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**The contribution of an integrated management system to the manufacturing  
strategy: a case study**

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## **Abstract**

This article studies the contribution of the implementation of an integrated management system (Quality, Environmental and Health & Safety Systems) to manufacturing strategies. It was carried out a case study in an automotive company in the south region of Brazil. After the development of a Conceptual framework, the study searched for the identification of the predominant characteristics of the integrated system and their utilization as managerial tools by the company leadership. There were considered ten respondents from the supervision level and another ten respondents from the managerial level, and the AHP method was applied. In a second step a comparison was done between strategic indicators values from before and after the integration of the individual systems. The results obtained are showing higher values for the compared indicators after the system integration and also are pointing out the linear contribution of the integrated systems main characteristics to the indicators.

**Keywords:** Manufacturing strategy, Integration, AHP, Integrated Management Systems

## **Introduction**

The current competitive scenario (new technologies, consumer's market fragmentation, growing awareness about environment conservation etc.) pressures the companies to adapt their selves, in all levels – strategic, tactic and operational – to meet the market requirements.

This new reality brings concerns with waste, control and reduction on pollutants emission to the environment, assessing the global performance of the company towards the environment, quality and health & safety variables.

To deal with those issues, many companies adopt norms, such as ISO 9001 (Quality), ISO 14000 (Environment) and OHSAS 18001 (Health and Safety). Those norms prescribe requirements to be followed and observed by the adopters. They address different aspects and all of them need a bunch of data and time from the companies (Wilkinson and Dale 1999).

The application and use of each norm require that companies collect data, with its own database, form and maintain auditors and accomplish many actions, for example meetings, audits, machine stoppages etc. To save money, time and resources, companies might integrate their systems of quality, environment & health and safety.

But even though many companies are pursuing such integration, literature and practice still do not offer many 'solutions' for that.

Understanding manufacturing strategy as Swamidass and Newell 1987, were "Manufacturing strategy is viewed as the effective use of manufacturing strengths as a competitive weapon for the achievement of business and corporate goals", we can

analyse the effect of an Integrated Management Systems (IMS) on a manufacturing strategy.

This paper presents an integrated system of quality, environment and health & safety (SQEHS). Based on a case study of a car engine producer in Brazil (internal-combustion engine), the integrated systems was applied and fourteen performance indicators were measured for twenty-five months before and after the integration, providing comparison of the performance changes with the integration of the systems. The results show that the company increased its performance on almost all indicators that were analyzed. To go deeper into the used SQEHS, 20 employees managers and supervisors were interviewed to evaluate which requirements had a stronger impact on performance.

The paper is structured in the following sections: initially it is presented the methodology and the research design. The common requirements of the SQEHS are presented, followed by the performance indicator values comparison. Afterwards, we present the managers and supervisor perception of the relative contribution of each SQEHS requirement.

### **Methodology and Research Design**

This study can be classified as empirical research (Flynn et al. 1990), and according to Gupta, Verma and Victorino 2006, may be further classified as follows:

- *Research Purpose*: theory-building, since an integrated systems of quality, environment and health & safety is proposed; and theory-verifying, since the proposed integrated systems is tested through several performance indicators;

- *Data collection approach*: it was carried out a case-study, using interviews and archival data;
- *Data analysis*: descriptive statistics and t-tests.

The case study was carried out in a multi-national company that produces car engines (internal-combustion engines) in Brazil. It was developed a framework to represent the Integrated Management System, in terms of common requirements. At the time of the SQEHS implementation, the company had about 450 employees, and produced car engines to its parent company as well as to third-party companies. In the same period, the company was ISO 9001 and ISO 14001 certified, and was migrating from the BS 8800 to OSHA 18001 Occupational Health Safety System.

Before the framework started being used, it was developed a list of terms, linking the common requirements stated on the framework to the existing terminology for the same variables/aspects/norms/policies used by the company. This action helped for the understanding about the new integrated system.

