

Chapter 3 – Empirical Study

3.1 Introduction

In order to effectively conduct research it is realised that the quality of data collected from the question set developed, must as far as possible be based on a sound scientific approach. In order to achieve this, data is collected in a group representative of the population. This ensures that participants in the research give answers that are not fully based on their perceptions. Although it is realised that subjective inputs will never fully be eliminated, much more valued input will be gained by presetting a fixed standard. The research methodology is based on a few simple steps, discussed in this chapter.

3.2 Research Steps

In order to understand the methodology used in the research it will be broken down into a few simple steps:

- Defining population and representative members for participation.
- Establish the dimensions of measure.
- Integrate the understanding of equipment capability (Chapter 2) and break it down to possible drivers to be measured.
- Define different elements for measure.
- Present questions to be used for the collection of the relevant data required for analysis.
- Interpretation of results obtained from the empirical study.
- Conclusion and recommendations (Chapter 4).

3.3 Population for Conducting Research

In order to conduct research the population of maintenance activities is divided into three logical sections, each with its own management. Each of these sections will individually complete the question set in order to effectively compare results and identify the section with the best results. These sections will then be used as the internal benchmark for other sections to learn from. The different sections include:

- Engineering Services 46 Employees;
- North & South Plants 66 Employees;
- West and Advalloy 39 Employees.

In order to collect the data from the question set developed, representatives from each section are selected throughout all the levels of the maintenance management and execution team. The groups of people included for data collection for each section include:

- 1 x Maintenance Superintendent;
- 3 x Maintenance Engineers (Mechanical, Electrical and Instrumentation);
- All Development Engineers (1-2 per section);
- All Planners (Maintenance controllers) (2-3 per section);
- 3 x Foreman (Mechanical, Electrical and Instrumentation);
- 6 x Artisans (two from each discipline, mechanical, electrical and instrumentation).

The total amount of people completing each question as a group (of more or less 17 persons) are then representative of all activities throughout the field of maintenance management and execution. This group activity will result in a more accurate representation of the actual situation as this will encourage group discussion on the actual situation. The answers to the questions are then the result from the group and not that of an individual.

3.4 Dimensions of Measurement

With the development of the questionnaires for research, the managerial functions of planning (approach), organising (deployment), leading and controlling (results and improvement) are used to determine the level of maturity of each element defined in the literature study (Chapter 2).

Hellriedel et al. (2002:10) define the steps embedded in control as:

- setting standards for performance;
- measurement of current performance against those standards;
- take actions to correct any deviations, and
- adjust the standards in necessary.

Taking above into account, the following assessment dimensions (illustrated in Figure 3.1) will be used.

