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Simple Multi-Attribute Rating Technique (Smart) Decision Making for Technology Selection of Real-Time Well Monitoring Project

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ABSTRACT

The real-time data availability is very important for analysis and decision-making process in oil and gas industry. This research objectives are to identify the major root cause of oil production loss and selecting the best alternative of Supervisory Control and Data Acquisition (SCADA) technology for real-time oil wells monitoring project. The manual wells monitoring is one of major contributor for oil production loss causes. The licensed frequency radio modem is selected SCADA technology based on Simple Multi-Attribute Rating Technique (SMART) process combined with the cost and benefit analysis. The implementation plan will be focus on project integration management with risk assessment recommendations.

Keywords: decision making, oil wells, project, real-time, SCADA, SMART

1. Business Issue

XYZ is one of oil and gas company in Indonesia which has more than 5,000 oil wells with Mechanical Pumping Unit (MPU) scattered in ±125 square miles area (D-Field). The manual well monitoring activity with its equipment (Figure 1) is conducted to monitor the MPU performance such as: pressure, temperature, On-Off status, rod load, motor status, etc. Historically, this method potentially causes oil production loss. The new method is real-time well monitoring by using SCADA (Supervisory Control and Data Acquisition). This method had been implemented for 30% of total oil wells population. In 2019, the company wants to expand the utilization of this real-time method for additional 1,500 wells in D-Field to increase the monitoring coverage until 50% of total oil wells population. The company requires to select the best alternative for SCADA technology implementation for the real-time oil wells monitoring project with some given constraint from internal management.

The Figure 2 shows the oil production loss for the implementation of manual well monitoring (3,500 wells) since March 2017 – June 2019 with total accumulation oil loss was 42,000 bbls or 53 BOPD in average.

Figure 1. Manual Well Monitoring Equipment

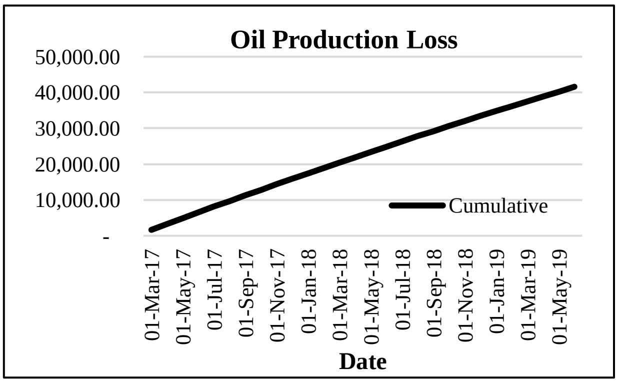

Figure 2. The Oil Production Loss from Manual Well Monitoring Implementation

2. Methods

2.1. Conceptual Framework

The conceptual framework block diagram for this research is shown in Figure 3 below

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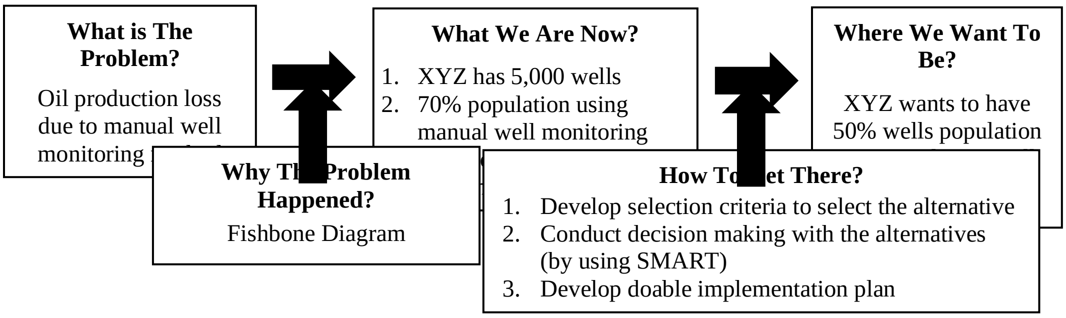

Figure 3. Conceptual Framework of The Research

2.2. Analysis of Business Situation

2.2.1. Manual Well Monitoring Operation

The manual well monitoring is conducted regularly by the operation team. Design concept of this method involves several sensing / traducer equipment (load cell, position transducer, current probe and clamp on transducer) and computer. The work sequence of this method is shown in the following Figure 4.

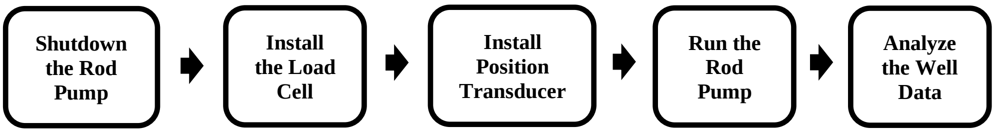

Figure 4. The Manual Well Monitoring Work Sequence

2.2.2. Real-Time Well Monitoring Operation

The real-time well monitoring architecture (See Figure 5) is based on SCADA technology which are consist of six major equipment: Remote Terminal Unit (RTU), Field devices (transmitters, load cell, transducer), Modem, Base Transceiver Station (BTS) Tower, Server, and Fiber Optic.

