Oil and Gas Well workover Operation Analysis Through an Integrated Approach of Lean Manufacturing, Just-in-Time, and Multi Attribute Failure Mode Analysis

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Abstract

Workover operations in oil and gas well are the life line of mature well, but with oil and gas price today, the cost-effective operation is the heart of future operation. Offshore well workover is a sequential activity with high equipment, personnel, transportation, and safety constraints. This study examines an ESP change out program well WSU-3HZ performed with Hydraulic Workover Unit (HWU)-225 based on operational data where experienced an increasing on operational cost up to 101,2% and operating days up to 165%. This study aims to develops an operational improvement by integrating Value Stream Mapping (VSM), Just-In-Time (JIT), Just-In-Case (JIC), and Multi Attribute Failure Mode Analysis (MAFMA). Historical time log and lookahead data shows 335.5 hrs completion time, comprising 137.25 hrs of Value Added (VA), 67.75 hrs of Essential Non-Value Added (ENVA), and 130.5 hrs of Non-Value Added (NVA), yielding a Process Cycle Efficiency (PCE) of 40.91%. The root cause analysis by 7 waste tool and fishbone diagram indicates that the largest systemic issue was an unplanned change in work scope without corresponding with logistic readiness, particularly the introduction of CSG scrapper activities after ESP damage was identified. Survey on 36 workers shows stronger acceptance of JIC (HI 5.68) than JIT (HI 4.34), supporting the differentiated logistics policy rather than full JIT implementation. MAFMA-WRI places the unplanned CSG scrapper, weather related problem, Vessel/transportation waiting, equipment preparation, and Slickline related problems among the principal improvement priorities. The proposed future state retains JIC for critical and long lead resources while applying JIT for selected lower critical item. The modelled configuration reduces Leadtime to 241 hrs, raises PCE to 77.7%, and indicates potential savings of approximately USD 225,260. The study therefore supports Hybrid JIT-JIC policy reinforced by pre-job engineering verification, equipment readiness, logistic synchronization, and contingency planning.

Keywords: *Workover, Value Stream Mapping, Hybrid JIT-JIC, MAFMA-WRI.*

A. INTRODUCTION

The crude oil is a main source of fossil energy which is not renewable. Since founded by Edwin Drake in 1859 at Titusville Pennsylvania, crude oil has been not separable with human being. In his book, Damsuki, (2009) said that hydrocarbon is from sedimentation from organic materials millions of years ago on source rock then migration to reservoir rock which known as "Trap". Sakharddande, (2011) in his research said "oil and gas is the main source of transportation and other product, oil and gas industries giving 6% contribution in US employment. The nature of oil and gas well production cycle is drilling – build up production flow – plateau – decline – abandonment. Workover is one of several activities to maintaining well integrity, restoring production performance, and extending well life span of mature oil and gas well without drilling. Zarei (2014) and Santos (2023) said in their research workover in life well is needed to maintain well integrity, flow assurance, and repair bottom hole assembly. Bissoli (2016) in Journal of Petroleum Science and Engineering 139 said one of production losses from crude oil well is ESP motor problem on artificial lift well. Heavy workover using workover RIG is needed on this project to replace ESP motor. Offshore workovers differ substantially from onshore operation because the process is constrained by limited deck space, specialist availability, transportation, offshore weather, equipment readiness, and stringent safety requirements. Because of these, short interruption may propagate through a sequential work sequence and generate substantial standby cost.

PT. ABC is one of oil and gas operator in East Kalimantan Indonesia, the company operating offshore oil and gas well transferred from the Chevron Indonesia Company in 2018. The case examined in this study is WSU-3HZ offshore well, a mature artificial lift producing well drilled in 199 and put on production in 2000. The intervention involved replacement of the ESP string using a Hydraulic Workover Unit (HWU) rated 225 Klb. Although operation planned was approximately 8.5 days, the actual campaign extended to 14 days. The operation records standby exposure, logistic constrain, changes to the work scope, equipment problem, Non-Productive Time (NPT, so this case is suitable for evaluating the interaction between process waste, logistic policy, and risk failure. Operator standby, unit standby, unused material and expired are founded in the field, high-cost seacraft logistic, last but not least is as researching by Rizal et al. (2018), Suranta et al. (2023), this operation not free from Non-Productive Time (NPT) which is cause deliverability delay and increasing of operating cost

Lean Manufacturing offers a structured way to distinguish productive work from activities without directly advancing the required transformation. Value Stream Mapping (VSM) is particularly relevant for sequential workover because it may reconstruct the time relationship among activities and allow elapses time to be separated into Value Added (VA), Essential Non-Value Added (ENVA), and Non-Value Added (NVA). ENVA should not automatically be removed because it associates with well integrity, safety, inspection, and mandatory preparation activities that may be essential for operation.

