CHAPTER 7: BREAKDOWN MAINTENANCE MANAGEMENT (BMM) AS A MODEL AND ITS PRACTICAL APPLICATION TO CONSTRUCTION MACHINERY BREAKDOWNS

7.1 Introduction:

Although maintenance is performed in order to increase the safety and intended operation of the plant and machinery, incorrectly performed maintenance can lead to reduced safety of the systems and create losses (Holmgren M, 2003). Maintenance personnel, who, although skilled, choose not to follow best maintenance repair practices, potentially cause another 20 % to 30 % of those failures. Ricky S, (2003) supports this statement that between 30 % and 50 % of the self-induced failures is the result of maintenance personnel, not knowing the basics of maintenance. A key to overcome these issues could be the incorporation of the newer and improved techniques in maintenance.

Rao B K N, (2009) also informs that one of the challenges in maintenance is to continuously improve the maintenance management efficiency as the demand for the same is felt as a vital need in today's competitive environment. Crespo Márquez., A (2009) confirms that models can be evolved for organizations to adapt to the faster changes that occur in various industry situations and this is applicable to the maintenance field also.. The right and efficient strategy chosen should always aim at guaranteeing the level of performance and availability of the system and at the same time allowing for reduction in resource expenditures (Borgonovo et al, 2000). Umar A.T. (2011) also suggests that the process of development of such strategic plan in maintenance differs from other areas because of its intangible benefits to the organization and special type of stakeholders. The identification of BMP Codes, BMP Ruler, BMP Resource Sheets, BMP Method of Rectifications which have been developed with this study in the previous chapters, if used in proper order as a model might yield better results for the effective breakdown management. It can find greater application on construction machinery which is used by construction companies in the United Arab Emirates.

The machinery whose failure data has been considered for the development of this model includes wheel loaders and dumpers. We will be analysing the application of this model to various failures which have incurred on these machinery and the effect of improvements on the same.

7.2 Input, Process and Output analysis of the Breakdown Maintenance Management (BMM) Model

With studies done in the previous chapters and also with the additional inference through literature and survey the breakdown codes and BMP Ruler for effectively executing the breakdown maintenance have been identified. Further the requirements and systems formulated as models which can help to manage the breakdown maintenance management efficiently even with the complexity of its environment are discussed below. The Breakdown Maintenance model, called as Breakdown Maintenance Management (BMM) Model which is incorporated with the Breakdown Maintenance Management Protocol (BMP) system will keep the entire maintenance crew under alertness, readiness and preparedness to execute any kind of breakdowns in an effective manner and thus the effective breakdown durations will be shortened and reduced. This tool is a continuous improvement tool, as for newer problems relative new protocols and solutions are prepared and inducted as and when required.

The BMM Model which is the combination of three sub models and it is together termed as the BMM Model. The sub models include Failure Analyzer Model, BMP Identifier Model and the BMM Analyzer Model.

The cycle of breakdown maintenance management which is the general output of the model will bring in better results for the breakdown maintenance. Here all the end users of model (whenever there is a breakdown) will have complete control on the breakdowns, as all of these breakdowns are predetermined within the modified maintenance management techniques.

The end users of this model including the crew concerned with repairs and maintenance of construction machinery, operatives, site mechanics, site supervisors, maintenance crew, maintenance supervisors, and maintenance engineers will use one or all of the components of this model. The process basically involves inputs, process and outputs as well.

7.2.1 Failure Analyzer Model:

7.2.1.1 Input:

This model has inputs of 5 year failure data of the target company and the critical machinery of the target company.

- The failure data is taken from the target company for the period 2007 to 2011 through Breakdown Registers, Job Cards and Plant History Cards
- The critical machinery from the list of machinery includes representations from earthmoving, utilities, lifting and compaction machines. The breakdown data is analyzed through breakdown ratio analysis, breakdown percentage impact analysis and cumulative consequential cost analysis and the resultant machine that contribute to most of the breakdowns and cost are identified.

7.2.1.2 Process:

The process of this model is through maintenance tools which are conventionally used in the maintenance management studies.

- CEA Tools, which are used to identify the basic root causes of failures. The cause effect analysis relationships which are developed with the knowledge base of the maintenance teams help to identify the first level of breakdown causing factors known as breakdown codes.
- Pareto Analysis: This is the technique used to identify the critical codes which cause maximum breakdowns to machinery. The Pareto principle is used here which helps in identifying the minimum causing the maximum impact.
- FMEA Tool: The Failure Mode Effect Analysis tools used to identify the significance of the identified codes with the severity effect analysis on associated components and also as a system.
- FTA Tools: The Fault Tree Analysis techniques are used to evolve further root causes of these codes to identify the symptom and the reason codes.

7.2.1.3 Output:

- Breakdown Main Codes (BMC), the basic breakdown factors which are the direct high level cause factor of the failure

- Breakdown Sub Codes (BSC) are secondary level failure causing factors in relation to the BMC's
- Breakdown Symptom Codes (BSyC) are the symptoms of the failure causes
- Breakdown Reason Codes (BRC) is the closer reasons or the root cause of the particular breakdown/failure.
- Breakdown maintenance protocol ruler (BMP Ruler). This ruler has 4 levels of codes rings with relationship of each code matched with other codes. This ruler will be utilized by the end users namely the operator of the machinery/site mechanic/maintenance crew/store-man/maintenance supervisor/maintenance engineer. Subsequent to the correct identification of final Breakdown Reasons from this ruler which is otherwise called as BRC, and the related protocol numbers are selected. This specific identity has got its own methods of rectification and the resource requirements specified.

7.2.2 BMP Identifier Model:

7.2.2.1 Input:

This model has the inputs of BMP Ruler, BMP Resource Sheet and the BMP Method of Rectification.

- BMP Ruler
- BMP Resource Sheet – This is the entire resource requirement for every BMP Number identified from the BMP Ruler. Each BMP will need certain specific and common resources for the execution of the particular breakdown maintenance. The resources of manpower, spares, tools, equipment, machinery, supervision, special requirements are all specified in the resource sheet against each breakdown reason as identified from the BMP Ruler.
- BMP Method of Rectification (MOR): The MOR's are the specific guidelines to the technicians who execute the breakdown rectification process. There are clear instructions on to the step by step requirements of each of the breakdown maintenance process are listed for the easy and clear guidelines to the end user.

7.2.2.2 Process:

The processes of this model include the BMP Ruler and the protocol systems which are detailed below. The protocol systems constitute of the usage of the multi ring ruler to the breakdowns, utilizing the resource tools to specify the resource requirements and also the method of rectification instructions for guideline procedures to the rectifications.

- The multi ring assembly of BMP Ruler has the list of all the breakdown codes in its front side. It is used by the person at site and the relative crew members who are in the job of breakdown maintenance execution. The four levels of rings are called as BMC, BSC, BSyC and BRC rings respectively. The color codes are uniformly maintained on all four rings for easy relationships of components and systems. The numbers printed on the first two rows of rings namely BMC Ring and BSC Ring to be matched together. Similarly the numbers printed on the last two rows of rings namely BSyC Ring and BRC Ring to be matched together.
- Breakdown Maintenance Protocol (BMP) process: This is similar to the medical/patient protocol which is practiced by the ambulance and medical professional. The information of the breakdown/failure upon assessment by the concern mechanics/crew triggers the follow on procedures.
- The tools required, the tradesmen required, the supervisory staff required, the spare parts required, the statutory vehicles required, the method of rectification required, all these requirements are known to every level of people who are associated with the breakdowns. A high level of ownership is established with all the end users.

7.2.2.3 Output:

The output of the process is basically on the breakdown maintenance management system which is a model approach to facilitate effective breakdown management and the identification of the breakdown causes. It supports on defining the problem, root cause identification of the problem and the resource requirements to facilitate rectification process. If the failure is small in nature with the available tools the same can be managed by the operative himself. If the failure is complex in nature it can be managed by the crew along with the supervisory support. The BMP Ruler is a handy tool which will be used by all levels of crew and gives them the interest to approach the failure. The failures are interpreted with codes and the code language becomes standard language by all concerned. Every operative or the mechanic after knowing the codes upon frequent usage will inform the requirements only through code language. If a breakdown on an engine happens, the relative breakdown reason code and the relevant BMP number only if informed will facilitate all the resources required for the same.

Even the store man can stock the spare parts with reference to the BMP number. The site which has got a group of machinery will get its frequency of failures over a period will have its BMP priority list and accordingly the resource planning will be done and the storage also can be kept at the site level which will further reduce the duration of the breakdown rectification jobs.

7.2.3 BMM Model:

7.2.3.1 Input:

The input for the model is the breakdowns occurring at the target company.

7.2.3.2 Process:

The process includes application of the BMM model process to the live breakdowns. Breakdown Codes, BMP Ruler, BMP Resource Sheets and the BMP Method of Rectification techniques are used in this process. Comparison of the time effects and approach to the breakdowns with this newer technique is analyzed.

7.2.3.3 Output:

The output of this process is the results of comparisons. The breakdown rectifications approached with this model are effective and the duration of the repair process is reduced substantially. The ambiguity of the technicians towards problem identification, spare parts planning, resource planning, and resource management by the supervisors are improved. The statistical results are listed in the following parts of this chapter.

