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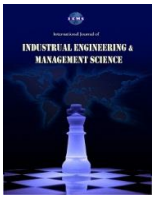

Evaluation Framework Inventory Management System and Spare Parts Warehouse and presenting Roadmap (MRO-iREAM)

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ABSTRACT

Warehouses play an important role in the modern supply chain and account for 24% of the total cost of the logistics and are considered as a competitive advantage in the supply chain. There must be necessary instruments to evaluate warehouse for the sake of identifying its strong and weak points so as to achieve high performance in inventory management and warehouse system which eventually helps managers make better, more effective and efficient decisions to improve the warehouse performance. There are various models for evaluating performance that the lack of a framework Specific, comprehensive and all-encompassing for evaluating spare parts warehouses is felt. Therefore, in this article, first the dimensions and indicators of the proposed framework have been determined and defined through surveying and considering different performance evaluation models and also considering the related literature in addition to considering the expert opinions in different sessions. This proposed framework includes 9 dimensions containing 10 indicators each. The final framework was prepared after assessing and evaluating its validity and reliability through using questionnaire resulted in removing the indicators that did not obtain the required scores. After evaluating the car parts warehouse based on the proposed framework criteria a roadmap is presented in order to improve the warehouse performance level of the inventory and warehouse management based on the current warehouse situation.

1. Introduction

Warehouse plays an important role in the modern supply chain [1] In a study of logistics costs in Europe, it was found that warehouse costs included 24% of the total logistics costs [2]. In today's competitive market circumstances, companies are constantly forced to improve their warehouse operations. [3] Warehouse is also important in terms of customer service and is also critical to the success or failure of the supply chain. [4] not controlling MRO can stop producing, lost selling, delay in delivering the product to the customers and human and environmental dangers [5] If we want to have a suitable benchmark for a warehouse, this model is a warehouse with high availability of spare parts when there is a need, timely delivery of the product to the customer, increase customer satisfaction and decrease lost selling and the overall increase in chain performance is provided. Performance Evaluation in a warehouse paves the way for the related authorities to locate the unfavorable and insufficient efforts and helps them plan for the higher level of warehouse performance. [3] Due to the gap analysis that was done, the lack of a specific, comprehensive and comprehensive framework for the evaluation of spare parts warehouses was felt. The novelty of this article is to provide a framework with a specific, comprehensive and integrated method for evaluating the stock of spare parts.

2. Review of Literature

2.1. Performance evaluation

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Performance evaluation has been studied from different perspectives because of its importance and has been defined differently by various experts.existing perspectives. Some experts consider it from the organizational perspective as a synonym of the effectiveness of activities and efficiency whose definitions are equal to the extent to which goals and programs are achieved based on the efficiency of the activities and operations. Other experts consider performance evaluation as a way to make a comparison between the present and the desired condition which is done based on the predetermined criteria and specific features [6].

2.2. Global evaluation models

2.2.1. Organizational performance evaluation models

Various models have been used to evaluate the performance of the organizations during different periods organizational construction. Some limited indicators and criteria are used initially to evaluate the performance of organizations just based on their needs. Different factors including the expansion and development of the focal points of the activities and areas of organizational performance, dynamics of environmental factors and the introducing new management issues and subjects such as customer satisfaction, social responsibility and so on led organizations not to be content with limited indicators. Therefore, comprehensive and multi-criteria models for evaluating organizations have been formed and gradually evolved. These models generally evaluate the organization from different dimensions and by considering multiple indicators and provide appropriate tools so as to evaluate the performance of new organizations. Some widely used examples are presented in Table (1).

Table 1. performance evaluation models

Dimensions considered in the model	Year	model name
Leadership 120 points, Strategic planning 85, Customer focus 85, Data analysis 90, Human resource focus 85, Process management 85, Process management 45	۱۹۹۸	Molcom Buldrige
Empowerment Index: Leadership, staff, policies and strategies, resources and stakeholders and processes Outcome Index: Individual results, customer results, community results, key performance results	۱۹۹۱	European Foundation For Quality Management
Financial aspect, internal aspect of business, customer aspect, growth and learning aspect	۱۹۹۲	Balance Score Card
Customer satisfaction, continuous improvement	۱۹۹۰	Total Quality Management

2.2.2. Physical Asset Management Evaluation Models

In order to identify the current status of maintenance management system as well as to analyze the existing gap with the world class net, the current position of system needs to be audited and reviewed. One of the most popular checklists of the maintenance and asset management system audit is Terry Wireman's Asset Management Checklist consisting of 16 sections with 10 questions in each section. The maximum score for each question is 4. The evaluation criteria are as follows: maintenance organizations, maintenance training, maintenance work flow, maintenance timing and programming, preventive maintenance, maintenance purchasing and inventory, maintenance automation, facilities involvement, maintenance system report, predictive maintenance, reliability engineering, maintenance general activities, financial optimization, continuous improvement, document management and contract management [7]. Another checklist of asset system audition is proposed by Campbell et al. presenting an official structure for effective maintenance management. [8]

