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Symbiotic types of systems thinking with systematic management in occupational health & safety

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ABSTRACT

A systems approach to Occupational Health & Safety Management (OHSM) acknowledges that entities of people, equipment, tools, processes and policies are all interconnected and interrelated, and in conjunction affect the outcomes and achievements of any business undertaking. Although several internationally recognised standards for OHSM systems draw on the synergy between systematic management, which reflects the degree of system control, and systems thinking, which represents the degree of system knowledge, the different levels of application of these two approaches during their symbiosis within a given system has not been visibly articulated. In our work, we reviewed relevant literature and reflected on the possible combinations of systematic management practice with the knowledge generated through systems thinking from a sociotechnical perspective. Based on the degree to which any variability is seen as inevitable and the extent to which the organisation aims to control it, we translated the various blends of the two paradigms into the ways an organisation generates and establishes objectives and procedures. Our premise is that there is no golden rule and that systems thinking and systematic management must be combined with caution and an understanding of the inherent limitations of each approach and the context in which they are introduced.

1. Introduction

Historically, several schools of thought have developed system theories that are generally quite similar and share the same goal of explaining systems thinking. These theories share commonalities in acknowledging key system elements such as boundaries, goals, inputs, processes, outputs, and subsystems (Adams et al., 2013). A system can be defined as "…a set of connected components that interact to perform a specific function or to achieve a specified purpose" (Muschara, 2018, p. 123). To fulfil requirements and accomplish its purpose, usually within a larger system, all of the system's components must be present when their function is required and arranged in a specific way to perform that function and, where applicable, use feedback to achieve local and system-wide stability (Muschara, 2018).

The primary aim of Occupational Health and Safety Management Systems (OHSMS) is the protection of workers against the risk of harm related to their occupational activities. An OHSMS is comprised of components such as, policies, procedures and processes that are arranged systematically, considering component interrelationships (Robson et al., 2007). The OHSMS specifies the functions of components, for example, types of documents, accountability arrangements, and approaches to continuous monitoring, review and improvement to assist in creating a work environment predisposed to being safe (Robson et al., 2007). The necessity for a systems approach to OHS has been acknowledged and embedded into respective standards as best practice (e.g., AS/NZS Standards, 2018). As noted by Borys et al. (2012), a systems approach to OHSMS incorporates both systematic management and system thinking.

Typical OHS initiatives and programmes (e.g., risk management, training, audits, inspections, investigations, consultative arrangements) suggest a systematic way to approach OHS (Gallagher, 2000). This entails design and implementation of specific processes and steps, use of appropriate equipment and tools, maintenance of records, structured evaluation and monitoring as well as an integrated way to improve

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health and safety performance (Gallagher, 2000). Employees are expected to execute their tasks according to defined work procedures, which implicitly or explicitly embed safety-related features. Procedures are the nuclei of a systematic approach and describe the *who*, *what*, *how*, *when* and *where* aspects of each task based on best practice and standards. The latter, along with legislation constitute, typically, the first layer of the *why* aspect, complemented by reasoning that is usually elucidated during respective education and training.

However, tasks, procedures and staff interrelate, while, at the same time, employees interconnect with their surrounding social, organisational, technical and physical environments. The detection and management of relationships and dependencies amongst all system agents relate to systems thinking, according to which sociotechnical systems must be human-centric to yield their maximum possible effectiveness and meet their intended objectives (Waterson et al., 2015; Carayon et al., 2015; Sittig and Singh, 2010). Systems can be complex and viewed as networks of interconnected nodes with aspects that are not directly measurable or understood (Koehler, 2014). When a complex system is broken down into components, explanations and measurements, as a systematic approach typically necessitates, the system being described becomes limited by its definition and is considered as complicated instead of complex as well as limited to the system phenomena identified (Tarride, 2013).

Dekker (2003) suggested that an overemphasis on procedures, which are the focal point of systematic management, can hinder local effectiveness, productivity and, even, safety. At the same time, the author mentioned above acknowledges that uncontrolled local practices emerging due to variable and conflicting demands at the work floor, as reflected in system complexity and system thinking theories, can lead to divergence from system goals. Thus, on the one hand, excessive systematic management might lead to over-decomposition of systems, and, consequently, over-simplification, over-description and over-proceduralisation. On the other hand, systems thinking alone and passive acceptance that sociotechnical systems always demonstrate performance variability and emergence of behaviours that cannot be entirely anticipated beforehand, may lead to a highly inconsistent and misaligned organisation with a negative impact on the achievement of its objectives, the safety included, as well as legislative non-compliance.

This paper focuses on these principal constituents of a systems approach to OHSMS, namely systematic management and systems thinking, and through a literature review and the reasoning of the authors, explores avenues through which these two paradigms could coexist and presents a mapping of their intersections. Within the broader OHS context, this paper contributes to the discussion about the safety clutter recently introduced by Rae et al. (2018) and connected with the duplication, generalisation, and over-specification of safety activities that might result in cynicism and superficial compliance with standards.

2. Literature review

2.1. Systematic OHS management

An OHSMS is part of the overall management system and represents a coordinated and systematic approach to managing health and safety risks via policies, planning, procedures, implementation, measurement, evaluation, and continuous improvement (Reese, 2008; Asif et al., 2013). Clear responsibilities, employee consultation and specific OHS programme elements (e.g., training, inspection, incident reporting and investigation, hazard identification and prevention, data analysis, and system monitoring and reviews) comprise essential features of an OHSMS (Gallagher et al., 2003). Rather than static and merely reactive, an OHSMS involves dynamic thinking about hazards, proactive risk management and design, and continual balancing and reinforcing feedback loops as well as positive performance indicators for proactive improvement (Phillips et al., 2016; World Health Organization, 2009).

