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Operational Analysis of the Maintenance Structure of Special Public Services in Nigeria

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Abstract

Basically, Maintenance culture is one of the key indices in any institution. While the operational activities determine the range of institutional activities, the framework, personnel and productivity are crucial towards attaining the set vision of the institution concerned. This work is to discuss the maintenance services of the Nigerian public service, with special emphasis on the Nigerian Air force activities using risk structure of air safety flight operations to do the analysis and review as a mini- Risk –informed case model. It is imperative to understand that the period under review and analysis of the Air force maintenance operation is between the year 2015 and 2023.

Keywords: *Risk, Maintenance, Integrity and Efficiency*

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Background to the Study

The Institute of Risk Management (IRM) defines risk as the combination of the probability of an event and its consequence. Consequences can range from positive to negative. This is a widely applicable and practical definition that can be easily applied. While, the international guide to risk-related definitions is ISO Guide 73 and it defines risk as 'effect of uncertainty on objectives. Guide 73 also notes that an effect may be positive, negative, or a deviation from the expected. These three types of events can be related to risks as opportunity, hazard or uncertainty. The guide notes that risk is often described by an event, a change in circumstances, a consequence, or a combination of these and how they may affect the achievement of objectives. Also, the Institute of Internal Auditors (IIA) defines risk as the uncertainty of an event occurring that could have an impact on the achievement of objectives. The IIA adds that risk is measured in terms of consequences and likelihood.

Hopkin (2010), states that, Risk in an organizational context is usually defined as anything that can impact the fulfilment of corporate objectives. However, corporate objectives are usually not fully stated by most organizations. Costard (2008) defines Risk as the likelihood of occurrence and the magnitude of consequences of a specified hazard being realized. In addition, Holton (2004) in a paper on defining risk, argues that there are two ingredients that are needed for risk to exist. The first is uncertainty about the potential outcomes from an experiment and the other is that the outcomes have to matter in terms of providing utility. Although, in 1921, a scholar Frank Knight established the difference between Risk and Uncertainty. His views states as follows "risk that is measurable is easier to insure but we do care about all uncertainty, whether measurable or not".

Furthermore, Risk is incorporated into so many different disciplines from insurance to engineering to portfolio theory that it should come as no surprise that it is defined in different ways by each one. It is worth looking at some of the distinctions:

a. Risk versus Probability: While some definitions of risk focus only on the probability of an event occurring, more comprehensive definitions incorporate both the probability of the event occurring and the consequences of the event. Thus, the probability of a severe earthquake may be very small but the consequences are so catastrophic that it would be categorized as a high-risk event.
b. Risk versus Threat: In some disciplines, a contrast is drawn between risk and a threat. A threat is a low probability event with very large negative consequences, where analysts may be unable to assess the probability. A risk, on the other hand, is defined to be a higher probability event, where there is enough information to make assessments of both the probability and the consequences.
c. All outcomes versus Negative outcomes: Some definitions of risk tend to focus only on the downside scenarios, whereas others are more expansive and consider all variability as risk. The engineering definition of risk is defined as the product of the probability of an event occurring, that is viewed as undesirable, and an assessment of the expected harm from the event occurring.

Risk Identification

How can you identify the causes and effects of the risks in your company?

What can happen?

i. In this first stage of the methodology, the possible specific causes of business risks are identified in a systematic manner, together with the range and possible effects thereof, which an entrepreneur must confront.
ii. The proper identification of risks calls for a detailed knowledge of the company, of the market in which it operates, of the legal, social, political and cultural environment in which it is set.
iii. Risk identification must be systematic and begin by identifying the key objectives of success and the threats that could upset the achievement of these objectives.

However, Hilber (2005) in his research work on reliability indices for maintenance of networks, used Johansson (1997) model to explain the concept of maintenance structure. Which is shown in figure 1 below in the maintenance process different phases.

