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Standard Budget Value in the Maintenance of Automated Weather Observing System (AWOS) Equipment at The Meteorology, Climatology and Geophysics Agency

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Abstract:

This research addresses the inefficiencies in proposing maintenance budgets for optimizing the utilization of Automated Weather Observing System (AWOS) spare parts. The primary objective is to analyze the calculation methodology for establishing an ideal standard budget for AWOS maintenance, considering various influencing factors. Employing an applied research method with a qualitative approach, data for the study are derived from interviews and literature studies. The findings reveal that several factors impact the standard budget, encompassing the number of technicians, duration of maintenance, geographical location, transportation, accommodation, daily allowances, type of damage, and the nature of maintenance (preventive/corrective). The standard budget calculation is grounded in maintenance service costs, official travel expenditures, and spare parts procurement costs. Service fees for third-party maintenance are determined through collaborative contracts, while official travel costs align with predetermined standard input expenses. Replacement costs for spare parts are based on UPT reports, expert recommendations, historical maintenance records, priority scaling, and budgetary constraints. The ongoing development of a spare parts analysis method, factoring in these considerations, indicates that the optimal procurement for data logger spare parts is 8 units, with a 90% confidence level for all of Indonesia. This approach aims to ensure AWOS functionality aligns with its technical life (reliability), ease of repair in the event of failure (maintainability), and consistent proper operation (availability).

Keywords: *AWOS, Budget, Maintenance, Spare Parts Analysis*

1. Introduction

Aviation safety is significantly influenced by weather conditions, necessitating reliable weather monitoring tools for airport authorities to ensure safe flight operations. Among these tools, the Automated Weather Observing System (AWOS) plays a crucial role. AWOS is a computerized system designed to automatically measure various weather parameters, including air temperature, humidity, barometric pressure, wind direction and speed, visibility, and cloud height (Sulistya et al., 2019).

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The collected data is then analyzed and disseminated to air traffic control (ATC) and pilots through communication channels such as VHF radio, NAVAID, or ATIS (Putra, 2020).

Meteorological information provided by BMKG (Meteorology, Climatology, and Geophysics Agency) serves as a vital source for aeronautical service users, disseminated through airport authorities. This information encompasses critical elements for aviation, including temperature, weather conditions, cloud cover, surface wind speed, and visibility. However, to ensure the continuous reliability of the disseminated information, regular maintenance of the AWOS equipment becomes imperative. This maintenance includes both preventive measures and corrective actions.

Despite the evident advantages of AWOS in supporting aviation safety, operational challenges may arise, hindering the optimal distribution of flight information. In this context, effective and efficient maintenance, especially in spare parts procurement, becomes crucial. Maintenance issues have been identified, particularly in the procurement process, leading to inefficiencies and increased costs. A recent report (BPK RI, 2022) highlighted challenges in the maintenance and replacement activities of AWOS All Weather Parts in 2021, indicating an excess expenditure of IDR 841,262,400. Notably, discrepancies were found in the installation of spare parts, raising concerns about adherence to maintenance regulations.

Despite the essential role of AWOS in aviation safety, there exists a significant research gap regarding the standardization of budget values for its maintenance costs (Iannou et al., 2021; Hussaini & Yakubu 2019). The current challenges, as exemplified by the reported discrepancies and excess expenditures, underscore the need for a comprehensive study to establish a standardized budget value. The novelty of this research lies in addressing the specific issues related to the maintenance budget of AWOS, especially in spare parts procurement, to enhance effectiveness and efficiency in maintaining equipment integrity. The urgency of this study is evident in the potential consequences of ineffective maintenance practices, including compromised aviation safety and unnecessary financial burdens on the agency. By conducting this research, a standardized approach to budgeting for AWOS maintenance costs can be developed, ensuring optimal performance, cost-effectiveness, and adherence to regulations.

2. Theoretical Background

Nafarin (2004) defines a budget as a plan expressed in numbers based on an approved program for a certain period of time. Pribadi et al. (2020) also argues that a budget is a work plan expressed quantitatively, measured in standard monetary units and other units of measure, covering a period of one year. The characteristics of the budget are as follows: 1). The budget is expressed in units, 2). The period of budget implementation is one fiscal year, 3). Budget managers are bound by their commitment and ability to achieve the goals set in the budget, 4). Approval of the proposed budget is done by the authorized party after going through the budget review process, 5). Under certain conditions the budget may be amended, 6). Budgets are monitored and evaluated on a regular basis.

