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Identifying inaccuracy of MS Project using system analysis

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Abstract. The problem encountered in project owner's financial accounting report is the difference in total project costs of MS Project to the Indonesian Standard (Standard Indonesia Standard / Cost Estimating Standard Book of Indonesia). It is one of the MS Project problems concerning to its cost accuracy, so cost data cannot be used in an integrated way for all project components. This study focuses on finding the causes of inaccuracy of the MS Projects. The aim of this study, which is operationally, are: (i) identifying cost analysis procedures for both current methods (SNI) and MS Project; (ii) identifying cost bias in each element of the cost analysis procedure; and (iii) analysing the cost differences (cost bias) in each element to identify what the cause of inaccuracies in MS Project toward SNI is. The method in this study is comparing for both the system analysis of MS Project and SNI. The results are: (i) MS Project system in Work of Resources element has limitation for two decimal digits only, have led to its inaccuracy. Where the Work of Resources (referred to as effort) in MS Project represents multiplication between the Quantities of Activities and Requirements of resources in SNI; (ii) MS Project and SNI have differences in the costing methods (the cost estimation methods), in which the SNI uses the Quantity-Based Costing (QBC), meanwhile MS Project uses the Time-Based Costing (TBC). Based on this research, we recommend to the contractors who use SNI should make an adjustment for Work of Resources in MS Project (with correction index) so that it can be used in an integrated way to the project owner's financial accounting system. Further research will conduct for improvement the MS Project as an integrated tool toward all part of the project participant.

1. Introduction

Contractors, as implementers in the project, should be supported with software applications to improve project implementation more effectively. All various management software, whether they have been available at the market for structured decision making, such as Winest [1], MS Project [2], Solver [3], Primavera [4], or even they have been developed by researchers for unstructured decisions for special purposes, such as Neural Network [5, 6], Fuzzy Logic [7], Expert Systems [8], demand a high degree of accuracy. This inaccurate problem of software must be solved immediately so that the use of the software will maximally support the performance and productivity of construction project in Aceh as maximum as possible.

One of the problems encountered, regarding the accuracy of using the MS Project software, is the difference in total project costs. This difference is seen in the inequalities between the nominal of the

project cost plan and performance cost of the project (Realization). The project owner, as a responsible party for paying the contractor's work, does not tolerate this difference, especially in the project owner's financial accounting system. Data accuracy increases confidence in any decision-making decision [9]. Learning and knowing how to operate MS Project, as a tool to improve work productivity in the context of project management is not enough. The contractors should also consider whether the software would provide sufficient accuracy of results of an analytical tool for decision making in a project. The inaccuracy of software output can lead to the contractor's decision-making process to be hampered and even improper. This administrative problem, in its turn, will cause a delay in project completion. This is a case happened in Aceh for those who use MS Project as a tool for project management. This condition illustrates that on the one hand, the use of project management software will improve project management productivity and, on the other hand, its inaccuracies will lead to project administration matters.

The main purpose of this study is to find the cause of the inaccuracy of cost analysis in MS Project against standard cost analysis in Indonesia (referred to as SNI / Standard Nasional Indonesia). Several studies have been conducted such as [10, 11, 12, 13]. The studies are oriented towards the implementation of the MS Project in various object reviews. This research focuses on the accuracy analysis of MS Project. The method of System analysis will be used in this research. This method can also be applied to analyse inaccuracy in other software. This method will immediately find the cause in detail of the components that build the total cost [14]. This study will describe how we can find the cause of inaccuracy of MS Project and in what system elements of the cost estimating process it occurs. To get the correct answer, the MS Project cost and it analysis procedure will be compared to the current one as a manual cost analysis (using Indonesian National Standard). Operationally, the aims of this study are (i) identifying cost analysis procedures for both current methods (SNI) and MS Project; (ii) identifying cost bias in each element of the cost analysis procedure; And (iii) analysing the cost differences (cost bias) in each element to identify what is the cause of inaccuracies in MS Project toward SNI is.

