Reliability Centered Maintenance (RCM) of the Autonomous Passenger Ferry in Trondheim

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Objective and scope

The objectives for the master thesis is to describe the Reliability Centered Maintenance (RCM) method and adapt it to the autonomous passenger ferry in Trondheim, and to define the RCM decision logic. Then analyze and derive the maintenance strategy and plan. Followed by recommendations on which failure and maintenance data that needs to be registered to improve the decision basis during operation. This poster will shortly present how the failures are evaluated and a short summary of the results obtained.

Method

The method used to derive the maintenance program is called Reliability-centered maintenance (RCM). Which is a systematic way to create a maintenance program for different types of equipment or systems, where the focus is on maintaining the systems functions. The method also aims to be cost reducing, therefore a maintenance task should only be chosen if it is worth doing and technically feasible. The maintenance task used here are adapted from J. Moubray [2], and a short description will follow.

Scheduled on-condition task: A periodic or continuous task used to detect a potential failure [2].

Scheduled restoration: Restoring the capability of the item.

Scheduled discard:Replacement of item.

Scheduled failure-finding: Finds the failure.

Run-to-failure: Allowing the failure to occur.

Conclusion

In terms of effects of failures, such as loss of reputation, effects on safety and asset, the most critical system were identified to be the navigation system, anti-collision system, propulsion system and battery cooling system. As the analysis shows the ferry has a high percentage of failures in the unacceptable are, consequently many of the maintenance task will be preventive. The analysis performed is conservative, which reflect the fact that the concept is new and unfamiliar.

References

[1] E. Eide. Autonomous Shuttle Ferry, Ferry in Trondheim

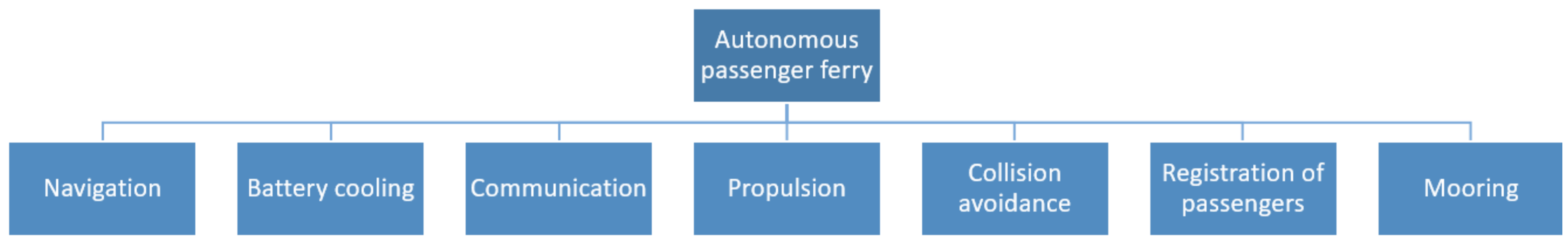
[2] J. Moubray. Reliability-centred maintenance. Oxford: Butterworth-Heinemann, 2nded. ed., 1997

Introduction

Over the past years more and more interest has been shown to the field of autonomous vessels, and in 2019 Trondheim will get one of the first unmanned and autonomous ferries in the world. The concept includes a "On-demand ferry", push a button and the ferry will come shortly. With a crossing time of one minute, one has frequent departures and short waiting times. The ferry can take up to 12 passengers, and shall be available for both wheelchairs, bicycles and strollers. [1] Before the ferry can be commissioned there are several aspects related to safety, operating and maintenance that has to be solved.

Analysis

The analysis is performed system for system, where each system has its intended function together with secondary functions. The most important functions identified for the asset are shown in the figure below.



The systems are analyzed in terms of the effects of failure when it comes to safety, asset, environment and unavailability. All of them are divided in classes from one to five, where five is critical and one is negligible. Each failure is associated with a failure cause. The criticality for the failures are measured with the risk index. Which is a sum of the consequence and the probability, and can range from 2 to 10. The RI is divided in three different areas, green, yellow and red. Green is the acceptable area, while red is the unacceptable. Yellow is the ALARP area: As low as reasonable practicable. The areas for this analysis is set to be conservative, where the ALARP area ranges from 5-6.

The maintenance task assigned for a failure must be worth doing, which implies cost effective. Cost effective compared to run-to-failure which is a default action. Cost of a failure involves loss of income, repair costs, injuries and loss of reputation. Where loss of reputation and injury costs are the most significant ones. Since loss of reputation is difficult to measure, levels from one to five has been used here as well where five is a total loss of the investment.

Results

The criticality of each failure for each component in all the system has been assessed, where the figure below shows the split in risk index. The figure shows that over 50% of the failures are in the unacceptable area when it comes to their effects, while only a small fraction is in the acceptable area.

The maintenance program for all of the systems has been derived in the thesis, the figure below shows the distribution between the different maintenance tasks. Over 80% of the failures are assigned to some sort of preventive maintenance.

The most important maintenance tasks are the ones concerning the new ideas, navigation-and anti-collision system. A failure will not only affect the reputation for the ferry, but also further use of the technology. Consequently the navigational sensors and the control algorithms has been assigned to continuous scheduled monitoring via a shore-based station.