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# Effectiveness of maintenance approaches for High Reliability Organizations

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**Abstract**: In recent years companies are paying more attention on Business Continuity Management. BCM focuses both on potential threats identification and on management of unexpected block process. These two aspects are the basis of High Reliability Organization. The HRO paradigm was developed several years ago in high-risk organizations. It integrates two relevant approaches: preventing unexpected events and resilient organizations. The aim of this study is to define a rough but effective approach to support HROs in evaluating their most "compliant" maintenance approaches. The main phases of the study are: the identification of the main HRO features (both prevention and resilient ones), the identification of the main maintenance approaches used to date and finally the evaluation of their compliance according to HRO features. The paper presents a new method to evaluate the different maintenance approaches: in addition to productivity, it's also considered the necessity to guarantee production continuity following unpredictable events.



*Keywords:* High Reliability Organizations, Maintenance Approaches, Reliability, critical analysis

## 1. INTRODUCTION

Business continuity is becoming relevant for companies (Giacchero et al., 2013). Firms have to provide products (or services) even in the case of unexpected events. Business continuity management considers risk factors and actions for preventing them efficiently and quickly. These two aspects are the basis of High Reliability Organization paradigm. This paradigm was developed by a group of researchers at the Barkley campus of University of California (Rochlin et al, 1987) (Hopkins, 2007). The HRO paradigm has been applied to promote and ensure safety in complex conditions; it proposes a more optimistic mind-set from what has been pointed out by Perrow's pessimistic contribution (Perrow, 1984, Hopkins, 1999) defining that accidents characterized by tight coupling and interactive complexity will be normal or inevitable as they often cannot be foreseen or prevented. The HRO point of view, instead, argued that high-hazard organizations can safely operate although a high level of complexity (Weick et al., 1999). The integration of preventive and resilient approaches is the pillar of the HRO paradigm in safety management (Schulman, 2004). The aim of the study is to evaluate how current maintenance strategies "fit" the HRO paradigm; the analysis will support a more clear comprehension of impacts derived by the HRO paradigm application in complex companies. The paper is organized as follows: in section 1 and 2, the HRO paradigm is described. In section 3 a first analysis about how HRO features could be "translate" to the maintenance field is proposed. Next, the definition of the main maintenance approaches and the "rough" analysis about how each approach is compliant with HRO paradigm, are proposed in sections 4 and 5.

## 2. "HIGH RELIABILITY ORGANISATIONS" PARADIGM: A BRIEF SUMMARY

A recent definition of the HRO paradigm is: "These are a family of organizations that operate continuously under trying conditions and have fewer than their fair share of major accidents. These high reliability organizations practice a form of organizing that reduces the brutality of audits [accidents] and speeds up the recovery process" (Weick & Sutcliffe, 2007). Two main pillars characterize HROs (Saleh, 2010), such as:

The Prevention approach: Prevention requires that organisational members try to anticipate and identify the events and occurrences that must not happen, identify all possible precursor events that may lead to them and then create a set of procedures for avoiding them (Schulman, 2004). One limitation is that you cannot write procedures to anticipate all the situations and conditions that shape people's work. Moreover, even if procedures could be written for every situation, there are costs of added complexity that come with too many rules. This complexity increases the likelihood that people will lose flexibility in the face of extensive rules and procedures. Reliability is far broader: it requires resilience as well as prevention (Sutcliffe, 2011);

The Resilience approach: HROs are unique in that they understand that reliability is not the outcome of organisational invariance, but rather, results from a continuous management of fluctuations in job performance and human interactions (Weick et al., 1999) (Schulman, 2004). The essence of resilience is the intrinsic ability of an organisation (team, unit, system, etc.) to maintain or regain a dynamically stable state, which allows it to continue operations in the presence of a continuous stress and/or after a major mishap (Sutcliffe & Vogus, 2003). An HRO is not


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error-free but that errors do not disable it. HROs prevent and manage mishaps before they can spread throughout the system, thus, causing widespread damage or failure. These abilities are generally traced to dynamic organising principles (Weick et al., 1999). HROs have mechanisms for monitoring and reporting small signals that the system may be breaking down. Furthermore, they have the flexibility and the capabilities to respond in real time, reorganising resources and actions to maintain functioning in spite of failures (Sutcliffe, 2011).

