CHAPTER 9   CONCLUSIONS AND RECOMMENDATIONS

9.1   Introduction – Chapter Overview

This thesis has presented a complete and integrated solution for plant control and asset management systems. The objectives of this study were stated in the first chapter of thesis to include the design, development and implementation of an integrated asset management solution for different plant control and asset management systems (see 1.1) using the SAMI model as reference. The goal of the project further included the design of an interface that would enable plant managers to effectively identify problems pertaining to plant-based assets and react appropriately so that plant uptime and profitability is optimised.

This chapter provides an overview of the completed research and the most important research results and findings are highlighted. Recommendations are thereafter being presented and limitations are considered. Suggestions for further research are discussed and in closing, the benefits of the findings of this thesis are emphasised.

9.2   Overview of thesis

The purpose and aims of the study were presented in the first chapter of this thesis. Contextual information was provided in order to describe the plant maintenance problems that were identified and resulted in this research project.

The aims of the study and research methodology were outlined in Chapter 1. In addition the actuality of the research was emphasised and the need for an applicable solutions and outcomes was stated.

As part of the introductory chapter, the SAMI operational reliability maturity model which was used as a point of departure for the research was discussed. The SAMI

Model is shown below, overleaf. The focus of the research was identified to be the second stage of the SAMI Model, namely proactive maintenance.
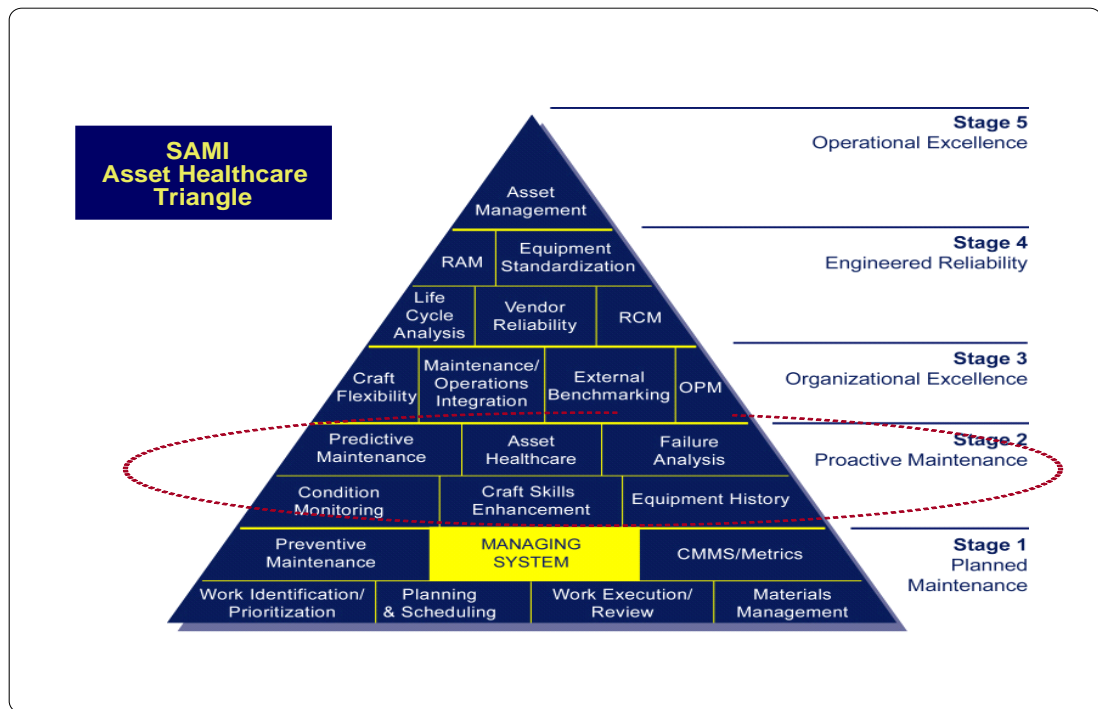

Figure 95: SAMI Asset Healthcare Triangle: Focussing on Stage 2

The literature study was presented in Chapter 2 of this thesis. The different plant control and asset management systems that were installed at the Sasol Solvents site were discussed. The concept of virtualisation was introduced to show how the different systems were linked by means of virtual machines in order to test the different interface functionalities off line (see 2.13). The integrated solution that was developed to communicate with diverse software interfaces was discussed in the second chapter of this dissertation.

