CHAPTER 3 RESEARCH METHODOLOGY AND DESIGN

3.1 Introduction

An overview of the research methodology employed in this project is presented in this chapter. The research design is described as action research in the first part of this chapter and the action research cycle is presented graphically. The scope of the project is outlined in terms of three cycles: technical discussions with personnel, interviews with technology vendors and design and implementation of a time line review. Assessment and prioritisation of asset maintenance tasks are integral to optimise plant performance. The action research cycle presented in this chapter allows for the use of the research cycle process in order to solve the stated problems so that an integrated solution for predictive maintenance can be realised.

3.2 Action research methodology

Action research is defined by Lewin as comparative research on the conditions and effects of various forms of social action and research leading to social action that uses “a spiral of steps”, each of which is composed of a circle of planning, action and fact-finding about the result of the action” (Lewin 1946).

Coghnan and Brannick (2001) define action research as a form of applied social research that differs from other types of research in terms of the proximity of the researcher’s involvement in the action process.

This thesis presents a strategic research project that was developed with the intention of addressing plant maintenance concerns at the Sasol Solvents plants. Terreblanche and Derheim (1999) states that strategic research generates knowledge about specific needs and problems with a view to eventually solving or reducing the problem through further development and evaluation.

Research in practice involves collecting new information known as primary data from physical sources. According to Babbie and Mouton (2001:100) sufficient access to primary data of a technical nature is essential. As an employee at the Sasol Solvents Plant the researcher had sufficient access to data obtained from field devices which may be considered a physical source of data. The research design used quantitative data obtained from the field devices and also made use of qualitative techniques to investigate the research problem stated in the first chapter of this thesis.

According to Taylor (1993:58) the use of multiple appropriate data gathering techniques improves the predictive validity of the research. Validity of the research findings are influenced by aspects such accuracy and consistency of measurement (Taylor 1993:58). Due to the complexity of human nature (Van den Berg 1993): absolute consistency of results will probably never be achieved.

The value of data obtained from qualitative techniques such as personal interviews and surveys should however not be underestimated. According to Prinsloo (1993) personal interviews and surveys are diagnostic techniques that make it possible for the researcher to pinpoint sources of anger, frustration or unhappiness. Plant maintenance is reliant on personnel to cope with a very large range of devices and incompatible platforms. In order to develop a solution that effectively could improve plant performance the qualitative techniques were essential to obtain information from maintenance personnel.

Babbie and Mouton (2001:105) distinguishes between field research and the use of secondary or historical data. In this research project active data collection methods are used to obtain information from field devices. This data is then stored in a historical database which is used to identify trends and prevent the failure of equipment by means of pro-active maintenance. Mouton emphasizes the importance of meticulous documentation if the data is intended to be used in the future for secondary research.

Action research is not only research that describes how humans and organizations behave in the outside world but also a change mechanism that helps human and organizations reflect on and change their own systems (Reason & Bradbury 2001).

The outcome of this research will impact the way asset management solutions and assets utilization in modern plants will be planned, developed, prioritized, and implemented. The findings of this research show that the selection of technology and the development of a single software interface have a beneficial impact on work processes, task and expertise optimization and performance measurement at modern plants such as Sasol Secunda.

The management planning at plants such as the Sasol Solvents Site is greatly enhanced by means of improved information provided in a manner that appropriately trained personnel can take advantage of. Due to improved information receipt and processing times of data obtained from a single software interface that plant personnel can read and interpret based on data obtained from field devices based on diverse operating platforms.

By means of the Action Research Model, this thesis shows that continuous improvement is one of the driving forces to obtain maximum value from an asset management system. Figure 15 shows a graphic representation of the action research model that is used to implement the global asset management solution in the Sasol Solvents plants.

Throughout the entire action research process the SAMI model (see 1.2.2) was used in conjunction with the action research model as the basis for the design and implementation of the integrated solution. The different blocks in stage 2 are used to ensure that they are addressed and incorporated into the integrated solution.