2.2.3. Supply-Chain Operations Reference Model (SCOR Model)

This model provides a common framework for the supply chain and provides standard terms and common parameters obtained by comparative evaluation and the best obtained practices. Since many of the contents and processes of this model have already been used by companies and expert members for years, the SCOR Model is based on five specific management processes in the supply chain. [9]

2.2.4. Excellence Model of Spare Parts Management

One of the models of excellence in the field of spare parts management is the Philip Slater Model including 4 main dimensions in which each dimension has several indicators. [10]

2.2.5. Warehouse Evaluation

Khan et al. (2016) in a paper using an integrated approach proposes the Fuzzy-AHP approach that combines the relationship of operational and strategic criteria to create a system for measuring overall warehouse performance [15]

Faezeh Shams Yazdi and Amirhossein Enzebati (2016) proposed a checklist including 71 important factors in six main areas of inventory, layout, safety, building, environmental conditions and training- automation to assess and evaluate the amount of the desirability and systematic features of the warehouse , the inventory management system and also the adaptations and non-adaptations issues and finally analyzed them and offered suggestions to improve the current situation [16].Seyed Ali Ayazi et al. (2017) evaluated the efficiency of the distribution warehouses of eleven branches of the Iran-Khodro Car Manufacturing Company by a combined two-stage DEA model through employing the rough set theory and finally ranked the warehouses based on their efficiency features. [17]

Razik et al. (2017) in a paper on suggested a maturity model on the concept of Critical Success Factors (CSFs) to evaluate the warehouse performance considered to be a new approach to improve it based on the maturity model which can improve the identification, clarification, determination and improvement of the vital functions in a supply chain. This proposed maturity model is based on three dimensions: 1: maturity level dimensions 2: four main components of warehouse performance 3: critical success factors [18]. Ribion et al. (2018) in an article performed a survey on the agent-based simulation to analyze the behavior of automatic logistic warehouses under the influence of specific factors, thereby

obtaining indicators to support decision making during warehouse performance improvement [19]. Elisa et al. (2018) in their article have identified 25 key warehouse indicators in terms of five warehouse activities based on the Frazelle Model. They identified the most important key performance indicators in the warehouse using the Analytic Hierarchy Process (AHP), assessed and evaluated the warehouse performance and determined its functions through using SNORM and proposed a BENCH MARKTING method to improve the warehouses [20].

Table 2. Warehouse evaluation models and methods

Reference	Method used	Year	author
[11]	Warehouse evaluation using dimensions of quality, time, cost, indirect productivity	1999	Kifer&etal
[12]	Measuring the optimal use of warehouse space, quality level, use of assets and customer relationships to measure warehouse performance	2009	Liviu&etal
[13]	Evaluate warehouse performance levels by developing a wms framework and cost analysis	2012	Rama & etal
[14]	Evaluating the dimensions of productivity and indirect quality of warehouse by developing a methodological framework	2012	Banaszewska & etal
[21]	Ranking of traditional and modern storage criteria through hierarchical technique	2014	Mahmoudi &et al
[15]	Integrating the relationship between operational and strategic metrics by fazzy AHp to create a performance measurement system	2016	Khan & etal
[16]	Provide a checklist to assess the principles of the warehousing and inventory management system	2017	Faezeh Shams Yazdi and Amir Hossein enzebati
[17]	Warehouse evaluation with a combined DEA model and warehouse ranking based on performance	2018	Seyed Ali Ayazi &et al
[18]	Maturity model proposal (csfs)	2018	Razik & etal
[19]	Obtain evaluation indicators or use factor-based simulation of automated warehouses	2018	Ribion & et
[20]	Ranking of 25 key inventory valuation indicators based on the model (frazel) by AHP	2018	Elisa Kusrini& etal

3. Methodology

3.1. Typology and Research Method

This research is considered to be a developmental research from the perspective of the research purpose. The present study is a descriptive survey method in terms of data collection based on using questionnaires.

3.2. Statistical Population and sample

The statistical population of the present survey includes the officials, experts, staff and experts of the spare parts warehouses of a multi-level defense organization playing some roles in the inventory and warehouse management. Because of the specialization of inventory and warehouse management nature, it has been tried to use experts who have the necessary knowledge and expertise in the field of warehouse and have sufficient experience in warehouse management and planning for the sake of data collection.For content validity of the questionnaire, 10 knowledgeable experts were selected intelligently.