7.3 Breakdown Maintenance Management (BMM) Model – The Approach

As this model (Figure 7.1) is a combination of three models namely Failure Analyzer, BMP Identifier and BMM Analyzer models, the output of every model is the input of the other models and it should be read together. The first model Failure Analyzer is developed with the conventional maintenance tools including CEA, FMEA, FTA and Pareto Tools with the output BMP Protocol Ruler which is a newer development in the Breakdown Maintenance Management and studies. This BMP Ruler can be used by the first level of the maintenance crew (Operative and site mechanic) to the highest level of the crew, maintenance engineer/manager. Additional resource outputs identified through this model are BMP Resource Sheets and BMP Method of Rectifications (MOR) which are supporting the BMP Ruler. The second model is the self developed model with the integration of all the resources. The outputs of the first model (Failure Analyzer model) are the inputs for this model and this BMM model processes the breakdown cases and the effective execution of the same are proposed wherein the Protocol solutions are identified and documented for the end users. The third model which is termed as the BMM Analyzer Model analyzes the applications and results of this model study. The logical flow process is detailed in Figure 7.2.

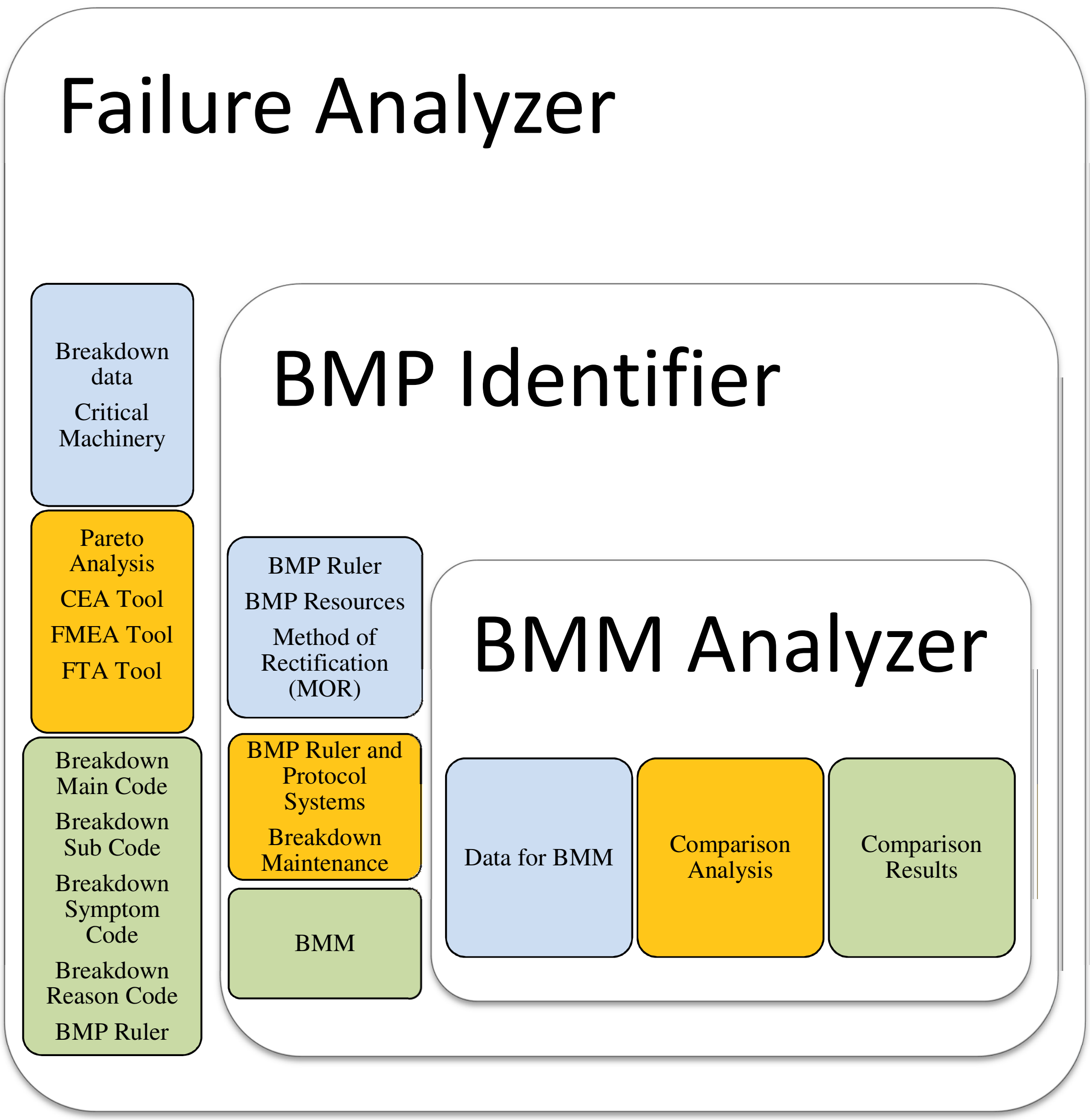

Figure 7.1 Breakdown Maintenance Management Model – The Approach

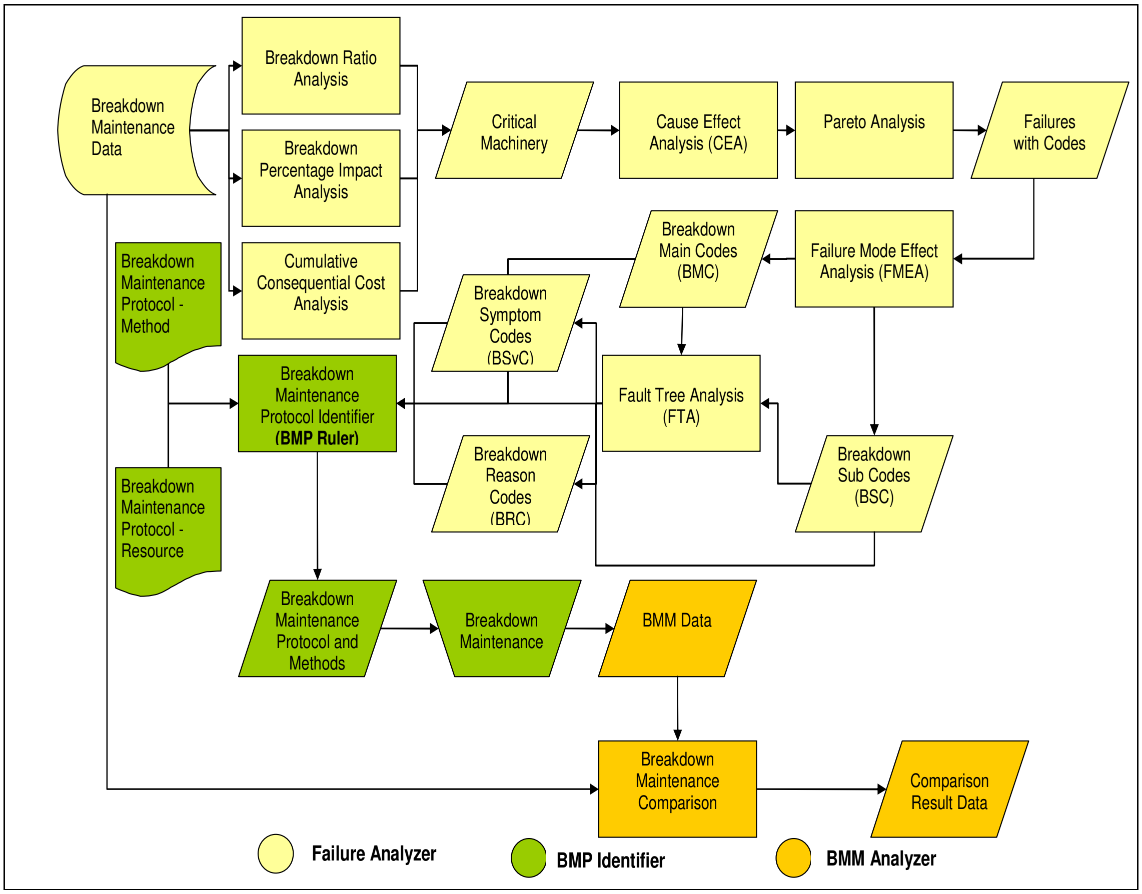

Figure 7.2 Breakdown Maintenance Management Model (BMM) – Flow Process

7.4 Practical Application and study – BMM Model to a Machinery Failure

The breakdown of machinery occurs due to the unpredictable failure of components and due to gradual wear and tear of the parts, which cannot be prevented. The site mechanics that will be generally posted at the site along with the operator have sufficient knowledge on the breakdowns with their previous technical education and knowledge base and supported by confidence which is developed through the BMP techniques present in the BMM Model. The standard procedures of BMP lead to unambiguous situation and systematic evaluation of breakdown trouble shooting.

The cause of the failures are identified with the step by step procedure of BMC which is followed with BSC and the closer reasoning codes of BSyC an BRC reveal the exact cause of the breakdown/failure. The Turn Around Time (TAT) of the breakdown cycle is greatly reduced. The spare part planning is listed with the specific BMP and upon information of this

BMP numbers to the breakdown management supervisor all the resources pertaining to the particular BMP were sent immediately. The activities including methods of rectification were also listed specific to each BMP and the entire process was very smooth and fast.