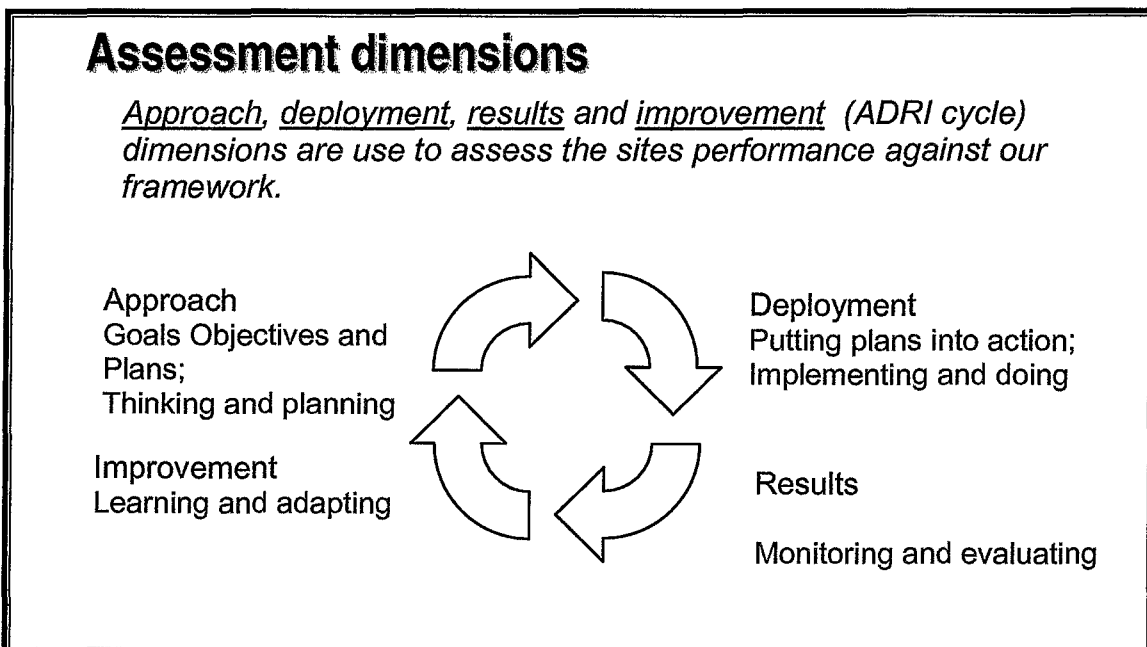


Figure 3.1 – Assessment dimensions of questionnaire set (Australian Maritime College, 2005).

The elements defined later on in Table 3.1 will be assessed in the four dimensions namely: *approach*, *deployment*, *result achieved* and *improvement*. A summary of the ARDI cycle and approach towards improvement can be studied in Appendix D.

One of the aspects of interest with the data collected from the assessment is to determine the correlation between the approach (planning), deployment (implementing) and result achieved. It is expected that a strong rating in the approach and the deployment together will automatically be displayed in the result. It is also expected that a strong rating in the approach, deployment as well as the result achieved will be seen in the improvement phase.

Question sets are developed on the lowest possible level of measure in order to be able to group elements together that are logically related in order to determine if opportunities exist on a higher level within management.

3.5 Integrating the Understanding of Equipment Capability

In order to effectively focus on and define the different elements of measure it is of importance to integrate the understanding of equipment capability. Assuring productive capability of plant and equipment needs to be broken down to the lowest possible driver in order to effectively measure the equipment capability performance in terms of the ARDI cycle (Australian Maritime College, 2005):

- Approach;
- Deployment;
- Results achieved;
- Improvement methodology.

Figure 3.2 displays a breakdown of equipment capability into the different KPIs and their respective drivers (to be measured with the question set). This then

sets the path for the development of the different areas of measure. Some of these drivers can be further broken down to define the lowest possible level of measure.

