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RISK-BASED ASSESSMENT ON MALAYSIA'S OFFSHORE JACKET PLATFORM

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Abstract: Malaysia has approximately 200 fixed offshore structures, some of which have been in operation for over 40 years, which is well beyond its design life. In order for these ageing fixed structures to continue in service or extend its operation, their current structural integrity condition needs to be identified, addressed, prioritized and appropriate mitigation measures should be implemented. The aim of the research was to modify the framework for Structural Integrity Management developed by AMOCO for carrying out risk based assessment of Malaysia's fixed offshore platforms. This required acquiring actual fixed offshore structure data, which comprises of design, assessment and inspection records. Two important components of this framework were identified as 1) Base line Risk ranking of Malaysia's offshore platforms and 2) Development of a Risk Based Underwater Inspection (RBUI) programme. The classification of the platforms showed that many of the structures have exceeded the design life of 30 years. The baseline risk evaluation of the 186 platforms showed that fifty five platforms were in "very high risk" category. A risk based underwater inspection guideline was also developed. A case study was done to illustrate how it affects the inspection planning of the offshore structures.

Keywords: *risk based inspection (RBI), risk based underwater inspection (RBUI), structural reliability analysis (SRA), structural integrity management (SIM), working stress design (WSD)*

1.0 Introduction

Structural Integrity Management (SIM) is a continuous assessment process applied throughout the life namely during design, construction, operations, maintenance and decommissioning to assure that the structures are managed safely. The SIM process ensures that the structures are fit for purpose and maintain structural integrity throughout the life cycle and maybe longer. The SIM strategy will reflect the risk associated with each fixed platform. Where the risk is higher, the greater will be the rigor of the integrity management (IM) strategy and the robustness of the implementation program. Knowing the importance of managing aging platforms, this study has undertaken the structural integrity review covering all the platforms in Peninsular Malaysia, Sabah and Sarawak. Offshore O&G operations in Malaysia are divided into three regions namely Peninsular Malaysia Operations (PMO), Sabah Operations (SBO) and Sarawak Operations (SKO). Figure 1 shows the age distribution of existing installations in Malaysia. It shows that many platforms have exceeded the design life of 30 years (Akram and Narayanan, 2011). This highlights the need for a more detailed study of the platform characteristics (region wise, age wise etc) and the need for a much focused SIM for the continued use of the platforms.

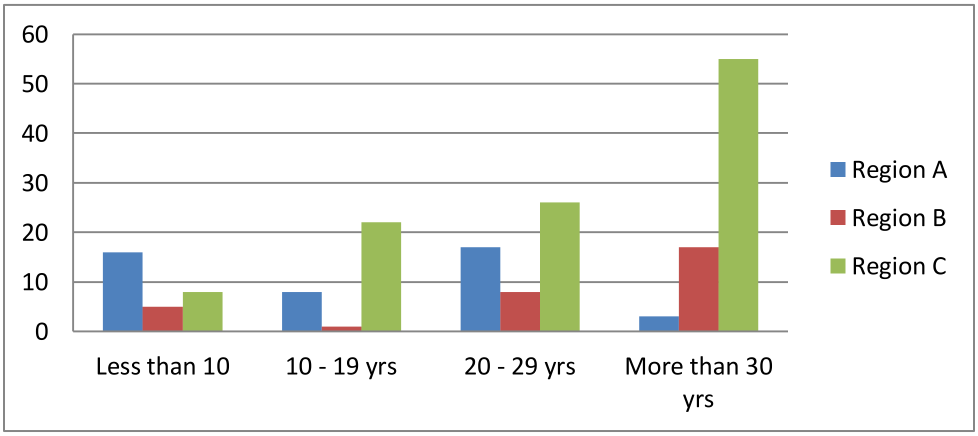


Figure 1: Age distribution of Malaysia's Fixed Offshore Platforms

2.0 Literature review

Even if rather large reconstructions, repairs and inspections have to be performed, using existing installations beyond their design life will in many cases be economically preferable. However the requirements regarding safety should not be compromised (Ersdal 2002, 2005; and HSE 2009). The current SIM approach to managing platforms is based on GOM and NS, established by operators such as Exxon Mobil (EM) and British Petroleum (BP) (Fraser, 2007). EM has approximately 400 fixed platforms of which nearly 50% has exceeded the 20 year design life. As the first step, EM conducted a gap analysis to determine the gaps against HSE expectations and existing requirements for life extension. Then data was gathered on current condition of assets, consisting of general information, original design data, construction records, platform history, present condition and future operating strategy.

API RP2A (2005), Section 14 has a recommended practice for inspection intervals given in Table 1. L-1, L-2 and L-3 refer to categories of life safety namely manned non-evacuated, manned evacuated and unmanned respectively. Four levels of survey are undertaken periodically based on the exposure category of the platform.