This research has been able to identify the causes of differences in total project costs between MS Project and SNI. This difference is caused by the decimal limitation on the element of the Work of resources ($W_{i,j}$) in MS Project. The limitation on the number of decimals in this element (Work of resources/$W_{i,j}$) has been truncated to be two decimal digits. These truncation has caused a bias in the total cost using MS Project against SNI. As a consequence is the more resources used in a project, the more accumulating cost bias occurred. The result of identification of the cost bias problem in MS Project caused by truncation into two decimal digits in Work of Resources ($W_{i,j}$), encourages the contractor to adjust the cost (correction index) so that the MS Project will be used in an integrated way in the project owner's financial accounting system. It is a future research for MS Project improvement as an integrated tool for all of the participant project. In addition, there is a fundamental difference for the cost estimation procedure in MS Project against SNI, i.e., MS Project does not use the components of the Requirement of Resources ($R_{i,j}$) and Quantity of project activities (Q_i). Both components have blended in the Work of Resources ($W_{i,j}$). Improving the utilization and accuracy of MS Projects can be done by implementing the Requirement of Resources ($R_{i,j}$) and Quantity of project activities (Q_i) in the MS Project system.

2. Methods

This study was conducted with the intention to identify and to review the accuracy of the MS Project to support the performance in managing projects in Aceh. For this purpose, The framework has been built in this research, as shown in Figure 1. The stages and method used in the study are described operatively from the objectives of this study.

Method to identify the costing procedure for both current methods (SNI) and MS Project uses the system analysis approach, as shown in Figure 2. System analysis is to understand the complete

composition of a system or procedures in order to be able identifying and evaluating various problems or obstacles that arise in that system [15]. System analysis could also be used to combine two or more systems into a structured system as well or evaluating problems that have been identified before. Describing the system analysis uses the data flow approach and showing how data moves through the system is, it will have four advantages:

1. It could further understanding of the interrelatedness of systems and subsystems
2. It could communicate the system knowledge to users through data flow diagrams
3. It could be to determine if the necessary data and processes have been defined.

Method to identify the bias in specific elements of the costing procedure is done using a unit cost case of the project activity, where each element of the unit cost of the activity in MS Project will be compared with the cost elements of the SNI. The elements and its connections in the cost system must be indicating their relationship to the cost theory of the body of knowledge, as detail description in the project cost structure [16]. This bias identification is started from the bottom element of the bottom-up procedure for the activity cost, as shown in figure 2. The mathematical equations of each cost element will be used to analyse for both SNI and MS Project. The abbreviation of the mathematical model is as shown in Table 1.

Table 1. Abbreviations

Notation	Description	Notation	Description
i	Number of Activities	OV_i	Overhead of Unit Price
j	Number of Element of each Activity	FC_i	Fixed Cost of each Activity
Q_i	Quantity of Activities	UP_i	Unit Price of each Activity
$S_{i,j}$	Standard Rate of Resources	Qi	Quantity of each Activity
$R_{i,j}$	Requirement of Resources	Cp	Cost of Project
$W_{i,j}$	Work of Resources of each Activity	CA_i	Cost of each Activity
DC_i	Direct Cost	Cp	Project Cost

The case used to identify the MS Project inaccuracy is the unit cost (unit price) of foundation work of a building as an object focus. It makes easier to detect cost differences [17]. The difference will be seen more clearly when uses the real cost data of the project activity in the costing procedure. A case of project activity, the foundation work activity, will be used to describe the bias of MS Project.

