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Setting the standard: a systems approach to the design and evaluation of safety standards.

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Abstract. In 2003, adventure activity providers in Victoria, Australia, began to develop a set of common operating standards. The resulting Victorian Adventure Activity Standards became a model for similar standards in other Australian states. However, the development process lacked systematic rigour. This article argues that sociotechnical systems theory methods are suited to safety standard design and evaluation. A Work Domain Analysis revealed system weaknesses along with potential avenues for modifying and optimising the standards. Potential improvements and broader implications are discussed.

Keywords. Work Domain Analysis, Safety standards, Systems thinking, Regulation

1. Introduction

Led outdoor activities (LOA) are a popular means of providing educational and recreational experiences to people who may not have the skills, experience or equipment to undertake such activities themselves (Dickson, Gray, & Mann, 2008). A common feature of LOAs is that they rely on deliberate engagement of participants with risk in order to achieve their objectives (Lynch & Dibben, 2016). Like all service providers, LOA practitioners hold a legal and a moral obligation to keep activity participants safe (Australian Government, 2011). Maintaining adequate safety while intentionally helping people to do risky things presents special challenges.

In many countries, regulatory systems have been implemented to control safety across the activities of LOA providers. Regulatory approaches include accreditation systems, voluntary industry standards and statutory regulations (Ministry of Business Innovation and Employment, 2010).

Following the collapse in 2001 of major Australian insurance company, HIH Insurance (Haines, 2011, p. 125), steep rises in the price of liability insurance threatened the viability of LOA providers (Barnett, 2002). In response, with the support of Government, the Outdoor Recreation Centre (ORC) in Victoria, Australia, began working to develop a code of practice for LOA providers. The purposes of these standards were to promote safety for participants and providers, protection for providers against legal liability claims, and assistance in obtaining insurance cover (Outdoors Victoria, 2006, p. 4). Activity standards drafts were developed by volunteer committees, comprising experts in the relevant activity. The drafts were published for public comment. After a few iterations of this process, the Victorian Adventure Activity Standards (AAS) were launched in 2004, with an initial set of standards published as downloadable documents on the ORC website. From 2005, projects started in other Australian States to develop similar standards (ORIC, 2014; Outdoors WA, 2014; QORF, 2014; Recreation SA, 2016; Tasmanian Government, 2009). These development projects were supported by various private organisations and government agencies.

Following concerns and criticisms raised within the LOA sector, a project started in 2015 to reform and integrate all of Australia's state-based AAS into a single national set of AAS

(Outdoors Victoria, 2015a). While this process aims to improve efficiency by eliminating interstate duplication and reduce unnecessary duplication within standards by consolidating common content into a single location, the development process is similar to that used in the development of the original Victorian AAS, relying exclusively on expert opinion (Outdoors Victoria, 2015b). No systematic evaluation of the AAS has been undertaken to support the current reform process. So a close examination of the functional structure of the Victorian AAS appears warranted.

Recent research has applied systems thinking methods to understand the LOA work system (Salmon, Williamson, Lenné, Mitsopoulos-Rubens, & Rudin-Brown, 2010; Salmon, Cornelissen, & Trotter, 2012; Salmon et al., 2016). Subsequent research has confirmed the validity of systems theory for describing and understanding LOA work systems (Carden & Salmon, 2017) and for analysing the functional structure of LOA regulatory systems (Carden, Goode, Salmon, & Read, 2016). This paper is a continuation of this research, outlining the findings from a study in which Work Domain Analysis (WDA) was used to describe and analyse the Victorian AAS. The aim was to evaluate the capacity of the Victorian AAS to achieve its purposes and identify any structural weaknesses that may prevent it from doing so. This could inform the development of the new Australian standard.

