Maintenance Logistics Management: A Survey Study in the Moroccan Industrial Context

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***Abstract*— Global logistics system performance could not be achieved without an available intern logistics system for production systems. Indeed, availability is the fastest path to performance where maintenance logistics occupies the central role. In this paper we define a systemic framework for maintenance logistics to manage all maintenance resources and their interactions. In order to define main maintenance logistics management problems we conducted a structured survey study in the Moroccan industrial context. The study presents results based on 152 surveys responses from 281 surveys addressed to different industrial production systems. Results analysed on SPSS statistical software revealed an insufficient involvement level for production operator and insufficient organization level for maintenance logistics environment. Therefore we propose a new sustainable model conception based on empirical conclusions.**

***Keywords*—** *Maintenance logistics system; management model; Operator involvement; maintenance logistics environment; SPSS software; maintenance improvement.*

1. Introduction

Nowadays industrial competitiveness and production constraints address more complex challenges to supply chains at both scales intern logistics systems of production systems or extern logistics systems. In intern logistics availability notion is a performance key improving or penalising the totality of logistics system .Therefore insuring production systems availability is crucial and justifying the need for a new generic context for maintenance logistics definition to manage all maintenance resources and their interactions. However, human factor involvement being the most difficult aspect is considered an important dimension to reach perennial improvement within sustainability scope.

Maintenance logistics management could not be guided towards sustainability path and serious performance alternatives without basing its model on real industrial facts. The reason why conducting reliable survey studies is as much important as exploiting their results to build strong empirical evidence guiding the model development via the concluded research objectives.

2. Maintenance logistics management: A new generic framework

2.1 Maintenance logistics context

In the context of a challenging competitive industrial world, the logistics notion is the angle gathering the main involved parts and systems setting the way to manage their interactions. To approach this thematic managerial notion, it stays useful to recall main maintenance logistics related notions:

Logistics points out an availability centered dimension associated with "the 7 Rs": "the Right goods, the Right amount, the Right condition, the Right place, the Right time, the Right customer and the Right costs" [1] Chankov, Becker and Windt express the necessity to overcome the passive manner of logistics characterization adding the synchronization aspect to the logistics definition to make of it "an active perspective"[2].

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Logistics support is considered " a structured set of products or necessary services for a client to insure: the availability maintaining of the main system, and the maintenance in an operational condition of all or part of it (kit, replacement, simulator, documentation, infrastructure)" [3].

Maintenance logistics context which is a fertile field and vision for maintenance management still remains unexploited in production systems.

2.2 Maintenance logistics: Systemic approach

Maintenance logistics (ML) definition being rarely identified and poorly mentioned in the literature ,we propose a new definition considering ML a set of subsystems included in a larger system (industrial production system) [4]:

Maintenance logistics manages material and non-material resources to allow a smooth running of maintenance activities. Maintenance logistics dealt with from a systemic approach vision could be a supporting system compound of three subsystems interacting with each other by means of ascendant and descendent flows [4][5] as shows figure1.

- 01. Maintenance strategic management subsystem (MSMS)
- 02. Maintenance information and communication Subsystem (MICS).
- 03. Maintenance physical subsystem (MPS)

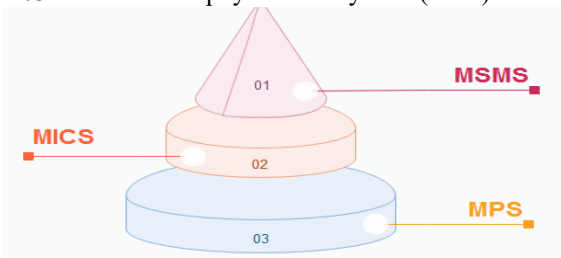

Figure 1. Maintenance Logistics System.

3. Maintenance logistics management: A survey study

3.1 Scope and Objectives of the study

To discuss maintenance logistics management from an empirical point of view, we conducted a survey study in the Moroccan industry context as a methodology allowing us to set the scene of maintenance management practices and critical points to be dealt with in the context of Maintenance strategic management subsystem (MSMS) and Maintenance Information and communication subsystem (MICS) .Especially, to evaluate the involvement of the human factor in maintenance problem solving process and also to assess maintenance logistics environment organization to have a nearer vision about Maintenance physical Subsystem.