The term *systematic* describes the repeatability and control of actions, including the concept that items within systems must be arranged in an orderly manner, and originates from the fields of quality management and process engineering (Frits Philips Institute for Quality Management, 1994). In general, a successful OHSMS relies on the continuous improvement practice (i.e. Plan, Do, Check, Act – PDCA cycle) as suggested by the quality management system paradigm (Ladewski and Al-Bayati, 2019; Karanikas, 2014). The quality PDCA cycle provides the framework for individuals regardless of their experience as to when and where certain aspects are to occur, who is responsible for their undertaking and what is to be done and in what timeframe (Zanko and Dawson, 2011).

Systematically managing OHS offers streamlined and clearly identified methods, the implementation of which spans from the level of the individual employee to the whole business and reaches those in charge of finance, operations, human resources and other key organisational actors and systems (Makin and Winder, 2008). However, a sole PDCA-based approach to OHS might lead to oversimplification of the complex nature of systems and inter-relationships amongst their agents, resulting in deviations from established methods and procedures (Bashford et al., 2018; Taylor et al., 2014). Literature suggests that OHSMS designed according to the quality management paradigm have demonstrated a failure rate in the range of 67–93%, secondary to inappropriate generic models used, and seemingly may be incongruent with complex workplaces, such as healthcare, and, therefore, must be adapted, individualised and developed specifically for the targeted working context to become and remain effective (Gullo and Dixon, 2018; Gardner, 2000 cited in Robson et al., 2007).

2.2. System thinking in OHSMS

Arnold and Wade (2015) identified the diversity of approaches to systems thinking by presenting several definitions stated in the literature, a situation that could arguably create confusion across disciplines. The endeavour of the authors above to reconcile the various perspectives and merge complementary positions resulted in the definition of systems thinking as “a set of synergistic analytic skills used to improve the capability of identifying and understanding systems, predicting their behaviours, and devising modifications to them in order to produce desired effects. These skills work together as a system” (Arnold and Wade, 2015, p. 675). The particular definition denotes that the first and crucial step of systems thinking is the acquirement of the maximum possible knowledge of the system of interest and the ultimate goal is to introduce suitable interventions.

Considerable work has been undertaken to apply systems theory within the realm of OHSMS (Waterson et al., 2015). The sociotechnical system approach is often used within OHS management and proposes the replacement of reductionist linear cause-effect models with more holistic macro-system models where causation is not necessarily linear (Carayon et al., 2015). The complex sociotechnical systems paradigm attempts to unravel the interconnected factors that affect safety within the workplace with a focus on the interactions between people, processes and technology within their environment and context (Carayon et al., 2015; Waterson et al., 2015). The principal challenge to manage sociotechnical systems comes from the complex nature of human performance variability, along with the multiple connections amongst system components and their tight couplings (Perrow, 1984) at both macro and micro levels of modern systems (Masys, 2016).

At the managerial level, OHSMS were developed to facilitate an interdepartmental cohesion, where human resources, operations, logistics, strategic planning and all other business functions flow along with OHSMS to achieve the optimum balance amongst safety, efficiency, productivity and quality (Reese, 2008). Regardless of individual aspects of the given business, this integrated approach is key to the effectiveness of any OHSMS (Borys et al., 2012) and is aligned with the view that a system fulfils its mission effectively when used concurrently

within the larger system (Thomas, 2012), and, at the same time, the larger system allows for optimal functionality and efficiency of the whole business (Cliff, 2012). For example, the "systems-spiral improvement" healthcare framework was used to analyse multiple systems; this framework highlights an iterative process of continuous improvement through comprehension, design, delivery and sustainability and considers the behaviours of all agents (e.g., people, processes, technology, environment) (Royal Academy of Engineering, 2017). Even more broadly, standards, such as AS/NZS ISO 45001 (2018), call for the consideration of the broader context, including outside influencing factors such as political climate, legislative changes, economic and technological changes and an understanding of all interested parties.

At the operational level, OHSMS involve bidirectional communications, participative models for job design, decentralised management and self-managed work teams (National Occupational Health and Safety Commission, 2001). An effective OHSMS must be able to adjust and be tailored to achieve appropriateness under all circumstances (Mohammadfam et al., 2016). Thus, employees' and contractors' awareness of the OHSMS structure and processes, including their relevance to current business activities (Walters and Frick, 2000), and customisation to differing business intentions and objectives (Carayon et al., 2015; Waterson et al., 2015), promotes adoption and adherence (Robson et al., 2007). A real-world case was presented by Sittig and Singh (2010) who attempted to improve health information technology within a complex health care system by identifying people as a core aspect of their complex sociotechnical system ranging from persons developing or using software (employees) to people receiving the outcomes (patients) of the system (healthcare). Sittig and Singh (2010) identified workflow and communication as a core aspect of their approach with an emphasis on collaboration which enabled them to establish a deep understanding of the relationships between workers, other people, system protocols and expected work outcomes.

