Applying the Data Center Infrastructure Management (DCIM) Tool to Enhance the Quality Management of the Data Centers by Decreasing the Unplanned Outage Reasons

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ABSTRACT- All previous reports and practical life have proven that the human errors and devices failure are responsible for the unplanned outage of the data centers at a rate of up to 88%. And for this reason, it was important to find a way to reduce this percentage.

In this study, we discuss how the Data Center Infrastructure Management system (DCIM) tool can reduce this percentage and enhance the management quality that helps to make most of the daily operations inside data centers run routinely and easily. So, the main target of this case study is finding that "if the Data Center Infrastructure Management (DCIM) tool can help to reduce the main reasons of the unplanned outage of the data centers and enhance the quality management The information technology industry consists of several stages, and one of the most important stages of this industry is to provide a safe environment for its devices where placed. A secure environment provides safety for devices, whereas providing the devices needs for cooling, clean electricity and information networks, etc. and this place should be secured from intrusions and natural disasters such as earthquakes and lightning strikes. This place is called Data Center. It contains many systems and devices to achieve the previous purpose of the data centers".

KEYWORDS- DCIM, Data Center, the quality management of the data centers, ISO 9001:2015 for data centers, data centers standards, and data centers management tools

I. INTRODUCTION

The information technology industry consists of several stages, and one of the most important stages of this industry is to provide a safe environment for its devices where placed. A secure environment provides safety for devices, whereas providing the devices needs for cooling, clean electricity and information networks, etc. and this place should be secured from intrusions and natural disasters such as earthquakes and lightning strikes. This place is called Data Center. It contains many systems and devices to achieve the previous purpose. These data centers contains a lot of systems which working together to achieve the goal of the data center. All these system should be working together by harmony and integrity ways. The workflow of each system should manage carefully to be aligned with its targets. The data center contains very critical data; this data could not be loss or corrupted, so the data center should be reliable and protected from the unplanned outage. All infrastructure system inside data center should be redundant and have fully maintenance plan to prevent the unplanned outage which could be happened by devices failure. But the outage which could be by human errors should be prevented by managed the data center well throughout strict and obligated procedures, standard, and workflows for all staff.

Each system inside the data center is working as knowledge framework, so these systems should be managing carefully and professionally, there are a lot of management ways, but the best management tools which contain one platform to manage the entire data center knowledge framework.

When managing all the systems of the data center into one automated platform, this platform contains, controls, and maintains the following:

All required goals and baseline,

All internal resources,

All requirements to meet the required quality standard,

All (procedures, policies, documentation, work instructions, etc.) that will be obligated; and

Monitor and control all the systems of the data centers.

II. OBJECTIVES

The unplanned outage of the data centers is affected on the business continuity and increasing the operational risks of the data centers, which must be managed effectively to reduce it and reduce its impact and enhance the quality level of the data center. These are more than one management tools could be used for this purpose, we will use the Data Center Infrastructure Management Tool (DCIM) which can manage and control all the knowledge framework of the data center, and choose the management principle (ISO 9001:2015) which will be followed and managed by this tool. This study's objectives revolve around the following main themes (see Table 1).

Table 1: The Case Study Objectives
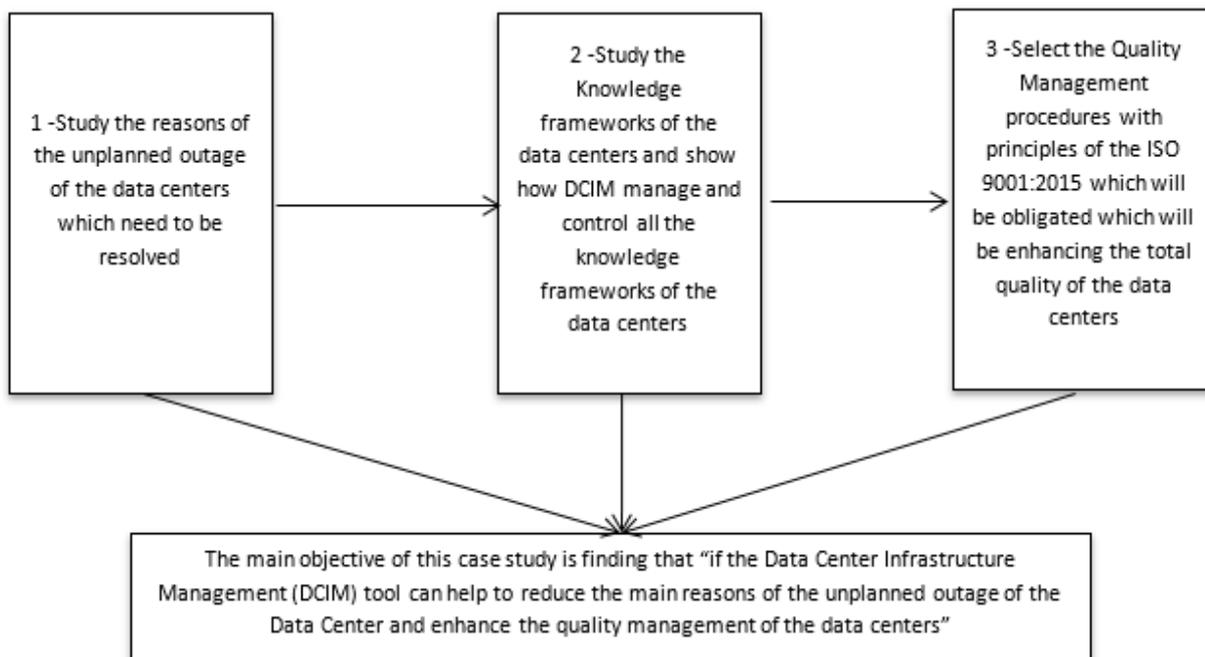
III. LITREATURE REVIEW

Managing the IT infrastructure contains many difficulties, which had to be found the best solutions to manage it to maintain the business continuity and to achieve the normative objectives of the IT systems and align it with the strategic plan of the business.

one of the most important reasons that can lead to the disruption the IT business continuity is an unplanned outage of the data centers which contain the IT's devices and equipment, this unplanned outage causes a forced shutdown for all IT's devices and equipment which could lead the entity for being exposed to a large financial loss due to the following:

- Damage some or all of the IT's devices and equipment,
- The Data Center's data could be lost or corrupted during this unplanned outage time,
- The reputational risks that could be effect on this entity at the future, and
- Stop the IT services for the company's customer.

The reasons of the unplanned outage need to be solved by using the DCIM as a management tool to enhance the quality management of the data centers by automated the performing the Total Quality Management (TQM) procedures with principles of the ISO 9001:2015 which will be obligated and enhancing the total quality of the data centers.

