Water efficiency management systems for transport drinking water supply

D Cvelihárová¹ and A Pauliková²

¹Institute of Environmental Engineering, Faculty of Civil Engineering of the Technical University of Košice, Vysokoškolská 4, 042 00 Košice, Slovakia
²Institute of Industrial Engineering and Management, Faculty of Materials Science and Technology in Trnava, Slovak University of Technology in Bratislava, 917 24 Trnava, Slovakia

Abstract. The quantity of management systems standards (MSSs) is increasing every year. Standards are significantly associated with common requirements and differences for many providers of services as well as for manufactures. The drinking water supply management system is certainly one of the important services. The aim of this article is to introduce a basic application of management system (MS) using visual management. The standard applied in a model, defined as a complex solitaire or “singlet”, is the Water Efficiency Management Systems (WEMS) standard. Visualised model is built by creating clusters using a software program designated for Small World Networks. This phase is preceded by the compilation of Excel spreadsheets, where requirements are divided into common and specific ones. The resulting cluster of selected areas includes the context of organizations that provide services, considering the common and specific requirements of interesting parties, managing their leadership, planning, support, operation, performance evaluation and improvement. It could be very useful to extend the cluster by another standard depending on the needs of the drinking water supplier and the transport piping systems at the site. This approach to management systems intensively clarifies managerial decision-making processes related to the implementation of the WEMS.

1. Introduction

The International Organization for Standardization is a leader for manufacturers and service providers in many stages of a company's existence. Standards are a set of powerful and useful business tools for organizations. They increase productivity and profits, inspire confidence, and reduce costs, [1]. Certifications according to standards are not mandatory, but they help to create added value for the services provided. At the same time, by using them, the organization sends a signal that it is interested in the quality of services or environmental protection. Moreover, ISO certification gives organizations confidence that the steps they take to provide services are constantly improving and easier to measure. However, if senior management strives for certification based on a strategic decision and implements, for example, a quality management system in the organization, its compliance becomes mandatory, [2]. For an organization to be successful, it needs to be managed systematically and transparently, while meeting stakeholders’ requirements and maintaining the required quality of services. The objective of this task is to elaborate a comprehensive overview used on a global scale and subsequent coordination of individual areas of management system. The providers of water supply manage for us the most valuable commodity there is, drinking water. The set of selected areas will include the organization's connections with supply operations, key customer requirements, leadership, planning, operational support, operations, performance evaluation, and improvement. Coordination will be performed using hierarchical organizational diagrams and finally visualized by Small World Networks and Scale-Free Networks.
1.1. Application of MSSs

With 40% of the world’s population living in water-stressed areas or exposed to polluted water sources, managing the current and future needs of communities is another pain point for cities. ISO standards cover virtually every aspect related to water use and represent the international consensus on best practice for effective water management. [3]. In any organisation, the process of MSS application is time-consuming, requires a high degree of flexibility and a lot of effort. The standard used in this paper, defined as a solitaire or a “singlet”, is the Water Efficiency Management Systems standard (WEMS). [4]. The main reason for listing this solitaire standard reflects its need for use in water supply facilities. Well-balanced efficiency, excellent water quality, sustainable and refreshing environment have become an inherent part of human life. This standard can be implemented in many sectors, regardless of the type of activity, size, and number of employees of the organization. [5]. As suppliers continuously adapt to the customer requirements, the environmental pressure grows and the environmental improvement of the service must be considered in relation to the impacts on quality, health, and safety, [6].

1.2. Visualization using the Small World Networks

This paper proposes, with the help of gradual visualization, a much simplified form of implementation of the WEMS standard, which is one of more than seventy management system (MSS) standards. The visualization process is a process of interpreting data and presenting them in pictographic or graphical format, [7]. Humans are highly visual creatures and since a picture is worth a thousand words, they prefer to use a picture to understand the problem rather than read about it a thousand times. We live in an age of data, which means that the amount of information that needs to be processed to achieve the desired result is enormous. The more data or information we can process, the better and faster we are able, as the organization, how to react to the possible challenge. With a growing number of processing requests, organizations are facing a challenge where they are simply unable to react, either due to the lack of time or resources. The inability to adapt costs time, reputation and possibly a future of the organization.

Data visualization, or rather visualization management, helps organizations understand the significance of the requirements that the organization needs to comply with. It points out the interconnection of requirements by summarizing and presenting them in a simple and easy-to-understand format. Visualization supports the transformation of organizational culture by transforming data into images that tell the story of the business and the goals that the organization wants to achieve. Visualization is achieved by forming clusters through a visualization program for small network models of the world (e.g., TouchGraph). According to Milgram (1967) sometimes it is useful to visualize the abstract properties of a scientific problem before studying it in detail; that is, we construct a model of the main features of the phenomenon as we understand them, [8].