For practical application purposes, BMP Ruler with four levels of codes arrangement as the front side and one level of code and BMP number at the reverse side is available with every member of the maintenance crew.

The identification methodology of the right codes up to the reach of the correct BMP number by the mechanic and the end user with the BMP Ruler is detailed as a flow process is described in the following figure 7.3.

BMP 091 is the protocol which requires the right crew presence due to many component dis-assemblies and repair works requirements. Hence the site mechanic informs the Workshop Maintenance Department to come prepared for the Breakdown Maintenance Protocol Number 091.

Upon receipt of this call, the following Breakdown Maintenance Crew is organized by the maintenance supervisor along with other resources as mentioned in the BMP 091 Resources:

- Foreman
- Mechanic
- Assistant Mechanic
- Hand Tools
- Special Tools (Allen – Keys, Bearing Puller, Milling Box)
- Breakdown Vehicle
- Lubricant including Coolant, Grease, Cotton Waste, Hand Glouse, Paste
- Spare Parts – (Fan Leaf Assy., Fan Belt A43, Fan Cover Assy., Bearing 6206, Bots, Nuts and Belt Guard)
- Method of Rectification MOR 091

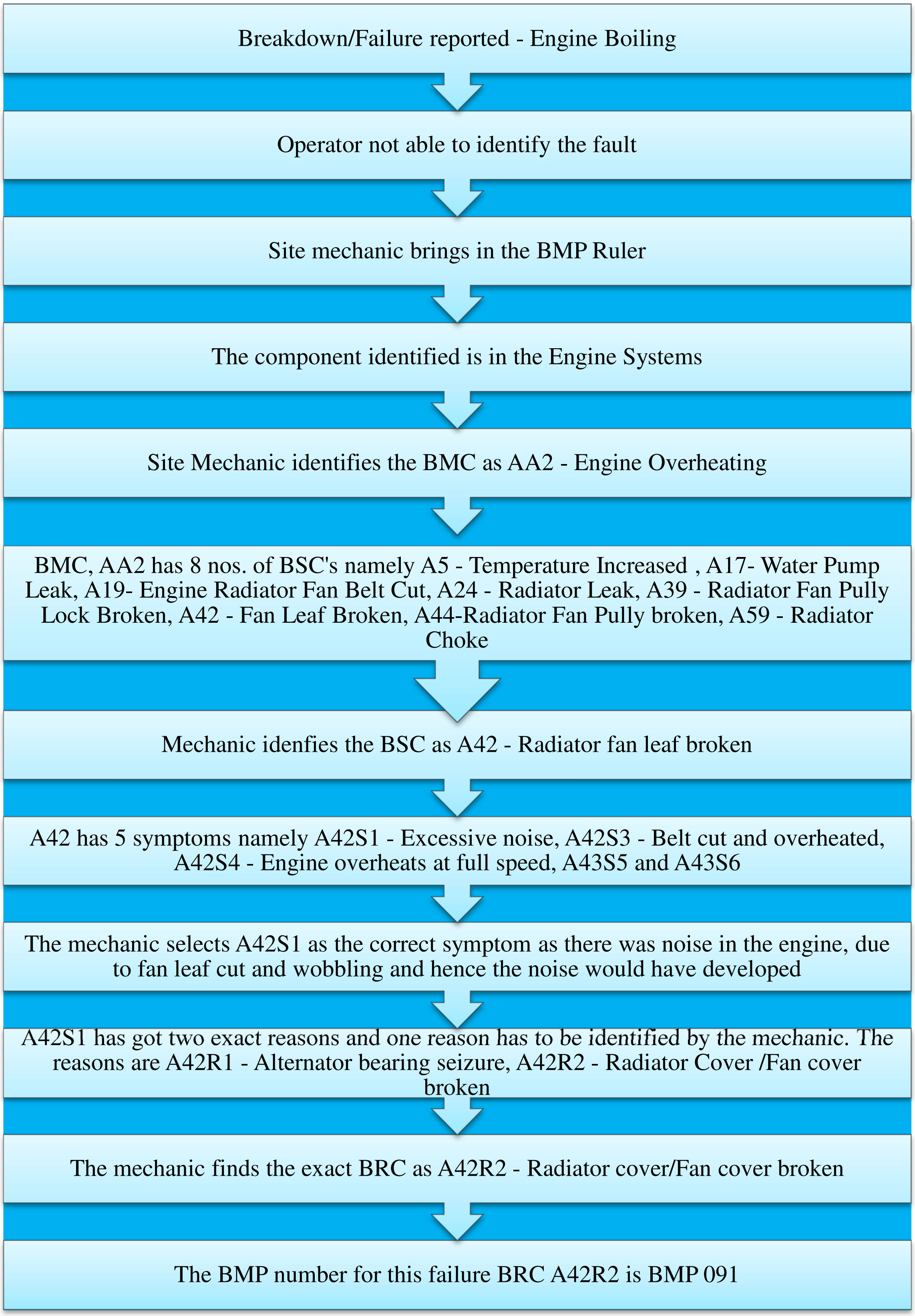

Figure 7.3 BMP Applications - Process Flow

With all of the above process the complete failure/breakdown has been rectified without any ambiguity and within a short time as everyone involved was focused. The conventional rectification time for this type of breakdown in previous occasion has been 120 hours.

[Ref: 2007 - BITS PILANI - Wheel Loader 68 - Job Card No. 262 - ENGINE OVER HEATING - FAN LEAF BROKEN - RADIATOR FAN LEAF CHANGED - RADIATOR Conventional Duration 120 Hours]

As presented above the conventional breakdown rectification has taken a time of 120 hours. Enormous amount of time has been taken in the conventional process due to the reasons of: right mechanic not visiting the job site (BITS Pilani, Dubai Campus Construction), identification delays of the problem, work allocation delays, mechanic and other resource delays, spare parts delays, and waiting delays due non supply of certain items.

If BMP approach is made for the same problem, the effective execution of the failure can be done in a systematic manner, as everyone involved in the rectification process is well understood of the exact identification of the failure reasons, the relevant BMP indicates the exact resources required for the failure in no time through the BMP Ruler and other resource tools. The code language by the team involved clearly specifies the complete list of facilities and spares required with a clear rectification process namely method of rectification.

The modified methods will have all these resources ready as a pack at the workshop stores/site stores and immediate action can be taken without waiting for any hurdles. Due to these right practices and system of procedures followed with BMP Tools, the problems and delays had in the conventional breakdown management are overcome.

7.5 Using the Breakdown Maintenance Management (BMM) Model as a standard

The BMM Model along with BMP can be applicable to all kinds of construction plant and machinery. The construction machinery working at the United Arab Emirates as discussed in previous chapters, are subjected to working in different atmospheric conditions. The breakdown of these plant and machinery happen in construction sites of U A E often.

The construction companies, operating in this region, can adopt the BMM Model along with the BMP technique for their fleet. The failure data is the prerequisite for any organization who deal with machinery. The failure data give an opportunity to maintenance crew on the analysis of the same and reaching conclusions about the failure patterns existing with the organization. The operatives / maintenance technicians / maintenance department / user departments must be given the initial awareness of the breakdowns and the conventional approach of the breakdown maintenance. They should be provided with the Components and Breakdown codes knowledge of BMP. As per their previous breakdown records (if maintained by the company), if all the listed codes fit in with their breakdown history, then the same can be used. If there are newer breakdowns which are not covered, then the newer BMP can be developed.

As BMP gives the clear idea of how to approach and execute the breakdown maintenance, this system/model will be accepted by the maintenance/operation crew and can be easily implemented. The application of this tool will give sufficient knowledge to the entire crew starting from the operator of the machinery up to the maintenance engineer of the machinery. The systematic approach of breakdown management will be ensured with all concerned. The code language will be ruling with the maintenance crew and the easy diagnosis/fault finding will be an easy and unambiguous approach followed with clear demand of the resources. The spare parts can be pre planned at the stores as inventory based on the frequency of various BMP's happening with sites. The sites which have a group of machinery can be planned for a limited BMP as the history of failures of these machines would have been known to all the users at the initial stages itself.

Most of the construction companies working in this region are similar in nature with the machinery base and the maintenance crew base. The occurrence of failure is also similar and consistent as per the environmental conditions and the general output demands from the machinery are always uniform. All of these factors justify the usage and application of this model of breakdown management to be useful to the construction companies in the United Arab Emirates.

The BMP provides a framework of the component scope of the machine which is very much general with all the construction machinery. The addition of hydraulic systems in the BMP tool also provides wider scope to this application. All these codes of main code, sub code, symptom code and reason code are all similar failure sequential approach which can be acceptable by any construction machinery maintenance technician. The method of rectification and the resource tool which is part of the BMP management cannot get changed even for conventional breakdown maintenance management with the exception that the BMP basically deals with everything right approach from the initial triggering up to completion of the breakdown maintenance of any failure. The process flow of the BMM Model that can be used by Construction Companies of the region is given in figure 7.4

Whenever breakdowns occurs at the construction project site or at factories, the maintenance crew will get a call from the user/operator/site.

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Upon analysing the given breakdown information, the Breakdown maintenance Mechanic/Team checks the broader area of the breakdown as to which system is basically at fault and relate it to the main code of the breakdown (BMC) to which it aptly fits which will be generic.

↓

It is further checked with the many available Breakdown sub codes (BSC) which are associated and related with the BMC and get the lead information on the specific area of the breakdown.

