June 21, 2011 (Tuesday) 55th EOQ Congress

CONCURRENT SESSIONS **Tuesday 13:30 – 17:30**
KEMPINSKI HOTEL CORVINUS **Erzsébet tér 7-8, Budapest V.**

REGINA BALLROOM II. **Tuesday 15:30 – 17:30**

11.2. REPOSITIONING QUALITY FOR MANUFACTURING II. 15:30 – 17:30

Session Chair: ***Hans Dieter Seghezzi****, University St. Gallen, Switzerland*

16.45 Management Systems Integration: Should „Quality" be Redefined?
José Pedro Teixeira Domingues, University of Minho and Delphi-Bosch Ferreiros, Portugal
Paulo Sampaio and P. M. Arezes, University of Minho, Portugal

Teixeira Domingues, José Pedro (Portugal)

He was born in Braga, Portugal and went to Universidade do Minho where he obtained his Chemistry degree in 1995. Has a Master in Environmental Chemistry (UMinho) and is a PhD student in the Production and Systems Department at Universidade do Minho under Dr. Paulo Sampaio's and Dr. Pedro Arezes' supervision. He is a Management System (MS) Manager at Laboratório Químico Marques Ferreira at Delphi-Bosch industrial complex.

Sampaio, Paulo (Portugal)
Paulo Sampaio is Researcher and Assistant Professor in the Systems and Production Department at the University of Minho in Portugal; Assistant Professor at the Lusíada University, Portugal; Quality Management Consultant in several companies; Founder Member and President of the Industrial Engineering Alumni Association, University of Minho; President of the General Assembly of the University; Product and Project Manager of the Portuguese Association for Certification. He is member of the American Society for Quality (ASQ). He graduated in Industrial Engineering (2002, 5-year degree) and received his doctorate (PhD) in systems and production engineering from the University of Minho in 2008 entitled "ISO 9000 worldwide phenomenon research: origins, motivations, consequences and perspectives". His research interests include quality management, ISO 9001 certification, ISO 9000 standards and quality management systems.
Paulo participates as a speaker in many quality management international conferences and he is currently author of several publications in the quality management area (books, papers in international and national journals). He is member of the research team of several quality management research projects and also supervises several Master and PhD thesis. In 2006, 2008 and 2009 Paulo has been distinguished with the award of the Best Paper Presented in the Student Technical Paper Competition during the ASQ World Conference. In 2008 his PhD Thesis was distinguished by the Portuguese Association for Quality as the best thesis developed in Quality. In 2009, Paulo has been distinguished as Senior Member of the American Society for Quality.

MANAGEMENT SYSTEMS INTEGRATION: SHOULD "QUALITY" BE REDEFINED?

Domingues, J. P. T.[1,2], Sampaio, P.[1], Arezes, P.M[1]

[1] Systems and Production Department
School of Engineering
University of Minho
Guimarães, Portugal

[2] Laboratório Químico Marques Ferreira
Complexo Delphi-Bosch
Ferreiros
Braga, Portugal

pedrodomin@sapo.pt; paulosampaio@dps.uminho.pt; parezes@dps.uminho.pt

ABSTRACT

Concepts like interfaces, synergies, fuzzy logic, organisational synapses and networking rule our days. These concepts orbit around the term "interactions". Literally, interactions are everything. For instance, graphite and diamond are just carbon atoms "interacting" differently. Currently, customers demand a broader vision from organizations. In order to fulfil this demand organizations implemented and certified their management systems focusing different stakeholders' requirements and according to several organisational standards, being the most reported ones ISO 9001, ISO 14001 and OHSAS 18001. Despite of the difficulties to achieve a consensual definition, if we consider concepts like quality tools, "Quality" is mainly an "action" concept. Thus, the main challenge faced by quality management systems (QMS) in an integrated environment would be philosophical: to leave the spotlights of an "action" based approach and to embrace the subtleness of the "interaction" approach. It is common sense that the system defining, promoting and stimulating interactions should not be involved in the action itself. Implications of this new role to play by quality management system are huge. Traditional organisational structures place quality transversally to production processes. It is expected that quality management system adopts a more vertical organisational orientation in order to accomplish new objectives posed by management systems integration. Human behaviour towards item production or service performance should change according new organisational placement by QMS. Each worker despite their organisational function should have *a priori* and *a posteriori* quality requirements knowledge, being critical a precise boundaries definition among elements constituting the responsibility chain. Auditing procedures should be adjusted too. Potential synergies between processes, internal and external communication flow, objectives redefinition, policies adjustment and a new vision horizon are among some check-points to be assessed by the audit team. It should be assure that top management commitment is not with a system but with an organisational philosophy. Processes indicators should be available at all time and by several persons. This requirement is not far fetch in our days due to the currently available networks and information systems. Non conformity detection, treatment and correction, under an integrated approach, should not be a middle management meeting of the affected process. In this case, quality procedures should assure that Environmental and Occupational Health and Safety representatives are involved and empowered to discuss decisions to be made. In this article we analyze the reposition of the quality management system after an integration process pointing out the practical implications of this newly perspective. It is intended to be an initial contribution to a newly task already achieved by other systems and sciences: the assessment of "interactions" in management systems.

Keywords: integrated management systems, actions, interactions

1. INTRODUCTION

Currently, QMS faces an organizational cross-road: management systems integration. Suditu (2007) synthesized the two choices presented to companies since the development of many management systems stating that companies should leave these (management systems) to function as specific systems or integrate them. According to a noticeable number of papers, reports and surveys it seems that organizations option felled on the integration option. A company, understood as a formal organization of people and capital, aims, traditionally, to create add value by generation of economical products or services satisfying customers' needs (Correia, 2010). Current perspective focusing requirements equilibrium from several stakeholders, namely, customers, shareholders, collaborators, raw material providers/partners and general society lead to the implementation of several management systems and to the integration of them. The traditional Quality gurus, such as Deming, Juran, Crosby, Ishikawa and Taguchi provided their own definitions of Quality as shown in Table 1.

Table 1: Quality definitions (adapted from Correia, 2010)

Deming	Predictable degrees of uniformity and dependence at low cost and suitable to the market.
Juran	Suitability to performance.
Crosby	Conformity to requirements.
Ishikawa	Customer satisfaction.
Taguchi	Losses generated to Society, at the moment that a product is delivered when a discrepancy related to target value is detected.

Several benefits, resistances, drawbacks and definitions (Table 2) related to management systems integration had been reported in the literature (Domingues, Sampaio and Arezes, 2010a). Usually, an Integrated Management System (IMS) has its genesis on the QMS. The subsequent implementation of Environmental (EMS) and/or Occupational Health and Safety (OHSMS) management sub-systems has been widely reported. Integration process is an act of management which could trigger several unexpected consequences being mistakes potentially causes for corporate crisis (Dubrovski, 2009).