Logistic policy introduces a second optimization trade off. JIT attempt to synchronize delivery with the actual time and reduce inventory exposure, while JIC deliberately maintains protective stock to absorb uncertainty. Offshore operation requires the balance between the two. Excess inventory occupies deck space, increasing handling, and create additionally safety exposure. insufficient inventory, on the other hand, can stop an expensive operation when replenishment required long lead times or scarce marine transport.

Risk prioritization must also reflect the financial consequences of downtime. Conventional FMEA commonly ranks failure using Severity (S), Occurrence (O), and Detection (D). Multi Attribute Failure Mode Analysis (MAFMA) provides a multi attribute extension, and this study further incorporates the economic exposure of downtime through a cost Weighted Risk Index (WRI). This approach I particularly relevant where an interruption on only several hours may have a high financial consequence.

Accordingly, this study seeks to: (1) establish the current state efficiency of the WSU-3HZ workover operation using VSM; (2) identify the principal waste mechanism and their root cause; (3) determine where JIT or JIC is more appropriate for personnel, equipment, and materials; (4) prioritize failure and waste using MAFMA-WRI; (5) formulate a future state configuration that reduces avoidable time without compromising safety and critical activities.

B. LITERATURE REVIEW

Various previous studies have been conducted in review of operation process, logistic, and transportation including in oil and gas industries. Lean Manufacturing focuses on waste and improving the proportion of resources that contribute to required value while reducing unnecessary consumption of time, motion, inventory, transportation, and processing. Value Stream Mapping (VSM) support this objective by representing the process connected flow rather than isolated tasks. According to Durakovic et al. (2018), Sumi (2024), LM is a group of methods and tools for identifying and eliminating process inefficiency and waste without adding new resources. Hardianza (2026) said in his research that one of effective tools of LM to analysing production process is VSM and this tool used to see production activities that add value, necessary but not value added, and not value-added activities by creating current and future maps. For the present case, the map is used to identify of VA, ENVA, and NVA and to locate delays that can be addressed through operational or logistic changes.

Just In Time (JIT) is logistic method to optimized production stock and put on minimized to reduced inventory cost, Nuraini et al. (2024). JIT logistic is appropriate when demand and timing can be predicted with sufficient confidence, suppliers and transport are reliable, and late delivery does not create unacceptable operational consequences. The main principle of JIT is material arriving in production line on time of production, so the intensive coordination with supplier when this method is fully implemented, Sharland et al, (2023), Pemberton et al. (2023). JIT is one of LM concept which is focussed on inventory waste. On the other hand, JIC provides a buffer when uncertainty is high, replenishment is slow, or a missing item can cause a major disruption. The offshore setting makes hybrid policy is more practical because critical item and low criticality consumable do not have the same risk profile.

Multi Attribute Failure Mode Analysis (MAFMA) is the recent development of Failure Mode Effect Analysis (FMEA) and founded by Braglia (2000). Instead of focused on RPN, MAFMA included Severity factor (S), Occurrence factor (O), Detectability factor (D), and Expected Cost factor (CI) which determined based on highest weighting value, Hetharia (2009). MAFMA evaluates potential failure mode using multiple attributes, S, O, D, are each scored from 1 to 10 and combined as RPN.

To reflect economic exposure of a workover, the study used cost weighted prioritization index, WRI = RPN x CI. WRI interpreted as a prioritization index and to prevent high-cost, low frequency events from being overlooked merely because the conventional RPN is comparatively modest. Because of the complexity workover operation, limited resources, lead time variation, changing task priority, and risk management requires optimal management of resources and activities. Semwogerere et al. (2025) said Mitigating risk and consequences of failure can help in designing effective and more cost-efficient workover programs. The integration of VSM, JIT-JIC, and MAFMA to review the last workover program expected to provide significant theoretical and practical contributions to workover operations optimization in this sector. This research aims to identify waste in workover operation process, defects of operation process and logistic, and provide optimization model that can be replicated and adapted in worksites.

C. METHOD

This research adopts a quantitative applied case-study design using historical operations data, direct observation, and field surveys aimed to find the cause of waste and optimizing workover operation in offshore oil and gas well. The primary data consist of the WSU-3HZ workover timelog, 7-days/lookahead plans, field observations, and surveys from 36 personnel involved in the operation. The operation unit analysis is the offshore ESP change out with Hydraulic Workover Unit with capacity 225 Klb.