3.3. Instrumentation

Data collection methods in this research was conducted based on the library method through using a questionnaire. In order to compose and compile the theoretical foundations of research, definitions, concepts, conceptual model and extract criteria to evaluate the inventory management system and spare parts warehouse, library method have been used including using books, articles, dissertations and reputable sites in this field. After preparing the definitions, concepts of warehouse valuation and extracting warehouse valuation criteria a Likert Scale Questionnaire was prepared in order to analyze the data and to provide a basis for the accreditation and approval or non-approval of the proposed framework of the inventory management model of the warehouse.

4. Proposed Evaluation Framework of Inventory Management System and Spare Parts Warehouse (iREAM-MRO)

According to the existing indicators in the discussion of warehouse evaluation (Table 2) as well as techniques and effective areas for inventory and warehouse management (inventory, layout, safety, building, environmental conditions, training and automation)[16] and indicators of Performance Evaluation Models of Malcolm Baldrige[8] and the Excellence of the Organization [22]as well as the inventory audit checklist and the status of spare parts of Philip Slater [10] and also holding expert meetings in this area, the desired dimensions for the proposed model were selected. Spare parts of suppliers' management dimension are used in the proposed evaluation model, so the dimensions of the proposed model for evaluating inventory and warehouse management system are as follows. The conceptual framework of inventory and warehouse management evaluation of spare parts has 9 dimensions and each dimension has 10 indicators, each of which is divided into five levels (Figure1).

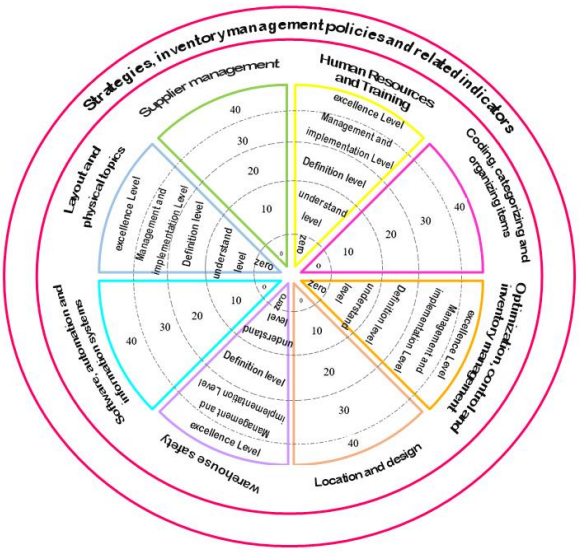


Figure 1. Conceptual framework for evaluating inventory management system and spare parts warehouse (iREAM-MRO)

Dimensions Strategies, inventory management policies, and related indicators Policies and strategies are the rules of the game. These are the policies and procedures that link expectations and provide guidelines for specific activities. This dimension affects all other dimensions and leads to other dimensions. In this dimension, by asking the indicators, the status of the warehouse in terms of strategies and general policies of the inventory and warehouse management system, as well as the warehouse processes at what stage (compilation, notification, implementation) is determined.

Supplier management: Methods of supplying goods and the relationship between buyers and suppliers have been changed by the increasing nature of the market competition and developments, as well as political developments. The relationship between the organization and suppliers is vital for any organization. Suppliers directly affect the performance of inventory management. Manpower and staff training are the backbone of any inventory management system of the spare parts. Computer systems, softwares and defined approaches, procedures, processes, organizational policies, geographical constraints of various types of equipment, suppliers and so on are certainly effective but the only factors connecting these elements are the organization employees who interpret the situations and consequently make decisions and implement the plans. Employees are the key to the success. Because of the importance of the employees and trying to make them understand the importance of warehouse issues in this dimension, there has been an attempt to have a survey on the present statues of the employees and providing better education and instruction in order to have an appropriate atmosphere for them to understand the topics (inventory and warehouse) better.

Coding, categorized and organized items: Using the technology of goods classification and coding systems has been employed in the field of product identification for about 30 years. Coding is a common language to have a better and faster understanding of the information and is considered as a factor in coordinating and providing better and more efficient coordination and communication among the various parts of the system. Categorizing and organizing items makes storekeeping operations such as receiving, shelving, maintenance and so on more efficient and makes the inventory process better. In this dimension, we examine the methods of classifying, coding and organizing inventory items through indicators.

Optimization, control and inventory management: One of the most important topics in the warehouse is optimization, control and inventory management which optimizes the inventory management issues (order point, order quantity, provided time and so on) resulting in the availability of goods in the warehouse and the optimal amount of goods is available in the warehouse. In this dimension, the optimization policies are examined thoroughly in terms of definition, implementation and revision by means of indicators. In addition, there is an attempt to have a survey on the other activities that lead to inventory management optimization.

Location and design of a warehouse: One of the most basic requirements to create a suitable warehouse is its location and design. Its appropriate design to store different parts is a necessity. The indicators of this dimension are going to be surveyed and examined in terms of location, availability, controllability (especially for a defense organization) as well as in terms of designing appropriate locations based on the nature of the materials which are going to be stored and the capacity of the warehouse.