The cost of Data Center Downtime as the latest white paper at 2011 by (Emerson Network Power) has been calculated approximately by $5,600 per minute, so as example the one hour of Data Center down time could be cost around $336,000 [1]. The cost of outage is hitting to $8,851 per minute at 2016 [2]. But imagine if the outage occurs at the peak of the business day [1].

Amazon experienced an outage in June of 2008 that persisted for close to two hours; Amazon suggested a loss between $29,000 per minute and $31,000 per minute and the revenue impacted by $3.6 million dollars [3].

IV. METHODOLOGY

This case study using the Cause and Effect Diagram, or FISHBONE DIAGRAM to identify the all causes of the unplanned outage of the data centers (see Figure 1) [4].
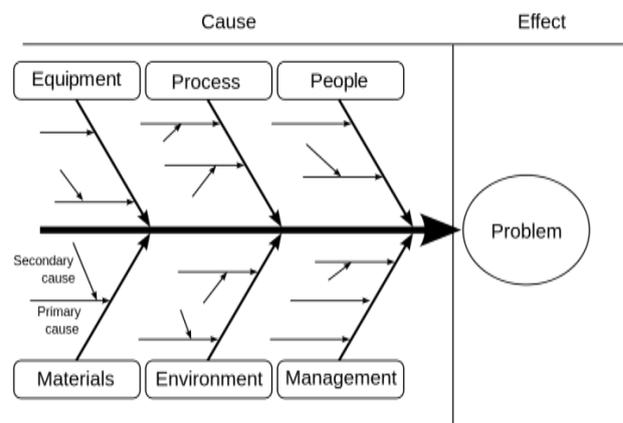

Figure 1: Cause and Effect Diagram [4]

This methodology helps to identify all main causes and analysis these causes to find the sub-causes, this splitting process helps to find all reasons and find the optimal solutions which help to prevent this problem to recurrent again [4].

V. REASONS OF UNPLANNED OUTAGES

When referring to the white paper of Uptime Institute by Kevin Heflin, The Uptime Institute estimates (see Figure 2) as following:

about 59% of the unplanned outages have been occurred by the result of failure the devices of the data centers, as UPSs, Generators, cooling, and etc.;

about 24% of the unplanned outages have been occurred by the result of operators or management errors and have been occurred as a result of poor (O&M) operations and/or maintenance practices, and it found that "the human errors

are the second causing for reported unplanned outages"; and

- Finally found about 12% of the unplanned outages have been occurred by the result of weather and natural disaster [1], [3], [5], and [6].
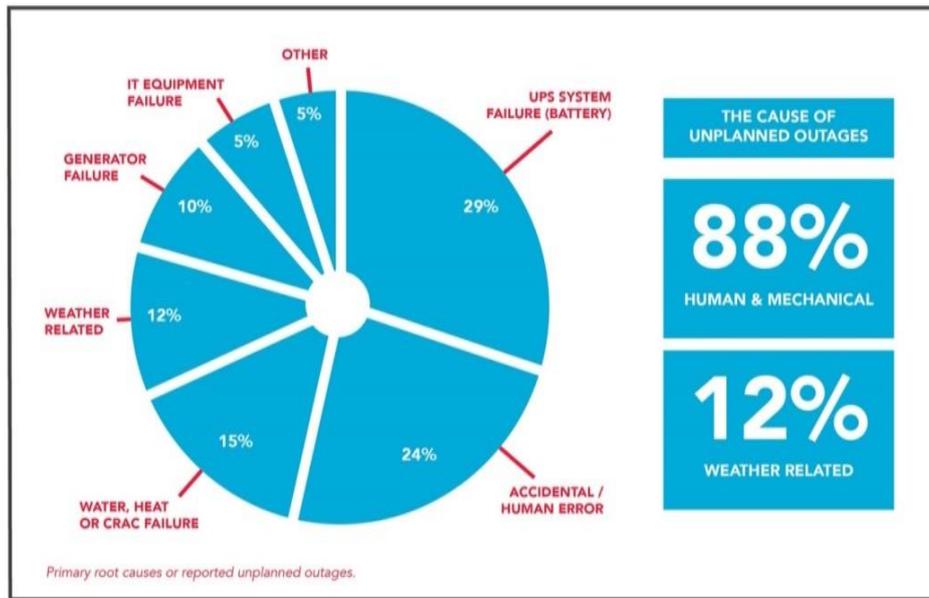

Figure 2: Reasons of the unplanned outages [6]

So, there are three reasons of unplanned outages of the data centers:

- Human error,
- Devices failure, and
- Weather/Natural disaster [7].

A. *The reasons of the Human Errors*

1) *Miss Communications Between Teams*

The mission of maintaining a good communication between data centers' teams is very difficult. The data centers have more than one professional related to it; we have a network team which manage the network systems, switches, and routers devices; team for operating systems admins like Windows team and Linux team; and team for Data Center infrastructure operation and maintenance etc. Each team has a different technical background which make the miss communications between them could cause the unplanned outage [8].

2) *Ongoing Training*

The ongoing training process is essential to preventing human error. The Data Center managers should ensure that all staff has been entered to the Data Center has the basic knowledge of equipment and appliances so that it is preventing to shut down by mistake [8].

3) *Implement and Control the Secure Access Procedures*

Implementing, Controlling, and Developing the secure access policies is critical. Organizations without Data Center's access procedures run with a risk of physical security [8]. The ongoing control and update processes in this policies and procedures can maintain the safety and security Data Center's operations [8].

4) *Standard Operating Procedures (SOPs)*

The human is normally doing errors, so the Standard

Operating Procedures (SOPs) using to reduce the error of the Data Center operations. A detailed (SOP) and the all operation engineers are trained to abide by them [8].
Moreover, the redundancies do not stop at system levels; it is also applied at the human. A commercial plane flies with two pilots on board and can run on auto-pilot mode [8].
A Data Center Standard Operating Procedures (SOPs) would have multiple sections:

- Methods of Statements (MOS) for all maintenance and all operations works (at Method of Procedure (MOP)),
- the actions should be taken if one or more devices fails (at Method of Procedure (MOP)),
- The back-up plans (at Method of Procedure (MOP)),
- The disaster recovery plans (at Method of Procedure (MOP)),
- The roll back plans (at Method of Procedure (MOP)),
- All Service Level Agreement SLA for all devices with all teams even 3rd parties,
- Secure access procedures,
- As-build updated drawing for all Data Center's devices, appliances, data connection, communication mapping, and etc.; and
- All appliances need from cooling, electrical, network, and space requirements [8].

5) *As-Build Drawing*

When we use wrong diagrams or wrong as-build drawing during making maintenance for one of Data Center's items that increase the risk of this process and making the human error will inevitable; so, the Data Center facilities' diagrams should be updated annually as minimum or after any facilities upgrades. These diagrams should to be updated by Methods of Statements (MOS) and have to be mentioned in the Method of Procedure (MOP) of the Data Center [8].