2. Methodology

WDA is the first phase of Cognitive Work Analysis (CWA), a framework of STS methods designed to analyse the cognitive tasks associated with systems of work (Vicente, 1999). WDA involves building a functional representation of the system under analysis. The output, an Abstraction Hierarchy (AH) (Jenkins, Stanton, Salmon, & Walker, 2009), describes the system across five levels:

1. Functional purposes: the reasons why the system exists e.g. a regulatory system may exist to control safety within the regulated domain.
2. Values and priority measures: ways of guiding or measuring the achievement of the functional purposes e.g. to determine whether a set of safety standards is working one measure may be the rate of injuries within the domain in which the standards apply.
3. Purpose-related functions: the things the system needs to do to achieve its purposes e.g. one function of a set of safety standards is to support good safety management by providers.
4. Object-related processes: things that the objects within the system do to support the functions e.g. a physical process that supports service provider safety management may be detailed advice on how to safely conduct a particular activity.
5. Cognitive and physical objects: the actual objects deployed to serve the system's purposes e.g. a physical object that supports provision of safety advice may be a webpage; a cognitive object may be the content of that webpage.

The nodes at each of these levels are then linked together based on means-ends relationships. For each node in the system, an upward link shows why that node is in the system and a downward link shows how it is supported in the system. The example in Figure 1 shows a limited AH for a vehicle. The functional purpose of the vehicle is transportation. The engine and brakes afford the processes of propulsion and stopping. These processes in turn afford the system function of responsive vehicle mobility. This function is guided and could be measured by safety and speed, affording the system purpose of transportation. For any node in the AH, a link to a node above indicates why the first node exists in the system. A link to a node below indicates how the first node is supported in the system.

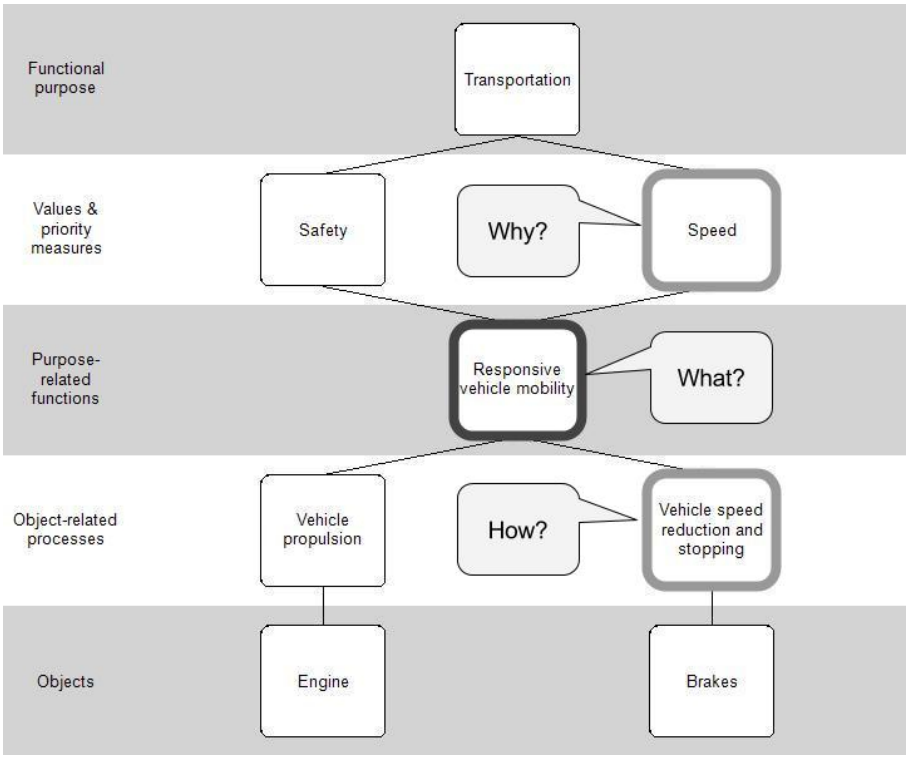

Figure 1. An example Abstraction Hierarchy (adapted from Carden et al., 2016).

Although the application of WDA to regulatory systems is novel, it has been used in many areas for many purposes ranging from training system design (Naikar & Sanderson, 1999), to hazard identification (Walker, Cooper, Thompson, & Jenkins, 2014).