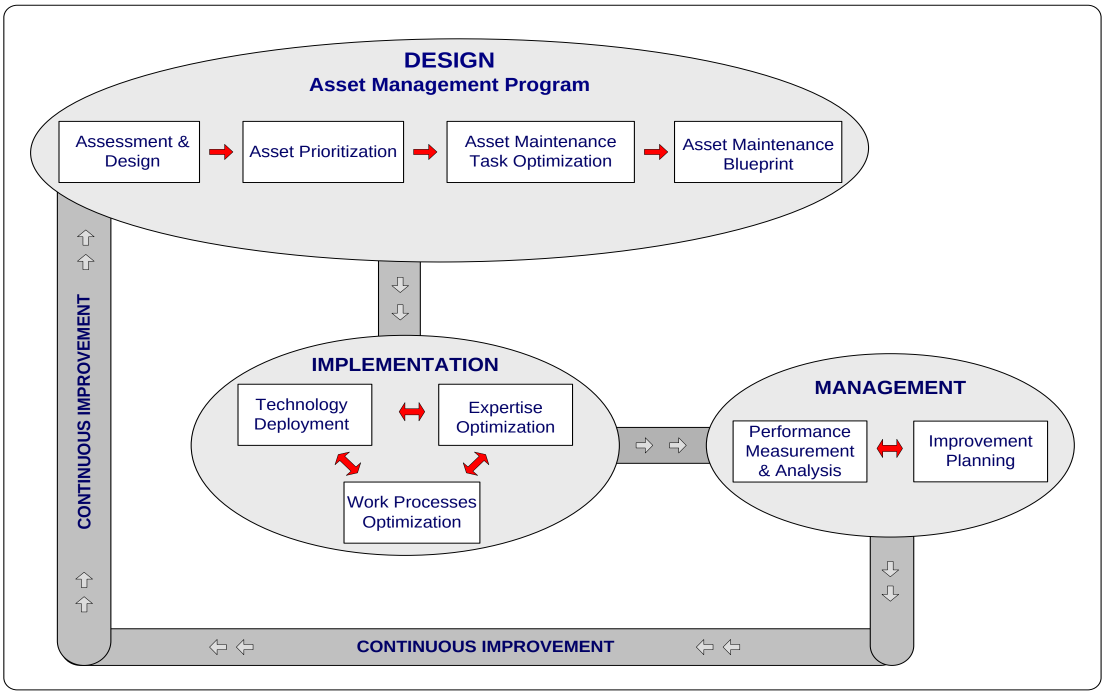

Figure 15: Action research cycle

3.3 Scope of work

The information required for the asset management solution was obtained by discussions with the Electrical/Instrumentation (E/I) maintenance manager, maintenance technicians, process managers and engineers as well as reliability engineers to determine what the requirements for such a system would be.

Based on Norton and Horsman (1999:6) research philosophy an assessment of:

- the problems associated with asset management at the three plant, based on installed technology;
- and the desired outcome of an integrated solution are done.

Based on the above assessment it was possible to build and strengthen the connection between research and practice with a view to improve practice, building the required knowledge and extending or shifting the perspectives of users of the various systems.

Three cycles, presented below, were followed to assess and design the proposed solution:

- Cycle 1: Technical discussions with process, maintenance and reliability staff and preliminary system layout and design.
- Cycle 2: Interviews with technology vendors to determine integration capabilities of the different systems on site.
- Cycle 3: Design and implementation time line review.

3.4 Cycle 1: Technical discussions with process, maintenance and reliability staff

3.4.1 Assessment and design

The first cycle of technical discussions with process, maintenance and reliability staff indicated that emphasis should be given to the way the solution should be implemented. The plant information would be structured based on the physical plant assets and systems. The typical structure of the plant assets was discussed and it was decided that the structure shown in Figure 15 should be followed.

The discussion with personnel was also aimed at verification of the assets tags that were used in the design and how the data would be managed. Data management between the different interfaces, control systems, asset management systems and third party vendors is an important aspect of the integrated solution that was developed.