The research methodology used to address the objectives of thesis was presented in Chapter 3. The benefits of the action research methodology were discussed. The action research steps taken (figure 96) were outlined in this chapter.
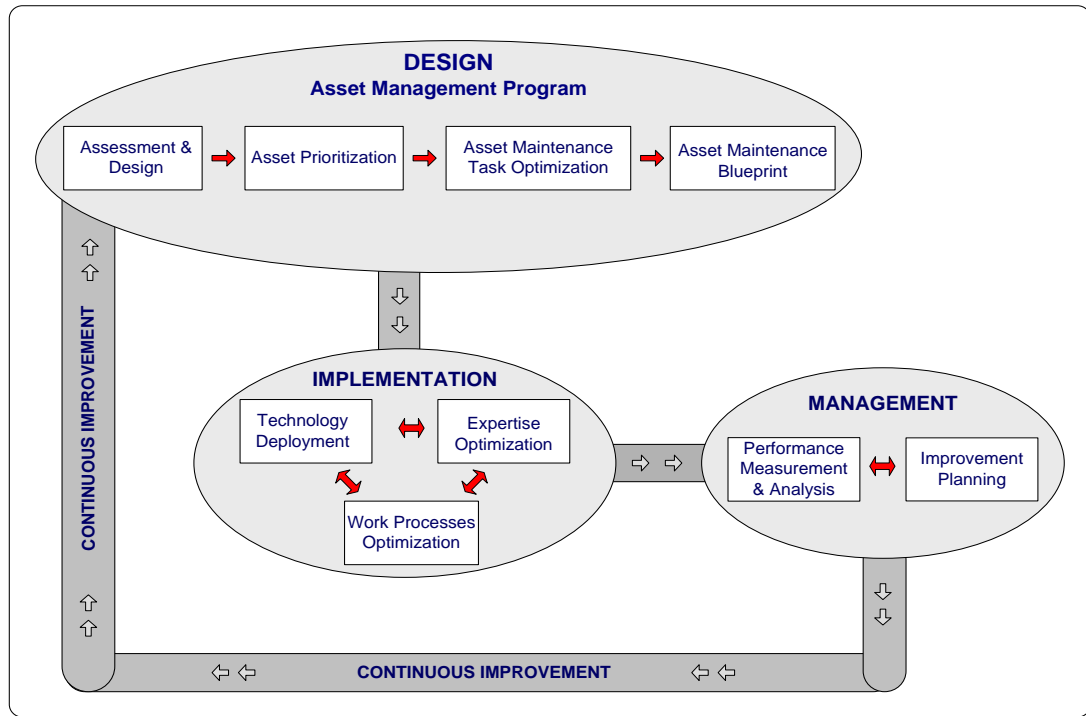

Figure 96: Action research cycle

Chapter 4 provided an in-depth discussion of the symptom and fault models for different assets (see figures 19a and 19b). The failure analysis processes were shown in the Sasol work process for maintenance. The DataScout configurations were explained to illustrate the setup and configurations and how they are used in the AlertManager to produce active alerts when equipment or systems are busy failing or have failed.

Chapter 5 discussed asset healthcare for the different field devices and systems. The interfaces that were developed were discussed. The manner in which these interfaces communicate with different systems was discussed in the fifth chapter. The graphic user interface of the AlertManager application was shown. Views of the configured

equipment and systems in the AlertManager were displayed and described. The Asset Healthcare information obtained from the various systems presented in this chapter was used in the maintenance strategies that were developed and rolled out.

Chapter 6 considered the historic information captured by the asset management system. Historic information is an important part of asset management and is used in maintenance plans, maintenance scheduling and data processing. The Plant Historian Database (PHD) provides information that is used to identify and locate typical process problems. The PHD data is an important outcome and this would assist the process engineers to redesign the process, building on the history information referring to the problems that was experienced and captured in the asset management system.

Chapter 7 presented a discussion of the skills enhancement of maintenance personnel using the integrated solution. It is argued that by making maintenance and process data available from one central point, it is possible for maintenance and process staff to access to this data from one a single platform. Using the AlertManager it is possible to interface to web-based applications to retrieve the required data for the configured assets.