The analytical frameworks follow a diagnosis-to-improvement sequences. First, reconstructed the actual process data through VSM and its elapses times is allocated to VA, ENVA, and NVA. Second, the avoidable and optimizable activities are classified according to 7-waste and investigates through fishbone diagram using material, man machine, method, and environment categories. Third, logistic requirements are evaluated against JIT and JIC characteristics. Fourth, workers perception is incorporated through Human Impact (HI) indicators. Finally, the identified failure/waste are scored using MAFMA and ranked with WRI so that improvement resources can be directed toward the most consequential condition.
The principal calculation is;

$$PCE = \left(\frac{VA}{Total\ Leadtime}\right) x\ 100\%$$

$$RPN = S\ x\ O\ x\ D$$

$$WRI = RPN\ x\ Cost\ Impact$$

The operational cost basis used in the analysis is approximately USD 2,180 per operating hours, corresponding to reported offshore workover cost structure. Cost figure in the MAFMA table is derived from the same operational dataset used to calculate the duration of each failure or waste.

D. RESULTS AND DISCUSSION

1. Current State VSM analysis

The current state map contains 20 principal activities started from well kill to finished a backload equipment. Total elapses time was 335.5 h. productive activity accounted for 137.25 h, mandatory but non value adding activities for 67.75 h, and avoidable NVA 130.5 h. the resulting PCE was 40.91%. thus, less than half of the operating time represented direct process transformation, while the remaining was associated with necessary support activities and avoidable interruption. The list of workover activities and VSM time categorisation can be seen on table 1.1. bellow. PCE calculation from the data as follow;

$$PCE_{Current} = \frac{VA}{Total}$$

$$PCE_{Current} = \frac{137{,}25}{335{,}5} \text{ x } 100$$

$$PCE_{Current} = 40{,}91\%$$

Table 1. Current state VSM activity and time classification on WSU-3HZ

No	Activity Description	Leadtime	VA	ENVA	NVA	Quantity	%CA
1	*Well Kill*	7,75	7,75			1	100%
2	*Slickline Operation*	20,5		20,5		3	100%
3	*Emergency Drill*	0,75		0,75		2	100%
4	*Nipple Down X-tree*	2,5	2,5			1	100%
5	NPT *Setup Cable Spooler*	2			2	1	100%
6	*Rig Up* HWU	28,75	28,75			1	100%
7	NPT *Powerpack Overheat*	3,5			3,5	1	100%
8	POOH ESP String	29,75	29,75			193	100%
9	NPT Barge C*rane Problem*	4,5			4,5	1	100%
10	Program Changing ESP *Shroud* and Run CSG *Scrapper*	59,5			59,5	400	100%
11	NPT *Waiting* ESP Shroud	12			12	1	100%
12	New ESP Preparation	14		14		1	100%
13	Run New ESP Completion String	45	45			187	100%
14	Slickline Plug Reposition Twice	19		19		2	50%
15	NPT *Slickline Plug Problem*	9			9	2	50%
16	*Rig Down* HWU	17,5	17,5			1	100%
17	NPT *Waiting* Bad Weather	16			16	10	100%
18	*Nipple Up X-tree* and *Commissioning*	6	6			1	100%
19	*Waiting AHTS/Vessel*	24			24	1	100%
20	*Backload Equipment*	13,5		13,5		8	80%
	Current State Elapses Times	**335,5**	**137,25**	**67,75**	**130,5**		
	Percentage (PCE)		**40,91%**	**20,19%**	**38,90%**		

2. Waste Identification and Fishbone Analysis

Eight NVA points and three ENVA activities with improvement potential were identified from the table 4.1 above. The evidence analysis does not indicate a single dominant failure; instead, several wastes were connected through changes in work scope, logistic readiness, transportation constraints, and sequential execution. The fishbone analysis threats the waste as an interconnected system rather than independent as shown in figure1 bellow:

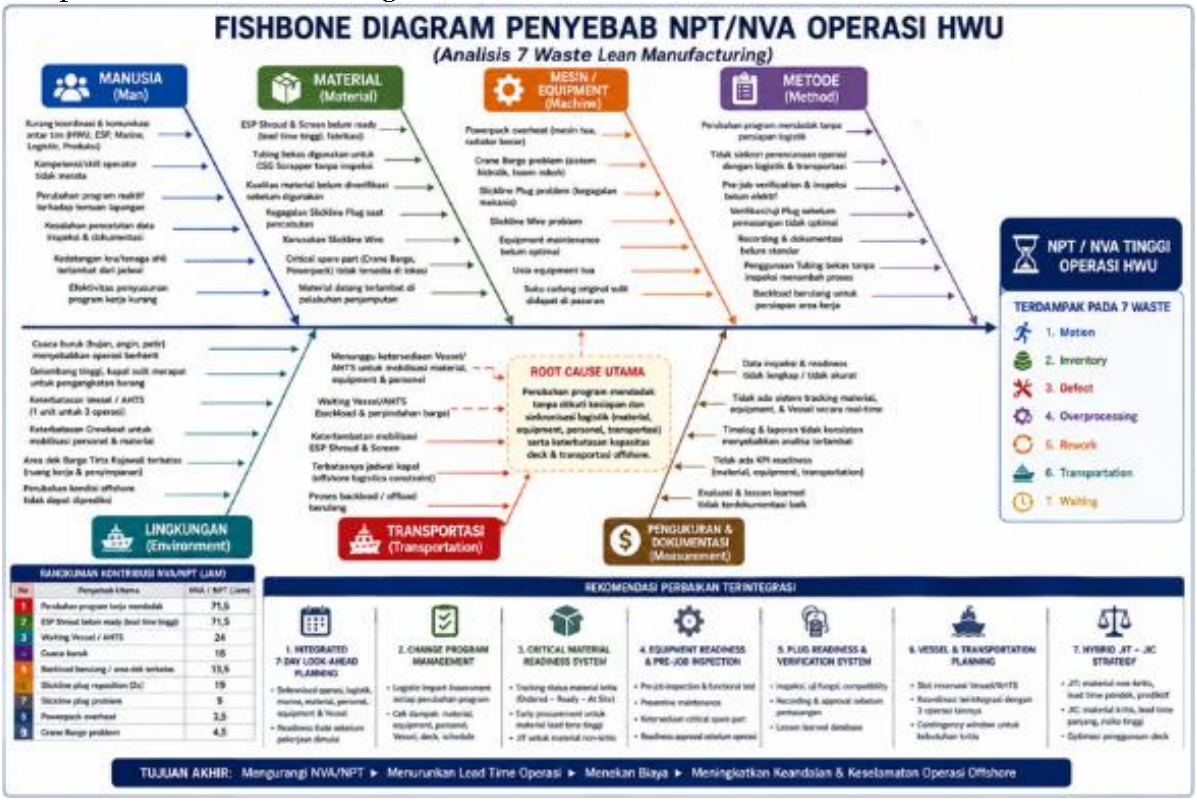

Figure 1. Fishbone Diagram And 7 Waste Analysis

Table 2. Analysis of Seven Wastes and Root Causes

Waste	Observe source	Root-cause interpretation
Waiting	Weather, ESP Shroud part, Vessel	Weather is safety constraint; logistics waiting is controllable through planning and readiness
Transportation	Vessel/boat limitation and marine coordination	Program changes shift completion time and disrupt shared-vessel scheduling
Rework	Plug repositioning and plug/wire problems	Plug verifications, testing, depth selection, and records are not sufficient robust
Overprocessing	CSG scrapper with used tubing, repeated support activities	Unplanned work is executed with non-ready tubing and require strengthening
Defect	Slickline plug, Barge Crane, HWU Powerpack	Equipment readiness, preventive maintenance, testing, and critical spare part availability required to strengthening
Motion	ESP cable spooler setup	Setup was performed as a separated interruption although it could be prepared during another activity before
Inventory	ESP shroud, tubing readiness	Limited deck space and unplanned demand make full JIT unsuitable for offshore workover

The central systemic cause is the introduction of new work requirements after work execution had already started without ensuring that the associated inventory and resources were ready. The ESP Shroud as pilot project associated with CSG scrapper decision illustrated the operation interruption mechanism. The change generated secondary effect: ESP Shroud fabrication, CSG scrapper activities with used tubing, additional deck movements, logistic disruption, and boat scheduling.

3. JIT versus JIC Logistic Assessment

The logistic assessment distinguishes resource according to their consequences of late arrival, lead time, transportation tendency, and ability to be prepared close to the point of use. JIT is recommended where timing can be synchronized and delay does not threaten the operation continuity. JIC is retained where an item is critical, difficult to replenishment, long lead time, or capable of stopping the operation if unavailable. This classification avoids that one inventory policy should be applied uniformly to all resources.

Responses from 36 workover personnel support the differentiated approach. The JIT Human Impact (HI) was 4.34, whereas JIC obtained 5.68, indicating greater field acceptance of protective inventory for logistic. At the same time, logistic HI 7.27 indicates that personnel generally recognized the important of logistic readiness. Therefore, the survey result should be interpreted as supporting evidence for the operational trade off rather than as proof that JIC is universally superior. The table 4.2 bellow is the list of logistic and the risk based logistic policy.