Based on the assessment and application design indicated in Figure 16, the integration design was planned, implemented and finally executed in the live plant during a shutdown period of one month.

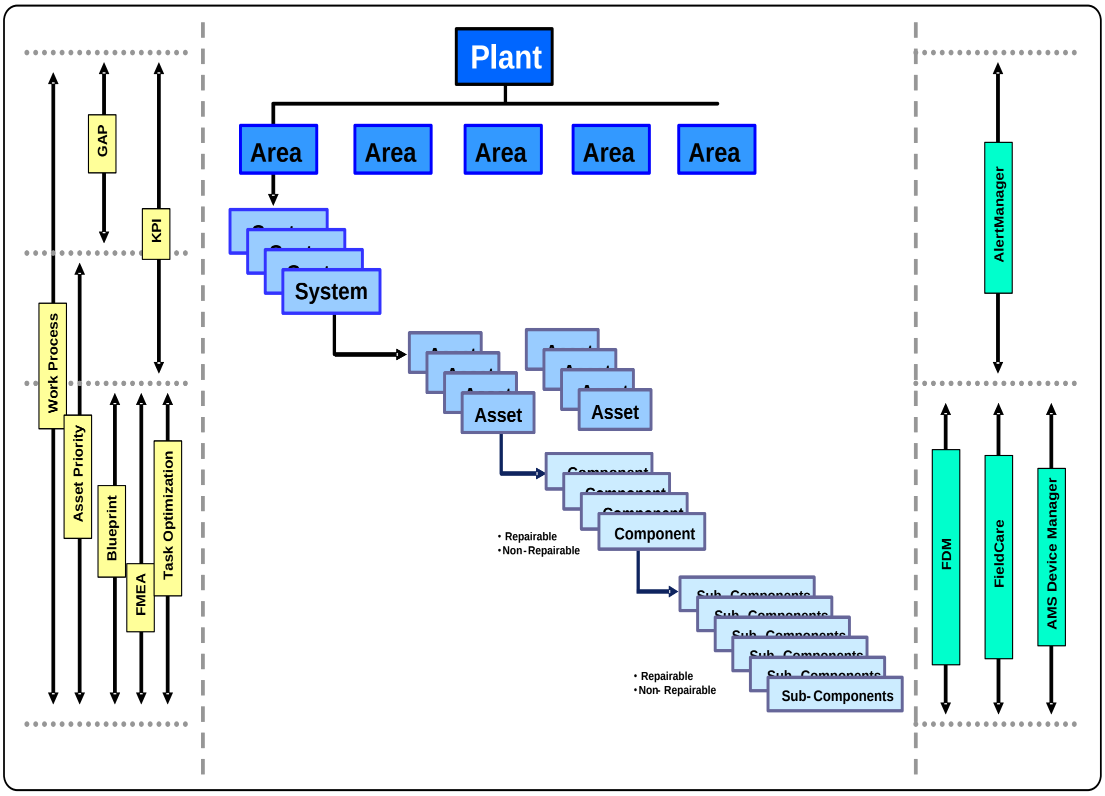

Figure 16: Assessment and application design

3.4.2 Asset Prioritization

There was a need to consider division of the operational units at the different plant systems and to bench mark them to the specific Sasol business requirements. The business criteria applied that were applied are presented below:

- Safety
- Regulatory compliance
- Product quality
- Process throughput
- Operational costs

These criteria were taken into consideration in the calculation of priorities. The weighted average was derived from these criteria and used to determine the operational criticality ranking. The asset failure probability factor was determined and finally the maintenance priority index was calculated. These values were used in the design phase for the integrated asset management solution.

3.4.3 Asset maintenance task optimisation

Various consultations were conducted to obtain an understanding of key performance indicators (KPI), work flow execution, the prioritization concepts used and implementing a possible asset maintenance matrix referencing all plant assets and their impact on process.

3.4.4 Asset maintenance blueprint

The maintenance blueprint was discussed in terms of a typical cause and effect diagram where the different assets are priority validated and mapped into its functional requirements. All particulars pertaining to the assets are complied in the blueprint to ensure that all required details were available for configuration and implementation. The blueprint then formed the basis for the design of the integrated solution.