Data analysis

The WDA was conducted based on a review of documentation describing the history and purpose of the AAS, collected from the AAS pages on the Outdoors Victoria website (http://outdoorsvictoria.org.au/). The documentation was analysed using the qualitative analysis software Nvivo 10. This involved coding the text to each level of the AH, and then aggregating the specific quotes into higher level themes. For example, “minimize the risk of injury” (Outdoors Victoria, 2006, p. 6) was coded to the AH level ’Functional Purpose’, and then aggregated into the theme “Safety”. Based on this, a Victorian AAS AH was constructed. The draft AH was reviewed by two analysts with significant experience in applying WDA to describe and analyse complex systems and two subject matter experts in the development and application of the Victorian AAS. Differences of opinion on exclusions and inclusions of nodes and links were discussed and modifications made until consensus was reached.
Nodes that were clearly identified as present in the system were outlined in black. Nodes that were required for system integrity but not identified as clearly present were outlined in grey. Means-ends links that were clearly identified as present were shown as solid lines while those identified as weak were shown as dotted lines.

3. Results

Figure 2 shows the AH representing the functional structure of the Victorian AAS.

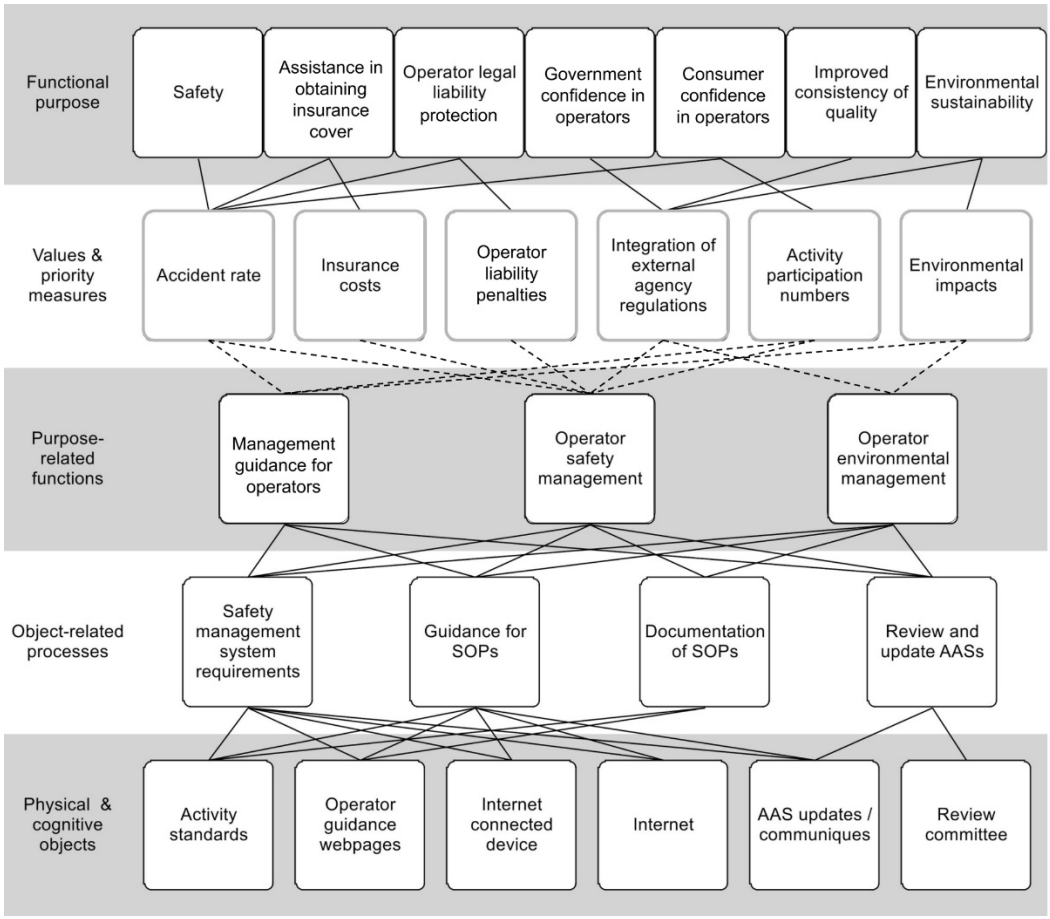

Figure 2. Abstraction Hierarchy of the Victorian AAS. Values and priority measures are outlined in grey and links to functions below are dotted to show that no mechanisms exist within the system to measure these criteria.

