving block system has already implemented in European, Asian, and Australian countries. In railway infrastructure design planning, it need to be considered the plan to increase the number of trains that will be used in the future. Therefore, it need to consider the signaling process that will be chosen.

Technology selection in airport railway construction will affect to the cost of investment. Technology selection reccomendation in airport railway will improve additional value and reduce overrun cost in construction, operation, even maintenance.

3. RESEARCH METHOD

This research use qualitative and quantitative efforts using interviews with the experts in railway. Technology selection analysis is done using Value Engineering method approach. VE implementation result validation is performed using Life Cycle Costing (LCC) analysis to obtain IRR and NPV. In PPP scheme, LCC is a representation of Value for Money that has become a basic concept in a project that will be constructed using PPP financing.

Net Present Value (NPV) is a appropriate technique to calculate cashflow comparisons for long term, such as infrastructure projects that use Public Finance Investment scheme [17]. The formula to calculate NPV is:

$$NPV_i = \sum_{t=0}^{T=N} \frac{(B_t - C_t^i)}{(1+r)^t} \qquad (3,1)$$

where B is profit in year *t*. If NPV (+), investment is accepted and if (-), investment is rejected.

Meanwhile, Internal Rate of Return (IRR) is a discount rate that give NPV value become zero. The formula to calculate IRR is:

ISSN : 2354-6905

$$IRR = i\colon \sum_{t=0}^{T} \frac{R_t}{(1+i)^t} - \sum_{t=0}^{T} \frac{C_t}{(1+i)^t} = 0 \qquad (3,2)$$

The appraisal criterias using this method is, "if the received IRR value is bigger than the valid interest in public, the investment is accepted. If IRR is lower than the valid interest in public, then investment is rejected.

Using Life Cycle Cost tool, it can be known how much the cost components of the infrastructure that will be used can affect the Net Present Value (NPV) or the Internal Rate of Return (IRR) from the planned project. Thus, the technologies that can give optimal result will be known.

4. RESULT AND DISCUSSION

4.1. Initial, Operation, and Maintenance Costs

These airport railway infrastructure construction costs consist of Initial Cost (IC) and Operation & Maintenance Cost (OM) that include seven main components, which are track way (elevated way & subway; d: 5.6m), buildings (elevated stations, underground stations, depot & workshop, office & operation control center) track, electricity (OHC, stations), signalling and telecommunication, train (EMU), and ticketing system. In this research, the track way, building, train and ticketing system cost components are already estimated. Meanwhile, for track, electricity, and signalling cost components will be based on technology selection options. There are eight technology selections options that combine each of these technologies from those three cost components.

Table 3. Identification and Options of Technology Selection

	Component	Technology Selection	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6	Option 7	Option 8
A	Track	Slab Track	A		A		A		A	
B	Track	Ballasted Track		B		B		B		B
C	Electricity	25 KV AC	C	C			C		D	D
D	Electricity	1500 V DC			D	D		D		
E	Signaling	Moving Block	E	E	E	E				
F	Signaling	Fixed Block					F	F	F	F

These cost related data in this research are obtained from previous research literature studies, similar projects and railway construction plans study report results that have been done. After the study of the functions and specifications from the components, the used costs for construction and O&M will be normalized within these costs. Then these costs converted to Rupiahs.

ISSN : 2354-6905

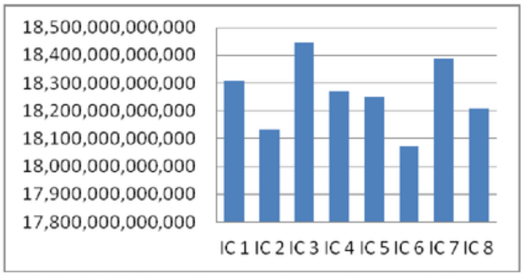

Figure 2. Initial Cost Comparison Chart of Option 1 – 8

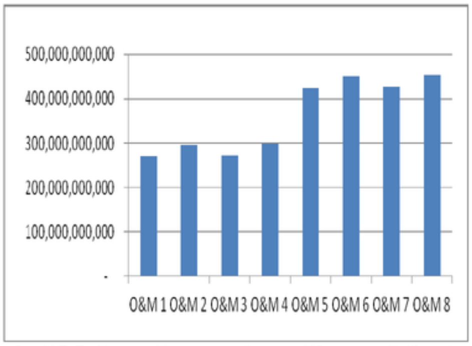

Figure 3. OM Cost Comparison Chart of Option 1 – 8

4.2. LCC Analysis Result

The Life Cycle Cost in this research uses three infrastructure components which each has two technology selections that will be used to calculate LCC. By combining that technology selection, the results will be different. The LCC calculated is conducted using Microsoft Excel. The used financial assumptions for LCC estimation are detailed in the table below.

Table 4. Financial Analysis Assumption

Assumptions	Value	Explanation
Discount Rate	6,81%	The interest rate of Bank of Indonesia in last 5 years
Inflasi Rate	5,95%	The inflation rate in last 5 years (Bank of Indonesia report)

Source: Bank of Indonesia and Central Bureau of Statistic

From LCC calculation with option 1 to option 8, different NPV and IRR value are obtained. This can be seen in Table 5 below which shows the highest NPV is option 1 with 9.11% IRR, while lowest NPV from LCC calculation is option 8 with 8.07% IRR.

