Indonesia Spaceport Selection Based on Multicriteria Analysis: A Study on Relative Importance and Priority Regarding Spaceport Selection Location Attributes Utilizing AHP

Intan Perwitasari
Magister of Economic Development Sciences, Faculty of Economics and Business
Universitas Diponegoro
Semarang, Indonesia
Aeronautic and Space Policy Center, National Institute of Aeronautics and Space (LAPAN) Jakarta, Indonesia
Intanperwita@gmail.com

***Abstract*— The background of this research is the needed a new spaceport location to replace Pameungpeuk lauch site in Indonesia and accomodir a safe new locations for static testing and test flight of experimental 550 rocket rockets and stratified rockets to support rocket and satellite programme. According Legislation Law Number 21 of 2013 on Space, has authorized the Institute to establish spaceport. The purpose of this study is to investigate relative importance and priority regarding location attributes and conclude the best alternative location between Biak Island and Morotai Island to built a new spaceport. The method in this research is an interview with questioner with key-person from researcher and decion maker in LAPAN. Analytical Hierarchy Process is using as multi criteria decision-making tools, to analysis related the most important selection attributes and the best alternative location based on that. From this study, technical requirement is the first priority and Biak Island is the first choice according multicriteria.**

***Keywords*: Spaceport, Location Factor, Biak Island, Morotai Island, Analytical Hierarchi Process**

I. INTRODUCTION

Domestic efforts through research and development (R & D) continue to be pursued to achieve the independence of space technology. National Institute of Aeronautic and Space (LAPAN) is national space agen and has successfully launched a satellite of LAPAN Tub-sat (LAPAN A-1) and LAPAN A-2 (2015) as a part of the experiment satellite for mastery towards operational satellites. Mastery of rocket technology continues to be developed towards the Satellite Orbiter Rocket (RPS), which is expected to be able to carry spacecraft into orbit. In conducting both static and dynamic testing, current R & D activities and future operations require a safe location to function as a launch pad which is then called the spaceport.

LAPAN itself already has a flight test site in Pameungpeuk Garut, West Java, but the available location is not safe and close to residential activities. The need for greater testing requires and encourages to find new and eligible locations for static testing and type 550 experimental rocket flight tests and multilevel rockets. Legistation Number 21 of 2013 on Space, has mandated the Institute (LAPAN) to establish spaceport and space industry facilities. Limitations on the current location encourage the study of the selection of spaceport locations.

Not all states have seriously contemplated the prospect of establishing a state spaceport. For any country, coastal location is not an absolute requirement since Russia and China both launch from inland areas. The major state spaceport initiatives emphasize their location for safety and ease of operations including access by customers. One's location on the earth has effects upon commercial launch prospects in several other way. In fact, location represents an advantage for different states in terms of launch direction and ease of access for potential customers [1] **.**

General location determination factors that influence are endowment factors, markets and prices, raw materials and energy, agglomeration, linkages between types of industries and savings, government policies, and entrepreneurial policies [2]. Endowment factor likes enviroment regulation and social opinions of the chosen location also effect and determine on spaceport activities (construction, operational) [3]. These factors will also influence the planning of the location of the spaceport. Space activities themselves cannot be separated from the wisdom or role of the government, the development of space R & D in the context of a country is influenced by political, military and economic decision making, and the government has prerogative rights (as well as in the United States, Russia, Europe, China, India and Japan) in provide guidelines and management tools in space activities [4].

In spaceport development planning, the determination of the suit location does not only consider spatial aspects, requires deep thinking and involves many parties so that the results obtained and how to obtain results can be accepted by the community and involve many people both directly and indirectly [5]. The determination of location, design, planning, and construction of spaceports, including the surrounding

area, must pay attention to national interests, security and safety of the launch of space vehicles, and environmental sustainability of the spaceport [6]. Potential locations before are proposed to be prospective locations for establish of spaceports, such as Enggano Island, Nias Island, Morotai Island, and Biak Island, and then have screening until 2 location. The problem in this research is which areas are more ready and appropriate for spaceport development planning ? The purpose of this research is (a) investigate high relative importance and priority regarding spaceport location factor attributes; and (b) knowing the the best alternative location to establish spaceport in Indonesia based on multiple criteria analysis.