### *2.1 Basic characteristics of High Reliability Organisations*

Lekka (2011) suggest a mind map depicting HRO characteristics as an overarching organising framework: the proposed mind map identifies five categories except for the "definition" one, of HRO features as depicted in Figure 1 and described in Table 1.


Figure 1. Mind Map of High Reliability Organization processes and characteristics (source Lekka, 2011)

Table 1: HRO categories and main features

| HRO categories | Main features |
|---|---|
| **Just Culture:** it refers to a strategic approach that promotes both organizational learning and highly reliable operations | a. Open reporting system of near misses/accidents<br>b. Individual accountability<br>c. Abandon work on safety ground<br>d. Open discussion of errors |
| **Mindful leadership:** it refers to a strategic business orientation aiming to avoid both prevent quickly manage unexpected events with high consequence for company productivity. | a. Bottom up communication of bad news<br>b. Proactive Audits<br>c. Management by exception<br>d. Safety production balance<br>e. Engagement with front-line staff<br>f. Investment of resources |
| **Problem Anticipation:** it refers to the firm's capability of forecasting unexpected events that could heavily affect business continuity. | a. Preoccupation with failure<br>b. Reluctance to simplify<br>c. Sensitivity to operations |
| **Containment of unexpected events:** it refers to the firm's capability to respond quickly to unforeseen events and to contain its consequences. | a. Commitment to resilience<br>b. Defence to expertise/Oscillation between hierarchical and flat structures<br>c. Redundancy. |
| **Learning Orientation:** it refers to firms' activities that involves both preventive and resilient approaches. | a. Continuous Technical Training<br>b. Open Communication<br>c. Root Cause Analysis of accidents/incidents<br>d. Procedures Reviewed |

## 3. HRO COMPLIANT MAINTENANCE APPROACHES

In order to check if the main maintenance approaches identified are consistent with the "reliability-enhancing" HRO characteristics, the temporal sequence of HRO approaches was transferred from the safety field to the maintenance one. From the safety point of view, five temporal phases have been considered in the safety management process, and three "safety" critical events, that have to be managed, have been identified (alarms, near misses and accidents). The five temporal phases are described in Table 2.

Table 2. Temporal phases of Safety Management Process

| | |
|---|---|
| **Normal condition** | it's the phase in which business processes are carried out under normal conditions; in this phase HROs carry out monitoring and prevention activities |
| **Alarm** | it's the phase in which HRO identify and manage alarms for avoiding the happening of unexpected events. *Alarms* are all unsafe events, in terms of workers' behaviours or workplace conditions (Gnoni et al., 2013); |
| **Near miss** | it's the phase in which HRO identify, analyse and correct *Near Misses* to prevent accidents (Gnoni et al., 2013); |
| **Accident** | it's the phase in which an *Accident* happens and HROs carry out resilient activities to contain the negative consequences; |
| **Post-accident** | it's the phase in which HROs carry out root causes analysis to learn from unexpected events occurred to improve prevention activities. |

As shown in Figure 2, the HRO prevention approach is developed in four temporal phases, such as Normal Condition, Alarms, Near Miss and Post-Accident; on the other hand, the HRO resilient approach is applied only in the Accident phase.

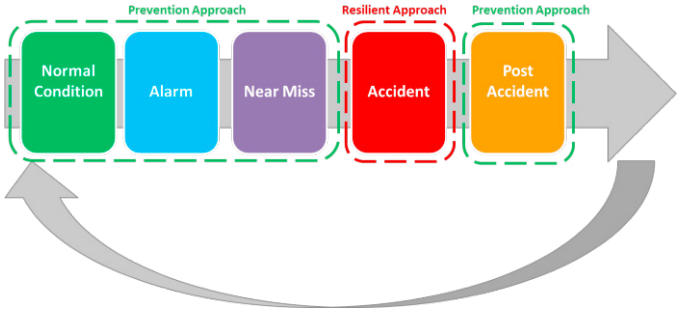


Figure 2. Temporal sequences of HRO approaches

Similarly to the safety field, from the maintenance point of view, the main temporal phases of its process have been defined; these are Normal Condition, Alarms, Anomalies, Fault e Post-Fault. The HRO resilient approach is present in the Fault phase, while the HRO prevention approach is typical of the other phases. Also in this field, three "maintenance" critical events have been identified (Alarms, Anomalies, Fault); these are described in Table 3.