Table 2: IMS definitions (adapted from Domingues, Sampaio and Arezes, 2010b)

Source	Year	Definition
Garvin	1991	"…measure of the alignment or harmony in an organization".
MacGregor Associates	1996	"…a single top level management "core" standard with optional modular supporting standards covering specific requirements".
Karapetrovic and Wilborn	1998	"…interrelated processes set sharing human and financial resources, information, materials and infrastructures aiming several objectives focus on stakeholders satisfaction".
Griffith	2000	"…blend together quality, environmental and health and safety procedures in order to demonstrate externally the company commitment to deliver a product or service, improved environmental performance and better health and safety management".
Suditu	2007	"…organisational structure, resources and procedures that support the planning, monitoring, quality control, safety and environmental activities of an organization".

A cross analysis of Tables 1 and 2 highlights the convergence of Taguchi "Quality" definition and the latest IMS definitions, namely, on the implication of Society from the first and on the IMS holistic approach and *inside out* perspective from the latter.

Three generic strategies may be adopted by QMS, as the genesis management sub-system, in order to deal with this newly organisational endeavour: the *divide et impera*, the *concordia discors* approaches and the rather naïf and minimalist *e pluribus unum* approach. Several published papers focused, implicitly, this issue, and later on this paper these approaches will be unveiled.

Suditu (2007) on the identification of the positive and negative aspects regarding the implementation of an integrated Quality-Environmental-Health and Safety management system stated that the simple action of implementing management systems does not guarantee that the organizations will improve performance and, later on the same article, that it is necessary to link to the management systems, a well-structured performance evaluation methodology to help organizations to achieve their objectives in a more efficient way. This vision suggests that QMS should act as a *pivot* system promoting links between newly implemented management sub-systems. Ramly, Ramly and Yusof (n.a.) identified that the companies look for strategies, operations and processes realignment in order to achieve the higher competitiveness level, which is *per se*, one of the main reported reason leading organizations to integrate their management sub-systems. Jonker and Karapetrovic (2004) stated that when striving to integrate systems with different and sometimes even contradictory objectives, scopes and purposes, companies face tremendous difficulties, which illustrates one of the resistances to integration.

Several authors analysed QMS acting as the genesis management sub-system. Excessive complexity due to misunderstanding of the quality management standard requirements and the development of the management system by external consultants were identified by Suditu (2007) as potential drawback factors on the IMS implementation process. Other authors emphasized the fact that the standards integration and the management sub-systems integration are two clearly separate issues (Karapetrovic, 2002). In fact, currently, there is not available a standard to implement an Integrated Management System (IMS), but at the same time, IMS are a reality among a significant number of organizations. Therefore, it seems that organizations are finding IMS implementation paths that are not pre-defined or constrained by rigid standard requirements. This is the main reason why management systems integration has been, and it is, an active research issue among management systems community.

1.1. The *divide et impera* approach

The *divide et impera* approach by QMS has been subtly suggested by several authors. Currently ISO 9001, ISO 14001 and OHSAS 18001 management systems implementation standards are design, each of them, focusing a single ultimate goal. Customers satisfaction (ISO 9001), minimum environmental impacts (ISO 14001) and workers health and safety assurance (OHSAS 18001) are, generically, those specific goals. QMS as the genesis management sub-system may, voluntary or not, act as a potential division promoter in order to protect their own inherent philosophical nature. This fact, perfectly acceptable and understandable in a non-integrated context, is contradictory under an integrated organisational "umbrella" leading to integration process failure, inefficacy or inefficiencies.

Asif, Bruijn and Fisscher (n.a.) emphasized the importance of the philosophical aspects related to management organisation categorize the areas surveyed in IMS (Figure 2). QMS implementation, focusing solely customers' satisfaction generates some organizational "anti-bodies" facing new stakeholders and their requirements. Compromise between different, but not always contradictory, specific interests from QMS, EMS and OHSMS should be expected in an integrated context.

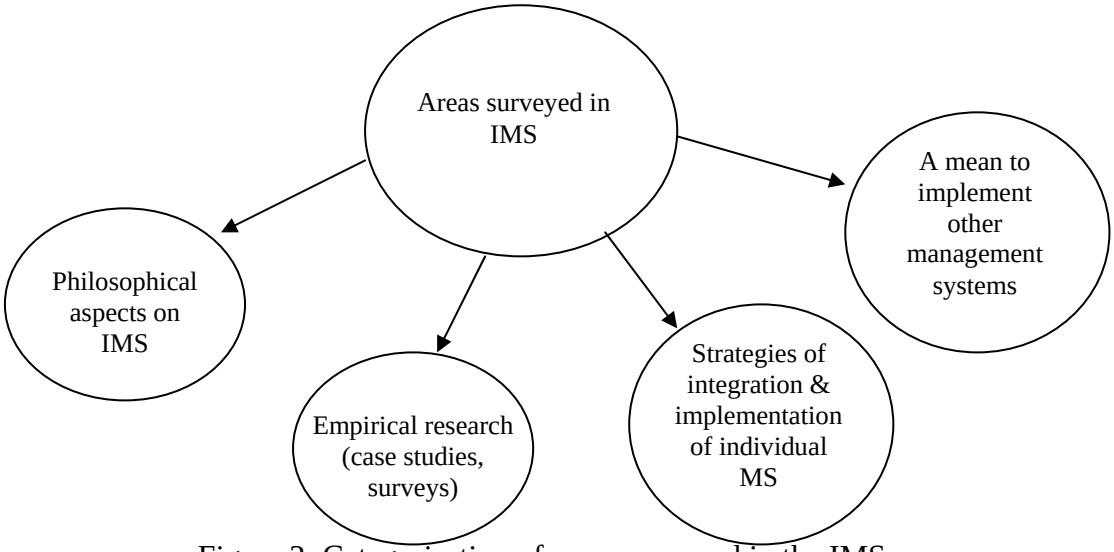


Figure 2: Categorisation of areas surveyed in the IMS
(Asif, de Bruijn and Fisscher, n.a.)

QMS prior to EMS and/or OHSMS implementation provided a "tailored" management system fulfilling "Quality" concept needs, being all the resources focused on service/product quality assurance. The emergence and implementation of novel management systems implies less resources availability and focus in diffusivity, which is expected in any organisational change. The magnitude of management systems integration, as an organisational change, is far from common. Less resources availability and focus diffusivity will be permanent and QMS like a "blind that already saw" feel these changes on a different perspective and scale than EMS or OHSMS. The *divide et impera* approach by QMS is sustained on the lack of action by this management system related to requirements from the newly management sub-system(s) implemented, contributing to the integrated management system lack of cohesion. Some characteristic features related to this approach are the non existence of integrated indicators (Elg, 2007), the lack of a supervisor for the integrated management, minor authority given to the EMS/OHSMS responsible and lack of guidance to business leaders to deal with new responsible from EMS or OHSMS (Lawrence, 2009). Companies where resources availability is scarce, namely, small and medium size enterprises (SME's) are more prone to this kind of organizational behaviour by previously existing QMS.

QMS, EMS and OHSMS standards contribute themselves to the *divide et impera* approach by QMS. All the standards are based on a process approach. IMS more than a process approach requires a system approach or a system thinking approach being this issue pointed out by other authors (Karapetrovic and Willborn, 1998b).