Table 3. List of Logistic and Risk Based Logistic Policy

No	Logistic	Categories	Methods	Remark	No	Logistic	Categories	Methods	Remark
1	HWU 225 Klbs	Rig Equipment	JIC	Long time contract	15	Barge Crew	Main Crew	JIC	Contract package
2	Slickline Unit	Well Service equipment	JIC	Long time contract	16	HWU Crew	Main Crew	JIC	Contract package
3	ESP Cable Spooler	Special ESP Equipment	JIC	Critical equipment	17	Slickline Crew	Main Crew	JIC	Specialist
4	220 Joint New Tubing and Spare	Main Material	JIC	NPT if delayed	18	ESP Crew	Main Crew	JIT	Specialist
5	Tubing Pup Joint	Main Material	JIC	NPT if delayed	19	Scaffolder Crew	Support Crew	JIC	Contract package
6	X-mass tree, Tubing Hanger and accessories	Main Material	JIC	NPT if delayed	20	X-tree Specialist	main Crew	JIC	Specialist
7	New ESP Assembly and Cable	Main Material	JIC	NPT if delayed	21	Construction Crew	Support Crew	JIT	Leadtime <12 hrs
8	Chemical KCL	Consumable Material	JIC min - max	Critical material	22	Dokter on duty	Support Crew	JIC	Just In Case
9	Chemical Hi-Vis, Safe Lube, Friction reducer	Contingency Material	JIC min - max	excess from last job	23	Rig Move Crew	Support Crew	JIT	Lead time <24 hrs
10	Casing Scrapper	Contingency Material	JIC	JIC from last job	24	Air Tugger Operator	Support Crew	JIC	Contract package
11	3,5" Tubing Plug	Well Control Equipment	JIT with spare	Lead time <12 hrs	25	HWU Consumable Material	Consumable Material	JIC min - max	Leadtime <1 day
12	BOP Support Frame	Special Material	JIT	Onboard from last job	26	Weekly Refilling Diesel Fuel	Consumable Material	JIT	Leadtime <1 day
13	Wing Valve and Surface Choke	Main Material	JIT	Lead time <12 hrs	27	Fresh Water twice a week	Consumable Material	JIT	Weekly scheduled
14	Weekly Food Container	Consumable Material	JIT	Weekly scheduled	28	AWB Tirta Rajawali	Barge	JIC	Already on hire

For specialist personnel, the operation record indicates that more precise mobilization cans reduce personnel standby exposure. the modelled opportunity with JIT oriented personnel deployment is approximately USD 16,632. For equipment and materials, however, full JIT is not recommended because the financial consequences for critical items can exceed the carrying cost. The preferred configuration is therefore hybrid JIT-JIC. The summary result from JIT-JIC logistic analysis can be seen on table 4 bellow:

Table 4. JIT-JIC Logistic analysis and recommendation

Logistic Group	Recommendation	Implementation Principle
Specialist personnel	30% JIT / 70% JIC	Use JIT for personnel with predictable activity windows, retain protective availability for critical specialist
Equipment and materials	≈33.5% JIT / ≈66,7% JIC	Use JIC for critical/long-lead items, use JIT for Low-criticality support items
Overall strategy	Hybrid JIT-JIC	Avoid full JIT because offshore uncertainty and marine lead time can create high-cost NPT

4. MAFMA Prioritization

MAFMA was applied to 11 identified wastes. Conventional RPN highlights condition with high Severity, Occurrence, and poor Detectability. When estimated cost exposures is incorporated through WRI, the ranking changes dramatically because of low frequency event become a major improvement priority when its duration and financial consequences are large. The unplanned ESP Shroud associated with CSG scrapper is the cleared example: its occurrence is low, but its duration its long duration produces the highest WRI. The MAFMA-WRI ranking analysis can be seen on table 4.4 bellow:

Table 5. MAFMA-WRI analysis

No	Failure Mode	Class	Waste	S	O	D	RPN	NPT (h)	Cost (USD)	WRI
1	Unplanned program CSG scrapper	NVA	Method	10	2	8	160	59,5	129.710	20.753.600
2	Weather waiting	NVA	Waiting	9	10	5	450	16	34.880	15.696.000
3	New ESP preparation	ENVA	Inventory	8	8	8	512	14	30.520	15.626.240
4	AHTS/vessel waiting	NVA	Transportation	9	10	3	270	24	52.320	14.126.400
5	Slickline plug repositioning	ENVA	Overprocessing	9	8	3	216	19	41.420	8.946.720
6	Slickline Plug problem	NVA	Defect	7	7	9	441	9	19.620	8.652.420
7	Backload equipment	ENVA	Overprocessing	5	9	5	225	13,5	29.430	6.621.750
8	Waiting ESP Shroud part	NVA	Waiting	9	3	5	135	12	26.160	3.531.600
9	Crane barge problem	NVA	Defect	6	6	9	324	4,5	9.810	3.178.440
10	Powerpack overheat	NVA	Defect	6	7	6	252	3,5	7.630	1.922.760
11	ESP cable spooler setting	NVA	Motion	4	9	5	180	2	4.360	784.800

The resulting priority logic is therefore different from frequency only approaches. The highest WRI is associated with unplanned work scope, followed by weather waiting, New-ESP preparation, Vessel waiting, and Slickline relates activities. The ranking provides a bridge between the descriptive waste analysis and that allocation of improvement resources.