Safety, building and environmental conditions of the warehouse: Nowadays, warehouses, especially spare parts warehouses, have an important role in any organizations and it is necessary to maintain and prevent any disturbances and damages. Therefore, observing all available safety tips is vital to prevent any damages and unexpected events. In this dimension, the indicators have been determined using the existing safety instructions for the warehouse such as the oil company instructions through which all the safety considerations available for the warehouse are examined.

Software, automation and information systems: In recent years, information systems have been the most important and the most effective solutions to facilitate, control and monitor any organizations. It is necessary to have a proper integrated office system in which a huge amount of information is located. Warehouse management software has created a change in the management system of factories and productions that affects the speed of work, production of goods, delivery to the customer and so on and has increased the efficiency of warehouse. In this way, all the warehouse processes from inventory announcement to shipment are well managed to save both money and time. In this dimension, we examine the existence and availability of such warehouse softwares and their various potential capabilities by means of using the relevant indicators.

Arrangement and physical issues: The most important function of efficiency of warehouses is the storage of goods and products in terms of the most possible and potential capacity and quick access to goods. Warehouses should be equipped in such a way that they are appropriate to make maximum use of space for storage, movement and exchange of goods. Equipping the warehouse with shelves suitable for goods and products makes access to items and goods easier and more efficient and results in better management of goods and productions. In this dimension, the discussion of shelving, the type of shelves, the arrangement of goods according to the process of consumption, classifying and storing items based on their categories, their volume and arrangement systems and so on are going to be examined through using the relevant indicators.

5. Leveling the proposed pattern

Each of the dimensions has several indicators each of which is divided into 5 levels to evaluate the related warehouse. This

leveling has been developed from the inspiration by the models of Campbell, Terry Wireman, the only maturity model presented in the field of warehouse [18] and also five levels of the Capability Maturity Model Integration (CMMI) namely 1- introductory, 2- managed 3- defined 4- quantitative management 5- optimized.The leveling of each of the indicators is shown in Table (3)

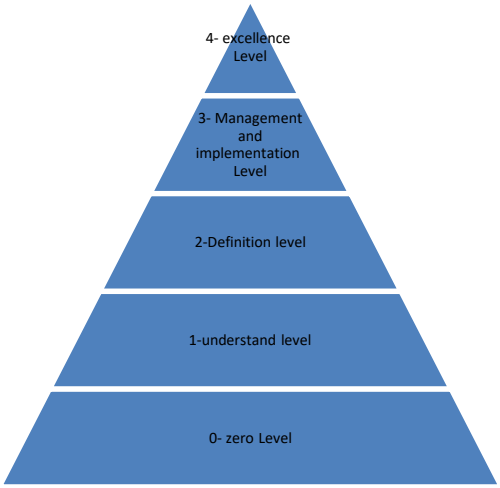


Figure 2. leveling of indicator

Table 3. Explanation: leveling of indicator

The system is updated and there is continuous evaluation and improvement of existing processes	Level 4
Implementation of general inventory management processes as well as spare parts warehouse requirements (location, space division, etc.)	Level 3
Defining goals, policies, inventory management processes as well as defining the existing requirements of spare parts warehouse (location, space division, etc.)	Level 2
Existence of spare parts warehouse and willingness to implement total inventory management processes	Level 1
There is no spare parts warehouse as well as inventory management processes	Level 0

6. Validity and reliability of the model

The validity and reliability of the model has been estimated and assessed through using the questionnaire. After preparing the questionnaire (content validity, Likert scale) and asking the selected experts to answer the questionnaire, the validity (content, divergent and convergent) of the proposed framework was assessed which the results proved its validity. Then, the reliability of the model was estimated by Cronbach's alpha method used for all the questionnaires and all dimensions separately indicating the reliability of the proposed framework.

Table 4. Cronbach's alpha of the entire questionnaire

Cronbach's Alpha	N of Items
.992	85

After obtaining the validity and reliability of the proposed framework, a number of indicators were removed from the model due to not obtaining the required scores, and finally the final model includes 9 dimensions and 82 indicators fully listed in the Appendix (a).

7. Case study: Evaluation of auto parts warehouse

After evaluating the auto parts warehouse by the assessment team, the scores obtained by this warehouse have been presented in Table (5) and Radar Chart (1).