6) The Correct Labelling

All Data Center activities must be labelled correctly. That ensuring the correct operation and maintenance processes and limited the human errors which could to be happened due to un-correctly labelling, as example what could be happened when switching off a wrong Circuit breaker during the maintenance. The labelling must be updated with any facilities upgrades and be maintained when falling down or removed [8].

7) Perform Preventive Maintenance (PM)

The human error risks can be reduced by performing a preventive maintenance but the preventive maintenance services should be performed as the following:

- As mention above, the data centers contains different integrated facilities systems such as electrical, cooling, network, access control, etc. each system must be installed, and maintained by the qualified third-party companies;
- The end-users or the owner's operators can provide early preventive support, such as monitoring the UPSs alarms, but the maintenance process must be occurred by a qualified third-party company;
- The service provider should have a good experience with this type of services. The owner must be signing the Service Level Agreement (SLA) with the Service Provider/s. This Service Level Agreement (SLA) must be containing the following:
- The duties and responsibilities for each service providers and owner;
- Data Center facilities maintenance requirements such as the frequency of Periodical maintenance (PM) visits which be recommended by the manufacture, that helps to maximize the mean time between failures (MTBF), increases system reliability and reduce the unplanned outage risk; and
- Maintenance and operation procedures.
- The service provider should support the following as minimum:
- Emergency services by 24x7;
- Committee with the response, and repair times;
- The availability of spare parts;
- Provide a qualified engineers and technicians; and
- Detailing the best practices and the required early preventive support for the owner's reprehensive or for the Data Center operators [8].

8) Cover and Label the Emergency Power off Buttons (EPO)

Emergency Power Off buttons (EPO) are almost located near the Data Center doors, it used to shutting down power to the Data Center in case of emergency case like earthquakes or water leakage inside Data Center .if these buttons have not been covered or labelled, it could be mistakenly pressed by anyone .so it is very important if the Emergency Power Off buttons (EPO) are implemented to be covered and labelled to prohibited the false use [8].

9) Some Bad Activities

These are some bad activities increase the human error risks, so these actions should never be permitted in the Data Center as following:

- Food and drink should never be permitted inside Data Center, so we should make a suitable rest room for the staff to eat or drink in there; and
- The equipment and Data Center appliances must be unpacked outside of the Data Center. When the devices' packages are opened, they may produce some unwanted dust or impurities that can accumulate on the devices and equipment located inside the data centers, so we must implement a staging room to be used for unpacking process [8].

10) Secure Racks

When we put the appliances of the Data Center inside secured and locked racks, it prevents the unauthorized person for making unplanned actions which could make the unplanned outage for the data center [8].

Table 2: human errors reasons [8]

1	• Miss communications between teams
2	• Ongoing training
3	• Implement and control the secure access procedures
4	• Method of Procedure (MOP)
5	• As-Build drawing
6	• The correct labelling
7	• Perform preventive maintenance (PM)
8	• Cover and label the Emergency Power Off buttons (EPO)
9	• Some Bad Activities
10	• secure racks

B. The reasons of the Device Failure

There are some critical devices that related to devices or systems failure (see Figure 3) [9].
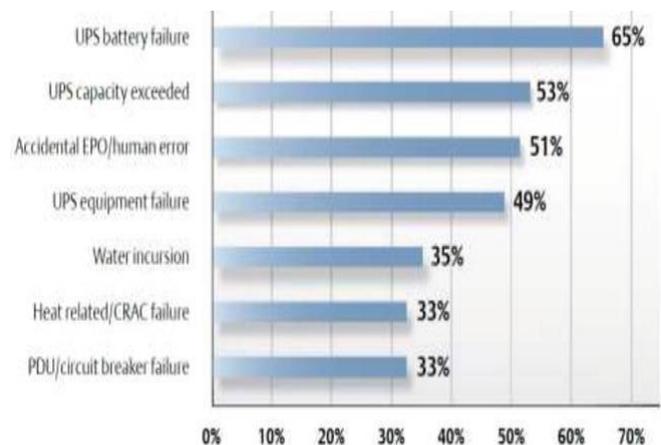

Figure 3: Critical devices that related to system failure [9]

The main key to prevent the unplanned outage from the device failure is (No Single Point of Failure for all the devices, cables connections, systems, power cords, raisers of cables, control circuit, cooling units, drainage, and etc. of the data centers), all of those should be backed-up and have no single point of failure for any part of the data center [9], [10].

The required level of redundant is determined during the design of the data center and before implementation phase, we have to decide the required level of redundancy for all Data Center infrastructure components such as electrical,

cooling, and etc. [5], [11].

The (ANSI/TIA-942) from Uptime Institute provides the design and construction standards for physical data center infrastructure, this standard is classifying data centers by the required value of planned down time per year (level of Data center availability) dependent on its redundancy level;

it was classified into 4 Tiers [10]. The following (Table 3) shows the availability with the allowed planned down time and the redundant components required for each Tier according Uptime Institute. The main different between Tiers levels at TIA942 standard is the different of the redundancy level [12].

Table 3: The Main Different Between Redundancies at Levels of the Tiers Standard [12]

Tier Rating	Tier 1	Tier 2	Tier 3	Tier 4
Active Capacity Components	N	N+1	N+1	N after Failure
Distribution Paths	1	1	1 Active + 1 Alternate	2 Active
Concurrently Maintainable	No	No	Yes	Yes
Fault Tolerant	No	No	No	Yes
Compartmentalization	No	No	No	Yes

As Shown at (Figure 4) – the appliance at the rack has dual power supply, and each power supply is feeding through

different path; at this solution of the Tier4, there are redundant for all electrical devices and all electrical paths [13].
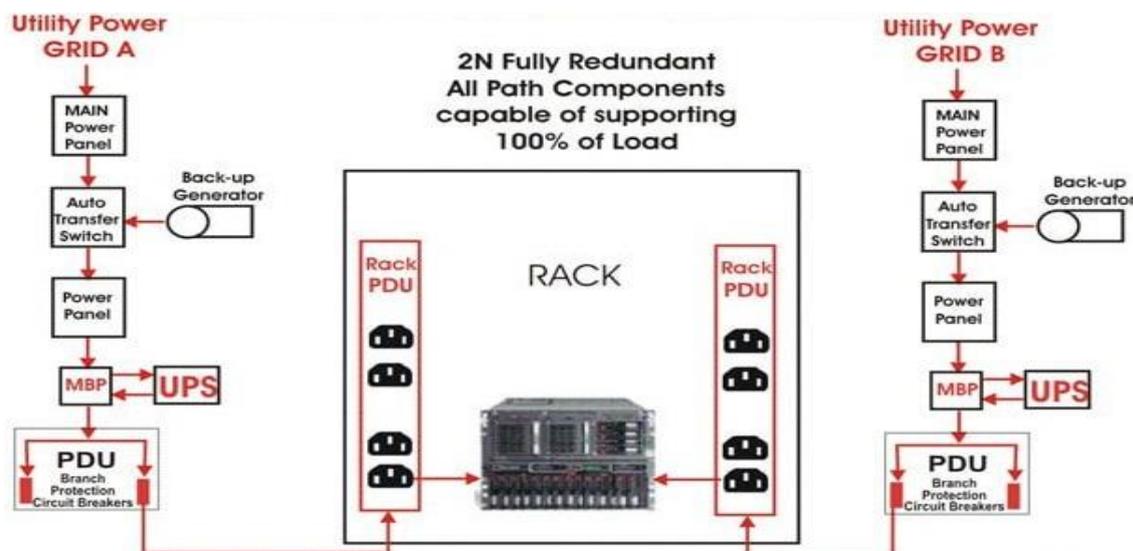