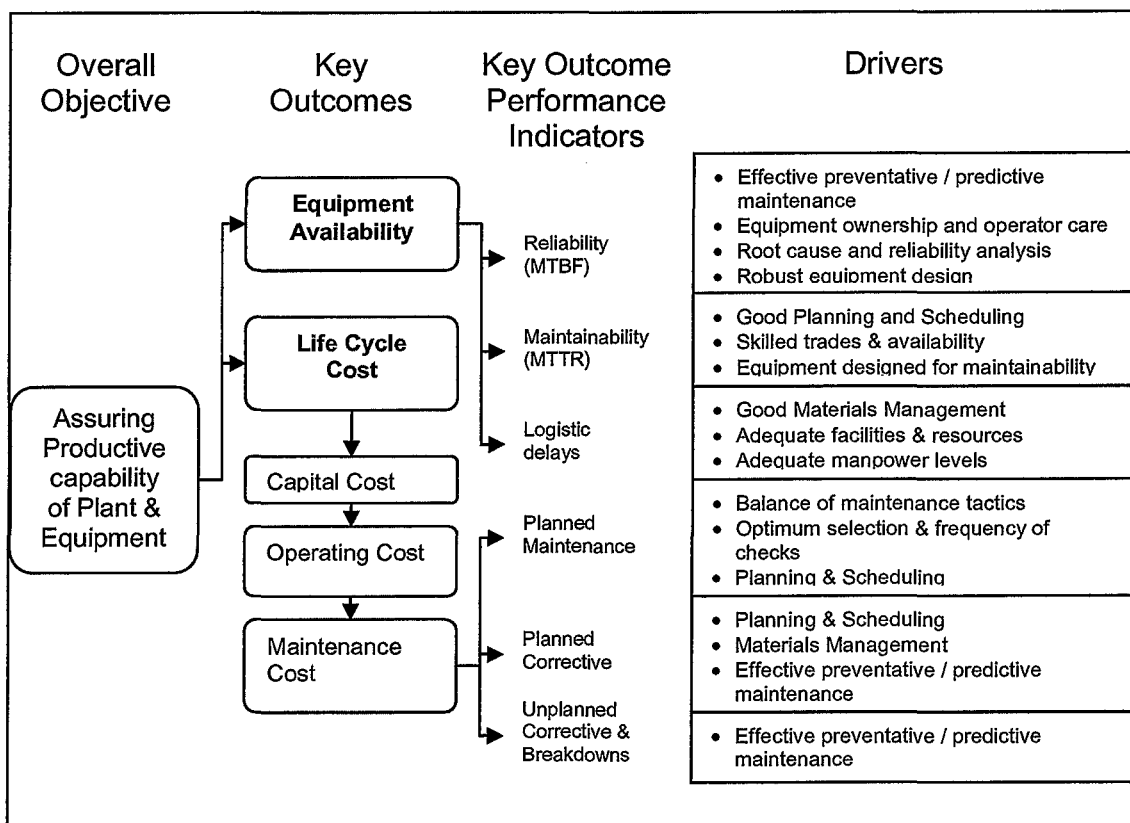


Figure 3.2 – Breakdown of Plant and Equipment Capability into Outcome KPIs and their respective drivers.

3.6 Elements of Effective Maintenance Management

Taking Figure 3.2 and Chapter 2 into consideration the areas of focus for measurement can now effectively be determined. Ten areas of maintenance management (capability assurance) are defined and broken down into lower levels of management described in Table 3.1 below. These elements are compiled in order to cover the widest range of activities and management throughout maintenance. These activities start with elements including the gathering of information through to activities like improvement focused initiatives

in order to cover the complete management cycle, and close the loop from start to finish.

Ref.	Element of maintenance measure
1	Plant condition monitoring
1.1	• Equipment maintenance plans
1.2	• Careful operation
1.3	• Equipment inspections
1.4	• Predictive maintenance
1.5	• Preventative triggers
2	Work origination
2.1	• Information to originate work
2.2	• Work origination methodology
2.3	• Review and feedback
3	Planning
3.1	• Information required for planning
3.2	• Planning methodology
3.3	• Creating a standard job library
4	Scheduling
4.1	• Scheduling (two weekly, monthly)
4.2	• Scheduling (daily)
5	Work allocation and execution
5.1	• Information for allocation and execution
5.2	• Methods of allocation and execution
5.3	• Communicating shift handover
5.4	• Equipment handover
6	Work Completion and recording
6.1	• Work completion and history recording methodology
6.2	• Information recorded as history at completion of work
7	Shutdown management
7.1	• Shutdown formulation
7.2	• Shutdown planning
7.3	• Shutdown execution
7.4	• Start up and commissioning
7.5	• Post shutdown review
8	Facilities, equipment and tools
8.1	• Tools
8.2	• Facilities and equipment
9	Determining root cause of losses
9.1	• Determining root cause of losses
10	Achieving improvement in Capability assurance
10.1	• Routine improvement
10.2	• Focused improvement

Table 3.1: Elements regarding capability assurance to be measured from literature study.

Questions for each of these elements and practices are developed (Appendix B) in order to measure the different aspects of capability assurance against the four dimensions discussed earlier in this chapter.

