37

Experiences in information systems development for maintenance management: a techno-organisational view

Paula A. Silva[1], António L. Soares[1,3], José M. Mendonça[2,3]
[1]INESC - Manufacturing Systems Engineering Unit, R. José Falcão, 110, 4050 Porto, Portugal. Email: {psilva,asoares}@inescn.pt
[2]Agência de Inovação, R. de Sagres 11, 4150, Porto, Portugal. Email: jmm@adi.pt
[3]FEUP/DEEC Univ. of Porto, R. dos Bragas 4099, Porto Codex, Portugal.

Abstract

The need of a functional integration in the manufacturing area (Production, Quality, Maintenance), outlooking for a new manufacturing agility, causes the emergence of concerns with reliability, maintenance and security of the manufacturing equipments at the shop-floor. Several models and methodologies, encompassing technical, human, social and organisational aspects such as Total Preventive Maintenance (TPM) or Continuous Improvement (Kaizen), are today available to help in implementing new paradigms in this area. In this paper, we briefly relate our experiences in the development of a maintenance management information system in a shoes manufacturing company, highlighting the socio-organisational context influence on this development. This project was part of the ESPRIT project Real-I-CIM, aimed at providing low cost shop floor advanced management tools, inside an open and distributed architecture.

Keywords

Maintenance management, shop-floor management, techno-organisational development.

1. INTRODUCTION

The openings to new markets more and more competitive and the rapid development of technologies, globally available, compel industrial companies in searching improvements, both technological and organisational. Several models and methodologies, encompassing technical, human, social and organisational aspects are today available to help in implementing new paradigms such as Total Preventive Maintenance (TPM) or Continuous Improvement (Kaizen). In those paradigms, it is very clear the need of a functional integration in the manufacturing area

L. M. Camarinha-Matos (ed.), *Re-engineering for Sustainable Industrial Production*

(Production, Quality, Maintenance), outlooking for a new manufacturing agility. From this need emerges in particular the concern with reliability, maintenance and security of the manufacturing equipment at the shop-floor. Therefore, one can say that the Maintenance function, embedded in an adequate organisational model, comes out to a key position side by side with the Production and Quality functions.

2. ORGANISATIONAL MODELS OF MAINTENANCE AND INFORMATION SYSTEMS SUPPORT

2.1 Centralisation vs. decentralisation

In organisational terms, the Maintenance function can be classified as centralised or decentralised, both at the physical and the decision-making levels. Traditionally, a hierarchical centralisation should allow easy cost management, process standardisation and communication, the homogeneous attendance of equipments and its breakdowns and a good maintenance staff management. A centralised Maintenance is indeed characterised by an isolated department where are concentrated all important resources (tools, materials and manpower) to the Maintenance function and where all the decisions concerning planning, intervention, reaction, purchasing, etc. are made. This type of traditional Maintenance management stills diffused in Portugal, and presents only some adequacy to companies with few production equipments and simple design, as well as breakdowns with a small weight in the company budget.

In a decentralised organisation, people not belonging to the maintenance department is actively involved in this function. The formal existence of a maintenance department, holding specific knowledge and historical data, provides (in principle) the capability to undertake all the required maintenance assigned tasks such as reacting in face of breakdowns, planning preventive interventions, repair spare parts, continuously improve the equipment, security areas and work environment. The distribution of some of these tasks for other manufacturing related departments, has the potential to simplify the maintenance tasks and involve a significant number of people, enabling a better planning, repairing costs and time reduction, production stops due to breakdown, etc.

2.2 Total Productive Maintenance and Continuous Improvement

In Takahashi and Osada, 1990, it is advocated a decentralized organisation, with a total involvement of everyone in the company, adopting an equipment oriented management from which depends the reliability, safety, maintenance and operational characteristics of the shop-floor. The main goal of this concept is the way to "zero defects" and "zero breakdowns". The implementation of a Total Productive Maintenance (TPM) philosophy implies a decentralisation in decision making regarding maintenance, requiring the serious concerns about pervasive aspects such as the workers professional qualification, incentives creation, vocational training, professional careers, responsibility assignment, subcontracting quality, inter-departmental cooperation, etc. Correctly considered these aspects, where the key element is the human factor (actually more important than technological or organisational impositions), the result is the reliability improvement in the shop-floor and as consequence the improvement of the internal competitiveness factors: productivity, quality, delivery on-time and costs (Takahashi and Osada, 1990; Ishikawa, 1982). The fulfilment of these goals in a scope of a decentralised philosophy raises, as referred, communication and interaction needs between the different company departments, excluding some isolating perspectives in functions such as Quality Control, Industrial Engineering, Production Control, Production Maintenance and Cost Control.