To this end, and for the specific purpose of assessing the level of involvement of the human factor (the production operator in particular) in the resolution of equipment-related problems, we conducted a structured survey study based on the responses collected from 152 questionnaires after Addressing 281 surveys to industrial production systems in different activity sectors in Morocco, which can be translated into a response rate of 54.09%.

All the following analysis was carried out on SPSS software (Statistical Package for Social Sciences) which is a statistical analysis software developed by the company SPSS inc and sold by IBM which bought the company that created the software in 2009. SPSS is currently one of the most used software for statistical analysis in various fields. The companies surveyed are of different sizes (small, medium and large), as shown in the graph of figure2.

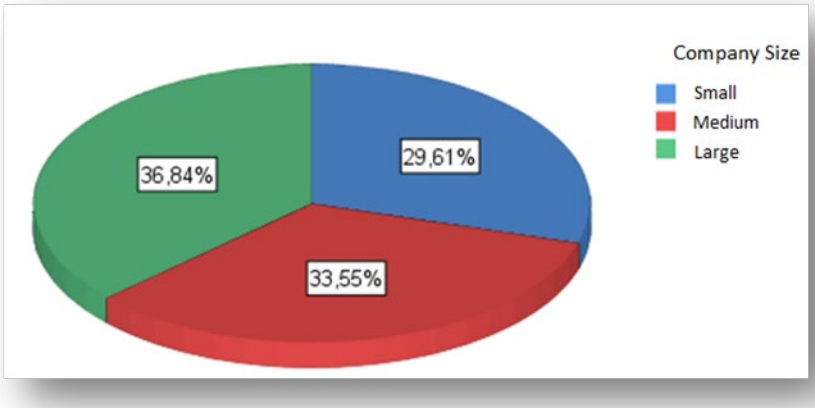

Figure 2. Sample distribution by company size.

The collected data represent responses from 152 production systems operating in different industrial activity sectors as detailed in the distribution of figure 3.