3.7 Development of Question set for Element Measure

For each of the elements and practices defined in Table 3.1 a question is developed. Figure 3.3 shows a typical example of a question. The element of measure together with the sub-element is displayed followed by the actual question.

<p>Question Type A/D: Element: 3 Planning</p> <p>Practice: 3.3 Creating a standard job library</p> <p>Question: Are standard jobs compiled using a scientific approach based on the OEM specifications. Are these tasks reviewed according to the current state of the equipment's condition?</p>
--

Figure 3.3 – Example of question developed for measure of capability assurance elements defined.

Following the approach of a group evaluation towards the collection of data, the risk of leaving the question open to the reader in order to answer according to one person's perception, is reduced. This will result in meaningful comparisons between data from different sections completing the question set. The complete question set is included in Appendix B.

3.8 Criteria for Rating of Performance on Elements & Practices

In order to effectively benchmark internally between the different departments discussed in Chapter 1, a criteria needs to be developed in order to determine the maturity of each measurement on the different elements and practices previously listed in Table 3.1.

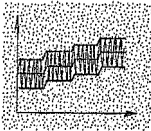
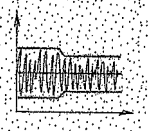
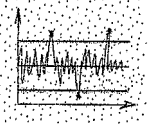
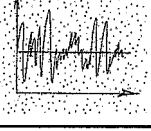
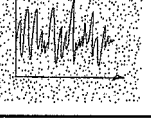

Maturity	Score	Indication	Description
Stable Improvement	5		Controlled Step Improvements. Targets & Limits
Defect Elimination	4		Control limits reduced
Proactive Maintenance	3		Measurement with Targets and Control Limits
Planned Maintenance	2		Measurement with Targets
Reactive Maintenance	1		Measurement without Control
Regressive Maintenance	0		No measures

Table 3.2: Definitions for the maturity and criteria of measurement.

The criteria for the measurement of the different questions is defined in Table 3.2 above together with the maturity level. A score of five will indicate a maturity level of stable improvement defined as controlled steps of improvement between set limits as indicated. A score of zero will indicate a maturity level of regressive maintenance were no measures are in place to manage the respective element or practice.

3.9 Summary of Empirical Study Results

The results of the evaluation are divided into five major groups. These groups include the different dimensions of evaluation per department and the approach, result, deployment and improvement per department compared to the high and low values. From these results opportunity areas for each department could be obtained by internal benchmarking between the different departments. The final aim of the process, being improvement of the maintenance activities, can thus be achieved by tapping on internal resources. Detail of the results can be studied in Appendix C.

3.9.1 Results from the Approach Questionnaires

Comparing the approach results to that of the deployment, it can be seen that the results, in general of the approach is lower than that of the deployment. This illustrates that the original intentions of managing a specific element / practice or area of maintenance is not fully implemented. This might be due to insufficient buy-in of personnel on lower levels of the organisation (which is required to implement and drive the new initiatives) as result of the lack of a proper change management process followed.

The average of the approach results can be summarised as follow:

- Engineering Services 2.6 Planned Maintenance
- North and South Plants 3.2 Proactive Maintenance
- West and Advalloy Plants 3.8 Defect Elimination

The overall combined average of the highest scores results in 4.0, corresponding to a maturity level of defect elimination. Without any major effort it will be fairly simple to get all the different departments on a maturity level of defect elimination by copying the best practices according to the approach from the department with the highest score for that specific element.

3.9.2 Results from the Deployment Questionnaires

The average of the deployment results can be summarised as follow:

- Engineering Services 2.0 Planned Maintenance
- North and South Plants 2.7 Proactive Maintenance
- West and Advalloy Plants 3.1 Proactive Maintenance

The overall combined average of the highest scores results in 3.4, corresponding to a maturity level of proactive maintenance. The effort in getting all departments firstly to a level of 3.4 and later on the same level as the approach of 4.0, will be much more than that of the approach alone. The major effort within getting the deployment level on an average of 4.0 (defect elimination) lies in the effectiveness of the proper implementation, managing and leading of a change management processes.

