9 EVALUATING THE OPERATIONAL MANAGEMENT PHILOSOPHIES

9.1 INTRODUCTION

The three operational management philosophies Total Quality Management (TQM), Just-in-Time (JIT) and the Theory of Constraints (TOC) were discussed in chapters 5 to 7. The key values, specific problem solving and measurement tools and techniques as well as their impact on functional areas were described. From these elements those that are most applicable in an underground coal mining production unit must be selected. In this selection the main differences between a mining and manufacturing unit, as discussed in chapter 8, needs to be taken into account

Table 11 provides a summary of the elements of the three philosophies.

Table 11: Summary of the elements of JIT, TOC & TQM

KEY VALUES		
JIT	**TQM**	**TOC**
▪ Elimination of waste ▪ Quality ▪ Continuous process improvement ▪ Total employee involvement	▪ Total customer satisfaction ▪ Continuous improvement ▪ Fact based decision making ▪ Total employee involvement	▪ Causality & necessity ▪ Constraints ▪ Five focusing steps for continuous improvement ▪ Constraint based measurements

Table 11 continues

IMPACT ON FUNCTIONS		
JIT	**TQM**	**TOC**

• Procurement & Supply Management
  ○ Supplier management
  ○ Design & development
  ○ Storage
• Production & scheduling
  ○ Group technology
  ○ Model mixes
  ○ Reduced set-up times
  ○ Scheduling
  ○ Uniform work loads
  ○ Engineering
	• Safety
	• Marketing
	• Product design
	• Procurement
	• In-bound & out-bound logistics
	• Quality assurance
	• Organisational structure
		• Finance
		• Marketing & sales
		• Scheduling
		• Project Management

Table 11 continues

PROBLEM SOLVING TOOLS AND TECHNIQUES		
JIT	**TQM**	**TOC**

• Universal problem solving sequence
• Specific measurements
  ○ Value added efficiency
• Process improvement through Statistical Process Control
	• 14 Quality control tools
	• 7 Quality management tools
		• Thinking processes
		  ○ Current reality tree
		  ○ Evaporating cloud
		  ○ Future reality tree
		  ○ Pre-requisite tree
		  ○ Transition tree
		• Fundamental measurements
		  ○ Throughput, inventory and operating expense
		• Control measurements
		  ○ Througput-rand-days, inventory-rand-days, operating expense

9.2 RATING THE ELEMENTS

In chapter 4 the three functions that are critical for the mining operational management model were determined to be "streamline processes, manage bottlenecks and identify root causes". These functions are therefore the criteria against which the elements in table 11 are evaluated. The tool that is used for the evaluation is a perspective-modelling matrix (VM Services (v4), 1992).

In paragraph 4.4 the functions were scored, indicating the level of importance of the function. Utilising the score the functions are weighted proportionally on a scale of 1 to 10 (10 being the highest). The function "streamline processes" achieved the highest score, and therefore carries a weight of 10. "Manage bottlenecks" came second with a score of 10, and is weighed proportionally against the score of 13 of "streamline processes", thereby having a weight of 8 allocated. Similarly "identify root causes" is weighted as 7. The weighting of the functions is illustrated in table 12.

Table 12: Weighing the functions

FUNCTION	SCORE (as per par. 4.4)	% BASED ON HIGHEST SCORE	ALLOCATED WEIGHT
Streamline processes	13	100	10
Manage bottlenecks	10	76	8
Identify root causes	9	69	7

The weight per function is used in the perspective matrix to ensure that the importance of a function (with relation to the mining operational management model) is taken into account when evaluating the elements. The function plus its allocated weight is inserted at the top of the perspective matrix (refer to tables 13, 14 & 15).

The different elements are listed per category (key values, impact on functions and problem solving tools and techniques). The elements are evaluated per category, i.e. all the key values of each of the three management philosophies are compared against each other. Tables 13, 14 & 15 illustrate the evaluation of the elements per category, and following the tables the evaluation process is explained.

Table 13: Scoring of key values

Key to score
1 : poor
2: fair
3 : good
4 : very good
5 : excellent

ELEMENT OF PHILOSOPHY *Key values*	Function	Streamline processes	Manage bottlenecks	identify root causes	Total	Ranking
	Score	13	10	9		
	Weight	10	8	7		
JIT						
Elimination of waste	weighed score	50	32	7	89	3
	score	5	4	1		
Quality	weighed score	30	16	7	53	8
	score	3	2	1		
Continuous process improvement	weighed score	20	16	14	50	9
	score	2	2	2		
Total employee involvement	weighed score	30	24	21	75	5
	score	3	3	3		
TQM						
Total customer satisfaction	weighed score	10	8	14	32	10
	score	1	1	2		
Continuous improvement	weighed score	40	24	28	92	2
	score	4	3	4		
Fact based decision making	weighed score	20	16	28	64	4
	score	2	2	4		
Total employee involvement	weighed score	30	24	21	75	5
	score	3	3	3		
TOC						
Causality & necessity	weighed score	10	8	7	25	11
	score	1	1	1		
Constraints	weighed score	30	40	7	77	4
	score	3	5	1		
Five focusing steps for continuous improvement	weighed score	40	24	35	99	1
	score	4	3	5		
Constraint based measurements	weighed score	30	24	14	68	6
	score	3	3	2		