Table 5. Warehouse scores

Dimensions of inventory management system evaluation framework and spare parts warehouse	warehouse score	Maximum warehouse number
Strategies, inventory management policies and related indicators	16	40
Supplier management	10	32
Staff and training	21	40
Coding, categorizing and organizing items	14	36
Optimization, control and inventory management	16	40
Location and design	23	36
Safety	22	40
Software, automation and information systems	21	36
Layout and physical topics	25	28

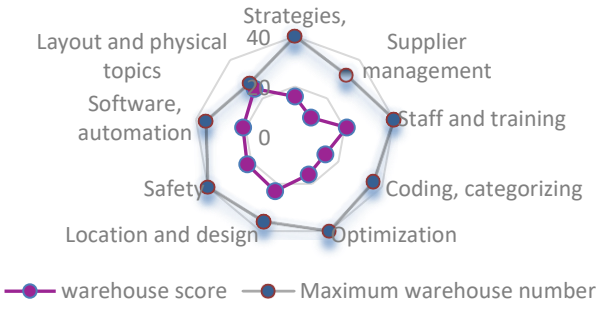


Chart 1. Warehouse status radar chart

Based on the results and the obtained scores, the warehouse situation is the average or normal situation. Some practical solutions have been presented to achieve a more favorable situation as follows.

8. Steps of roadmap drawing (iREAM-MRO) based on the proposed framework:

First, a working group is drawn to draw the roadmap, then the concept of the roadmap is taught and the general model of the roadmap is explained to the members of the working group. Manage inventory and warehouse of spare parts obtained by the

members of the working group and determine the current position based on the checklist, then identify the remaining actions for each of the sections defined in the roadmap. It is based on two factors of effectiveness (advantage, profit) and simplicity (feasibility and cost) that the effectiveness factor is scored like the Likert scale (5-1) so that the effectiveness (importance) gets more points and the factor of simplicity (feasibility) And cost) is scored like an effectiveness factor, so that the lower the cost and the easier it is to implement, the higher the score shown in Table (6) and then to the final development of the Inventory and Spare Parts Warehouse Roadmap (iREAM). MRO) shown in Figure (4) and move towards it and finally determine the person in charge and duration of each of the activities listed in the roadmap and determine the start date of each action and prepare a roadmap implementation schedule and instructions for evaluation and review Roadmap courses are written.

Table ٦. Prioritize roadmap activities

Solution priority	Score	simplicity (feasibility in performance and cost)	effectiveness (advantage, profit)	Approach	Dimensions
A	18	4	4/5	compiled policies, strategy and vision for inventory and spare parts warehouse management	Strategies, inventory management
B	14	3/5	4	compiled key performance indicators for inventory and spare parts warehouse management	
C	9/6	3	3/2	Calculation of key performance indicators of inventory and warehouse management	
B	13/02	3/١	4/2	compiled of spare parts crisis procedure / instructions	
B	14/06	3/7	3/8	Creation a supplier performance appraisal system	Supplier Management
A	16/81	4/1	4/1	Extract supplier evaluation indicators	
A	21/07	4/3	4/9	Creating an Approved vendor list	
B	12/92	3/4	3/8	Evaluate and review suppliers	
D	5	2/5	2/5	Specify the supplier of each part	
B	15/17	3/7	4/1	Preparation of instructions / procedure of ergonomics principles in spare parts warehouse	Human Resources and Training
A	21/6	4/5	4/8	compiled a process for leveling employees based on their skills	
D	4/5	2/5	2	Reward employees based on their performance	
B	15/54	4/2	3/7	Staff needs assessment and training according to the needs assessment	
B	15/05	4/3	3/5	Implement coding / cataloging system for all items	Coding, categorizing and organizing items
C	9/92	3/2	3/1	Categorize items based on lead time	
A	22/56	4/8	4/7	compiled / execute instructions for categorizing spare parts (ABC, XYZ, VED, ... MUSIC3D)	
B	14/82	3/8	3/9	Compile Bill Of Material lists for equipment	
A	18/06	4/3	4/2	compiled / implement inventory optimization policies (order point, order quantity, contingency reserve, procurement time, crisis, etc.)	Inventory optimization, management and control
A	24/01	4/9	4/9	Identification of insurance parts, low consumption and high consumption	
C	9/3	3/1	3	Obtaining the cost of ordering and the cost of the inventory system and training it to employees	
A	20.09	4/1	4/8	Run the 5s program and tidy up the warehouse environment	Location and design
B	15/96	3/8	4/2	Warehouse shelving and maximum use of the warehouse	
C	8/6	2/6	3/1	Appropriate use of the type of shelf material appropriate to the type of items stored	
B	13/69	3/7	3/7	Observance with safety requirements related to hazardous substances	Software, automatioand information systems
A	22/56	4/7	4/8	Observance of safety requirements for the layout and physical environment of the warehouse (electricity, exit doors, material of the warehouse building, passageway)	
B	17/63	4/3	4/1	Observe the safety requirements of firefighting equipment	

A	21/62	4/6	4/7	Software training for warehouse staff	Software, automationand information systems
B	16/38	4/2	3/9	Employee access to all software modules	
A	19/74	4/2	4/7	Integrated access of the maintenance unit to the warehouse software	
D	4/1	2	2/1	Systematize all warehouse processes (purchase, etc.)	
A	22/08	4/8	4/6	compiled optimal product arrangement policies (high-consumption parts in the nearest, etc.)	Layoutand physical topics
B	15/58	4/1	3/8	compiled and implement LIFO and FIFO policies in warehouse	

The priority table of solutions is based on two factors of effectiveness and simplicity. The priority of solutions is obtained by multiplying these two factors. For example, Priorities A are the product of two factors of effectiveness and simplicity, 16 to 25, which are placed in a green environment.