Table 1: Guideline Survey Intervals (API, 2005)

Exposure Category	Survey Level			
	1	**2**	**3**	**4**
L-1	1 year	3 through 5 years	6 through 10 years	*
L-2	1 year	5 through 10 years	11 through 15 years	*
L-3	1 year	5 through 10 years	*	*

** Based on outcome of Level 3and Level 4 survey*

RBI, however, uses risk as a basis to give priority to types of inspection and inspection intervals. The methodology of RBI sets inspection and maintenance to a platform giving priority to higher risk platforms before paying attention to lower risk platforms. The RBI system determines the likelihood of failure (LOF) and consequence of failure (COF). Risk is defined as:

$$\text{Risk} = \text{LOF} * \text{COF} \qquad (1)$$

The LOF (structural) is a function of two primary factors, the platform strength and the extreme load. The COF corresponds to the safety, environmental and financial issues that would arise should the platform fail at a future date. It groups a structure into High, Medium and Low inspection risk. Using these groups, it can be easily decided which platform should be inspected first and which platform should be inspected last. RBI identifies which platforms have high risk, to design an inspection program and to manage the risk so that it doesn't fail. The RBI process consists of performing risk assessment of structure; determine inspection frequency and scope of work. The risk assessment is done to determine the current and anticipated condition of the platform. It can be done by determining the following, but not limited to: Rate of marine growth, Rate of corrosion and Scouring condition. Many important characteristics such as age, framing patterns, deck elevation, etc., are not influenced through inspection Thus all platforms in a ranking system will have an intrinsic "risk" value. A platforms risk ranking will always stay the same or be higher than its intrinsic value as determined through a systematic measurement system. A ranking process must be updateable to account for inspection results. For example, platforms that are found through further inspection to be in good condition, with no signs of damage or other degradation, would receive either a lower risk ranking or maintain its intrinsic value. Between inspections, a platform would move towards the top of the list again, where its relative risk level would trigger an underwater inspection. Depending on inspection findings, a platform's ranking would stay the same or increase should significant deterioration have occurred. The concept of ranking the platforms for underwater inspection using a risk-based process is based on a similar approach being developed by API for refineries and chemical plants. The RBUI LOF corresponds to the probability that the platform will fail at some point in time through environmental overload. Failure, in RBUI, is defined as collapse of the platform as a result of deterioration, extreme loading (storm or earthquake), or a combination of both. Fire, blast, and other accidental conditions are not considered in RBUI.

The determination of the LOF requires information on a platform's structural configuration in order to determine its "baseline" susceptibility to failure (e.g., tripod, 4 leg, 6 leg or 8 leg), as well as its current state, based upon inspection, that may influence the baseline likelihood (e.g., damaged members) (DeFranco *et al.*, 1999).

Newer platform are designed to better standards, such as joint cans, and has more redundant structural configuration. However, should the SIM cycle reveal that the newer platform has a track record of damage such as corrosion or fatigue cracking, then this may move the platform up the priority list, to a point where it is higher risk ranked than the older platform. The contribution of appurtenances such as risers and conductors to LOF was also considered. Appurtenance failure may not necessarily lead to collapse of the platform (except in the case of a severe explosion) but may cause an environmental and/or financial loss (DeFranco *et al.*, 1999).

The COF corresponds to the safety, environmental and financial issues that would arise should the platform fail at a future date. These are the standard consequence issues typically addressed in risk assessments for any type of facility, either onshore or offshore. Each of these consequences are converted to an abstract dollar value and then summed to result in the overall consequence. While the resulting value is not expected to be a quantitative estimate of the real dollar due of a failure, monetary value was adopted so that the effects of safety, environmental and business losses can be combined. (DeFranco *et al.*, 1999).

The LOF is determined using a rule-based system that determines the likelihood score based upon key platform information. The likelihood categorization system identifies the platform characteristics that affect the platform strength and loads, such as the year designed the number of legs, the bracing scheme, etc. Factors which indicate that the strength of the platform has deteriorated or is not up to current standards increase the likelihood. Factors which indicate that extreme platform loads may increase in frequency or severity also increase the likelihood.

To develop the rules for platform risk ranking for underwater inspection 12 elements were considered by AMOCO. Each of these elements was given a specific score. The following weightages were given for the factors: year and location (5), design practice (5), bracing and legs (10), earthquake (8), grouted piles (3), damaged members (10.5xBL/100), flooded members (6xBL/100), remaining wall thickness or corrosion (7.5xBL/100), marine growth (6), last inspection (8), scour (2), appurtenances (5), deck load (5) and fatigue (5). The summation of the score was used to risk rank the structure for future inspection programs.

Each of the said platforms will then be inspected based on its risk ranking. The higher the risk of the platform, the sooner it will be inspected and vice versa. Furthermore, the risk ranking provides a brief detail of the required scope of work which is to be executed during underwater inspection programs. This is because, the qualitative risk ranking methodology used a scoring for each of the rules. If a rule obtains the maximum score, the particular rule has to be inspected to ensure that the score is brought down to a tolerable level, thus ensuring the reduction in risk of the platform. Inspection affects only the LOF.