II. LITERATURE REVIEW

2.1 *Spaceport Location Factor*

Spaceport is an area of land or water that used or intended to be used for the launch and recovery of space access vehicles (orbital or suborbital) and includes its building and facilities (integrate launch vehicle components, to integrate vehicles with payloads, to fuel and maintain vehicles, and to launch vehicles) [7]. Several general principles that need to underline the establishment of the spaceport location are (i) depends on strategies and general plans in the development of national space; (ii) answering existing needs or requests; (iii) adjust to national conditions and the economic status of a country and the development of technology owned; (iv) perfect security; (v) good natural and social environment; (vi) sustainable development; (vii) economic efficiency; and (viii) contribution to local economic development [8].

During the investigation of the best candidate spaceport location, a number of criteria are taken into consideration. The siting of spaceport for early phase in USA for Federal government vehicle dominated by technical, military and political factors (proximity to equator, proximty to the coast, having enaugh controlled access property, proximity to a military base, and be able to any azimuth angle). Then by 1990-an addition requirement for the entrepeneurial operator, the technical, financial and scheduller factor different from chosen for government vehicle [9].

According Xinhua, Chen [8] spaceport location factor is related to the criteria of good natural and social environment measured by the existence of: (i) the superior geographic location, (ii) wide land, (iii) small population, (iv) atmospheric conditions, (iv) weather, (v) geology, (vi) hydrology, (vii) energy, (viii) infrastructure, (ix) culture, (x) education, (xi) hospitals, and (xii) good social security. Other issues relevant the construction and operation spaceport in identification of areas are: technical infrastructure, facilities, bussiness and commercial, safety and security, medical and training, geography, community and enviroment [4] and then the criteria for selecting space locations are more specifically as follows: (a) facing the vast sea that can accommodate the launch of polar orbiting satellites and the launch of equatorial orbit satellites; (b) approaching the equator, which will provide maximum benefit from the support provided by the earth's rotational speed; (c) has a wide location that is safe for launch; (d) location of spaceport that is close to the seaport; (e) airstrip for short and long distance flights (3,000-meter runway); and (f) stable political conditions [10].

In this study, the factor and criteria to determined spaceport location has modified based on literature, indept interviews and previouse research (see Fig. 1)

III. METHODOLOGY

The type of data used in this study is primary data, by conducting interviews with respondents, then we called “keyperson”. Primary data is obtained from the opinions of experts or stakeholders, who are chosen technically (snowball), who are considered to fulfill the expertise as

2.2 *Analytical Hierarchi Process*

Analytic Hierarchy Process (AHP) was developed by Thomas L. Saaty, a mathematician from the University of Pittsburg, United States and published in his book entitled The Analytic Hierarchy Process in 1980. AHP is basically designed to capture rationally people's perceptions that are closely related to certain problems through procedures that designed to arrive at a preference scale among various alternative sets. This analysis is intended to create a problem model that does not have a structure, usually determined to solve measurable problems (quantitative), problems that require opinion or in complex or unreliable situations, in situations where data, statistical information is very minimal or nonexistent once and only qualitatively based on perception, experience or intuition. AHP is also widely used in decisions for many criteria, planning, resource allocation and prioritizing the strategies that players have in conflict situation.

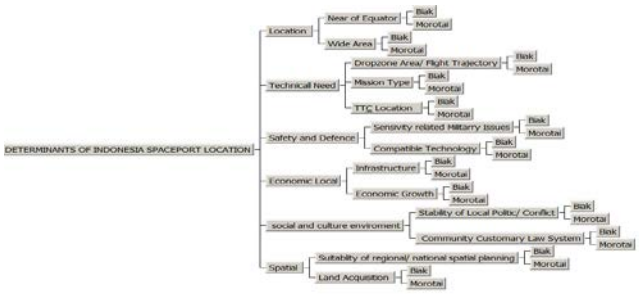


Fig.1. AHP Hierarchi

assessed, with the following requirements: having experience and competence in the field under study, having a reputation, the position or position studied and credibility. In distributing AHP questionnaires, keryperson will be asked to give their perceptions. Keyperson or stakeholder according to the IAEA are defined as those who are interest in a particular issue, from internal who are involved in decision making and eksternal, that are most often affected [11]. In this research they are reseacherer (multi diciplines)

and decicion maker in internal LAPAN. AHP data analysis is used to draw evaluative conclusions about the selection of regions that have suitability in supporting the development planning of spaceports.

The weighting was obtained by the AHP approach where the weight of each variable against the criteria was obtained from the questionnaire results of the experts who were considered to have adequate knowledge and experience and were declared to be inconsistent with 0.1 (10%) using expert choice software. A value of 0,1 or less is considered " acceptable" [12]. The input data for multicriteria decision analysis can be arranged in a tabular form (Table 1). The table, also called decision matrix, shows alternative-attribute relations. The matrix rows represent the alternatives. Each alternative is described by its location and its attribute data. Each attribute is recorded in a column in the decision matrix. The matrix cells contain the values of the attributes measured or evaluated with respect to alternatives [13]. The resulting data is in the form of comparative data paired with the likert scale 1–9 to input in Table 1.