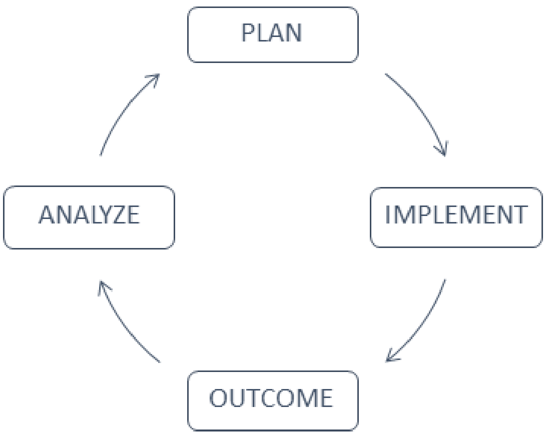

Figure 1: Maintenance Process Different Phases

The concept outlined that; the maintenance plan coordinates all parts of the total maintenance. Hence, the plan is based on the organizations goals and shall grant that the goal can be achieved, at least with regards to aspects affected by maintenance. Though, the plan can be viewed as a tool for the organization to reach objectives. While the implementation phase is the phase where the "physical" maintenance is performed and it consists of corrective maintenance, preventive maintenance, condition monitoring, modifications, replacements, data collection (regarding failures, costs, etc...).

Thus, the outcome can be seen as a result of the implementation and gives an indication of total system reliability and maintenance costs. The analysis of the outcome involves identification of extreme maintenance and interruption costs and to link technical causes to the achieved outcome. The outcome gives information that can be analyzed in order to enhance the maintenance plan. The analyzation phase involves development of new or modified procedures and for example to investigate whether it is economical beneficial to replace certain parts of the equipment.

Though, according to Association for Manufacturing Technology (AMT) Maintenance Can Improve Asset Reliability. This happens when improving reliability boils down to minimizing the frequency of unplanned downtime events. Organizations use a range of maintenance techniques to reduce the frequency of unplanned downtime including:

i. Planned corrective maintenance (CM)
ii. Preventive maintenance (PM)
iii. Condition-based maintenance (CbM)
iv. Predictive maintenance (PdM)

While ISO55000, defines an asset as an item that has potential or actual value to a company. These assets may fall into different classes. They may tangible, which are the products you produce and the equipment you use, or intangible, which encompasses your reputation, image, social conscience, etc., or financial concerns, such as costs, investment and performance. However, according to Optimal's Asset-Reliability-as-a-Service ie ARAS, (2023), asset integrity management is an attempt to reduce or eliminate unplanned downtime. Since corrosion is a major cause of these costly incidents, asset integrity management includes corrosion management as a key component.

According to an online asset integrity management firm, arcweb, Asset Integrity Management (AIM) is a term used to describe the practice of managing an asset (power plant, oil rig, refinery, etc) to ensure its ability to perform its function effectively and efficiently is maintained. Well run AIM strategies ensure that the people, systems, processes and resources that enable an asset to deliver its function are in place over the life cycle of the asset, while simultaneously maintaining health and safety and environmental legislation. AIM applies to the entirety of an asset's operation, from its design phase to its decommissioning and replacement.

In addition, oil and gas IQ, an asset integrity management firm, explains Asset integrity, or asset integrity management systems (AIMS) as the term for an asset's capacity to run effectively and accurately, whilst also protecting the wellbeing of all personnel and equipment with which it interacts – as well as the measures in place to assure the asset's life cycle. Asset integrity applies to the entirety of an assets operation, from its design phase to its decommissioning and replacement.

This entails the constant business challenge for asset integrity managers on how to balance the designing, maintenance, and replacement of assets throughout their life cycle with the costs to business – in terms of finance, time, and resources. At its heart, it is the managing of the degradation of assets.

Furthermore, oil and gas IQ, explained that there are elements that affect asset integrity management. It itemized these elements as follows below:

Human element, asset integrity is built on a belief that the majority of people within the institution will do things properly, and however optimistic that may sound, most of the time maintenance, inspection, and data management is conducted with the best of intentions.