Table 14: Scoring of impact on functions

Key to score
1 : poor
2: fair
3 : good
4 : very good
5 : excellent

ELEMENT OF PHILOSOPHY *Impact on functions*	Function	Streamline processes	Manage bottlenecks	identify root causes	Total	Ranking
	Score	13	10	9		
	Weight	10	8	7		
JIT						
Supplier management	weighed score	10	8	7	25	5
	score	1	1	1		
Design & development	weighed score	10	8	7	25	5
	score	1	1	1		
Storage	weighed score	10	8	7	25	5
	score	1	1	1		
Group technology	weighed score	10	8	7	25	5
	score	1	1	1		
Model mixes	weighed score	10	8	7	25	5
	score	1	1	1		
Scheduling	weighed score	10	8	7	25	5
	score	1	1	1		
Uniform work loads	weighed score	10	8	7	25	5
	score	1	1	1		
Engineering	weighed score	30	16	7	53	4
	score	3	2	1		
TQM						
Safety	weighed score	10	8	7	25	5
	score	1	1	1		
Marketing	weighed score	10	8	7	25	5
	score	1	1	1		
Product design	weighed score	10	8	7	25	5
	score	1	1	1		
Procurement	weighed score	10	8	7	25	5
	score	1	1	1		
In-bound & out-bound logistics	weighed score	10	8	7	25	5
	score	1	1	1		
Quality assurance	weighed score	10	24	21	55	3
	score	1	3	3		
Organisational structure	weighed score	30	24	21	75	1
	score	3	3	3		
TOC						
Finance	weighed score	10	8	7	25	4
	score	1	1	1		
Marketing & sales	weighed score	10	8	7	25	4
	score	1	1	1		
Scheduling	weighed score	30	32	7	69	2
	score	3	4	1		
Project Management	weighed score	10	8	7	25	4
	score	1	1	1		

Table 15: Scoring of Problem solving tools & techniques

Key to score
1 : poor
2: fair
3 : good
4 : very good
5 : excellent

ELEMENT OF PHILOSOPHY	Function	Streamline processes	Manage bottlenecks	identify root causes	Total	Ranking
Problem solving tools & techniques	**Score**	13	10	9		
	Weight	10	8	7		
JIT						
Universal problem solving sequence	weighed score	40	16	28	**84**	**2**
	score	4	2	4		
Value added efficiency	weighed score	10	8	7	**25**	**6**
	score	1	1	1		
Process improvement through SPC	weighed score	30	24	21	**75**	**3**
	score	3	3	3		
TQM						
14 Quality control tools	weighed score	30	24	21	**75**	**3**
	score	3	3	3		
7 quality management tools	weighed score	20	16	7	**43**	**4**
	score	2	2	1		
TOC						
Five trees	weighed score	30	24	35	**89**	**1**
	score	3	3	5		
Fundamental measurements	weighed score	20	8	7	**35**	**5**
	score	2	1	1		
Control measurements	weighed score	20	8	7	**35**	**5**
	score	2	1	1		

Each element is evaluated against each function, with the purpose to determine the extent of the impact that the element has on the function. In effect it measures the level of influence the element has on achieving the function. For example, in table 15, the first element of Just in Time is "universal problem solving sequence". The evaluation process is to consider the details of the element (for this element provided in paragraph 6.5.1), and based on that knowledge, determine if the "universal problem solving sequence" will streamline processes in the mining unit, will assist in managing bottlenecks, and will assist in identifying the root causes of problems. Depending on the answer, a score is given on a scale of 1-5 (1=poor; 5=excellent), and entered in the bottom row against the element in the perspective matrix (named score). In the example, the "universal problem solving sequence" is deemed to

influence the streamlining of processes very good, but will only assist moderately with managing bottlenecks.

To account for the importance of the relevant function, the weight of that function is multiplied with the score of that element relative to the function. Again referring to the example, the score of 4 given to the element "universal problem solving sequence" for the function "streamline processes" is multiplied with the weight of the function (10) and the result (40) is entered in the top row of the element (named weighed score)

When all the elements have been evaluated the weighed scores per element are summed and entered in the column named "Total". Relating to the example, the total weighed score for the element "universal problem solving sequence" equals "streamline processes weight + manage bottlenecks weight + identify root causes weight" (40+16+28) equalling the total score of 84.