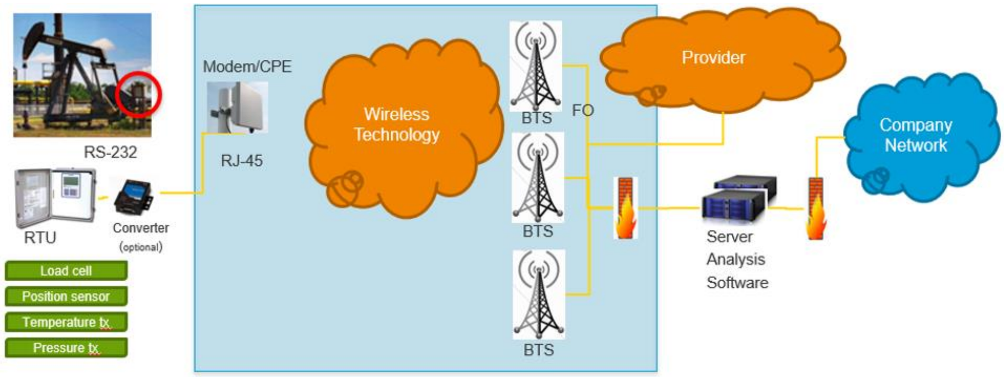

Figure 5. The Real-Time Well Monitoring Infrastructure

The real-time well monitoring equipment is using real-time dynamometer which installed permanently at field with SCADA technology. The typical field installation of this method is shown if Figure 6 below

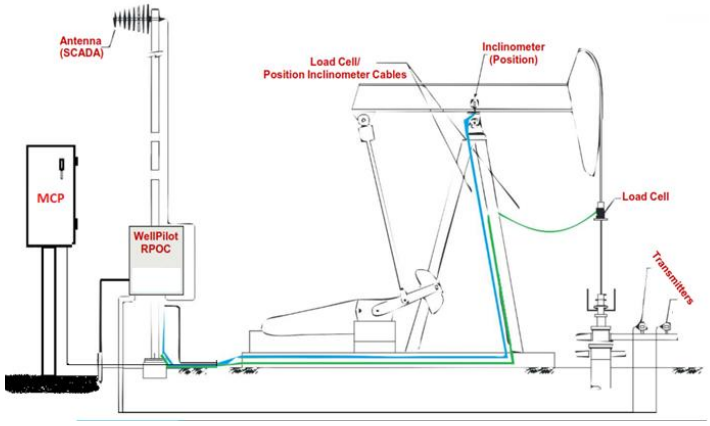

Figure 6. Typical Real-Time Well Monitoring Installation

2.2.3. Fishbone Diagram

This research utilizes Fishbone Diagram to find the root cause of oil production loss in XYZ. The fishbone diagram is a proven tool that can help this research to perform a cause and effect analysis to solve the problem in this research. The fishbone diagram is developed with five (5) steps below:

1. Draw Problem Statement (Oil Production Loss)
2. Draw Major Cause Categories (Person, Method, Machine, Material, Environment)
3. Brainstorm Causes/Issues
4. Categorize Causes/Issues
5. Identify Root Causes

The Figure 7 is the Fishbone Diagram that shows the root cause of oil production loss relates with five categories in XYZ.

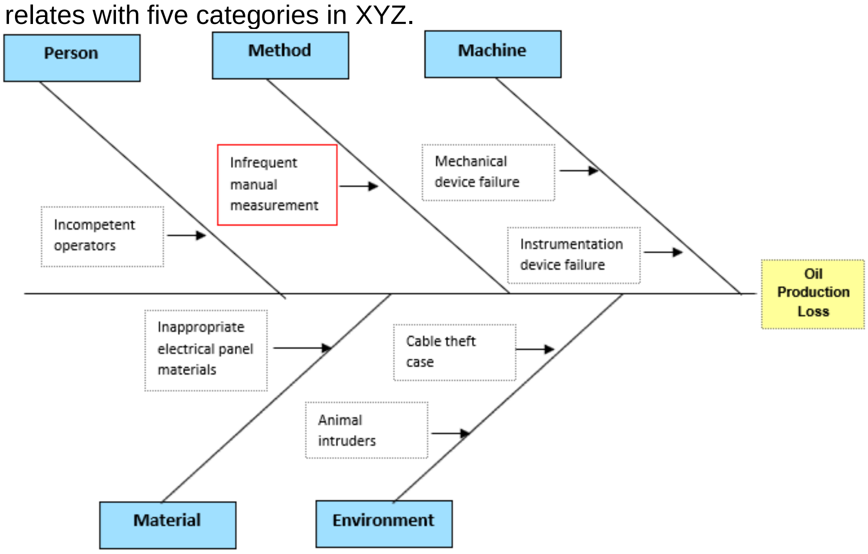

Figure 7. Fishbone Diagram of Oil Production Loss

Based on the root cause analysis with Fishbone Diagram, infrequent manual measurement method is a major root cause that cause oil production loss with *high urgency to be solved*, *rising trend likelihood* and *having the greatest impact*. This manual method needs to be solved by implementing real-time well monitoring method which has many advantages in preventing oil production loss for some selected oil wells in D-Field area.

3. Results and Discussion

3.1. Alternative of Business Solution

Supervisory Control and Data Acquisition (SCADA) is a technology used in telemetry system to gather the information from any instrumentation devices. This technology is widely used in oil and gas industry including real-time well monitoring. Some proven technology assessed for this research are :

a. Radio Trunking
b. Licensed Frequency Radio
c. Fiber Optic
d. GPRS/GSM
e. Satellite

3.2. Analysis of Business Solution

There are many SCADA technology are available in the market to be selected by the project team. The decision-making process is required to be performed to select the best technology for real-time well monitoring to meet the criteria and the company constraints.

The decision-making process will be performed by using multi criteria with Simple Multi Attribute Rating Technique (SMART). This method is used in this research due to ease of use in practical to perform faster decision making.