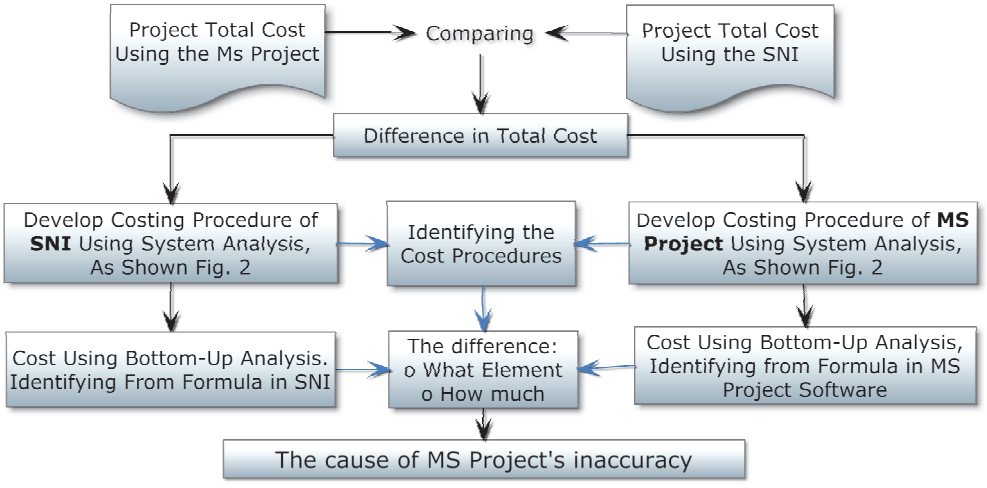

Figure 1. Framework for identifying the project cost accuracy on MS Project toward SNI

3. Result

3.1 Identifying the costing procedure

At this stage, we will identify the costing procedure for both of MS Project and SNI as the current method of project cost analysis. The procedure can be described as a system analysis of inputs, processes, and outputs. System analysis is the decomposition of a complete information system into its parts to identify and evaluate the problems, opportunities, constraints and expected needs so that the proposed improvements could be achieved, as shown in figure 2.

Based on figure 2, the MS Project cost system built on input, process, and output is based on Activity Based Cost (ABC) [18]. Process input is performed at the lowest level of WBS (Work Breakdown Structure) of the project. ABC method is a process to generate project cost from data input done at the activity level. The MS Project input data is on the Work of Resource element($W_{i,j}$), Standard Rate ($S_{i,j}$), both of which are used to generate Direct Cost and Fixed Cost (FC_i). While direct cost is sum product of $W_{i,j}$ and $S_{i,j}$. Direct Cost (DC_i) and Fixed Cost (FC_i) are to generate Activity Cost (CA_i). The Project Cost (Cp) can be generated by cumulative of all of the activity cost. This cost planning analysis method is referred to as bottom-up analysis.