2.1 Current SIM practices in Malaysia

There is minimal information on SIM practices in Malaysia compared to the GOM. Nichols *et al.*(2006) discussed the approach taken by Petronas Carigali Sdn. Bhd (PCSB) in managing aging platforms. Over 60% of PCSB assets have been in operation for over 20 years. It describes the challenges faced and the solutions in managing the ongoing long term structural integrity of PCSB ageing platforms. The study touched on the assessment procedures, tools and technology programs implemented to ensure the long term fitness for purpose of PCSB's assets. It was acknowledged that platform robustness plays a vital role in ensuring its long term structural integrity. The need for advanced structural assessment by Structural Reliability Analysis (SRA) or optimum Risk Based Inspection (RBI) using quantitative, and not qualitative method was highlighted.

Quantitative risk systems are based on estimating the level of risk by direct assessment of the probability and consequences of failure. Depending on the sophistication of the approach, the probability of failure may be estimated using historical failure rate data or advanced (structural) reliability methods.In a quantitative risk-based system the likelihood is often defined as the annual probability of failure, L, and the consequences of failure are defined as the failure loss, C. However, this research has taken the lead to develop a qualitative RBUI methodology. A Qualitative system is based on rules, where a weighing system is used to capture the relative importance of each rule. The summation of the products of the weights and the scores, will give the overall risk score for each platform.

3.0 Methodology

The methodology adopted consists of the following steps:

1. Data gathering and verification
2. Determination of the Baseline Risk ranking of the platforms
3. Determination of current risk level and inspection plan for the platform.

The data on platforms is collected from different operators and verified for correctness. The baseline risk is based on pre-service conditions whereas the Risk based underwater inspection (RBUI) and planning is based on in-service conditions. Figure 2 shows the RBUI and planning methodology developed in the research.

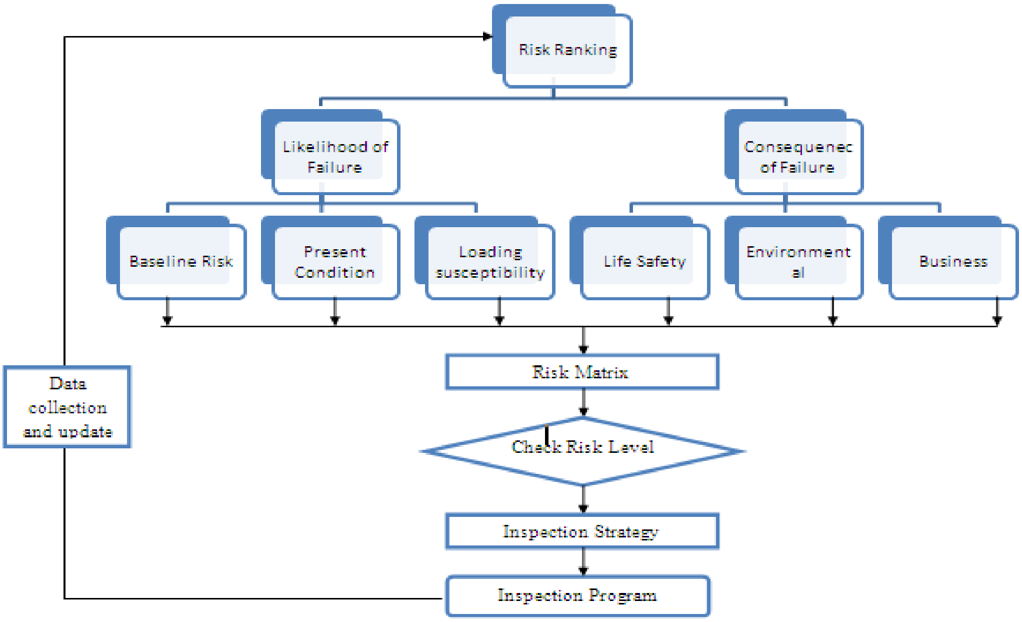


Figure 2: RBUI and planning methodology

To select the appropriate platform for inspection under RBUI, an objective method that removes all subjectivity and ambiguity is employed where a baseline risk of a platform is identified. Baseline LoF evaluates the platform robustness, where the year of design, number of legs and bracing types plays a vital role, each having the numerical scoring system; where the higher the score, the higher the platform baseline LoF will be. The scoring range and weighting was adopted using the AMOCO methodology that was developed by O'Connor and Andy Tallin (1999). To arrive at a score, each rule is given a score range of between 0 to 10. The reason why only the year of design rule and bracing leg rule is used for baseline LoF is because, these two criteria describes the as installed condition of the structure without considering any deterioration. A weighing system is used to capture the relative importance of each rule. The summation of the products of the weights and the scores, as given in the following expression, will give the score for overall likelihood of structural failure for each platform.

$$S_{total} = \sum_{i}^{o} WiSi \qquad (2)$$

S_{total} = Total score for likelihood of failure
W_i = Weightage attributed to i-th rule
S_i = Score attributed to the i-th rule

The baseline LOF selection rules are given in Table 2. API design codes are divided into three distinct periods: Pre-RP2A, Early-RP2A and Modern-RP2A with scoring as in Table 3. The bracing leg rule is shown in Table 4.

