Maintenance Optimisation for LNG Marine Loading Arms on New LNG Processing Facility Using RCM and FMECA Methodologies

INPEX

Introduction

There is opportunity in new facilities, to make significant improvements to reliability, availability and maintainability (RAM), aiming for high RAM and lowest possible life-cycle costs (LCC). Pre-emptive interventions, through Preventative Maintenance (PM), should balance the cost of maintenance with elimination of degradation and failure mechanisms. PM is performed to avoid failures and costly unplanned Corrective Maintenance (CM) which tends to be more expensive and less safe to carry out. Insufficient PM could allow equipment to wear out, leading to increased failures and reduced overall reliability. Excessive PM can introduce additional damage by maintainers, leading to increased LCC, reduced reliability and availability, and it costs money. Determining optimum frequency and type of PM requires cost/benefit/risk factors to be analysed and optimised.

To optimise the maintenance program, analysis of failure modes, effects, and criticality (FMECA) should be carried out, then recommendations for maintenance, inspection and testing programs be made, using Reliability Centred Maintenance (RCM) decision logic methods. This aligns the maintenance strategies with how the equipment fails, how predictable the failure is and what overall impact the failure has to safety, the environment, and production. Some other positive impacts an RCM project has, are improvements in morale, teamwork, individual motivation, and buy-in to maintenance plans. The RCM process has been applied to the maintenance strategy for the INPEX Ichthys LNG marine loading arms, the method of application based on extensive research of RCM and FMECA application theory from the Aviation, Nuclear, Petrochemical and Nuclear sectors.

Method

A detailed FMECA study has been carried out on the marine loading arms (MLA), which identified all credible failure modes, their effects, causes and criticality ranking, or RPN score. Existing maintenance tasks and operator rounds were mapped to the failure modes in the FMECA sheet.

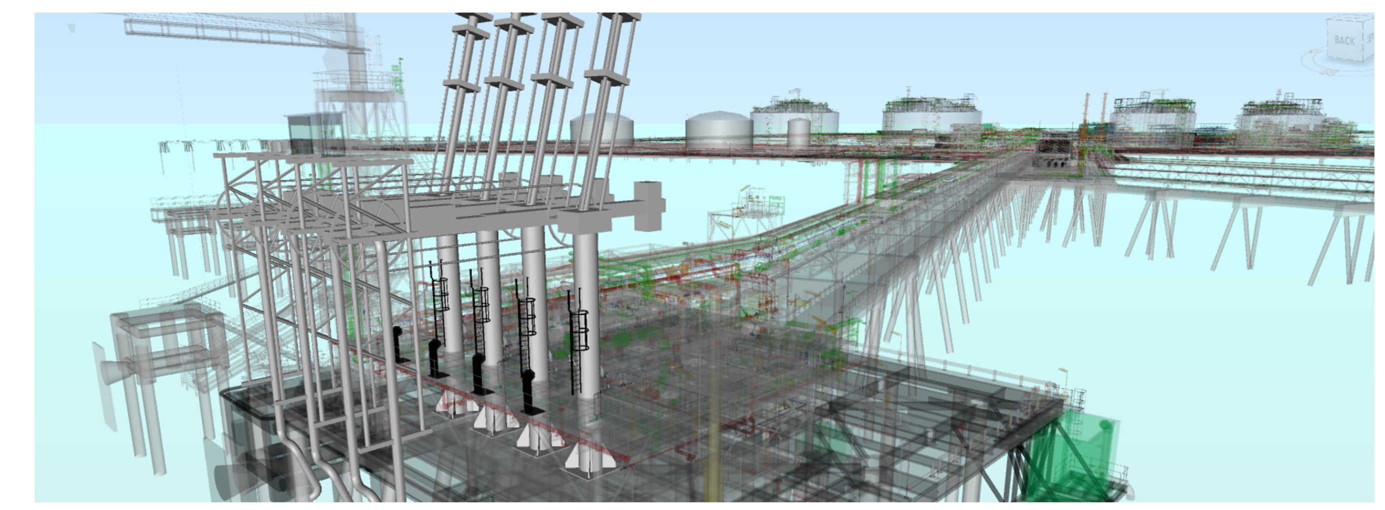
An RCM analysis workshop was then carried out, through application of the RCM decision logic, which is to be adopted by INPEX, to formulate recommendations for optimised maintenance strategies. Stakeholders from multiple departments and disciplines participated, including Engineering, Production and Maintenance.