In general, OHSMS are expected to connect macro and micro levels by integrating the environment, people and systems in proportions that reflect an organisation's unique characteristics, with no one-size-fits-all system (Cliff, 2012). Such a system has higher chances to succeed, but, in some cases, an individually tailored system that fits best the intended organisation/business (Thomas, 2012) may not be economically viable or effective and depends on the organisational, operational and wider environment of each enterprise and its willingness to accept this challenge (Gallagher et al., 2003).

2.3. Common denominators

Regardless of the degree to which an organisation adopts systematic management and/or systems thinking, an effective OHSMS necessitates managerial commitment. The latter is demonstrated through leadership and encouragement of staff's involvement in the development and implementation of the OHSMS (Robson et al., 2007; Wachter and Yorio, 2014) as well as with resource and funding support from the overall management system (Asif et al., 2013; Glickman et al., 2007). Leadership and management which are ineffective, non-responsive, unsupportive, lack commitment and delegate its OHS responsibilities can threaten the success of any OHSMS (National Occupational Health and Safety Commission, 2001; Torabizadeh et al., 2016). Where the workers are treated as valuable and are empowered, their job satisfaction and positive work outcomes increase (e.g., Boamah et al., 2018) as well as the adoption and adherence to structured policies and procedures.

Moreover, when employees are engaged, a higher OHSMS adoption is expected (Ismail et al., 2012), particularly when employees feel valued and are critical components of the business structure (Robson et al., 2007). Worker participation provides crucial input from the employees undertaking the assigned tasks and informs decision-makers at managerial levels, which, nonetheless, should view the workforce as participants in organisational management and not just as information sources (AS/NZS, 2018; Carayon et al., 2015; Sittig and Singh, 2010; Zanko and Dawson, 2011). Lack of participation can harm operations by reducing health, safety and productivity outcomes (Almost et al., 2018; Donovan et al., 2017; Mohammadfam et al., 2016). Any "information bottleneck" where frontline workers' reports become lost or not actioned, on the one hand, might lead to safety failures and, on the other hand, might lower worker participation if management is seen as uncommitted to the goals of health and safety (Matias and Coelho, 2002). Fragmented information and weak communication mechanisms for feedback and tracking across multiple subsystems and levels constitute barriers to effective OHSMS (Niskanen et al., 2016).

Furthermore, a systems approach extends traditional safety culture of shared norms, values and beliefs by an understanding of occupational risks, work authority, controls and processes which can enhance or reduce how the individual interacts and behaves within systems (Reiman and Rollenhagen, 2014). While employee engagement in building a positive safety climate and culture can be challenging, worker involvement in the OHSMS design and deployment, leadership support, training and adequate communication can ameliorate potential difficulties (Niskanen et al., 2016) and lead to greater systemic success. A system can exist without a safety culture, and safety culture can exist without a formally delimited system; however, a systems approach towards OHS management requires both to work in unison in meeting the intent of the organisational OHS policy successfully (Archer et al., 2018).

2.4. Overall benefits and challenges

Archer et al. (2018) assert that a systems approach to OHS is the most effective means of promoting health and safety, as it has been associated with a decrease of worker harm, reduction of costs and improvement of productivity (Cross, 2018; Young et al., 2018). Additional benefits include the decrease of injury-related costs (Frick et al., 2000), improvement of business opportunities, establishment of measurements to verify OHS performance (Reese, 2008), and enhancement of the organisation's overall reputation due to its commitment to a safer and healthier work environment as well as the well-being of its workers (Mohammadfam et al., 2017).

Positive effects such as the ones mentioned above are attributed to a more informed decision making, strengthening of corporate culture and demonstration of due diligence which are critical components to prevent workplace injuries while maintaining compliance with laws and standards (Comcare, 2017; Gallagher et al., 2001). Additionally, the benefits from a systems approach are linked to the much broader view across multi-level systems to plan, mitigate and respond to OHS hazards (Lingard et al., 2013) and proactive risk management strategies that focus on controlling hazards via design, timely involvement of key parties and continuous feedback loops (Archer et al., 2018; Mohammadfam et al., 2016; National Occupational Health and Safety Commission, 2001).

Nonetheless, the systematic review of safety management systems (SMS) undertaken by Thomas (2012) notes that the effectiveness of an SMS might only be seen at an organisational level, meaning that when evaluating the merit and performance of such a system, someone should observe the behaviour of the system as a whole rather than the practices of its individual components. Momentary variations in the performance of system elements that can negatively affect the achievement of organisational objectives can be attenuated or compensated by the interventions of other interconnected parts. The balance between acceptable and fully controlled variability of system components has been one of the recent approaches to safety management (Hollnagel, 2012; Pariès et al., 2017).

Moreover, precarious employment and the changing synthesis of workforce characteristics reinforces the need for a systems approach (Archer et al., 2018). For example, established practices such as long-distance commuting of employees in the resources and mining sector in Australia [a.k.a Fly-in/Fly-out (FIFO); Drive-in/Drive-out (DIDO)]

produce negative effects on workers such as drain on time and energy of workers, isolation, lack of available communication with family, workplace stress, irregular and extended shifts, rosters and work hours, uncertain work future and fatigue (SBEnrc, 2015) and adverse conditions for families including emotional and behavioural impacts on children and difficulties in parenting (Meredith et al., 2014). A systems approach that considers both processes and behavioural aspects and promotes adaptation to a more transient, mobile and dispersed workforce provides the framework to ensure consistent system operation under the effects of technology changes and the current financial, commercial, political and regulatory environments.