Table 3. Description of Maintenance critical events

| Event | Description |
|---|---|
| **Alarm** | which are unexpected changes of the parameters of a machine that does not involve operating anomalies, but if not managed, could generate them; |
| **Anomalies** | which are deviations from the normal operation of the machine that involve process deviations, symptomatic of a machinery malfunction; |
| **Faults** | which are damages or breakages, which compromise the regular functioning of a machine, generating its stop. |

In this step of the work is important to identify both operational and strategic HRO features. A framework proposal is summarized in Figure 3: the strategic HRO features are transversal to all the five phases. The proposed framework will be used to evaluate how maintenance approaches meet the several HRO features based on a specific process phase.

In accordance with the proposed framework, three levels of compliance have been introduced for assessing how each maintenance approach is compliant to both operational and strategic HRO characteristics, such as:

- *Low*: the feature is present in the analysed approach by definition, but it's not examined in depth, or to which the approach is compliant only as a support;
- *Medium*: the feature is present in the approach with relative importance;
- *High*: the feature is present in the approach and is emphasized as one of the main pillars.

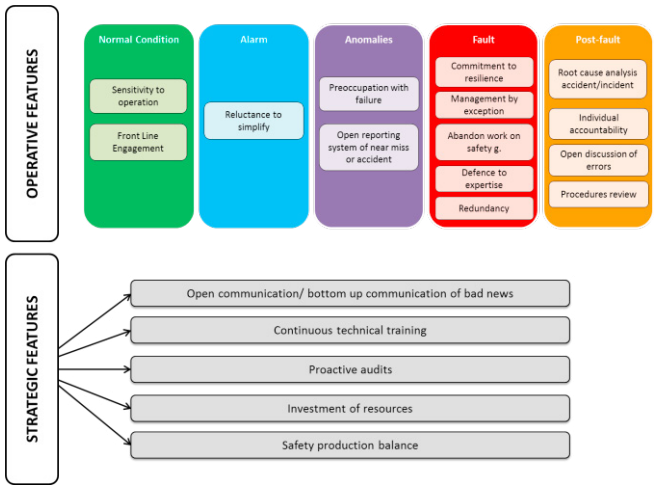


Figure 3. HRO features organized in the maintenance process

## 4. MAINTENANCE APPROACHES FEATURES

The international scientific literature has been studying maintenance approaches for a long time. Garg et al. (2006) proposed a critical analysis of the current maintenance approaches today applied. These are showed in Table 4.

Table 4 The main maintenance approaches analysed

| Maintenance approach | Main features |
|---|---|
| **Preventive Maintenance (PM)** | Its aim is to avoid as much as possible the occurrence of failures. PM activities are scheduled according to predetermined time intervals or criteria (*UNI EN 13306, Maintenance—Terminology.*, 2010). PM activities can be also scheduled simultaneously to corrective maintenance (Opportunistic Maintenance) (Di Dio et al., 2013) |
| **Condition Based Maintenance (CBM)** | It is a type of PM that considers the real health status of the system or component, thanks to monitoring or inspection (UNI EN 13306, Maintenance—Terminology., 2010) (Legát et al., 1996) |
| **Total Productive Maintenance (TPM)** | Is a Japanese maintenance approach focused on eight key elements (Nakajima and Bodek, 1988): *autonomous maintenance* (Bhadury, 2000), *focus improvement*, *planned maintenance*, *Quality Maintenance* (Ollila and Malmipuro, 1999), *TPM in offices*, *Development Management*, *Education and training*, *Safety Health and Environment*. |
| **Reliability Centred Maintenance (RCM)** | It considers reliability as focus to define maintenance plans. Smith (1993) summarizes its key features. |
| **Maintenance Outsourcing (MO)** | Maintenance activities are committed to external parties that are able to carry out maintenance effectively and efficiently. |
| **Effective Centred Maintenance (ECM)** | Pun et al. (2002) present the main features of ECM that is based on four key points: people participation, maintenance strategy, quality improvement and utilization of performance index to monitor maintenance improvements |
| **Strategic Maintenance Management (SMM)** | It derives from need to define a maintenance-oriented approach to a long-term strategic vision (Murthy et al., 2002). Its key features are the study of systems' mechanism degradation through data analysis and the use of mathematical models to evaluate the different maintenance strategies and to choose the optimal one |
| **Risk-Based Maintenance (RBM)** | It derives from will to consider maintenance and safety as linked elements, like suggested by some authors (Arunraj and Maiti, 2007) (De Carlo et al., 2011). |

## 5. CROSS ANALYSIS OF HRO FEATURES AND MAINTENANCE APPROACHES

The evaluation of each maintenance approach according to HRO features has been done using, as support, interviews to sector's experts; their judgments have been improved using analytical procedures. The assessment grid obtained for the operational HRO features is shown in Figure 4.