1.2. The *concordia discors* approach

Concordia discors approach by QMS embraces a subtle organisational "agreement" or compromise between QMS, EMS or OHSMS requirements. This approach has been suggested mainly in organizations where QMS was not so rigid and massive but where quality, environmental and occupational health and safety issues are regarded as central and fundamental to perform a successful service or develop the desirable product. A noticeable example is nuclear industry, which is described in several published papers (Beckmerhagen *et al.*, 2003a,b). In this particular case, quality of the service/product is equally regarded related to environmental or occupational health and safety issues due to the catastrophic consequences of an EMS or OHSMS non conformity. In this kind of approach embraced by QMS, the above mentioned compromise is achieved, nevertheless the fact of organisational "disagreement" between conflicting interests deriving from

QMS, EMS or OHSMS. Characteristic features from this approach are integrated objectives development, definition and use of different performance indicators (Elg, 2007), namely, condition performance indicators (CPIs), management performance indicators (MPIs) and operation performance indicators (OPIs), system approach to management more than process approach and suitable human resources in key organisational positions, namely, human resources with a profile able to compromise and excellent communications skills (Zink, 2008).

1.3. The *e pluribus unum* approach

This approach, probably the desirable perfect system status focused by IMS practitioners, is rather a "pot at the end of the rainbow" in nature. Some features of QMS, EMS and OHSMS are not at the same level. As an example, the consequences of an OHSMS non conformity are not comparable with an EMS or QMS non conformity (Domingues, Sampaio and Arezes, 2011c). It is not possible to say how many batches of a generic product equal a human life loosed in an occupational accident. It is not possible to say how much injured workers equal an oil spillage by an industry. Even though the same methodological procedure may be used to detect, assess and propose corrective actions, the ultimate comparison between non conformities requirements from QMS, EMS or OHSMS is not possible or even desirable. The lack of methodologies to achieve fully integrated systems has been pointed out by several authors (Jonker and Karapetrovic, 2004). The *e pluribus unum* approach, holistic in nature, is ultimately materialized by the systems model for IMS proposed by Karapetrovic and Willborn (1998b). For the above mentioned, a complete fully integrated management system, according to this approach is not possible, being the question that IMS practitioners should ask:
"Has our integrated management system reached its maturity level?" or "It is worthwhile to integrate more processes or organisational levels?"

2. CURRENT STATUS ON IMS

Despite the fact of ISO Surveys do not include objective data on IMS, the rate between ISO 14001 to ISO 9001 number of certificates may be used to check the evolution of (potential) IMS. In a broader sense, an increase on the number of ISO 14001 number of certificates is related to the number of organizations with an IMS due to the fact that ISO 9001 number of certificates seem to reached (or near) the saturation level. According to this ratio (Table 3), countries were environmental pressures are stronger (Sweden, Finland, Denmark, Japan) are leading the Top 5.

Table 3: Countries Top 10 on ISO 14001/ISO 9001 ratio (2009)

#	Country	ISO 14001/ISO 9001 ratio
1	Sweden	0,78
2	Japan	0,58
3	Denmark	0,56
4	Finland	0,49
5	Romania	0,43
6	Norway	0,41
7	Philippines	0,36
8	Czech Republic	0,34
9	Korea Republic	0,33
10	Greece	0,32

Concerning the ISO 14001/ISO 9001 ratio growth (1999-2009) (Table 4) we may conclude that Romania is clearly leading the ranking, followed by China, Korea Republic and United Kingdom.

Table 4: Countries Top 10 on ISO 14001/ISO 9001 ratio relative growth (1999-2009)

#	Country	ISO 14001/ISO 9001 ratio growth (%)
1	Romania	20159
2	China	1464
3	Korea Republic	1250
4	UK	1130
5	Italy	969
6	Belgium	951
7	USA	938
8	Czech Republic	834
9	Greece	732
10	Saudi Arabia	723

Figures 3-5 describe the ratio evolution between 1999-2009 in North and South America (Figure 3), Europe (Figures 4a-4d), and Middle and Far East (Figure 5). It may be concluded that this ratio increased in all the analysed countries suggesting an increase of IMS. Europe has the countries with highest scores. Moreover, the noticeable evolution that took place in Asia (Middle and Far East), namely, in Korea Republic, Thailand and Philippines should be pointed out. North and South America countries present similar results in 2009 and a similar evolution pattern since 1999, suggesting that some localized factors (geo-economical) are involved on ISO (both 14001 and 9001) certification phenomenon.