In order to evaluate the effect of the SQEHS on performance, there were selected 14 performance indicators and analyzed their values for 25 months before and after its implementation. The indicators were identified from the strategic processes of the company. The authors used the documentation from the Quality System, once the company is ISO 9001 certified and its strategic processes are mapped. There were identified 7 strategic processes.

For each strategic process, all related sectors were listed, as well as:

- The main activities and responsible persons, inputs and suppliers, as well as main outputs and customers;
- Main materials and equipments;
- Main general and specific competences;
- Main employed methods and indicators of process efficiency and effectiveness.

The number of performance indicators (process efficiency and effectiveness) varied from 4 to 9 among the 7 strategic processes. However, since during the 50 months they were measure many of them were changed, in order to assure the consistency of the comparison, only 2 indicators per strategic process were used in the analysis, resulting in 14 performance measures. We used descriptive statistics and t-Test (Aczel, 1989) for the mean comparison.

Figure 1 presents a framework of this research step.

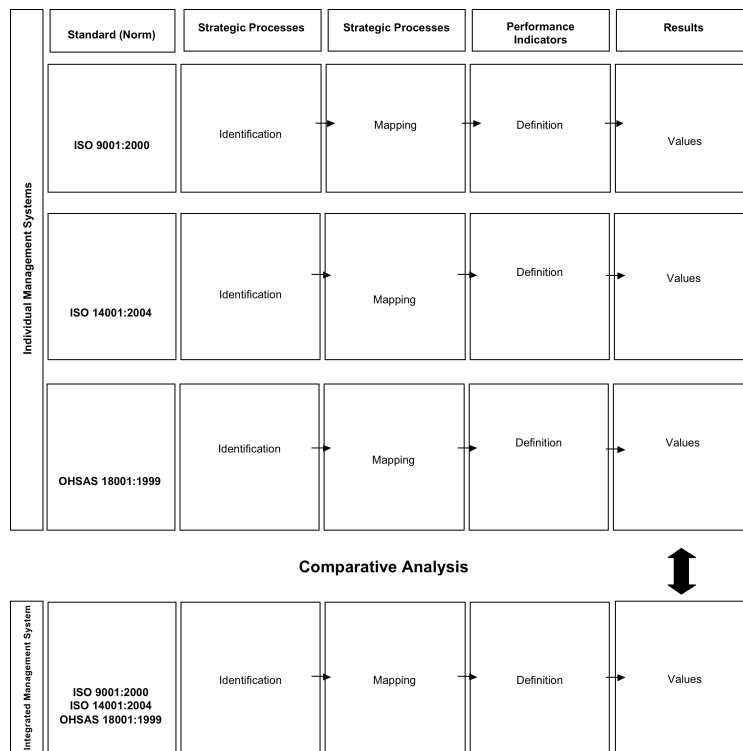


Figure 1: First research step

After the comparison of 50 months for the 14 performance indicators, 20 employees were interviewed – 10 from the managerial level and 10 from the supervision level – to assess the impact of each common requirement on the company’s performance. We used AHP (Satty, 2006) to analyze the findings. Literature reports other works on the same subject that applied AHP as a method (for example, Chan, Kwok and Duffy, 2004; Law, Chan and Pun 2006)

Figure 2 shows this second research step.