Continuous Improvement philosophy (Kaizen), foresees an involvement of every manager and worker in continuously improving the company competitiveness, particularly through adequate Quality and Maintenance systems. Once more, it is fundamental the use of technical systems supporting a decentralized organisation through integration and communication mechanisms (Mizuno, 1988).

The mentioned organisation philosophies (TPM and Kaizen) develop naturally in a decentralised organisation. Currently, in the portuguese scenario, we can find some difficulties in their implementation due to deeply rooted Tayloristic concepts in the organisation, together with an average low skilled work force, both in technical and social competencies. However, survival lead those companies to (at least) assume the importance of decentralising decision making particularly in Maintenance management.

2.3 Information systems support

In this context it is clear that tools supporting the implementation and exploitation of TPM and Kaizen can play a role of utmost importance. However, IS's developed under the requirements of a tayloristic and hierarchical organisational structure can greatly hinder the adoption of TPM and Kaizen, since frequently result in tools supporting individually the shop-floor management functions, satisfying departmental confined requirements. One counter-example is the concept of Process Condition Monitoring - PCM (Ribeiro et. al., 1996) emerging from the need of an integrated view of the operations at the manufacturing execution level: production, quality and maintenance management. This view requires technical solutions that integrate information usually managed and used independently, reflecting the vision of a decentralised organisational structure. In the particular aspect of maintenance, tools based on this concept enable an improved maintenance policy and a better maintenance personnel performance.

In the following sections, we briefly relate our experiences in the development of a maintenance management information system in a shoes manufacturing company. This development was part of the ESPRIT project Real-I-CIM, aimed at providing low cost shop floor advanced management tools, inside an open and distributed architecture.

3. THE SOCIO-ORGANISATIONAL CONTEXT

The company considered in this case study is a shoes manufacturer that, as many other companies in this industrial sector in Portugal, relied its competitiveness on the manpower low costs. However, the increase of those costs in Portugal, when compared with other countries of the Asian south-west, triggered changes in the strategy i.e., the increasing of the manpower qualification in order to produce with more quality and competitive prices, and to fulfil delivery times. This change in strategy called for the use of advanced technologies of production, maintenance and quality, and profound changes to the actual organisation.

3.1 Social characteristics

The human resources characteristics such as qualification levels, age levels, seniority in the company and schooling levels, have a marked influence on the people attitudes towards a techno-organisational change. Participation and change acceptance or resistance are always framed by the company's social context. In the initial phases of the prototypes testing, a study was conducted regarding the analysis of the relevant company's social characteristics using data from the last 3 years (Moniz and Soares, 1995). The main conclusions of this study clearly identified factors capable of positively influencing a process of technical and organisational change: an on-going personnel re-qualification process, a strong job stability, an age structure very young, a significant increase in the schooling levels, an increase in the technical skills and a mix of a large experience with solid technical knowledge. Nevertheless, some negative factors were also identified: an increasing absenteeism rate, very few vocational training actions, a difficulty to recruit personnel with specific technical skills.

A subsequent field-study further extended our understanding of the socio-organisational context by collecting the subjective views of the operators and managers influenced by the information system, concerning technological and organisational innovation within the company (Santos et al., 1996).

3.2 Attitudes towards new organisational forms

The company was facing a restructuring process of its production organisation, although the traditional model was prevailing. Work organisation forms based on individual enriched jobs (more complex tasks, fulfilled with initiative and responsibility) and team work were being adopted, looking for an increased manufacturing flexibility. There was a general positive feeling, from both managers and operators, towards the adoption of team working as the way to reach better results in productive and organisational terms. Managers and operators perceptions and opinions didn't differ to much and are resumed in the following attitudes:

- strong adherence to working groups organisational form,
- preference for a multi-skilled kind of work,
- acceptance of an increased intervention and participation of operators, particularly in preventive maintenance and quality control tasks,
- foreseeing the need to have competencies, at the middle management level, that associate a strong technical competence to a capacity to disseminate information and co-operate with the operators,
- foreseeing the need to change the middle management role from line supervisors to group leaders,
- foreseeing the need to change the role of operators in direction to an increased responsibility sense, initiative and change capability,
- willingness to see implemented broader forms of participation.