↓

Further analysis is done for the symptom codes (BSyC) which are the basic symptoms which existed during/on account of these breakdowns, and it will reveal the crew to the further closer reasoning of the problem from the system of symptom codes and get closer to the correct reason codes (BRC) which has attributed the breakdown.

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Each BRC is associated exactly with a BMP which is the Breakdown Maintenance Protocol for every Breakdown Reason Code.

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The BMP provides required information and the focused attention/actions required for executing the particular breakdown effectively.

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The BMP triggers all the crew who are at site and those at the central workshop to get ready with a set/system of operation, wherein the necessary tools, tackles, manpower, supervision, spares, workplaces, logistics to be prepared are kept ready/ prepared/dispatched as required/specified. It will also indicate the time management/duration of works, skill levels of technicians, outsourcing requirements, material handling devices required etc.

Figure 7.4 BMM Model – Application Process

7.6 Impact of BMM Model on the Conventional Breakdown Process

The modified approach of the failure / breakdown process with the BMP Tools is given as a process flow on the following figure 7.5.

The improvements / modifications on the conventional system are highlighted adjacent to the processes.

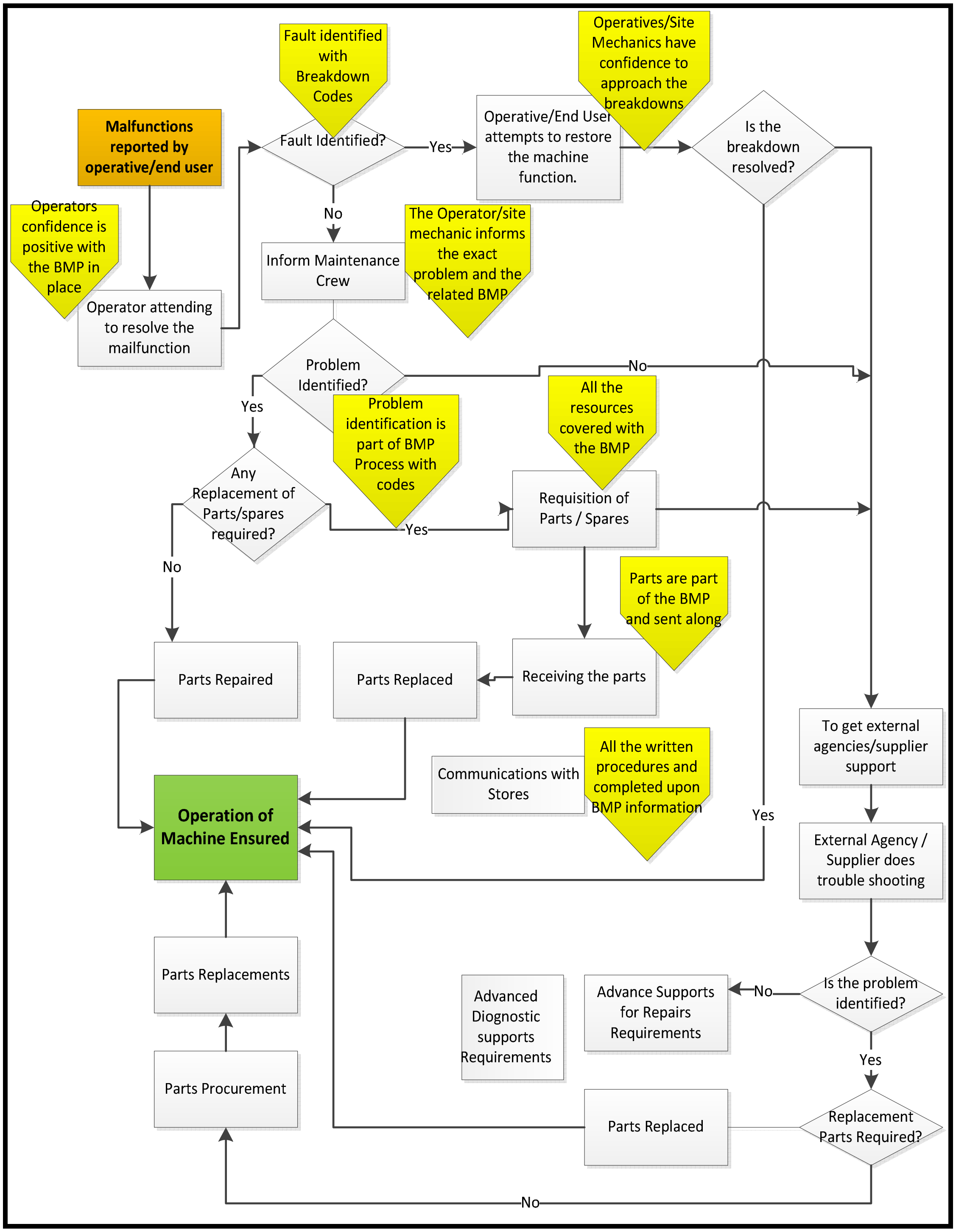

Figure 7.5 Impact of BMM on Conventional Breakdown Flow Process

7.7 Results and Analysis of BMM Model Application

The active repair time of machinery during the breakdown rectification has many factors which compound the overall duration to the breakdown duration. The length of active repair time reflects direct and indirect factors such as product complexity, diagnostic adequacy, nature of product design and installation and the skill and training levels of the maintenance staff (Dhillon B.S, 1999).

The results and analysis is the important part of this chapter as we study the application of the BMM Model to breakdowns with the conventional breakdown maintenance execution process. We have applied this model to 4 numbers of failures on the wheel loaders and dumpers. The failure analysis in this study includes the detailed description of the breakdown, the relative sub code for the same for easy identification, the machine identification and the total duration of the breakdown.

The present analysis which is detailed in figure 7.6, includes 7 broad areas including the entry of the breakdowns in a systematic manner, the registration of the breakdown for the records, the fault finding and diagnosis of the failure/breakdown to ascertain the cause of the failure, the actual execution of the breakdown maintenance, inspection of the breakdown works, analysis of the breakdowns/failures, and records entry. There are 27 attributes with which the present breakdown maintenance are managed and executed with each attribute having specific time duration for the execution.

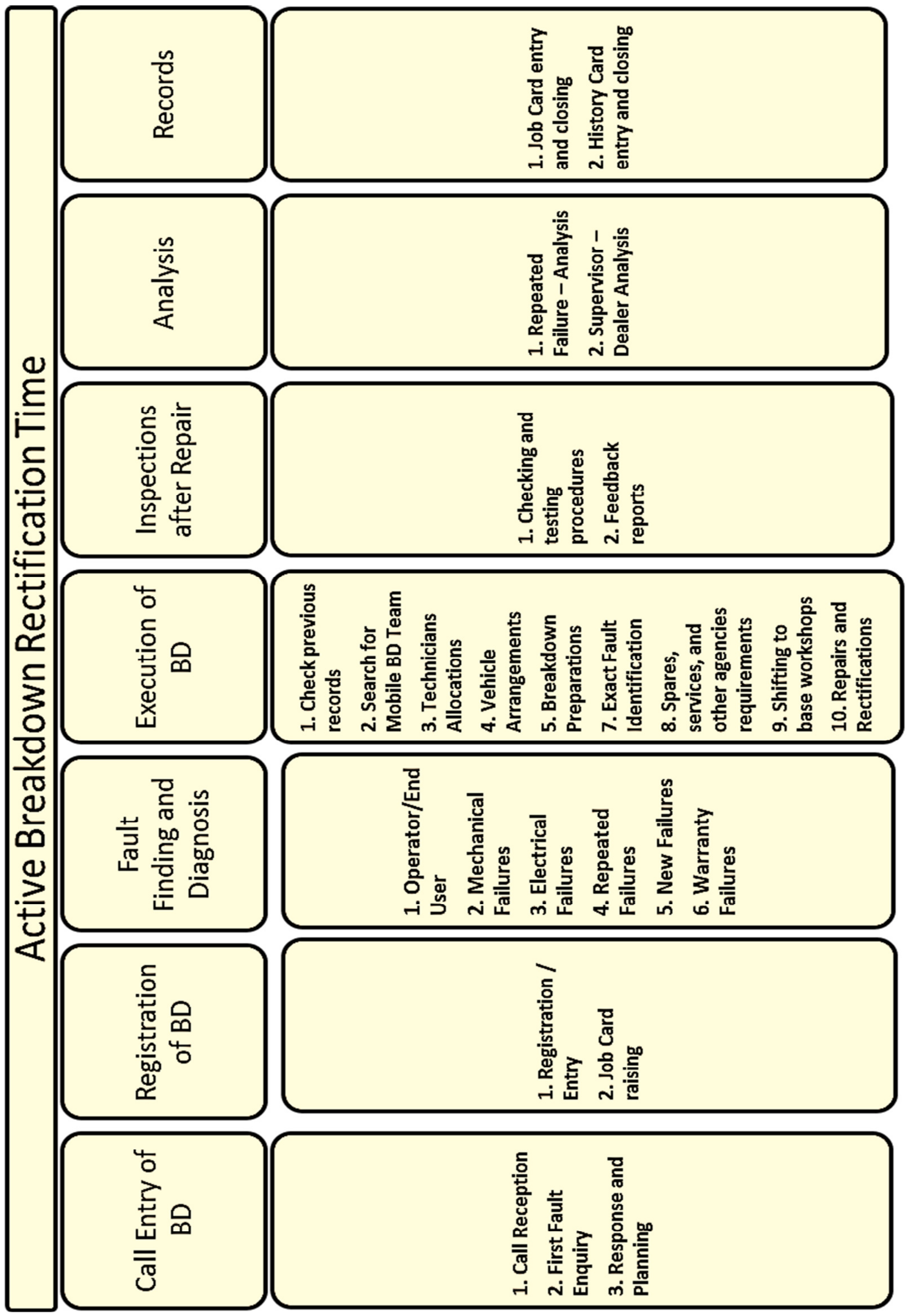

Figure 7.6 Active Breakdown Rectification Time

Here we have utilized the BMM model for the execution of the live breakdowns and a comparison analysis is done for the similar breakdown rectification process in the conventional methods, which has happened earlier. The comparison reveals that the newer BMM model along with BMP approach yields a saving of about 40 to 45 % on time. We find that most of the savings are obtained on the areas of fault finding and analysis, actual execution duration of the breakdown maintenance wherein there is existence of many individual decision making process and ambiguities with the conventional breakdown execution process which will be completely overcome in the BMM Model Process.