Table 1. Matrix Alternative-Altribute Relationship

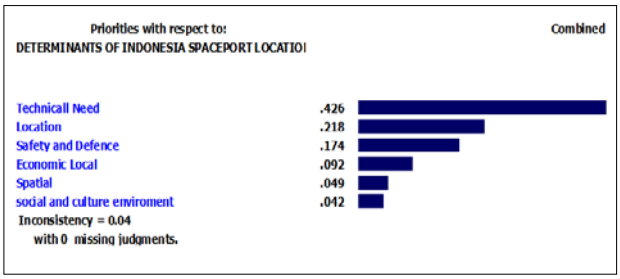
	Attribute 1	Attribute 2	Attribute n
Alternative 1	X_{11}	X_{12}	X_{1n}
Alternative n	X_{n1}	X_{n2}	X_{nn}

Multicriteria decision problems typically involve criteria that vary in importance for decisionmakers [14]. Therefore, it is necessary to have information about the relative importance of each criteria to another is to be aim on this study based on multidiscipline perspective expert.

III. Result and Analysis

From data processing using expert choice software, the priority of the location factor of spaceport determinant based on keyperson perception are (1) technical requirement with value 0,43; (2) location with value 0,22; (3) safety and defence with value 0,17; (4) economic local with value 0,09; (5) spatial with value 0,05 and (6) social and culture environment with value 0,04 (see **Figh 2**). This result is acceptable with inconsistency 0,04 (< or less than 0,1).

Consideration of technical requirements factors is the first priority in screening the potensial location of spaceport logically due to the nature of the technology that is high technology, where in the operation of spaceport must consider technical standards to avoid failure in operating space activities inside (including load integration activities, launching rocket, etc) which has an impact on high recovery costs due to accident. The spaceport location is a technology function [12], in production theory is described where the product or output from a location is a spaceport (construction and operationalization) which is influenced by the readiness of technology, built based on the potential use of which is launch objects by using space launch vehicles both in R&D and commercialization stage. In these activities, consider the potential drop zone area and locations to perform telemetry and tracking (TT&C) to ensure the health and success of the launch. This requierement condition is to avoid potential losses from the nature of high-cost space technology. Launch activities are emerging industries and include higher level of risk, with space technology restrictions and protection [13].



Figh 2. Rank Priority of Spaceport Location Factor

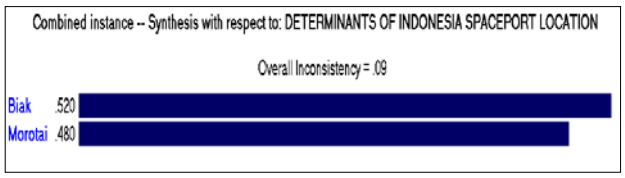
Then location is second priority in this study. Location factor related with geographic condition that is endowment factor to support mission, desaign and technology impac, that are near equoator and wide area. Spaceport is restrictied area and must secure from resident activities. This need a wide area to establishing a number facilities, with integrated moda transportation. So, support for the existence of land area is needed to fulfill the design of the spaceport later. Its a national strategic area consisting of 3 zones, namely: danger one, danger two, and danger three, which is a restricted area for residential activities etc [6].

Table 2. Rank Priority of Spaceport Location Criteria

Level 1	Level 2	Precentage Priority	Rank
Location	Near of Equatorial	9,4	6
	Wide Area	12,4	3
Technical Requirement	Dropzone / Flight Trajectory	21	1
	Mission	10,7	5
	TT & C	10,9	4
Safety and Defence	Sensitivity relate military issues	14,1	2
	Compatible technology	3,2	9
Economic Local	Infrastructure	6,8	7
	Economic Growth	2,3	11
Sosial and Culture	Stability of Local Politic/ Conflict	3,4	8

Environment	Community Customary Law System	0,7	13
Spatial and Land Use	Suitability of regional/ national spatial plan	2,9	10
	Land aquisition	2	12

Then, from pairwice comparation between criteria and alternative, the best alternative location to establish spaceport in Indonesia is Biak Island, with value 0,520, acceptable with inconsistency index 0,09 (< or less than 0,1) (see Graph 2). This study is relevant with previous research, that Biak is the first choice. The potensial of Biak Island is an investment target for Russia in the Air Launch System (ALS) mission and there has been a MoU between the Government of Indonesia and Roscomos Russia since 2005, but until now the discussion was still constrained.



