

# Diagnosis of the Safety Culture of Carriers of Dangerous Goods by Road: A Case Study of Morocco

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## Abstract

Through an exploratory survey, this article assesses the level of safety culture of companies involved in the transport of dangerous goods (TDG) by road in Morocco while giving an overview of similar work already carried out in the world in general.

The results of this survey conducted via a questionnaire administered between March and May 2019 among 50 companies mainly located on the Casablanca-Tangiers axis in Morocco, reveal a response rate of 56% and that 77% of the companies questioned are at a stage of calculative maturity and 23% at a proactive stage. Our study is innovative in the sense that, to our knowledge, no survey related to this research topic has been carried out on a Moroccan or African scale. It is also innovative because, on one hand, it proposes for the first time in the African continent, the National Profile of Safety Culture, which is an indicator of performance of occupational health and safety, and on the other, it makes available to the national and international companies of TDG an adapted questionnaire (Toolkit) for self-assessment to gauge their performance in relation to the national profile proposed by this study.

**Keywords:** Safety culture, Dangerous goods, Road transport, Questionnaire, Statistics.

## I. INTRODUCTION

The emergence of the safety culture dates back mainly to 1986, when two major accidents occurred, the Challenger shuttle [1], [2] and the Chernobyl nuclear accident [3], which highlighted the organizational origin of accidents and the concept of a safety culture. In addition, investigations of other accidents such as those of AZF chemical plant (AZote-Fertilizers) in Toulouse and Texas City Refinery [3] have all revealed a deficiency in the safety culture and have shown that the ways of thinking and doing of all actors are at the origin of these accidents [4].

According to the Moroccan Ministry of Transport and Logistics, traffic accidents cause an annual average of nearly 3,500 deaths and 12,000 serious injuries, an average of 10 deaths and 33 serious injuries per day. The professional carriers represent 8.7%

of these fatalities [5]. Organizational safety practices of dangerous goods carriers significantly impact the gravity of these accidents on vulnerable areas and people, hence the importance of diagnosing the current level of safety culture in this sector of activity and then acting with public and private stakeholders on the risks and opportunities for its improvement.

## II. RELATED RESEARCHES

In the literature, several studies defining safety culture have been identified, such as the publications of Kennedy & Kirwan in 1995 [4], Gordon et al. in 2006 [6], Occelli in 2010 [7], the Health Foundation in 2011 [8], the Institute of Nuclear Power Operations (INPO) in 2012 [9], the International Association of Oil and Gas Producers [IOGP] in 2013 [10] and the World Association of Nuclear Operators (WANO) in 2013 [11]. According to the Institute for an Industrial Safety Culture [ICSI in French] in 2017 [12] "A safety culture is a set of ways of doing things and thinking that are widely shared by the actors of an organization about controlling the most important risks related to its activities." According to a recent study of the ICSI institute [12], the safety culture reflects the influence that organizational culture has on the ways of doing things and thinking that affect safety. It must focus on the most important risks. We find in the same study that improving safety performance requires coherent action on technical aspects, safety management, human and organizational factors. These different pillars are linked to the safety culture. The results of this research show that there is no single model and that each organization must strive to be exemplary in terms of security in its own world of constraints, nevertheless, for most companies that have advanced in the field of security, the challenge is to evolve towards a culture that makes management and field actors better collaborate on security issues. According to Simard's publications in 2012 [13], four main families of safety culture have been defined, namely: a) fatalistic culture, b) craft culture, c) normative culture and d) integrated culture, in which, the management of the company takes the place of leadership in security through coherent actions on the technical dimensions, the management of security, the human and organizational factors.

The ICSI institute, presents different typologies of the security culture [12], including: I) the typology according to the actors involved, detailed by Simard in 2000 [14], II) the typology according to the desirable attributes of the culture detailed by several researches such as Reason in 1997 [15], the International Atomic Energy Agency (AIEA in French) in 1998 [16], the Health and Safety Executive (HSE) in 1999 [17], Gordon et al in 2006 [6], WANO in 2013 [11] and Schein in 2016 [18], and III) the typologies according to the degree of maturity of safety culture. These were detailed by the AIEA in 1998) [16] and Westrum in 2004 [19] with three stages of maturity, while Hudson in 1999 [20], Parker, Lawrie & Hudson in 2006 [21] and the Hearts and Mind Program of the IOGP in 2010 [22] proposed five stages. Thus, depending on its maturity, the safety culture is described as pathological, reactive, calculative, proactive or generative.