SMART is one of the methods for decision involving multiple criteria or objectives with a finite set of alternatives. The performance of each alternative is expressed in grades on numerical scales, which are evaluated through a direct-rating procedure. (Makowski, 2001:3). By using this methodology, the decision maker from many different backgrounds can easily apply the method and understand its recommendations. There are eight (8) main stages of SMART are shown in the Figure 8 below

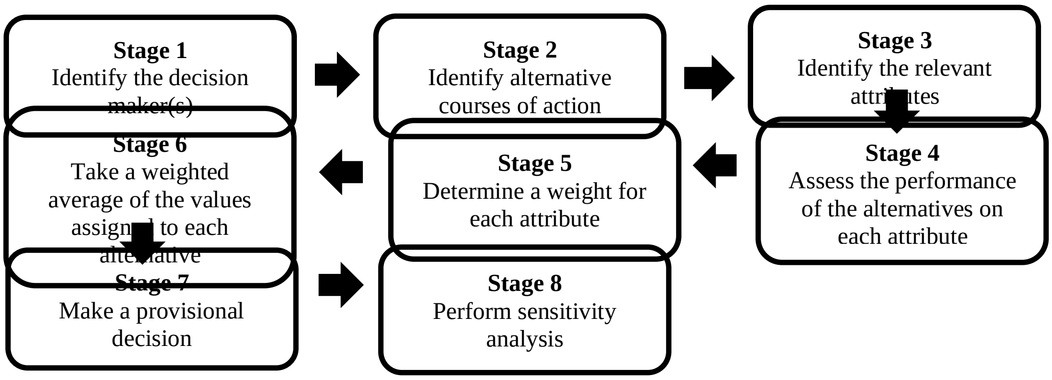

Figure 8. SMART Process Flow Diagram

1) **Stage 1 : Identify decision maker(s)**

The decision maker of this project is Decision Executive, a person in managerial level that has the highest interest in this project. The decision maker is supported by Decision Review Board (DRB) during decision making process. The member of DRB are representative from each related department in managerial level.

2) **Stage 2 : Identify alternative courses of action**

The alternatives were developed based on previous project and discussion or interview with some expertise in the company, which are consist of: Project Manager, Senior Petroleum Engineer, Instrumentation Engineer, Information Technology Specialist, Operation and Maintenance Representatives.

3) **Stage 3 : Identify the relevant attributes**

The relevant attributes in the alternatives is called the “Decision Criteria”. The project team has two major attributes, *Cost* and *Benefits* attributes as seen in Figure 9. The criteria were developed based on the group discussion and lesson learn from previous project.

The project team develop the scoring matrix based on defined criteria in Table 1. The scoring matrix use a number range between 1-5 which can represent the preference of each criteria.

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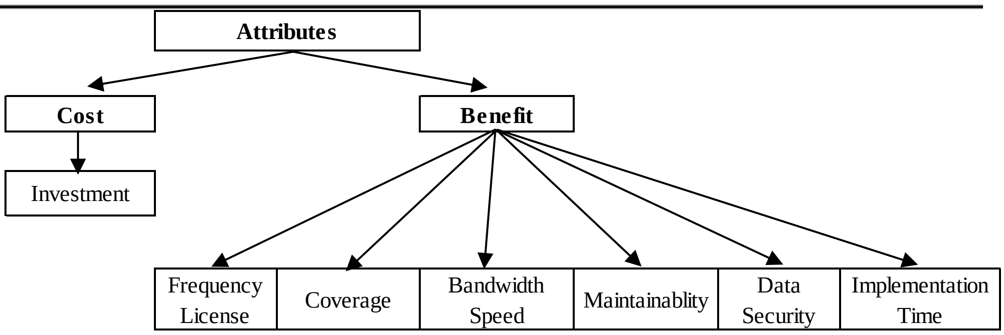

Figure 9. Value Tree of Cost and Benefits Attributes

Table 1. The Scoring Matrix for the "Benefits" Attributes

BENEFIT ATTRIBUTES	SCORING MATRIX		
	1	3	5
Criteria #1 Frequency Licensing	Frequency License is needed		Doesn't Need frequency License
Criteria #2 Coverage	Limited coverage	Full coverage with additional repeater	Full coverage without additional repeater
Criteria #3 Bandwidth Speed	up to 9.6 kbps	9.6 - 1 Mbps	> 1 Mbps
Criteria #4 Maintainability			
Maintenance cost per unit (annually)	> US$ 3000	US$ 2000 - US$ 3000	< US$ 1000
Mean Time Between Failure (MTBF)	2 years	2 - 4 years	> 4 years
Criteria #5 Data Security	Low	Medium	High
Criteria #6 Implementation Time	> 2 years	1 - 2 years	1 year

4) Stages 4 : Assess the performance of the alternatives on each attribute

In this stage each possible alternative of SCADA technology is assessed with defined criteria or attribute with the scoring matrix as explained in Stage 3 of SMART. The following Table 2 shows the summary of scoring for each alternative with its selection criteria. The detail scoring for each alternative can be found in Appendix A.

Table 2. The Scoring Matrix for Each Alternative

CRITERIA	RADIO TRUNKING	LICENCED FREQ. RADIO MODEM	FIBER OPTIC	GPRS/ GSM	SATELLITE
1. Frequency License	1.0	1.0	5.0	3.0	5.0
2. Coverage	5.0	5.0	1.0	3.0	5.0
3. Bandwidth Speed	1.0	4.0	5.0	3.0	3.0
4. Maintainability	2.0	4.0	5.0	3.0	2.0
5. Data Security	3.0	5.0	3.0	2.0	2.0
6. Implementation Time	5.0	5.0	1.0	5.0	3.0

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5) **Stage 5 : Determine a weight for each attribute**

The weight for the "Benefits" attributes/criteria is obtained through group discussion or workshop involved some expertise as mentioned in Stage 2. Based on the focus group discussion, the implementation time is the most important benefits criteria. Criteria about the data security and coverage is the second important criteria. The swing and normalized weight of each criteria is shown in the Table 3 with Direct Rating method.

