Improving Oil and Gas Wireline Log Data Quality Using Six Sigma Methods

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Abstract

Wireline log data is one of the subsurface data that always generated and used in every exploration and production (E&P) activity in oil and gas industry. The quality of subsurface data will help companies shorten the "time-to-first-oil" and extend the production phase. The Monthly Subsurface Data Management Report shows that from October 2018 to July 2020 there were 20 of 34 incident tickets for data quality information problems that were sourced from wireline log data. This study uses the six sigma DMAIC method to identify problems, measure the quality of wireline log data as a product of oil and gas drilling projects and analyze the main causes of wireline log data quality problems. And finally, at the improvement and control stage recommends some steps that can be taken to reduce the problem and how it will be improved in the future.

Keywords
Data Quality, Wireline Log, Six Sigma.

1. Introduction
Every exploration and production (E&P) activity in oil and gas industry always use and generate large amounts of subsurface data. The data obtained from this activity has a very high value because it will be processed into information which will later be used in various decisions regarding the discovery, search, and uptake of oil and gas. Subsurface data have a significant impact on the performance of an exploration and production (E&P) company as a whole. The quality of subsurface data has a contribution of 25-30% of the total value generated by oil and gas companies annually (Hawtin and Lecore 2011). Bad quality of subsurface data will increase the uncertainty of underground geology which will have implications for increasing the risk of oil and gas well drilling failures (Koesoemadinata 2012) and other potential impacts for the company such as operational, tactical and even strategic impacts (Redman, 1998). The current level of data quality can be measured by mapping the data into the dimensions of data quality. The relevant quality dimensions in subsurface data in oil and gas industry are Completeness, Uniqueness, Consistency, Accuracy and Validity (Fuad 2018).

This study uses the six-sigma method with the DMAIC Define-Measure-Analyst-Improve-Control approach in order to identify problems, measure the quality of wireline log data and to identify the main causative factors. And finally, give recommendations in the improvement and control stages to solve the problems.

2. Background Problem
Subsurface Data Management monthly reports in period October 2018 to July 2020 notes that there are 834 subsurface data acceptance tickets with wells data types obtained from exploration activities. In that timeframe, there were 34 incident tickets of inconsistencies in the quality of drilling well data information. Consisting of 20 incident tickets

derived from wireline log data, 13 tickets came from well report data and 1 ticket came from well rock sample data. Incidence details are mapped to the quality dimensions of completeness, uniqueness, consistency, accuracy and validity as shown in Table 1.

Table 1. Well data incident ticket

Well Data Type	Quality Dimensions incident tickets				
	Completeness	Uniqueness	Consistency	Accuracy	Validity
Well Sample	1	0	0	0	0
Well Log Data	5	0	5	0	10
Well Report Data	8	0	2	0	3

3. Six Sigma Quality Improvement Process

The Six Sigma QI tool is a data-driven process improvement management method for minimizing process errors and variations (Elbireer et al. 2013). The basic principle of Six Sigma is product improvement by making improvements to the process so that the process produces the perfect product (Tathagati 2017). Six Sigma is a structured methodology that aims to improve processes by reducing process variance (Chakravorty and Shah 2012), reducing manufacturing and service costs, increasing customer satisfaction, (Näslund 2008, Drohomeretski et al. 2013, Manville et al. 2012), measure and reduce defects and improve product quality (Lee, L. and Wei, C 2009). Six Sigma is a systematic five-step process to help identify and solve problems: Define, Measure, Analyze, Improve and Control (DMAIC) (Neri 2008, Schweikhart 2009).

4. Method

4.1 Data Collection

This is a quantitative research. The initial step is to collect primary data and secondary data related to problems arising from the quality of information on wireline log data. Questionnaires are created and compiled to be used as primary data in determining customer needs and identifying factors that cause problems. The research questionnaire will be used in the Define and Analyst phases as well as validation from the expert.

The number of experts who were asked to validate the results was 8 peoples. The expert requirements are as follows:

1. Respondent is an expert in subsurface oil and gas data
2. Minimum education of respondent is bachelor degree in Geoscience
3. Respondent has minimum 10 years working experience in subsurface oil and gas data

Questionnaires are created and compiled to be used as primary data in determining customer needs and identifying factors that cause problems. The content of the questionnaires can be seen in Table 2.

Table 2. Research questionnaires

No	Questions	Answer	
1	How is the condition of subsurface data management?	Expectation	Reality
		0 - 1 - 2 - 3 - 4 - 5	0 - 1 - 2 - 3 - 4 - 5
2	(if realty < Expectation) what factors cause your assessment of your reality to be smaller than your expectations?	Data Quality	
		Data Services	
		Management Information System	
3	What is the quality level of the wireline log data?	Expectation	Reality
		1 - 2 - 3 - 4 - 5	1 - 2 - 3 - 4 - 5

Table 2. Research questionnaires (cont.)