Figure 4: The Redundant for All Electrical Paths [13]

By applying the network topology of the Telecommunications infrastructure redundancy which redundant internet service providers, redundant routers, edge switches, redundant pathways and all of those are physically separated that make the reliability of the communications infrastructure can be increased and eliminate the single points of failure [10].

C. The Reasons of by the Weather/Natural Disaster

The unplanned outage of the data centers by the natural disaster could be enhancing by building another Disaster Recovery (DR) data center, the DR data center will prevent the unplanned outage which could be affected on the main

data center due to the natural disaster, and the DR data center must be implemented with the following standard:

- The DR data center must be away from the main data center by 250 KM at least;
- The DR data center might be implemented at another stable country if applicable;
- The data which transferred between the Main Data Center and the Disaster Recovery Data Center will be transferred through two communications channels (N+N) at least; these two lines should be fast, stable, secure, and from to different source [1], [3], [8].
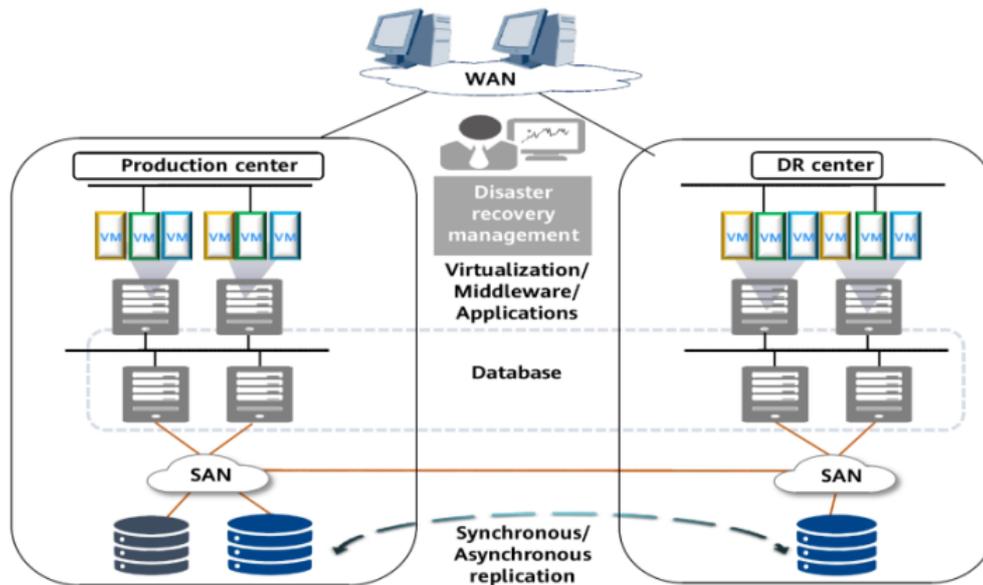
Figure 5: Disaster Recovery (DR) Data Center Solution [14]

VI. THE KNOWLEDGE FRAMEWORK OF THE DATA CENTERS

Data center is containing of at least 16 systems. Each system requires knowledge area, most of its explicit knowledge of the Data Center have been known by best practices, lesson learned, standards, polices, and case studies, but its implicit knowledge of the data center is undocumented and not updateable but it has been informed by specific, certified and expert people [15].

The integration between the explicit and the implicit knowledge needs special tool like the technology enhanced learning (TEL) to integrate between all knowledge areas of the data center management [15].

The following (Figure 6) shows the knowledge framework of the data centers which need to be controlled by Intelligent Infrastructure Management tool to align it with the organization's strategies and comply with business needs [15].
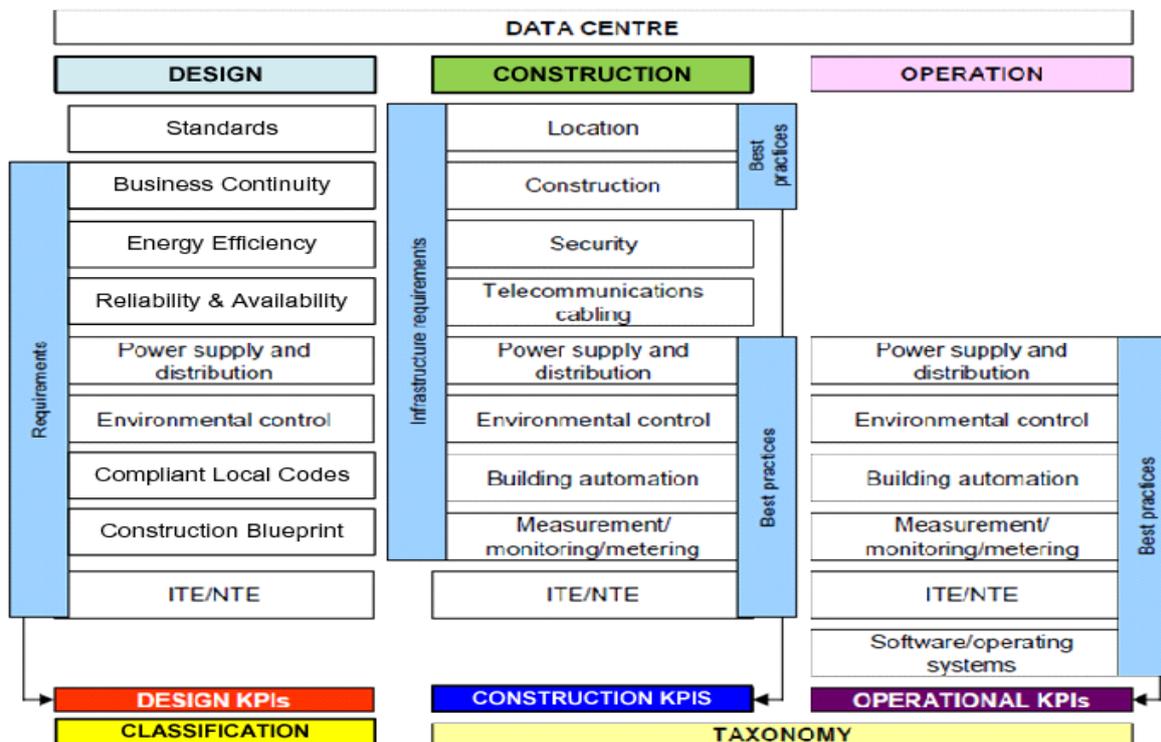