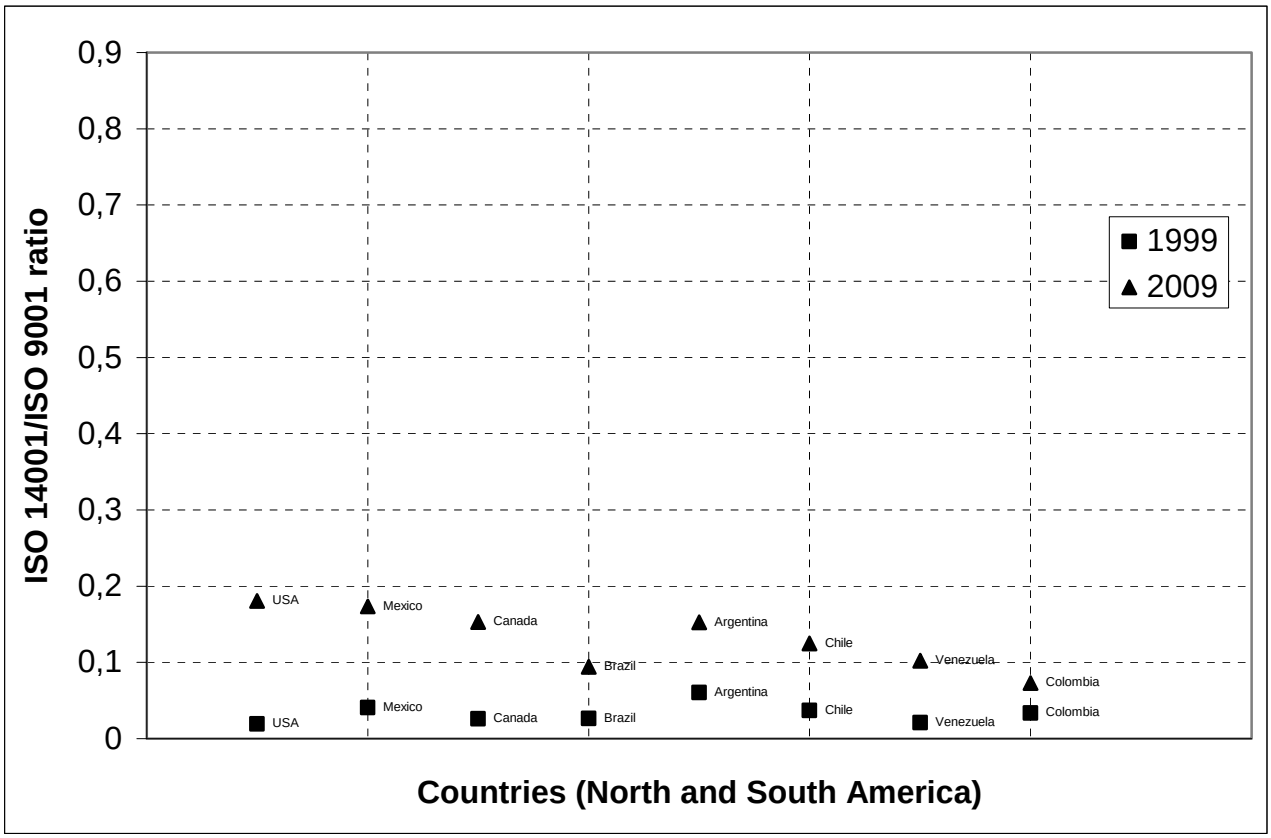
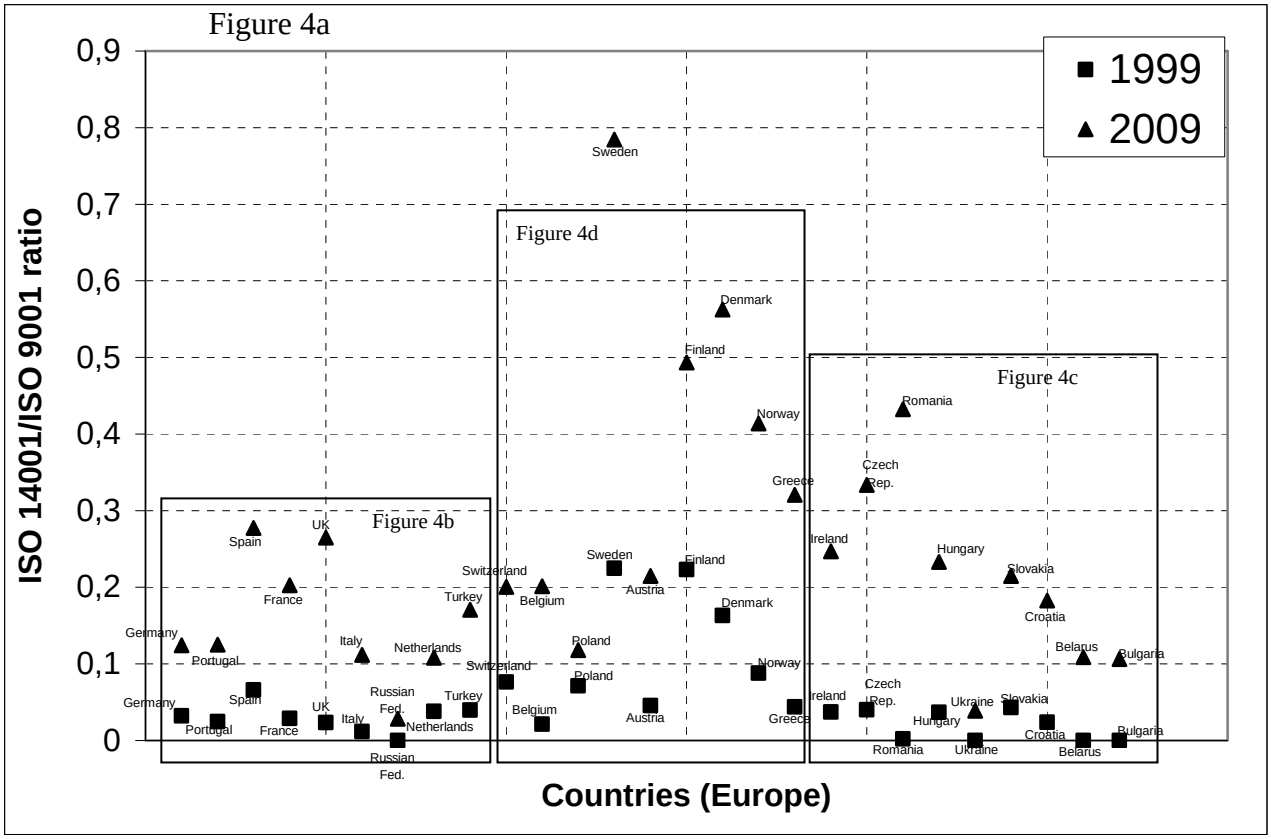
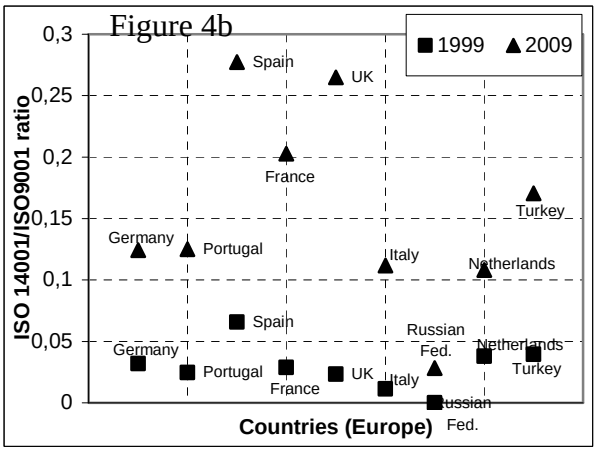
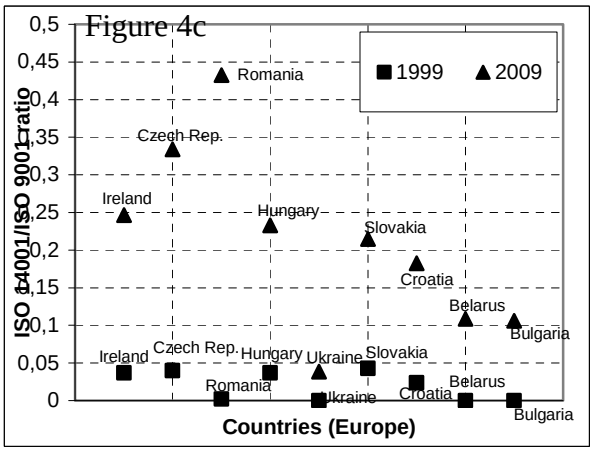
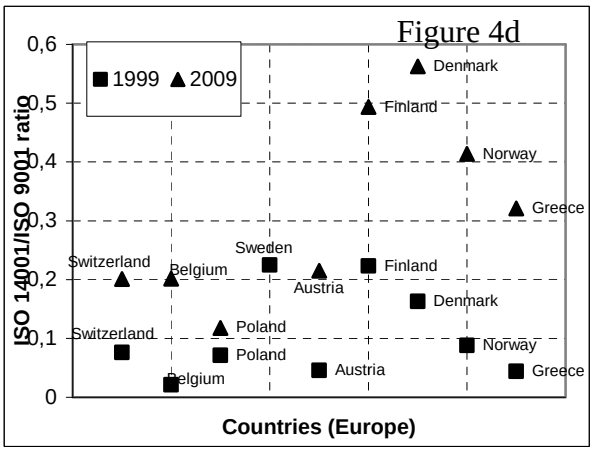


Figure 3: ISO 14001/ ISO 9001 number of certificates ratio (1999-2009) in North and South America









Figures 4a-4d: ISO 14001/ ISO 9001 number of certificates ratio (1999-2009) in Europe