In the Normal Condition phase the first feature analysed is *Sensitivity to operation*; in CBM it has an average level as its focal point is to monitor system parameters, but it doesn't involve the worker vision for doing the "big picture". TPM, instead, is strongly compliant, in fact workers are directly involved in defining the operational status of the day; also ECM (medium level) incorporates this principle and uses performance indexes that allow to highlight any problem to solve. For *Engagement with front-line staff*, as mentioned above, the approaches that fully comply are TPM and ECM.

For the Alarm phase the characteristic evaluated is *Reluctance to simplify:* the most compliant approach is CBM as it analyses each slight overcoming of the threshold value of the monitored parameters; TPM is compliant (at a medium level) as workers have to manage also weak signals of malfunctioning, in particular in the start-up phase of a plant (Development Management). Also medium level is given to SMM and RBM, which, in order to make respectively a model of degradation and a potential risks analysis, have to consider any alarm of the system.

In the Anomalies phase, the first feature is *Preoccupation with failure:* TPM is strongly compliant thanks to the Quality Maintenance pillar; CMB has a high level of compliance thanks to the sensibility for managing effectively any deviations. The RCM is also highly compliant as it identifies and corrects anomalies, to preserve the overall system functionality. PM is on average compliant as it prevents faults only considering *MTBF;* it does not use anomalies or passed faults as informative source for preventing. Also ECM, SMM and RBM are typically compliant: the first is due to the use of TPM prevention policies (but not with the same efficiency), while the last two for the same reasons mentioned in the Alarms phase. The *Open reporting system* is present in TPM (Safety, Health and Environment) and ECM is highly compliant for the same reason.

| | Maintenance approach / HRO operative feature | PM | CBM | TPM | RCM | MO | ECM | SMM | RBM |
|---|---|---|---|---|---|---|---|---|---|
| Normal condition | Sensitivity to operation | - | M | H | - | - | M | - | - |
| | Eng. With frontline staff | - | - | H | - | - | H | - | - |
| Alarms | Reluctance to simplify | - | H | M | - | - | - | M | M |
| Anomalies | Preoccupation with failure | M | H | H | H | - | M | M | M |
| | Open reporting system | - | - | H | - | - | H | - | - |
| Fault | Commitment to resilience | - | - | H | - | H | M | - | - |
| | Management by exception | - | - | H | - | M | - | - | - |
| | Abandon work on s.g. | - | - | H | - | M | - | - | - |
| | Def. to expertise | - | - | H | - | H | - | - | - |
| | Redundancy | - | - | L | - | M | H | - | - |
| Post-fault | Root cause analysis | H | H | H | H | - | M | M | - |
| | Ind. accountability | - | - | H | - | - | M | - | - |
| | Open discuss. errors | - | - | H | - | - | M | - | - |
| | Procedures rev. | H | H | H | H | - | M | - | - |

Figure 4 Assessment grid of maintenance approaches according to HRO operational features (H=high, M=medium, L=low)

In the Fault phase *Commitment to resilience* is the first feature*:* MO is highly compliant, as, being this its core business, it's resilient to respond quickly for managing faults; TPM is also highly compliant as maintenance activities are made daily as needed (Autonomous Maintenance). ECM has medium level as, it needs to respond in resilient way to guarantee machines availability. High value were given to TPM for *Management by exception,* as this is a typical principle of lean thinking (workers' commitment and intervention only by exception); high value for MO, as the firm requiring service may act by exception on the work of the supplying firm, if needed (errors or dissatisfaction). *Abandon work on safety ground* is strongly present in TPM as workers are trained to have more attention for avoiding accidents (Safety, Health and Environment); also for MO, the firm requiring service has to protect the supplying firm in case of danger (medium level). High compliance for TPM and MO for *Defence to expertise:* the first underlines that operators are the most suitable to carry out maintenance activities (Autonomous Maintenance), while the second is chosen just for its expertise. The last feature is *redundancy:* a high level was estimated for ECM as it uses parallel systems to allow faults adjustment without stopping the productivity. MO shows a medium level as it should ensure these features because of its core business. Low level was been estimated for TPM, as lean concepts is in contrast with the redundancy feature (Focus improvement pillar).