(BSN, 2018) defines a standard as a technical requirement or something that is standardized, including procedures and methods that are determined by all parties / governments / international decisions by taking into account the requirements of safety, health, environment, development of science and technology, experience and current developments and maximum benefits. Based on the definition of budget and standards described above, the standard value of the budget is defined as a standardized value in the preparation of the budget in a quantitative form that allows it to be compared, analyzed, summed up within the limits of a certain period in its implementation.

Maintenance is defined as an activity to service, maintain and repair or replace facilities/equipment satisfactorily according to plan (Aritonang & Sukardi 2019; Meanwhile, according to (Corder, 2018) Maintenance is a combination of any actions taken to maintain an item or to repair it to an acceptable condition. Based on Government Regulation Number 27 of 2014 concerning BMN / D Management Chapter VII Safeguards and Maintenance Second Part Article 46, maintenance is a series of activities to maintain the condition and repair of all state / regional property so that it is always in good and proper condition and ready to be used in an efficient and effective manner. From some of the above definitions, it can be concluded that maintenance is a collaboration of repair or replacement activities to keep the equipment in good condition so that it can produce the expected performance. The decision variables in the maintenance system policy include 4 (four) things, namely (Corder, 2018)

1. What needs to be maintained? Includes a list of facility components to be maintained and the costs involved. AWOS performance support components consist of many sensors.
2. How is maintenance performed? A maintenance schedule should be drawn up for the components to be maintained starting with a few key components "critical units", after experience is gained in the use of the schedule, more and more machine components are included in planned maintenance until the optimum economic maintenance level is reached.
3. Who does the maintenance? Technology and the need for maintenance services drive the implementation of maintenance programs, both internal and external (through service providers). The main consideration when deciding on a maintenance provider is the lowest cost.
4. Where is the maintenance? The location of maintenance affects the cost

3. Methodology

The research methodology employed in this study is qualitative descriptive analysis. This approach involves obtaining data through in-depth interviews and adapting it to provide insights into the research problem under investigation. The data collected through interviews are then systematically compared with relevant theoretical frameworks to enhance understanding and generate meaningful interpretations.

The research informants selected for this study play pivotal roles in the process of identifying Automated Weather Observing System (AWOS) maintenance needs. The key informants include individuals holding diverse positions and responsibilities within the realm of AWOS maintenance. These individuals comprise the Head of the Unit Pelaksana Teknis (UPT), maintenance personnel specializing in meteorology, members of the Budget Taskforce, technicians responsible for the actual maintenance work, external experts with insights into AWOS systems, the Budget Planner, and the Project Management Group (PMG) specializing in the field of observation.

By conducting interviews with this array of informants, the research aims to capture a comprehensive understanding of the various perspectives, challenges, and practices associated with identifying AWOS maintenance needs. The qualitative nature of the analysis allows for a nuanced exploration of the intricacies involved in the decision-making process related to AWOS maintenance, providing valuable insights for improving maintenance procedures and optimizing resource allocation in this critical domain

4. Empirical Findings/Result and Discussion

AWOS maintenance is carried out by the Center for Instrumentation Calibration and Engineering (Inskal) for meteorology starting in 2019 after previously AWOS maintenance was carried out by the Aviation Meteorology Center. The average AWOS Maintenance Budget compared to the overall Inskal Center maintenance budget is only = 15.52% (based on data from the report on the implementation of PPK Inskal activities for Meteorology from 2019 to 2022).