No	Questions	Answer
4	(if realty < Expectation) What factors cause your wireline log reality data quality assessment to be smaller than expected?	Completeness
		Consistency
		Uniqueness
		Accuracy
		Validity
5	Sort the quality dimensions: completeness, consistency, validity, uniqness, Accuracy from 1 to 5 (1 = less important, 5 = very important)	Completeness
		Consistency
		Uniqueness
		Accuracy
		Validity

4.2 SIX SIGMA

Define Phase. The first step in a DMAIC Six Sigma method is the Define phase. The main purpose in this phase is to define the problems, mapping the company's business processes to identify core processes and supporting processes, determining key outputs from core business processes and customers (Tathagati 2017). To properly define and determining the problem, the team use Pareto diagram of the potential loss as a result of the quality problem of subsurface data information. It can be calculated based on the cost of adding a rework process and the non-productive time (NPT) of data users plus the acquisition cost of each subsurface data type. And the second tool was a Sipoc diagram that is used to document business processes from start to finish and serves to identify relevant elements of an improvement project that will be carried out (Tathagati 2017). Using Secondary Data that has been collected in the form of business process documents related to the wireline log project.

Measure Phase. At the measure stage, the main purpose in this phase is to measure the process performance and the capability level of sigma of the wireline log data quality. To properly measure it, the team using Defect Per Unit (DPU) and Defect per Million Opportunity (DPMO) equation as shown below.

a) *Defect per Unit* (DPU)

$$\text{DPU} = \frac{\text{Total Defects Observed}}{\text{Total Units Inspects}}$$

b) *Defect Per Million Oppurtunity* (DPMO)

$$\text{DPMO} = \frac{\text{Number of defects}}{\text{Number of Units X Number Of Defects Opportunities Per Unit}} \text{ x 1 million}$$

Analysis Phase. The main purpose in analysis phase is to identify and analyze root cause of the problems. What needs to be done is to identify the sources of variation and set targets for performance improvement. In identifying the sources of variation, the researcher used questionnaire data mapped on the fishbone diagram. After all the factors causing the problem have been mapped on the fishbone diagram, then a Failure Mode Effect Analysis (FMEA) is carried out. Through FMEA, you will find potential problems that have the potential to arise. The assessment of the factors causing the defect quality of the wireline log data is based on the level of impact, frequency and detectability of events. The scoring results obtained from the Risk Priority Number (RPN) value are used as a priority sequence for corrective actions that need to be taken.

Improve Phase. The main purpose at this stage are to find several solutions to the problems that occur. Based on the FMEA Pareto diagram from the analysis phase. The team create 5w2h tables to generate each improvement activities from each potential problem. This table will be validated by the expert.

Control Phase. This stage is an important stage in creating continuous improvements towards achieving zero defects. Continuous improvement can only be achieved if the control process is consistently carried out and evaluated. At this stage, the control mechanism steps are determined from implementing the improvement solution

5. Results and Discussion

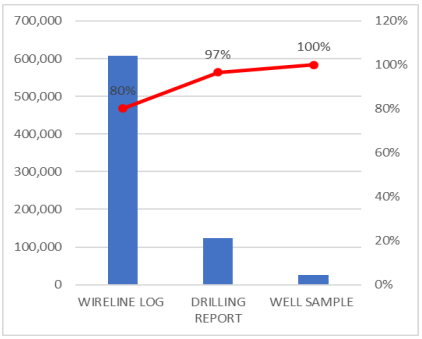
5.1 Results

The questionnaire activity lasted for 7 days with the number of respondents who participated as many as 8 people. Respondents are workers from the internal company who are already considered experts because the respondents already have more than 10 years of work experience, where the field of work is closely related to the use or management of drilling well wireline log data. The questionnaire consists of 11 questions. Based on the expert requirements, the following table shows profiles of the experts.

Respondent's answer to question no. 1 and 2 show the condition of the management and quality of information on the wireline log data that still has a fairly large gap between expectations and reality with an average data management value of 3.25 out of 5. The gap is based on the quality of the subsurface data. Based on the respondents' answers to questions 3 and 4, the mean value of the wireline log data quality is 3,375 out of 5, this is due to issues of validity, completeness and consistency of the record. The gap that occurs between the expectations and the reality of the respondents can be used as an opportunity for continuous improvement of the quality of drilling well's wireline log data information as part of improving the quality of the operation performance.

The respondent's answer to question number 5 is used by the author as primary data in the Define and Analysis stage, while the respondent's answer in numbers 6 - 8 is used by the author as primary data and expert validation in the Analysis stage. The respondent's answer to question number 9 is used by the author as primary data in the Define and Improve stage, while questions number 10 and 11 are used by the author as expert validation in the improve and control stages. A more detailed discussion will be given at each stage of the DMAIC.