All this breakdowns executed with the newer model technique are analyzed and the overall savings are displayed as area graphs with the blue areas representing the earlier conventional execution compared with the red area (reduced levels) which represents the present execution methods. Tables 7.1, Table 7.2, Table 7.3, Table 7.4 and Figures 7.7, Figure 7.8, Figure 7.9, Figure 7.10 and 7.11 imply these results clearly.

Substantial reduction in the duration was observed in the areas of Call entry of breakdowns, Fault finding and diagnosis of breakdowns and the Execution of the breakdowns.

In the call entry segment, most of the savings was achieved in the first fault enquiry and the response time for the calls. This was possible since breakdown codes and ruler were practiced by all the crew members and identification of the faults was easy. About 10 to 15% improvements were achieved in this area.

In the Fault finding and diagnosis segment, the operator or the end user of the machinery was easy to locate the problems, since the BMP Ruler has been practiced by all the team members. The root cause identification of the failure was easy with the BMP Ruler and this made the job easy for them and resulted in reduction of time. About 50% average improvements were achieved in this area.

On the Execution of the breakdowns, the achievements were substantial up to 58%. This was possible with the BMM Model, as the resources requirement for each of the breakdowns, the decision making requirements on shifting of various resources and other aspects required for the effective execution was in place.

The conventional hours were taken from similar breakdowns happened and executed in the target company in earlier occasions.

Other benefits with the implementation of this model include effective spare parts and inventory management. The store man can stock the spare parts with reference to the BMP numbers. The site which has got a group of machinery will get its frequency of failures over a period will have its BMP priority list and accordingly the resource planning will be done and the storage also can be kept at the site level which will further reduce the duration of the breakdown rectification process.

With reduction of Turnaround time of breakdowns, which is the actual duration of breakdown from its failure reporting time, to the completion of the breakdown maintenance, the improvements will be observed in the Mean Time To Failure, Mean Time To Repair and the availability values. Other outputs include job confidence to the mechanics, unambiguous and focused approach on to the failures/breakdowns, time and cost reduction to the overall breakdown maintenance management, improved inventory planning at workshop and site stores based on the BMP occurrence and overall reliability improvement due to the SOP's in place for every failure, which will give confidence to the organization and client as well.

Table 7.1 Breakdown Data Sheet for BSC D18

Breakdown Analysis : 1			
Fault description: Noise during operation (Propeller shaft bearing)			
BSC : D18 - Noise during operations / D12S1 - Grinding noise developed while driving / D12R2- Self Starter Bentex not released			
Machine Name : Wheel Loader			
Machine No : 17500			
Total hrs : 29.9 hrs			
Description		**MB2M Duration in Hours**	**Conventional Duration in Hours**
CALL ENTRY OF BREAKDOWN	CALL RECEPTION	0.02	0.02
	FIRST FAULT ENQUIRY	0.10	0.10
	RESPONSE / PLANNING	0.15	0.25
Sub Total of Call Entry of Breakdown Duration		**0.27**	**0.27**
REGISTERATION OF BREAKDOWN	REGISTERATION / ENTRY	0.05	0.05
	RAISING OF JOB CARD	0.05	0.05
Sub Total of Registration of Breakdown Duration		**0.10**	**0.10**
FAULT FINDING AND DIAGNOSIS OF BREAKDOWN	OPERATOR/ END USER	0.15	0.45
	MECHANICAL PROBLEMS / FAILURES	0.10	0.25
	ELECTRICAL PROBLEMS / FAILURES	0.00	0.00
	REPEATED PROBLEMS / FAILURES	0.05	0.05
	NEWER PROBLEMS / FAILURES	0.00	0.00
	WARRANTY ISSUES	0.02	0.02
Sub Total of Fault Finding and Diagnosis of Breakdown Duration		**0.32**	**0.77**
EXECUTION OF BREAKDOWN	CHECK PREVIOUS RECORDS	0.10	0.10
	SEARCH FOR MOBILE B/D TEAM	0.02	0.02
	ALLOCATION OF TECHNICIANS	0.15	0.15
	ARRANGE VEHICLE	0.00	0.10
	ARRANGE ENTRY PASS / STATUTORY PASSES	0.00	0.00
	PREPARDNESS FOR ATTENDING	0.20	0.45
	EXACT FAULT IDENTIFICATION	0.00	2.00
	SPARES, SERVICES - EXTERNAL AGENCIES INVOLVEMENT	8.00	10.00
	IF MAJOR, SHIFT EQUIPMENT TO BASE WORKSHOP	0.00	24.00
	REPAIR & RECTIFICATION	20.00	20.00
Sub Total of Execution of Breakdown Duration		**28.47**	**56.82**
INSPECTION AFTER REPAIRS	CHECKING / TESTING	0.30	0.30
	USER FEED BACK	0.05	0.05
Sub Total of Inspection after repairs Duration		**0.35**	**0.35**
ANALYSIS OF BREAKDOWN	IF REPEATED PROBLM ANALYSE ROOT CAUSE	0.02	0.02
	SUPERVISOR / DEALER DISCUSSIONS	0.02	0.02
Sub Total of Analysis of Breakdown Duration		**0.04**	**0.04**
RECORDS OF BREAKDOWN	JOB CARD CLOSING	0.20	0.20
	HISTORY CARD ENTRY & CLOSING	0.15	0.15
Sub Total of Records of Breakdown Duration		**0.35**	**0.35**
TOTAL		**29.90**	**58.70**