According to The Health Foundation [23]: "Measuring safety culture or climate is important because the culture of an organization and the attitudes of teams have been found to influence patient safety outcomes and these measures can be used to monitor change over time".

Numerous different tools have been used to assess safety culture around the world, most of them are questionnaire which require the respondent to answer using a rating scale. For example, the Health Foundation published on 2011 an overview of tools that have been used to assess safety culture in the health sector (Hospitals) [23] but before that, on 2005, the Health and Safety Executive (HSE) gave an overview of these tools on offshore technology [24]. Other tools are also available for use in the oil and gas, nuclear and rail industries [23]. But extremely rare are the publications that deal with the safety culture of carriers of dangerous goods by road, such as the research of De-Marcellis, Peignier and Trépanier in 2012 in Quebec [25].

### III. METHOD

Based on a model of an integrated safety culture with five levels of maturity, we developed a questionnaire survey that was sent to 50 dangerous goods road carriers in Morocco between March and May 2019 by e-mail. This document has been calibrated by two international experts in Quality-Safety-Environment, by a national expert in transport and logistics and by an approved occupational physician. Trial tests of this questionnaire were carried out on two companies for its adaptation and validation before generalizing its final version for the targeted companies. The approval of the quantitative and qualitative results of the responses was carried out by statistical tests (Chi-square test and Multiple Correspondence Analysis - MCA).

## IV. RESULTS AND DISCUSSIONS

### IV.I Toolkit for self-assessment

The Toolkit for self-assessment is a questionnaire survey composed of 50 questions spread over 04 axes and 12 sub-theme. Each question should be answered by selecting one of these 04 levels of commitment ("never" / "sometimes" / "often"

/ "always"). The score ranges from 0 to 3 according to the answer given (0 for never and 3 for always). If the question is not applicable to your activity, the Non-Applicable answer (N/A) is chosen, in which case, it will not be counted in the calculation of the total score of this document.

### IV.I.I First Axis - Managerial involvement and learning feedback

#### Sub-theme N°1: Safety Constant Concern

- Q1: I start management meetings that I convene with a safety session and I personally chair the discussion.
- Q2: I monitor and encourage the safety action plan progress.
- Q3: I demonstrate my interest in safety by asking my employees questions about it.
- Q4: I discuss safety in a positive manner and draw attention to best practices.
- Q5: I decide which accompanying measures are appropriate for the partners.
- Q6: I assess each subcontractor's safety policy and approach and I take account of this information in selecting them.
- Q7: I perform a critical review of my safety system and raise each time my level of safety standards.
- Q8: I include a restitution of high potential events on the agenda of the management meetings that I convene.
- Q9: I innovate and encourage innovation regarding safety within my team.

#### Sub-theme N°2: Knowledge and Respect for Rules

- Q10: I make sure that my employees, temporary workers and subcontractors know and understand the safety rules.
- Q11: I'm looking for the right balance between rule-based safety and managed safety.
- Q12: I immediately put a stop to work that involves a safety risk and I discuss the situation with the people involved in order to understand their behaviour and change it.
- Q13: I don't focus on the simple achievement of objectives, I also look at the human cost that my teams have achieved (difficulties, effort, etc.).
- Q14: I set up an appropriate reaction grid and ensure that it is used and respected within my perimeter.

#### Sub-theme N°3: Sharing Successes & Failures

- Q15: I schedule safety feedback sessions to analyse difficulties as well as success factors.
- Q16: I make sure that high potential events go through a detailed analysis going back to root causes.

- Q17: I meet with or ensure that others meet with accident victims when they return to work so as to better understand the causes of the accident.
- Q18: I publicly commend entities and employees who made the most progress in ensuring safety and/or developed proactive approaches.
- Q19: I regularly set up a feedback meeting on the "safe driving"

#### ***IV.I.II Second Axis - Human and Organizational Factors***

##### ***Sub-theme N°4: Safety Example***

- Q20: I wear and make wear all necessary personal protective equipment, including specific one (gloves, glasses, hearing protection devices, etc.)
- Q21: I put in place a climate of trust conducive to freedom of speech (moments of exchange, addressing feedbacks...).
- Q22: I set up a recognition and upgrading grid and ensure that it is used and respected within my perimeter.
- Q23: I am personally involved in the change of standards following the analysis of a high potential event or in the monitoring of improvement action plans.
- Q24: I'm developing a fair culture in order to promote the flow of information.