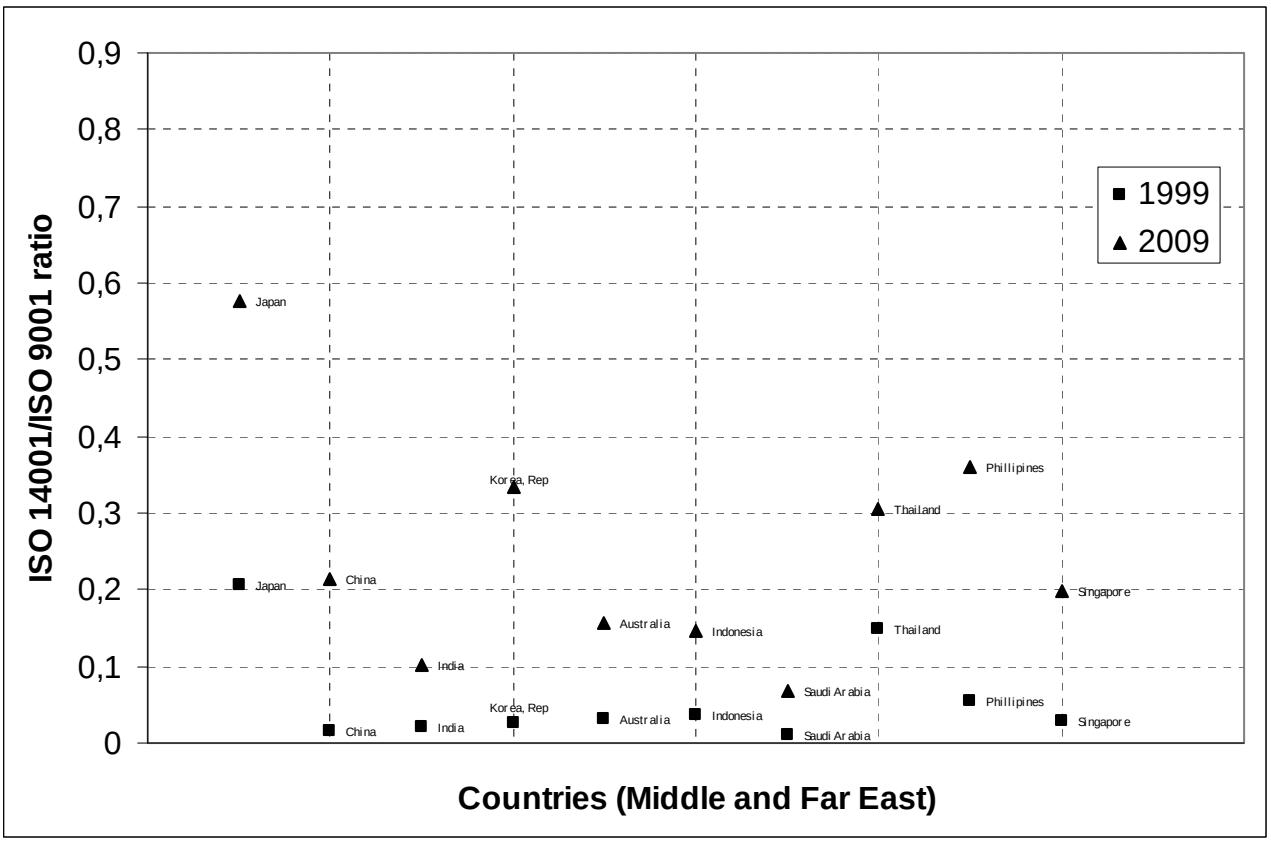


Figure 5: ISO 14001/ ISO 9001 number of certificates ratio (1999-2009) in Middle and Far East

Comparison between macro-economical data, namely Gross Domestic Product (GDP) and Gross Net Income (GNI_{Atlas}) per capita, and ISO 14001/ISO 9001 number of certificates ratio (Figures 6 and 7), shows a faint relationship between those indicators.

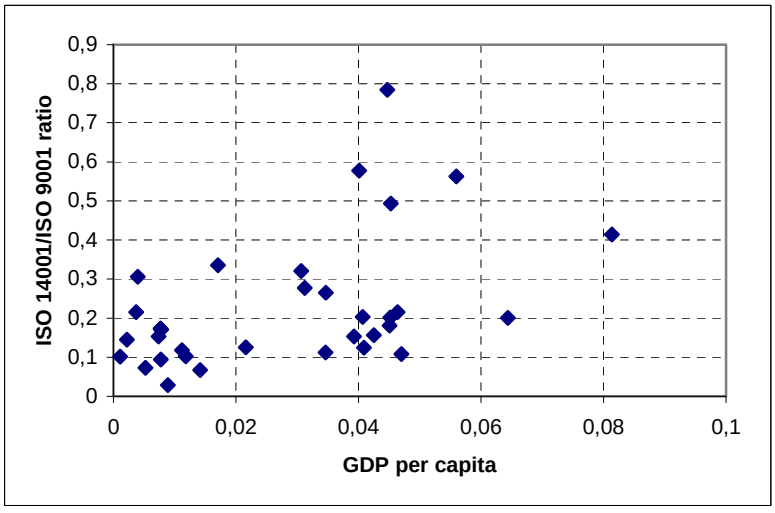


Figure 6: ISO 14001 to ISO 9001 number of certificates ratio per GDPpc (2009)

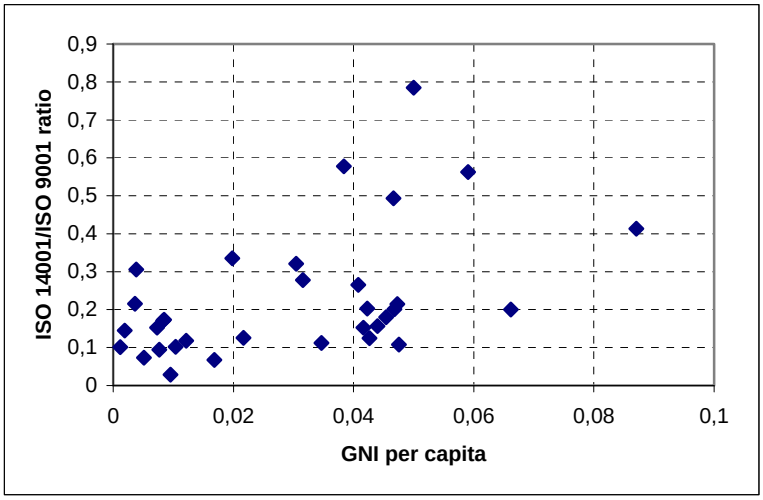


Figure 7: ISO 14001 to ISO 9001 number of certificates ratio per GNI_{Atlas}pc (2009)

3. ORGANISATIONAL INTERACTIONS DERIVED FROM IMS

It is appropriate to state that two major features are implicit in the evolution to an IMS:

- A management holistic perspective.
- Organisational interactions between several management sub-systems requirements.