Table 1. Average AWOS Maintenance Budget Compared to Pusinkal Maintenance Budget 2019 to 2022

Years	Maintenance ceiling inskal/year (Rp)	Awos maintenance ceiling/year (Rp)	Percentage (%)
2019	167,279,500,000	27,605,700,000	16.50
2020	58,495,075,000	27,388,026,000	17.28
2021	93,426,237,000	30,149,370,000	15.59
2022	239,833,152,000	32,641,110,000	13.61
Amount	**759,033,964,000**	**17,784,206,000**	**15.52**
Average	**189,758,491,000**	**9,446,051,500**	**15.52**

Source: data from one DJA and Report on the implementation of PPK Pusinkal Meteorology activities in 2019-2022 (data processed)

Based on the Aloptama update data (updated March 7, 2023), the AWOS baseline data for 2021 and 2022 are obtained as follows:

Table 2. AWOS baseline data for 2021 and 2022

No	Tool Name	Unit	Baseline 2021	Baseline 2022
1	AWOS Category 1	Location	127	128
2	AWOS Category 2	Location	20	19
3	AWOS Category 3	Location	34	37
Total AWOS Categories 2 and 3		**Location**	**54**	**56**
Total AWOS Categories 1,2 and 3		**Location**	**181**	**184**

Source: Memorandum of Service for updating Aloptama data at the Aviation Meteorology Center, Number: B/ND/084/KMP/III/2023 March 7, 2023.

In 2021 the maintenance of all AWOS categories 1,2 and 3 is carried out by the Center, for 181 AWOS locations the average maintenance cost is IDR 166.5 million / location (including official travel costs, maintenance services if carried out by providers and spare parts replacement costs).

Table 3. Average AWOS maintenance cost per site (Year 2021 and 2022)

Year	AWOS maintenance ceiling (Rp)	Number of AWOS (Baseline)	Average AWOS maintenance cost/Location (Rp)
2021	30,149,370,000	181 Lokasi	166.571.105
2022	32,641,110,000	184 Lokasi	177.397.337

Source: PPK Pusinskal activity implementation report and Aviation Meteorology Center Aloptama data update (data processed)

The picture above shows the limited budget that must be managed for the maintenance of each AWOS with the condition that each tool is not the same level of damage, the type of maintenance that must be carried out (PM or CM), the number of times maintenance is carried out in a year, the distance (location) the AWOS is installed, the number of technicians who must carry out maintenance, the AWOS category (1,2 or 3), the AWOS brand and the parts that must be replaced. In the opinion of (Putra et al., 2023) To minimize maintenance costs and maximize maintenance results, it is necessary to consider conditions such as the level of damage impact, location, technical age, and category level of the equipment to obtain practical maintenance costs and assist maintenance decision making.

The data generated by AWOS is considered good quality if it meets the required needs. Therefore, a maintenance mechanism is needed to maintain the quality of the data produced. AWOS maintenance at BMKG is regulated in Decree No. 7/2014. According to Mourning et al. (2024), AWOS that the quality of data generated by AWOS is influenced by AWOS maintenance, maintenance is usually carried out preventively and correctively. Corder (2018) also have the same opinion that preventive maintenance is in the form of regular inspection, maintenance and cleaning to prevent damage. While corrective maintenance aims to restore conditions or repair damage so that it functions properly again (Koke & Moehler 2019; Corder 2018)

Based on the results of interviews and the study of supporting documents, it was found that the AWOS maintenance policy at BMKG is carried out in a preventive and corrective manner. Divided by the level of difficulty of maintenance and who performs the maintenance, there are 4 levels of maintenance, namely a). periodic maintenance (preventive), b). maintenance Level 1, c). maintenance Level 2 and maintenance Level 3; where the maintenance guidelines are based on regulation no. 7 of 2014. To determine the condition of the equipment and the type of maintenance that must be carried out based on input from the work unit and reports from past vendor maintenance results.

The needs that are taken into account in financing maintenance include maintenance services expenditure (for contracted maintenance) and spare parts expenditure. Assessment of spare parts proposals is carried out from users both at the center and in the regions. Identification of spare parts needs is needed to support optimal maintenance, the problem is how to determine the number of spare parts proposals to be effective and efficient. According to (Budiningsih & Jauhari, 2017) In carrying out maintenance, it is necessary to maintain the availability of spare parts in an amount sufficient to meet the needs of spare parts inventory.