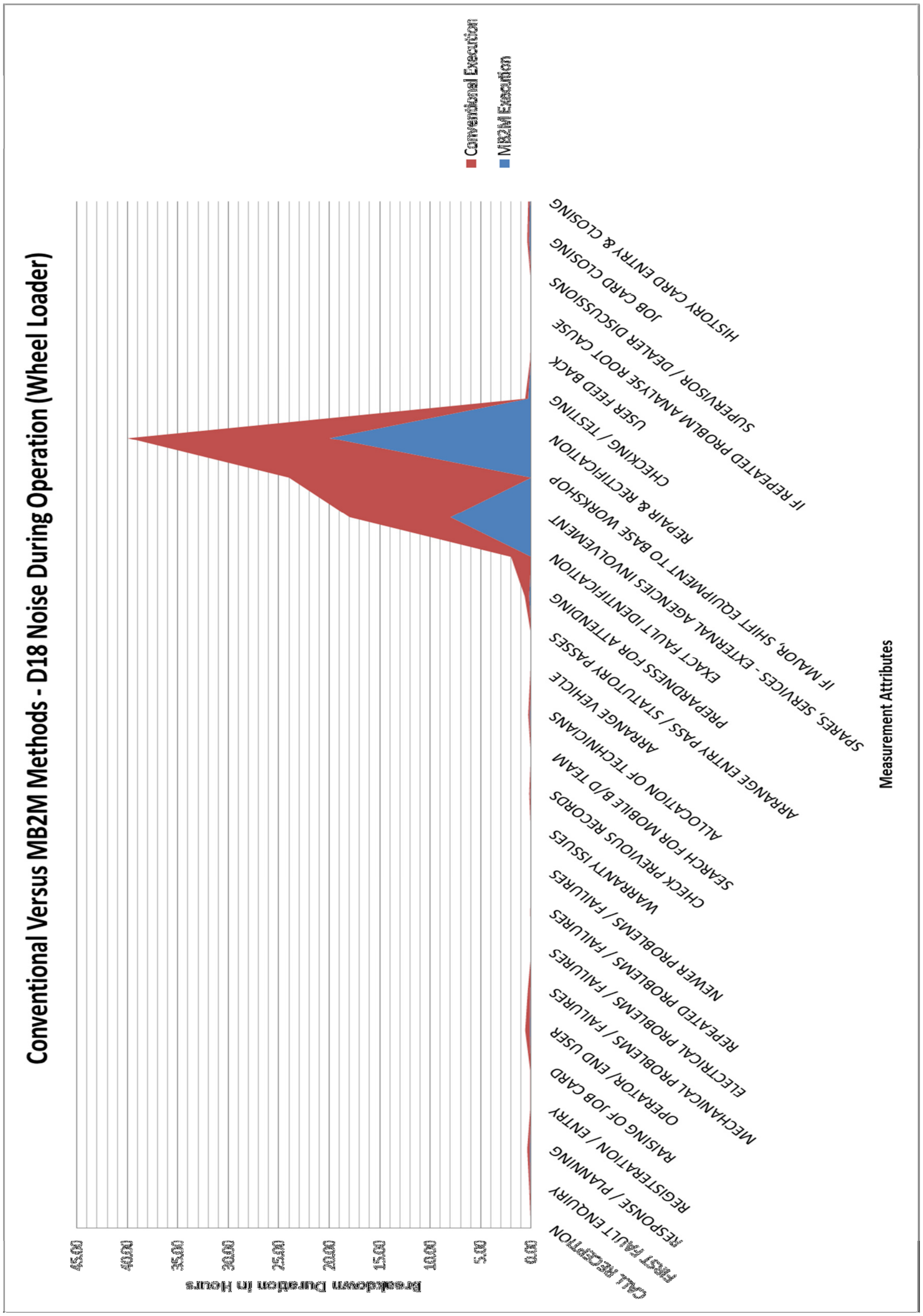

Figure 7.7 BSC D18 / Wheel Loader - Conventional Vs. BMM

Table 7.2 Breakdown Data Sheet for BSC D6

Breakdown Analysis : 2			
Fault description: Clutch Slippery			
BSC : D6 - Clutch Slippery Parts / D6S1 Not getting pickup speed / D6R1 - Overload operations			
Machine Name : Dumper			
Machine No : 1014			
Total hrs : 30.49 hrs			
Description		**MB2M Duration in Hours**	**Conventional Duration in Hours**
CALL ENTRY OF BREAKDOWN	CALL RECEPTION	0.02	0.02
	FIRST FAULT ENQUIRY	0.05	0.15
	RESPONSE / PLANNING	0.05	0.10
Sub Total of Call Entry of Breakdown Duration		**0.12**	**0.27**
REGISTERATION OF BREAKDOWN	REGISTERATION / ENTRY	0.05	0.05
	RAISING OF JOB CARD	0.05	0.05
Sub Total of Registration of Breakdown Duration		**0.10**	**0.10**
FAULT FINDING AND DIAGNOSIS OF BREAKDOWN	OPERATOR/ END USER	0.04	0.20
	MECHANICAL PROBLEMS / FAILURES	0.00	0.25
	ELECTRICAL PROBLEMS / FAILURES	0.00	0.00
	REPEATED PROBLEMS / FAILURES	0.10	0.10
	NEWER PROBLEMS / FAILURES	0.00	0.00
	WARRANTY ISSUES	0.00	0.00
Sub Total of Fault Finding and Diagnosis of Breakdown Duration		**0.14**	**0.55**
EXECUTION OF BREAKDOWN	CHECK PREVIOUS RECORDS	0.10	0.10
	SEARCH FOR MOBILE B/D TEAM	0.02	0.02
	ALLOCATION OF TECHNICIANS	0.05	0.15
	ARRANGE VEHICLE	0.02	0.10
	ARRANGE ENTRY PASS / STATUTORY PASSES	0.00	0.00
	PREPARDNESS FOR ATTENDING	0.10	0.20
	EXACT FAULT IDENTIFICATION	0.00	2.50
	SPARES, SERVICES - EXTERNAL AGENCIES INVOLVEMENT	8.00	16.00
	IF MAJOR, SHIFT EQUIPMENT TO BASE WORKSHOP	6.00	18.00
	REPAIR & RECTIFICATION	14.00	22.00
Sub Total of Execution of Breakdown Duration		**28.29**	**59.07**
INSPECTION AFTER REPAIRS	CHECKING / TESTING	1.50	1.50
	USER FEED BACK	0.05	0.05
Sub Total of Inspection after repairs Duration		**1.55**	**1.55**
ANALYSIS OF BREAKDOWN	IF REPEATED PROBLM ANALYSE ROOT CAUSE	0.01	0.01
	SUPERVISOR / DEALER DISCUSSIONS	0.01	0.01
Sub Total of Analysis of Breakdown Duration		**0.02**	**0.02**
RECORDS OF BREAKDOWN	JOB CARD CLOSING	0.12	0.12
	HISTORY CARD ENTRY & CLOSING	0.15	0.15
Sub Total of Records of Breakdown Duration		**0.27**	**0.27**
TOTAL		**30.49**	**61.83**