Table 5. NPV and IRR Comparison of Option 1 – 8

	NPV		IRR
Option 1	Rp	5.670.741.614.402	9.11%
Option 2	Rp	5.421.999.630.606	9.04%
Option 3	Rp	5.512.322.002.926	9.03%
Option 4	Rp	5.263.580.019.129	8.96%

ISSN : 2354-6905

		NPV	IRR
Option 5	Rp	3.361.222.044.359	8.23%
Option 6	Rp	3.112.480.060.563	8.15%
Option 7	Rp	3.202.802.432.883	8.16%
Option 8	Rp	2.954.060.449.086	8.07%

5. CONCLUSION

From the benchmarking and Life Cycle Cost analysis result, the selected infrastructure technology component is:

- The suitable track technology in airport railway infrastructure is *slab track* system. Slab track is selected because the required O&M total cost for 30 years is cheaper than ballasted track.
- The suitable electricity technology for airport railway infrastructure is 25 kV AC. The 25 kV AC technology is selected because this system has fewer required relay station than 1500 V DC, it need 1 relay station every 50 km than 1 relay station every 5 km for DC system.
- The suitable signaling technology in airport railway infrastructure is *moving block* system. The moving block system is chosen because the required O&M total cost for 30 years is cheaper than fixed block system. It also simplifies the process of adding trains when passengers have already escalated because it doesn't need design modification.

After the Life Cycle Cost analysis of the track, electricity, and signaling technology selection combination options has been done, it can be concluded that the first Option, that consists of slab track, 25 kV AC, and moving block signaling system technology, produces the largest NPV in 30 years estimation, which is Rp. 5.670.761.614.402,00 with 9.11% IRR.

6. REFERENCES

[1]. Jurnal Tranportasi Darat, 2010, Jakarta : Badan Penelitian dan Pengembangan Perhubungan, Pusat Penelitian dan Pengembangan Perhubungan Darat vol 12, Juni 2010

[2]. Airports Council Internasional, 2012

[3]. PPP Book, 2009

[4]. PPP Book, 2013

[5]. Fong, P. S. (1998), "Value Management Applications in Construction", AACE, International Transactions, AACE, Morgantown, USA

[6]. Bytheway, Charles W (1971), The Creative Aspects of FAST Diagramming, SAVE Proceeding 6: 301-312

[7]. Berawi, M.A. & Woodhead, RM (2005c), Application of Knowledge Management in Production Management, Human Factors and Ergonomics in Manufacturing, Vol. 15, No. 3, pp.249 – 257, Wiley and Son

[8]. Woodhead, R.M. & Berawi, M.A. (2008), An Alternative Theory to Idea Generation, *International Journal of Management Practice*, Volume 3, No. 1, pp.1 19, Inderscience.

[9]. Abdul-Rahman, H & Berawi, M.A. (2002), Power Quality System, A new System for Quality Management in Globalization-Towards Innovation and Competitive

ISSN : 2354-6905

Advantages, Quality Assurance: Best practice, Regulation, and Law, Vol.9, Issue 1, pp 5-30, Taylor & Francis

[10]. Berawi, M.A. (2004). *Quality Revolution: Leading the Innovation and Competitive Advantages*. International Journal of Quality & Reliability Management, Volume: 21, Issue: 4, pp. 425-438, Emerald

[11]. Berawi, M.A. & Roy Woodhead. (2005a). How-Why Logic Paths and Intentionality, Value World Volume 28 Number 2 Fall 2005, pp. 12-15.

[12]. Berawi, M.A. & Roy Woodhead. (2005b). The If-Then Modelling Relationship of Causal Function and Their Conditioning Effect on Intentionality, Value World Volume 28 Number 2 Fall 2005, pp. 16-20.

[13]. Berawi, M.A. (2009), Establishing a Reliable Method of Distinguishing Functions and Processes, Value World, Volume: 32, Number: 1, pp. 13-16, SAVE International Press

[14]. Society of American Value Engineers (SAVE) International, 2007

[15]. Hyun, Chang-Taek, et. al (2010), Development of Improved VE Subject Selection and Fuctional Analysis at Planning Phase for Program Level, *Value World*, Vol. 33, Number 2, SAVE International.

[16]. Esveld Coenraad (1999) Professor of Railway Engineering, "*Recent Development in Slab Track Application*". TU Delft.

[17]. Kelly, John and Male, Steven (2005), Value Management in Design and Construction: The Economic Management of Projects, E & FN Spon, London.

Acknowledgement

The research was fully supported by a grant from Research Grant Council of Indonesia Goverment (Hibah Strategis Nasional) 2013.

ISSN : 2354-6905

Question:

Answer:

TECHNOLOGY SELECTION IN AIRPORT RAILWAY PROJECT USING VALUE ENGINEEREING APPROACH

ORIGINALITY REPORT

3%	3%	0%	0%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	english.ftsl.itb.ac.id Internet Source	3%

Exclude quotes	Off	Exclude matches	< 3%
Exclude bibliography	On		