The data used for visualization is stored in a database in the format of a data mining table. In our case, this table defines the requirements as specific and general. Data mining involves researching and analysing large blocks of information to gather meaningful patterns and trends. The visualization goes beyond the list of requirements defined by the standard. The process reveals on a larger scale patterns typical of a given integration. It provides a better and faster way to identify patterns, trends, and correlations in sets of requests that would otherwise remain undetected when working with the text alone. The results are shown in context. It is thus possible to see how they fit into the overall picture, including their correlation and connection with metadata, such as e.g. additional requirements or documented information.

The outcome of the process is a visualized complex of selected area. It simplifies, speeds up and clarifies managerial decision-making processes related to the application of system management standards. Data that previously appeared to be unrelated or independent are now merged into a cluster. Data visualization is a real asset for any business as it supports real-time business decisions. It visualizes extracted information into logical and meaningful parts and helps users avoid information overload by keeping things simple, relevant, and clear. It helps companies to analyse their different processes so the
management can focus on other areas in order to generate more revenue and improve productivity. It is beneficial for managers to understand customers’ behaviour and interests because it helps retain clients and market share, [7].

2. Development of a cluster of water efficiency management systems (WEMS)
The main task of management systems standards (MSS) is their use in supporting management and leading functions within the entire organizational structure. WEMS standard is designed to be applicable in different sectors as it is focused on end-use consumers and is an excellent tool for creating a solid organizational management.

2.1. The general managerial reasons for the selection of the WEMS.
- WEMS have their own internationally recognized standard ISO 46001:2019.
- WEMS are relatively new, 1st edition, publication date: July 2019, [3].
- The WEMS standard is a type A standard, i.e., it is a type of standard that contains requirements against which an organization can claim conformance. In order to claim the conformance, the organization must provide evidence to support that the organization meets the requirements specified in the standard. Evidence is usually obtained through an audit process. There are first-party, second-party and third-party audits used in the process. The first party audit is an internal one, done by the organization itself; second- and third-party audits are external. The third-party audit is the one that could result in certification. This can only be done based on a document that contains these requirements.
- WEMS is conceptually drawn up with High Level Structure (HLS). It is a very useful aspect because other management systems standards, which have the same structure of articles and contain many of the same terms and definitions, can be integrated with the WEMS and simultaneously meet the requirements of additional management system standards, [9].
- WEMS operates based on the PDCA cycle and considers a process approach and risk-based reasoning.
- WEMS is certifiable, i.e. it is applied in an autonomous mode, which means that the management systems operate in one organization independently.

2.2. The specific managerial reasons behind the selection of the standard for unique cluster formation.
- WEMS contributes to the following Sustainable Development Goals cited in The 2030 Agenda: 11 - Sustainable Cities and Communities, 12 - Responsible Consumption and Production, 13 - Climate Action, 14 - Life Below Water, [10].
- WEMS identifies water as a resource that can be considered as part of organizational and budgetary planning.
- WEMS assists an organization to better manage water use and optimize water demand.
- WEMS recognizes the impact on others that can occur with changing water use.
- WEMS ensures a greater level of accountability in water use.
- WEMS provides a process for regular review for possible improvement and adoption of opportunities arising in water efficiency, [3].

WEMS’s application is appropriate in the decision-making process in the organization of all types and sizes that use water, for example: drinking; spa; manufacturing a product and as part of a product; cleaning; transportation; heating and cooling; drinking, sanitation, irrigation, fire suppression; recreational, water sport and aesthetic purposes, [3].

Ms Wai Cheng Wong, Chief Engineer in the Water Supply Network department of PUB, Singapore’s national water agency, is Convenor of the ISO working group that developed ISO 46001 and worked on Singapore standard SS 577. She comments: “As one of the most water-stressed countries in the world, managing industrial water use has been a priority for Singapore, given that the bulk of our water demand
comes from the non-domestic sector, which is expected to increase further. Therefore, we strongly believe that ISO 46001 will be an important tool for all organizations around the world to bring about greater water efficiency and savings in their operations”,[11]. Based on the above-mentioned aspects and characteristic, the WEMS was selected for the solitaire or singlet cluster. ISO 46001, *Water efficiency management systems – Requirements with guidance for use*, aims to help organizations of all types and sizes be more water-efficient. Through a clear framework and guidance on water efficiency management, it provides methods and tools for assessing and accounting for water usage, as well as ways to identify and implement measures to optimize water use and continually improve ways of doing so,[12].

2.3. The MSS visualization software
Cluster visualization is increasingly used to present various models ranging from communities, and relationships, to flows, hierarchies, or spatial networks. The overall process of visualization consists of the following steps:

- Data extraction, data cleaning and transformation, and data import.
- Creation of nodes and edges and their layout to emphasize the properties of the cluster.
- Adding various attributes to improve visualization (size of nodes, width of edges, colour resolution).
- Research and interaction - the possibility of interactive work with the cluster.