##### ***Sub-theme N°5: Presence and Vigilance in the Field***

- Q25: During my visits (Client site / Fleet Transportation...), I take part in at least one of the key stages of the "Safe driving" scheme (Risk-assessment analysis, Regulatory compliance. ...).
- Q26: I ensure that the major risks of each of my client work sites / Fleet Transportation are clearly identified and shared with my teams.
- Q27: I make sure that the support and management departments directly observe the implementation of several specific procedures to ensure their feasibility.
- Q28: I ensure that dangerous situations and near misses are reported and analyzed and that corrective action is taken.
- Q29: I make sure that everyone has understood the concept of "STOP" to stop a task when a procedure is misunderstood, a change is made or a risk has not been taken into account.

##### ***Sub-theme N°6: Performance Assessment***

- Q30: I have defined with the employees reporting directly to me their specific safety responsibilities.
- Q31: I assess the safety experience and skills of applicants during the recruitment phase.
- Q32: I take account of safety in assessing my employees' potential for promotion.

- Q33: I include the managerial involvement concept as a significant criterion in defining the year-end bonus of my employees.
- Q34: I schedule one or two interim review(s) with my employees to update their roles and safety objectives during the year.

#### ***IV.I.III Third Axis - Training and Induction***

##### ***Sub-theme N°7: Safety Management Training***

- Q35: I ensure that all my operational managers have received training in safety management.
- Q36: I ensure that my staff have assessed their level of personal involvement in safety matters and I exchange with them on the outcome.
- Q37: I ensure that the training plans of the entities in my area take into account decisions arising from the analysis of major risks and high potential events.

##### ***Sub-theme N°8: Initial Safety Training***

- Q38: I check that every newly hired employee has received a "hands on" safety induction from the first days of his arrival in the company.
- Q39: I make introductory and concluding remarks at safety induction meetings for newly hired employees or for any safety management training.

##### ***Sub-theme N°9: Vocational Skills Training***

- Q40: I ask employees directly reporting to me what safety lessons they have learned from their vocational skills training.
- Q41: I check that the technical training provided to my employees incorporates our safety requirements.

#### ***IV.I.IV Fourth Axis - Risk Management***

##### ***Sub-theme N°10: Transport of Dangerous Goods***

- Q42: I ensure that safety is taken into account in the various phases of the tendering process
- Q43: I make sure that the ADR or other rules have been implemented and are followed over time.

##### ***Sub-theme N°11: Worksite Preparation***

- Q44: I ensure that worksite preparation and logistic include a strong, visible safety component.
- Q45: I ensure that each phase of works is preceded by a daily risk analysis shared with the teams (PreStart).
- Q46: I verify that the operating procedures have been explained to the work teams before any new activity (PreTask) and that their remarks have been taken into account.

- Q47: I ensure that the necessary stopping points are defined and organized for each phase of works.
- Q48: I make sure that prescribers (Supervision) are informed of developments on the working procedures.

**Sub-theme N°12: Operating Methods and Approval**

- Q49: I ensure that the safety procedures are updated and given to whom it may concern whenever the operating method is unexpectedly changed.
- Q50: During a Client site / Fleet Transportation... visits, I make sure that the implementation of the operating procedures is planned over time so that they are disseminated before their first implementation.