For the Post-fault phase, the *Root cause analysis* is the first feature considered: PM is highly compliant, since it could consider the root cause of faults to better define the time interval between two actions. Also CBM and RCM have a high level: for CBM, for example, knowing that temperature is the root cause of a fault, it's possible to choose this parameter for the monitoring phase; also for RCM for the Functional Failure Analysis. High level is assigned to TPM thanks to the Quality Maintenance pillar. Medium level for ECM and SMM: ECM needs to identify all fault causes for preventing an availability reduction; similarly the study of degradation development (SMM) is assisted by the knowledge of real causes of degradation. The *Procedures review* feature is quite present in ECM (medium level) and in PM, CBM, TPM and RCM (high level). ECM is connected to it because of the process efficiency improvement, while PM, CBM and RCM for the phase of updating and improvement of procedures. TPM is highly compliant with procedures review thanks to the focus improvement pillar. Furthermore, TPM has a strong bond with the last two features of post-fault (*Individual accountability* and *Open discussion of errors)*: the operator's involvement, in fact, is a basic idea of this approach that fosters and promotes both of them. ECM has a medium link with these two features since it promotes people participation.

The assessment grid for strategic features is shown in Figure 5. The communication feature (*Open communication/Bottom up communication of bad news*) was identified in TPM and ECM, with high level of relationship, since they foster people participation. *Safety production balance* is present in RBM and RCM (high level) and in SMM (low level). RCM and RBM, in fact, make risk analysis and failure modes analysis, respectively, on the basis of what happens in other organizations; this is true also for SMM for the definition of degradation models.

| HRO strategic feature \ Maintenance approach | PM | CBM | TPM | RCM | MO | ECM | SMM | RBM |
|---|---|---|---|---|---|---|---|---|
| Open Comm/Bottom up comm. of bad news | - | - | H | - | . | H | . | - |
| Continuous Technical Training | L | L | H | L | H | L | L | L |
| Proactive Audits | - | - | H | - | - | - | - | - |
| Investment of Resources | L | M | M | L | H | M | L | L |
| Production Balance | - | - | - | H | - | - | L | H |

Figure 5. Assessment grid of maintenance approach according to HRO strategic features (H=high, M=medium, L=low)

The *Continuous technical training* is present in all approaches: for this reason it was given at least a low level. High level is given for TPM for pillar of *Education & training* and for MO, as maintenance issues are the core business of supplying service firms. For *Investment of resources*, MO has a strong relationship since its core business too, while a link is more or less present in the other approaches. Finally *Proactive audits* is highly present only in TPM because of the Safety Health and Environment pillar.

To enhance and draw up quantitative information on the results obtained in the assessment grids observed above, a numerical value has been assigned to each level of compliance: low level =1, medium level = 2, high level = 3.

This will be helpful to see how, at each phase, every approach is compliant to the HRO paradigm and which of these are compliant both on operational and strategic point of view. The first analysis was exploited calculating the score obtained considering all of operational and strategic features, whose total number is 19. Results are in Figure 6

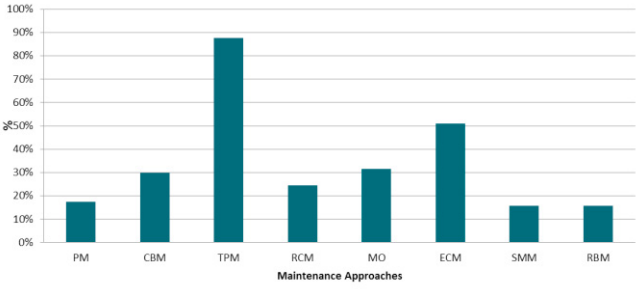


Figure 6. Maintenance approaches classification

Data show that TPM has the highest value (88%) followed by ECM (51%); MO, CBM and RCM are less compliant (32%, 30% and 25% respectively) according to the global HRO features. Other maintenance approaches (PM, SMM and RBM) are less compliant to global HRO features as they are only focused on preventive features. In order to deepen the analysis, the conformity of maintenance approaches respectively for operational (Figure 7 and Figure 8) and strategic (Figure 9) features were evaluated.