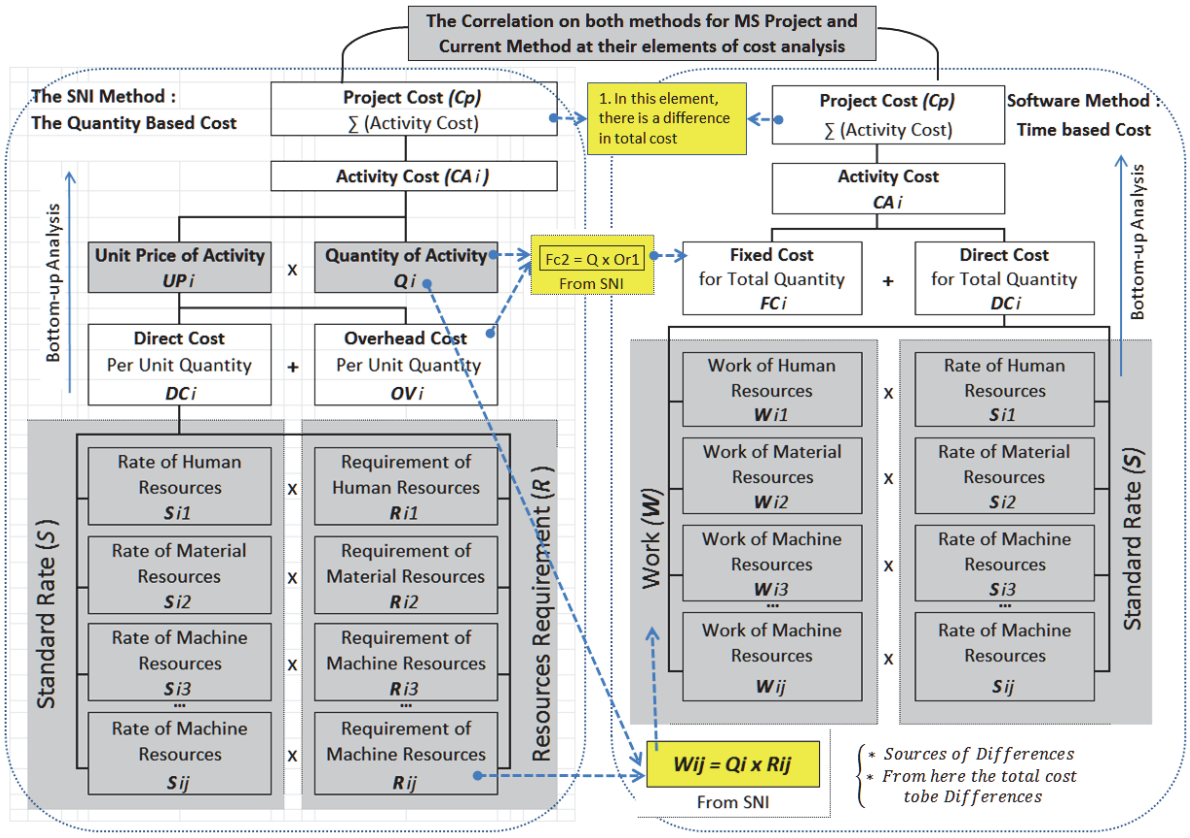

Figure 2. System Analysis for SNI and MS Project

MS Project input data is on the element Requirement of Resource ($R_{i,j}$), Standard Rate ($S_{i,j}$) both of which are used to generate Direct Unit Cost (DC_i) and Overhead Unit Cost (OV_i). Direct Unit Cost (DC_i) and Overhead Unit Cost (OV_i) are to generate Activity Unit Cost or Unit Price of each Activity (UP_i). Cost of each Activity (CA_i) is a multiplication of the Unit Price (UP_i) and it Quantity (Q_i). The result of Project Cost (Cp) is cumulative cost of each project activity ($\sum CA_i$) is cumulative of each activity. This cost planning analysis method is referred to as bottom-up analysis, as shown in figure 2.

3.2 Identifying cost bias in the specific elements of MS Project

Identifying cost bias in the specific element of MS Project can be done by comparing mathematical models of cost analysis to MS Project and SNI, as shown in Formula (15).

3.2.1 Costing Procedure of MS Project

The mathematical model for analysing the total project cost (Cp), which is based on bottom-up analysis, can be explained as follows:

For activity-i in project

$$Cp = \sum_{i=1}^{n} CA_i \quad (1)$$

$$CA_i = (DC_i + FC_i) \quad (2)$$

$$DC_i = \sum_{j=1}^{m} (W_{i,j} x S_{i,j}) \quad (3)$$

$$CA_i = \sum_{j=1}^{m} (W_{i,j} x S_{i,j}) + FC_i \quad (4)$$

For all activity in project

$$Cp = \sum_{i=1}^{n} \sum_{j=1}^{m} (W_{i,j} x S_{i,j}) + \sum_{i=1}^{n} FC_i \quad (5)$$

3.2.2 Costing Procedure of SNI

The mathematical model for analysing the total project cost (Cp), which is based on bottom-up analysis, can be explained as follows:

For activity-i

$$Cp = \sum_{i=1}^{n} CA_i \quad (6)$$

$$CA_i = Q_i x Up_i \quad (7)$$

$$For\ Up_i = \sum_{j=1}^{m} (R_{ij} x S_{ij}) + OV_i \quad (8)$$

$$CA_i = Q_i x (\sum_{j=1}^{m} (R_{ij} x S_{ij}) + OV_i) \quad (9)$$

$$CA_i = Q_i x \sum_{j=1}^{m} (R_{ij} x S_{ij}) + (Q_i x\ OV_i) \quad (10)$$

$$CA_i = \sum_{j=1}^{m} (Q_i x R_{ij} x S_{ij}) + (Q_i x\ OV_i) \quad (11)$$

$$Cp = \sum_{i=1}^{n} CA_i \quad (12)$$

For all activity in the project are:

$$Cp = \sum_{i=1}^{n} \sum_{j=1}^{m} (Q_i x R_{ij} x S_{ij}) + (Q_i x\ OV_i) \quad (13)$$