3.1. Functional purposes

The seven functional purposes identified in the resource documentation relate to the interests of multiple stakeholders. While activity providers (denoted in the AH as 'operators') are served by assistance in obtaining insurance and protection from legal liability, other purposes serve the interests of consumers and Government. It appears that the purpose of safety, toward which much of the content of each activity standard is directed, is closely related to the purposes of obtaining insurance and protection from liability.

3.2. Values and priority measures

The values and priority measures shown represent the criteria identified during this analysis as necessary for the purpose-related functions to achieve the functional purposes. While some of the elements at this level could perhaps, in principle, adequately serve as unmeasured values to guide achievement of system purposes, most would work best as tangible measures. Such measures would need to be well supported by functions, processes and objects e.g. accident rate could be measured by an incident reporting system to guide system performance and reform. The values and priority measures identified in this system are shown in grey and the means-ends links to the functions below are shown as dotted lines. This is to illustrate that

the values and potential priority measures are only indirectly and weakly supported by the objects deployed within the system and by the processes and functions that they afford.

3.3. Purpose-related functions

The sole purpose-related function afforded directly by this system appears to be the provision of management guidance for LOA providers. Assuming that providers follow this guidance, the additional functions of safety and environmental management become system functions. However, the absence of a compliance checking function places the control of these two critical system functions beyond the scope of this system.

3.4. Object-related processes

One of the four object-related processes, documentation of standard operating procedures, is supported by objects within this system, but dependent also on the action of providers. The other three processes identified are afforded directly by objects deployed within the AAS system.

3.5. Physical and cognitive objects

In addition to the static objects deployed by the AAS system, and the technical objects required to access them, this level also shows the dynamic objects, AAS updates and review committee. These two objects indicate a capacity for the AAS to adapt to changes in the operating environment.

4. Discussion and conclusion

The aim of this article was to use WDA to describe and analyse the Victorian AAS. The analysis provides several important findings regarding the functional structure of the Victorian AAS. These are discussed below.

4.1. Mechanisms to measure performance are absent.

While the Victorian AAS is not, and does not purport to be, a complete regulatory system for LOA activity safety, the absence of capacity to objectively measure its performance is a significant weakness. Each of the seven identified functional purposes and the associated six values and priority measures could in theory be associated with a performance measure. However, currently they are not.

4.2. No compliance mechanism

Not only is there no mechanism to measure the effectiveness of the AAS, no compliance mechanism was identified by the analysis. While even the best regulatory systems have limitations on the capacity for compliance auditing and enforcement (Coglianese, 2015), the existence of a compliance mechanism can be sufficient to influence the majority to comply without regulator intervention (Gunningham, 2016). As a corollary, it is not possible to determine whether LOA providers are complying with the AAS.

4.3. Objects are insufficient to support stated purposes

There are limited processes and objects that afford each function. For example, in the absence of compliance auditing, performance measurement or any means of communicating with all stakeholders, the mere existence of activity standards seems insufficient to reliably achieve

any of the identified system purposes. This suggests that either the system purposes or the objects deployed to serve them, need to be changed.

4.4. Regulatory capture

The earliest references confine the original purposes of the AAS to improving safety, limiting operator liability and reducing insurance costs (Adventure Victoria, 2006; Barnett, 2002; Outdoors Victoria, 2006). The purpose of limiting environmental impacts only appears in later references (Outdoors Victoria, 2015c). No rationale for this extension is provided. It is therefore reasonable to ask whether this development was a case of 'regulatory capture' (Carrigan & Coglianese, 2016), whereby a regulating body expands its reach beyond its original remit, in order to serve special interests.