It is noted that industries such as agriculture, construction, trade, transport, medical and manufacturing are inherently riskier and, expectedly, present higher frequencies of worker injuries than other sectors (Safe Work Australia, 2018). Therefore, companies within high-risk sectors are most likely to be asked to present evidence of "good OHS management" and "due diligence" before judges or regulators. This might drive such organisations to the pursuit of increasingly rigorous systematic management (e.g., rigid rules, enforcement of consistent documentation and record-keeping) to ensure that they will able to prove that their OHSMS is "under control" and they have exercised their best to avoid unwanted outcomes.

Over time, this intense focus on robust and impenetrable systematic management might become best industry practice or raise implicit or explicit expectations across organisations regardless of their operational profile, resources capacity and context. Nguyen and Stinglhamber (2018) claimed that an organisation could de-humanise people through its excessive policies and detailed processes, which denote an appetite for over-systematisation, and, thus, unintentionally generate decreased job satisfaction. Essentially, organisational dehumanisation occurs when a person perceives the organisation as treating its staff as mere elements with programmatic functions and easily replaceable cogs in the system. Therefore, increased bureaucracy, which is typically coupled with organisational efforts to demonstrate rigorous systematic management, tends to be a hindrance to a successful OHSMS (Donovan et al., 2017). On the other hand, decentralisation and recognition may lead to a perceived loss of power within management especially in companies where procedures may have been the same for many years, and the concept of "if it isn't broken, it doesn't need fixing" prevails (Matias and Coelho, 2002).

3. Combinations of systematic management & systems thinking

The literature reviewed above presents the concepts as well as the benefits connected with the two prevailing paradigms in the systems approach (SYSAPR) to OHS: systematic management (SYSMAN) and systems thinking (SYSTH). The difference between these two constituents of a systems approach lies in their focus: systematic management relates to the establishment of consistency and reliability across the whole organisation to enforce desirable behaviours of system elements and achieve predefined outcomes whereas systems thinking focuses on the knowledge of the system and represents the validity parameter of the systems approach.

More specifically, SYSMAN is grounded in quality management and engineering principles and aims to minimise variability and maximise consistency across the organisation mainly through the establishment of objectives (i.e. what to achieve) followed by procedures to control behaviours and performance of subsystems and components and meet specific objectives (i.e. who, when, where and how). To achieve the above, SYSMAN suggests decomposition of systems into subsystems, hierarchical levels and elements to allocate responsibilities functions and tasks which jointly lead to the realisation of organisational objectives whose fulfilment is monitored mainly through deduction as well as quantitative analysis and description of processes (i.e. collection of input/output data from subsystems and elements to calculate local and aggregated performance indicators). This approach mirrors techniques such as the Fault Tree Analysis where negative outcomes (i.e. top events) are attributed to under-performance of system processes and elements at lower levels which are seen connected only through their allocated functions and assumed to have quantifiable behaviours. Techniques such as Six Sigma and Lean Management aim to optimise the system by removing waste, and tools and practices like audits and inspections target to the detection and minimisation of gaps between organisational expectations (a.k.a. Work as Imagined) and real practice (a.k.a. Work as Done).

On the other side, SYSTH recommends the investment in continuous efforts to understand systems deeper and considers the effects of interactions amongst system components that lead to emergent behaviours that cannot be predicted, thus cannot be completely controlled through systematic management, and are often testified in hindsight. Especially when it comes to the human element of sociotechnical systems, SYSTH recognises that variability is unavoidable, an undeniable reality and system characteristic. This occurs mainly due to the inability, and perhaps ethical restrictions, to fully control individuals and dictate the way they interact amongst them as well as with their social, organisational, technical and physical environments.

According to the SYSTH paradigm, when a sociotechnical system is decomposed, vital information is lost or misinterpreted because individual behaviours are dynamic, and objectives imposed from higher to lower system levels can be mixed with local and personal objectives or altered due to effects of various factors within and outside a given system. Therefore, the detection of behaviours of subsystems and elements through the breakdown of a system might not collectively represent and predict system-level behaviours and achievement of system-level objectives. Typically, systems thinking employs induction and qualitative description of processes to reveal underlying and emerging factors and concepts not captured by quantified performance measurements. Qualitative methods like ethnography, observations, interview and focus groups possibly complemented by quantification through surveys, network analyses etc. are used to obtain a deeper knowledge of system mechanisms and explain identified gaps between expectations and reality.

Despite literature examining the expected positive results from the adoption of each of these two paradigms along with possible negative implications of their absence, there is no reference to their intersections as a means to (1) provide a holistic SYSAPR framework, (2) illustrate what the possible combinations of higher or lower degrees of application of SYSMAN and SYSTH could represent for organizations both conceptually and practically, and (3) how these two paradigms could cohabit. Hence, in the following paragraphs, the authors unfold their perspectives and reasoning about different blends of systematic management and systems thinking within organisations to shed some light on this underexamined area. We want to stress that our approach is not connected with the cognitive or affective acceptance of any of the paradigms, but their operationalisation in the working environment.

To illustrate the various degrees of application of these paradigms within an organisation, we adopted the terms "EXCESSIVE", "PRUDENT" and "MINIMAL" for each of them. The latter term represents organisations that might be aware of or even acknowledge a paradigm, but they do not visibly embrace it in daily decision making and operations. The "EXCESSIVE" case reflects systems where the paradigm might be seen as the most effective pathway, and it carries some notion of dogmatism. The middle degree of application, "PRUDENT", corresponds to organisations where the paradigm is respected, understood with adequate awareness of its possible limitations and implemented with caution depending on the overall environment and context.