Based on the fact that there is a cost equivalent of the project activity on MS Project and SNI, the formula (4) of MS Project can be compared with formula (11) of SNI. The input element of the SNI is Requirement of Resources ($R_{i,j}$), Standard Rate ($S_{i,j}$), Overhead Cost (OV_i), and Quantity (Q_i).While the input of MS Project is Work of Resource ($W_{i,j}$), Standard Rate ($S_{i,j}$) and Fixed Cost (FC_i). In general, the similarity of both models for a single activity will be accurate if the Activity cost of the current method should be equal to an activity cost of MS Project.

$$(CA_i)\ of\ Current\ Methods = (CA_i)\ of\ MS\ Project \quad (14)$$

$$\sum_{j=1}^{m} (Q_i x R_{ij} x S_{ij}) + (Q_i x\ OV_i) = \sum_{j=1}^{m} (W_{i,j} x S_{i,j}) + FC_i \quad (15)$$

Based on the comparison of both methods it is seen that there are two components of cost procedure that are not analysed directly by MS Project, as shown in figure 2. Based formula (15), the element of Work of Resources ($W_{i,j}$) and Fixed Cost (FC_i) of MS Project defined as:

$$W_{i,j} = \sum_{j=1}^{m} (Q_i x R_{ij}) \quad (16)$$

This formula is also applied to Fixed Cost (FC_i), as shown in figure 2. In mathematically, as follows:

$$Fc_i = Q_i * OV_i \quad (17)$$

3.3 Identifying inaccuracy of MS Project

The data presented in Table 2, Table 3, and Table 4 are the results of cost estimating by using the unit price analysis for the foundation work using SNI. Table 2 illustrates resource assignment and Table 3 illustrates the calculation the unit price analysis at 1 M^3 of Foundation Activity. Table 4 illustrates bill of quantity of activity that is multiplying by Unit price and its quantities.

Table 2. Resource sheet as standard rate of resource

No	Resources name	Unit	Price per unit (in IDR)
1	Worker	Man days	60,000
2	Bricklayer	Man days	85,000
3	Head of Workers	Man days	110,000
4	Foreman	Man days	75,000
5	Mounting stone	M^3	165,000
6	Portland Cement	Kg	1,200
7	Sand	M^3	160

Table 3. Unit price analysis of project activities using the SNI standard

Unit Price Analysis of the Foundation Work							
Installing 1 M3 of *the Foundation Work*, with the mortar of 1 Portland Cement: 4 sand (Code: SNI DT:91:0007:2007-6.2)							
Components of the Activity	**Requirements**	**Unit**		**Standard Rate**		**Total**
I Materials						
Mounting stone	1.200	M3	x	165,000	=	198,000.00
Portland Cement	202.000	Kg	x	1,200	=	242,400.00
Sand	0.485	M3	x	160	=	77.60
		Subtotal of material			=	440,477.60
II Human Resources						
Worker	1.500	Man/days	x	60,000	=	90,000.00
Bricklayer	0.750	Man/days	x	85,000	=	63,750.00
Head of Workers	0.075	Man/days	x	110,000	=	8,250.00
Foreman	0.075	Man/days	x	75,000	=	5,625.00
		Subtotal of resources			=	167,625.00
		Grand Total of unit price of Foundation work (1) + (2)			=	608,102.60
		Overhead (15%)			=	91,215.39
		Grand Total include overhead			=	699,317.99

Table 4. Estimate Sheet of BOQ (Bill of Quantity) of the Project in the SNI standard system

WBS	Activity	Quantity	Unit	Standard	Unit price	Total
1	The Foundation Work	1	M3	SNI (2013) A.3.2.1.1	699,317.99	699,317.99

The comparative analysis of the nominal cost of the activity between SNI and MS Project is as shown in Table 5. Table 5 shows the difference between total cost of the activity of 925.80 or 0.13% (925.80/699,317.99), which is the difference between total cost of MS Project (1,626,900) and SNI (1,627,340). It shows the value of MS Project bigger than SNI.