Figh 3. The Alternative Spaceport Location Perception

Contribution of subfactor (see Table 1) from the highes priority of spaceport factor location are identified: (1) dropzone area or flight trajectory; (2) sensitifities related military issues; (3) wide area; (4) TT&C location; (5) Mission; (6) Near Equator; etc. To avoid potential conflicts in launching rockets and or satellites from spaceports, according to keyperson avoided conflict with neighboring countries from the potential of spacedebrice, so is recommended to be located in the coastal area, the outermost islands and vast beach. Sensitivity related military issues is second priority from keyperson perspective, because space technology is "dual use", and its identic with ballistic in military, so state must control them. Therefore, aspects of safety and security are one of the main considerations for determining location. Space technology is sensitive so makes the defense beside civil aspect one of the aspects that will influence, where in an emergency contidion the state can utilize this technology and facilities for the benefit of national defense and security as regulated in the Legislation[6]. According M Dahyar and H Purnomo, safety factor is the first priority factor, but it assosiated with population density and flight trajectory sub factor[14] that can impact on operasional spaceport. But, according several research technicall, military and policticall factors are considered in initial establishing spaceport in USA, and this relevant with the result from AHP analysis from this study.
LAPAN in a previous study recommended Morotai as a space location from consideration of technical factors related to the direction of launch and potential fall of rocket bodies when launch falls on the vast seas, and the presence of at least 2 TT & C locations that can still be in Indonesia, this is in line with the perception of experts about this criteria that Morotai's technical superiority compared to Biak. In terms of the ease of the process of land acquisition or minimum potential local conflict, considered easier community system and acceptance from spaceport project, Morotai Island is more acceptable or choosen.

IV. Conclusion

The results of the data processing obtained the following results, first, the highest priority location factor to establish spaceport are: the technical requirement, location, safety and defence, economic, social and culture and spatial factor. Second, based on multicriteria perspectives, Biak Island is the best alternative choice. The priority of Biak's superiority as a spaceport location based on technical considerations is based on the mission criteria of the existence of spaceport in the future. The mission of the space station in the future is to support the launch towards geostationer orbit. This is supported by the second consideration is the position of proximity to equator. Biak's infrastructure and economic conditions also contributed is better than Morotai island.

V. Acknowledgments

The author would like to thank to keypersons for the information and data provided, and to LAPAN for the opportunity to conduct further studies and support this research.

References

[1] R. Handberg, "Creating transportation infrastructure though state spaceport initiatives: Florida and other examples," *Technol. Soc.*, vol. 24, no. 3, pp. 225–241, 2002.
[2] D. Marsudi, *Teori Lokasi*. Jakarta: Faculty of Economic Publishing, University of Indonesia, 1992.
[3] S.-O. Oh and J.-W. Park, "A study on relative importance and priority regarding airport selection attributes utilizing AHP," *Int. J. Bus. Soc. Res.*, vol. 4, no. 10, pp. 43–53, 2014.
[4] M. Spagnulo, R. Fleeter, M. Balduccini, and F. Nasini, "Management of Small, Low-Cost Space Programs: A New Paradigm," in *Space Program Management*, Springer, 2013, pp. 247–276.
[5] R. Tarigan, "Perencanaan Pembangunan Wilayah, PT," *Bumi Aksara, Jakarta*, 2004.
[6] R. Indonesia, *Indonesia Legislation Law Number 21 of Space on 2013*. .
[7] A. Zauher, "Spaceport: The Necessary Infrastructur for Private Spacelight," 2008.
[8] C. L. T. Center, "Site Selection and Construction of Space Launch Site."
[9] G. Finger, D. Keller, and B. Gulliver, "Public-Private Spaceport Development," in *SpaceOps 2008 Conference*, 2008, p. 3584.
[10] CNES, "No Title." .
[11] IAEA, "Stakeholder Involvement in Nuclear Issues: INSAG-20," Vienna, 2006.
[12] E. H. Forman, "Multi criteria decision making and the analytic hierarchy process," in *Readings in multiple criteria decision aid*, Springer, 1990, pp. 295–318.

[13] V. B. Martins, T. S. Cunha, F. F. Lamego, and C. M. F. Lapa, “Site selection process for new nuclear power plants-a method to support decision making and improving public participation,” 2011.
[14] J. Malczewski, *GIS and Multicriteria Decision Analysis*. 1999.