Define Phase. The Pareto diagram of the potential loss as a result of the quality problem of subsurface data information show that 80% are came from wireline log data.



Data Type	No of Ticket Incident	Total Potential Loss (USD)	Cum. %
Wireline Log	20	607,216	80
Drilling Report	13	124,165	97
Well Sample	1	25,704	100

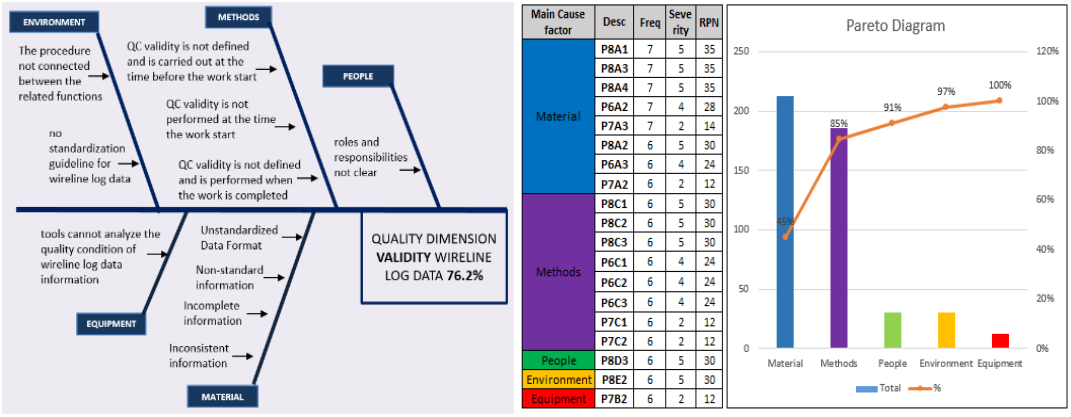
Figure 1. Pareto diagram define problem

Measure Phase. The wireline log data incidents ticket was used in the equations (a) and (b) and the result shown in Table 3.

Table 3. DPU and DPMO wireline log data

Quality Dimentions	No. of failures (defect)	No of unit	No of opportunities	DPU	DPMO
Consistencies	5	87	25	0.003831418	3831.417625
Validity	10	87	25	0.007662835	7662.835249
Completeness	5	87	25	0.003831418	3831.417625

Analysis Phase. In identifying the sources of variation, the researcher used questionnaire data mapped on the fishbone diagram. Respondent's answer to question number 6, number 7 and number 8 are used to fill the fishbone as shown in figure 1. After all the factors causing the problem have been mapped on the fishbone diagram, then a Failure Mode Effect Analysis (FMEA) is carried out. The frequency value is taken from the number of respondents who agree with the statement of the main causes of the problem in number 6-8. While the impact value is taken based on the respondent's answer to question number 5. Since the area of the quality object are in the same area the detection for all factors considered as 1. The Pareto diagram from FMEA shown in figure 2.



Main Cause factor	Desc	Freq	Severity	RPN
Material	P8A1	7	5	35
	P8A3	7	5	35
	P8A4	7	5	35
	P6A2	7	4	28
	P7A3	7	2	14
	P8A2	6	5	30
	P6A3	6	4	24
	P7A2	6	2	12
Methods	P8C1	6	5	30
	P8C2	6	5	30
	P8C3	6	5	30
	P6C1	6	4	24
	P6C2	6	4	24
	P6C3	6	4	24
	P7C1	6	2	12
	P7C2	6	2	12
People	P8D3	6	5	30
Environment	P8E2	6	5	30
Equipment	P7B2	6	2	12

Figure 2. Fishbone diagram validity dimension and pareto diagram FMEA

The FMEA pareto diagram shows that 85% of the causes of the problem are in the material and method factors. The main cause of quality problems on the wireline log data from the material factor is unstandardized data format, information is not written completely, inconsistent information and nonstandard information. While the main cause of the quality problem from the method factor is quality management in the wireline log work has not been defined and quality management procedures have not been established. Therefore it is necessary to have corrective action against the factors that cause the problem, corrective action will be discussed in the stages of improvement.

Improve phase. Based on the factors that cause the problems obtained at the Analysis stage, the team compiles a corrective action plan to be able to fix the problems that occur. Recommendations for improvement consist of 10 activities of improvement steps from material factors and 9 activities of corrective steps from method factors, namely in general, the activities of updating and making standardization documents, business requirements, process flow and reporting mechanisms, evaluation, monitoring quality control on wireline log data, as well as socialization activities and document knowledge sharing and implementation of new process flows. Improvement activities for each factor need to be done serially, while improvement activities between material and method factors can be carried out in parallel. The action plan is prepared using the 5W2H table which can be seen in Table 4.