Figure 6: Data Center Knowledge Framework [15]

The knowledge areas of the data center which needs to be controlled and managed as following:

- Implementation Knowledge:
- Staff management and training plan,
- health and safety plan,
- Documentation management,
- Infrastructure management, and
- Financial management.
- Maintenance Knowledge:
- Staff management and training plan,
- health and safety plan,
- Emergency Operating Procedures (EOPs),
- Maintenance management,
- Change management,
- Documentation management,
- Infrastructure management,
- Effective energy management program,
- Financial management, and
- Performance monitoring and review.
- Operation Knowledge:

- Staff management and training plan,
- health and safety plan,
- Emergency Operating Procedures (EOPs),
- Maintenance management,
- Change management,
- Documentation management,
- Infrastructure management,
- Effective energy management program,
- Financial management, and
- Performance monitoring and review [16].

VII. DATA CENTER INFRASTRUCTURE MANAGEMENT SYSTEM (DCIM)

The (DCIM) is a management tools and a complete solution of software and hardware tools used for monitoring, managing, planning, reporting and controlling infrastructure system components within the Data Center [17]. It is considered as an integrated software and hardware in one platform that manages all physical layers inside the Data Center [18].
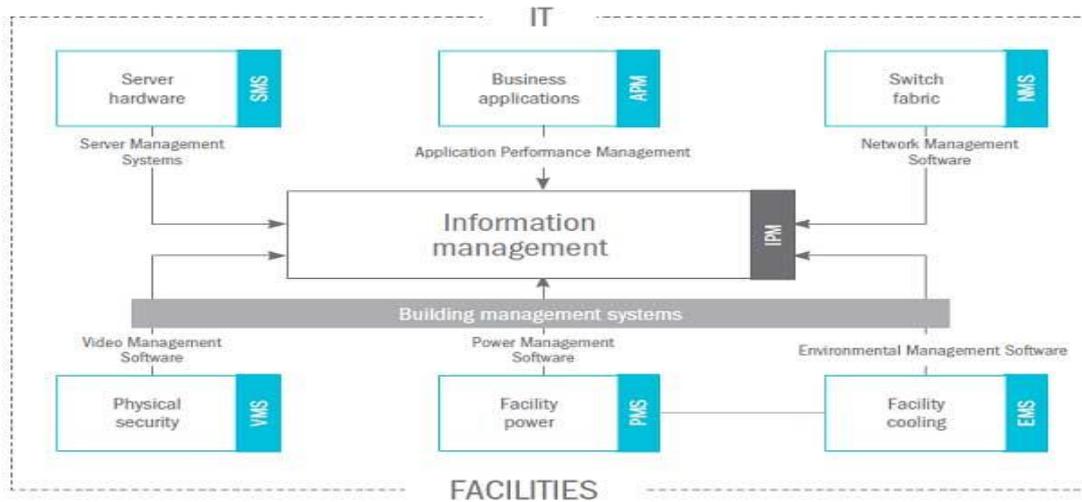

Figure 7: Data Center Infrastructure Management system (DCIM) [17]

The Data Center Infrastructure Management system (DCIM) helps for ensuring the data center systems' availability, maintains and/or improve efficiency, and makes the planning of capacity is more accurate and could to be used in the future strategic plan of the business [19].

Figure 8: DCIM supports the efficiency of the enterprise IT function [19]

The Benefits of the Data Center Infrastructure Management Tool (DCIM):

- Record all Data Center assets moves, ads, and changes for all servers, networks, equipment, and device. this record could to be manual in small scale Data Center and must be automated in the large-scale Data Center;
- Obviously, the existing racks capacity and the required expansion;
- Identify all racks data such as
- Rack location,
- Rack full 3D view,
- The appliances located inside,
- The connections between this rack and other racks with identifying labels,
- The required capacity of electrical and cooling,
- The existing value of cooling and electrical consumptions, and
- The exact U position, data outlets, and power outlets which are used and free;
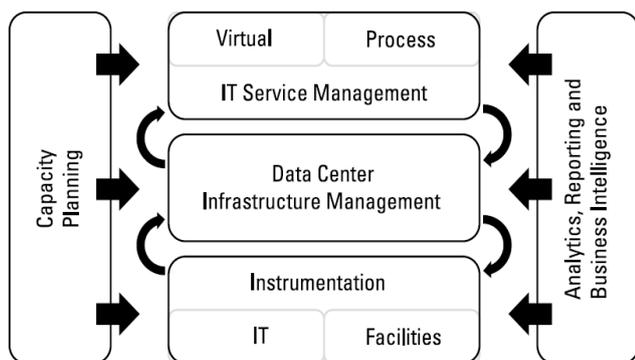
- The disaster recovery plans for all racks, applications, servers, infrastructure devices, and etc.;
- Monitoring, managing, planning, reporting and controlling the infrastructure system components;
- Preview the power chain circuits and could make a fault simulation;
- The alarms' actions could to be Configurable, this process help for automated the actions that required to be done after each alarm to reduce the fault effect and shortage the time of repair. These actions could to be calling the supplier, operate the back-up devise, increase the fan speed of another cooling units, ant etc.

– Tracks and monitors the utilization and capacity of resources, such as for example electrical power, energy efficiency, total Data Center availability, total available space required for new appliances and services, and all cooling capacity consumed and needed; and

– The reports could to be visualized data and in easily and quickly ways [20].

VIII. THE QUALITY MANAGEMENT OF THE DATA CENTERS

A. International Data Centers Standards

The standard is a technical document that is used as a rule or guideline, it is a method for finishing something that has been agreed on it and could be recurrence, all stakeholders are brought together to set the data center standards, the Standardization process helps all parties [21].

B. International Organization for Standardization (ISO)

The International Organization for Standardization (ISO) is a worldwide union of international standards organization [22]. The ISO standards apply to control systems, processes, services, and it is aimed to formalize quality assurance [23]. The International Standards is prepared throughout the ISO technical committees, these technical committees are consisting of each member body which interested in this subject, International organizations, governmental, non-governmental, and coordinated with (ISO); (ISO) participates with the International Electrotechnical Commission (IEC) on all subjects of the electrical standardization [22].