Based on the results of interviews with key informants above, it is obtained that the identification of AWOS Category I maintenance needs has been carried out in several work units even though not all of them have collected the form of the need for spare parts to be accommodated by the Center, while the identification of AWOS category 2 and 3 needs is fully carried out by the Center (Pusinskal) by considering the previous year's maintenance results report, the history of damage that often occurs even though it is limited by the limited maintenance budget. The factors affecting the standard budget value are influenced by the number of technicians (people), number of days, location, transportation, accommodation, daily allowance, type of damage and type of maintenance performed (CM/PM), spare parts to be replaced, type of damage. Problems faced in identifying needs include: a). difficulty in determining the ideal number of spare parts provided in the following year, b). there are still fundamental obstacles, namely the inequality of asset data between those who procure AWOS (Deputy for Meteorology), warehouses and users who carry out maintenance (Pus inskal) so that a well-maintained database is needed, c). in addition, regulations that are not firm and clear regarding how long Aloptama that has passed the technical age will continue to be maintained and become a BMN maintenance burden.

According to De Jonge & Scarf (2020) there are various maintenance costs that must be paid in the maintenance process, among others:

1) Labor cost: Labor costs incurred to maintain machine components to keep them in good condition;
2) Spare parts cost: It is the cost of replacing damaged components or purchasing new components.
3) Cost due to maintenance is the revenue lost during machine breakdown.

The difficulty of predicting the demand for spare parts replacement was also conveyed by (Bacchetti & Saccani, 2012) There are several aspects that make spare parts demand and spare parts inventory management a complex problem, namely the high number of spare parts managed and the existence of intermittent or lumpy demand patterns. Intermittent demand is demand that takes place in irregular time intervals and varies greatly in quantity. Meanwhile, lumpy demand is demand that is uneven in terms of time and the amount needed varies, besides requiring more investment in inventory or a longer response time than predicted.

a. Calculation of spare part requirements with the Spare part Analysis Method
This method was developed based on the Poisson distribution. This method helps the reliability of the tool according to the technical life (Reliability), ease of maintenance of the tool in case of failure (Maintainability) and ensures the system operates properly at all times (availability) of the tool. In Spare part analysis, the probability of spare parts with Poisson distribution is not only influenced by the average life of the product/system (failure rate/MTBF value), but also influenced by other constants, namely:

1. N = Quantity / number of products, installed in a system built in a project (in single channel configuration)
2. T= product procurement time (Lead Time), including the administrative process. The more lead time, the more spare parts are used.

So the Confidence level formula for spare part analysis is adapted to :

$$P(x \le k) = \sum_{x=0}^{k} \frac{(n.\lambda.t)^{x}.e^{-n.\lambda.t}}{x!}$$

Assuming:
Failure rate (λ) =3,00409
lead time (t) =8760 hours, (from 365x24 hours)
number of locations procurement year (n) =19
number of existing locations =19
average spare parts used in 2021-2022 = 5
Konfidence level =90%,

For the data logger installed in 2023 is considered 0 because there is no data logger installed, later if there are spare parts that are not installed it will reduce the 2024 plan. then in 2024, the ideal spare parts procurement is 8 units.

Table 4. Parts Analysis Table component parts

Planned quantity (k)	λ.n.t	k!	Xi	(λ.n.t)^xi	e^(λ.n.t)	(e^(λ.n.t)*(λ.n.t)^xi)/k!	probalitas poisson	confidence level (%)
0	5	1	0	1	0,006737947	0,006737947	0,67	0,67
1	5	1	1	5	0,006737947	0,033689735	3,37	4,04
2	5	2	2	25	0,006737947	0,084224337	8,42	12,47
3	5	6	3	125	0,006737947	0,140373896	14,04	26,50
4	5	24	4	625	0,006737947	0,17546737	17,55	44,05

5	5	120	5	3125	0,006737947	0,17546737	17,55	61,60
6	5	720	6	15625	0,006737947	0,146222808	14,62	76,22
7	5	5040	7	78125	0,006737947	0,104444863	10,44	86,66
8	**5**	**40320**	**8**	**390625**	**0,006737947**	**0,065278039**	**6,53**	**93,19**
9	5	362880	9	1953125	0,006737947	0,036265577	3,63	96,82

Data source: the results of the exercise of calculating spare parts analysis by the IRM team and biroren

Based on the results of the interview, it was found that the implementation of spare parts analysis must be adjusted to several conditions, among others: Previous maintenance history, reports from the region, expert recommendations, budgets and priority scales due to limited maintenance budget allocations.