Ichthys LNG Marine Loading Arms – Maintenance Optimisation using RCM methods

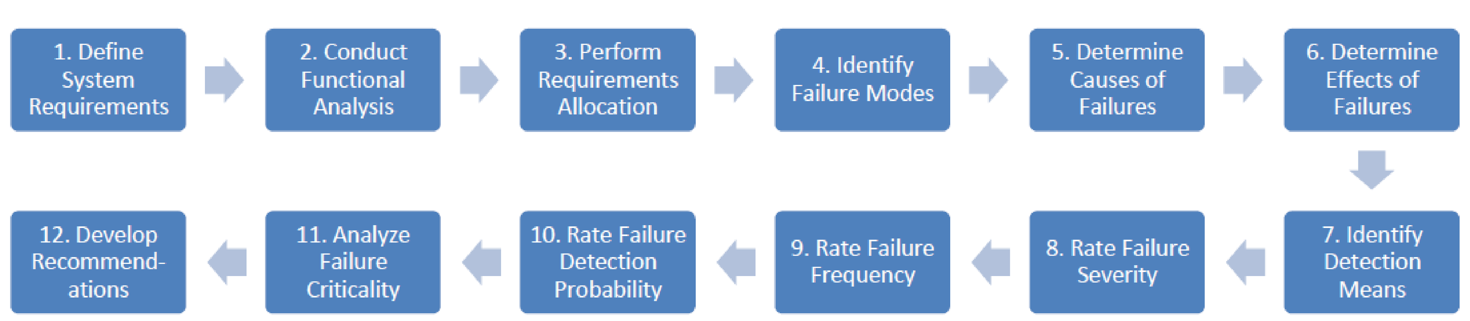
ID	Task Name	Start	Finish	Duration
1	Kickoff meeting to review opportunities and agree scope	24/07/2019	24/07/2019	1d
2	Prepare all information for RCM FMEA review workshop	7/08/2019	20/08/2019	10d
3	Workshop: Review RCM FMEA for completeness	28/08/2019	28/08/2019	1d
4	Update RCM FMEA in Meridium and map tasks and operator rounds to FM	29/08/2019	10/09/2019	9d
5	Workshop: Analyse and define maintenance tasks and operator rounds	11/09/2019	11/09/2019	1d
6	Analyse recommendations from Maintenance Task Analysis workshop	12/09/2019	1/10/2019	14d
7	Revision of SAA document and any MWIs	2/10/2019	2/10/2019	0d