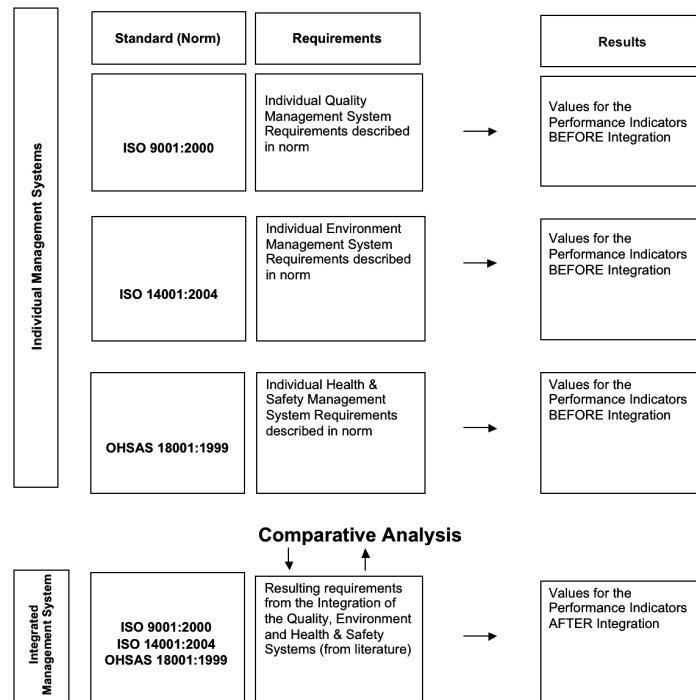


Figure 2: Second research step

## **The Integrated System of Quality, Environment and Health & Safety (SQEHS)**

Literature about Integrated Management Systems present many reasons for integrations, as well as suggests possible approaches for achieving it (Zutshi and Sohal 2005, Klassen and Angell 1999, Griffith and Bhutto 2009, Scipioni et al. 2001, Wilkinson and Dale 1999, Karapetrovic 2002, among others).

We adopted as a reference for the integration of the Quality, Environment and Health & Safety Systems requirements the PAS 99:2006 – *Specification of common management system requirements as a framework for integration* – elaborated by the BSI (British Standards Institution) (BSI 2006).

The following common requirements were considered:

1. General Requirements;
2. Management System Policy;
3. Planning;
4. Implementation & Operation;
5. Performance Evaluation;
6. Continuous Improvement;
7. Management Review.

To make the Integrated System understandable by the employees, it was developed a table with the correspondence among the common requirements and usual elements of management used by the company (Exhibit 1).

Exhibit 1: Common requirements and the companies' current terminology

1	2	3	4	5	6	7
General Requirements	Management System Policy	Planning	Implementation & Operation	Performance Evaluation	Continuous Improvement	Management Review
Company's Business System	Communication	APQP (Advance Product Quality Planning)	Sales	Process audit	Continuous improvement atmosphere	Management review meetings
ISO TS 16949	Awareness	PPAP (Production Part Approval Process)	Production	Management system audit	Problem solution methodology	Performance indicators monthly revision
ISO 14000	Application	PSO (Process Sign Off)	Maintenance	Tiers audit	Kaizen groups	Safety review meetings
Processes mapping	Strategic alignment	Production planning	Control plan	Product audit	Corrective actions	Customer concerns tracking
Safety system		Maintenance planning	Kanban	Employees performance assessment	Preventive actions	HR indicators revision meeting
TPS (Toyota Production System) 4 rules		Organization chart	Inventory reduction	Daily production tracking	Top problems	
Customer requirements		Job description	Training	EH&S audit	TPM (Total Productive Maintenance)	
Shareholder expectations		Scorecard targets	Suppliers	Safety observations		
		Environmental program	Infrastructure			
		Management system planning	Procedures			
			Just in Time			

From the Quality Systems it was possible to identify 7 strategic processes: (1) Strategic Management, (2) Human Resources Management, (3) Production, (4) Quality and Product; (5) Manufacturing, (6) Logistics and (7) Maintenance.

For each of the 7 strategic processes it was identified: The main activities and responsible persons, inputs and suppliers, as well as main outputs and customers; Main materials and equipments; Main general and specific competences; Main employed methods and indicators of process efficiency and effectiveness.

For each process was produced a chart with all identified information, as it is presented at Figure 3 for the strategic process 'Manufacturing'.