In the column "Ranking" the elements are ranked from highest total weighed score (1) to lowest total weighed score.

9.3 ANALISING THE RESULTS

To analyse the results, and determine the elements that will be the building blocks for the mining operational management model, different mathematical and statistical analysis are performed. The results from these are used to make the final decision regarding the inclusion or exclusion of the different elements.

9.3.1 Mathematical and statistical analysis

All the elements with their respective scores are combined, sorted and ranked from highest to lowest weighed score (table 16).

Table 16: Summary of scores

NR	ELEMENT	PHILOSOPHY	CATEGORY	TOTAL	RANKING
1	Five focusing steps for continuous improvement	TOC	Key values	99	1
2	Continuous improvement	TQM	Key values	92	2
3	Elimination of waste	JIT	Key values	89	3
4	Five trees	TOC	Problem solving	89	3
5	Universal problem solving sequence	JIT	Problem solving	84	4
6	Constraints	TOC	Key values	77	5
7	Total employee involvement	JIT	Key values	75	6
8	Total employee involvement	TQM	Key values	75	6
9	Organisational structure	TQM	Impact on functions	75	6
10	Process improvement through SPC	JIT	Problem solving	75	6
11	14 Quality control tools	TQM	Problem solving	75	6
12	Scheduling	TOC	Impact on functions	69	7
13	Constraint based measurements	TOC	Key values	68	8
14	Fact based decision making	TQM	Key values	64	9
15	Quality assurance	TQM	Impact on functions	55	10
16	Quality	JIT	Key values	53	11
17	Engineering	JIT	Impact on functions	53	11
18	Continuous process improvement	JIT	Key values	50	12
19	7 quality management tools	TQM	Problem solving	43	13
20	Fundamental measurements	TOC	Problem solving	35	14
21	Control measurements	TOC	Problem solving	35	14
22	Total customer satisfaction	TQM	Key values	32	15
23	Causality & necessity	TOC	Key values	25	16
24	Supplier management	JIT	Impact on functions	25	16
25	Design & development	JIT	Impact on functions	25	16
26	Storage	JIT	Impact on functions	25	16
27	Group technology	JIT	Impact on functions	25	16

28	Model mixes	JIT	Impact on functions	25	16
29	Scheduling	JIT	Impact on functions	25	16
30	Uniform work loads	JIT	Impact on functions	25	16
31	Safety	TQM	Impact on functions	25	16
32	Marketing	TQM	Impact on functions	25	16
33	Product design	TQM	Impact on functions	25	16
34	Procurement	TQM	Impact on functions	25	16
35	In-bound & out-bound logistics	TQM	Impact on functions	25	16
36	Finance	TOC	Impact on functions	25	16
37	Marketing & sales	TOC	Impact on functions	25	16
38	Project Management	TOC	Impact on functions	25	16
39	Value added efficiency	JIT	Problem solving	25	16

These results are plotted on a line graph as shown in figure 19. On the horizontal axis the elements are represented (with reference to the number in table 16), and the vertical axis represents the score.