Table 2: Baseline LoF selection rule

Rule Name	Input	Weight
Design Practice	Accounts for the historical development of the API's fixed offshore structure design code and the significant changes to the level of metocean loading and joint resistance formulations used in platform design.	5
Bracing Leg	Accounts for how the redundancy varies for basic structural bracing systems.	10

Table 3: Design code rule

Design Code	Pre – RP2A	Post – RP2A	Modern – RP2A
	Pre - 1971	1971 - 1979	After - 1979
Score	10	6	4
Weightage		5	
Total Score	50	30	20

Table 4: Robustness rule (Bracing Leg rule)

Bracing Configuration	Number of Legs				
	≤ 3	4	6	8	>8
K	10	10	8	6	4
VD	10	7	5	4	3
X	6	5	4	3	2
Weightage			10		
Total Score	100 - 60	100 – 50	80 - 40	60 – 30	40 - 20

The total score for the platform is the weighted sum of the individual scores. The overall weighted score range is shown in Table 5.

Table 5: Overall weighted score range for baseline LOF

Criterion	Min and Max Score	Weight	Score Range
Design Year	4 – 10	5	20 – 50
Bracing Type	1 – 10	10	10 – 100
	Total	10	10 – 150

The baseline risk ranking category is based on the Table 6.

Table 6: Baseline risk ranking and overall LOF score ranges

Baseline Risk Ranking	Overall LOF score ranges
Very High Risk	≥120
High Risk	≥ 90- < 120
Medium Risk	≥ 70 - < 90
Low Risk	≥ 50 - < 70
Very Low Risk	< 50

The LOF is then expanded to include the present condition of the structure (considering degradation during fabrication, installation and operation). The rules account for the severity of detected damage and the possibility of undetected damage. The rules are for the time period since last inspection, mechanical damage, corrosion, marine growth and scour. Further there are “platform loading susceptibility rules” accounting for deck load, deck elevation, Appurtenance load and fatigue loads. These rules are summarized in Table 7.

The bins representing categories of platforms with different LOF during the occurrence of the design event is shown in Table 8. The COF (safety, environmental and financial) are the standard consequence issues typically addressed in risk assessments for any type of facility, either onshore or offshore. Each of these consequences are converted to an explicit scoring system and then summed to result in the overall consequences. The life safety, environmental and economic impact COF categories are shown in Table 9.

The overall COF of a platform is the most restrictive of the three consequences in Table 9. Once the POF and COF are determined, the risk of the platforms is evaluated using the risk matrix (Figure 3). Five levels of risk are distinguished namely very low (VL), low (L), medium (M), high (H) and very high (VH) risk.

Table 7: Rules for evaluating LoF Scores based on baseline and present conditions

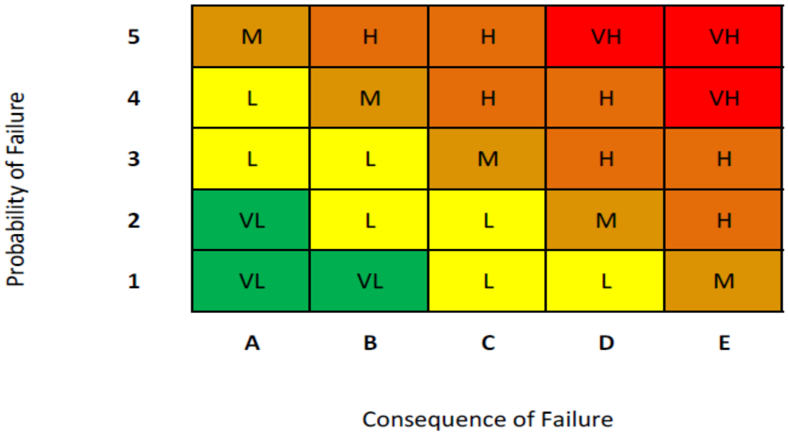
Rule	Score Range, S_i	Weightage, W_i	Total S_{total}
Installed Likelihood Failure			
Platform Vintage	4 – 10	5	20 – 50
Robustness	2 – 10	10	20 – 100
Grouted Piles	0 – 10	3	0 – 30
Platform Present Condition			
Last Inspection	0 – 10	8	0 – 80
Mechanical Damage	0 – 10	10	0 – 100
Corrosion	0 – 10	5	0 – 50
Marine Growth	0 – 10	6	0 –60
Scour	0 – 10	2	0 – 20
Platform Loading Susceptibility			
Deck Load	0 – 10	5	0 – 50
Wave in Deck	0 – 10	10	0 – 100
Appurtenance Load	0 – 10	5	0 – 50
Fatigue Load	0 – 10	5	0 – 50
Minimum to Maximum Score Range			40 - 740

Table 8: Categories of platform based on LOF scores

LOF category	LOF score ranges
5	≥ 650
4	≥ 500 to <650
3	≥ 350 to <500
2	≥ 200 to <350
1	<200

Table 9: COF Ranking for life safety, environmental and economic impact

COF Rank	Life Safety	Environmental	Economic	
	Manned Category	Qualitative BOE Bbl Oil Leak	Qualitative USD Million	cost
E	Manned Non-Evacuated	≥ 50,000	≥ 100	Very high
D	Not-Normally Manned with Temporary Accommodation	≥ 5,000 – < 50,000	≥ 75 – < 100	High
C	Not-Normally Manned with a Boat-Landing	≥ 500 – < 5,000	≥ 45 – < 75	Medium
B	Not-Normally Manned Bridged Link to a Quarters Platform	≥ 50 - < 500	≥ 6 - < 45	Low
A	Unmanned or Manned-Evacuated	< 50	< 6	Very low