4.5. Self-regulation

As the AAS documentation makes clear, it is a set of voluntary standards. As such, it is a system intended to support self-regulation. However, other entities have mandated requirements for LOAs in Victoria. These include government agencies such as the Department of Education and Training, WorkSafe Victoria, Parks Victoria and Maritime Safety Victoria. In addition, two independent accreditation systems for outdoor activity providers are available, each of which requires that accredited organisations comply with the AAS. The design of the AAS as a system of voluntary self-regulation may not support its adoption by other agencies as a set of mandated rules. Although the AAS documents themselves emphasise that compliance with them is optional, for providers bound by other agencies' adoption of the AAS, this is not the case. Furthermore, regulatory literature suggests that systems of industry self-regulation are rarely effective because of inherent economic incentives to minimise, manipulate or ignore requirements (e.g. Gunningham, 2011).

4.6. Practical implications for enhancing the AAS

This analysis shows that there is a significant gap between the stated purposes of the Victorian AAS and the objects deployed to serve them. Therefore, a better alignment could be achieved by modifying the purposes or the objects deployed to serve them. The current purposes of the AAS could be better served with the introduction of a compliance checking function and mechanisms to measure values and priority measures.

4.7. Limitations of this research

While this analysis provides a view of the functional structure of the Victorian AAS which illustrates structural weaknesses in the system's capacity to fulfil its purposes, analysis of how the system is used in practice would provide a more complete evaluation.

4.8. Conclusions

This case study has allowed the identification of several ways in which the structure of the Victorian AAS limits its capacity to achieve its purposes. The absence of compliance checking and performance measurement cast doubt upon the system's value. It is the hope of the authors that this illustration will support the efforts of those charged with implementing improvements to Adventure Activity Standards and other regulatory systems, by providing guidance for system reform. A final conclusion is that this study has provided further evidence that WDA provides a usable and useful approach for evaluating regulatory systems.

Further applications are encouraged, as are design applications in which methods such as CWA and the CWA-DT (Read, 2015) are used to design new or modified regulatory systems.

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References

Adventure Victoria. (2006). WHAT EXACTLY IS THE AAS PROJECT? Retrieved from http://www.adventurevictoria.org/aas_description.shtml

Australian Government. (2011). Work Health and Safety Act, Federal Register of Legislation. Retrieved from https://www.legislation.gov.au/Details/C2011A00137

Barnett, T. (2002, 03/03/2002). Vic Govt launches Adventure Tourism Action Plan. Retrieved from https://www.adventurepro.com.au/news/index.pl?action=details&id=vic_govt_launches_adventure_tourism_action_plan

Carden, T., Goode, N., Salmon, P. M., & Read, G. M. (2016). *Regulating safety in led outdoor activities: designing a better system.* Paper presented at the National Outdoor Education Conference, University of the Sunshine Coast, Queensland, Australia.

Carden, T., & Salmon, P. M. (2017). Simply Complex: Are Led Outdoor Activities Complex Sociotechnical Systems? In P. Salmon & A.-C. Macquet (Eds.), *Advances in Human Factors in Sports and Outdoor Recreation: Proceedings of the AHFE 2016 International Conference on Human Factors in Sports and Outdoor Recreation, July 27-31, 2016, Walt Disney World®, Florida, USA* (pp. 141-152). Cham: Springer International Publishing.

Carrigan, C., & Coglianese, C. (2016). Capturing Regulatory Reality: Stigler's The Theory of Economic Regulation. *U of Penn, Inst for Law & Econ Research, Paper No. 16-15.*

Coglianese, C. (2015). *Listening, Learning, Leading: A Framework for Regulatory Excellence*. Retrieved from https://www.law.upenn.edu/live/files/4946-pprfinalconvenersreport.pdf

Dickson, T. J., Gray, T., & Mann, K. (2008). *Australian Outdoor Adventure Activity Benefits Catalogue*. Retrieved from Canberra: http://outdoorcouncil.asn.au/doc/OutdoorActivityBenefitsCatalogueFinal270808.pdf

Gunningham, N. (2011). *Investigation of Industry Self-Regulation in Workplace Health and Safety in New Zealand*. Retrieved from http://www.dol.govt.nz/whss/resources/investigation-industry-self-regulation-whss-nz.pdf

Gunningham, N. (2016). *Fear, duty and regulatory compliance* [Retrieved from http://regnet.anu.edu.au/news-events/podcasts/audio/6539/neil-gunningham-fear-duty-and-regulatory-compliance

Haines, F. (2011). *The Paradox of Regulation: What Regulation Can Achieve and What It Cannot*: Edward Elgar Publishing Limited.