**IV.II Levels of maturity**

Based on the total score obtained from each questionnaire, the corresponding percentage of involvement is calculated, which will make it possible to determine the corresponding level of safety culture chosen from the five levels below:

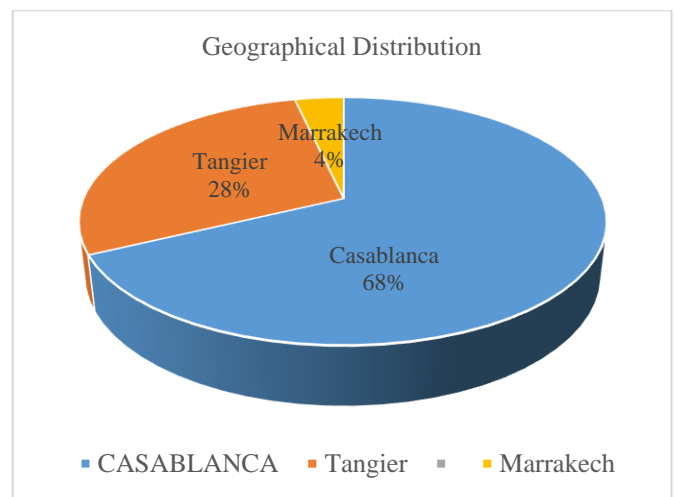
- 1) **Pathological culture level:** If the Percentage of commitment achieved is included in the range [0% -25%]. It is a level where people don't really care about health and safety and are only driven by regulatory compliance and by not getting caught. At this level, you can hear people saying things like: "Of course we have accidents, it's a dangerous business" Bad news is ignored.
- 2) **Reactive culture level:** If the Percentage of commitment achieved is included in the interval [25% - 50%]. In this stage, security is taken seriously, but it only gets sufficient attention after things have already gone wrong. People say things like: « You have to understand it's different here ». At the reactive level, managers say that they take safety seriously, but feel frustrated. « If only people could do what they are supposed to! ». « We need to force compliance! ». Bad news is kept hidden.
- 3) **Calculative culture level:** If the Percentage of commitment reached is included in the range [50% - 75%]. the organization is comfortable with systems and figures. A management system has been implemented successfully and because health and safety are taken very seriously, there is major concentration upon the statistics. Bonuses are tied to them. People feel comfortable by making changes to procedures and processes. There are many audits and people begin to feel that they have secured the situation. Nevertheless, businesses at this level still get people hurt and they are surprised when this happens. "The system should have worked". Bad news is tolerated but still unwelcome.
- 4) **Proactive culture level:** If Percentage of commitment achieved is included in the range [75% - 100%]. the organization is moving away from managing health and safety based on what happened in the past to really looking forward and not just working to prevent last week accidents. Proactive organizations consider what might go wrong in the future, and take steps before being forced to.

Proactive organizations are those where the workforce become involved in practice, not just in theory. They analyze the causes of the accidents in depth but also pay attention to dangerous situations and near misses. Suppliers and contractors are rated in terms of their safety record, not just because they are the cheapest.

- 5) **Generative culture level:** If the percentage of commitment achieved is equal to 100%. At this stage, the organization set very high standards and attempt to exceed them rather than being satisfied with a minimum compliance. They are brutally honest about failure, but use it to improve, not to blame anyone. They don't expect to get it right all the time, as long as they continue to get better. Management knows what's really going on, because the workforce is willing to tell them and trust them not to overreact by hearing unwelcome news. People live in at stage of chronic unease and are aware about what could go wrong. They are trying to be as informed as possible to get prepared for whatever will be thrown at them next. At this level, bad news is actively looked for, because it provides the best opportunity to learn.

**IV.III The Geographical Distribution of the Sample**

Among the 50 companies contacted, 28 of them responded with a distribution rate of 68% on the Casablanca axis, 28% on the Tangier axis and 4% on the Marrakech axis as presented in the Fig.1.



**Fig. 1.** Geographical distribution of the companies questioned

**IV.IV Survey Analysis**

We resorted to a national expert with more than 15 years of experience in transport and logistics to target the right people to contact to avoid the disinterest and reluctance of some companies contacted which allowed us to have a response rate of 56% over a period of 03 months (between March and May 2019).

For each of the fifty questions of the questionnaire, we calculated the percentage of the corresponding level of involvement chosen from the four levels already mentioned

(Always / Often / Sometimes / Never) and then we determined the overall average score per question, which allowed us to deduce the level of involvement of the typical safety culture profile below:

- The level of involvement "Always": concerns the answers to the questions Q12-Q20-Q42-Q43 and Q44.
- The level of involvement "Often": concerns the answers to the questions Q1-Q2-Q3-Q4-Q5-Q6-Q7-Q8-Q9-Q10-Q11-Q13-Q14-Q15-Q16-Q17-Q18-Q19-Q21-Q22-Q23-Q24-Q25-Q26-Q27-Q28-Q29-Q30-Q31-Q32-Q33-Q34-Q35-Q36-Q37-Q38-Q40-Q41-Q45-Q47-Q48-Q49 and Q50.
- The level of involvement "Sometimes": concerns the answers to the questions Q39 and Q46.