The current effectiveness of implementation can be measured by looking at the overall difference between the approach and deployment results:

- Engineering Services 0.6 (2.6 – 2.0)
- North and South Plants 0.5 (3.2 – 2.7)
- West and Advalloy Plants 0.7 (3.8 – 3.1)

The higher this difference the less effective is the implementation process followed by the specific department.

3.9.3 Results from the Result Questionnaires

As was previously expected (Section 3.4) it can be seen that a strong score (or high maturity level) in both the approach and the deployment is reflected in the results. This implies that if management has a sound approach towards managing a specific aspect and is successful in implementing and executing that approach the desired results are achieved.

The average of the results achieved can be summarised as follow:

- Engineering Services 2.6 Proactive Maintenance
- North and South Plants 2.7 Proactive Maintenance
- West and Advalloy Plants 3.5 Proactive Maintenance

3.9.4 Results from the Improvement Questionnaires

The results from the improvement drive per department can directly be compared to the amount of resources allocated towards the initiative of continuous improvement (CI). Engineering Services, 2 dedicated persons, North and South plants, 1 dedicated engineer and 3 part time engineers, West and Advalloy, 2 persons and 3 full time engineers.

The average of the improvement results can be summarised as follow:

- Engineering Services 2.2 Planned Maintenance
- North and South Plants 2.7 Proactive Maintenance
- West and Advalloy Plants 3.2 Proactive Maintenance

3.10 Overall Opportunity for Improvement

In order to assess the value of this study a comparison is made between the lowest and highest scores obtained from the question set for each assessment dimension. These opportunities are displayed in Figure 3.4 through Figure 3.5.