Probability of Failure	A	B	C	D	E
5	M	H	H	VH	VH
4	L	M	H	H	VH
3	L	L	M	H	H
2	VL	L	L	M	H
1	VL	VL	L	L	M

Figure 3: Risk Matrix based on POF and COF

The determination of COF ranking for life safety is shown in Figure 4. The RBUI framework for offshore structures is shown in Figure 5. This framework considers both the LoF and CoF factors and determines the risk of the structure.

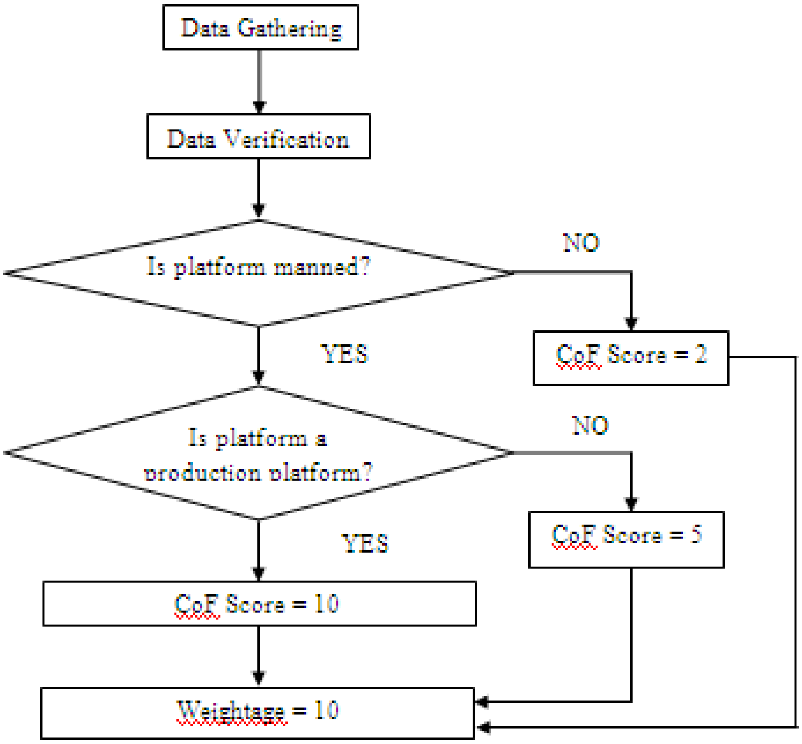


Figure 4: Platform selection criteria for CoF risk

Guidance for setting inspection intervals as part of an overall inspection plan may be achieved through an understanding of the risk posed to the offshore structure. For offshore structures the risk-based strategy optimizes future inspection requirements and will focus valuable resources on the platforms “most at risk”. These, most-at-risk platforms will be inspected more frequently and using more detailed inspection surveys, whereas those platforms with a low risk ranking will have less frequent and less stringent inspections. The inspection plan will define the frequency and scope of the inspection, the tools/techniques to be used and the deployment methods. The inspection plan should be developed for the operated platforms and would be expected to cover a number of years. The plan should be periodically updated throughout the platforms service life following receipt and evaluation of relevant SIM data, e.g. inspection data, results of platform assessments etc.

The risk-based inspection plan is designed to ensure agreement with the inspection intervals provided in Section 14 of API RP2A (2005) given in Table 1. Risk-based inspection intervals are assigned to each platform based on the matrix of intervals shown in Figure 6.