However, some limiting socio-organisational factors could restrain the change process. From the same group of people, the following negative attitudes were registered:

- some resistance to change the traditional power rationality restraining the participation of the operators in decision making related with planning and scheduling,
- limited management vision of team work being sometimes considered only as combining individual (simple and repetitive) tasks and doesn't implying necessarily an enlargement or enrichment of tasks,
- more concern in obtaining flexibility and multi-skilling than in increasing the level of operators decision/intervention in managing and organising working teams,
- feeling of a reward system not adjusted to the new competencies and organisation, raising some conflicting situations.

3.3 Attitudes towards information technology

The attitudes towards new technologies, in particular information technology, is another important indicator in the techno-organisational change process. The positive attitude found in the company concerning the introduction of new technologies can be illustrated in the statement of expected benefits both from operators and middle-managers.

In the perspective of the operators, the main advantages of new equipment are mainly the possibility of working in better conditions, an increase in productivity levels and higher quality performance. From the point of view of middle-managers, the perceived advantages are the possibility to increase technical skills and productivity levels, higher quality performance, easiness in the work execution and keeping the pace with technological development in order to stay competitive.

Summarising, there is generalised opinion that the introduction of new technologies at the manufacturing level would enable to manufacture with better quality and an increase in the skills of the organisation members majority. Also, new technologies would contribute to the company modernisation, coping better with the market and making the company more competitive.

3.4 The maintenance organisational context

In regard to the maintenance department, the implemented policy involves a mix between corrective and preventive actions, with more emphasis in the corrective ones. The organisation is centralised i.e., only maintenance staff carry out maintenance tasks. In terms of organisational chart, the maintenance manager reports to the production manager, meaning that all maintenance decisions reflect heavily the production manager views. This has obvious effects not only in the efficiency of the maintenance tasks, but also in the autonomy and responsibility of the organisational unit members.

3.5 The Maintenance Management System features

In functional terms, before the Real-I-CIM installation, the maintenance operators undertook corrective actions when an intervention request was made directly by the production operator to the maintenance department. The breakdown could be immediately solved or transferred for another day if the equipment could be replaced. There was not any time control and consequently time analysis (manpower, equipments, etc.) was not achieved. In a broader scope, the performance evaluation of the department was never accomplished due to the lack of relevant indicators. Other maintenance management tasks such as stocks management, equipment statistical analysis and predictive maintenance were never realised and were not part of the requirements for this system due to the very nature of the shoes manufacturing process and equipments.

The Real-I-CIM tool-box provides a module in the Industrial Maintenance area with the goal of supporting the maintenance tasks (Silva, 1995). The generic features of this module are the following:

- modelling of the physical, informational and functional aspects of resources, orders and manufacturing processes through the use of a powerful set of building blocks;
- easy integration with existing enterprise IT systems through access to manufacturing programmes issued by an upstream MRP system, machine data, etc., by using standard interfaces;
- coding, grouping and characterisation of the enterprise equipments;
- data acquisition and shop floor interaction through appropriate shop floor communication networks;
- continual information updating to the historic generation and important resources management for the maintenance intervention;
- Maintenance intervention planning according production planning;
- Production and Maintenance times optimisation provides the communication between departments to ensure the best planning;
- different levels of user interaction in an integrated, automatic and efficient way;
- time analysis for performance evaluation and improvement support;
- cost analysis and Maintenance policy evaluation;
- functional behaviour of equipments during its different life periods;
- extraction of indicators to estimate the industrial processes performance and/or the management policy;
- shop floor alarm notification.

The module specific features, together with the system envisaged architecture were designed aiming at an effective adaptation to the organisational requirements of each company. Particularly in this company, the system features where directed to following broad functional requirements: equipment inventory management, equipment dossiers, corrective and preventive maintenance management, cost analysis, record and control of maintenance times and reports and extraction of performance indicators.

4. THE PROJECT PROGRESS

From the software engineering viewpoint, the system development life cycle followed a mix between the traditional "waterfall" model and an evolving system prototyping approach. Detailed requirements gathering and analysis followed by the system specification were undertaken with several iterations. The prototypes were developed and installed in different phases, being tested and validated at the end of each one. In this section we analyse the IS development from the point of view of the workers participation and the organisational constraints influence.