For the purpose of this project, we selected the TouchGraph Navigator to create the MSS solitaire or singlet cluster. This software application allows to easily create interactive network visualizations of the available data, which can be loaded from various databases. The most widely used database is one from Excel. TouchGraph Navigator can perform analysis and illustrate relationships by configuring the cluster appearance and filter settings as well as export images and data and save the resulting project so that the results can be shared and start back exactly where you left off, [13]. Documented information in the form of data was inscribed and specially arranged in sheets of Excel file. This file serves as a database for our network visualization of MS cluster. Editing of individual cells in the Excel file requires rigorous attention, so the individual cells are correctly filled in. For this reason, a double control is required to ensure that the visualization base is completely accurate.

3. Creating the WEMS visualization cluster
Based on detailed examination of management systems, Table 1 was derived, where is the PDCA cycle adapted to individual clauses of VEMS. This table, also characterized as a summary table, allows for feedback control during the process of compiling the visualization cluster.

| Phase of PDCA Cycle | Standard ISO 46001:2019 WEMS |
|----------------------|------------------------------|
| 0 Introduction       | Subclauses                   |
| 1 Scope              |                             |
| 2 Normative references |                             |
| 3 Terms and definitions |                             |
| 4 Context of the organization | 4.1 Understanding the organization and its context |
4 Context of the organization

PLAN-> 4 Context of the organization

DO-> 4 Context of the organization

5 Leadership

PLAN-> 5 Leadership

DO-> 5 Leadership

6 Planning

PLAN 6 Planning

DO

7 Support

7.1 Resources

7.2 Competence

7.3 Awareness

7.4 Communication

7.5 documented information

8 Operation

8.1 Operational planning and control

8.2 Design

8.3 Procurement of water services, products and equipment

8.4 Maintenance and inspection

9 Performance evaluation

CHECK 9 Performance evaluation

10 Improvement

ACT 10 Improvement

The first step in the process is to create an initial central node or entity called "Standard ISO 46001:2019 WEMS" (light blue colour circle, Figure 1), with Degrees of Separation = 0. The second step includes the following cluster nodes – individual clauses (see Table 1) of WEMS, pictured on Figure 2, with 1st degree of separation. WEMS’s clauses represent a core of the cluster.

The visualised standard contains its own set of ten basic clauses and four Annexes A÷D. The standard and its parts, including clauses and subclauses up to the third structuring, (0; ... 1; 1.1; 1.1.1; ...D), are connected by means of relations that differ in their colour, thickness of lines and patterns.
Figure 2. WEMS cluster - sixteen core nodes (ten ones are the main and six ones are subsidiary) (Source: Authors).
Figure 3. PDCA cycle in the cluster - four yellow diamond-shaped nodes PLAN, DO, CHECK and ACT with their relations to clauses and subclauses, see Table 1 (Source: Authors).

With the 2nd degree of separation, the PDCA cycles are visualized through the nodes: "PLAN", "DO", "CHECK" and "ACT" of diamond shape and dark yellow colour. These entities or nodes are interconnected according to their representation within the structure of WEMS with an emphasis placed on the PDCA cycle. The node "PLAN" is linked with "Clauses 4, 5, 6", the node "DO" is linked with "Clauses 4, 5, 7 and 8", the node "CHECK" is linked with "Clause 9" and, finally, the node "ACT" is linked with "Clause 10", Figure 3.

In the same degree (the second degree of separation), the subclauses of WEMS are activated and subsequently the sub-subclauses are shown in the 3rd degree. The cluster is thus becoming more complex.

If the organization plans to apply the WEMS, it is necessary to elaborate a list of all requirements which will be needed for demonstration of correct implementation. These requirements are not marked in the document of ISO standards with bold or italic or underline letters. Implementers must search for them in the text. They must read with understanding so as not to omit any requirement. In the management system standard text, the requirements are indicated by using the verbal forms "shall". By moving to the 4th degree of separation, the requirements in our cluster are indicated by the halo size effect in the shape of a red circle. Also, the relationships leading from the requirements to a given clause have red colour as the requirement, see Figure 4.

One of the benefits for visualized MSS model application is the possibility of a quick view of its structure. MSS implementers can in a short time and easily find out how many requirements they need to comply with during the audit process. It leads to less time spent on the implementation process as well as financial savings, [14].
Figure 4. Complex cluster WEMS with their affiliated requirements, documented information, and notes (Source: Authors).