Thus, signs that things may not all be well in the world of asset integrity management and inspection can include:

1. Team members feel like any concerns they have about health and safety or the state of equipment are not being taken seriously, leading to an environment in which faults are not even reported.
2. Any changes made to asset integrity plans, or even basic running of the facility, only occur after a large-scale incident.
3. A lack of understanding around how to find root causes from simple fault reports, often resulting in people being lulled into a false sense of security and overstating the level to which the facility is safe and operational.
4. There is a reliance on tacit understanding, rather than a tangible and easily accessible set of rules surrounding AIM and reporting faults.
5. There is a lowest-bidder attitude surrounding maintenance contractors, and knowledge of and enthusiasm for asset integrity isn't valued particularly highly.

Risk Based Inspection (RBI), RBI, or risk-based inspection is one such method – whereby one must balance risk reduction with the minimum amount of effort required to streamline the process and free up more time. However, there are a near-infinite number of ways in which to carry our maintenance – and with many risks (such as calibration uncertainty or equipment accessibility) quantification is simply not possible. Therefore, each company must decide how far along the quantitative/qualitative scale it sits; whether to rely more heavily on experts, or statistics. Hence, for every easily-identifiable symptom of corrosion or asset instability, there are dozens of hidden issues: hydrogen attack, high-temperature tempering, thermal fatigue, metallurgy issues, internal system corrosion, and so on – and without dedicated and experienced professionals, implementing damage mitigation techniques is next to impossible. Once one has identified the need for thorough inspection, the next step is to enact it. Identifying damage conditions and the factors that alter them. Here, issues such as temperatures increases or decreases in operating environment with regards to rate of degradation, contaminations of any kind or source, basic strain that is evaluating stress inherent to the operation.

According to Centre for Chemical Process Safety of American Institute of Chemical Engineers (AIChE), asset integrity is the systematic implementation of activities, such as inspections and tests necessary to ensure that important equipment will be suitable for its intended application throughout its life. Where work activities related to this focuses on two area namely:

i. Preventing a catastrophic release of a hazardous material or a sudden release of energy.
ii. Ensuring high availability (or dependability) of critical safety or utility systems that prevent or mitigate the effects of these types of events.

It explained that maintaining containment of hazardous materials and ensuring that safety systems work when needed are two of the primary responsibilities of any facility. While it is imperative to note that, asset integrity activities range from technical meetings involving experts seeking to advance the state-of-the art in equipment design, inspection, testing, or reliability, to a plant operator on routine rounds spotting leaks, unusual noises or odors, or detecting other abnormal conditions.

However, asset integrity activities involve the following mainly. They are:

i. Inspections, tests, preventive maintenance, predictive maintenance, and repair activities that are performed by maintenance and contractor personnel at operating facilities.
ii. Quality assurance processes, including procedures and training, which underpin these activities.

Although, at an operating facility, the asset integrity element activities are an integral part of day-to-day operation involving operators, maintenance employees, inspectors, contractors, engineers, and others involved in designing, specifying, installing, operating, or maintaining equipment.

In addition, asset integrity operations are expected to produce the following outputs. They are:

1. Reports and data from initial inspections, tests, and other activities to verify that equipment is fabricated and installed in accordance with design specifications and is fit for service at startup.
2. Results from ongoing ITPM tasks, performed by trained or certified personnel and based on written procedures that conform to generally accepted standards, that help ensure that equipment remains fit for service.
3. Controlled repairs and adjustments to equipment by trained personnel using appropriate written procedures and instructions.
4. A system to control maintenance work, repair parts, and maintenance materials needed for the work to help ensure that equipment remains fit for service.
5. A quality assurance program that helps prevent equipment failures that could result from
    I. Use of faulty parts/materials.
    II. Improper fabrication, installation, or repair methods.

The main objective of asset integrity is to help ensure reliable performance of equipment designed to contain, prevent, or mitigate the consequences of a release of hazardous materials or energy. While a proper execution of asset integrity activities requires a high level of human performance, with the ultimate work output being in reliable and predictable equipment operation.