C. International Organization for Standardization (ISO) 9001 Definition

The ISO 9000 defines the fundamentals of quality management, which are especially major in service providers. There are different types of ISO specifications but the ISO 9001:2015 is especially for the quality management systems, and it is the only standard that can be certified and followed [23]. It is aimed to be utilized for any size company to assess any level of quality procedure [22], [23]. The ISO 9001 standard is based on series of guiding principles designed to produce a formalized quality management system (QMS) that outlines methodologies, procedures, and liabilities to enhance quality effectiveness on a continual base [23]. The ISO 9001 standard is aimed with the internal and external clients in mind, advancing better quality to enhance clients' satisfaction through risk operation and management, so the ISO 9001 is usable to any operation and addresses at three main areas as following:

- Organizing processes,
- Enhancing the effectiveness of processes, and
- Creating procedures for ongoing process [23].

To qualify for ISO 9001 requires establishing a documented management system that saves all quality methods and procedures, including ongoing changes process, and requires the corrective and the preventative actions to assure the quality, there is ongoing training for
The staff for the developed procedures; the periodical internal and external auditing by independent parties is very important for maintaining periodical the standard requirement to insure that the procedures which have been established by the Quality Manual are being followed [23].
The ISO 9001:2015 is the last version of the standard, expands the procedures that define continuous quality upgrades; the ISO 9001:2015 standard is arranged based on the Plan-Do-Check-Act cycle (PDCA) (see Figure 9) and that supports ongoing quality enhancement as following:

- Plan – Establish objectives and processes to deliver required results;
- Do – execute the plan and implement the processes to implement the product;
- Check – Assess the factual results against the planed results; and
- Act – If the Check shows that the Plan executed in Do is an efficient further that becomes the new standard. This is named by "Deming Cycle" [24].
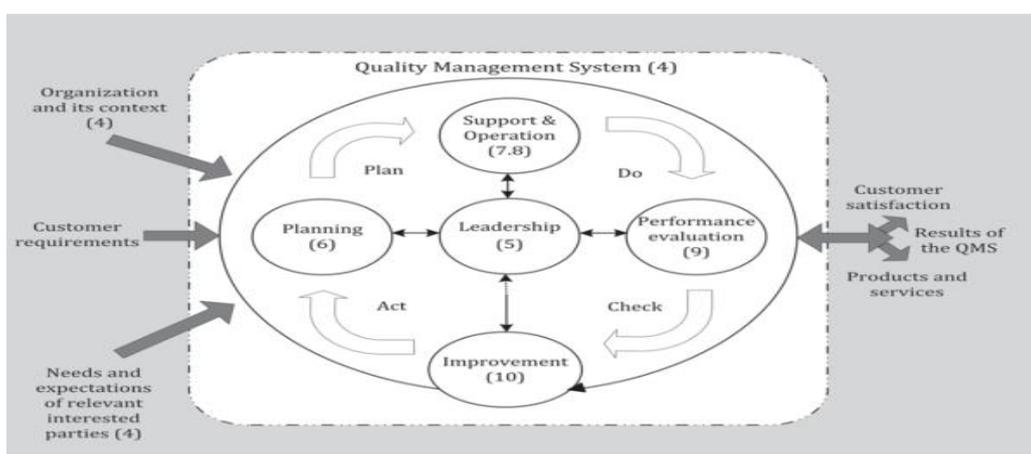
NOTE Numbers in brackets refer to the clauses in this International Standard.

Figure 9: The PDCA cycle with ISO 9001:2015 Standard [24]

D. The Quality Management Principles of ISO 9001:2015 at Data Center

ISO 9001 is an essential component at the implementation and the ongoing services of operations because it sets a group of quality levels at the construction processes, documentation and provides a standard framework to certify the required level of quality [25].

As a part of quality management, The ISO 9001 standard is concentrated to raise the cooperation at all quality management component by applying the following seven quality management principles:

- QMP1 (Customer focus) – Meeting needs and outstanding the clients expectations is the main target of ISO 9001, the main target of this principle is to create a real client value for all needs from currently to the future, the internal and external customers' needs should be obvious for all workers of the data center;

- QMP2 (Leadership) – The standard also needs from leaders at all management levels to drive the common goals which meet the quality objectives, this action required also obvious vision and mission to create the same goals for all;

- QMP3 (Engagement of people) – The standard also needs for ensuring that all the staff and workers of the data centers takes personal responsibility for their missions, and the goal of all data center's employees must be unified which leads to effective construction, operation, and maintenance processes;

- QMP4 (Process approach) – Standards codify processes to create repeatable results, ISO 9001 helps to create an obvious structure and improve the correlated processes for the data center activities like implementation, operation , and maintenance; that defining objectives, knowledge , manage the processes and assessment risks of the quality management system; to achieve this principle it needs for assessing the internal and external factors and the correlating and integrating processes at the process workflow, and all the inflows and outflows should be designed to achieve a specific result;

- QMP5 (Improvement) –the ongoing quality improvement process is essential for ISO 9001 as part of quality management, this action requires continuous improvement for all activities processes, and the total performance to meet the internal and external customer satisfaction; there is an ongoing auditing process for all data center knowledges from planning, operations, and implementation to completion of services, any quality control problems should be documented, the staff must be well-trained so the problems, will not be repeated;

- QMP6 (Evidence based decision making) – the decision-making is the risky part of quality management, the decisions need to be taken based on evidence and real information that helps to show cause and effect, implement the quality metrics, and analysis the assess main quality indicators, the right actions need the right data and this data should be managed correctly; and

- QMP7 (Relationship management) – the Quality needs to be managed through unique process, this process makes all members of this chain and all data center's staff need to co-operate together to achieve the required quality performance, this principle is maintaining the relationships with all suppliers, partners, internal and external clients, that is helping to share resources, expertise, and co-operate to improve quality and management processes [25].

Figure 10: The Principles of ISO 9001 [26]

E. The Benefits of Applying the (ISO) 9001 in Data Center

The ISO 9001 standard provides the following:

- Methodology to ensure the production quality, and provide ongoing quality improvement;
- Methodology to develop data center eliminates human errors and ensures from the integrity of the system layouts and the right parts are ordered;
- Quality management also helps to test and inspect the systems as a part of quality assurance; and gives a common framework to improve quality control systems, increasing the service efficiency, reduces operations costs, minimizes operations, and maintenance risks [27].

IX. PROPOSED MODEL

We need to integrate between the quality management principles of ISO 9001:2015 and all knowledge areas of the data center, and establish PDCA cycle for each activity inside each knowledge area and this Combination must be managed by modern and automated technology platform like the (DCIM).

A. The Benefits of this New Methodology

This new methodology has the following advantage in addition to the benefits of the DCIM which explained before at this study:

- Enhanced all data center quality and eliminate the unplanned outage of it services;
- Automated all data center management processes like (Asset Management, Capacity Planning, and Change Management);

- Automated record all Data Center assets moves, ads, and control all changes for all servers, networks, equipment, and device, all these actions performed under the activities controllers and procedures;
- Focused on removing risks in all operational and maintenance processes, activities, and procedures;
- Proactively treated with all potential risks on the availability of the system and on the staff safety, which Prevents risks from becoming problems;
- reduce the time of response and minimal the time of repair,
- helps to build a Comprehensive understanding of all functions and the interconnectedness of the data center's systems and its components;
- helps to Commitment to continuous learning, and developing, that Increases the skills and the operational efficiency with constantly changing environment;
- helps to Commitment to continuous process improvement;
- Establish the safety plans which describe the safety works practices and its procedures to be followed by all workers and the training programs which should be conducted; and
- Statement the quality management procedures for all knowledge areas of the data centers [28].

