

Association Internationale de Signalisation Maritime ***IALA- AISM***

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**On**

**Risk Management in Design and Maintenance**

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IALA Guideline No. #### on RISK MANAGEMENT IN DESIGN AND MAINTENANCE

# INTRODUCTION

This guideline outlines the various techniques available for using **Risk Assessment** as a tool for delivering sound designs and robust maintenance techniques.

# dESIGN RISK ASSESSMENT

Risk Assessments will, if used correctly, deliver the following from designs:

1. Equipment that is safe to build, operate and dispose of.
2. Equipment that functions correctly & reliably
3. Equipment that the end user or customer wants

## Concepts and key areas

The following diagram represents the key factor when considering design risk.



## User Requirements

It is important to capture the key user requirements, ideally in a consistent format from project to project. These are the initial key user requirements which might be refined as the details of the project develop. The key users may well be, Navigation, Marine, Maintenance and Legal. These requirements are at a high level.

## Priorities Requirements

It is helpful when focusing on design, with a limited budget and /or resource to understand the customer’s priorities of what is the most important thing to achieve and what is the least. This can often be difficult when trying to compare if it is more important that the light achieves the correct range against the impact of achieving a minimal maintenance solution. To help achieve this a process called Quality Functional Deployment (QFD) is used.

## Quality Functional Deployment

Employing a member from each key stakeholder group, a process is followed that allow this group to define what their desired outcomes are for the project and then to prioritise what is the most important goal to be achieved. This can then be used to rate the suitability of any concept or solutions and focus on these key areas.

## Concept Generation and Selection

As the output from the QFD has clarified the importance of the user requirements and expectations, a number of concept generations for systems, equipment, materials, structures, access, etc. can be produced. For each concept they can be compared to see how effective each is at meeting the stakeholder requirements and for those that may be of a critical performance nature, then a system failure mode and effects analysis can be applied.

## System FMEA

Failure modes and effects analysis (FMEA) is a formal method of identifying all possible failures in a design by assessing each failure mode in turn and considering the effect that each failure mode will have.

“Failure mode” is the manner in which something may fail. Failures are any errors or defects that effect the performance of the system, sub system or component.

“Effects analysis” is the studying of the consequences of these failures.

Failures are categorized according to the seriousness of their consequences and how frequently they may occur. The purpose of the FMEA is to take actions, in this case re design the item, to eliminate or reduce failures starting with the highest-priority ones.

An FMEA workshop is convened with subject matter experts where the potential failures and their effects are considered and rated. From this a list of actions required is produced prompting a re think on the initial design proposal. The FMEA has its scope formally documented to limit the discussion. Each system is reviewed and its purpose identified and accepted; this can have the outcome of eliminating the need for entire systems. A table of the severity rating and the risk rating of a failure occurring is drawn up which will guide whether a control or re design is required.

System FMEA will determine any areas where additional systems, monitoring or response may be required. This in turn can be rated against meeting the stakeholder requirements. It will set the level of redundancy within systems as well as areas to monitor and predict failure. This will set the maintenance response need on completion of the installation.

Factors that will impact on the FMEA will be topics such as; System complexity, Site accessibility, cost, standard equipment used.

## Design and Installation Standard

Ensuring the use of any existing design standards may well reduce the time to achieve the design as any necessary FMEA would be complete, this also tends to lead to consistent solution. Having a suitable installation standard also adds quality into the final solution and consistency of the product.

## Standard Equipment

This again allows a reduction in time for design and consistency for maintenance. This inturn has positives for the organisation by reducing the scope for spares and training.

## Design Reviews

These are design control points. They are periodic peer review of a system, design or part solution at key points in the design process. This ensures that as the design develops all factors are taken into account maximising any added value.

## Design approval

A formal sign off by a senior designer / principal Engineer, peer Engineer or external subject matter expert will ideally provide adequate scrutiny to designs before final manufacture or installation.

## Design Risk Registers

These are risk registers maintained by designers through the process of design, which record how the health and safety factors as well as financial risks have been mitigated, reduced and eliminated. They will also identify any remaining risk that need to be communicated to the installation team.

## Project Risk Registers

This is simply a risk register to identify risks that may have an impact on the project that would result in the project goals not being achieved. These are frequently updated and reviewed throughout the project.

## Customer Consultation

This is achieved through a periodic review of the design at key milestones. Additionally, frequent periodic feedback should be provided through the whole project / design process.

## Facilities Risk Register

In order to effectively assess the level of facilities for personnel needed against the level of complexity, ease of access, duration needed to repair and periodic maintenance duration, a facilities risk register is used to quantify the needs against these factors. The level of facilities and investment can then be scaled accordingly.

## Cost Benefit Analysis (CoBA)

At both the concept and system solution stages of any project, a Cost Benefit Analysis can be done either on the whole solution or on parts of the concepts to determine a the most cost effective solution. This factoring should only be applied after achieving all of the customers goals, or without detriment to them.

## Summary

From the above factors two things should be able to be developed:

1. A model that can be used during the design process that can determine the impact of simplicity against complexity relative the customer requirements and risks.
2. A process that can be followed to effectively achieve the customer requirements and an effective system solution, with the necessary infrastructure at a suitable cost.

# Maintenance Risk assessment

Determining and delivering the appropriate level of maintenance for Aids to Navigation is a significant and important part of the Competent Authorities’ duty. If maintenance is neglected the consequences can be extreme, however if too much maintenance is carried out this will be a very expensive and unnecessary financial overhead.