Table 5. Cost Comparison for the Foundation work (1 m^3) using MS Project and SNI

Resources	Unit	Requirement	Standard Rate	Unit Price of SNI	MS Project		Differences between MS Project and SNI
					Work	Total	
	Q	*R*	*S*		*W*	Ct_2	
(1)	(2)	(3)	(4)	(5)=(3)x(4)	(6)=(2)x(3)	(7)=(4)x(6)	(8)=(7)–(5)
Foundation Work	1 M^3						
Materials							
Mounting stone	M^3	1.200	165,000	198,000.00	1.20	198,000.00	-
Portland Cement	Kg	202.000	1,200	242,400.00	202.00	242,400.00	-
Sand	M^3	0.485	160	77.60	0.49	78.40	0.80
Human Resources							
Worker	Man/days	1.500	60,000	90,000.00	1.50	90,000.00	-
Bricklayer	Man/days	0.750	85,000	63,750.00	0.75	63,750.00	-
Head of Workers	Man/days	0.075	110,000	8,250.00	0.08	8,800.00	550.00
Foreman	Man/days	0.075	75,000	5,625.00	0.08	6,000.00	375.00
			Total	608,102.60		609,028.40	
			Fixed cost (overhead 15%)	91,215.39		91,215.39	
			Unit Price *(Up)* using SNI	699,317.99	Using MSP	700,243.79	
Total Foundation work with quantity 1 m3				(700,243.79 - 699,317.99):			925.80

Based on this identification, the cause of the differences in total cost is on the truncation decimal of the work of resource ($W_{i,j}$) component of the resources of the Foreman of MS Project. The value should be 0.075 but rounded up to 0.08. The rounding causes the difference in cost to 0.027%.

$$W_{i,j} = Q_i * R_{i,j} = 1 * 0.075 = 0.075 \sim 0.08 \quad (18)$$

While on other elements such as Mountain stone, Portland cement, sand, worker, and Bricklayer is no difference in results, because decimal digits on the element do not exceed two digits. Based on these conditions we have concluded that in MS Project the existence of rounding in a decimal digit of work of resources. Rounding in decimal digits of work of resources may occur in other activities of the project, so the cost may be greater or less than that value, depending on rounding up or down, resulting in the +/- condition in every activity. The cumulative can vary from one project to another project, which is caused by the difference of errors in each project activity and the number of activities of each project varies [19].

4. Discussion

4.1 Comparing the MS Project and SNI

The concept of cost plan for both SNI and MS Project is the same, i.e., using activity-based cost (ABC) concepts that using bottom-up analysis. Principles of cost analysis in MS Project are consistent and applicable in SNI platform, but there are some differences from the data input method. MS Project does not use the cost estimating unit price (unit cost) method, which is built from direct costs and overhead costs. The current method uses the cost estimating unit price (unit cost) method, which is constructed from direct cost units and overhead unit costs. This condition describes MS Project system can only be applied partially to SNI based system. The main difference lies in the use of unit price (unit cost) of SNI and it is not in MS Project. This will make difficult for MS Project that regard to the project implementation in the unit price contract type, it is in line with [20]. The unit price contract type uses the quantity as a basis for contract payment. The unit price will be used as the basis for determining the unit price of quantity performed. Therefore, quantity can be regarded as a basic estimate for project cost estimating. This is a cost plan analysis at an early stage and should be the basis during the implementation phase, as a benchmark of cost control and schedule. For MS Project implementation to be fully implemented, development of MS Project must also be used to analyse the unit price. This requires integration of Quantity of Activity (Q_i) and Requirement of Resource ($R_{i,j}$)

on MS Project system. Furthermore, it will also improve the accuracy of Work of Resource ($W_{i,j}$) calculation on MS Project, as formula (16).