B. The Purposed Data Centers Quality Cycle

When implemented this new quality methodology and managed automated by DCIM, the purposed flow chart when implement, operate, and maintenance the data centers could be as following table (see Figure 12).
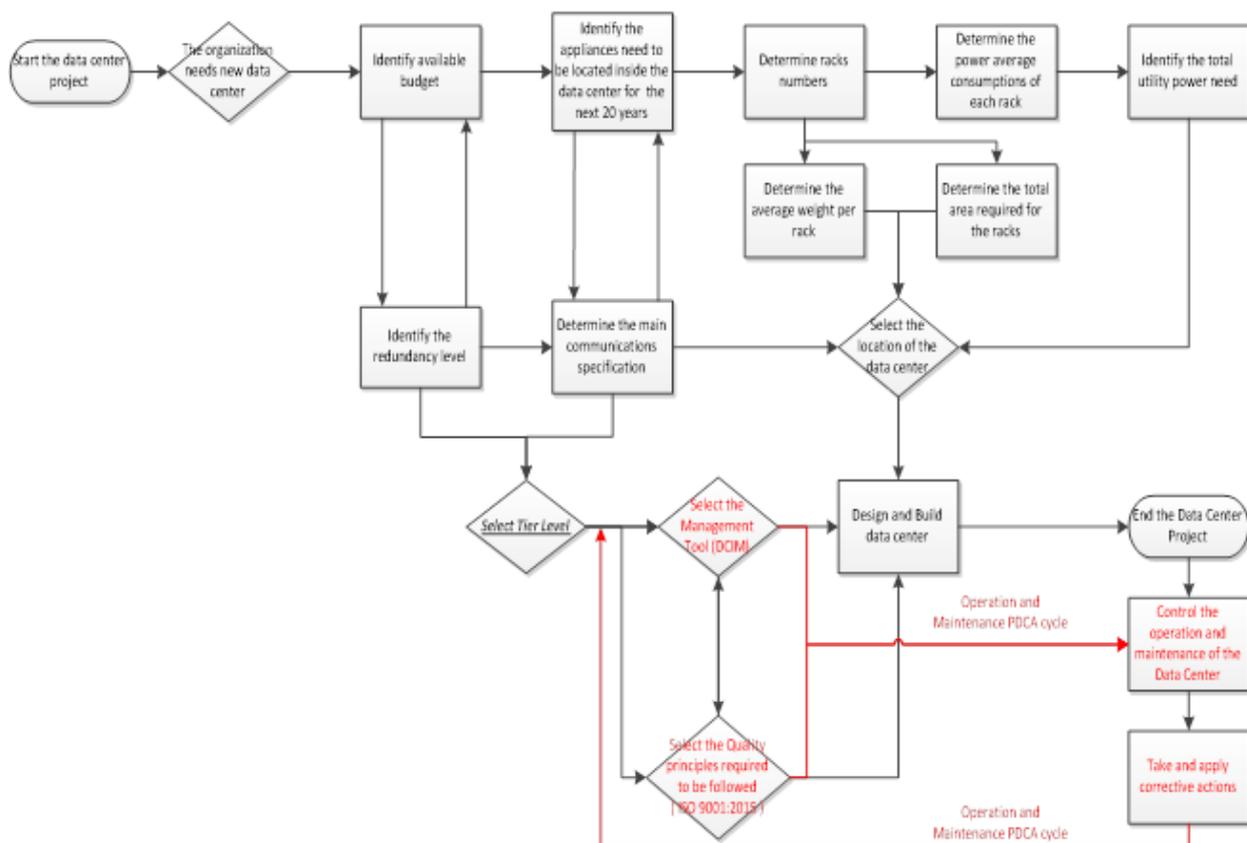

Figure 12: The Purposed Data Centers Quality Cycle

X. CONCLUSIONS

When built the new data center to be complying with recommendations of TIA942 to provide the required value of redundancy for all systems to prevent the unplanned outages which could be happened by device failure, also implement, operate, and maintenance the facility of the data center to be integrated with ISO9001:2015 principles and contained the procedures, methodologies, and the new generated practices for all data center's knowledge to prevent the unplanned outages which could be happened by human errors.

This solution will be managed by modern and automated technology platform like the Data Center Infrastructure Management system (DCIM) to automated actions required and enhancing all data center quality. All these actions will help to limit the reasons of unplanned outages and enhance the quality management of the data center.

The Proposed Solutions for the Reasons of Unplanned Outages of the Data Centers (see Table 4):

Table 4: Proposed Solutions for the Reasons of Unplanned Outages of the Data Centers

No.	The Reasons	Proposed Solutions
1	Human Errors	The Data Center's Knowledge Framework will be implemented, integrated, and comply with the Principles of ISO 9001:2015 (Customer focus, Leadership, Engagement of people, Process approach, Improvement, Evidence based decision making, and Relationship management)and managed by (DCIM) Platform
2	Device Failure	1- Select the required Redundancy level then suitable Tier level 2- Perform fully maintenance plan 3- Comply with Principles of ISO 9001:2015 (Customer focus, Leadership, Engagement of people, Process approach, Improvement, Evidence based decision making, and Relationship management)
3	Weather/Natural disaster	Build another Disaster Recovery (DR) data center, the DR data center will prevent the unplanned outage which could be affected on the main data center due to the weather/natural disaster

The Benefits of this solution will be as following:

- The DCIM tool Helps for making an automated Standard Operating Procedures ((SOP)) as a part of the Data Center Management tools and used by all Data Center operators, A Data Center Standard Operating Procedures (SOPs) would have multiple sections:
  o Methods of Statements (MOS) for all maintenance and all operations works (at Method of Procedure (MOP)),
  o the actions should be taken if one or more devices fails (at Method of Procedure (MOP)),
  o The back-up plans at the (MOP),
  o The disaster recovery plans at the (MOP),
  o The roll back plans at the (MOP),
  o All Service Level Agreement SLA for all devices with all teams even 3rd parties,
  o Secure access procedures,
  o As-build updated drawing for all Data Center's devices, appliances, data connection, communication mapping, etc.;
  o All appliances need from cooling, electrical, network, and space requirements;
  o Real-time monitoring using to make the error of the Data Center operations rarely.