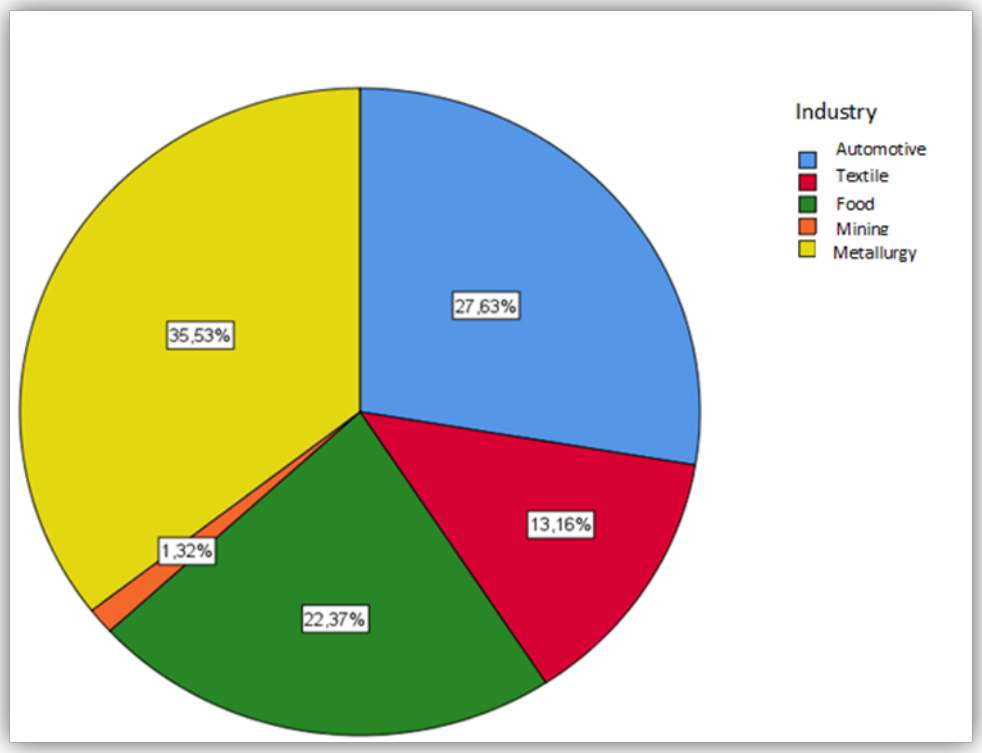

Figure 3. Sample distribution by activity sector.

3.2 Communication and collaboration level assessment

3.2.1 Communication level between maintenance and other departments

In order to assess the communication aspect of maintenance service, we asked the different companies of the sample to answer specific questions so as to measure the level of communication and coordination, on the one hand, between maintenance service and the other services of the company, on the other hand and more particularly between the maintenance service and production operator.

We first asked the question: How do you assess the communication level between maintenance department / service and the other services? Offering a 5 points scale from not at all satisfactory to very satisfactory.

Responses distribution is presented by the results of figure 4 as follows:

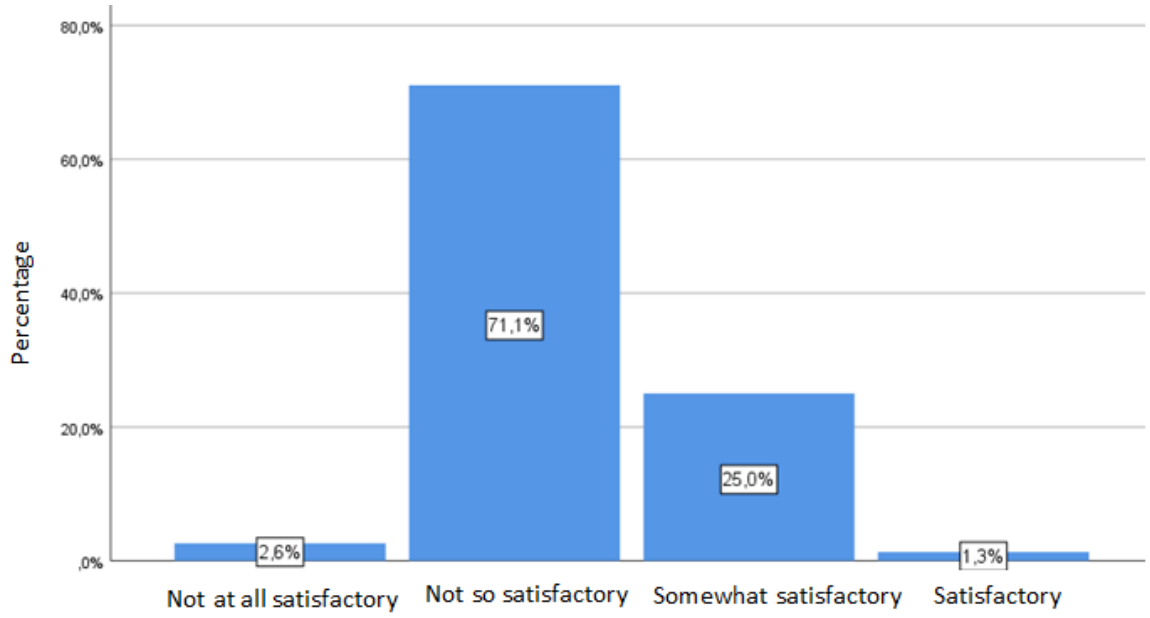

Figure 4. Satisfaction level of communication between maintenance department and other departments.

71% of the responses admit that communication level between maintenance service/department and the other services or departments of the company (in particular production service /department) is still unsatisfactory. The fact that was confirmed at the physical system level, by a case study results in a Moroccan iron production system where 78% of production operators have chosen the adverb "rarely" to describe the communication frequency of maintenance strategies [14].