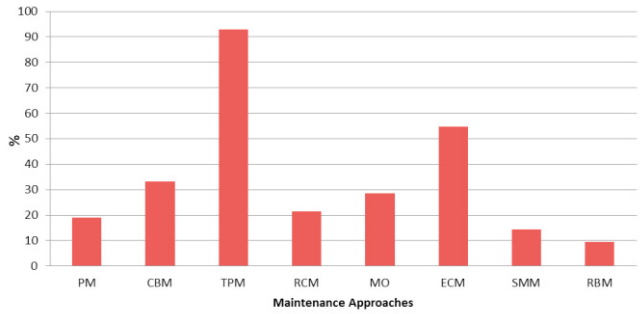


Figure 7. Maintenance approaches according to HRO operational features

*TPM* is strongly compliant to operational features (93%) and the analysis according to HRO maintenance phases confirms its attention to lead high reliability in both of preventive and resilient phases; also from the strategic point of view, TPM has a high level of compliance (73%). *ECM* follows TPM in terms of conformity to operational (55%) and strategic (40%) aspects: this is clear as ECM includes most of policies of TPM. ECM has a gap of 40% to TPM because of its major focalization on preventive phase (Normal Condition 83%, Anomalies 83% and Post-Fault 67%), neglecting the resilient phase (Fault 33%). From the operational point of view, CBM and MO are almost equal in terms of conformity with discreet values (respectively 33% and 29%). Analysing each maintenance phase, CBM has high values (33%, 100%, 50% and 50%) respectively for Normal Condition, Alarms, Anomalies and Post Fault, that are prevention phases, but it's completely absent in the resilient phase (Fault). MO, instead, has high value in the Fault phase (80%) but it is completely absent in the prevention phases. From a strategic point of view CBM and MO have different level of compliance (20% and 40 % respectively).

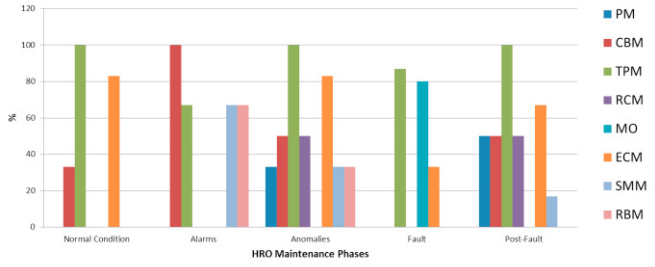


Figure 8. Compliance of maintenance approaches for each maintenance phases

RCM, despite the good score for the overall features (25%), is poorly compliant to the operational features (21%), while is more compliant considering the strategic ones (33%). Other approaches (PM, SMM and RBM) confirm their low accordance with HRO both in the operational and in the strategic fields: the main cause is their great focus only on the prevention dimension.

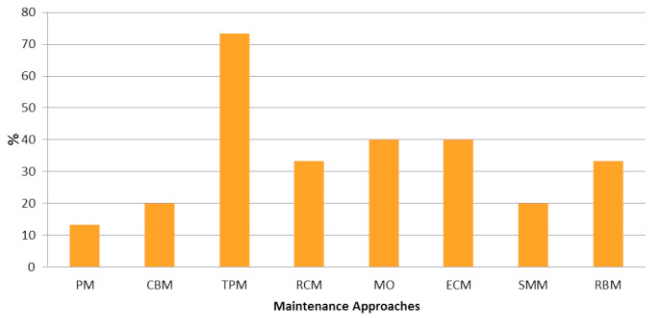


Figure 9. Maintenance approaches according to HRO strategic features

After this analysis, two types of maintenance approaches are identified according to HRO, and these are Starting HRO and HRO experts. The first one is suggested to all organizations that want to start to use the HRO paradigm in their policies: these maintenance approaches can help them to begin small. For this category an example could be the ECM as it is present both in preventive and resilient phases, in spite it has low value in resilient phase. The second one is suggested to all organizations that have a strong expertise to use HRO paradigm, so these maintenance approaches can optimize their compliance according HRO standard. For this category, an example could be TPM that is highly careful to be reliable in both preventive and resilient phases.

## 6. CONCLUSION

A rough but effective analysis is proposed in this paper to evaluate the different maintenance approaches. Both strategic and operational aspects are considered; furthermore, the main features of HRO were correlated to each main maintenance management process. Thus, a numeric not structured analysis was carried out aiming at assessing the level of compliance characterizing each maintenance approach towards HRO features. This application is a preliminary study. Further development will be oriented to apply more quantitative and structured analysis, for example basing on a multi-criteria model such as AHP.