- The DCIM tool is containing all the conditions of device failures and the root cause analysis of the failures and the analysis of equipment helps to either improve performance and prevent unexpected failures,
- The DCIM tool ensures the complying with the change management and all required approvals before any change to prevent any unplanned actions and ensuring from any action and how it is complying with the approved action plan order, and this approved work

order is containing What the actions must be taken and by whom,
- The DCIM tool is containing all updated and approved procedures, all these procedures are updated annually at least,
- The DCIM tool is containing all updated training programs,
- The DCIM tool Records all Data Center assets moves, additions, and changes for all servers, networks, equipment, and device. this record could to be manual in small scale Data Center and must be automated in the large-scale Data Center;
- The DCIM tool containing the racks capacity and the required expansion,

  o The DCIM tool Identifies all racks data such as:
  o Rack location,
  o Rack full 3D view,
  o The appliances located inside,
  o The connections between this rack and other racks with identifying labels,
  o The required capacity of electrical and cooling,
  o The existing value of cooling and electrical consumptions,
  o The U position, data outlets, and power outlets which are used and free; and
  o The disaster recovery plans for all racks, applications, servers, infrastructure devices, and etc.;

- The DCIM tool is Monitoring, managing, planning, reporting and controlling the infrastructure system components;
- The DCIM tool Previews the power chain circuits and could make a fault simulation;

- The DCIM tool is making all alarms' actions could to be Configurable, this process help for automated the actions that required to be done after each alarm to reduce the fault effect and shortage the time of repair. These actions could to be calling the supplier, operate the back-up devise, increase the fan speed of another cooling units, etc.;
- The DCIM tool Tracks and monitors the utilization and capacity of resources, such as for example electrical power, energy efficiency, total Data Center availability, total available space required for new appliances and services, and all cooling capacity consumed and needed; and
- The DCIM tool is making all reports could to be visualized data and in easily and quickly ways.

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REFERENCES

[1] Understanding the cost of data center downtime - Anixter.com.(n.d.).from https://www.anixter.com/content/dam/Suppliers/Liebert/White%20Paper/Downtime%20-%20data-center-uptime_24661-R05-11.pdf. (n.d.);

[2] Industry, V. (2016, January 25). Average cost of a data center outage.from https://datacenterfrontier.com/average-cost-of-a-data-center-outage/. (n.d.);

[3] 2013 cost of Data Center outages final 12 - Ponemon Institute. (n.d.);

[4] [4] Framework of Knowledge Management, data mining and IDSS withknowledge.(n.d.).fromhttps://www.researchgate.net/figure/Framework-of-knowledge-management-data-mining-and-IDSS-with-knowledge-warehouse_fig2_228726162. (n.d.);

[5] Uptime Institute (2010) Data Center Site Infrastructure - Tier Standard: Operational Sustainability, Uptime Institute Professional Services, LLC New York pp. (n.d.);

[6] Heslin, K. (2014, September 24). Data Center outages, incidents, and industry transparency. (n.d.);

[7] Payton, S. (2016, October 15). HOW DCIM impacts DC infrastructure outage reduction– HOW DCIM impacts DC infrastructure outage reduction. (n.d.);

[8] 13, R. (2010, August 13). How to prevent downtime due to human error.from https://www.datacenterknowledge.com/archives/2010/08/13/how-to-prevent-downtime-due-to-human-error. (n.d.);

[9] Condition-based maintenance for Data Center Operations

[10] Management. (n.d.). from https://www.intechopen.com/chapters/73642. (n.d.);

[11] TIA-942 (2014) Telecommunications Infrastructure Standard for Data Centers, Telecommunications Infrastructure Association ANSI/TIA-942-March 2014, Arlington VA pp. 1 – 99. (n.d.);

[12] W. P. Turner IV, P. Seader and K. Brill, "Tier classification define site infrastructure performance", Uptime Inst., 2006. (n.d.);

[13] 06, S. (2018, October 04). Data Center Design: Which standards to follow?from https://www.datacenterknowledge.com/archives/2016/01/06/

[14] TIA 942 standard and the tier. (2019, March 10). from https://blogs.salleurl.edu/en/tia-942-standard-and-tier. (n.d.);

[15] Olive.zhao, Wissal, Little_fish, Maithi, VinceD, Anno7, . . . Thisu. (n.d.). Disaster Recovery Solution Architecture. from https://forum.huawei.com/enterprise/en/disaster-recovery-solution-architecture/thread/781997-891. (n.d.);

[16] Wiboonrat, M. (2018). Knowledge management in data center project lifecycle. 2018 Annual IEEE International Systems Conference (SysCon), 1-6. (n.d.);

[17] Sawhney, Jyoti & Raisinghani, Mahesh & Idemudia, Efosa. (2018). Quality Management in a Data Center: A Critical Perspective. (n.d.);

[18] About us | Anixter. (n.d.). Retrieved June 18, 2022, from https://www.anixter.com/en_us/about-us.html. (n.d.);

[19] Data Center Infrastructure Management (DCIM). (2020, July 17). from https://www.ecoxplore.com/data-center-infrastructure-management/. (n.d.);

[20] (n.d.), from https://novacontext.com/dcim-for-dummies/index.html. (n.d.);

[21] (DCIM) datacenter infrastructure management - ABB. (n.d.).from https://new.abb.com/docs/librariesprovider56/nieuws-in-de-benelux/7---arto-lind-rev1.pdf?sfvrsn=5aa16f14_2. (n.d.);

[22] Angara, J. (2022, June 10). Introduction to international data center standards. from https://www.akcp.com/blog/introduction-to-international-data-center-standards/. (n.d.);

[23] ISO 9000:2005(EN), Quality Management Systems ? fundamentals and vocabulary. (n.d.). from https://www.iso.org/obp/ui/#!iso:std:iso:9000:ed-3:v1:en. (n.d.);

[24] ISO 15378:2017(EN), primary packaging materials for medicinal products ... (n.d.). from https://scc.isolutions.iso.org/obp/ui#!iso:std:iso:15378:ed-4:v1:en. (n.d.);

[25] The PDCA cycle and the ISO 9001:2015 Standard. (2017, April 17). from http://9001quality.com/plan-do-check-act-pcda-iso-9001/. (n.d.);

[26] Quality Management principles - ISO. (n.d.). from https://www.iso.org/files/live/sites/isoorg/files/store/en/PUB100080.pdf. (n.d.);

[27] The Ultimate Guide to ISO 9000. (n.d.). from https://www.smartsheet.com/ultimate-guide-iso-9000. (n.d.);

[28] How the 8 quality management principles of ISO 9001:2015 impact data ... (n.d.). from https://info.pcxcorp.com/blog/how-the-8-quality-management-principles-of-iso-90012015-impact-data-center-construction. (n.d.); and

[29] The 12 essential elements of data center facility operations. (n.d.). from https://go.schneider-electric.com/rs/178-GYD-668/images/The_12_Essential_Elements_Data_Center_Facility_Operations.pdf?tsk=75513P&pc=47163T&. (n.d.)