Chapter 8 discussed the various maintenance strategies available, with particular emphasis on predictive maintenance. The change management strategy followed was explained. Methods to move from reactive to proactive maintenance strategies were discussed and consideration was given to how the integrated solution was used to achieve objectives of the project.

9.3   Findings

9.3.1   Findings for Aim 1 - To develop a failure analysis model consisting of a symptoms and fault model that will be used for all plant assets. The model will be used to configure all the symptoms and faults via the software interfaces using configuration tools allowing different interfaces to communicate to a central software interface called AlertManager within the AssetMax software application.

In terms of Aim 1, the following deductions can be made:

- The use of the symptoms and fault model make it is possible to determine the diagnostic information needed for any piece of equipment or system to link to the AlertManager (see 4.2).

- Using Device Descriptor (DD) files from the different HART-based equipment vendors, it is possible to configure and update symptoms and fault models to be used in the AlertManager.

- Non-intelligent systems can be interfaced to the AlertManager using the DataScout interface (see 4.3) and real time data interface RDI's configured in PHD (see 4.4).

- The symptoms and fault model enables use of information pertaining to specific failure analysis for equipment or systems to assist RCFA and FMEA processes when needed (see 4.15).

- Failure analysis enables the use the information in maintenance strategies to determine corrective actions to sustain 100 percent plant uptime.

9.3.2 Findings for Aim 2 - To develop software interfaces between the different plant control systems and field devices to retrieve diagnostic information to determine the status conditions of these assets and their availability

In terms of the second aim of this thesis, the following deductions can be made:

- As the volume of diagnostic information that can be retrieved from integrated systems increases, the accuracy of the plant status also increases.
- The availability of on-line diagnostic information will assist maintenance staff to detect failures earlier and faster, thereby contributing to the transition from reactive to maintenance actions (see 8.3.3).
- Different types of plant-based assets and systems may be monitored and the diagnostic information will enable a more accurate view of plant-based assets and systems availability (see 5.7.1).
- Different views of specific types of equipment or systems would allow the maintenance staff to focus faster and more accurately on problems or faults indicated for specific equipment or systems (see 5.7.9).

9.3.3 Findings for Aim 3 - To develop and configure an interface retrieving history from the different configured plant assets and using the data in root cause failure analysis (RCFA) processes

In terms of the third aim of this thesis, the following deductions can be made:

- Improved accuracy of historic data will allow maintenance staff to isolate particular equipment or system faults trends (see 6.2.1)
- The asset management solution contains a detailed history of faults and problems that will improve preventative and predictive maintenance actions (see 6.2.7).

- Historic data will assist process engineers to determine possible problems in the operation of a particular section of a plant by referring to equipment malfunctions or erratic equipment behaviour under certain process conditions (see 6.2).

- Symptom and fault counts over a period (see 6.2.4 and 6.2.6) may be used as a measure of the effectiveness of equipment, the effectiveness of maintenance actions and maintenance services (KPI's) from contractors (see 6.4).

- Reports retrieved from the available history may be applied to a variety of purposes such as manager's report to see faults for a specific instrument or groups of equipment over a period of two months (see 6.3).

9.3.4 Findings for Aim 4 - To develop and configure an interface to have access to maintenance procedures, user manuals, data sheets and relevant process information to enhance the technical skills of the maintenance and process personnel

In terms of the fourth aim of this thesis, the following deductions can be made:

- By using the integrated solution that was developed in this study, all relevant maintenance and process related information to plant and maintenance personnel will be available from any web based computer (see 7.3).

- As a result of the integrated solution, plant personnel have faster access to reference manuals and data sheets. In addition, maintenance procedures can be implemented from a single platform, negating the need to look at different places to find equipment related information required for maintenance (see 7.2).

- The use of loop performance assessment will assist maintenance and process staff to optimize control loops for maximum plant performance and process control (see 7.5).

- Valve signatures will assist maintenance staff to establish which valves are producing problems and must be removed during a shutdown period for

repairs; maintenance and calibration (see 7.6). The base signatures may be used as reference to determine the differences between the signatures before and after a certain period of time. This would result in a shutdown cost saving of close to a R1 million, on valves alone (Joubert 2005).