We are particularly interested in communication and collaboration aspect between maintenance department and the production operator who is in a daily interaction with his production tool (equipment). In this perspective, we targeted the assessment of the production operator involvement level in maintenance problem solving.

3.2.2 Production operator involvement in equipment problem solving

Among main success key factors for lean implementation Management commitment, Training and education, understanding the tools and techniques, skills and expertise, employee involvement, and culture change [12]. These two last factors are the most dependent, critical and important ones.

In order to assess the level of involvement of the production operator in solving equipment-related problems, we designed a global scale of three Items (3 questions), each of which is evaluated using a Likert scale of five points (5 levels) as detailed in table 1.

Table 1. Assessment scale for production operation involvement level in equipment-related problem solving.

Item	Assessment variable	Question	Item scale
1-Production operator involvement in failures detection.	Failures declaration frequency	**How often does the production operator declare the occurrence of failures at the right time?**	**Likert scale of 5 levels :** Never, Rarely, Sometimes, Often, Systematically / always.
2-Production operator involvement in the proposition of solutions for equipment related problems.	Solutions proposition frequency for equipment related problems.	**How often does the production operator propose solutions for equipment related problems?**	
3-Production operator involvement in solutions implementation for equipment related problems.	Frequency of production operator implementation/ participation in the implementation of improvement propositions and maintenance plans	**How often does the production operator Participate in improvement and maintenance plans implementation for equipment related problem solving?**	

In order to ensure the reliability of the constructed scale, we conducted a reliability test on the SPSS software, which provided us with a Cronbach's alpha coefficient of 0.715 greater than 0.7 (the limit required as defined by Nunnaly [6] and and which is currently considered of wide acceptability in the majority of fields) which confirms the reliability of our scale. Effectively, many scales was discussed in the literature [7] ranging their reliability results between 0.68 and 0.86 [8] or between 0.70 and 0.90 [9].

The reliability test also provided descriptive statistics for each item: the mean and the standard deviation. The means are almost all equal to 3. So, in average the respondents adopt the same perception concerning the three elements measuring the involvement of the production operator in equipment-related problem solving.

Table 2. Item Statistics.

Item	Mean	Standard Deviation	N
Solutions proposition frequency	2,99	0,661	152
Improvement propositions/plans implementation	3,02	0,888	152
Failures declaration frequency	3,31	0,739	152

The correlation matrix of table 3 summarizing the correlation results between the three elements of the scale shows a correlation coefficient r> 0.4 (exceeding 0.3) which ensures that these elements are sufficiently correlated to consider that it all measures the same construct (involvement of the production operator in equipment-related problem solving).

Table 3. Inter-Item Correlation Matrix.

	Solutions proposition frequency	Improvement propositions/plans implementation	Failures declaration frequency
Solutions proposition frequency	1,000	0,576	0,402
Improvement propositions/plans implementation	0,576	1,000	0,415
Failures declaration frequency	0,402	0,415	1,000

The test performed on SPSS allowed us to check the potential value of Cronbach's alpha in case of one of the elements deletion. All the values indicated are less than 0.715 which justifies the consistency of the three items as shows table 4.

Table 4. Inter-Item Correlation Matrix.

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Solutions proposition frequency	6,33	1,878	0,590	0,364	0,579
Improvement propositions/plans implementation	6,30	1,375	0,586	0,372	0,570
Failures declaration frequency	6,01	1,901	0,460	0,212	0,711

The statistical analysis of the scale performed on SPSS shows an average of 9.32 which translates an orientation towards the frequency "sometimes" and thus explaining that the production Operator involvement in equipment related problems still stays timid and not sufficient to answer actual industry needs in terms of effective resources collaboration. In other words, the 152 companies surveyed claim an involvement average around 3, which reflects an insufficient involvement level, from which the involvement in solutions proposition remains the least satisfactory, which reflects an innovation potential that is still timid drawing attention to a production operator who is insufficiently involved.