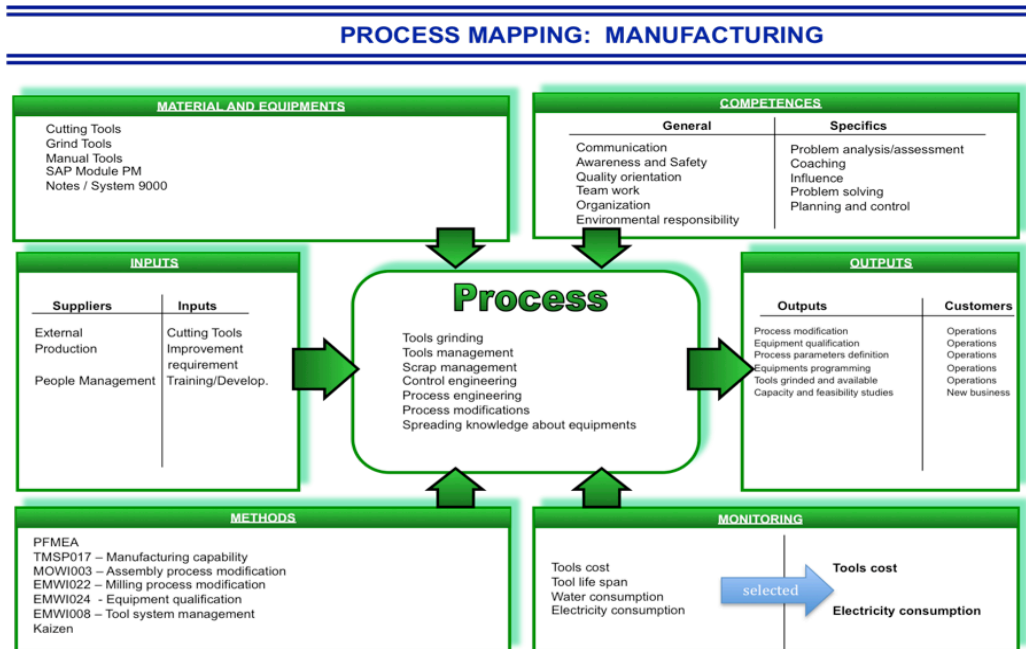


Figure 3: Process mapping for the strategic process 'Manufacturing'

For the 51 performance indicators identified, it was chosen 2 indicators per strategic process, resulting in a set of 14 performance indicators, as presented at Exhibit 2 below.

Exhibit 2: Performance indicator per strategic process

Process	Performance indicator	Improvement direction
Strategic Management	Operational costs	Lower
	Customers non satisfaction	Lower
Human Resources Management	OSHA Index	Lower
	Absenteeism	Lower
Production	Hour per product	Lower
	Scrap	Lower
Quality and Product	Dimensional audit	Lower
	Functional audit	Lower
Manufacturing	Tools cost	Lower
	Electrical energy consumption	Lower
Logistics	First Time Capabilities Product	Raise
	Number of produced products	Raise
Maintenance	Cost per Unity maintenance	Lower
	Amount of scrap	Lower

## Results and Discussion

In this section we will present the results for the use of the SQEHS.

The values of each performance indicator were measured for 50 months – 25 months before integration and 25 months after integration.

For each performance indicator, it was made a comparison using a t-student test of means, considering 95% of confidence.

To visualize the results, 3 graphics were constructed: dispersion, box plot and temporal series. For example, Figures 4, 5 and 6 present the 3 graphics for the performance indicator ‘tool cost’, respectively. The values are presented without unities, because of confidentiality purposes.