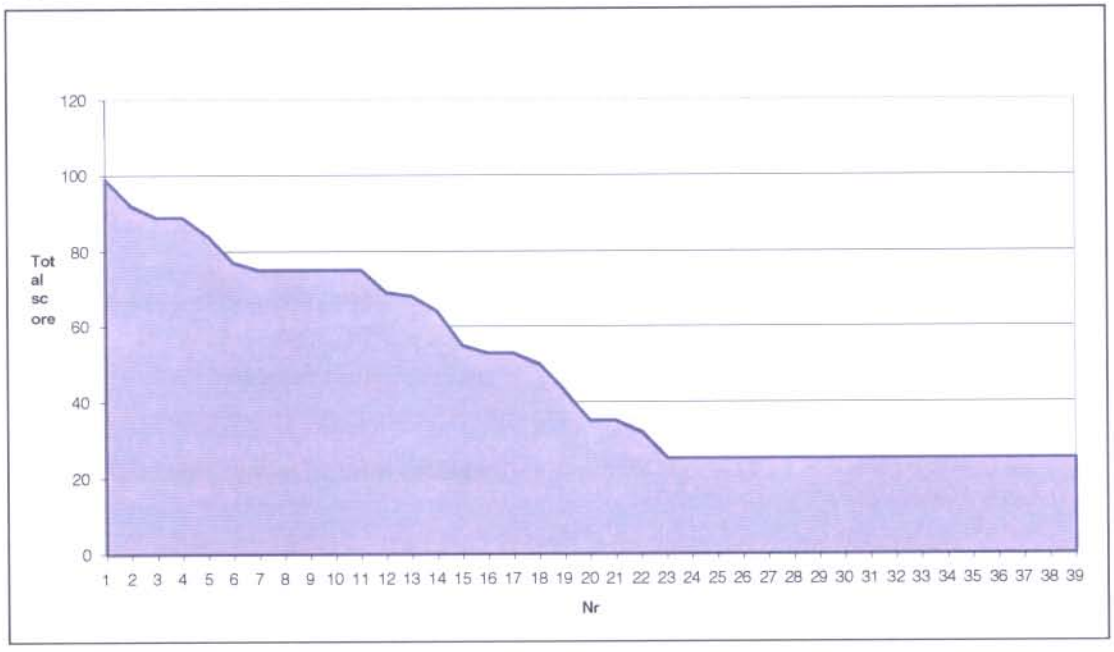


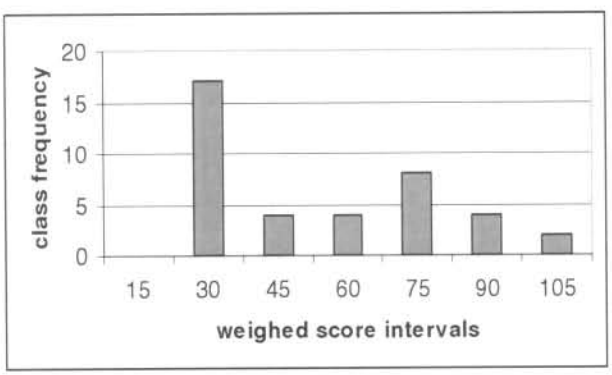
Figure 19: Graphical representation of score values

Basic statistical measures of the dataset containing the scoring results are performed (refer to table 17).

Table 17: Statistical analysis of data set

Measure	Value	Explanation
Mean	48.38	Average (arithmetic mean) of the score ratings
Median	35.00	Tthe number in the middle of the set of score ratings
Mode	25.00	Most frequently occurring, or repetitive, value in the set of score ratings
Standard Deviation	25.39	Measure of how widely values are dispersed from the average value (the mean).
Kurtosis	-1.32	Relatively flat distribution if compared with the normal distribution
Skewness	0.51	Indicates a distribution with an asymmetric tail extending toward more positive values.
Range	74.00	Maximum minus minimum values
Minimum	25.00	Minimum value in set of score ratings
Maximum	99.00	Maximum value in set of score ratings
Sum	1887.00	Sum of score ratings
Count	39.00	Number of elements in set of score ratings

Lastly a histogram based on the dataset is constructed. The aim is to determine if any pattern exists with reference to groupings of weighed score values. Refer to figure 20.



Bin	Frequency	Cumulative %	Indiv %
15	0	.00%	
30	17	43.59%	43.59%
45	4	53.85%	10.26%
60	4	64.10%	10.26%
75	8	84.62%	20.51%
90	4	94.87%	10.26%
105	2	100.00%	5.13%

Figure 20: Histogram of scored ratings

9.3.2 Discussion of analysis

From the line graph (figure 19) a separation between two sets of elements, at element 11 and 12 is observed. In the first set (1-11) the elements exhibit a natural closeness in the

value of the scores, with stability in the ratings from element 7 – 11. In the second set (12-39) the elements depict a constant, linear drop in the scored ratings.

From table 16 it follows that elements 1-11(28% of total number of elements) represent 48% of the total score. If a Pareto ranking is performed on the dataset it does not provide any insight, as the 80% mark (based on the cumulative score) is only reached at element 24 (62% of the number of elements). The 80/20 rule is therefore not applicable as a method of determining which elements to include.

The statistical analysis in table 17 indicates a fairly flat distribution, with a large standard deviation. The large standard deviation between weighed scores is expected as the scoring process followed is fairly robust, and a difference of 1 on the score given can be amplified greatly due to the multiplication with the weight.

An interesting pattern is found in figure 20, the histogram. The bin range 0 – 60 contains 25 elements that contribute to 64% of the total score. This equates to an average of 2.6% per element. The bin range 60-105 contains 14 elements that contribute to 36% of the total score. This also equates to an average of 2.6% per element. Therefore elements 1-14 carry an equal weight compared to elements 15-25, and can be seen as a natural grouping.

To summarise, from the line graph elements 1-11 stand out as a possible cluster of elements, and from the histogram (and supporting data table) elements 1-14 stand out. As elements 12-14 support elements 1-11 and are not in disparity with any of the underlying assumptions of these elements, elements 1-14 are chosen as building blocks for the mining operational model.

9.4 CONCLUSION

In this chapter a set of 14 elements were identified as being the most suitable and applicable as building blocks for the mining operational management model. These elements all support the functions of the mining model as defined in chapter 4.