9.3.5 Findings of Aim 5 - To use the results from the developed interfaces and use them in different type of maintenance strategies to ensure maximum asset availability and plant up time

In terms of the fifth aim of this thesis, the following deductions can be made:

- The integrated solution that was developed during this study will enable plants to effect the transition from a run-to-failure mode to a preventative and finally predictive mode of maintenance (see 8.2).
- The historic information available in the AlertManager can be used to optimise maintenance plans and procedures as well as being used in RCFA and FMEA processes (see 8.4 and 8.5).
- Maintenance procedures (see appendix D) and maintenance plans will form the maintenance strategy that must be implemented at particular plants (see 8.3).
- In order to successfully implement a maintenance strategy, it is important to follow a well formulated change management process and work process (see 8.6).
- By using the correct maintenance strategy it would contribute to a decrease of maintenance cost by sustaining plant availability of 100 percent over longer periods of time and it would move away from reactive to more predictive maintenance modes (see 8.3).

9.4 Recommendations

9.4.1 Recommendation 1

By using the integrated asset management solution presented in this thesis it is possible to address particular problems that have been identified by means of the second stage of the SAMI operational reliability continuity model.

9.4.2 Motivation

By referring to each problem in the second stage of the SAMI triangle it is possible to solve the specific problems associated with maintenance in modern plants. Each block should be used as reference to address the proper type of system or integrated solutions to ensure effective predictive/proactive maintenance.

9.4.3 Recommendation 2

An integrated asset management solution interfaced to different asset management systems and equipment should be used for proper management of plant-based assets to eliminate the use of various stand alone systems.

9.4.4 Motivation

The review of literature revealed that many industrial plants have stand-alone systems that make it difficult to monitor the status of various equipment and systems installed on these plants (see 1.1).

By interfacing the different systems it is possible to centralize asset management and allow maintenance staff to monitor the status of all equipment and systems installed on a plant.

Vendors that supply asset management systems generally only focus on vendor-specific equipment which makes it very difficult for maintenance staff to monitor a variety of systems and equipment. As a result certain systems may be overlooked during monitoring, which may lead to crucial diagnostic information that could prevent a possible plant trip being overlooked.

9.4.5 Recommendation 3

The use of a centralised solution will make it possible for maintenance staff to use different views to monitor particular field equipment and systems and have access to symptoms and faults for these systems (see 1.2.1).

9.4.6 Motivation

The literature review revealed the importance of having access to plant-based asset information in order to ensure maximum plant uptime and availability. The availability of current and accurate diagnostic information will improve performance and enable more effective maintenance actions.

9.4.7 Recommendation 4

Increasingly complex integrated asset management systems are required to ensure that equipment without diagnostic capabilities can be interfaced, monitored and used for highly efficient maintenance.

9.4.8 Motivation

Condition-based monitoring of compressors, pumps, reactors and electrical motors that lack specific diagnostic information (such as HART-based field instrumentation) need to be interfaced to an asset management solution as described in the study (see 1.6.1).

A large portion of equipment installed at older plants lacks onboard diagnostic information; this is a shortcoming that must be addressed to ensure that all equipment is optimally utilised in the total asset management plant solution. This should further assist the maintenance staff and managers to see the status of the complete plant.