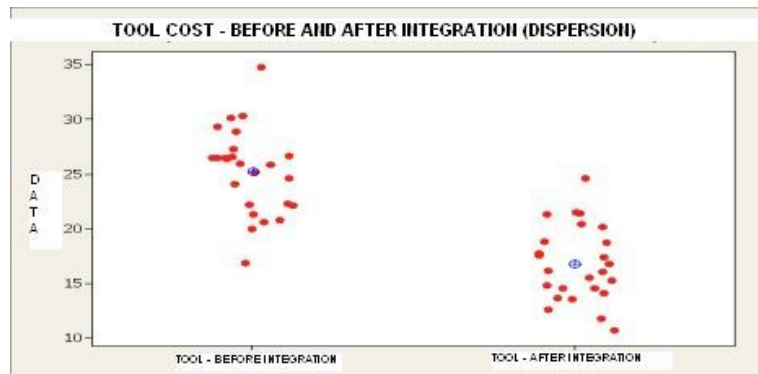


Figure 4: Dispersion graph for the Tool Cost before and after SQEHS

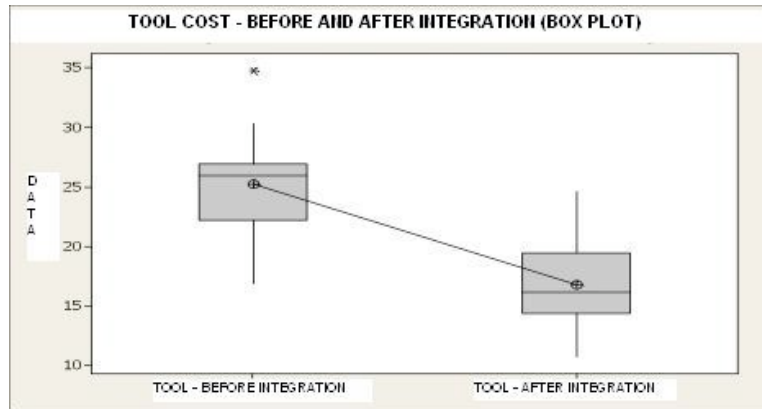


Figure 5: Box-Plot graph for the Tool Cost before and after SQEHS

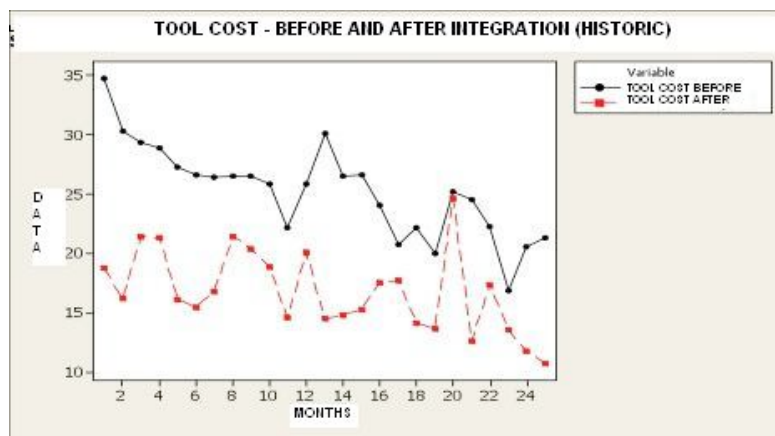


Figure 6: Temporal series graph for the Tool Cost before and after SQEHS

It can be seen from the former 3 Figures that after the integration the mean value of Tool Cost was decreased.

To better compare the mean value of each indicator for the 25 months before (‘before’) and 25 months after (‘after’) the SQEHS implementation, the t-Test (Aczel 1989) was applied, considering 95% of confidence.

As a decision criteria for the improvement, there were considered 2 hypotheses:

H0: the 2 means (before and after) are statistically the same;

H1: the 2 means (before and after) are statistically different.

And for:

$p < 0.05$  H0 is rejected;

$p \geq 0.05$  H0 is accepted.

Exhibit 3 presents the mean, before and after the SQEHS, with their respective standard deviation (SD), the *p-value* and the assessment of improvement. Once again the values are presented without unities.