First, it can be claimed that SYSMAN and SYSTH cannot coexist in their extremities (i.e. both EXCESSIVE). On the one hand, rigid systematic management targets to zero variance in the system, thus total inflexibility; on the other hand, passive acceptance of variability and emergent properties leads to complete self-regulation without or little

appreciation of the objectives and needs of other system levels and/or agents. Second, whereas in their extremes SYSMAN and SYSTH are incompatible, in their lowest levels of application or absence (i.e. both MINIMAL) actually denote the lack of a system as "…a set of connected components that interact to perform a specific function or to achieve a specified purpose" (Muschara, 2018, p. 123). Lack of systems thinking means ignorance or rejection of undocumented connections and emerging interactions, thus leading to a lack of system understanding. Entirely unsystematic management means complete lack of coherence in executing functions and achieving a shared purpose which expectedly generates a chaotic environment.

Further, we examine other combinations of the various degrees of each paradigm's application by focusing on the key terms of Objectives, Procedures and Variability and their classifications listed below. We adopted the first two terms as proxies through which the organisation realises acceptance and control of Variability.

- Objectives: the term is used to denote the achievements aimed and incorporates policies, strategies, visions, etc. of (sub)systems as well as personal goals, desires etc. of human agents. Depending on the source, direction and inclusiveness of objectives, they can be classified as:
  - o Top-down, where the most senior level decides about the overall system objectives, which in turn are translated into sub-objectives that are imposed by each higher on each lower system level and agent. In this category, locally generated objectives are not considered and permitted, and all partial objectives of any level and employee must relate to higher-level objectives that ultimately lead to the achievement of overall system objectives. Such alignment ensures that all organisational resources are efficiently used toward the same goal, and there is no deviation that could be labelled as waste and possibly hazardous for the business in the broader meaning of the term hazard.
  - o Negotiated, where system levels and agents converse towards a mutual agreement on the objectives of individuals, subsystems and the overall system with multidirectional compromises when objectives conflict. In this category, many of the objectives are aligned and lead to higher-level and overall organisational ones, but there are side and additional objectives that serve local goals and needs without a mandatory alignment with higher-level objectives. This type accepts some form of temporary waste of resources under the premise that, in mid- or long-term, the permission and acceptance of local objectives in parallel with system-targeted ones, will lead to faster and better achievement of the latter (e.g., effects of motivation, reciprocity).
  - o Bottom-up, where system levels and agents develop objectives based on local rationality and push these across the system to gain support from higher and other system levels and agents and secure necessary resources. In this category, higher system levels are deemed ignorant of the reality in lower system levels but have the will and power to support the pursuits of lower system levels.
  - o Localised, where system levels and agents generate their own objectives based on local rationality without consideration of the objectives of other levels and agents and any interest to gain support from within the system due to real or perceived resource autonomy. This category represents cases where junior levels view senior system levels as useless, and any hierarchy serves only administrative purposes.
- Procedures: the term relates to the realisation of objectives by defining the who, when, where and how and includes any form of methods, rules, standards, directives etc. Depending on the source and direction of procedures and the extent to which represent individual and (sub)system practices, they can be classified as:
  - o Top-down, where each senior system level decides about the procedures that junior levels and agents must follow. In this category, emerging (i.e. locally generated practices through experience) and transferable practices (e.g., workforce moving between positions and companies) are rejected if not formally reported and approved through the chain of command.
  - o Negotiated, where system levels and agents converse towards a mutual agreement on suitable procedures depending on the context and based on the optimum mixture of externally driven practices (e.g., industry, other similar systems), transferrable and emerging practices. In this category, "what" is the best procedure matters more than "who" claims its ownership since the latter is commonly shared across the organisation.
  - o Bottom-up, where system levels and agents develop procedures based only on local rationality and experience as well as transferred practices, ignore any externally driven practice and push their practices to gain approval from higher and other system levels and agents to render their choices legitimate. This category corresponds to a "we know our work better than anyone else" attitude.
  - o Localised, where system levels and agents generate their own procedures based on local experience and rationality alone, reject any other transferred or externally driven solution and are not interested in legitimising their choices due to real or perceived autonomy. In this case, the attitude "it's our business, not yours" prevails.
- Variability: we use this term to reflect the variances of behaviours of subsystems and elements (i.e. inputs, operators, processes, controls and outputs in engineering terms) within, across and amongst system levels and agents, including their connections, as well as the change of these over time. Typically, depending on the focus, organisations apply quality assurance to measure and manage variability of inputs, operators, controls and processes and quality control over the outputs under a continuous exchange of information to drive interventions (i.e. in addition to checking for compliance against standards to minimise variability, quality assurance uses data from quality control to examine the effectiveness of its measures).
  - o The degree of welcoming variability (unconditionally, considerably, unwelcomely) signals the extent of accepting the knowledge gained through systems thinking application as an unavoidable reality. This relates to the objectives of the various systems levels and agents, considering that objectives are meant to drive behaviours. The more variability is accepted as an inescapable condition, the more the need for parallel satisfaction of different personal, local and broader objectives is recognised, the emergence of diverse behaviours is excused, and possible conflicts between the objectives of various system levels and elements are approached as normal.
  - o The degree of controlling variability (fully, moderately, loosely) signals the extent of systematic management application. This is linked with the source and direction of procedures implemented across various system levels and agents to realise the fulfilment of objectives. The more the desire to control, the more procedures are dictated by higher system levels, and the more the trust in lower system levels, the more procedures are generated with a bottom-up direction.