5. Conclusions

The conclusion drawn from this study indicates that various factors influence the standard budget value for Automated Weather Observing System (AWOS) maintenance. These factors encompass the number of technicians, duration of maintenance, geographical location, transportation, accommodation, daily allowances, nature of the damage, type of maintenance (Corrective Maintenance/Preventive Maintenance), replacement parts, and the specific type of damage incurred. The calculation of the standard AWOS maintenance budget value is primarily grounded in three components: a) Maintenance Service Costs, b) Service Travel Costs, and c) Parts Procurement Costs.

However, it is crucial to acknowledge certain limitations in this study. The research focuses primarily on the identified factors influencing the standard budget value, and while comprehensive, there may be additional variables or nuances not fully explored. Additionally, the study provides a snapshot of the existing conditions, and dynamic factors, such as evolving technologies or changes in regulations, may impact the long-term applicability of the findings.

For future research, an in-depth exploration of the interplay between budget allocation and maintenance effectiveness could yield valuable insights. Furthermore, investigating the integration of emerging technologies, predictive maintenance models, or alternative procurement strategies could contribute to enhancing the efficiency of AWOS maintenance. Additionally, a comparative analysis of AWOS maintenance practices across different regions or countries may provide a broader perspective on best practices and potential areas for improvement in the field.

References:

Aritonang, R., & Sukardi, T. (2019). Implementation of Maintenance and Repair of Workshop Tools on Machining Expertise Vocational High School in Yogyakarta Industry-Based. *American Journal of Educational Research*, *7*(10), 670-676.

Bacchetti, A., & Saccani, N. (2012). Spare parts classification and demand forecasting for stock control: Investigating the gap between research and practice. *Omega*, *40*(6), 722–737. https://doi.org/10.1016/j.omega.2011.06.008

Budiningsih, E., & Jauhari, W. A. (2017). Analisis Pengendalian Persediaan Spare Part Mesin Produksi di PT. Prima Sejati Sejahtera dengan Metode Continuous Review. *PERFORMA : Media Ilmiah Teknik Industri*, *16*(2), 152–160. https://doi.org/10.20961/performa.16.2.16994

Carnero, M. C., & Gómez, A. (2021). Optimisation of maintenance in delivery systems for cytostatic medicines. *BMC Health Services Research*, *21*(1), 1-25.

Corder, A. (2018). *Teknik manajemen pemeliharaan*. erlangga.

De Jonge, B., & Scarf, P. A. (2020). A review on maintenance optimization. *European journal of operational research*, *285*(3), 805-824.

Hussaini, A., & Yakubu, S. O. (2019). Automation and modernization of meteorological observation network in Nigeria. *Journal of Applied Sciences and Environmental Management*, *23*(7), 1225-1231.

Ioannou, K., Karampatzakis, D., Amanatidis, P., Aggelopoulos, V., & Karmiris, I. (2021). Low-Cost Automatic Weather Stations in the Internet of Things. *Information,* 12, 146.

Koke, B., & Moehler, R. C. (2019). Earned Green Value management for project management: A systematic review. *Journal of Cleaner Production*, *230*, 180-197.

Nafarin, M. (2004). *Penganggaran Perusahaan* (Edisi revi). Salemba empat.

Puslitbang Transportasi udara. (2020). *Kajian Pengaruh Kondisi Meteorologi bagi perencanaan jalur penerbangan*.

Putra, M., Ilyas, A., Retnoningsih, A. I., Bureau, P., Erwanto, A., Bureau, P., Nugraha, H. A., Santoso, B., Hidayat, A. M., Susilowati, A., & Bureau, P. (2023). *Determination of The Automated Weather Observing System (AWOS) Maintenance Cost Index Based on Fuzzy Inference System*. 121–125.

Pribadi, L. D., Kanto, D. S., & Kisman, Z. (2020). Budget absorption performance in financial education and training agency. *Journal of Economics and Business*, *3*(2).

Sulistya, W., Nugraha, H. A., Dharmawan, G. B., Putra, M., Furqon, A., Sugiarto, S., & Pramagusta, A. P. (2019, September). Development of Automated Weather Observing System Based on Realtime Web Display. In *2019 International Electronics Symposium (IES)* (pp. 577-581). IEEE.