Exhibit 3: Values for the Performance Indicators after and before SQEHS

Process	Performance indicator	Mean before	SD before	Mean after	SD after	p-value	Improvement
Strategic Management	Operational costs	357.7	49.2	358.4	92.3	0.971	✗
	Customers non satisfaction	548	558	231	226	0.013	✓
Human Resources Management	OSHA Index	2.94	2.55	1.12	1.03	0.002	✓
	Absenteeism	2.891	0.519	2.09	1.30	0.008	✓
Production	Hour per product	3.24	0.447	2.86	0.417	0.004	✓
	Scrap	12.18	4.80	5.60	1.91	0.00	✓
Quality and Product	Dimensional audit	0.0988	0.0517	0.0408	0.0256	0.00	✓
	Functional audit	0.1196	0.0926	0.0272	0.0320	0.00	✓
Manufacturing	Tools cost	25.26	3.92	16.81	3.44	0.00	✓
	Electrical energy consumption	171.20	20.6	138.20	19.2	0.00	✓
Logistics	First Time Capabilities Product	93.84	3.18	97.64	0.633	0.00	✓
	Number of produced products	15185	3534	15702	2730	0.565	✗
Maintenance	Cost per Unity maintenance	23.46	7.49	17.68	6.30	0.005	✓
	Amount of scrap	87.8	12.7	31.1	24.3	0.00	✓

It is worthy to note that for the 14 performance indicators considered, there were statistically proved improvement on 12 of them. The 2 chosen performance indicators for the processes HR Management, Production, Quality & Product, Manufacturing and Maintenance were improved. For the processes Strategic Management and Logistics, 1 indicator of each process had no improvement, namely Operational Costs and Number of Produced Products, respectively. In relation to the Operational Costs, it is important to note that during the 50 months considered, there was no monetary update to include inflation, neither the salary raises were considered, what may affect the cost comparison. With respect to the Number of Produced Products indicator, there were external factors influencing the volume produced: the parent company decreased the demand and the studied company could not find third-party customer to compensate the volume. This also affects the indicator.

In order to better understand the SQEHS, we looked deeper into the effect of each requirement on performance.

With the results for the 25 months after SQEHS was implemented, we interviewed 20 employees (called observers), being 10 from the management level and another 10 from the supervision level. The number of 20 observers was considered expressive, once the company had 30 positions of management and supervision. The criteria for observers' selection were:

- Experience at the company: at least 4 years, in order to guarantee that the employee took part on the whole process, since the data were relative to 50 months;
- Activities: the employee should perform any function monitored by some of the perform indicators chosen to compare the results after the SQEHS implementation.

The AHP (Saaty 2006) was used to measure the perceived contribution of each common requirement. The observers were individually asked to value the contribution of each requirement of the SQEHS to the achievement of the targets defined at the strategic plan. The contribution of each requirement was valued in pairs, that is, the potential contribution of one requirement against the potential contribution of another requirement, as defined by the AHP method.

Before answering the questions, each observer was ‘trained’ by a half-hour presentation of the methodology and the Saaty scale, shown in Exhibit 4.

Exhibit 4: Intensities of relative importance for pairwise comparison

Intensity	Definition	Definition adapted to requirements
1	Equal importance	The 2 requirements have the same importance to the targets achievement
3	Moderate importance of one over another	One requirement is slightly more important over another to the targets achievement
5	Essential or strong importance	One requirement is strongly more important over another to the targets achievement
7	Demonstrated importance	One requirement is very strongly more important over another to the targets achievement
9	Extreme importance	Evidence favouring one requirement over another is of the highest possible order of affirmation
2,4,6,8	Intensities values between the two adjacent judgments	

Source: adapted from Saaty 2006

So the data were tabulated, being generated a normalized table and calculated the vector of priorities for each respondent. The dominant matrix was then calculated (Saaty 2006), and Figure 7 presents the results for the 10 managers, and Figure 8 for the 10 supervisors.