Table 1 summarises the categories of Objectives and Procedures discussed above, according to which the authors reflected on the possible combinations of SYSMAN and SYSTH with reference to the concepts discussed in the literature reviewed in Section 2 above and the degree of welcoming and controlling variability. These combinations are mapped in Fig. 1, which illustrates their symbiotic spaces, while Table 2 presents their symbiotic types.

4. Discussion and conclusions

Today's systems are becoming increasingly complex due to the

Table 1
Categories of Source, Direction and Inclusiveness/Representation of Objectives and Procedures.

Objectives & Procedures	Source	Direction	Inclusiveness/Representation of Different Subsystems and Elements
Top-down	Senior system levels/elements	Senior to junior system levels/elements	Minimum
Negotiated	All system levels/elements	From and to all system levels/elements	Average
Bottom-up	Junior system levels/elements	Junior to senior system levels/elements	Maximum
Localised	Individual system levels/ elements	None – restricted within the individual system level/element	Not of interest/concern

emergence of newer technologies, stricter legislation, scarcer resources, harsher environments, diverse workforce compositions and locations and desire for progressively more productivity and efficiency. Hence, an understanding of systems and their effective management in ensuring proper application of a tailored OHSMS is critical now more than ever. Literature suggests that the multidisciplined underlying theoretical paradigms that underpin systems theory coupled with a lack of universally agreed approaches (Arnold and Wade, 2015; Adams et al., 2013; Tarride, 2013) provide excellent opportunities for multi-domain adaptations but also a substantial room for error (Waterson et al., 2015). Therefore, OHS professionals are expected to view the term "system", as well as any approach aiming to comprehend and manage systems, with an awareness of their limitations. In this paper we did not intend to review the whole literature relevant to systems theory; we decided to focus on the paradigms of systems thinking in sociotechnical systems (SYSTH) and systematic management (SYSMAN) and open an avenue for discussions about their optimum combination.

These two paradigms constitute widely communicated aspects of a systems approach to OHS management and represent two different, but complementary view angles; SYSTH focuses on the understanding of the system to minimise assumptions about its functioning and SYSMAN emphasises the control of the system under existing, recognised or not, assumptions. In other words, systematic management is concerned more about the practical side of systems, meaning how to ensure reliable and consistent performance and deliverables within the known environment (e.g., physical, technical, social, political). Systems thinking is interested in understanding systems to enrich knowledge about reasons and effects of detected behaviours and interactions and is concerned about the validity of any management practice without directly suggesting the need for the manipulation of systems' reality.

Although these two approaches come with their own theories, assumptions, aims, techniques, tools and are often mentioned in literature and OHS standards, to-date there has been no proposition on their possible blends and cross-sections. To fill this gap, we combined the various extents of applications of these two paradigms, which were conceptualised by using their shared term Variability based on the degree to which the latter is welcomed and/or controlled. To enable the translation of the two paradigms through observable phenomena, we classified the different paths an organisation can follow when generating Objectives and Procedures with categories that encapsulate