3.4.5 Technology deployment

The technology installed was considered in terms of how these systems could be integrated and into the main integration solution. As discussed in Chapter 2, a large variety of systems are installed and this requires a complex and involved solution.

3.4.6 Expertise optimisation

The level of expertise of the maintenance staff was evaluated and the need for skills development was considered to ensure that once the integrated solution was installed, it could be used effectively and correctly by the different parties.

3.4.7 Work process optimisation

The existing work flow processes were reviewed and the "execution" work flow process evaluated to ensure compliance to best maintenance practises. Suggestions were made to adapt the work process where needed. The focus was to move away from the traditional way of doing maintenance to a totally new approach (Emerson 2005a).

3.4.8 Performance measurement and analysis

This action could not be conducted because the process was still in the design phase and no final decision had been reached regarding how the total integrated solution should be implemented and interfaced. No analysis was made.

3.4.9 Improvement planning

Planning was discussed and the final proposal was submitted to determine the impact on planning. After going through the processes in cycle 1 it was seen that the processes needed to go through another cycle to solve more system related issues. After this session, a three month period was set aside to resolve certain system related issues that had not been clarified by process and maintenance staff.

3.5 Cycle 2: Interviews with technology vendors to determine integration capabilities of the different systems on the Solvents site

3.5.1 Assessment and design

The outcome from the first cycle identified certain concerns:

- Implementation of the integrated solution was possible but licensing of OPC connections was a problem had to be resolved with the system vendors.
- The interfaces should have been tested on the systems but due to the environment being an active production plant, it was impossible to test the interfaces on a live process – if the interfaces caused a system crash, the cost implication would be phenomenal. It was necessary to find a solution for testing.
- The technical skills of maintenance personnel were not up to standard for using the new technology and solutions.
- Change management was a major concern, since management was not buying into the proposed integrated solution and there was resistance to use the new technology solution by maintenance and reliability staff.

Most of the vendors that were involved with the different systems were prepared to consider possible license issues to resolve integration problems. In essence all the vendors were able to assist with open licenses to get involved in the planned integration and solution. This was an opportunity for vendors to learn from the exercise and to adapt their software and platforms to be more open and accessible to third party integration (see 2.1).

The design was reviewed looking at system architecture and all the components. This information was compiled into a preliminary functional design specification (FDS) document. This was submitted to all parties for review. The FDS was discussed again, after four weeks of review.

3.5.2 Asset Prioritization

Although certain changes were suggested after review of the FDS, there was general consensus that that the design should remain according to the priorities decided in cycle 1.

3.5.3 Asset maintenance task optimisation

With the proposed preliminary design (FDS) the maintenance tasks were evaluated in terms of the integration that would take place. Certain changes were suggested which would be effected after implementation of the solution.

3.5.4 Asset maintenance blueprint

The asset maintenance blueprint was re-evaluated and certain changes were implemented in order to incorporate the systems that had originally not been part of the integration planning. These systems were the Metso's FieldCare system managing the shut-off valves and the Field Device Manager. These systems are the only two systems that could be used to interface to each other, retrieving the required diagnostics information from the shut-off valves. The blue print document (refer to appendix C) was updated with these changes.

3.5.5 Technology deployment

The decision regarding what technologies would be used was made by management. No additional software would be purchased to facilitate the integration. Installed systems were to be used and integrated into the proposed solution. It was necessary to keep integration costs to a minimum.

3.5.6 Expertise optimisation

Training programmes were initiated which also formed part of the change management that needed to be implemented. Device and system specific training was given over a period of two years to ensure that the solution and integrated systems could by optimally utilized.

3.5.7 Work process optimisation

The work process that normally followed at Sasol was adapted to facilitate the new approach to conduct maintenance smarter and more effectively. A mind shift was required to start thinking about predictive maintenance strategies. The importance of change management was stressed because a new way was needed for all maintenance actions.