No	SCADA Technology	Total Cost (US$)
1	Radio Trunking	2,616,000
2	Licensed Frequency Radio	2,471,000
3	Fiber Optic	7,780,760
4	GPRS/GSM	2,010,000
5	Satellite	12,470,000

Table 3. The Swing and Normalized Weight for Each Criteria

No	Attribute/Criteria	Weight	Normalized Weight
1	Frequency License	60	0.12
2	Coverage	90	0.18
3	Bandwidth Speed	80	0.16
4	Maintainablity	70	0.14
5	Data Security	90	0.18
6	Implementation Time	100	0.20
	Total Raw weight	**490**	**1.00**

6) **Stage 6 : For each alternative, take a weighted average of the values assigned to that alternative**

After the criteria weights have been normalized, the next step is to calculate the aggregate score of each alternative by multiplying each score in Table 5 with normalizing weight from Table 3. The detail of aggregate scoring for each alternative can be found in Appendix B.

7) **Stage 7 : Make a provisional decision**

The *Cost and Benefit Analysis* is conducted to give more comprehensive information for Decision Maker and DRB Members prior to take the final decision about selected SCADA technology for real-time well monitoring project.

The Table 4 and Figure 10 are show the *Cost and Benefit Analysis* between alternatives for SCADA Technology.

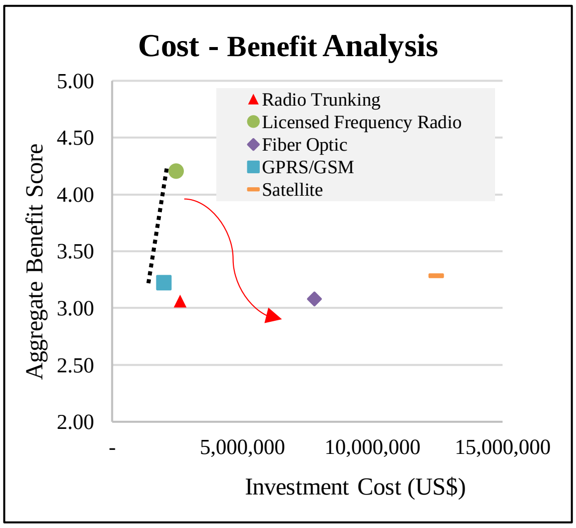

Table 4. The Cost and Aggregate Score for Each Alternative

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Efficient Frontier Line

Figure 10. The Cost – Benefit Analysis for Each Alternative with Efficient Frontier Line

There are 2 alternatives that can be selected in term of **Cost & Benefit** attributes. Those alternatives are **Licensed Frequency Radio (LFR)** and **GPRS/GSM**. The both alternatives are connected by *Efficient Frontier Line.*

No	SCADA Technology	Aggregate Score
1	Radio Trunking	3.06
2	Licensed Frequency Radio	4.20
3	Fiber Optic	3.08
4	GPRS/GSM	3.22
5	Satellite	3.29

Table 5. The Cost and Benefit Analysis Between LFR vs GPRS/GSM

Cost and Benefit Analysis		GPRS/GSM	
		$2,010,000	3.22
Licensed Frequency Radio	$2,471,000	**$470,604/point**	
	4.20		

Based on the Table 5 about *Cost and Benefit Analysis* for both alternatives, the project team and decision maker can make the consideration as follows:

- **If the extra available budget < $ 470,604 ➔ GPRS/GSM**
- **If the extra available budget ≥ 470,604 ➔ Licensed Frequency Radio**

Based on the Cost and Benefit Analysis (highest benefit with available budget), the project team choose the **2nd alternative** by **using licensed frequency radio** for real-time well monitoring SCADA technology.

8) Stage 8 : Sensitivity Analysis

To evaluate how robust the solution, the sensitivity analysis can be done. Sensitivity analysis shows how the changes in the decision criteria's weight can influence its aggregate score.

Sensitivity analysis can be calculated by changing the raw weight and computing each decision criteria to the weight. In this research, sensitivity analysis is used to evaluate the robustness of Alternative 2 (Licensed frequency radio modem) in criteria **"Coverage"** and "**Implementation Time".**

The sensitivity analysis result in "**Coverage**" criteria is shown in Figure 12(a) which conclude that the changing on weight of coverage will not have significant impact on the selected alternative.

The sensitivity analysis result in "**Implementation Time**" criteria is shown in Figure 12(b) which conclude that the changing on weight of it will not have significant impact on the selected alternative.

The Alternative 2 is still has the highest aggregate score among the other solution.

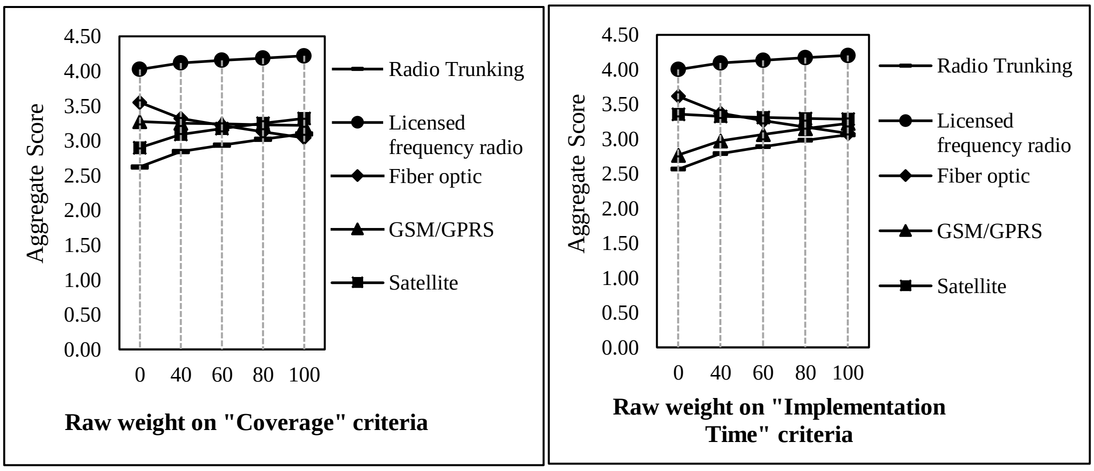

Figure 12. (a) Sensitivity Analysis for Weight on “Coverage” Criteria
(b) Sensitivity Analysis for Weight on “Implementation Time” Criteria

4. Implementation Plan

4.1. Project Integration Management

The implementation plan for the selected alternative is use project integration management strategy which include the scope, schedule, cost, quality, resource, communication, risk, procurement and stakeholder management. The integration management will be conducted during initiating, planning, executing, monitoring, controlling and closing phase of the project. The Table 6, below shows the process area of project integration management.