The requirements displayed in this way are the basis for managerial decision-making. During visualization, it is possible to effectively identify the "health condition" of the organization and its potential unconformities when performing Clause 9 Performance evaluation and the subclause 9.3 Management review. The organization determines which WEMS requirement is binding, and which is irrelevant. In our comprehensive visualization, all the requirements of the given WEMS are considered. These requirements will be selectively chosen for a particular company regardless of its operational type (national or international), [15].

Additional requirement for the effective implementation of the WEMS is the submission of evidence in the form of "Documented information". For this reason, we considered it appropriate to include "Documented information" in the overall requirements and to visualize it using special nodes marked as rounded rectangles with white colour backgrounds, see Figure 4. As with the requirements, there is a set number of documented information which is binding. If no evidence is submitted, according to the WEMS rules, the given fact is not meaningful, i.e., as if it did not exist.

The final information that may be useful when implementing WEMS is the visualization of "Notes". These are included to explain the requirement. In the cluster there are labelled as rounded rectangles with light grey colour backgrounds.
4. Conclusions
From the perspective of previous studies, it is noticeable that it is more suitable to use visualization cluster to get a quick view of the structure of the WEMS. From this standpoint, it is further possible to create a new visualization cluster, MSS groupings in the form of solitaire (singlet), duplet (twin), triplet, etc. Some of the management systems that have great potential to be visualized are:

- “Environmental management systems — Requirements with guidance for use” according to ISO 14001:2015, recommended for the environmental protectors, [16]
- “Energy management systems. Requirements with guidance for use” according to ISO 50001:2018.
- “Event sustainability management systems — Requirements with guidance for use” according to ISO 20121:2012.
- “Tourism and related services — Sustainability management system for accommodation establishments — Requirements” according to ISO 21401:2018.
- “Adventure tourism — Safety management systems — Requirements” according to ISO 21101:2014.
- “Quality management systems — Requirements” according to ISO 9001:2015, recommended for the producer of various industry sectors, [17, 18].
- “Security and resilience - Business continuity management systems – Requirements” according to ISO 22301:2019.
- “Collaborative business relationship management systems — Requirements and framework” according to ISO 44001:2017.
- “Food safety management systems. Requirements for any organization in the food chain” according to 22000:2018, recommended for the food producers, [19].

By using TouchGraph application, the final WEMScluster offers simplified and more effective navigation through all clauses, subclauses, sub-subclauses, including related requirements, documented information, and notes. This ultimately shortens the implementation time since the requirements need to be addressed only once within the entire process. By clicking on different visualisation areas, the cluster becomes more compendious and shows important interactions in individual characteristics of the WEMS.

The benefits of the application can be summarized in three areas:

- Professional and personal awareness of the demand to implement management systems in an organization.
- Business.
- Administration.

The ultimate objective of every service provider is to offer high quality services, to be successful and competitive while meeting all the necessary requirements for the sustainable provision of services. Part of the organization's development strategy should be the need to build awareness of the importance of production and service delivery within a sustainable framework.

From the business perspective, the WEMS cluster visualisation is a powerful decision-making tool. Its efficacy is evident in the increased efficiency and adaptability of the processes, and reduced reaction time to implement changes. Navigation within the management system is more effective. The amount of unintentional repetitions of meeting the requirements is reduced. Time is saved when searching for interactions in individual articles of the management system.

From an administrative point of view, the implementation process involves a considerable amount of supporting documentation. Simplifying the process will significantly reduce the amount of documentation. The WEMS gives examples of scenarios each having the possibility to improve water
efficiency e.g. “Use of water-efficient fittings, apparatus, appliances and products”. The facility uses approximately 100 m$^3$/month for its staff usage (e.g. basin taps, pantry, toilet flushing). By installing water-efficient fittings, the facility saves approximately 15 m$^3$/month. Or “Optimization of manufacturing processes”. A manufacturing facility uses approximately 50 000 m$^3$/month of water to produce 25 000 units of product A. The facility has calculated its baseline water efficiency indicator to be 2 m$^3$/unit/day. By optimising manufacturing processes, it achieves the following:

- The facility reduces the water use to 40 000 m$^3$/month, resulting in 20% water savings.
- The facility produces 40 000 units of the product per month, while the water use remains the same at 50 000 m$^3$/month. Thus, the facility uses the same Vol. of water in an improved manner to produce more goods or services. The water efficiency indicator has reduced 37.5% from 2 m$^3$/unit/day to 1.25 m$^3$/unit/day, [3].

The common requirements of the WEMS for drinking water supply can be about the geometrical characteristics of transport system, drinking water physical and chemical factors as well as operating factors, [20]. However, the incrustation factors can belong to among the specified requirement of the VEMS. Bureaucracy is unpopular, and many times it is the origin of a reluctance of employees and managers to implement any new management tools. Visual management removes the monotony from the implementation process replacing it with a picture of a successfully executed project. It supports culture transformation by turning data into information or pictures that can help tell the story about the successful service providing.

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