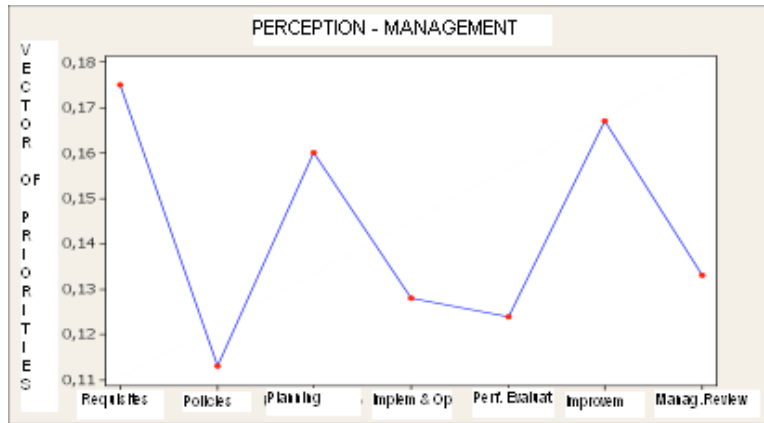


Figure 7: Perceived contribution of each requirement - Management

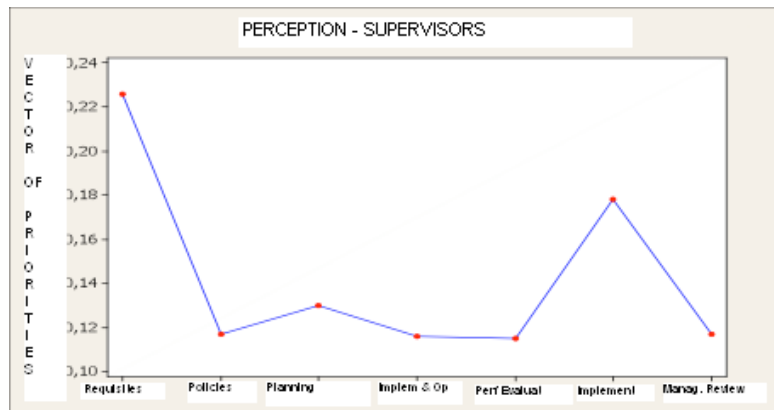


Figure 8: Perceived contribution of each requirement - Supervision

Exhibit 5 presents an ordained list of perceived contribution of each SQEHS requirement for the performance achievement, for both managers and supervisors perspectives, with their respective value for the vector of priority, obtained by the AHP Method.

Exhibit 5: Perceived contribution of each requirement for performance

Perceived importance	Hierarchical Level			
	Management	Vector of priority	Supervision	Vector of priority
1	General Requirements	0.175	General Requirements	0.226
2	Continuous Improvement	0.167	Continuous Improvement	0.178
3	Planning	0.160	Planning	0.130
4	Management Review	0.133	Management Review	0.117
5	Implementation & Operation	0.128	Management System Policies	0.117
6	Performance Evaluation	0.124	Implementation & Operation	0.116
7	Management System Policies	0.113	Performance Evaluation	0.115

As can be observed by the Exhibit 5, both levels of management and supervision consider the General Requirements as the most important ones for the company's targets achievement. This fact demonstrates that company is focused on attending the stakeholders. And, for example, the fact that Continuous Improvement is of higher importance for the supervision level may be because the majority of improvements are realized at the supervision level and below. Likewise, Planning was considered more important for the management level. Similar analyses can be done for the other requirements.

## Conclusion

This work presented an Integrated Management System, called SQEHS. Beginning from a set of common requirements of the Quality, Environment and Health & Safety standards, based on the PAS 99:2006, we identified and selected 14 performance indicators from the company's strategic processes. They were analyzed for 50 months, 25

before and another 25 after the SQEHS implementation. 12 performance indicators improved their values, while the other 2 did not. However, after an analysis of the context of those 2 indicators, their failure in terms of improvement may be credited to external factors. From these results, considering the analyzed organization, we can conclude that the IMS contributed to the achievement of the manufacturing strategy objectives.

To go deeper into the SQEHS, we interviewed 20 employees to observe their perception about which requirements had a higher influence on performance.

The field research is plenty of data and not all of them were presented in this paper.

As limitations, we could mention that we used only 14 performance indicators, among 51. The main reason was that many of the 51 indicators were changed during the 50 months of the study. Another limitation was the fact that we analysed only one company in our study. This is a serious restriction, since it would be difficult to find another company where we could have access to implement the same SQEHS for comparing the results.

### **Acknowledges**

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