Table 6. The Project Integration Management

Project Integration Management								
Scope	**Schedule**	**Cost**	**Quality**	**Resource**	**Communication**	**Risk**	**Procurement**	**Stakeholder**
Define Scope	Develop schedule	Cost Estimate	Manage Quality	Develop Team	Manage Communication	Identify Risk	Conduct Procurement	Stakeholder Engagement
WBS				Manage Team		Manage Risk		

Information described on implementation plan documents includes:

A. Stakeholder analysis and engagement plan
B. Project team development
C. Work breakdown structure (WBS)
D. Contracting plan
E. Project schedule estimate

The detail implementation plan can be seen in Appendix C.

4.2. Risk Management

Another focus in this research is about the risk management for the project. The activity is started from planning until monitoring and controlling phase. The objective is decision makers clearly understand critical project risks and uncertainties and the appropriate mitigation strategies including the clear owner, an understanding of how, why, when and by whom the critical project risks or uncertainties will be managed.

Table 7. The Project Risk Register and Mitigation

Risk to Project Success	Probability of Occurring (H/M/L)	Mitigation Strategy (Options to deal with the stated risk)	Probability Success (H/M/L)	Person Responsible
Delay on budget Approval	M	Conduct Pre-liminary meeting with the government and closely monitor the flow of the document	H	Project Engineer/Manager
Lack of stakeholder support	L	Effective communication with Steering Team/DE	H	Project Engineer/Manager
Un-readiness operations and maintenance to operate the unit	M	Involve operations/maintenance in manpower requirements early and effectively communicate with Steering Team/DE	H	Project Engineer/Manager
Weather conditions	M	Develop a working plan wherein field work activities dependent on the weather shall be one during dry season	H	Project Engineer/Manager
Poor planning	M	- Define and communicate the project execution plan with project members, contractors and Steering Team/DE - Work activities should be defined clearly	H	Project Engineer/Manager
Poor performance by contractors	H	- Monitor closely the work progress and liaise with Contractor's Site Management for any slippage in schedule	H	Project Engineer/Manager/Procurement
Material shortage/ Major equipment delay	H	- Apply some contingencies on the material quantity - Assign QA to perform quality check and expediting	H	Project Engineer/Manager, QA/QC, Procurement
Possibility of un-compatible Field Device	M	- Make software & system testing as part of Bidding process, - Make sure the bidder offer RTU that	H	Project Engineer/Manager/IT

RTUs with SCADA	compatible with existing analytic software

5. Conclusion and Recommendations

5.1. Conclusion

From this research can be concluded:

1) Manual well monitoring is one of major contributor on oil production loss in XYZ based on urgency, trend and its impact criteria.
2) The manual well monitoring required well shut in and provide in-frequent data and cannot providing real-time information.
3) The real-time well monitoring is required SCADA technology selection as the replacement of manual well monitoring.
4) There are several alternatives for SCADA technology available in the market, such as radio trunking, licensed frequency radio, fiber optic, GSM/GPRS and satellite.
5) The selection of SCADA technology in this research is using SMART methodology for decision making process due to it is ease of use in practical
6) The selection criteria are developed by the project team which are consist of: Cost to Implement, Requirement on Frequency Licensing, Signal Coverage, Bandwidth speed, Maintainability, Data Security and Implementation Time
7) Based on SMART methodology, the frequency licensed radio modem is selected as the best alternative for SCADA technology.
8) Based on sensitivity analysis, the selected alternative has good robustness in term of “Coverage” and “Implementation time” benefit criteria.

5.2. Recommendations

1) The project team is recommended to focus on developing Project Execution Strategy for activities that included in Critical Path schedule.
2) The SCADA technology with Radio Licenses was selected for this project. The project team is recommended to conduct “prove of concept test” during tender process to ensure the compatibility and performances of the system meet our expectation.
3) The project team is recommended to conduct risk assessment prior the installation of the real-time well monitoring device.

6. References

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APPENDIX A

A. Radio Trunking

Table A.1 The Scoring Matrix for Radio Trunking

Criteria	Score	Description
1. Frequency license	1.0	This technology requires this license
2. Coverage	5.0	Full coverage is possible without additional repeater
3. Bandwidth speed	1.0	Low speed data transfer rate (9.6 kbps)
4. Maintainability	2.0	Maintenance cost US$ 3,000, MTBF 3 years
5. Data security	3.0	Medium data security because have specific license
6. Implementation Time	5.0	Can be implemented in 1 year

B. Licensed Frequency Radio Modem

Table A.2. The Scoring Matrix for Licensed Frequency Radio Modem

Criteria	Score	Description
1. Frequency license	1.0	This technology requires this license
2. Coverage	5.0	Full coverage is possible without additional repeater
3. Bandwidth speed	4.0	Up to 1 Mbps data transfer rate
4. Maintainability	4.0	Maintenance cost US$ 1,500, MTBF 4 years
5. Data security	5.0	High data security because have specific license
6. Implementation Time	5.0	Can be implemented in 1 year