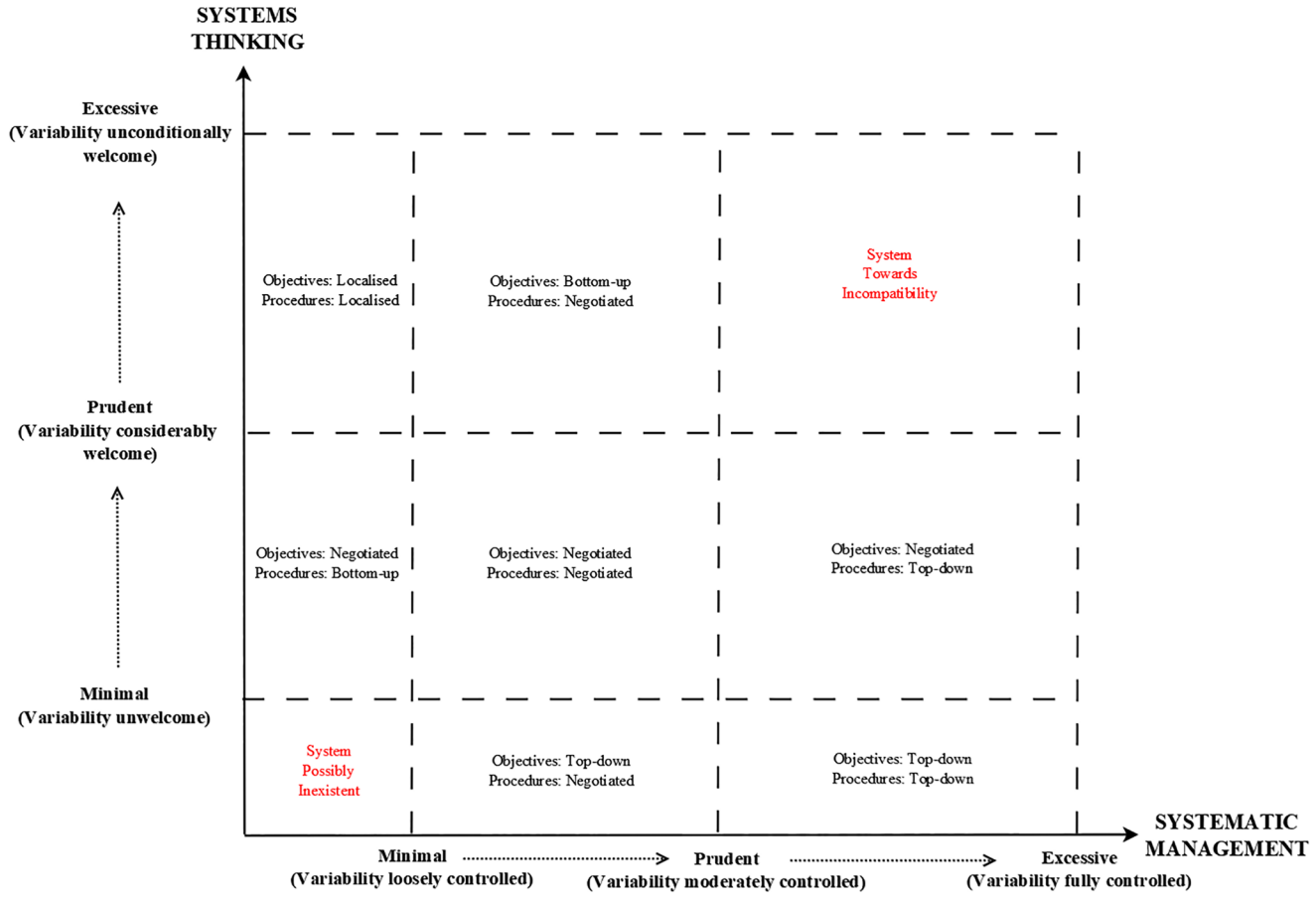

Fig. 1. Symbiotic spaces of Systematic Management and Systems Thinking in OHS.

Table 2
Symbiotic types of Systematic Management and Systems Thinking in OHS.

Systems approach		**Degree of Controlling Variability through Application of Systematic Management**		
		EXCESSIVE (Variability fully controlled)	**PRUDENT** (Variability moderately controlled)	**MINIMAL** (Variability loosely controlled)
Degree of Welcoming Variability based on Knowledge Gained from Application of Systems Thinking	**EXCESSIVE** (Variability unconditionally welcome)	System: Incompatible	Objectives: bottom-up Procedures: negotiated	Objectives: localised Procedures: localised
	PRUDENT (Variability considerably welcome)	Objectives: negotiated Procedures: top-down	Objectives: negotiated Procedures: negotiated	Objectives: negotiated Procedures: bottom-up
	MINIMAL (Variability unwelcome)	Objectives: top-down Procedures: top-down	Objectives: top-down Procedures: negotiated	System: Inexistent

behavioural aspects of (sub)systems and agents. The mapping presented in Fig. 1 and Table 2 above was based on the reasoning that (1) the more the tendency towards solid systematic management, the more system objectives and procedures are generated and directed top-down, and (2) the higher the embracement of the knowledge gained through the application of systems thinking, the more the generation of objectives and procedures is delegated to lower and local system levels and/or by individual agents.

The cases of coexistence of these two paradigms in the highest and lowest degrees of their application were excluded as unfeasible (EXCESSIVE-EXCESSIVE) and atopic (MINIMAL-MINIMAL). The cases of opposite extremes (EXCESSIVE SYSMAN – MINIMAL SYSTH and MINIMAL SYSMAN – EXCESSIVE SYSTH) reflect correspondingly a dictatorial-style, where local and individual bottom-up inputs are prohibited, and a chaotic system, where diverse local and/or individual needs and practices dominate and, expectedly, clash amongst them. The authors of this paper have not experienced or detected such cases in recent academic literature and industry reports, but we included them mainly for reasons of completeness of our mapping. The reasoning behind the rest of the combinations is based on the descriptions provided for the various categories of Objectives and Procedures in Section 3 above and summarised in Table 1.

We acknowledge that, under a systems approach, vertical and horizontal communication, leadership support, feedback opportunities, and employee empowerment across systems and hierarchies render systems more responsive, promote safer practices and lead to decreased incidences and enhanced quality outcomes (Donovan et al., 2017; Glickman et al., 2007; Reiman and Rollenhagen, 2014). These and the rest of the common denominators discussed in Section 2.3 above were not considered in our mapping because their mixture can drive a shift from one SYSMAN – SYSTH blend to another, and, at the same time, sign the operationalisation of any combination of the paradigms apart from the co– and opposite extremities explained above. For instance, in a SYSMAN EXCESSIVE – SYSTH PRUDENT mixture, effective communication and feedback are necessary to negotiate objectives under a positive and committed leadership that, in turn, can motivate and empower the workforce even if procedures are imposed top-down. Another example, in the SYSMAN PRUDENT – SYSTH EXCESSIVE blend, the aspects described above are required not only to negotiate objectives but also allow the transfer of ideas bottom-up as well as their endorsement. Thus, these common aspects of a systems approach do not denote directly the degree of application of a SYSTH or SYSMAN approach but can function as change and/or implementation agents regarding any combination of systematic management and systems thinking. There have been plenty of examples in human history where totalitarian approaches were well-received by large parts of the population due to the successful implementation of leadership, communication, motivation etc. principles falling under the domain of human-to-human interactions.