5. **Root Cause and Recommended Improvements**

a. Unplanned CSG scrapper program change

The highest WRI arise from the unexpected introduction of ESP Shroud pilot project installation after the pulled ESP was found to have heavy erosion on the pump body and solid contamination. Because this requirement was absent from the original work scope, ESP Shroud and Screen were not immediately available and need to fabrication. The used tubing was selected for the scrapper activity, but the tubing required cleaning, drifting, thread and body inspection before it could be safely used. The additional work extended the campaign, increase equipment utilization, and contribute to secondary effects such as powerpack overheating.

The principal controls are earlier verification of historical well information, explicit CSG scrapper contingency provisions in the workover program and a tubing readiness program on onshore base before mobilization. These controls convert a reactive field inspection into controlled readiness process and reduce dependence on unplanned offshore preparation.

b. Weather waiting

Weather related waiting is a legitimate offshore constraint rather than a conventional process defect. Activities must be stopped when wind, rain, lightning, wave conditions, or barge movement create unacceptable risk. I this case, weather interruptions occurred repeatedly and accumulated to 16 h. the appropriate objective is not to eliminate, but to reduces its propagation into other waste.

Improvement should combine more intensive weather window monitoring with activity sequencing, marine transportation, and contingency work. Weather forecast should be reviewed as part of 7-days planning and updated before critical activities. Barge orientation and sea state information can also be considered when determining suitable work windows. The survey results for HSSE, with an HI of 6.92, supports the interpretation that personnel already recognized safety implication; therefore, planning and weather monitoring are the more relevant improvement levers.

c. New ESP preparation and ESP Shroud part waiting

Preparation of the new ESP is classified as ENVA because it is necessary but does not directly create outcome. Its duration may be reduced by proper parallel preparation before the time is come. The main issue was coordination around the pilot project new ESP Shroud design and the availability of the specialist crew. pre-job technical review and interface checks, and surface readiness should be completed before the HWU reaches the activity window. ESP shroud and screen readiness should also be treated as a logistic rather than as a response to a late operational changing.

d. Vessel Waiting and Backload

The workover activities on this case is relied on single AHTS shared among barge move requirements. When the completion forecast is shifted, the Vessel window also shifted and waiting was created. The solution is not simple to add new Vessel, because vessel cost is high; instead, marine and workover planning should used an integrated scheduled that linked to expected completion, next-well readiness, and vessel availability. The changes to the workover scope should trigger an immediate scheduled update so it can be revises before waiting condition develops.

Backload and offload should be managed as part of phase-based deck planning. The deck layout should identify which equipment is required for the active work stage and which items can be moved out of the opening area. This reduces unnecessary material handling while protecting access and emergency routes. A shared vessel schedule and defined deck management plan are therefore complimentary controls.

e. Slickline plug repositioning and plug failure

Slickline work is an essential well-integrity and well control activities, but repeated repositioning creates avoidable overprocessing. Two repositioning events were recorded, together with plug related failure. The improvement focuses should be on the pre-job engineering review, accurate depth selection, function tested and inspection records. A joint review involving the well engineer, Slickline specialist, Wellsite manager, and HWU supervision can convert previous operating experience into a more robust plug-placement decision.

f. Crane and Powerpack failure

The Tirta Rajawali and HWU Powerpack are critical assets because its failure can interrupt the work sequences. The observed problems indicate a need for stronger preventive and predictive maintenance, particularly for aging equipment for which original spare part may difficult to sources. Pre-use checks should cover unit and hydraulics condition, leakage, cooling and temperature trends, and availability of critical spares. The objective is to identify deteriorating conditions before the equipment enter critical workover step.

g. ESP cable spooler setup

The two-hour ESP cable spooler setup is a small event in absolute duration but illustrates motion waste because preparation was performed as a separate interruption. Where crane access and safety condition permits, the setup should be prepared during an earlier activity. Earlier mobilization of the ESP specialist and closer coordination with crew boat availability can provide the preparation window without extending the main operating sequence.

6. Implementation Roadmap

To accepting the integrated analysis VSM, logistics JIT-JIC assessment, and MAFMA analysis before, the future state recommendation roadmap as seen on table 4.5 bellow. The logistic model is explicitly hybrid JIT-JIC. JIT is assigned to selected specialist personnel and lower criticality supports items. JIC protection is maintained for critical or long lead resources such as new tubing, ESP materials, X-mass tree and components, and other items whose absence could generate prolonged waiting. This policy also considers the limited deck capacity: protective inventory should be risk based rather than indiscriminate.