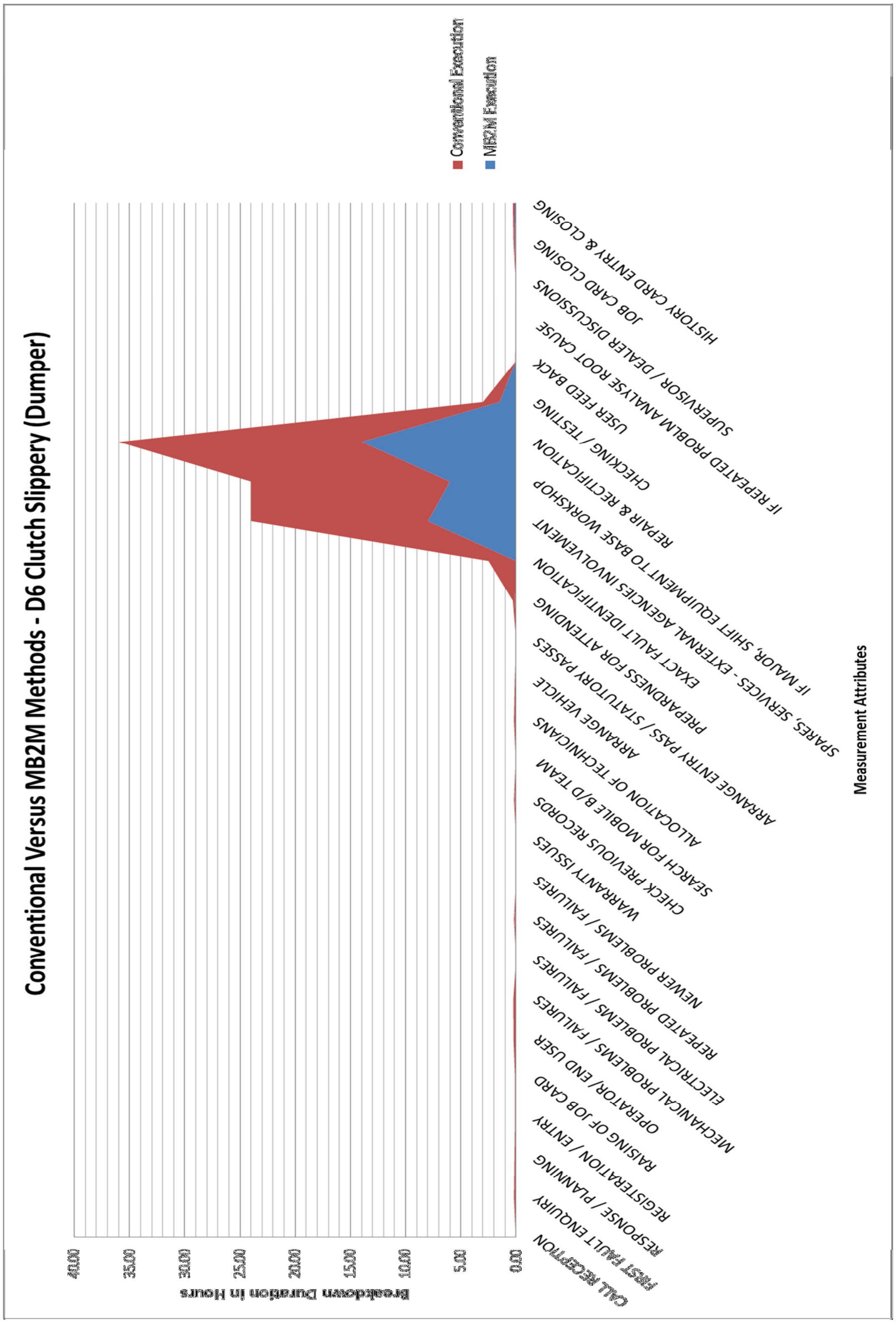

Figure 7.8 BSC D6 / Dumper - Conventional Vs. BMM

Table 7.3 Breakdown Data Sheet for BSC A6

Breakdown Analysis : 3			
Fault Description: Engine cylinder head gasket malfunctions			
BSC : A6 - Engine Cylinder Head Gasket Malfunction / A6S2 - Engine over smoke/ improper fuel combustion / A6R2 - Engine cylinder head gasket cut/bolt cut			
Machine Name : Dumper			
Machine No : 518			
Total hrs : 25.05 hrs			
Description		**MB2M Duration in Hours**	**Conventional Duration in Hours**
CALL ENTRY OF BREAKDOWN	CALL RECEPTION	0.02	0.02
	FIRST FAULT ENQUIRY	0.12	0.15
	RESPONSE / PLANNING	0.10	0.20
Sub Total of Call Entry of Breakdown Duration		**0.24**	**0.37**
REGISTERATION OF BREAKDOWN	REGISTERATION / ENTRY	0.05	0.05
	RAISING OF JOB CARD	0.05	0.05
Sub Total of Registration of Breakdown Duration		**0.10**	**0.10**
FAULT FINDING AND DIAGNOSIS OF BREAKDOWN	OPERATOR/ END USER	0.15	0.25
	MECHANICAL PROBLEMS / FAILURES	0.10	0.20
	ELECTRICAL PROBLEMS / FAILURES	0.00	0.00
	REPEATED PROBLEMS / FAILURES	0.10	0.10
	NEWER PROBLEMS / FAILURES	0.00	0.00
	WARRANTY ISSUES	0.00	0.00
Sub Total of Fault Finding and Diagnosis of Breakdown Duration		**0.55**	**0.75**
EXECUTION OF BREAKDOWN	CHECK PREVIOUS RECORDS	0.10	0.10
	SEARCH FOR MOBILE B/D TEAM	0.02	0.02
	ALLOCATION OF TECHNICIANS	0.10	0.15
	ARRANGE VEHICLE	0.05	0.05
	ARRANGE ENTRY PASS / STATUTORY PASSES	0.00	0.00
	PREPARDNESS FOR ATTENDING	0.05	0.15
	EXACT FAULT IDENTIFICATION	0.00	1.50
	SPARES, SERVICES - EXTERNAL AGENCIES INVOLVEMENT	8.00	18.00
	IF MAJOR, SHIFT EQUIPMENT TO BASE WORKSHOP	0.00	0.00
	REPAIR & RECTIFICATION	14.00	22.00
Sub Total of Execution of Breakdown Duration		**22.32**	**41.97**
INSPECTION AFTER REPAIRS	CHECKING / TESTING	1.50	1.50
	USER FEED BACK	0.05	0.05
Sub Total of Inspection after repairs Duration		**1.55**	**1.55**
ANALYSIS OF BREAKDOWN	IF REPEATED PROBLM ANALYSE ROOT CAUSE	0.02	0.02
	SUPERVISOR / DEALER DISCUSSIONS	0.02	0.02
Sub Total of Analysis of Breakdown Duration		**0.04**	**0.04**
RECORDS OF BREAKDOWN	JOB CARD CLOSING	0.15	0.15
	HISTORY CARD ENTRY & CLOSING	0.10	0.10
Sub Total of Records of Breakdown Duration		**0.25**	**0.25**
TOTAL		**25.05**	**45.03**

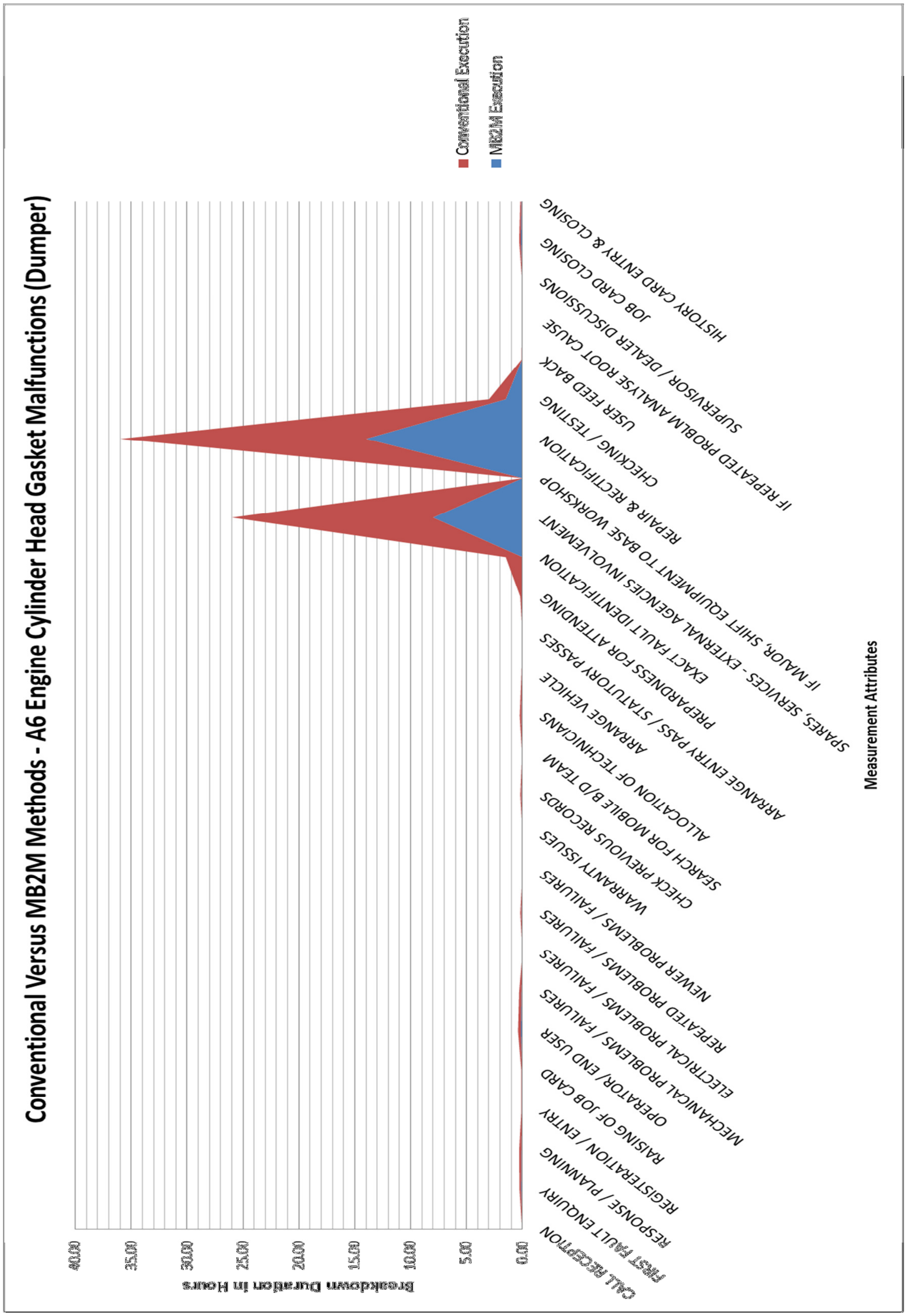

Figure 7.9 BSC A6 / Dumper - Conventional Vs. BMM

Table 7.4 Breakdown Data Sheet for BSC J2

Breakdown Analysis : 4			
Fault Description: Starting trouble (Self starter malfunctions)			
BSC : J2 - Starting trouble (Self starter malfunctions) / J2S1 - Starting trouble / J2R1 - Solenoid Failure (Bentex not released)			
Machine Name : Wheel Loader			
Machine No : 68			
Total hrs : 30.86 hrs			
Description		**MB2M Duration in Hours**	**Conventional Duration in Hours**
CALL ENTRY OF BREAKDOWN	CALL RECEPTION	0.02	0.02
	FIRST FAULT ENQUIRY	0.05	0.10
	RESPONSE / PLANNING	0.10	0.15
Sub Total of Call Entry of Breakdown Duration		**0.17**	**0.27**
REGISTERATION OF BREAKDOWN	REGISTERATION / ENTRY	0.05	0.05
	RAISING OF JOB CARD	0.05	0.05
Sub Total of Registration of Breakdown Duration		**0.10**	**0.10**
FAULT FINDING AND DIAGNOSIS OF BREAKDOWN	OPERATOR/ END USER	0.05	0.20
	MECHANICAL PROBLEMS / FAILURES	0.00	0.15
	ELECTRICAL PROBLEMS / FAILURES	0.00	0.20
	REPEATED PROBLEMS / FAILURES	0.00	0.00
	NEWER PROBLEMS / FAILURES	0.00	0.00
	WARRANTY ISSUES	0.00	0.00
Sub Total of Fault Finding and Diagnosis of Breakdown Duration		**0.05**	**0.55**
EXECUTION OF BREAKDOWN	CHECK PREVIOUS RECORDS	0.10	0.10
	SEARCH FOR MOBILE B/D TEAM	0.02	0.02
	ALLOCATION OF TECHNICIANS	0.05	0.12
	ARRANGE VEHICLE	0.05	0.05
	ARRANGE ENTRY PASS / STATUTORY PASSES	0.00	0.00
	PREPARDNESS FOR ATTENDING	0.05	0.25
	EXACT FAULT IDENTIFICATION	0.00	2.00
	SPARES, SERVICES - EXTERNAL AGENCIES INVOLVEMENT	16.00	36.00
	IF MAJOR, SHIFT EQUIPMENT TO BASE WORKSHOP	0.00	5.00
	REPAIR & RECTIFICATION	12.00	23.00
Sub Total of Execution of Breakdown Duration		**28.27**	**66.54**
INSPECTION AFTER REPAIRS	CHECKING / TESTING	2.00	2.00
	USER FEED BACK	0.05	0.05
Sub Total of Inspection after repairs Duration		**2.05**	**2.05**
ANALYSIS OF BREAKDOWN	IF REPEATED PROBLM ANALYSE ROOT CAUSE	0.01	0.01
	SUPERVISOR / DEALER DISCUSSIONS	0.01	0.01
Sub Total of Analysis of Breakdown Duration		**0.02**	**0.02**
RECORDS OF BREAKDOWN	JOB CARD CLOSING	0.10	0.10
	HISTORY CARD ENTRY & CLOSING	0.10	0.10
Sub Total of Records of Breakdown Duration		**0.20**	**0.20**
TOTAL		**30.86**	**69.73**