Control Phase. As a recommendation at this stage, the team proposes a control activity implementation of a improvement solution by applying a zero defect wireline log data quality as one of the key performance indexes.

Table 4.5 W2H improvement activities

Main Cause Problems	WHY	WHAT	WHEN & WHERE	WHO	HOW	HOW MUCH
Material	1. unstandardized data format 2. information is not written completely 3. inconsistent information 4. nonstandard information	- Information Guidelines for Drilling Wireline Logs	TW 2 2021 at Head Office	- Data Owner - Data Management	1. Drafting material for updating the Wireline Log Information Guide, which contains: a. List of mandatory wireline log information that must exist in every log data generated b. Standard format for writing mandatory information c. Standard coordinate system and data units used 2. Focus Group Discussion about wireline log information guideline 3. Updating the Guidelines for Standardization of Oil and Gas Technical Data by adding material to guide wireline log information 4.Publish Revised Guidelines for Standardization of Oil and Gas Technical Data	0
		-Socialization of Guidelines and Individual Work Procedure Document within the company -Guidelines socialization to job executors before work begins	TW 1 2022 at Head Office	- Data Owner - Data Management	1. Socialization of Guidelines and TKI within the company 2. Socialization of Guidelines and TKI to executors before work begins	0
		Monitoring and Evaluation of the Implementation of guideline and Individual Working Procedure	TW 1 2022 at Head Office	Data owner	1. Monitoring reports on the completeness and format of wireline log data by the data management function 2. Regular evaluation and discussion with the data owner function regarding the report on the completeness and format of the wireline log data by the data management team	0
Methods	quality management in the wireline log work has not been defined and quality management procedures have not been established	- Updating and adding of implementation items and quality control mechanisms before, during and after work along with monitoring and evaluation mechanisms for data quality and wireline log information in Guideline A-001 Drilling and Workover Operations Manual	TW 2 2021 at Head Office	- Data Owner - Data Management	1. Updating and adding of implementation items and quality control mechanisms abefore, during and after work along with the monitoring and evaluation mechanisms for data quality and wireline log information in Guideline A-001 Drilling and Workover Operations Manual, including: a. Addition of discussion items regarding mandatory data log information, standard format for writing and filling in data information at the Well Drilling Technical Meeting b. Addition of items. Quality control activities and evaluation of the implementation of filling and writing of wireline log information at the Well Drilling Trajectory Meeting c. Addition of items. Quality control activities and evaluation of the implementation of filling and writing of wireline log information at the Post Job Meeting 2. Publish Guidelines A-001 Guidelines for Drilling and Workover Operations revision-01	0

Main Cause Problems	WHY	WHAT	WHEN & WHERE	WHO	HOW	HOW MUCH
		-Socialization of Guidelines and Individual Work Procedure Document within the company -Guidelines socialization to job executors before work begins	TW 1 2022 at Head Office	- Data Owner - Data Management	1. Socialization of Guidelines and TKI within the company 2. Socialization of Guidelines and TKI to executors before work begins	0
		Monitoring and evaluation of the implementation of the quality control process of the Wireline Log Drilling Information	TW 1 2022 at Head Office	Data owner	1. Monitoring reports on quality control performance of wireline log data by the data management function 2. Regular evaluation and discussion with the data owner function regarding the report on quality control performance of the wireline log data by the data management team	0

5.2 Discussion

1. Management of oil and gas technical data which is currently running is still not quite meeting the expectations of the respondents. There is still a gap between expectations and reality. However, this gap can be used as an opportunity for continuous improvement of the quality of wireline log data information as part of improving the quality of process performance
2. The DPU value and DPMO level from the quality of wireline log data information can be used as an initial reference or comparison in order to assess the effectiveness of the improvement implementation steps proposed in this study
3. problems factors from defects in the quality of information on oil and gas technical data consist of **material** and **method** factors. The main causes of quality problems in wireline log data from material factors are non-standard data formats, incomplete information, inconsistent information and non-standard information. While the main cause of quality problems from the method factor is that quality management in wireline log work has never been defined and quality management procedures have not been standardized
4. Knowing the factors causing the main problem, helping researchers in the improve stage to be able to describe which consists of 8 steps of improvement activities and 4 steps of control activities that have been validated and given additional input and suggestions by experts

6. Conclusion

We conclude that the six sigma DMAIC framework approach can identify the main causes of problems and measure the quality of information on wireline log data. It can help us develop a solution strategy plan for improvement activities in order to solve the problems that occur, and assessing the effectiveness of these improvement activities. The results of this study are expected to provide improvement and control activities that is measurable to evaluate. Further research is necessary to analyze are these improvement activities is truly optimum, effective and efficient.

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Biographies

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