## REFERENCE

De Carlo, F., Borgia, O., Tucci, M., 2011. Risk-based inspections enhanced with Bayesian networks. Proc. Inst. Mech. Eng. Part O J. Risk Reliab. 225, 375–386.

Di Dio, M., Iannone, R., Miranda, S., Riemma, S., 2013. A framework for the choice of the opportunistic maintenance policy in industrial contexts, in: 2013 IEEE International Conference on Industrial Engineering and Engineering Management (IEEM). Presented at the 2013 IEEE International Conference on Industrial Engineering and Engineering Management (IEEM), pp. 1716–1720.

Garg, A., Deshmukh, S.G., 2006. Maintenance management: literature review and directions. J. Qual. Maint. Eng. 12, 205–238. doi:10.1108/13552510610685075

Giacchero, A., Giordano, F., Schiraldi, M.M., 2013. Int. J. Eng. Technol. 0975-4024 5.

Gnoni, M.G., Andriulo, S., Maggio, G., Nardone, P. (2013). ''Lean occupational'' safety: An application for a Near-

miss Management System design. Safety Science, 53, 96-104.

Hopkins, A. (1999). The limits of normal accident theory. Safety Science, 32(2-3), 93-102.

Hopkins, A. (2007). The problem of defining high reliability organisations. Working Paper 51. The Australian National University.

Labib, A.W., 2004. A decision analysis model for maintenance policy selection using a CMMS. J. Qual. Maint. Eng. 10, 191–202. doi:10.1108/13552510410553244

Legát, V., Žaludová, A.H., Červenka, V., Jurča, V., 1996. Contribution to optimization of preventive replacement. Reliab. Eng. Syst. Saf., Maintenance and reliability 51, 259–266. doi:10.1016/0951-8320(96)00124-X

Lekka, C. (2011). High reliability organizations: a review of literature. Health and Safety Laboratory, London.

Murthy, D.N.P., Atrens, A., Eccleston, J.A., 2002. Strategic maintenance management. J. Qual. Maint. Eng. 8, 287–305. doi:10.1108/13552510210448504

Nakajima, S., Bodek, N., 1988. Introduction to TPM: Total Productive Maintenance, Eleventh Printing edition. ed. Productivity Pr, Cambridge, Mass.

Ollila, A., Malmipuro, M., 1999. Maintenance has a role in quality. TQM Mag. 11, 17–21.

Perrow, C. (1984). Normal accidents: Living with high-risk technologies. New York: Basic Books.

Pun, K.-F., Chin, K.-S., Chow, M.-F., Lau, H.C.W., 2002. An effectiveness-centred approach to maintenance management: A case study. J. Qual. Maint. Eng. 8, 346–368. doi:10.1108/13552510210448559

Rochlin, G.I.., La Porte, T.R., Roberts, K.H. (1987). The self-designing high reliability organization. Reprinted in Naval War College Review, 51(3), 17.

Saleh, J.H., Marais, K.B., Bakolas, E., Cowlagi, R.V. (2010). Highlights from the literature on accident causation and system safety: Review of major ideas, recent contributions, and challenges. Reliability Engineering and System Safety, 95, 1105-1116.

Schulman, P.R. (2004). General attributes of safe organizations. Quality and Safety in Health Care, 13(Suppl. II), ii39-ii44.

Smith, A.M., 1993. Reliability-centered maintenance. McGraw-Hill New York.

Sutcliffe, K.M & Vogus, T. (2003). Organizing for resilience. In Cameron KS, Dutton JE & Quinn RE (eds.). Positive organizational scholarship. San Francisco: Berrett-Koehler, 94–110.

Sutcliffe, K.M. (2011). High reliability organizations (HROs). Best Practice and Research Clinical Anaesthesiology, 25, 133-144.

UNI EN 13306, Maintenance—Terminology., 2010.

Weick, K.E., and Sutcliffe, K.M. (2007). Managing the unexpected: Resilient performance in an age of uncertainty. Second edition. San Francisco: Jossey-Bass.

Weick, K.E., Sutcliffe, K.M., and Obstfeld, D. (1999). Organizing for high reliability: Processes of collective mindfulness. In R. S. Sutton and B. M. Staw (Eds.), Research in Organizational Behavior, Volume 1 (pp. 81-123). Stanford: Jai Press.