However, AIChE, states that an effective asset integrity depends on management ensuring the following. They are:

1. Equipment and systems are properly designed, fabricated, and installed.

2. The unit is operated within the design limits of the equipment.
3. ITPM tasks are conducted by trained and qualified individuals using approved procedures and completed as scheduled.
4. Repair work conforms to design codes, engineering standards, and manufacturer's recommendations.
5. Appropriate actions are taken to address deficiencies, regardless of how they are discovered.

According to Openlearningworld.com, an online educational review site, the performance of a system can be measured by two factors, viz., the efficiency and the effectiveness. The efficiency indicates the manner in which the inputs are used by the system. Being efficient means the system uses inputs in a `right' way. If the input-output ratio is adverse, we say that the system is inefficient though it produces the desired output. Thus, its effectiveness is the measure for deciding whether the system provides the desired output or not. On the overall, a system has to be effective and efficient for the highest utility to the user of the system.

Banton (2022) defined efficiency as a measurable concept that can be determined using the ratio of useful output to total input. Increased efficiency minimizes the waste of resources such as physical materials, energy, and time while accomplishing the desired output. Which is measurable and can be expressed as a ratio or percentage. Thus, expressed mathematically below as

$$Efficiency = \frac{Output}{Input} \quad known\ as\ equation\ (1)$$

It went further to note the types of efficiency. They are listed below as follows:

1. Economic efficiency, which refers to the optimization of resources to best serve each person in that economic state.
2. Market efficiency, which describes how well prices integrate available information. This means that markets are efficient when all information is already incorporated into prices.
3. Operational efficiency, which measures how well profits are earned as a function of operating costs. The greater the operational efficiency, the more profitable the firm or investment.

In addition, it described the impacts of efficiency as is an important attribute because all inputs are scarce. Hence, an efficient society is better able to serve its citizens and function competitively. Efficiency reduces hunger and malnutrition because goods are transported farther and quicker. Advances in efficiency also allow greater productivity in a shorter amount of time.

Dincer and Bincer (2020), defined efficiency as a measure of performance and effectiveness of a system or component. The main approach to define efficiency is the ratio of useful output per required input. Thus, efficiency assessment is critical for energy systems and it is broadly utilized for any systems and processes. As a result, if the efficiency definition is based on the first law of thermodynamics, it is termed energy efficiency. While, if the efficiency definition is based on the second law of thermodynamics, then it is termed exergy efficiency.

This mathematically expressed as the following below:

$$\eta_{en} = \frac{\Sigma \text{ E.useful}}{\Sigma \text{ E.input}} \quad \textit{known as Equation } (2)$$

Wills and Finch (2016) defined efficiency as a measure of performance and effectiveness of a system or component. The main approach to define efficiency is the ratio of useful output per required input. If the efficiency definition is based on the first law of thermodynamics, it is termed energy efficiency.

Materials and Methods

Table 1: Break-Down of Risk Structure of Safety Air Flight Operations

Air Operational Activities	Origin of Hazard	Consequences
Drills and Maintenance	Natural Hazards	Health
Training	Manmade Threads	Economic
Rehearsals	Technical and Technological Hazards	Socio-Economic
Combat Operations		Environmental

Basically, every operations have its own structure. Thus, for the purpose of this work, this risk structure of air safety flight operations will be adopted to do the analysis and review as a mini-Risk –informed case model. This segments flight operation activities into three categories namely:

i. Air operational activities
ii. Origin of hazard
iii. Consequences

Results and Discussions

Table 2: Summary of Nigerian air force Operational Incidents between 2015 and 2023