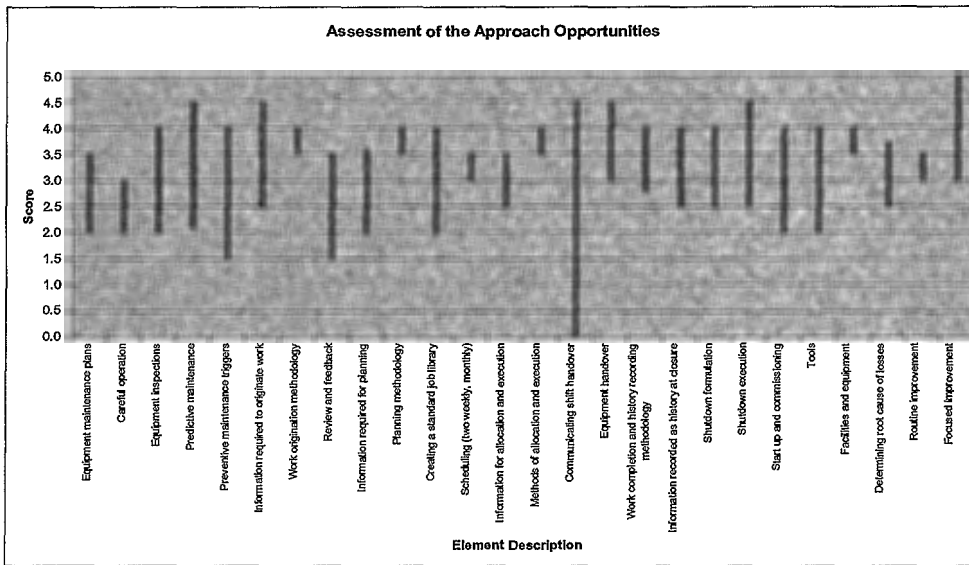


Figure 3.4 – Maximum Approach Opportunities

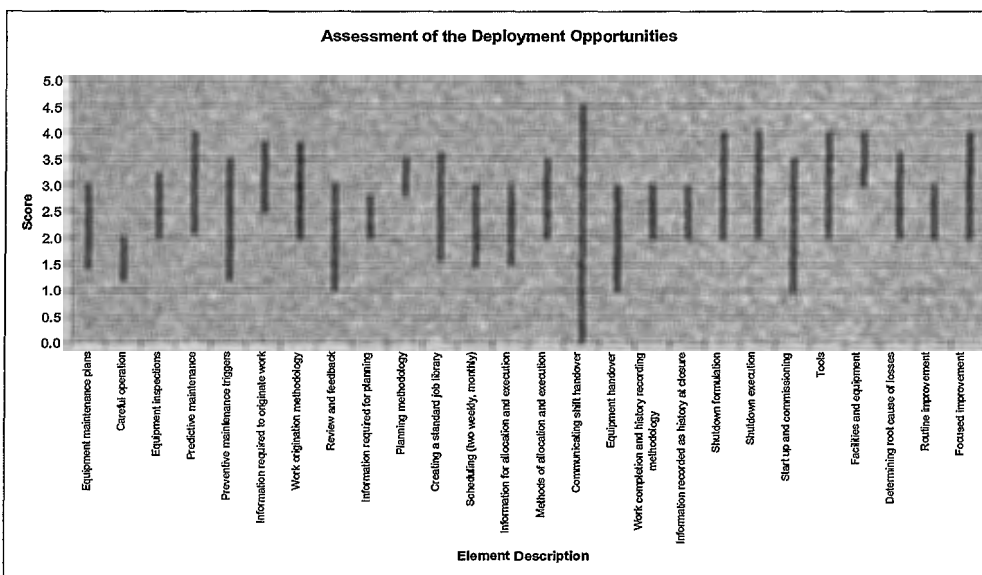


Figure 3.5 – Maximum Deployment Opportunities

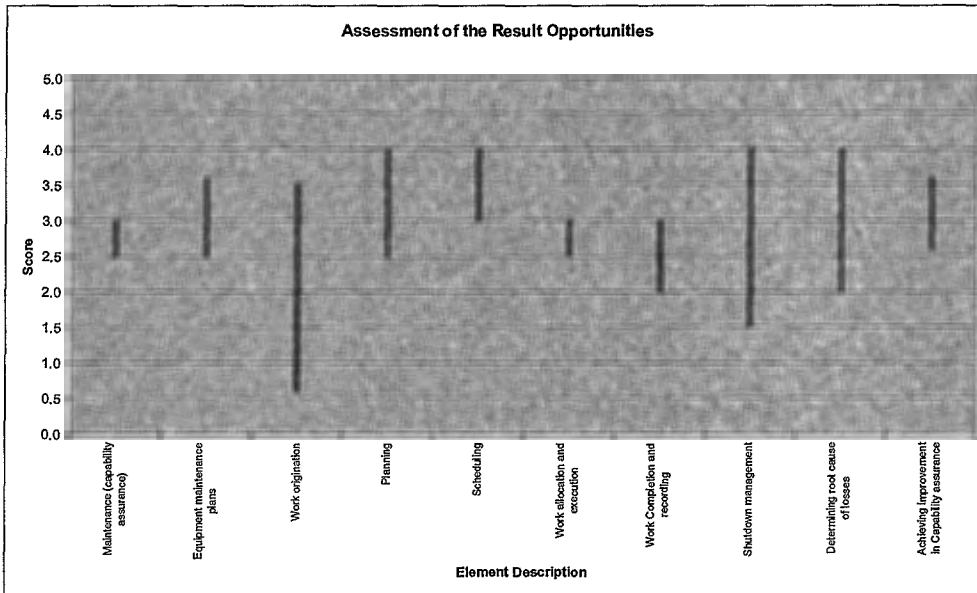


Figure 3.6 – Maximum Result Opportunities

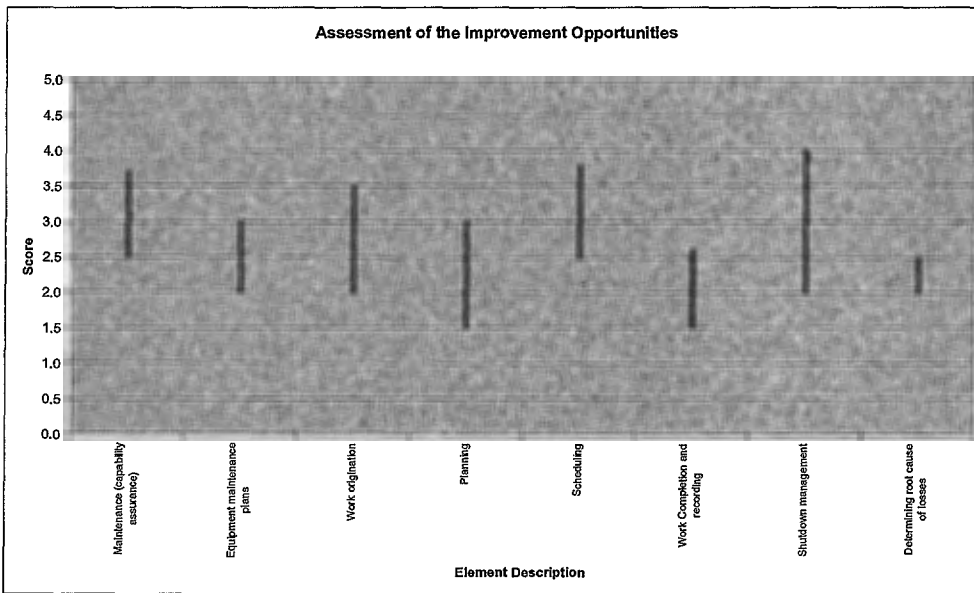


Figure 3.7 – Maximum Improvement Opportunities

Regarding the areas of improvement it can clearly be seen that, within the dimensions of approach and deployment, the largest opportunities lie within practices like:

- Communicating shift handover (A 4.5; D 4.5);
- Preventive maintenance triggers (A 2.5; D 2.3);
- Review and feedback (A 2.0; D 2.0);
- Creating a standard job library (A 2.0; D 2.0);
- Focused improvement (A 2.0; D 2.0).

Regarding the dimensions of results and improvement, opportunities between the departments lie within elements like:

- Work origination (R 2.9; I 1.5);
- Shutdown management (R 2.5; I 2.0);
- Planning (R 1.5; I 1.5);
- Scheduling (R 1.0; I 1.3).

The above summary clearly defines the areas of focus for the whole population. It needs to be understood that these opportunities are defined as the difference between the highest and lowest scores between the different departments evaluated and that this level of improvement can be realised by a single department (with the lowest score) through copying the approach, deployment, result or improvement methodology of the department with the highest score.

3.11 Opportunities of Improvement per Department

From Table 3.3 below, the different areas of improvement are highlighted in green together with the areas per department that will set the initial standard in yellow. Table 3.3 and 3.4 below is a comparison of the different sections to one another, a zero opportunity does not indicate that no room for improvement exist, but merely that, for the specific element, that section will be used as the internal benchmark before the second phase of continuous improvement will begin.