Based on the comparison of both methods it is seen that there are two components/elements of the software that are not analysed directly by MS Project, but analysed separately manner (Beyond the MS Project system). These two components are Quantity of Activity (Q_i) and Requirement of Resource ($R_{i,j}$). This is one of the difficulties in implementing of MS Project. The formula that is used to calculate the Work of Resources ($W_{i,j}$) is the formula (16). The data of Quantity (Q_i) of the project are very important for measuring the progress of construction projects, especially for engineers. The engineer prefers to see the progress of a project that based on the Quantity (Q_i). They are compared to measure the amount of the actual cost. Besides that, both baseline and actual quantity are required to the owner as a validation for the accuracy of the designer consultant jobs. For the contractor, quantity is also needed on determining payment job order for groups of workers, especially for subcontract, as a basis to determine payment.

The Requirement of resources ($R_{i,j}$) is also used as a basis for the baseline of productivity. The Productivity [21] is used as a performance for the workers on the project. This productivity performance is the most important data for the contractor in the next projects. In addition, the contractor will use the requirement as an index to determine the productivity level of the resources plan to be compared with the resource performance. For the further, it will be used to measure the project performance, whether it was about what if analysis for the schedule and cost. Under these conditions, MS Project needs to be developed further, with respect to the Requirement of Resources ($R_{i,j}$). Based on reviews these discussions, in the future research of MS Project needs more developed for both item of Quantity of Activity (Q_i) and the Requirement of resources ($R_{i,j}$), especially for use on the projects in Indonesia that using the SNI platform.

4.2. Root cause the difference for both of MS Project and Current Method

The difference in total cost of the project in case one item of work is estimated at 925.80 (in IDR) or as much as 0.13% (925.80 /699,317.99), as shown in Table 5. This difference is due to the decimal truncation in resources assignment of sand material, head of workers and foreman item, as shown in Table 5, and formula (18). The rounding is 0.23 where it should be 0.225. The nominal value of this difference may vary from an activity to other activities, depending on the number of items and items that have been made. The maximum value that can be achieved from each project activity is ± 0.005 (± 0.5%). This value represents the midpoint value for truncation, the roundup and rounds down. This occurs because of the input data on the work of resource ($W_{i,j}$) are limited only the two decimal places. Under these conditions, the MS Project needs to be developed any further, with respect to the option of decimal places [22]. It is not restricted to a maximum of two digits only. Identification of the root causes the differences of the total cost has been made by comparing of the cost calculation method (cost analysis method) is done by comparing the real cost of single activity of MS Project to SNI. The limitation in a decimal digit of work of resources ($W_{i,j}$) of MS Project is two decimal digit maximum. It is a deficiency of MS Project and it must be resolved to increase the accuracy of the software.

5. Conclusion

Implementing the MS Project in Indonesia, especially for contractors in construction work, have some obstacles. This research has been able to identify the obstacle, namely: The two-digit decimal limitation on elements of Work of Resources in MS Project is the root cause of inaccuracy in the cost analysis of the MS Project. This condition causes MS Project cannot be used in an integrated manner in the project system, especially on the project owner's financial accounting system, which requires no difference in the total cost of the project cost plan and its payment realization. For optimal accuracy performance in Indonesia practice, it needs to do further improvement in the next research.

The contractor's job system in Indonesia using the Quantity-Based Costing (QBC) system, where Quantity of Activity (Q_i), and Requirements of Resources ($R_{i,j}$) is a major component of the analysis of unit price. The contrary, MS Project uses Time-Based Costing (TBC), where Work of Resources ($W_{i,j}$) becomes the main component. This study has identified that there is a relationship between Work of Resources ($W_{i,j}$) in MS Project is same as by multiplying both Quantities of Activity (Q_i), and Requirements of Resource ($R_{i,j}$) in SNI. For MS Project to adapt the SNI system, the MS Project needs to include both of Quantity (Q_i), and Requirements of Resource ($R_{i,j}$) into the operating system cost calculation in MS Project. The development will be carried out in the follow-up study.

System analysis with bottom-up technique has been able to identify the inaccuracy of MS Project to SNI. Thus, the method is also applied to identify on other software in the same cases. In the analysis of the system is needed an understanding of the interrelatedness of systems and subsystems, data flow diagrams. Thus, this research method can also be used to combine two or more systems into a structured system as well, by first having evaluated the problems that have been identified before.

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