4.1 Workers participation

During the process, the well known difficulties of an waterfall approach to systems development revealed, being somewhat compensated later in the process during the phases of prototyping. Particularly during requirements analysis and system specification, several technical and organisational hindrances prevented a smooth running of the project:

- users found difficult to state their requirements for a technology that they did not understand,
- to foresee technical and organisational opportunities for improvement motivated by a new information system was even more difficult,
- technical questions conducing to further details in the system requirements were also found hard to answer by the users,
- different visions for a matching technical and organisational system made complex an agreement about the requirements for the system supported procedures and interactions;

These difficulties were somehow increased by some maintenance operators inhibition in stating their requirements, once this task was seen by them as a production manager responsibility. The formal organisational structure was, in a great extent, the main cause of this behaviour because all the "important" decisions (where the ones concerning the design of technology and work are included) were pulled to the production manager. Moreover, an inculcated tradition of autocratic management did not induce an effective relevant participation in the requirements analysis and system specification.

4.2 Organisational constraints

Regardless the restructuring process and the people feelings about technical and organisational innovation, the company's management imposed an unchanged manufacturing organisation as a major constraint for the new information system. The maintenance centralised organisation, the hierarchy, the use of the already implemented information systems (such as the data collection system), were to suffer minimal changes as to adapt to the new system.

However, in order to promote a best maintenance management service i.e., to be possible the time and maintenance costs analysis and to make the intervention more fast and efficient, the an integration between the Maintenance system and the data collection system was accorded. This fact allowed the direct communication between the shop floor and the maintenance department and changed the behaviour either on production staff (when they ask repairing after a breakdown) or on maintenance staff (to solve a breakdown). In the first prototype the Corrective Maintenance management and the Preventive Maintenance management modules were implemented. The earlier results pointed for a good system adaptation, either in the technical aspects or organisational aspects, and its enormous usefulness in the selection of new shop floor performance indicators.

5. ORGANISATIONAL CHANGE SUPPORT

Despite the requirements imposed by the company management, we believe that a profound change in the maintenance department organisation could be undertook with the support of the technical system described. In such comprehensive changes — possibly undertook within a Business Process Reengineering (BPR) — all the strategy must originate on the top management. Nevertheless, tactical and operational issues of change (both in the functional and social dimensions) strongly rely on everyone within the organisation. Management (in broad) and external consultants establish the vision, strategy and general tactical directions and the rest of the organisation implements it. Thus, management must create conditions for the effective participation of the people involved in those processes. Usually there are several options when it comes to restructure a process or part of a process as established by the BPR plan. Redesigning those parts should take into account socio-organisational and human-computer interaction best-practices. This is the case of the manufacturing reorganisation of this company, and particularly the maintenance services optimisation. In figure one are summarised the main factors influencing the techno-organisational change process.

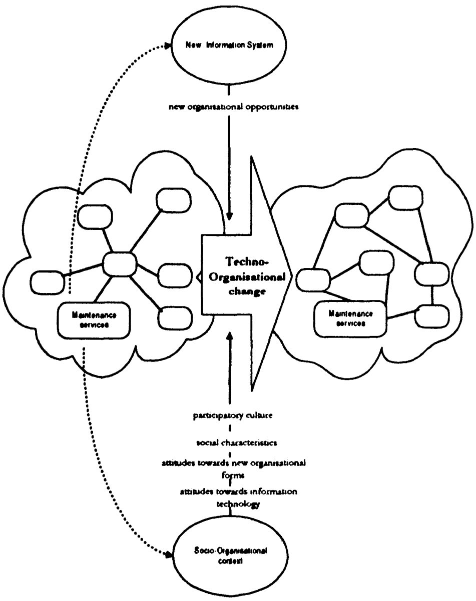

Figure 1 - Some factors influencing techno-organisational change

In the first place, the maintenance department autonomy, reaching a peer position with the production department, would in principle increase the reliability, security, quality and other operational characteristics in the shop-floor, if a decentralisation strategy is pursued. In the second place, this decentralisation would increase the flexibility of the maintenance tasks as well as the motivation potential of the maintenance related jobs. However, this was seen very sceptically by the company management that links this change to high investments without a clear return.

On the other hand the maintenance department had no way to prove, both qualitatively and quantitatively the advantages of the proposed change. It was thus, very important to make use of tools that could help to ascertain the current performance and enable in foreseeing future results.

The maintenance management system, developed within the Real-I-CIM project, can be used to support a decentralised organisation offering features such as:

- cost indicators collection, enabling the evaluation of the costs per maintenance resources and per maintenance intervention, the maintenance policy comparison i.e., corrective vs. preventive, and the quality of the equipment maintenance actions,
- temporal indicators collection, for the evaluation of immobilising times, maintenance times, etc.
- statistical indicators calculation concerning the availability, reliability, confidence levels, etc.