Waterson et al. (2015) stressed that there is a need for further validation of tools developed for addressing safety issues using the complex sociotechnical system paradigm. However, we believe that OHS professionals and scholars must first examine how and whether any paradigm could cohabit with others as a means to conclude to approaches and blends that are not absolute but rather contextualised and tailored as suggested by Cliff (2012), Thomas (2012) and Gallagher et al. (2003). The combinations of systematic management and systems thinking presented above are not meant to be used only as indications of where an organisation stands or would like to move but could also function as a basis to agree on schemes that match the size, resources and cultural elements of enterprises.

Indeed, the midway denoted by the PRUDENT SYSMAN – PRUDENT SYSTH symbiotic type might seem ideal and desirable for any organisation under a win–win approach. However, we shall not ignore that different systems might have different levels of maturity of perception and application of any of these two paradigms, adopt various

approaches to the common denominators of the system approach discussed above, and operate in diverse political, social, technical and physical environments and any other boundaries. Thus, it is not about which blend is the most preferred based on a win–win situation of the theoretical underpinnings of each paradigm. It is more about how much room exists to move to a combination other than the current one, if necessary and desired, without underestimating the practicalities related to the quantity, quality and availability of resources and their distribution between understanding through SYSTH and acting based on SYSMAN. The consideration of the parameters described above will contextualise the direction an organisation intends to take and minimise dogmatism about favourable SYMAN – SYSTH blends.

We cannot also ignore that there might be cases that different symbiotic types might match better different subsystems within the same larger system. In addition to the common denominators mentioned above that can differ across subsystems, the safety criticality of a subsystem and the time available to respond to changes might necessitate different symbiotic types for various subsystems and over time. The more the criticality and the less the time available, the more SYSMAN might be suitable; on the other hand, the lower the criticality and urgency to act, the more SYSTH might be appropriate. Notably, literature and standards suggest that both SYSMAN and SYSTH are needed in a healthy and mature OHSMS, and since these constituents refer to the same system, the outcomes from the application of each paradigm expectedly become inputs for the other. Knowledge gained through systems thinking when time and resources allow can inform best management practices; the successes or failures of the latter can signal the necessity for deeper investigation and understanding of the system to leverage positive lessons and reflect on negative results. Moreover, unbalanced workforce composition regarding experience and developed skills, cultural diversity and medium to high staff turnover might necessitate the investment on SYSMAN more than SYSTH due to the heterogeneity of the teams and lower validity of the knowledge obtained through SYSTH due to high unsystematic variances. On the other hand, increased focus on SYSTH and lower SYSMAN intensity might be more appropriate to relatively homogeneous subsystems.

Therefore, the mapping of systematic management – systems thinking blends described in this paper needs to be consulted with caution and an understanding of the context to avoid any dogmatism towards best or worst solutions within systems and across systems and subsystems. On the practical side, Fig. 1 and Table 2 could function as two-fold references; organisations can decide the degree to which they want to welcome and control variability and then transform the way they generate objectives and procedures respectively, or they can reflect on the way they produce their artefacts and recognise the way variability is treated in their systems.

Nonetheless, it is important to note that the threshold used to evaluate the need to control variability will move together with the transition of the organisation from one SYSMAN – SYSTH combination to another. What was unacceptable in the past under rigid systematic management can become acceptable when gaining a deeper understanding of a system and will shape a different reference point for future assessments. Inversely, what constitutes welcomed variability within a system can shift over time if the organisation moves towards systematic management that dictates increased control over the system and attempts to minimise, if not eliminate, variances. Therefore, the baseline for assessing variability and classifying it as acceptable or not must be decided within the current or preferred mixture of systems thinking and systematic management. This will also allow fair benchmarking and comparisons amongst different systems and subsystems.

Moreover, although the literature reviewed and our positions expressed in the current work were targeted to the domain of OHS, systems thinking and systematic management are not bounded to this particular field. The concepts presented in this paper can be connected and seen through the lenses of various system approaches mentioned in literature and sourcing from various fields. For example, participatory ergonomics suggest different levels of staff involvement and authority to influence changes in the design and execution of work (e.g., Brown, 2004). Also, the Functional Resonance Analysis Method (Hollnagel, 2012) suggests the detection and control of variability as a means to manage processes and systems and avoid unfavourable outcomes. In the project management field, Waterfall and Agile methods represent correspondingly sequential top-down management and iterative bottom-up approaches (e.g., Cobb, 2011). Therefore, future work could focus on the generation of an inclusive framework with reference to the different methods and tools focused on the principal components of systems approach discussed in this paper (i.e. system knowledge and system control) regardless of domain.

Additionally to the considerations discussed above (i.e. organisational maturity, resources and workforce parameters, fluidness of baseline of acceptable variability and cross-reference with other system-focused approaches) which were not examined in this work, other limitations of our prepositions expressed in this paper include (1) the lack of respective organisational research to suggest actual practicality and effectiveness of the various SYSMAN-SYSTH blends, (2) presence and combinations of other determinative factors that would suggest the appropriate blend and (3) ways to customise the proposed mapping to various organisational sizes and degrees of system complexity. Nonetheless, we believe that this paper could function as inspirational and starting point for discussions and future studies to address these limitations. Moreover, we envisage that apart from OHSMS, the mapping presented in this paper also applies to operational safety that relates to the safety of services and products as well as other business objectives (e.g., security, quality, productivity) taking into account that under a systems approach health & safety should not be approached in isolation from other organisational domains and management systems. However, different blends might be appropriate and suitable for different business areas, even within the same organisation and system levels, and this involves relevant knowledge and experience within each field of application.

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