The corresponding safety culture level was calculated for each of the twenty-eight questionnaires received, which allowed us to conclude that:

- 75% of the companies surveyed have achieved a calculative security culture.
- 25% have a proactive security culture.

Thus, the characteristic data of the safety culture profile of this sector of activity are:

- Safety culture level: Calculative
- Overall percentage of personal commitment to safety: 69%
- Overall Questionnaire Score: 103 points
- Geographical distribution: Tangier - Casablanca - Marrakech

Further statistical analyzes were carried out on the results of this survey in order to:

- Look for the most outliers using Multiple Correspondence Analysis (MCA) and then eliminate them in order to reconstruct the typical safety culture profile given above.
- On the other hand, to find the correlation between the geographical location and the level culture to safety achieved by the Chi-square test in order to validate the reconstituted profile for all the companies of the Kingdom.

#### IV.V Processing of the Survey Data by the Multiple Correspondence Analysis (MCA) method

Multiple Correspondence Analysis (MCA) is a multidimensional exploratory method that provides a synthetic representation of categories from a set of qualitative criteria, referential to an experimental or survey protocol [26], [27]. This method consists in synthesizing tables, presenting in abscissa, individuals and in ordinate, categorized variables. The results of an ACM are generally presented in the form of graphs composed of points positioned on a plane structured by two axes (abscissas and ordinates). The first axis is the one that summarizes the correlations between the variables. The second is the one that, independently of all the information summarized by the first one (orthogonally), best summarizes

the rest of the information. The contribution of a modality to an axis expresses the influence exerted by this modality on the definition of the axis. If the contribution is small (close to zero), the modality has no influence; if it is strong (It exceeds the average of the contributions of all the modalities), the modality can exert a positive or negative influence [26], [27].

By using the MCA method, we were able to:

- Establish the dispersion graph of the 28 companies surveyed and eliminate the aberrant results.
- Validate the calculation hypothesis by Chi Square tests.

According to the company dispersion graph as presented in the Fig.2, the company number 5 has a large dispersion in the first dimension and a low dispersion in the second dimension.

On the other hand, the companies number 3 & 28 have a significant dispersion according to the two dimensions 1 and 2. By checking the overall score of the questionnaire corresponding to these two companies, it follows that they represent the two extremes (respectively a score of 84 and 122). Thus, these values are the most discriminating and therefore can be excluded from this study. The remaining 26 companies have a low dispersion in both directions and therefore their responses are homogeneous.

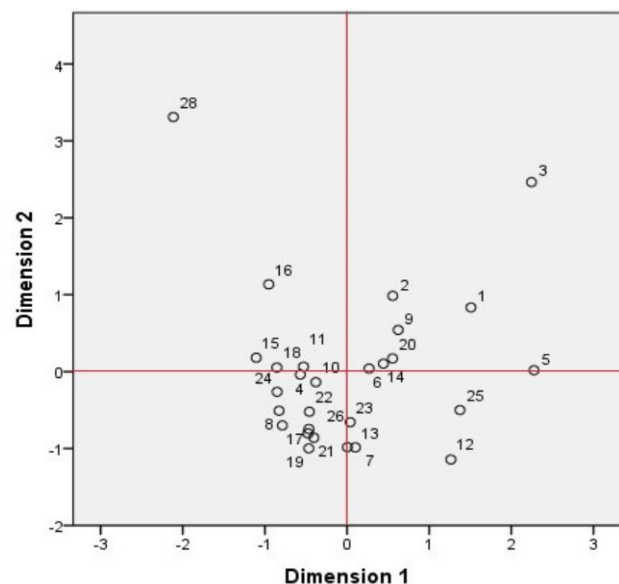


Fig.2. Companies dispersion graph

By eliminating the responses of companies 3 and 28 from the calculation data, it was found that the typical safety culture profile that was at the calculative stage did not change, except for the levels of involvement corresponding to the two questions Q23 and Q44 which became respectively "Always" and "Often" instead of "Often" and "Always".