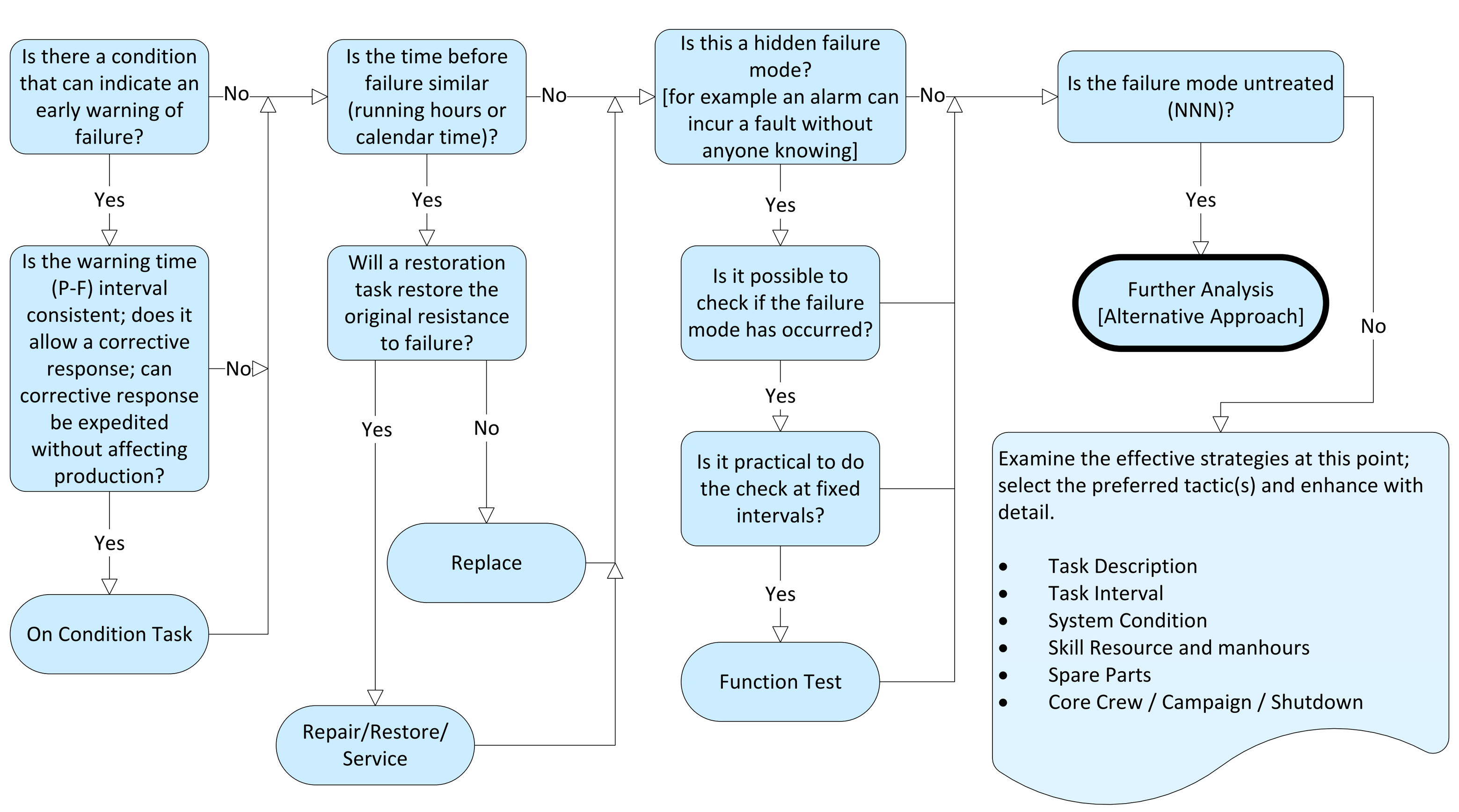
Results

- Rigid time-based overhaul schedules to be removed, representing ~30,000 hours of maintenance over the next 6 years, plus significant material & equipment cost savings
- Preventive maintenance (e.g. greasing) and predictive maintenance (e.g. condition monitoring) strategies to be employed, with major components replaced with 'rotable' spares only if required
- Major components requiring arm removal can last 20+ years (slew, fulcrum and apex bearings) where they were previously set at 5 yearly per OEM recommendations



FMECA and RCM decision logic





Discussion and next steps

Prior to the RCM analysis, frequent and costly OEM predetermined scheduled preventive maintenance strategies had been adopted, hard time-based preventive maintenance carried out without previous condition investigation. Many parts of the maintenance strategy now move to condition based preventive maintenance, preventive maintenance which includes a combination of condition monitoring and/or inspection and/or testing, analysis and the ensuing maintenance actions, based on preventive testing and inspection PT&I, which will maximise availability and minimise cost.

There are more opportunities to follow and document the RCM process, using new knowledge to optimise maintenance strategies, considering the actual site conditions, which will improve the visibility and understanding of how company engineers have formulated a recommendation for a maintenance strategy, in a routine, logical and auditable way. As this is only one area of a large, complex facility, this approach will be used as a blueprint for ongoing maintenance optimisation activities. The RCM process employed in this project should be formally documented and rolled out to the organisation.
The rationale or justification of many recommendations from discipline engineers and technical authorities is only recorded in brief in the current standards for availability assurance, examples like "frequency of task aligns with OEM requirements", with no clearly documented method showing how this decision was reached.

Once robust FMECA and RCM analysis has been completed on a system or equipment type, this new knowledge can be used to support improvement of maintenance and maintenance support, integrated logistic support, and maintainability strategies.

Conclusion

We conclude that following the FMECA process, followed by RCM decision logic, to formulate recommendations for optimal maintenance strategies has proven useful. There are many RCM decision logic trees available and in-use with multiple different structures and approaches. No approach is right or wrong, the key is selecting an approach that is simple enough to follow with repeatability, and that ensures a structured thought process is used to determine optimal maintenance strategies that optimise cost and use of resources without creating intolerable safety, environmental, or production risks.

By following the RCM process, there is a clear increased morale and engagement of the teams, making positive steps toward becoming a high reliability organisation, with an increase in operational discipline, strong teamwork and employee involvement that comes from adopting this process.

In addition to the increased maintenance optimisation that comes from the RCM process, there are clear flow on effects as this supports optimal maintenance support and sparing strategy development. RCM should be adopted as a 'living program', conducted periodically over time to continually review and reassess the preventive maintenance decisions that were made in the RCM baselines to ensure continuous improvement toward world class maintenance.

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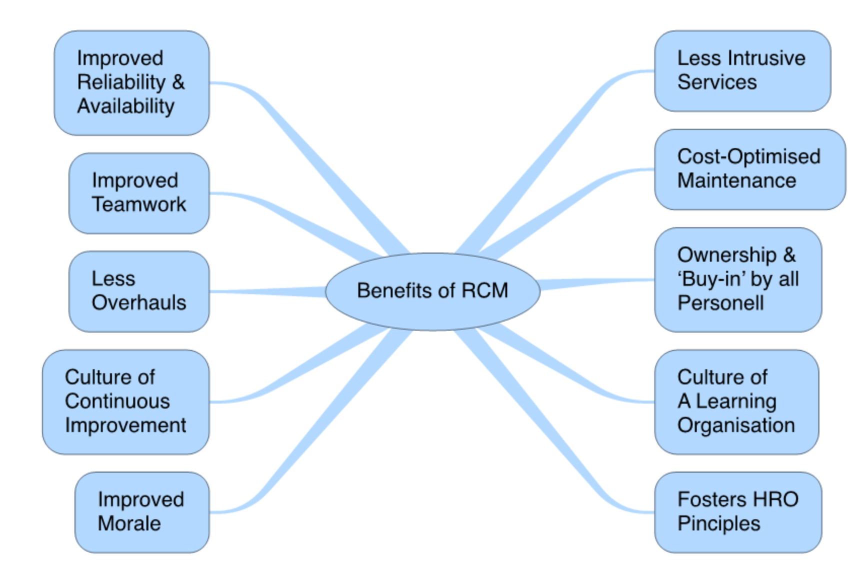

Vandenberg, Erik | Wilson, Mark | INPEX Ichthys LNG 144 Wickham Rd. Wickham, NT Australia, 0822 | erik.vandenberg@inpex.com.au | Gopinath Chattopadhyay | Federation University