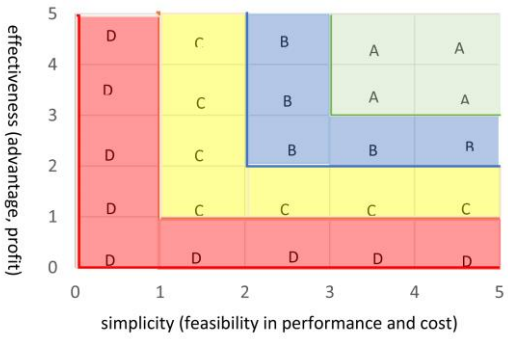
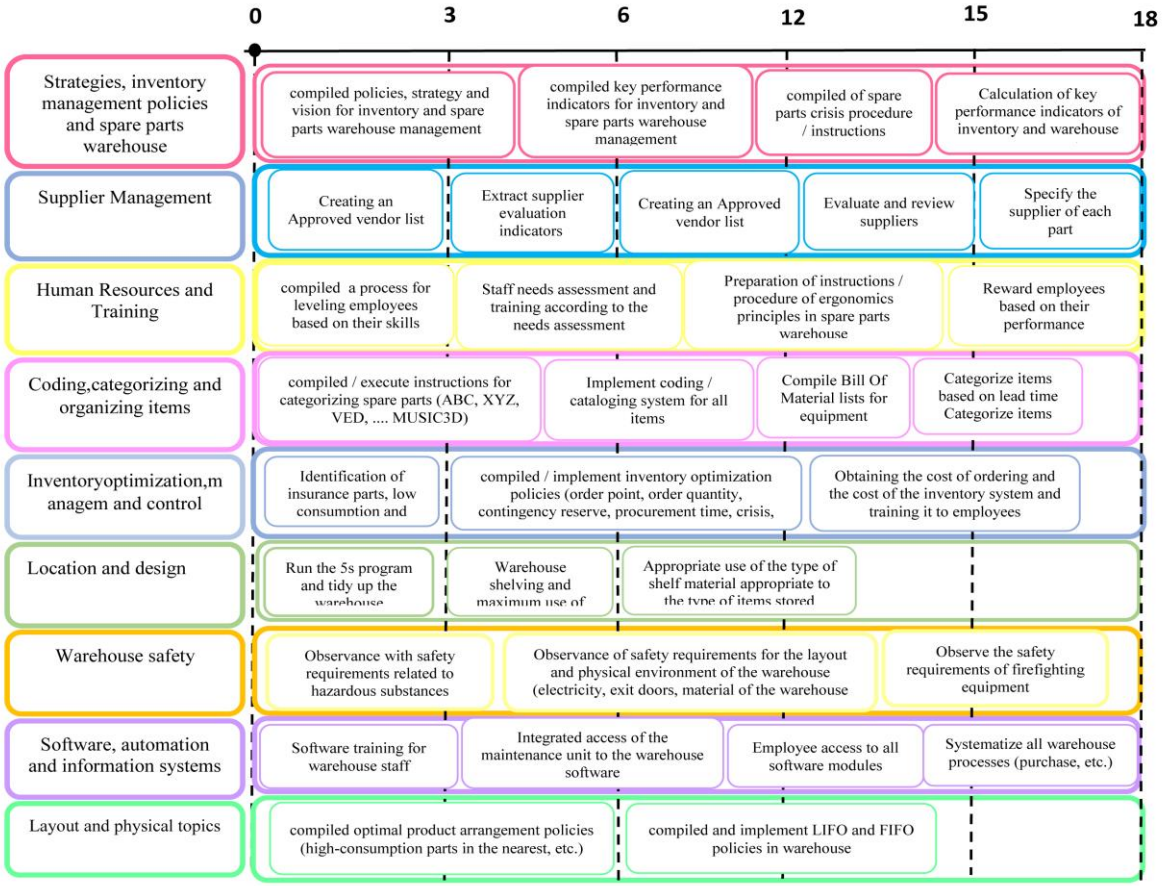


Figure 3. Prioritize solutions according to the points earned

Figure 4. Spare parts and inventory management roadmap (iREAM MRO)



9. Conclusion

Regarding the role and importance of the warehouse in the supply chain, having a high-performance warehouse leads to successfulness and promotion, as well as creating a competitive advantage in the warehouse. To achieve high performance, periodic evaluations should be done to identify strengths and weaknesses and decisions should be made to improve the weaknesses. In this paper, based on the results of the previous studies, the existing components for warehouse evaluation have been prepared. Then, a model for warehouse evaluation has been proposed containing 9 dimensions That each dimension containing 10 indicators each has been selected to cover all warehouse activities. Then, by the validity and reliability questionnaire of the proposed model, which eliminated 8 indicators, it was then evaluated by the obtained model of auto parts warehouse, and according to its condition, solutions to improve the condition of the warehouse were provided.