Table 5. Scale Statistics

Mean	Variance	Std. Deviation	N of Items
9,32	3,383	1,839	3

3.2.3 Responses Analysis

(a) 1st item: Production operator involvement in failures detection.

After representing different responses distribution in SPSS the percentages of figure 5 were obtained.

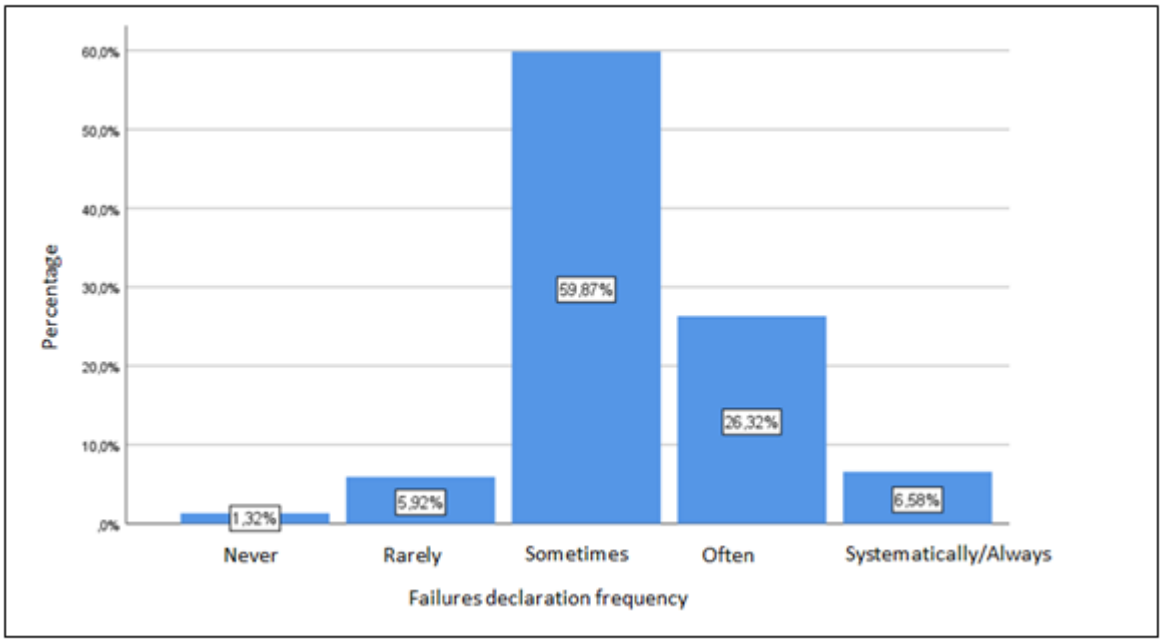

Figure 5. Involvement level of production operator in failure declaration.

59.87% of the companies surveyed describe the frequency of declarations of failures by the production operator via the answer "sometimes", which indicates a relatively insufficient level of declaration remaining still far from a systematic practice.

(b) 2nd Item: Production operator involvement in the proposition of solutions for equipment related problems

The same previous frequency analyse was conducted for the item 2 where 68.42% of the responses show that the production operator is still not very active concerning solutions proposition to equipment-related problems while contributing only "sometimes". On the other hand, only 10.53% of the respondents specified the frequency “often” and 3.29% of the companies answered with “systematically or always”, which ensures that the majority of companies have a low level of production operator involvement in solutions proposition process for equipment-related problems.

(c) 3rd Item: Production operator involvement in solutions implementation for equipment related problems.

61.18% of respondents confirm the reality of an insufficient involvement of the production operator in the implementation of solutions or improvement propositions and maintenance plans, which has often been explained to us by the absence of a practical and efficient formalism allowing collaboration in real time and also a better level of involvement of the production operator.

3.3 Organization level assessment of maintenance logistics environment and its influence

3.3.1 Reliability analysis

In order to assess the level of organization of maintenance means and tools and its influence on the progress of interventions within the production systems surveyed, a reliable scale of two items was constructed through two questions addressed to maintenance managers. The reliability of the scale was checked via the reliability analysis test on SPSS following the approach discussed in the previous paragraph (to measure the level of involvement of production operator in equipment-related problem solving). This reliability is justified by a Cronbach's alpha of 0.722.