Table 6. Future state implementation roadmap

Control area	Action	PIC	Timing
Pre-job engineering	Historical well data review, contingency review, plug depth installation verification	Well Engineer/WSM	Before program execution
Tubing readiness	inspection, cleaning, drift, acceptance checklist, contingency minimum quantity	Warehouse/WSM	Before mobilization, 7-days planning lookahead
Critical inventory	JIC classification and min-max control for selected consumables	Warehouse/Logistics	Before mobilization, 7-days planning lookahead
Personnel logistics	JIT mobilization windows for non-critical specialist	Operation/Marine	7-days lookahead
Vessel coordination	Integrated operation, logistics, and boat/Vessel scheduled and change-impact review	Marine/Logistics/WSM	Daily, 7-days lookahead
Equipment readiness	Pre-used checklist, PM/PDM, critical spares	Rig Superintendent/Barge Master	Daily, 7-days lookahead
Weather management	Weather forecast monitoring, contingency task	WSM/HSSE	Daily, 7-days lookahead
Performance control	Tracks PCS, NVA, NPT, and WRI actions	Well Engineer/WSM	Daily, post-job completion

7. Proposed Future State Operation

The future state configuration consolidates the finding from VSM, fishbone analysis, JIT-JIC logistic assessment, survey evidence, and MAFMA-WRI. Its main principle is to remove avoidable NVA while preserving safety critical ENVA. The CSG scrapper contingency is moved from reactive decision into the pre-job planning process, tubing readiness is established before mobilization, and specialist preparation is shifted toward earlier logistic synchronization. Table 4.5 bellow showed the future state VSM activity and time classification.

Table 7. Future state VSM activity and time classification

No	Activity	Time	VA	ENVA	NVA	Quantity	%CA
1	Well kill	7,75	7,75			1	100%
2	Slickline operation	20,5		20,5		3	100%
3	Emergency drill	0,75		0,75		2	100%
4	N/D X-tree	2,5	2,5			1	100%
5	NPT Setup cable spooler				0	0	0%
6	R/U HWU	28,75	28,75			1	100%
7	NPT Powerpack overheat				0	0	0%
8	POH ESP string	29,75	29,75			193	100%
9	NPT Barge crane problem				0	0	0%
10	Program CSG Scrapper, 8 Join/jam	50	50			400	100%
11	NPT Waiting ESP part				0	0	0%

12	Preparation New ESP	10		10		1	100%
13	RIH new ESP string	45	45			187	100%
14	1 time Plug reposition	9		9		1	100%
15	NPT Slickline plug problem				0	0	0%
16	R/D HWU	17,5	17,5			1	100%
17	NPT waiting on weather				0	0	0%
18	N/U X-tree and commissioning	6	6			1	100%
19	Waiting AHTS/Vessel				0	0	0%
20	Backload equipment	13,5		13,5		8	100%
	Future State Elapses Time	241	187,25	53,75	0		
	Percentage (PCE)		77,70 %	22,30 %	0,00 %		

The PCE calculation for future state from the table above as follows;

$$PCE_{Future} = \frac{VA}{Total}$$

$$PCE_{Future} = \frac{187{,}25}{241} \text{ x } 100$$

$$PCE_{Future} = 77{,}70\%$$

The modelled future state reduces elapses time from 335.5 h to 241 h and raises PCE from 40.91% to 77.7%. the economic benefit is approximately USD 225,260, equivalent to about 30.7% of the reported current operating cost basis used in the study. The improvement is obtained through prevention, synchronization, and parallel preparation rather than by removing mandatory safety work. The future state therefore represents a risk-controlled reduction of avoidable time rather than a simple compression of the work schedule. Table 4.6 bellow is the current state versus future state performance comparations.

Table 8. Current State Versus Future State Performance

Indicator	Current State	Future State	Improvement
Total elapsed time	335.5 h	241.0 h	-94.5 h
VA	137.75 h	187.25 h	+50.0 h
ENVA	67.75 h	53.75 h	-14.0 h
NVA	130.5 h	0 h	-130.5 h
PCE	40.91%	77.70 %	+36.79 percentage points
Operation duration	14 days	10 days	-4 days
Estimated cost	USD 734,004	USD 508,744	USD 225,260 saving

From the integrated VSM, JIT-JIC logistic assessment, and MAFMA analysis on this study, the proposed modelled future state VSM chart should be seen on the picture bellow;