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Appendix (a): Final Checklist

After assessing and evaluating the validity and reliability of the model and removing the indicators that have not obtained the necessary scores, the final checklist is obtained consisting of 9 dimensions, each of which has several indicators, which are fully listed in the table below.

ROW	Dimensions
Strategies, inventory management policies and spare parts warehouse and the related indicators	
1-1	Have the goals and policies for inventory management and spare parts warehouse been compiled? (compilation, notification, delivery)?
2-1	Are inventory control indicators being examined, evaluated and analyzed by high level managers
3-1	What is the position of the organization in terms of vision, strategy and roadmap considering inventory management system and spare parts warehouse?
4-1	Have warehouse processes been determined? (Price updating process, identification of repairable parts, supply and purchase, announcing needs and ordering)
5-1	Are warehousing processes being implemented? (Price updating process, identification of repairable parts, supply and purchase, announcing needs and ordering)
6-1	Are there any instructions or protocols for expertise of items and quality control of input components?
7-1	Are there any instructions or protocols to prepare and update inventory management indicators (MRO Key Performance Indicators: KPIs)?
8-1	Is the warehouse situation reviewed and audited?
9-1	Is there a procedure to identify and assign stagnant items?
10-1	Is there a process to manage, control and track repairable parts
Supplier Management	
1-2	Have the main suppliers been identified for each component?
2-2	Have the evaluation criteria been determined for the suppliers of the spare parts?
2-3	Are items being categorized based on the type of the supplier?
4-2	What methods are being used to select suppliers?
5-2	Is there a process to identify new suppliers (sourcing)?
6-2	Is the process of cooperating with suppliers being determined and reviewed?
8-9	Has the information needed to evaluate suppliers been compiled (is there enough information)?
9-2	Is the suppliers' database available and being updated?
Human Resources and Training	
1-3	Is there a way to evaluate employee performance (compiling, reviewing)
2-3	Have the staff at different levels been given the necessary training (specialized and so on)?
3-3	How is the relationship between people's expertise and organizational role considered?
4-3	Is there a special process to determine the staff's skills and training needs analysis?
5-3	What is the status of the organization in providing a suitable work environment for employees?
6-3	Have the warehouse staff received the necessary training on the S 5?
7-3	Are the employees fully informed about inventory control methods (minimum and maximum inventory, order point, optimal order amount and so on)?
8-3	Have the employees received the necessary training on safety and how to work with safety and firefighting equipment and performance in the event of a possible accident?

9-3	Have the employees received complete training in the proper use of automation (component management software)?
10-3	How is the status of salaries, wages and bonuses? (Each person receives a salary according to the way he works) 3
Coding, categorizing and organizing items	
1-4	Is there a BOM (byte order mark) list for the equipment?
2-4	Are ABC and XYZ analyses being used? 4-2
3-4	Have the components been categorized in terms of their importance and CRITICAL levels?
4-4	Have the items categorized in terms of the lead time?
5-4	have the items been categorized based on speed of consumption and are high-consumption and low-consumption groups determined?
6-4	Is there a way to avoid creating multiple codes for the same parts?
7-4	have the parts been classified regarding the fact whether they can be repaired or not?
8-4	Is the code definition and assignment process being done systematically and ultimately verified by one person?
9-4	Is the component coding inherent or practical?
Inventory optimization, management and control	
1-5	Have inventory optimization policies been defined for different categories of parts (order point, order quantity, supply time, precautionary measure)
2-5	Are inventory optimization policies implemented for different categories of parts (order point, order quantity, procurement time, precautionary measure)
3-5	Are inventory optimization policies being reviewed for different categories of parts (order point, order quantity, supply time, precautionary measure)
4-5	Is a special method used to predict the consumption of parts?
5-5	Has the list of expiration dates of perishable items in stock been prepared?
6-5	Is the service level of the parts determined according to their degree of criticality?
7-5	Have low-consumption parts of insurance been identified and their necessary inventory determined?
8-5	Has the excess inventory of low-consumption parts been determined and have any actions been taken to reduce it?
9-5	Have the cost of ordering and the inventory system been calculated?
10-5	Have the units of consumption and purchase of items (barrels, liters, meters, kilos, etc.) been specified separately and the main and sub-units been specified?
Location and design	
1-6	Does the storage capacity of the warehouse match the amount of goods stored?
2-6	Are the store rooms appropriate in terms of shelving and using the available space and the layout of warehouses?
3-6	Is the lighting and painting of the warehouse appropriate?
4-6	Is there a suitable place for the development of the warehouse in the future?
5-6	Is there an environmentally friendly place for perishable items?
6-6	Are chemicals and toxins being stored separately from the other goods?
7-6	Is access to the warehouse appropriate?
8-6	Is the warehouse building enclosed and controllable?
9-6	Has any place been predicted to receiving, dock and send goods to the warehouse?
10-6	Is the location of the warehouse building appropriate for the passage of vehicles and lift trucks without encountering obstacles in front of the warehouse entrance door?
Warehouse safety	