The above mentioned interactions and their emergence when integrating management sub-systems were identified earlier by Karapetrovic and Willborn (1998a) associating interlinking concept with integration and identifying the loss of independence of one or all of the integrated management sub-systems (Wilkinson and Dale, 1999).

Asif, Bruijn and Fisscher (n.a) focused implicitly the organizations interactions issue representing an IMS by the correspondent Venn diagram (Figure 8). Intersection areas suggest generic organisational features where interactions between management sub-systems standard requirements are expected to occur.

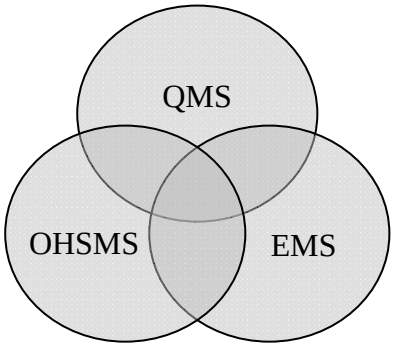


Figure 8: Venn diagram for IMS (Asif, Bruijn and Fisscher, n.a.)

A 3-dimensional methodology for organisational interactions assessment was proposed by Domingues, Sampaio and Arezes (2011a) and a conceptual framework for internal audits (Figure 9) embedding organisational interactions on it, suggested by the same authors (Domingues, Sampaio and Arezes, 2011b).

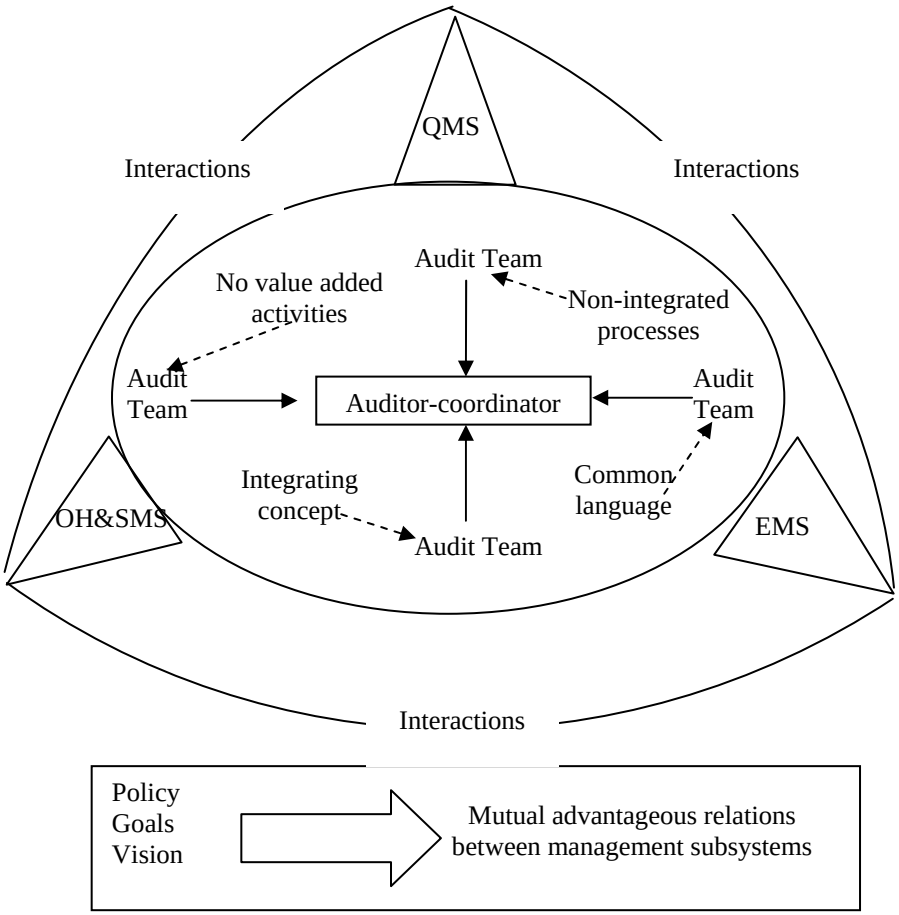


Figure 9: Proposed conceptual framework (adapted from Domingues, Sampaio and Arezes, 2011b)

The 3-dimensional methodology relies on a graphical and intuitive methodology being critical a suitable definition of indicators. Furthermore the conceptual framework tries to answer the following issue:
What happens to a Quality indicator after the implementation of an environmental or OHS action?

Mathematically this question could be represented by Equations 1 and 2, for non-categorical variables (Domingues, Sampaio and Arezes, 2011a). The authors proposed an action methodology to deal with variations or interactions on a generic quality indicator (Q_{ind}) after a non-categorical environmental (Env_{Act}) or OHS ($OH\&S_{Act}$) action takes place.

$$\frac{\partial Q_{ind}}{\partial (OH\&S)_{Act}} = f(OH\&S)_{Act} \Rightarrow \int \partial Q_{ind} = \int f(OH\&S)_{Act}.\partial (OH\&S)_{Act} \Rightarrow Q_{ind} = f(OH\&S)_{Act} \quad \text{Eq. 1}$$

$$\frac{\partial Q_{ind}}{\partial Env_{Act}} = f(Env)_{Act} \Rightarrow \int \partial Q_{ind} = \int f(Env)_{Act}.\partial Env_{Act} \Rightarrow Q_{ind} = f(Env)_{Act} \quad \text{Eq. 2}$$

Generically, the authors introduced the "organisational volume" concept taking into account, simultaneously, the environmental and occupational and health components (Eq. 3).

$$\partial Q_{ind} = f((OH\&S)_{Act},(Env)_{Act}) \Rightarrow \int \partial Q_{ind} = \iint f((OH\&S)_{Act},(Env)_{Act}).\partial (OH\&S)_{Act}.\partial (Env)_{Act} \quad \text{Eq. 3}$$

Further information could be exploited for more complex behaviour of Q_{ind} related to Env_{Act} or $OH\&S_{Act}$ (Figure 10).

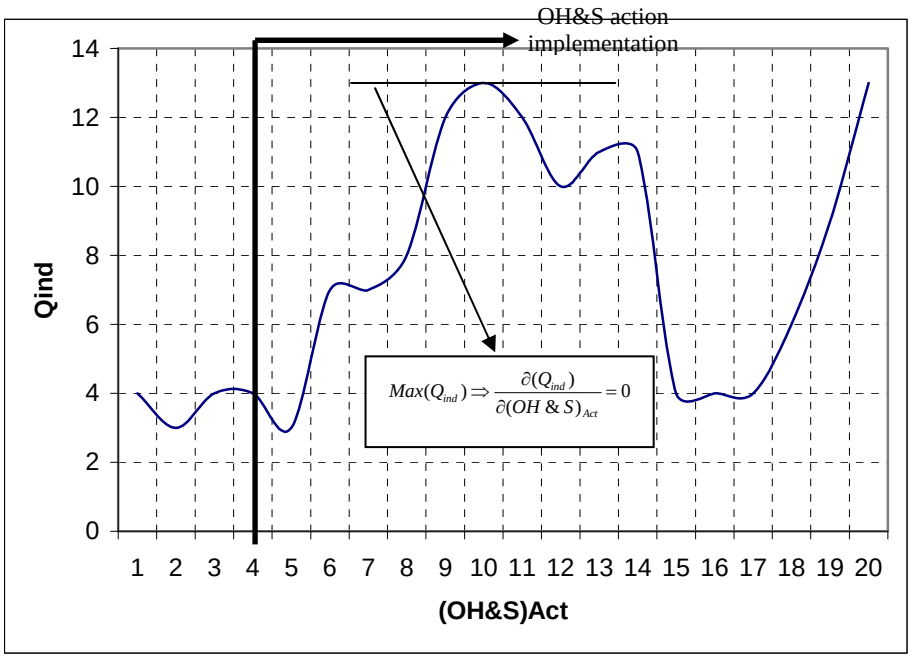


Figure 10: Generic Q_{ind} versus a generic non categorical $(OH\&S)_{Act}$

For instance, it is possible to ascertain which value from the non-categorical $OH\&S_{Act}$ provides the highest value to the Q_{ind} following Equation 4 (Figure 10).