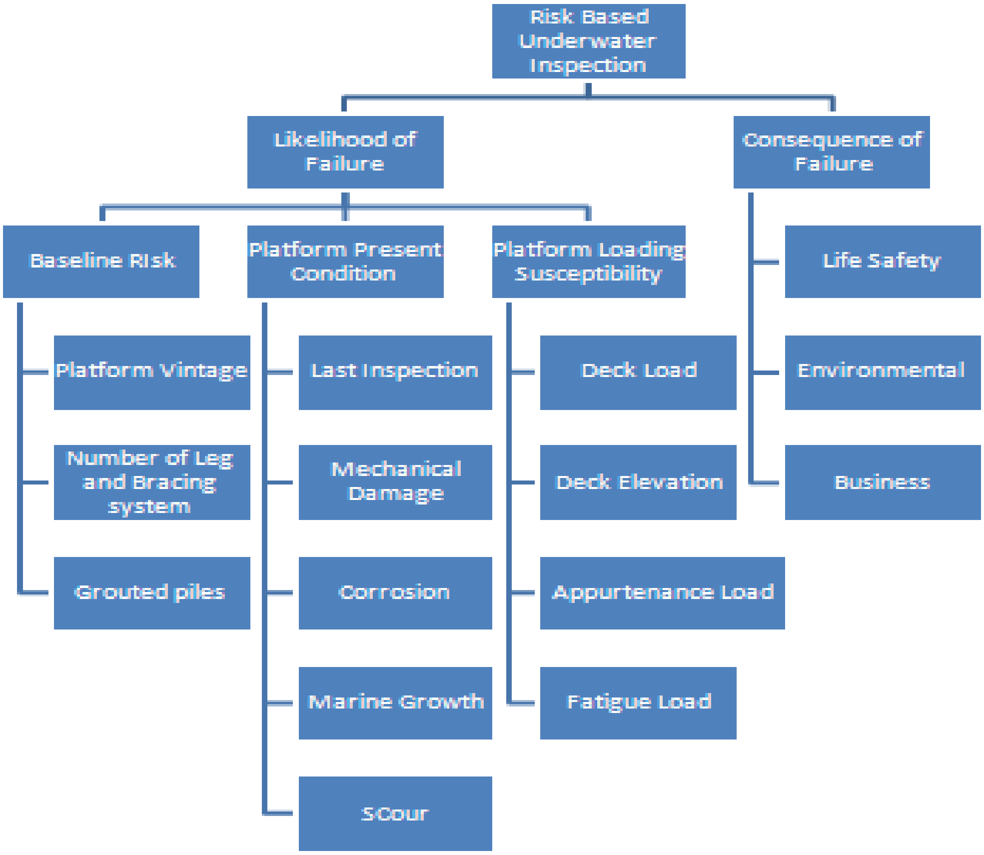
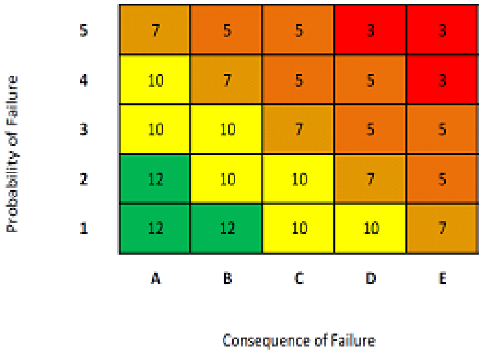


Figure 5: Platform selection criteria for RBUI



Probability of Failure	A	B	C	D	E
5	7	5	5	3	3
4	10	7	5	5	3
3	10	10	7	5	5
2	12	10	10	7	5
1	12	12	10	10	7

Consequence of Failure

Figure 6: Inspection Intervals

4.0 Results

The data gathered from the site included platform characteristic data, as-built drawings, design reports, assessment reports and inspection reports. The first two are pre-service and others are in-service reports respectively. The data is verified for consistency. Major changes are identified since these may change the loadings and increase the LOF or change in function to change the COF. The distribution of platforms based on period of design code, bracing type and number of legs for PMO, SKO and SBO are shown in Table 10. The results of the bracing configuration study indicate that the main bracing configuration for Malaysia fixed offshore structures is diagonal bracing. Figure 7 shows the number of platforms for different combination of bracing type and number of legs.

Table 10: The distribution of platforms based on design code, bracing type and number of legs

	Region	PMO	SKO	SBO	Total
Period of design code	Pre RP2A	0	6	0	6
	Post RP2A	3	48	6	57
	Modern	41	57	25	123
	Total	44	111	31	186
Bracing type	X	9	10	4	23
	K	21	28	11	60
	Diagonal	11	73	13	97
	Guywire	3	0	1	4
	Monopod	0	0	2	2
	Total	44	111	31	186
Number of legs	Monopod	0	0	2	2
	Tarpon	3	0	1	4
	3	6	29	4	39
	4	25	63	17	105
	6	0	12	2	14
	8	10	6	15	31
	16	0	1	0	1
	Total	44	111	31	186