9.5   Recommendations for further research

9.5.1   Recommendation 1- Integration of total Solution to SAP

Based on the experience gained from interfacing various systems and how to use the diagnostic information in various maintenance strategies, it should also be possible to integrate the total solution to SAP as shown in figure 97.
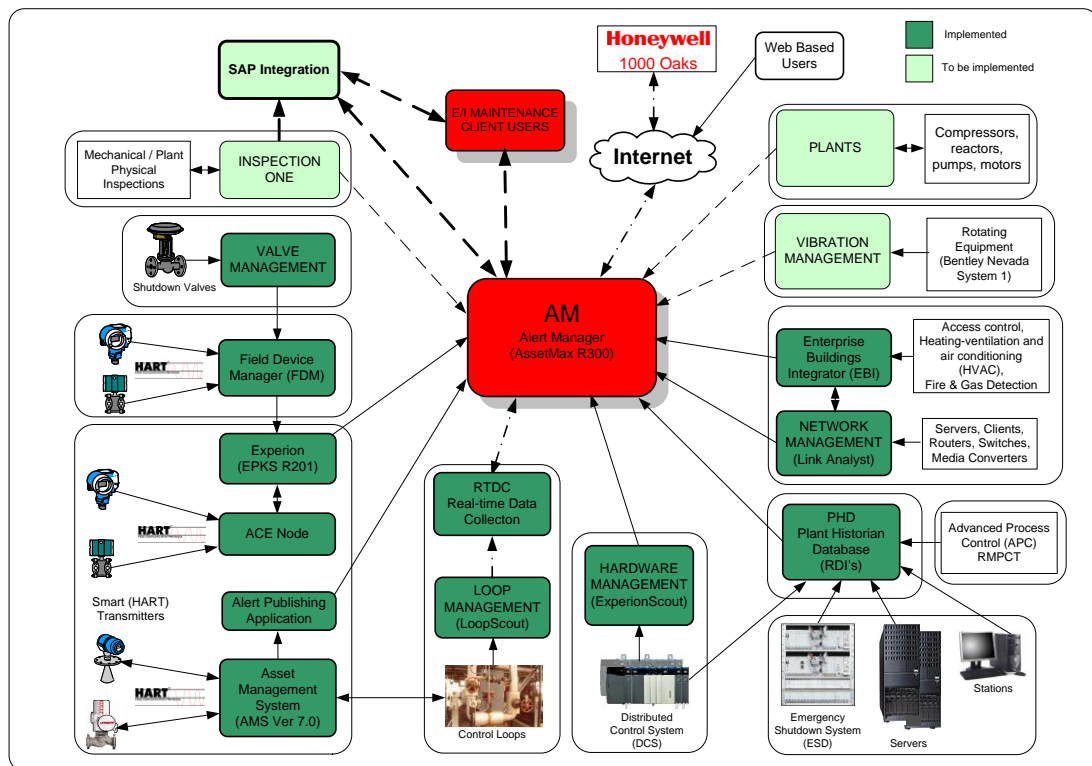

Figure 97: SAP integration

When a fault is flagged in the AlertManager, an electronic defect must be generated by SAP and the planners should then notify the instrumentation artisans and technicians to attend to the flagged problem. After the flagged defect is resolved, the artisan must close out the fault on AlertManager and this must in turn close out the defect in SAP.

This effect will be to close the maintenance loop and trends will subsequently be more readily obtained from SAP to establish whether the maintenance strategies and actions followed has been effective

9.5.2   Recommendation 2- Integration of Vibration Management

The vibration management for conditioning monitoring of mechanical equipment should be interfaced to the different data scouts and to AlertManager.

9.5.3   Recommendation 3- Interface to Inspection One System

The Inspection One system (bar coded system reading tags for preventative maintenance) should be interfaced to the global asset management solution to ensure all equipment on the plant is checked on a scheduled basis and that the recorded information is also used to detect symptoms or faults from non-intelligent devices.

9.5.4   Recommendation 4 - Integration of Process Monitoring

The different sections of the plant such as reactors, distillation columns, furnaces, coolers and heat exchangers as examples can also be interfaced to the total integrated solution to monitor the process side of the plant. Specific section of a plant may be monitored to show deviations to ensure that the mentioned section of the plant do not go in a premature trip condition. All the specific plant variables must be monitored and this will generate the faults if they are controlled wrongly.

9.6   Conclusion

In this chapter a summary of the completed research process were presented, by means of an overview of each chapter. A number of findings from the literature were presented, followed by recommendations and motivations.

In closing a final deduction can be made from the results of this study and is summarized as follows:

Extending asset management to field equipment and systems will empower employees and managers to affect changes in operations and maintenance, including:

- Commissioning efficiency.
- Increased plant uptime by quickly resolving process issues.
- Improved routine maintenance efficiencies.
- Enhanced communication between the control room operators, field operators and maintenance personnel.
- Integration of interfaced field and system data with the Asset Manager decreases the time needed for problem identification and improves decision-making accuracy.

The integrated asset management solution presented in this thesis provides a "best-in-class" infrastructure that allows plant personnel to make key decisions that increase uptime and improve production quality.

The integrated asset management solution functions as a significant productivity tool to release hidden plant profitability; the solution can improve business performance and profitability, decrease incidents, and increase plant availability. The integrated solution connects the right people across the supply chain with the right knowledge when it is needed, improving operational effectiveness and reducing maintenance costs.