Question Type A and D		A Opportunity			D Opportunity		
Ref	Description	ES	NS	WA	ES	NS	WA
1.1	Equipment maintenance plans	1.5	0.5	0.0	1.6	0.0	0.0
1.2	Careful operation	1.0	0.0	0.0	0.8	0.0	0.0
1.3	Equipment inspections	2.0	0.0	0.5	1.2	0.0	0.2
1.4	Predictive maintenance	2.4	0.5	0.0	1.0	0.5	0.0
1.5	Preventive maintenance triggers	2.5	2.0	0.0	2.3	1.5	0.0
2.1	Information required to originate work	2.0	0.5	0.0	0.3	0.0	0.3
2.2	Work origination methodology	0.5	0.0	0.0	1.8	0.0	0.8
2.3	Review and feedback	2.0	0.0	0.5	2.0	0.0	0.0
3.1	Information required for planning	0.0	0.6	1.6	0.3	0.0	0.8
3.2	Planning methodology	0.0	0.5	0.0	0.0	0.2	0.0
3.3	Creating a standard job library	2.0	2.0	0.0	2.0	1.1	0.0
4.1	Scheduling (two weekly, monthly)	0.0	0.5	0.0	0.0	1.5	0.5
5.1	Information for allocation and execution	1.0	0.0	0.5	1.5	0.0	0.5
5.2	Methods of allocation and execution	0.4	0.5	0.0	0.0	1.1	0.1
5.3	Communicating shift handover	4.5	1.0	0.0	4.5	1.5	0.0
5.4	Equipment handover	1.5	1.0	0.0	1.7	0.0	2.0
6.1	Work completion and history recording methodology	1.0	1.2	0.0	1.0	1.0	0.0
6.2	Information recorded as history at closure	1.5	1.0	0.0	1.0	1.0	0.0
7.1	Shutdown formulation	1.5	1.0	0.0	2.0	1.4	0.0
7.2	Shutdown execution	2.0	1.0	0.0	2.0	1.0	0.0
7.3	Start up and commissioning	2.0	1.0	0.0	2.5	1.0	0.0
8.1	Tools	2.0	0.0	0.0	2.0	0.0	1.0
8.2	Facilities and equipment	0.0	0.5	0.0	1.0	0.5	0.0
9.1	Determining root cause of losses	0.2	1.2	0.0	1.6	1.6	0.0
10.1	Routine improvement	0.0	0.5	0.5	0.5	0.5	0.0
10.2	Focused improvement	2.0	2.0	0.0	2.0	2.0	0.0

Table 3.3: Comparison of Different Departmental Results (A & D)

Question Type R and I		R Opportunity			I Opportunity		
Ref	Description	ES	NS	WA	ES	NS	WA
0.0	Maintenance (capability assurance)	0.0	0.5	0.0	0.0	1.2	0.2
1.0	Equipment maintenance plans	1.1	0.6	0.0	1.0	0.0	0.0
2.0	Work origination	2.9	0.0	0.5	1.5	0.0	0.5
3.0	Planning	0.5	1.5	0.0	1.5	0.8	0.0
4.0	Scheduling	0.0	1.0	0.0	1.3	1.3	0.0
5.0	Work allocation and execution	0.5	0.0	0.0			
6.0	Work Completion and recording	1.0	0.5	0.0	1.1	0.0	0.1
7.0	Shutdown management	2.5	1.5	0.0	2.0	1.0	0.0
9.0	Determining root cause of losses	1.0	2.0	0.0	0.5	0.3	0.0
10.0	Achieving improvement in Capability assurance	0.1	1.0	0.0			

Table 3.4: Comparison of Different Departmental Results (R & I)

ES = Engineering Services; NS = North & South Plants; WA = West and Advalloy Plants.

From Table 3.3 and 3.4 the different sections to be used for setting the initial standard can easily be defined. The larger the number corresponding to the different element / sub – element per department, the larger the opportunity.

3.12 Conclusion

The contribution of the maintenance management team towards assuring productive capability of equipment basically entails managing the availability and maintenance cost of equipment. Equipment availability (usually to much larger value to the organisation than the maintenance cost itself) is driven by MTBF, MTTR and logistic delays. These aspects are driven by the elements as described in Table 3.1 (plant condition monitoring, work origination, planning, scheduling and work allocation, completion and recording). Maintenance cost is managed through effective preventative and predictive maintenance, materials management and effective planning and scheduling.

Other aspects not covered by the availability and maintenance cost, include the softer side of maintenance measures like the attitude of the people towards their work environment. Although these aspects can only be measured subjectively it has a definite impact on both the availability and maintenance cost of equipment.

By measuring the elements defined in Table 3.1 a realistic and credible view of the current state of maintenance management was established. By defining the desired future state (Section 4.3 and Appendix A) a proper gap analysis can be conducted.