Jenkins, D. P., Stanton, N. A., Salmon, P. M., & Walker, G. H. (2009). *Cognitive Work Analysis : Coping with Complexity*. Farnham, England: Ashgate.

Lynch, P., & Dibben, M. (2016). Exploring motivations for adventure recreation events: a New Zealand study. *Annals of Leisure Research, 19*(1), 80-97. doi:10.1080/11745398.2015.1031804

Ministry of Business Innovation and Employment. (2010). *International stock-take of risk management and safety in the adventure and outdoor commercial tourism sectors*. Retrieved from Department of Labour, PO Box 3705 Wellington New Zealand:

Naikar, N., & Sanderson, P. M. (1999). Work Domain Analysis for Training-System Definition and Acquisition. *The International Journal of Aviation Psychology, 9*(3), 271-290. doi:10.1207/s15327108ijap0903_5

Health and Safety in Employment (Adventure Activities) Regulations 2011, (2013).

ORIC. (2014). Background : NSW Adventure Activity Standards. Retrieved from http://www.oric.org.au/AAS/Background.html

Outdoors Victoria. (2006). Canoeing and Kayaking Adventure Activity Standards: Outdoors Victoria.

Outdoors Victoria. (2015a). Australian Adventure Activity Standards. Retrieved from http://australianaas.org.au/

Outdoors Victoria. (2015b). FAQ | Australian Adventure Activity Standards.Retrieved from http://australianaas.org.au/about/faq/

Outdoors Victoria. (2015c). Background | Outdoors Victoria. Retrieved from http://outdoorsvictoria.org.au/resources/background/

Outdoors WA. (2014). Adventure Activity Standards. Retrieved from http://www.outdoorswa.org.au/Industry/aas

QORF. (2014). Adventure Activity Standards (AAS). Retrieved from http://qorf.org.au/industry/downloads-master/aas/

Read, G. J. M. (2015). Extension and application of cognitive work analysis to improve pedestrian safety at rail level crossings.

Recreation SA. (2016). Adventure Activity Standards (AAS). Retrieved from http://recreationsa.org/outdoors/

Salmon, P., Williamson, A., Lenné, M., Mitsopoulos-Rubens, E., & Rudin-Brown, C. M. (2010). Systems-based accident analysis in the led outdoor activity domain: application and evaluation of a risk management framework. *Ergonomics, 53*(8), 927-939. doi:10.1080/00140139.2010.489966

Salmon, P. M., Cornelissen, M., & Trotter, M. J. (2012). Systems-based accident analysis methods: A comparison of Accimap, HFACS, and STAMP. *Safety Science, 50*(4), 1158-1170. doi:http://dx.doi.org/10.1016/j.ssci.2011.11.009

Salmon, P. M., Goode, N., Taylor, N., Lenne, M. G., Dallat, C. E., & Finch, C. F. (2016). Rasmussen's legacy in the great outdoors: A new incident reporting and learning system for led outdoor activities. *Appl Ergon*. doi:10.1016/j.apergo.2015.07.017

Tasmanian Government. (2009). Adventure Activity Standards. Retrieved from http://www.dpac.tas.gov.au/divisions/csr/sportrec/publications/adventure_activity_standards

Vicente, K. J. (1999). *Cognitive work analysis : toward safe, productive, and healthy computer-based work*. Mahwah, N.J.: Mahwah, N.J. : Lawrence Erlbaum Associates.

Walker, G., Cooper, M., Thompson, P., & Jenkins, D. (2014). Practitioner versus analyst methods: A nuclear decommissioning case study. *Applied Ergonomics, 45*(6), 1622-1633. doi:http://dx.doi.org/10.1016/j.apergo.2014.05.017