3.3.2 Responses analysis

(a) 1st item: Organization level of maintenance logistics environment

To assess the organization level of maintenance necessary tools and means for the various maintenance interventions and activities, we asked the question: How are maintenance tools and means organized? Offering the choice between 5 levels:

- Very well organized,
- Well organized,
- Somewhat organized,
- Little organized
- Very little /not organized.

53.29% of the respondents attest that maintenance logistics tools and means remain poorly organized and require better organization or reorganization in order to control the work environment influencing the operator performance.

(b) 2nd item: Organization level of maintenance logistics environment

In order to assess this influence, the following question was asked of maintenance managers to what extent the organization of tools and means of maintenance affects search time for a tool and therefore the flexibility of the interventions process? Choosing between the five levels:

- Very influential
- Influential
- Moderately influential
- Little influential
- Almost no influence

96.05% of the responses are between influential (44.08%) and very influential describing the level of influence of maintenance tools and means organization confirming the importance of an effective organization allowing the reduction of the time to search for tools.

3.4 Discussion

The analysis results detailed above summarize the responses collected from 152 Moroccan production systems of different sizes and from different industrial sectors. these results shows an insufficient level of communication and involvement of the production operator as well as a level of organization requiring more effort to control work logistics environment being very influential on the progress of interventions and operators performance.

4. Maintenance Logistics Management: Towards a sustainable model

The study is spanned over the three maintenance logistics subsystems.in fact, the analyzed results express the need for a better involvement of the operators (especially production operator) as well as a better organization of logistics environment (equipment,.., especially maintenance tools and means).the improvement of these two pillars is required to improve Maintenance Physical Subsystem's performance. On the other hand, the same results are reflecting the strategic choices and generally maintenance models and practices defined by Maintenance Strategic Management Subsystem (MSMS) revealing the lack of a standard culture for the human factor activation and generally a sustainable resources management. This perspective could not be achieved without a dynamic real time interactional Maintenance Information and Communication Subsystem standing for the junction between the two previous subsystems communicating the ascendant feedback of the physical subsystem (MPS) and communicating back the Decision plans and strategy practices instructions from the Top subsystem (MSMS).

Maintenance logistics system, considered an intern logistics system should be able to manage all maintenance resources in a global interactive vision with a particular attention to the social dimension which stays so often ignored and not fully involved in maintenance improvement process. To deal with the problems detected through the survey study we define main objectives standing for guidelines for Maintenance Logistics System to build a new sustainable management model representing the managerial role of maintenance logistics (figure 6) within the following objectives:

- Positioning resources within maintenance logistics system
- Defining main managerial aspects for maintenance logistics model
- Encouraging the production operator to take part of maintenance improvement process:
- Exploiting its experience feedback in decision making
- Involving all operators in improvements Implementation
- Logistics environment organization (especially

maintenance tools) to reduce tool search time

- Insuring the connexion in real time between the top subsystem (MSMS) and the base one (MPS) via the central subsystem (MICS).