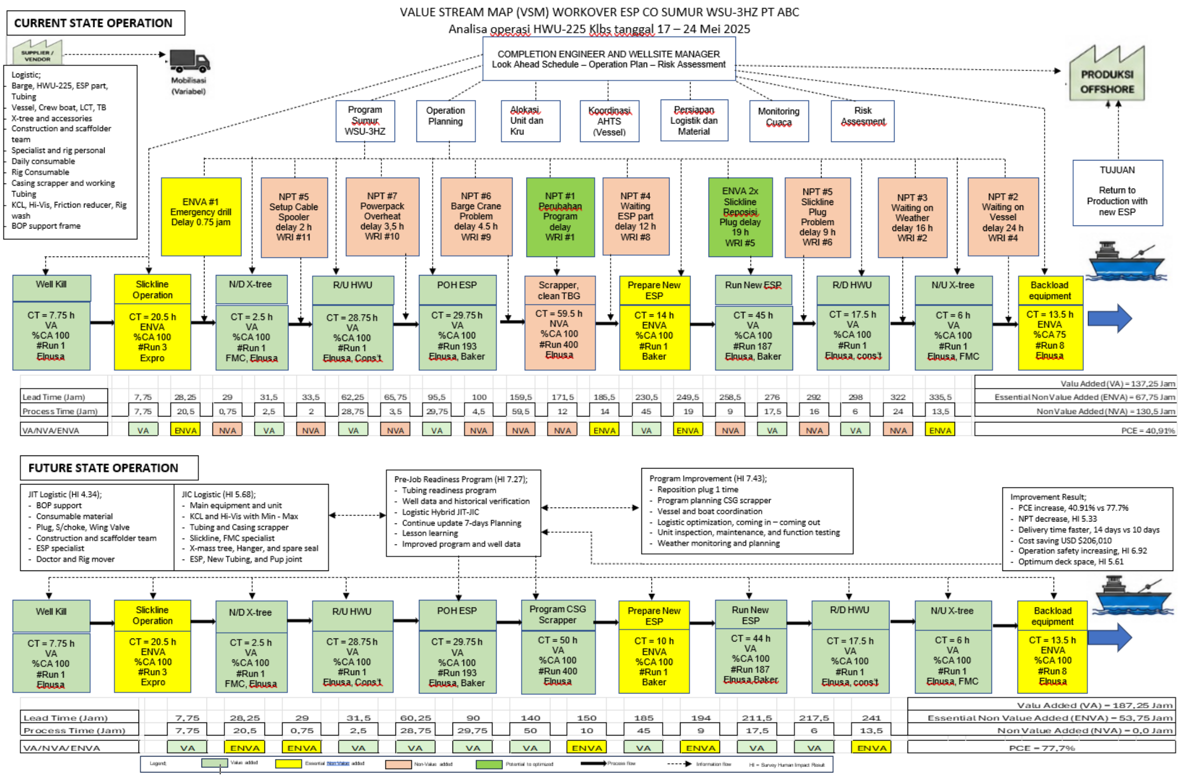

Figure 2. Proposed Current state and Future state VSM modelled

E. CONCLUSION

The integrated assessment shows to us that the WSU-3HZ offshore ESP change out contained substantial avoidable time. The current state VSM recorded 335.5 h, with 137.25 h of VA, 67.75 h of ENVA, and 130.5 h of NVA, corresponding to PCE of 40.91%. the fishbone analysis indicates that the principal systemic issue was not a single equipment defect but the interaction between an unplanned change I work scope and insufficient logistics readiness. The resulting effects propagated into inventory, transportation, motion, overprocessing, rework, waiting, and equipment related losses.

The logistics assessment does not support full JIT adoption, field operator favoured JIC for material, while the operational identified a limited but useful opportunity to apply JIT to lower criticality resources and long lead resources should retain controlled JIC because their absence may generate large downtime. The analysis resulting a hybrid JIT-JIC policy is more compatible with offshore uncertainty and limited deck capacity than either pure JIT or indiscriminate JIC.

MAFMA-WRI adds an economics dimension to waste diagnosis and change the improvement priority from simple frequency ranking towards combines operational and financial exposure. the highest priority is the unplanned change to install ESP Shroud and Screen in corporate to CSG Scrapper, followed by offshore weather, ESP preparation, Vessel waiting, and slicklines related activities. The recommendation therefore emphasizes pre-job well data verification and contingency planning, integrated operation, vessel scheduling and logistic planning, and equipment readiness.

Under the proposed future state configuration, elapses time reduces to 241 h and PCE increase to 77.7%, with the identified NVA removed. The estimated saving is USD 225.260. the main contribution us consequently not a blanket substation of JIC with JIT, but risk-based allocation of logistic policies supported by lean process analysis and cost-weighted failure optimization.

The study is limited to single offshore workover case and operational records associated with that campaign. Therefore, the analysis result is a case-specific estimate rather than a universal benchmark. Further validation across additional workover campaigns is required to test the robustness of hybrid logistic policies and the MAFMA-WRI prioritization framework.

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