1-7	Are the safety issues related to the passageways of the vehicles in the warehouse being observed closely? (lift trucks crossing passage, door height)
2-7	Is the safety regulation of goods in the warehouse being observed? (Safety of shelves / pallets and so on)
3-7	Have the safety regulations related to the storage of chemicals been observed? (Temperature control, ventilation, building materials and so on.)
4-7	Are the electrical safety regulations of the warehouse being observed (cable route, life-saving switch, electrical panel)
5-7	Are the safety regulations related to emergency exit doors being observed (location, distance to warehouse, width and so on.)
6-7	Are there safety equipment for fire alarm and extinguishing equipment in the warehouse? (Fire extinguishing system, fire extinguishing capsule)
7-7	Are the general safety regulations of the warehouse observed (communication devices, gloves, shoes, warning signs and so on)
8-7	Are the safety regulations related to the warehouse building being observed? (Material, doors, floor)
9-7	Are safety regulations for flammable and explosive materials being observed (electrical system, heating and cooling system, lighting system)?
10-7	Are warehouse safety regulations related to warehouse equipment and facilities being observed? (Fire extinguishing system, warning signs and so on)
Software, automation and information systems	
1-8	Is there a system and software to manage the warehouse and the inventory of spare parts?
2-8	Is the warehouse and spare part system linked to and synchronic with the other systems through using a special software?
3-8	Is it possible to have items on the shelf but not in the warehouse system? Or vice versa?
4-8	Is the complete piece of information sent by the applicant when announcing the need?
6-8	Are there records and documents of the previous years (order time, order amount, inventory at different times, inventory and monthly consumption) available in the related software?
7-8	Is the software system capable of forecasting demand?
8-8	Is the software properly upgradeable?
9-8	Is the software capability appropriate in reporting and making the necessary changes?
10-8	Are the capabilities of the software fully utilized?
Layout and physical topics	
1-9	Have low-consumption and high-consumption items been categorized based on the number of visits to them
2-9	Are the same goods or the ones similar to each other being stored close to each other?
4-9	Are the goods stored in the same place in terms of volume and size?
5-9	Does the LIFO and FIFO system work properly in all warehouses?
6-9	Have the stored items arranged in suitable containers and pallets?
7-9	Is proper metal shelving being used to store items?
8-9	Is there appropriate distance among the shelves to let people cross through the passages easily?

Appendix (b): Sample final checklist with five levels of indicators that have been sampled due to lack of space

row	Sub-criteria	Rating sub-criteria of points	score
Inventory management and spare parts warehouse strategies and policies			
1.1	Have the goals and policies of the MRO spare parts supply chainbeen formulated? (Development, communication, implementation)	No Objectives and policy documented	0
		Objectives and policies have been formulated	1
		Objectives and policies have been formulated and communicated	2
		Objectives and policies have been developed, communicated and implemented	3
		Goals and policies have been formulated, communicated and implemented and are understood by all staff	4
2.1	Are inventory control indicators reviewed and evaluated by higher level managers?	No, they do not have any index	0
		Yes, but it does not affect decisions	1
		Yes, but one in a while affect the process of decision making	2
		It is generally analyzed and leads to corrective actions	3
		Accurately the trend of indicators is analyzed and is considered as the basis of macro decisions	4
3.1	What is the status of the organization in terms of vision, strategy and roadmap regarding the supply chain of MRO parts?	There is no documented strategy, vision and roadmap in this regard	0
		There is a documented perspective on the spare parts supply chain	1
		There is a documented strategy to realize the vision of the spare parts supply chain	2
		There is a roadmap to realize the vision and strategy of the spare parts supply chain	3
		The roadmap, vision and strategy of the spare parts supply chain in the organization have been announced and understood by all employees.	4
4.1	Are warehouse processes developed? (Price update process, repair of identifiable parts, supply and purchase, declaration of need and order)	No, there is no process	0
		The process of updating prices has been developed and	1
		The process of identifying repairable parts has been developed	2
		The supply and purchase process has been developed	3
		The need announcement and ordering process have been developed	4
5.1	Are warehouse processes implemented? (Process of updating prices, identifying repairable parts, supply and purchase, announcing needs and ordering)	No, processes are not implemented	0
		The process of updating prices is implemented	1
		The process of identifying repairable parts is performed	2