REF	Facility	Number of Causalities	Type of Hazard Witnessed
3. 01	Airport Emergency Landing at Lagos airport	None	One of their jets lost its tyre
3. 02	Airport crash shortly after take- off from the Nnamdi Azikwe International Airport	7 NAF personnel	Death and Equipment wreckage
3. 03	Airport crash involving two pilots	Two pilots	Human disappearance and Equipment wreckage
3. 04	Military Beachcraft 350 aircraft crashed at the Kaduna, International airport.	Eleven people	Death and Equipment wreckage
3. 05	Alpha Jet Aircraft crashed in Zamfara	Unknown	Human disappearance and Equipment wreckage
3. 06	A trainer aircraft crashed in Kaduna	Two pilots	Death and Equipment wreckage
3. 07	Air force plane crash in Kaduna	Seven persons	Death and Equipment wreckage
3. 08	An F-7NI jet crashed	One person	Death and Equipment wreckage
3. 09	Augusta Westland 101 Helicopter crashed in Makurdi	Unknown	Equipment wreckage
3. 10	NAF Augusta 109 Light Utility Helicopter crashed in Borno River	None	Equipment wreckage
3. 11	Two F-7Ni aircraft crashed in abuja	One person	Death and Equipment wreckage
3. 12	NAF Mi-35M crashed near Damasak, Borno State.	Five persons	Death and Equipment wreckage
3. 13	NAF helicopter crashed while landing in Katsina State	None	Equipment wreckage
3. 14	NAF aircraft RV-6A Air Beetle crashed near Kaduna	Two persons (Pilot and Instructor)	Death and Equipment wreckage
3. 15	A Helicopter of the NAF crashed at the Enugu NAF base	None	Equipment wreckage

From the above, it clearly shows that between 2015 and 2023, the Nigerian air force witnessed fifteen key incidents. Whereby four incidents had no causality during occurrence. Five pilots were lost during this period in operational activities. While one instructor's life was claimed during the period under review. Seven personnel staff of the Nigerian air force lost their lives during this period. While fifteen people of different categories also lost their lives. Although, two operations are still under exhaustive review process with unknown number of causality. On the part of Asset and human management, the operations witnessed eight incidents of both human death and equipment wreckage. Though, with four incidents of equipment wreckage only. While it had two incidents of human disappearance and equipment wreckage, and one incident of tyre break-down and loss.

Table 3: Analytical Review of The Break-Down of Risk Structure Safety Air Operations

S/N	Risk Structure Analysis	Number of Incidents
1	Drills and Maintenance	Four
2	Training	Three
3	Rehearsals	One
4	Combat Operations	Seven
1	Natural Hazards	Two
2	Manmade Threads	Six
3	Technical and Technological Hazards	Seven
1	Health	At least eight
2	Economic	Fifteen
3	Socio- Economic	Fifteen
4	Environmental	Fourteen

From the method adopted earlier in materials and method, the risk structure analysis of Nigerian air force activities between 2015 and 2023 shows that during air safety operation, drills and maintenance recorded four safety hazardous incidents. Three safety hazardous incident were observed during training activities. Rehearsals witnessed one incident while combat operations recorded seven incidents.

On the origin of the hazard incidents, natural hazards were responsible for two incidents. While manmade threads were responsible for six incidents. Just as Technical and technological hazards were responsible for seven incidents. On the consequence of the operational incidents, the health issues that were involved were in eight incidents of air flight operations. While, economic concerns were in all fifteen incidents. Just as the socio-economic details were raised in all fifteen incidents. While environmental concerns were in fourteen incidents only.

Conclusions

However, recall that risk structure of air safety flight operations was adopted to do the analysis and review as a mini- Risk –informed case model. Hence, from the review of the break-down of the risk air operations structure and flight operational incidents of the Nigerian air force between 2015 and 2023. It shows that Nigerian air force operations, observed some basic safety principles during operational activities. Although there is the need for integration of more elements into key components of the management facilities on asset integrity and maintenance to enhance reliability and efficiency in its operations. The institution can assess the AIChE principles of asset integrity, while integrating more RBI to enhance asset reliability and efficiency. Also, the Hiber reliability indices for maintenance and Johansson model for maintenance structure should be used in the evaluation of Nigerian air force safety flight operation. This will not only sustain a global practice of asset maintenance and reliability but will set a standard in its overall operational activities thereby increasing productivity and quality service delivery.

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