C. Fiber Optic

Table A.3. The Scoring Matrix for Fiber Optic

Criteria	Score	Description
1. Frequency license	5.0	This technology does not require this license
2. Coverage	1.0	Limited coverage
3. Bandwidth speed	5.0	Fastest data transfer rate (>1 Mbps)
4. Maintainability	5.0	Maintenance cost <US$ 1,500, MTBF >4 years
5. Data security	3.0	Medium data security (common technology without specific license)
6. Implementation Time	1.0	Implementation time is more than 2 years, estimate in 3 years

D. GPRS/GSM

Table A.4. The scoring matrix for GPRS/GSM

Criteria	Score	Description
1. Frequency license	5.0	This technology does not require this license

2. Coverage	3.0	Full coverage is possible with additional repeater
3. Bandwidth speed	3.0	Up to 1 Mbps data transfer rate
4. Maintainability	3.0	Maintenance cost US$ 2,500, MTBF 3 years
5. Data security	2.0	Low data security (common technology without specific license)
6. Implementation Time	5.0	Can be implemented in 1 year

E. Satellite

Table A.5. The Scoring Matrix for Satellite

Criteria	Score	Description
1. Frequency license	5.0	This technology does not require this license
2. Coverage	5.0	Full coverage is possible
3. Bandwidth speed	3.0	Up to 1Mbps data transfer rate
4. Maintainability	2.0	Maintenance cost US$ 3,000, MTBF 2 years
5. Data security	2.0	Low data security because do not have specific license, vulnerable to computer threat in the network
6. Implementation Time	3.0	Can be implemented in 1-2 year

APPENDIX B

A. Radio Trunking

Table B.1. The Aggregate Score for Radio Trunking

NO	CRITERIA	1.RADIO TRUNKING		
		SCORE	WEIGHT	TOTAL
1	FREQUENCY LICENSE	1.0	0.12	0.12
2	COVERAGE	5.0	0.18	0.92
3	BANDWIDTH SPEED	1.0	0.16	0.16
4	MAINTAINABILITY	2.0	0.14	0.29
5	DATA SECURITY	3.0	0.18	0.55
6	IMPLEMENTATION TIME	5.0	0.20	1.02
	TOTAL AGGREGATE SCORE			**3.06**

B. Licensed Frequency Radio Modem

Table B.2. The Aggregate Score for Licensed Frequency Radio Modem

NO	CRITERIA	2. LICENCED FREQ. RADIO MODEM		
		SCORE	WEIGHT	TOTAL
1	FREQUENCY LICENSE	1.0	0.12	0.12
2	COVERAGE	5.0	0.18	0.92
3	BANDWIDTH SPEED	4.0	0.16	0.65
4	MAINTAINABILITY	4.0	0.14	0.57
5	DATA SECURITY	5.0	0.18	0.92
6	IMPLEMENTATION TIME	5.0	0.20	1.02
	TOTAL AGGREGATE SCORE			**4.20**

C. Fiber Optic

Table B.3. The Aggregate Score for Fiber Optic

NO	CRITERIA	3. FIBER OPTIC		
		SCORE	WEIGHT	TOTAL
1	FREQUENCY LICENSE	5.0	0.12	0.61
2	COVERAGE	1.0	0.18	0.18
3	BANDWIDTH SPEED	5.0	0.16	0.82
4	MAINTAINABILITY	5.0	0.14	0.71
5	DATA SECURITY	3.0	0.18	0.55
6	IMPLEMENTATION TIME	1.0	0.20	0.20
	TOTAL AGGREGATE SCORE			**3.08**

D. GPRS/GSM

Table B.4. The Aggregate Score for GPR/GSM

NO	CRITERIA	4. GPRS/GSM		
		SCORE	WEIGHT	TOTAL
1	FREQUENCY LICENSE	3.0	0.12	0.37
2	COVERAGE	3.0	0.18	0.55

3	BANDWIDTH SPEED	3.0	0.16	0.49
4	MAINTAINABILITY	3.0	0.14	0.43
5	DATA SECURITY	2.0	0.18	0.37
6	IMPLEMENTATION TIME	5.0	0.20	1.02
	TOTAL AGGREGATE SCORE			**3.22**

E. Satellite

Table B.5. The Aggregate Score for Satellite

NO	CRITERIA	5. SATELLITE		
		SCORE	WEIGHT	TOTAL
1	FREQUENCY LICENSE	5.0	0.12	0.61
2	COVERAGE	5.0	0.18	0.92
3	BANDWIDTH SPEED	3.0	0.16	0.49
4	MAINTAINABILITY	2.0	0.14	0.29
5	DATA SECURITY	2.0	0.18	0.37
6	IMPLEMENTATION TIME	3.0	0.20	0.61
	TOTAL AGGREGATE SCORE			**3.29**

APPENDIX C

A. Stakeholder Analysis and Engagement Plan
Stakeholder Analysis

The real-time well monitoring project is involving some stakeholders, both internal and external stakeholders, the people or organizations who are directly affected by the performance of the project. The key stakeholders are engaging early in the project initiation and planning stages to capture all their concerns, feedbacks prior to moving the project toward design and execution stages. Communication and engagement plan are defined earlier so that the project can obtain the full support from the stakeholders with minimum disruption later on during the project execution stages. The analysis was conducted to rate stakeholder's level of interest and power toward the project qualitatively. The developed stakeholder analysis and engagement plan is shown on table C.1

Table C.1. Stakeholder Analysis and Engagement Plan

Stakeholder	Level of Interest	Level of Power	What they consider a win – their drivers?	What do project need/seek from them?	How to engage/gain their support?
SKK Migas	High	High	Cost and Schedule Effectiveness	Technical and budget approval in timely manner	**Manage closely.** Conduct regular meeting, presentation, obtain their feedbacks
Operation and Maintenance	High	High	Minimum operation disruption during construction, operable and	Work coordination and acceptance	**Manage closely.** Involved on project decision and alternative selection. Maintain close relationship

			maintainable facility		and representative in project team
Facility Engineering Team HO	High	High	Predictable timeline and schedule for resources, budget allocation	Resources for engineering, project and construction	**Manage closely.** Involved on project team
Asset Team	High	Low	Oil production	Oil forecast and wells candidate	Inform the project update status of the project
Contractors	Low	Low	Constructability	Experience, manpower and quality of job	Follow the formal regulation and contract
XYZ Management	High	High	Corporate compliance, safety, cost, schedule	Full support, engagement with external and internal approval	Follow the normal Power of Attorney and Authorization process