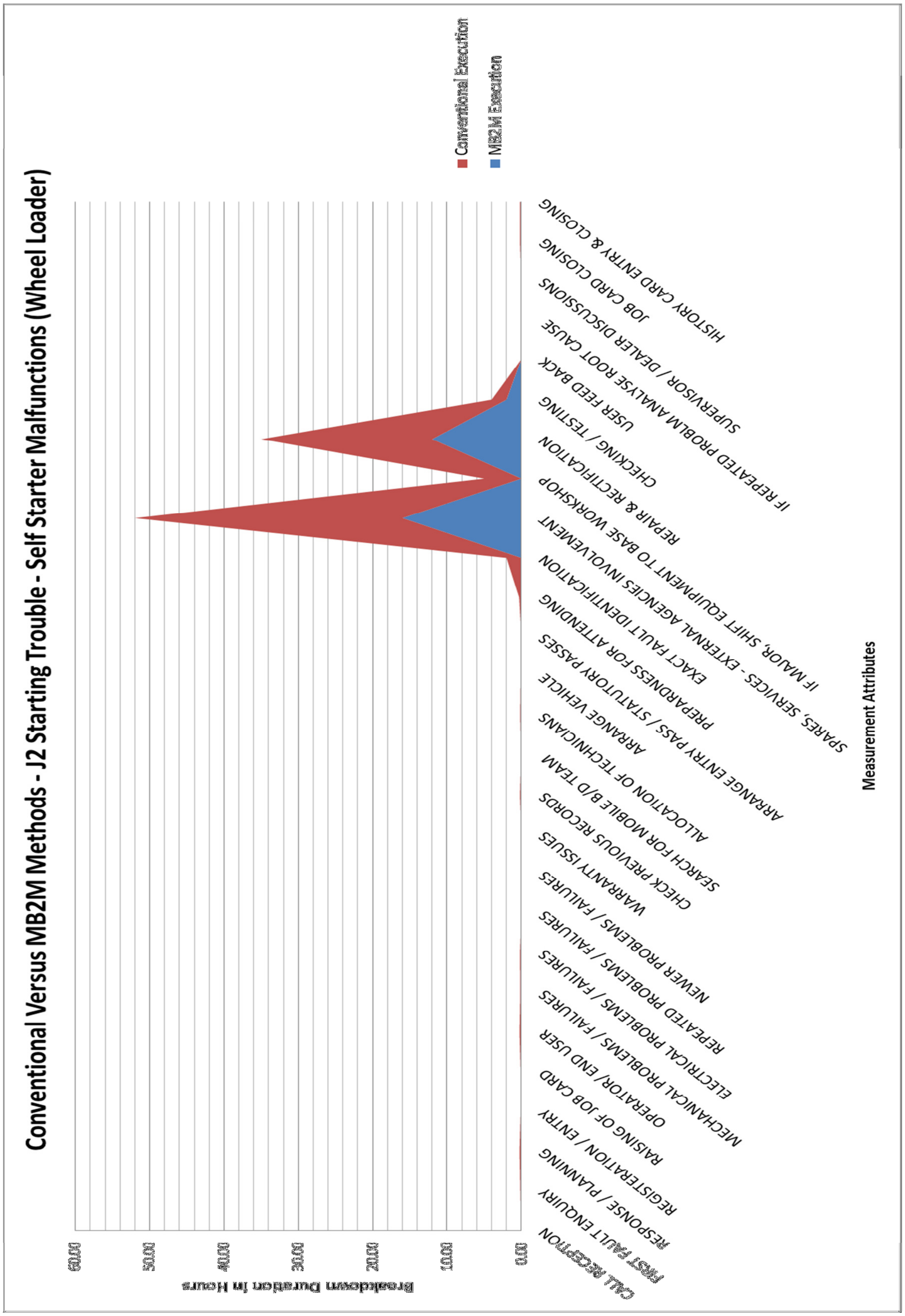

Figure 7.10 BSC J2 / Wheel Loader - Conventional Vs. BMM

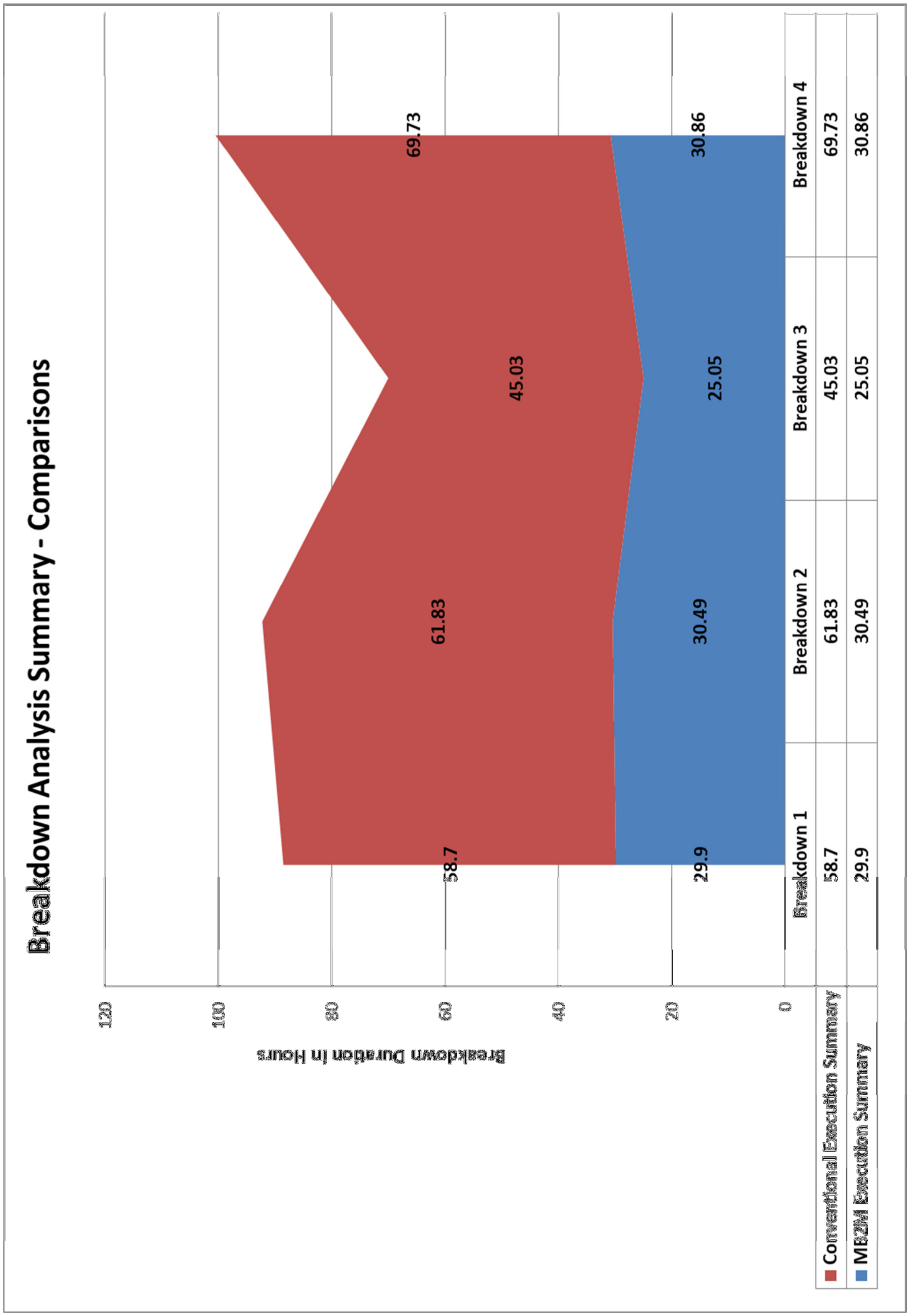

Figure 7.11 Breakdown Analysis Summaries -Comparisons - Conventional Vs. BMM

7.8 Breakdown Maintenance Strategy of Construction Industry in the UAE Based on BMM and BMP Studies

The breakdown maintenance execution in the region is always executed on a makeshift and haphazard basis and the cost of failures and related work disruptions are generally not taken seriously by the civil contractors. This approach is mainly due to lack of proper breakdown maintenance execution systems practiced in the country. The non-availability of trained maintenance crew/dedicated machinery controller makes the situation further aggravate the situation and the breakdown maintenance execution are generally unnoticed and the checks and balance are not existing to validate the efficiency and cost of such breakdowns and the execution process.

With the BMM Model with the BMP process in place, the breakdowns management of machinery will be no more executed as unplanned activity and every level of people in the frame of work will be aware of causes, rectification durations, methods of rectifications, resource requirements in advance. The control on the activities can be exercised at all every level with proper data and documentations. The confidence level of the entire team will be improved. The code language becomes the change strategy of the breakdown management execution and the ambiguities and uncertainties will be overcome to a great extent. The savings on the time and cost would be substantial as the time saved on the breakdown execution is to an average range of 40 to 45 % and hence the cost will be reduced and the availability of the machinery will be increased.

Furthermore the inventory carrying cost will be reduced as advance information will be available with the stores management on the regular breakdowns happening with company's individual projects, based on the population of machinery existing with each project. The focused critical code management approach will help to overcome 80 % of the breakdowns which are generally caused by the critical codes.