With this basic set of features and information, the maintenance responsible is able to evaluate, foresee and if necessary prove if the actual maintenance policy and maintenance organisation are the best for the company, and this way negotiate with the management the best future strategy concerning maintenance.

6. DISCUSSION

From the experiences depicted in this paper we intended to highlight three main points. Firstly, the technical and organisational requirements for a maintenance management information system. TPM and Kaizen are seen as the main inspiration sources for the maintenance organisation and generate the generic requirements for the information system support.

Secondly, the importance of the socio-organisational context in the system requirements definition and development and, more generally, in a more comprehensive change process such as BPR. It is essential the full participation of the company's stakeholders particularly the end-users, at least in the requirements definition phase, in order to obtain an effective and usable system. Aiming at this goal, the company's social characteristics (qualification, job stability, training, age structure, etc.), and the people's attitudes towards techno-organisational change must be assessed, providing the information on what to expect concerning the type and quality of participation. In this case study, we found good conditions in the company for an involvement of the end-users in designing the new system. However, this involvement was hindered by some organisational constraints and lack of willingness from the management side.

Thirdly, the influence of a maintenance management information system in the organisational change towards a decentralised organisation and in the implementation of best-practices in maintenance management. This is a most difficult topic because it involves: the *system developers* in orienting the system implemented features and the system adaptability towards a range of organisational needs; the *system end-users* in generating the requirements for a system in a maintenance organisation with redesigned tasks and structures; and finally the *company's management* in providing the vision and commitment as well as resources for the undertaking of the project. In the paper we identified some basic features in this system that could support an alternative maintenance organisation within this company.

7. REFERENCES

Ishikawa, K., 1982, "Guide to Quality Control", Quality Resources, White Plains NY.

Mendonça, J.M., Schulte, J.B., Távora, J., "Production Planning and Control Systems and their Factory Implementation ", Sharing CIM Solutions, K.H. Knudsen et al. (Eds.), IOS Press, 1994.

Mizuno, S., "Management for Quality Improvement: The 7 New QC Tools", Productivity Press, Inc., Cambridge MA, 1988.

Moniz, A., Soares, A., 1995, Techno-Organisational Analysis for Systems Implementation: Social Characteristics Analysis, EP 8865 Real-I-CIM deliverable D1.2.2.2.

Nayatani, Y., T. Eiga, R. Futami, H. Miyagawa, "The Seven New QC Tools: Pratical Applications for Managers", Quality Resources, White Plains NY, 1994.

Ribeiro, B., Silva, P., Mendonça, J., 1996, "Process Condition Monitoring - a Novel Concept for Manufacturing Management Tool Integration"; presentation document, Março.

Ribeiro,B., Silva, P., Távora, J., Mendonça, J., Romão, N., "Requirements Specification for the Growela Pilot Site", Real-I-CIM deliverable, 1994.

Santos, M., Urze, P., Moniz, A., Soares, A., 1996, Techno-Organisational Analysis for Systems Implementation: Real-I-CIM Support to Organisational Change, EP 8865 Real-I-CIM deliverable D1.2.2.2.

Silva, P., "A Relevância da Função Manutenção no Contexto dos Sistemas Integrados de Apoio à Gestão do Fabrico", in Actas do 2º Encontro Nacional do Colégio de Engenharia Electrotécnica, Lisboa, Portugal, 14-15 Dez 95.

Silva, P., "Manutenção Condicionada Baseada na Análise de Vibrações", Dissertação de Mestrado FEUP-DEEC, 1993.

Takahashi, Y., Osada, T., 1990, "TPM", Asian Productivity Organisation, Japan.

8. BIOGRAPHY

Paula Alexandra Silva, holds a MSc. in Industrial Informatics from the University of Porto. She is currently a researcher at INESC-UESP and her research interests are maintenance management, information systems for maintenance management.

António Lucas Soares is an Electrical Engineer teaching at the Faculty of Engineering of the University of Porto and doing research work at INESC-UESP. He holds a MSc. in Industrial Automation and is currently undertaking its PhD work in the area of collaboration models for techno-organisational development. The main research interests are the interdisciplinary collaboration in the development of integrated manufacturing systems and socio-technical systems.

José M. Mendonça is an Electrical Engineer and received the PhD in Electrical Engineering in 1985 and is currently Associate Professor at the University of Porto as well as one of the Innovation Agency directors. His interest areas are: manufacturing management, enterprise modelling, shop floor control and management of innovation.