$$Max(Q_{ind}) \Rightarrow \frac{\partial(Q_{ind})}{\partial(OH\ \&\ S)_{Act}} = 0 \qquad \text{Eq. 4}$$

Slope may be used to collect information in Q_{ind} that behaves directly proportional to the $(OH\&S)_{Act}$ (Figure 11). In this case, slope provides indications on the "intensity" or on the organizational "inertia" experienced by $OH\&S_{Act}$ on the Q_{ind}. In the given example (Figure 14), slope 2 indicates that the OHS related action experienced higher organizational "inertia" than OHS action related to slope 1.

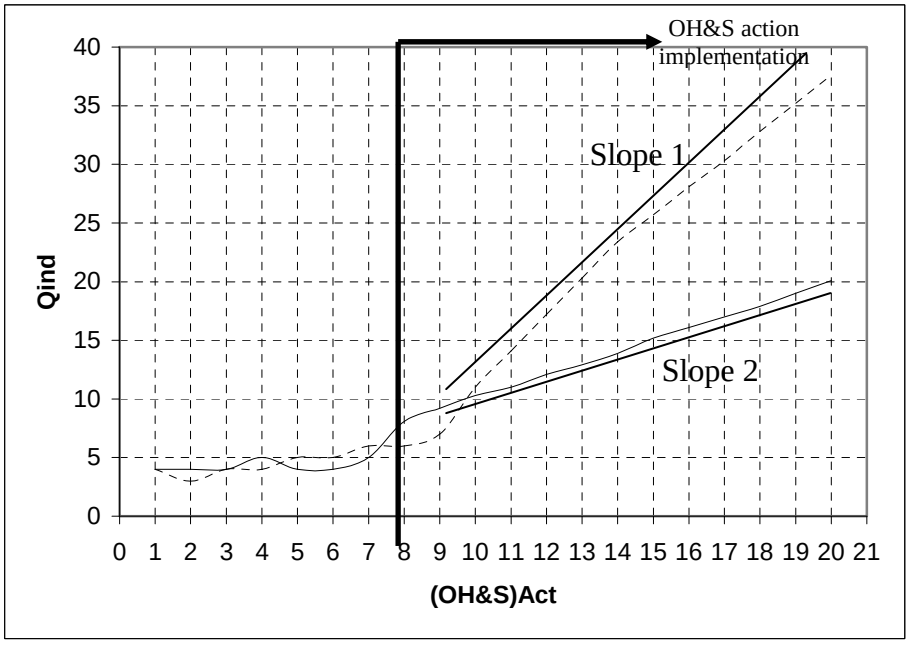


Figure 11: Generic Q_{ind} versus a generic non-categorical $(OH\&S)_{Act}$

In other publication, Domingues, Sampaio and Arezes (2011c), stated that similar to the intrinsic differences among vector and scalar quantities in an integrated environment the complete system status description is not possible based on a unique variable or dimension, and should be supported on dimensions identification, variables definition and on interactions assessment between *inputs/outputs* originated or derived from each management sub-system. Hence, a graphical vectorial approach to integrated management may be exploited in order to increase information availability regarding different components from the IMS. Advantages of a 3-dimensional graphical vectorial approach is that the target value, given a generic indicator and non categorical action variables, is not a single point but a cluster of points (Figure 12) allowing potential adjustments on each axis to reach it.

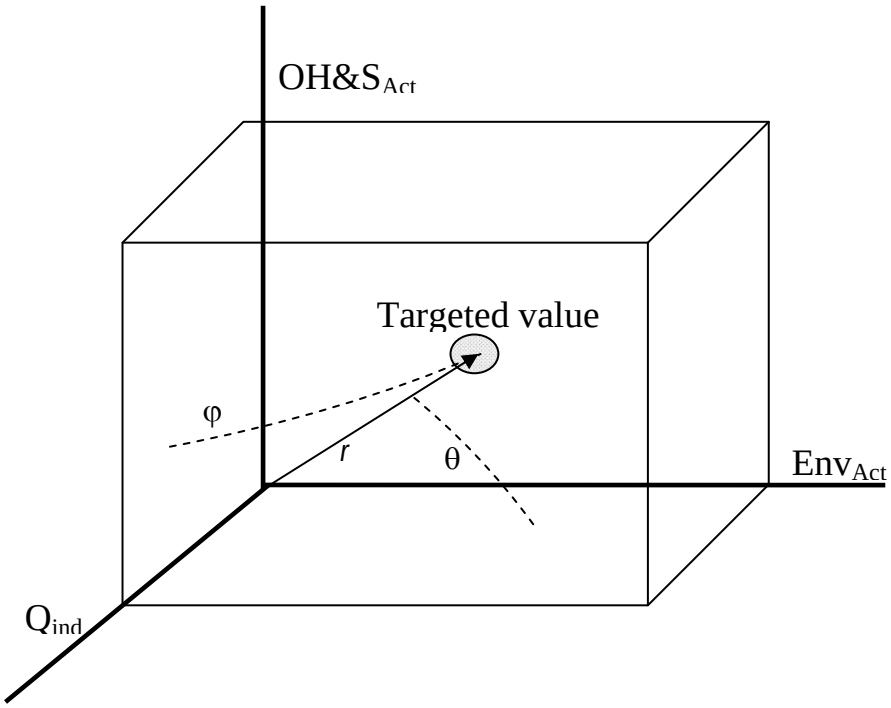


Figure 12: Vectorial approach on integrated management

Recalling the fundamentals of vectorial algebra, in Cartesian (Eq. 8-10) and spherical coordinates (Eq. 5-7).

$$r = \sqrt{x^2 + y^2 + z^2} \quad \text{Eq. 5}$$

$$\theta = \cos^{-1}\left(\frac{z}{r}\right) \quad \text{Eq. 6}$$

$$\varphi = \tan^{-1}\left(\frac{y}{x}\right) \quad \text{Eq. 7}$$

Where,
θ is the elevation angle, φ the azimuth angle and r the radial distance. Inversely, traditional Cartesian coordinates may be used (Eq. 8-10).

$$x = r.sen\theta.\cos\varphi \quad \text{Eq. 8}$$

$$y = r.sen\theta.sen\varphi \quad \text{Eq. 9}$$

$$z = r.\cos\theta \quad \text{Eq. 10}$$

In the given example (Figure 12), elevation angle and the azimuth angle may be achieved using the $OH\&S_{Act}$ and Env_{Act} plane. Radial distance (r) may be a generic indicator management goal. As been stated earlier, valid solutions fall under a 3-dimensional array. Hence, vectorial approach to integrated management allows higher degrees of freedom to a generic problem in a multi-dimensional environment like IMS.