Stakeholder Engagement

The key internal stakeholders are consisting of some department, such as Asset Team, Operation and Maintenance team, and Facility Engineering team who were already engaged earlier during the facility assessment, project initiation and development in earlier phase. The representative from each team are proposed to be kept involved during the project execution. The engagement for each team can be done by give them the project status, update, cost, schedule, finding, constraint during the design and execution stage. The project phase gate meeting is an important meeting to formalize the expected contribution and participation from the team's representative on project team.

The project phase gate meeting will be conducted to formalize any decision on the project from Decision Maker toward the proposed project, including the agreement of level support requested from the XYZ management such as internal resources and the budget approval.

B. Project Team Development

The proposed project will be managed by Projects Team from Facility Engineering Department. The project team also involving and collaboration from multifunctional team as well as resources. The proposed project charter is as follows:

Management of XYZ :

Table C.2. DE and DRB Members for The Project

Current Position and Organization	Project Role
VP Operation	DE/ Decision Executive
GM Facility Engineering	DRB Member
GM Operation	DRB Member
GM Maintenance	DRB Member
GM Asset	DRB Member

The Project Team :

Table C.3. Project Team Composition

Project Role	Current Position and Organization
Project Manager	Project Manager – Facility Engineering Team
Project Engineer	Project Engineer – Facility Engineering Team
Operation Representative-1	Team Leader of Production Area-1,2,3
Operation Representative -2	Team Leader of Production Area-4 and 5
Maintenance Representative-1	Mechanical maintenance Team Leader
Maintenance Representative-2	Electrical maintenance Team Leader
Construction Representative	Construction Engineer – Construction Management Team
Facility Engineer Instrumentation	Facility Engineer – Operation Engineering Team
IT Representative	IT Specialist
Petroleum Engineer	Asset Team

C. The Work Breakdown Structure

The Work Breakdown Structure (WBS) is developed by the project team to estimate the project activities until Level-4. WBS shows top-down hierarchy structure with systematic approach for all activities in the project. In WBS, each lower level provides more detail information and smaller elements of the overall works. The WBS will further be detailed during detail engineering stage and be elaborated for design development of Level-4 schedule and Class-3 cot estimation with accuracy level of ±10%.

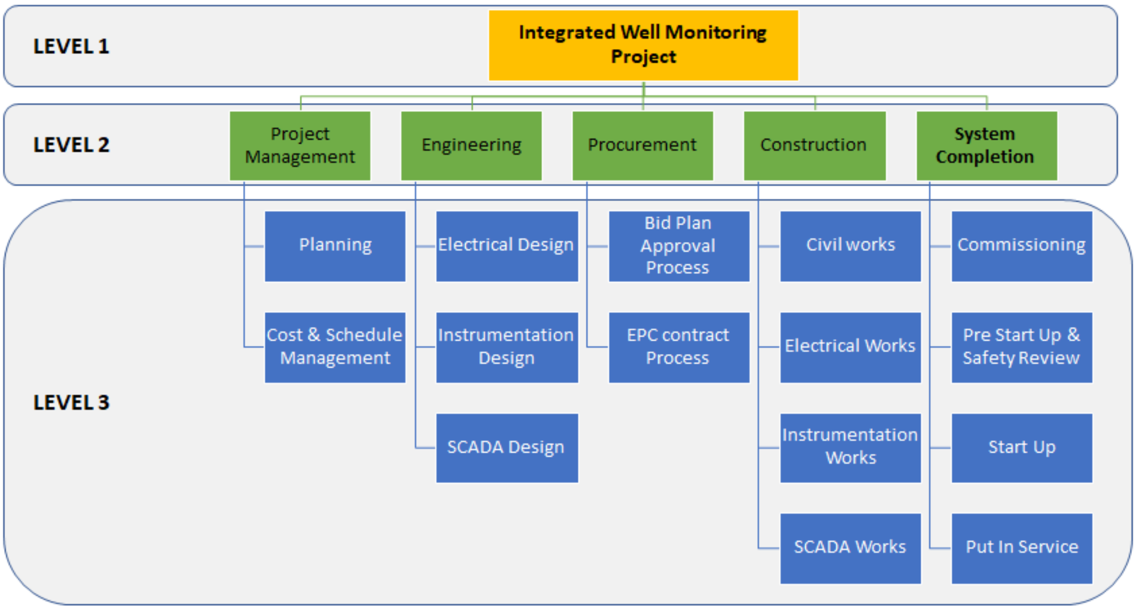

Figure C.1. The Project WBS

The following Table C.5 shows the level 3 and level 4 for WBS development.