## Overview

Maintenance has traditionally been carried out in either one or a mix of the following concepts:

1. **Run to failure.** This philosophy is appropriate on non critical systems or those with reliable back up where maximum life can be enjoyed. An example of this is a lamp in a multi lamp changer system.
2. **Calendar based planned maintenance.** This is the classic “Annual Engine Service” that was a convenient time to remember to deliver it rather than whether the engine or it’s oil needed a service or not. This has it’s application as it is simple to plan for and is usually a reliable maintenance approach.
3. **Operating time based maintenance**. A more intelligent form of calendar based maintenance setting out the run time before planned intervention, such as a car service following a set distance driven. An example here would be changing an AtoN lamp after xxx operating hours.
4. **Predictive maintenance** based on changing measured parameters such as vibration, heat, voltage etc. This requires an often complex monitoring process in place which in turn requires resource to manage it but it will eliminate un necessary maintenance and determine when maintenance needs to be done to promote maximum life from the plant.
5. **Inspection Led Maintenance** identified following an inspection regime. Here a planned inspection identifies what maintenance is required, this is ideally non intrusive and will optimise the maintenance workload though the inspection requires dedicate resource.

Many plant failures are maintenance induced so the optimum is to undertake the minimum maintenance intervention necessary to ensure plant reliability and longevity.

The location of the site has an impact on the final maintenance regime, for example, an AtoN close to the maintenance base may be allowed to run to fail as it can be repaired within an hour whilst a remote AtoN will have more robust systems and a more comprehensive maintenance programme in place.

## Concepts and key areas

The following diagram represents the key factor when considering maintenance risk:



## Location and Access

Reliability of access and location or distance from offices, depot or base (where the resource is) are key factors in managing the risk of aids to navigation (AtoN) failure. Often nearer and easier access locations can have less frequent and/or less onerous inspections and maintenance.

## Location Priorities

Some aids to navigation (AtoN) may be located in an area of high traffic density, high risk hazards, high impact or where high speed craft are in use. At these locations, a priority to repair maybe placed on these AtoN over those where this is not the case.

## Resource

This does not just refer to people, but may also relate to such things as ships, planes and helicopters that maybe key to access. However, these are merely resources used for access and as such have been considered as part of the access risk aspect. This therefore leaves us with the number and skills of the people who maintain and repair AtoNs’. Ultimately a critical mass of trained personnel is needed to reliably meet any organisations requirements.

## Equipment Type

This factor is not one that can easily be changed without reasonable investment, yet it is key to the frequency of visits, duration of maintenance and resources needed to respond to a failure.

## FMEA

The application of FMEA as described above will guide the maintenance manager to the optimum maintenance required and exactly what to do and at what frequency. By looking at each failure mode and its effects and assessing its impact and frequency, the maintainer will be able to assess what intervention is required to prevent it and how frequently.

Although this essentially is set at the design stage, FMEA also identifies the key point to be monitored and maintained throughout the life of the equipment or system. It is these monitoring points and maintenance, that set the frequency and duration of work and hence resource needed to achieve the organisational requirement across the whole estate.

## System Solution

This is really set at the design stage, but may inform what sort of failure response is required, subject to the number of redundant systems.

## Complexity

Dependant upon the complexity of any system, this will have an impact on both the skills of the resource need to repair but may also have an impact on the duration to repair. Counter to this, more complex systems may provide advanced warning to failure, may take automatic action to avert failure or may provide additional information to simplify repair. This is an area that is very much a double edged sword and is about how the technology is tested and applied.

## Maintenance Duration

This is subject to the age and type of equipment fitted. This factor may be adjusted over time, based upon performance learned. This factor significantly effects the facilities required to maintain the AtoN and hence the cost.

## Maintenance Philosophy

This again is driven by the type of equipment fitted, but may be adjusted by experience and easy access to the location and/or a low risk area.

## Performance Analysis

This is a periodic task that should inform the organisation about the engineering effectiveness of the AtoN. It should allow focus to the adjustment of any periodicity and duration of maintenance, but also help to prioritise any capital or engineering improvements.

## Surveys and Inspections

These are generally visual and condition based observations and are more likely to relate to civil and structural estate management but are required for the assessment of the performance of any AtoN. Poor inspections or surveys usually lead to the need for significant funding either for repair or replacement. Such monitoring and replacement is generally over a longer time period.

However, some inspection may be simple function testing that lead to confirmation of a good AtoN.

## Monitoring Points

These are points that on each occasion need to be measured. They are usually points used to either predict failure or predict the need for some maintenance action. Some of these points can be so important that they are monitored by telemetry.

## Maintenance Management & Information System (MMIS)

A well organised and maintained MMIS will deliver reports as to what items of plant are causing the most problems and costing the most to repair or maintain. This is invaluable information to guide the maintenance manager in adjusting the maintenance regime to attend to these identified items.

## Stores usage

An analysis of what stores are used over a period, typically a year, will inform the maintenance manager of the number of items being drawn out, this can be compared to the expected stock usage which will then identify plant problems that may be overcome by either a change to the maintenance regime or by re design.

## Brainstorming

Asking those who maintain the plant on site is a very practical method if identifying what items are unreliable or cause issues. Usually, plant maintainers are very keen to offer their practical experience on their work which will inform the maintenance manager what items need attending to in either revised maintenance or re design.

## Summary

Taking all of these factors into account it should be possible to develop the optimum maintenance requirements for each location. This in turn determines how the maintenance can be focused and with any asset risk management, may allow a clearer cost effective focus on any future capital or improvement works.