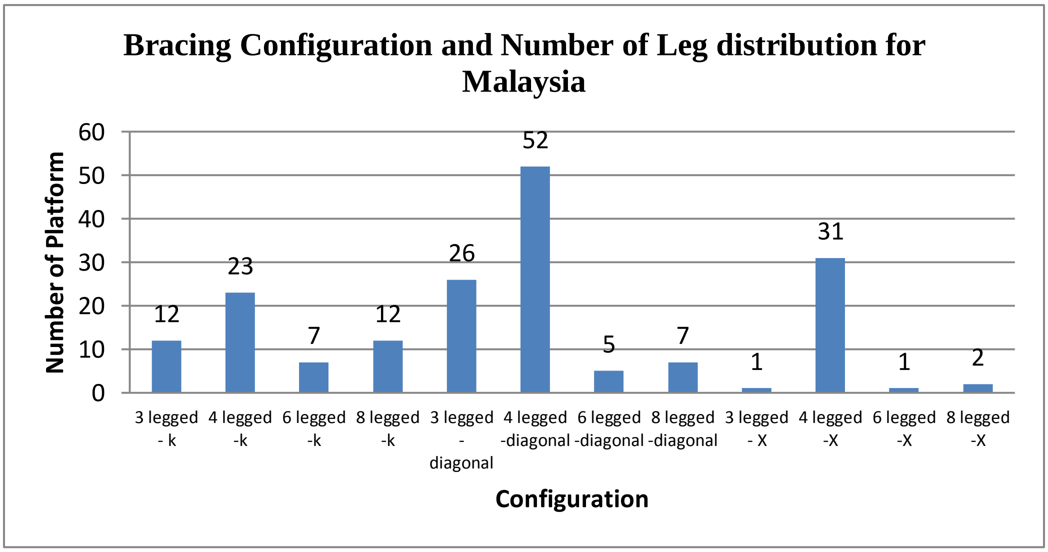


Figure 7: Bracing configuration and number of leg distribution for Malaysia

The base line likelihood of failure risk for all Malaysia's fixed offshore platforms were determined and tabulated for PMO, SKO and SBO as shown in Table 11, where only a few platforms from PMO are shown. The table is divided into 8 columns. The sum of the total design score (column 3) and the total robustness score (column 6) give the total baseline LOF score (column 7). Comparing this with Table 6, the baseline risk is determined (column 8).

The summary of the Baseline LOF risk ranking of Malaysia fixed offshore structure is given in Table 12. A qualitative risk based system for screening a fleet of platforms for underwater inspection was used, which was a modified version of the AMOCO system. The system makes use of physical characteristics of the platforms data to set baseline LOF scores. A platform is "ranked" according to a set of rules relative to other platforms in a fleet. Malaysia's fleet of offshore fixed platforms consisting of 186 platforms was tested using the methodology that was developed and the results closely match the risk ranking by (DeFranco *et al.*, 1999). Fifty-five platforms had "Very High" risk baseline LOF, forty-eight had "High" risk baseline LOF, seventy-six "Medium" risk baseline LOF, and seven "Low" risk baseline LOF, based on the methodology that was developed in this research.

Table 11: Sample Baseline Risk Ranking of PMO Platforms

Platform No	Design Year	Total Design Score	Bracing	No. of Leg	Total Robustness Score	Total Baseline LOF Score	Risk Level
10	1979	30	K	4	100	130	Very High
4	2003	20	K	3	100	120	High
6	2003	20	K	3	100	120	High
12	1986	20	K	3	100	120	High
13	1990	20	K	4	100	120	High
16	1993	20	K	4	100	120	High
18	1983	20	VD	3	100	120	High
27	2006	20	None	1	100	120	High
30	2003	20	None	1	100	120	High
31	2003	20	None	1	100	120	High
33	1983	20	K	4	100	120	High
36	1999	20	VD	3	100	120	High
44	1983	20	K	4	100	120	High
9	1978	50	K	8	60	110	High
32	1976	50	K	8	60	110	High
15	1993	20	VD	4	70	90	High
19	1995	20	VD	4	70	90	High
20	1983	20	VD	4	70	90	High
21	1983	20	VD	4	70	90	High
22	1983	20	VD	4	70	90	High
23	1983	20	VD	4	70	90	High
24	1983	20	VD	4	70	90	High
25	1982	20	K	4	70	90	High
2	1998	20	X	3	60	80	Medium

Table 12: Summary of baseline LOF risk ranking of platforms in Malaysia

Risk Level	PMO	SKO	SBO	Total
Very High	1	44	10	55
High	22	18	8	48
Medium	17	47	12	76
Low	4	2	1	7
Very Low	0	0	0	0
	44	111	31	186

5.0 Case study on the Risk Based Underwater Inspection (RBUI) Method

The case study demonstrates how the risk ranking will affect the inspection planning of the offshore structure for which one fixed offshore structure is taken as example. Using the data for this structure the LOF and COF and then the appropriate risk level and inspection plan of the platform is determined. The LOF and COF rules discussed in methodology are used. The basic platform information is given in Table 13 (column 1 and 2). The data will be used to calculate the LOF score of the platform. The score would then be summed up to obtain the risk level and subsequently the inspection plan of the structure. Table 13 shows the LOF rule score for platform. The case study of platform indicates a total LOF risk score of 449. Comparing this score with LOF risk category in Table 8 shows that the platform is a category three platform.