Table C.5. WBS Level 3 and Level 4

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Sub Task Level 3	Level 4 – Work Package	Sub Task Level 3	Level 4 – Work Package
Planning	Develop Project Team	**Electrical Design**	Develop datasheet
	Risk Assessment Workshop		Develop one line diagram
	Develop WBS		Develop wiring diagram
Cost and Schedule Management	Develop Project Schedule	**Instrumentation Design**	Develop datasheet
	Develop Project Cost		Develop SAFE Chart
	Request Budget Approval to SKK Migas		Develop instrumentation hook-up drawing
	Obtain Budget Approval	**SCADA Design**	Radio Modem Design
			Develop SCADA architecture
Sub Task Level 3	**Level 4 – Work Package**	**Sub Task Level 3**	**Level 4 – Work Package**
Bid Plan Approval Process	Develop Bid Plan	**Civil Work**	Clearing and Grubbing
	Submit Bid Plan Approval to SKK Migas		Concrete base installation
	Obtain Bid Plan Approval from SKK Migas		
EPC contract process	Contracting Plan Proposal	**Electrical Works**	Electrical power cable installation
	Contract Request		Motor Panel Installation
	Procurement Plan		Variable Speed Drive Installation
	Sourcing Preparation Process	**Instrumentation Works**	Transmitter Installation
	Qualification and Evaluation Process		Load Cell Installation
	Sourcing Process		Rod Pump Controller Installation
	Contract Approval	**SCADA Works**	Radio modem installation
	Post Award Management		Antenna installation

D. Contracting Plan Strategy

The contracting plan is referring to company business process procedure as shown in Figure C.2 below.

There are nine (9) steps to be followed by each project in procurement process which sometimes it will take 2-6 months depends on the value and complexity of the contract.

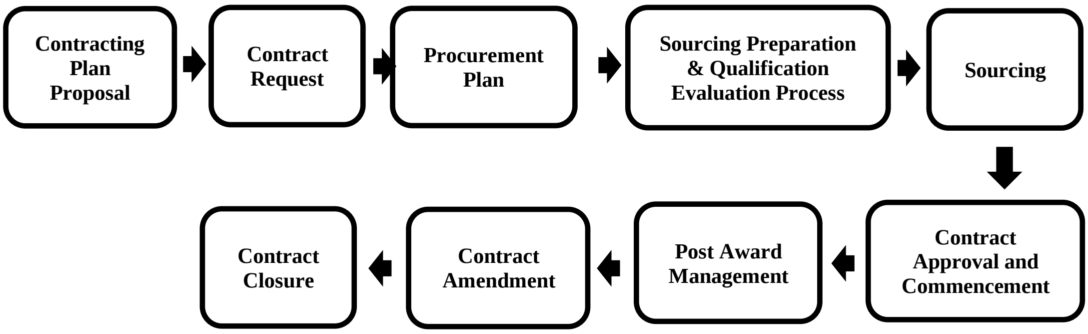

Figure C.2. The Company Contracting Process Summary

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E. Project Schedule Estimate

The following Figure C.3 shows the Gantt Chart of The Real-time Well Monitoring Project in XYZ. The Gantt Chart shows the critical path or major activities including the milestones.

	Task Name	Duration	Start	Finish	Predecessors
1	**Online Well Monitoring Project**	**255 days**	**Mon 07/01/19**	**Fri 27/12/19**	
2	SCADA Design	20 days	Mon 07/01/19	Fri 01/02/19	
3	Bid Plan Process	20 days	Mon 04/02/19	Fri 01/03/19	2
4	EPC Contract Process	80 days	Mon 04/03/19	Fri 21/06/19	3
5	Contract Award	0 days	Fri 21/06/19	Fri 21/06/19	4
6	Civil Works	30 days	Mon 24/06/19	Fri 02/08/19	5
7	RPOC Installation	60 days	Mon 05/08/19	Fri 25/10/19	6
8	Antenna Installation	30 days	Mon 28/10/19	Fri 06/12/19	7
9	Mechanical Completion	0 days	Fri 06/12/19	Fri 06/12/19	8
10	System Completion	15 days	Mon 09/12/19	Fri 27/12/19	9
11	Put In Service	0 days	Fri 27/12/19	Fri 27/12/19	10

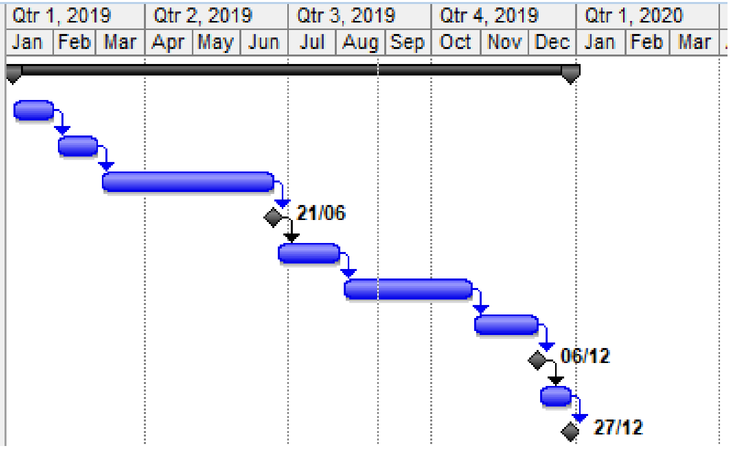

Figure C.3 The Project Critical Path and Milestones

A. SCADA Design
The activities cover the engineering design process for licensed frequency radio modem that will be used for the project.

B. Bid Plan Process
The activities are part of procurement process, such as contract development and contracting plan approval from higher management.

C. EPC Contract Process
The activities are part of contractor selection process, such as pra-qualification process, open tender process, tender evaluation, and negotiation process based on the applicable regulation.

D. Contract Award
This is one of the project milestones. The contract award is final official result from contractor selection process.

E. Civil Works
The civil works including the concrete based foundation installation for the antenna, clearing & grubbing at well pad area.

F. RPOC Installation
The major equipment of Rod Pump Optimization Controller (RPOC) will be installed in 1,500 oil wells.

G. Antenna Installation
The antenna will be installed in 1,500 oil wells.

H. Mechanical Completion
Mechanical completion is final completion for all equipment installation at field.

I. System Completion
System completion activities including Pre-Start Up and Safety review (PSSR), Site Acceptance Test (SAT), commissioning and start-up process.

J. Put in Services
The Milestone when all real-time well monitoring can be operated and functioning as per contract requirement.