4. QUALITY REDEFINITION IN AN IMS

Several features regarding organisational behaviour by QMS facing newly implemented management sub-systems have been discussed earlier on this article. As it had been stated, the integration process is seen by QMS through a different perspective than the perspective of EMS and/or OHSMS. QMS is usually the IMS genesis management sub-system and, prior to integration, the solely management system ruling the organization. Resources were located to QMS prior to integration and, in a post-integration scenario, resources should be dispersed by the newly added management sub-systems. In this paper we identified and described three organisational behaviour faced by QMS to the integrated environment. The "Quality" definition proposed by Taguchi converges with integration definition. Thus, it seems that a conceptual redefinition of the Taguchi "Quality" concept is not so critical than the QMS purpose redefinition in an IMS. From the above mentioned on the present paper the following characteristics should be embraced by QMS:

- Symbiotic relationship with EMS and OHSMS more than a competitive approach.
- Organisational verticality more than a transversal approach to internal company processes, favours the integration of new concepts introduced by added management sub-systems.
- Action approach as a benchmark to be achieved by other management sub-systems (Domingues, Sampaio and Arezes, 2011c).
- Embrace the *concordia discors* approach as the more suitable for the integration process.

5. FINAL REMARKS AND CONCLUSIONS

QMS is not just one of the management sub-systems composing an IMS. As the genesis management sub-system, QMS should assure all conditions for a successful integration process. Several reasons were mentioned weakening the QMS position, namely, less resources availability and lost of focus after an integration process.

Several QMS approaches were identified facing management systems integration based on available literature: the *divide et impera*, the *concordia discors* and the *e pluribus unum*. It seems that dimension of the organizations (and related resources availability) and QMS "weight" prior to integration, regulates the optioned approach by QMS.

Organisational interactions arise from management systems integration. Several authors implicitly identified these interactions earlier. This paper presented a graphical methodology to assess those interactions updating a paper previously published by the same authors. A novel interactions proposal, based on a vectorial approach, has been presented too. Further work is required in order to check these proposed methodologies.

More than a redefinition of the "Quality" concept, a redefinition of the QMS purpose under an integrated environment should be put on the agenda. A QMS with a wider focus embracing environmental and OHS issues as a requirement for customer satisfaction seems to be appropriate to deal with this, more than ever, organisational challenge entitled IMS.

6. AKNOWLEDGEMENTS

Acknowledgements are due to Delphi and Bosch Corporations.

7. REFERENCES

1. Suditu, C. (2007). Positive and negative aspects regarding the implementation of an integrated Quality-Environmental-Health and Safety management system. *Annals of the Oradea University- Fascicle of Management and Technological Engineering*, Volume VI (XVI), 2013-2017.
2. Ramly, E.F., Ramly, E.S. and Yusof, S.M. (n.a.). Effectiveness of quality management system audit to improve quality performance- A conceptual framework.
3. Jonker, J. and Karapetrovic, S. (2004). Systems thinking for the integration of management systems. *Business Process Management Journal*, **10**(6), 608-615.
4. Karapetrovic, S. (2002). Strategies for the integration of management systems and standards. *TQM Magazine*, **14**(1), 61-72.
5. Karapetrovic, S. and Willborn, W. (1998a). Integration of quality and environmental management systems. *The TQM Magazine*, **10**, 204-213.
6. Wilkinson, G. and Dale, B.G. (1999). Models of management system standards: a review of the integration issues. *International Journal of Management Reviews*, **1**, issue 3, 279-298.
7. Domingues, J. P. T., Sampaio, P. and Arezes, P. M. (2011a). Management Systems Integration: A 3-dimensional organisational perspective. *Proceedings of 12th International Symposium on Quality*, Osijek, Croatia.
8. Domingues, J. P. T., Sampaio, P. and Arezes, P. M. (2011b). Beyond "audit" definition: A framework proposal for integrated management systems. Accepted for publication at *Proceedings of 61st IEEE Annual Conference and Expo*, Reno, Nevada, USA.
9. Correia, H. (2010). Sistemas de Gestão Integrados. *APCER presentation*.
10. Domingues, J. P. T., Sampaio, P. and Arezes, P. M. (2010a), "Integrated Management Systems: a synergistic approach," *Proceedings of 13th Toulon-Verona Conference*, Coimbra, Portugal.
11. Dubrovski, D. (2009). Management mistakes as causes of corporate crisis: managerial implications for countries in transition. *Total Quality Management*, **20**(1), 39-59.
12. Domingues, J. P. T., Sampaio, P. and Arezes, P. M. (2010b). Management systems integration: An organizational milestone. *Proceedings of Semana de Engenharia 2010*, Guimarães, Portugal.
13. Asif, M., de Bruijn, E. J. and Fisscher, O.A.M. (n.a.). Why do firms engage in integration of management systems: A literature review & research agenda. *Corporate Motivation for Integrated Management System Implementation*.
14. Elg, M., (2007). The process of constructing performance measurement. *The TQM Magazine*, **19**(3), 217-228.
15. Lawrence, T. (2009). Out of the shadows. *Professional Safety*, April 2009, 25-27.
16. Karapetrovic, S. and Willborn, W. (1998b). The systems view for clarification of quality vocabulary. *International Journal of Quality & Reliability Management*, **15**(1), 99-120.
17. Beckmerhagen, I. A., Berg, H. P., Karapetrovic, S.V., Willborn, W.O., (2003a). Integration of management systems: focus on safety in the nuclear industry. *International Journal of Quality & Reliability Management*, **20**(2), 210-218.
18. Beckmerhagen, I. A., Berg, H. P., Karapetrovic, S. V. and Willborn, W. O., (2003b). Auditing in support of the integration of management systems: a case from the nuclear industry. *Managerial Auditing Journal*, **18**(6/7), 560-568.
19. Zink, K.J. (2008). Human resources and organisational excellence. *Total Quality Management*, **19**(7-8), 793-805.
20. Elg, M., (2007). The process of constructing performance measurement. *The TQM Magazine*, **19**(3), 217-228.
21. Worldbank Website, 2011-04-28.
22. Census.gov Website, 2011-04-28.
23. Domingues, J. P. T., Sampaio, P. and Arezes, P. M. (2011c). "Integrated Management Systems: The vision from the perspective of the OH&SMS." *Proceedings of SHO 2011*, Guimarães, Portugal.
24. Domingues, J. P. T., Sampaio, P. and Arezes, P. M. (2011c). Benchmarking on behalf of management systems integration. Accepted for publication at *Business Sustainaility II*, Póvoa do Varzim, Portugal.