Thus, the percentage of safety culture achieved by the companies questioned then becomes 77% for the calculative maturity level and 23% for the proactive maturity level.

#### IV.VI Data Analysis by Chi-square tests

The Chi-square test [26] used to check the possible correlation between the geographical distribution and the level of safety culture as presented in Fig.3, confirms that there is no statistically significant correlation between these two parameters [ $\chi^2 = 1.158$ ,  $p\text{-value} = 0.56$  (above 0.05)]. Thus, the general profile of the culture level to safety of companies involved in the road transport of dangerous goods proposed by this study can be generalized to all companies of this sector of activity established in Morocco without any geographical restriction.

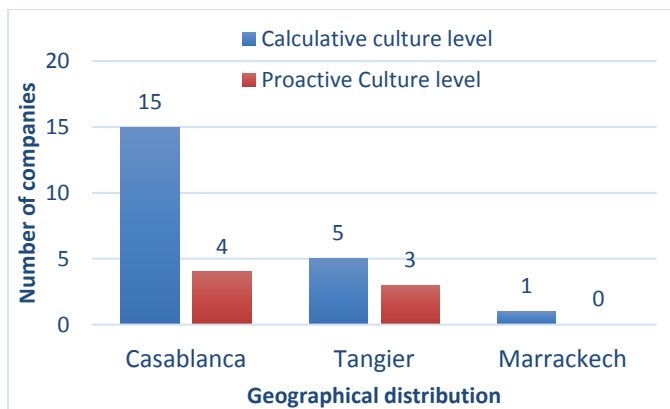


Fig.3. Safety culture level in relation to the geographical distribution

#### IV.VII Statistical Synthesis of the National Safety Culture Profile

The statistical results of MCA method and chi-square tests applied to the data of this survey enabled us to propose the National Profile of Safety Culture specific to the road transport of dangerous goods sector and having the following characteristics:

- Safety culture level: Calculative.
- Overall percentage of personal commitment to safety: 69%
- Overall questionnaire score: 103 points.
- Geographical distribution: Without restriction.
- The level of involvement "Always": concerns the answers to the questions Q12-Q20-Q23-Q42-and Q43.
- The level of involvement "Often": concerns the answers to the questions Q1-Q2-Q3-Q4-Q5-Q6-Q7-Q8-Q9-Q10-Q11-Q13-Q14-Q15-Q16-Q17-Q18-Q19-Q21-Q22-Q24-Q25-Q26-Q27-Q28-Q29-Q30-Q31-Q32-Q33-Q34-Q35-Q36-Q37-Q38-Q40-Q41-Q45-Q44-Q47-Q48-Q49 and Q50.
- The level of involvement "Sometimes": concerns the answers to the questions Q39 and Q46.

#### V. CONCLUSION

Several studies have examined the safety culture in the health, the gas and oil, the nuclear and in the railway industries, but extremely rare are those that have detailed the safety culture of the TDG by road. Apart from the research of De-Marcellis, Peignier and Trépanier in 2012 in Quebec that documented the types of companies working in this sector, the dangerous goods transported, and the health and safety conditions at work, our study remains innovative and unique in Morocco and Africa through the following major findings:

- The National Safety Culture Profile of the TDG by road, which is an occupational health and safety performance indicator that will be used to guide the sectoral policies of government bodies and to channel the efforts of professionals in the field of health and environmental protection.
- The Self-Assessment Toolkit of safety culture composed of 50 questions that will be an essential tool for national and international professional carriers to situate themselves in relation to the National Profile proposed above.

#### ACKNOWLEDGEMENTS

The authors would like to thank the companies SOGEA MAROC and CEGELEC of VINCI CONSTRUCTION corporate, for their contribution to the preparation and distribution of the questionnaire survey.

The authors express their gratitude to Mr. My Ahmed HAFIDI and Mr. Ahmed TABIT, international experts in Quality, Safety and Environment (QSE), Mr. Taha ALAOUI, Occupational Physician and Mr. Zakaria KARTOUBI, Moroccan Expert in Transport and Logistics, for their contributions and implications in improving the questionnaire survey.

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