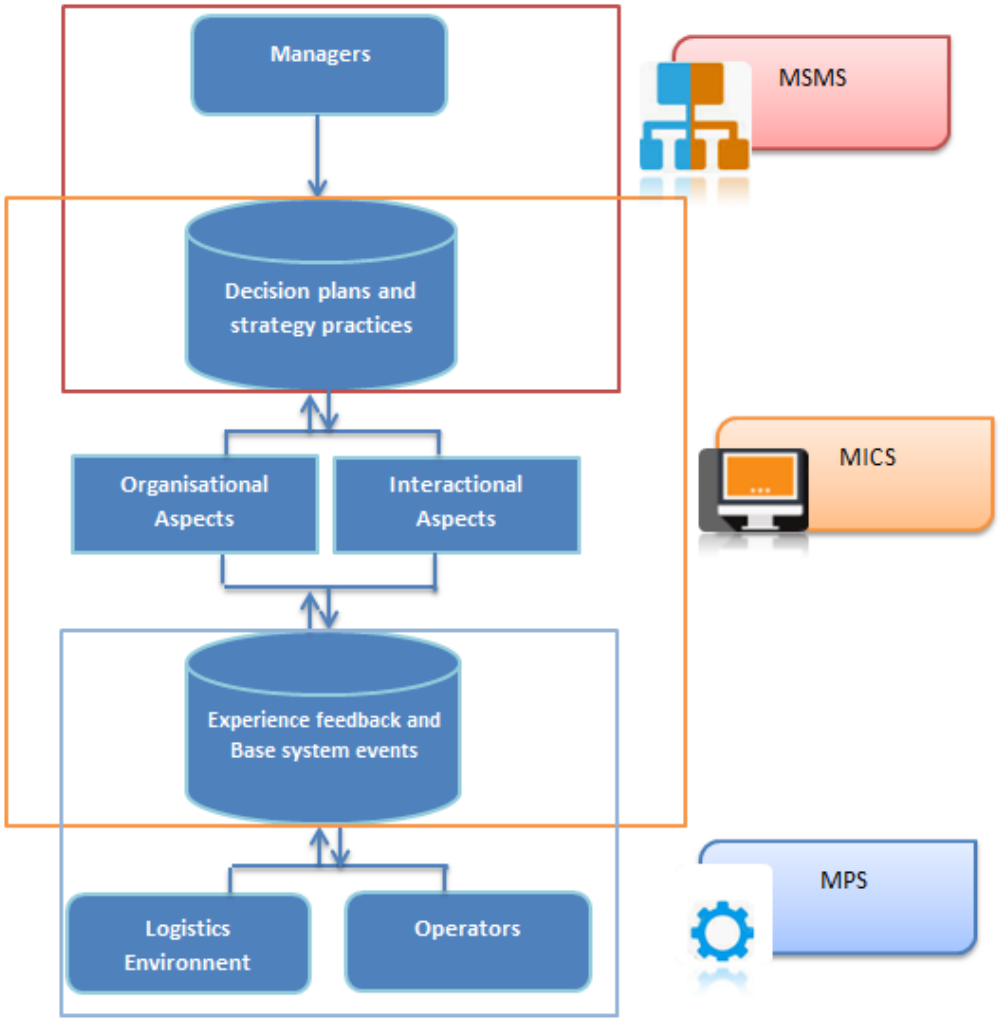

Figure 6. General maintenance logistics management Model.

To respect sustainability aspects, the model focus on the human factor potential activation. Therefore, in order to improve decision making and industrial performance.it is therefore practical and easier to capture and store passed experiences rather than to do it for more generic knowledge from experts, which proves the importance of experience-based approaches [11]. This is to conclude the necessity of operator's involvement and especially the production operator. Indeed, the significance of Knowledge gap considering the context and the implementation of lean philosophy over the world requires new supply chain management methodologies [13], and particularly maintenance logistics ones to involve effectively and sustainably the human factor.

As research perspectives and future model orientations, Knowledge management alternative remains a promising approach to exploit the human factor feedback. In fact, Knowledge in our approach is the specific fragment concluded from experience feedback. It is indeed the fruit of daily human machine interaction. In order to manage this interaction sustainably as well as the rest of maintenance processes and interactions. Moreover, to cover the organizational aspect, maintenance logistics and its management should be guided towards lean culture arena [10].

5. Conclusion

The presented survey study allowed us to underline main maintenance management problems impacting the three maintenance logistics subsystems to orient the global system "maintenance logistics system" to a new sustainable managerial framework. The presented study conclusions sat the real scene of industry needs to define our model objectives among others: ensuring a better involvement of all operators targeting the production operator as a rich experience resource to solve daily maintenance problems and look for a better organization for maintenance logistics environment. To answer these objectives, the proposed generic model focuses on two main aspects (organizational and interactional) within the perspective to integrate lean culture and experience management approaches to concretize the model objectives and further conceive practical implementation standards.

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