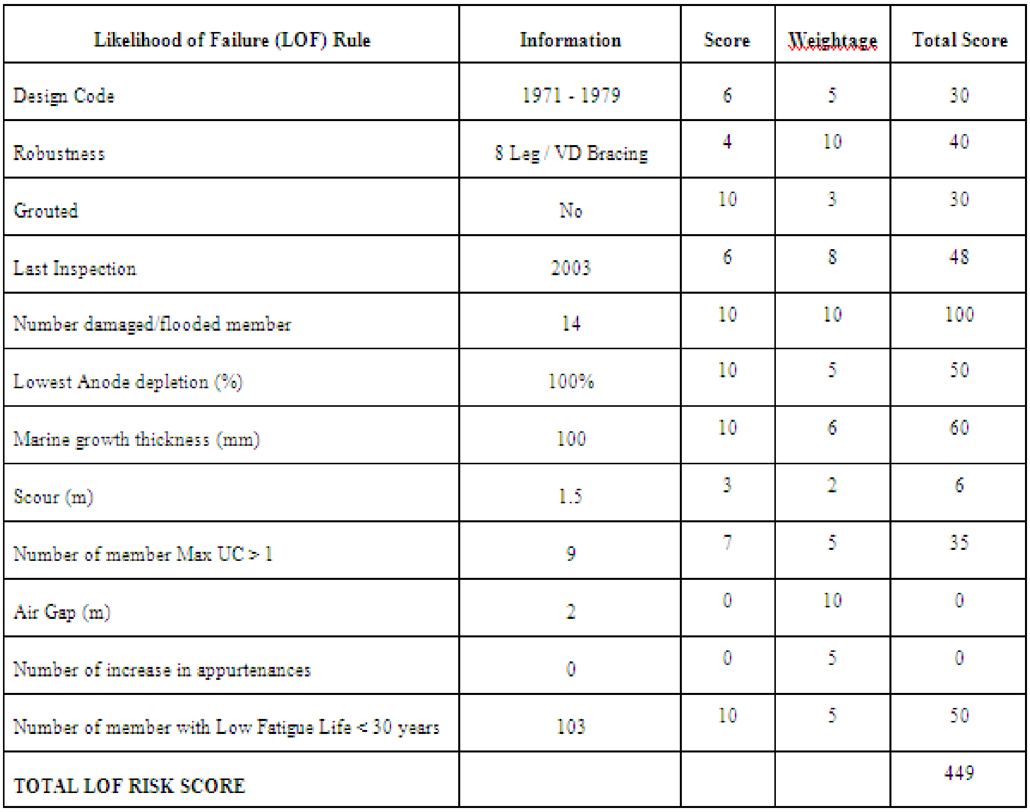
The next step would be the determination of the COF risk ranking for the platform. The COF rule has 3 major items namely Life safety, Environmental and Economics. The COF information of the platform is shown in Table 14. The information is compared to the COF rule developed in this research (Table 9) to obtain the COF risk ranking (Table 14). The economic consequence is taken as the most conservative of the values based on the experience of BP Horizon oil spill in the Gulf of Mexico (GOM). The result of the three COF rule are “E”, which implies that the overall risk ranking of the platform is 3E. Using the risk matrix (Figure 3), the overall risk ranking for the platform is 3E (High Risk). Referring to Figure 6, the platform should be inspected every five years. However, Table 13 indicates that the last inspection of the platform was conducted in 2003, with a lapse of nine years now. Therefore it can be concluded that the platform needs to undergo underwater inspection and maintenance as soon as possible to ensure the continued fitness for purpose of the structure.

6.0 Conclusion

Prior to this research, the current status of assets in Malaysia was evaluated. The result showed that many of the structures have exceeded the design life of thirty years. Safety guidelines are required to ensure that these platforms are safe to be used beyond their design life. This is done by ensuring the structural integrity of platform is not compromised. If so, it would lead to structural failures and therefore loss of business and also lives.

The RBUI framework recommended by O Connor *et al.* (2005) and DeFranco *et al.* (1999) was found to be the most relevant framework for the development of SIM framework for fixed offshore structure. The elements of these frameworks have been further investigated in this work. This includes an evaluation of current design practices that has an impact on future structural integrity of a platform, underwater inspection philosophies and failure modes of ageing structures. Data was available for 186 platforms. The baseline risks of these structures were determined. Fifty-five (55) platforms were identified to be “Very High” risk. A RBUI guideline was developed. The RBUI guideline is a procedure on how to conduct RBUI planning for in-service inspection of jacket structures. This Guideline is to be used for the planning of in-service inspection for offshore platform structures, considering possible total platform failure through structural collapse. This Guideline addresses the most commonly experienced degradation mechanism found on platform structures, but the inspection personnel should make themselves aware of any special hazards that are relevant to the platform structural integrity which are not included in this document. The case study demonstrated how the RBUI will affect the inspection planning of the offshore structure. The LOF and COF of the structure were determined. This provided the appropriate risk level and inspection plan of the platform. The overall risk ranking for the platform considered in the case study is 3E (High Risk), with an inspection interval of five (5) years. The last inspection of the platform was conducted in 2003, with a gap now of nine years. Therefore the platform needs to undergo its underwater inspection and maintenance campaign (UIMC) as soon as possible to ensure the continued fitness for purpose of the structure.

Table 13: LOF rule weighted score for the case study platform



Likelihood of Failure (LOF) Rule	Information	Score	Weightage	Total Score
Design Code	1971 - 1979	6	5	30
Robustness	8 Leg / VD Bracing	4	10	40
Grouted	No	10	3	30
Last Inspection	2003	6	8	48
Number damaged/flooded member	14	10	10	100
Lowest Anode depletion (%)	100%	10	5	50
Marine growth thickness (mm)	100	10	6	60
Scour (m)	1.5	3	2	6
Number of member Max UC > 1	9	7	5	35
Air Gap (m)	2	0	10	0
Number of increase in appurtenances	0	0	5	0
Number of member with Low Fatigue Life < 30 years	103	10	5	50
TOTAL LOF RISK SCORE				449

Table 14: COF information of the platform used for case study

COF Rule	Information	CoF
Life Safety	Unmanned	A
Environmental / BOE spilled / Storage capacity	20000	D
Economics	E	E

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