3.5.8 Performance measurement and analysis

The proposed solution was implemented on virtual machines (see 2.13) to facilitate integration between the different systems. By means of the virtual machines it was possible to do some sort of performance measurements. The analysis that was conducted on the different systems proved to be satisfactory to facilitate the final implementation in the live plant environment.

3.5.9 Improvement planning

At this stage the planning personnel had become involved in the process and made suggestions were made regarding how SAP could be used to generate work orders for defects detected by the proposed asset management solution and systems within the solution.

All parties were aligned regarding the proposed integrated solution and the only outstanding issue was the time line and when the system would be implemented into the live plant environment.

3.6 Cycle 3: Design and implementation time line review

3.6.1 Assessment and design

The final design was on the table with the virtual machines activated and running the different software packages and indicating the different interfaces. The final implementation time line was finalized and it was decided to implement the integrated solution in two phases. The two phases were divided as follows:

- The asset management solutions were in the first phase because this would have the least impact on field devices and asset management systems such as the AMS, ValveLink, FieldCare, FDM and AlertManager. The plants could still operate without these systems.
- The second phase was the RDI (see 2.4.2) implementation in PHD, the FSC (see 2.3.2) and the PlantScape (see 2.4.1) interfaces. LoopScout (see 2.5.3), network management (see 2.5.2) and the EBI system (see 2.5.11) would be the final systems to be integrated.

3.6.2 Asset Prioritization

No changes were made to the existing priority lists and it would be implemented as designed. The prioritization for the assets was to be conducted in AlertManager as the assets were built and configured.

3.6.3 Asset maintenance task optimisation

Asset maintenance task optimisation had already been done in the previous cycle. However, this remains a continuous improvement process as systems are better understood and more experience is gained from one integrated asset management solution.

3.6.4 Asset maintenance blueprint

The asset maintenance blueprint remained the same as had been decided in the previous cycle.

3.6.5 Technology deployment

The only change in terms of technology deployment was to incorporate the Experion™ PKS R201 software (see 2.10) as a test to establish the functionality and integration of the FDM server (See 2.9). This was implemented as a parallel connection to the existing PlantScape configuration in order for Honeywell SA to test certain functionality of the software in terms of HART integration into their new DCS embedded HART capabilities. Honeywell SA supplied the Experion™ PKS R201 server with the required software.

3.6.6 Expertise optimisation

Training was continued on a weekly basis and formed part of the change management process that was implemented to ensure that maintenance staff were competent to work with the final integrated solution. This training also formed part of career development of maintenance staff and they were evaluated on the different competencies required to work with these systems. An important component of this project was to provide training that would emphasise the effectiveness and advantages involved with using the integrated solution.

3.6.7 Work process optimisation

The work process was changed in a minor way but maintenance procedures were developed and incorporated into the asset management solution. This was necessary to assist in the skills enhancement of maintenance staff. The manner that the defects were managed was also adapted to the SAMI maintenance model (see 1.2.2). SAP was also modified to adapt to the SAMI approach to maintenance. This was a different process that would only be changed after implementation of the integrated solution.

3.6.8 Performance measurement and analysis

Some of the software packages were unable to run with the multiplexer network (see 2.7.1). Hart simulation software was used to simulate the symptoms and faults retrieved from the field devices (see 2.2.1). This was fairly successful but still needed to be tested in the live environment to determine the impact of the scanning times of the multiplexers and field terminal assemblies (FTA) (see 2.7.1).

3.6.9 Improvement planning

Due to the faster detection of faults from the integrated asset management solution, it would be possible to conduct more planned maintenance moving away from reactive maintenance to more predictive maintenance. Improvement of planning in order to optimise plant production was the primary purpose of the design and implementation of an integrated asset management solution.

3.7 Conclusion

This chapter has presented the action research process and research cycle that was followed. The selection of an action research design was motivated and the methodology employed was discussed. The identified problems were reviewed using the research cycle process to determine certain outputs that would be used to solve these problems. Implementation of the results obtained from the action research steps (see 3.3.1) will be discussed in the chapters that follow.