COPYRIGHT NOTICE

UB ResearchOnline
<http://researchonline.ballarat.edu.au>

This the accepted version of
Hale, Andrew., Borys., David. (2012). Working to rule, or working
safely? Part 2 : The management of safety rules and procedures.
Safety Science (2012)

Reproduced by permission of Elsevier
The published version can be found at
<http://dx.doi.org/10.1016/j.ssci.2012.05.013>

Copyright © 2012 Elsevier
This is the author's version of the work. It is posted here with
permission of the publisher for
your personal use. No further distribution is permitted
The publisher version is available via <http://www.sciencedirect.com/>

Working to rule or working safely? Part 2: The Management of Safety Rules and Procedures¹

Andrew Hale, HASTAM UK, and Safety Science Group, Delft University of Technology, Netherlands.

David Borys, Victorian Institute of Occupational Safety & Health, University of Ballarat, Victoria, Australia.

Abstract

Part 1, the companion paper to this paper (Hale & Borys 2012, this issue) reviews the literature from 1986 on the management of those safety rules and procedures which relate to the workplace level in organisations. It contrasts two different paradigms of how work rules and their development and use are perceived and managed. The first is a top-down classical, rational approach in which rules are seen as static, comprehensive limits of freedom of choice, imposed on operators at the sharp end and violations are seen as negative behaviour to be suppressed. The second is a bottom-up constructivist view of rules as dynamic, local, situated constructions of operators as experts, where competence is seen to a great extent as the ability to adapt rules to the diversity of reality. That paper explores the research underlying and illustrating these two paradigms. In this second paper we draw on that literature study to propose a framework of rule management which attempts to draw the lessons from both paradigms. It places the monitoring and adaptation of rules central to its management process and emphasises the need for participation of the intended rule followers in the processes of rule-making, but more importantly in keeping those rules alive and up to date in a process of regular and explicit dialogue with first-line supervision, and through them with the technical, safety and legal experts on the system functioning. The framework is proposed for testing in the field as a benchmark for good practice.

1. Introduction

Part 1 of this paper (Hale & Borys, 2012, this issue) characterises two contrasting paradigms of the development and use of rules in influencing and constraining behaviour in work

¹ The authors wish to thank the Institution of Occupational Safety and Health in the UK for funding the literature study on which this paper is based.

settings. We believe that these paradigms are relevant to any rules, no matter whether they are directed primarily at production, efficiency, quality, sustainability, or in our case safety, or at a combination of several of these. We talk in this paper of '*safety* rules and procedures' merely to provide a focus, but believe, with Waszink et al (1995), that rule sets for use at work can best be integrated, so that all rules relevant to a given activity are collected together rather than being scattered over several topic-specific rule books.

The review of the literature supporting these two models of rules and their development and use has resulted in the definition of a broad set of concerns and dilemmas, summarised in table 1, copied from the literature review. The picture that emerges is of a gap between the reality of work and its routines and the abstraction of the (often written) rules that are supposed to govern it and guide behaviour to carry out that work safely (see also Borys 2007). We have described two contrasting perceptions of violations of those written rules, either as deviations to be stamped out, or as inevitable and sometimes necessary adaptations to local circumstances to be used and reinforced. We have contrasted also the bottom-up development, through social interaction, of domain expert rules embodied in tacit knowledge, with the top down imposition of rules devised by external experts on operators perceived as fallible and relatively unskilled. We propose to reconcile these two views by making the monitoring and improvement of rules an explicit and central process in the rule management process and by arranging for explicit participation of those at the sharp end in the rule making and monitoring.

Model 1	Model 2
Strengths <ul style="list-style-type: none"> • Makes rule-making explicit & easy to audit • Makes consequences of rule violation explicit • Emphasises competence in rule-making & role of subject experts • Logical, rational, engineering approach • Works well for novices • Proven effectiveness for simple, 'golden rules' (Behavioural Based Safety) • Emphasises the role of organisational complicity in rule violation 	Strengths <ul style="list-style-type: none"> • Recognises operators as experts central to rule making • Recognises social processes as key to rule use • Sees rule-making as a continuous, dynamic process • Links rules to the crystallised competence of organisational memory • Recognises the importance of managing exceptions & their link to violations • Recognises the centrality of experience
Weaknesses <ul style="list-style-type: none"> • Sees operators as robots, lacking competence & social motivation & needing imposed rules • Encourages a blame culture & negative view of rules & violations • Sees rule-making as a one-off, static process, until accidents trigger rule modification • Fails to deal adequately with exceptions except as triggers for rule book growth • Tendency to bureaucracy & gap between rules & reality 	Weaknesses <ul style="list-style-type: none"> • Rule-making & modification process lacks transparency for auditing and for novices learning the skills • Undervalues the need for the organisation to explicitly manage rule development & use • Hides differences of interpretation & competence

Table 1: Summary of main strengths & weaknesses of models 1 and 2

Central to any system of management of rules is how to cope with diversity and exceptions to whatever rule is formulated. Central also is the need to see rule sets as dynamic and to place the focus of their management on the processes around monitoring and change (flexibility), rather than purely on development and communication. We draw these aspects from model 2, together with the need for the rules which are formulated to be calibrated to the competence, motivation and trustworthiness of the rule users. From model 1 we draw the need for transparency in rule making, so that it is clear to both rule users and supervisors, and to auditors what the current, agreed set of rules is. We also draw from there the need to clarify whether there is a subset of ‘golden rules’ which are so universally applicable that any violation can be seen as a *prima facie* case for discipline. From both models we draw the general principle that explicit written rules and procedures should not be seen as the first means of control to be proposed for hazards. Design and layout to reduce the need to interact with hazards takes precedence, and training to implant rules in the heads of users, plus social control to keep them central to practice, are possibly preferred alternatives to written rules for use at the sharp end. These characteristics define the gap between procedures and practice; Dekker (2005) urges us to monitor the gap and try and understand why it occurs, while Knudsen (2009) urges us to stop bitching about the fact that the gap exists and set about closing it. What follows tries to do both of those. As such it tends to modify a number of steps in rule management from essentially model 1, top-down steps towards model 2, bottom-up steps to improve the use of rules in practice by subjecting rules to continual dialogue, debate and adaptation. There remains, however, a dearth of research exploring exactly how rules are used in practice, and we would call for more ethnographic research to progress our understanding at this level. We would also call for more intervention evaluation research, including an evaluation of the framework of rule management presented in this paper.

2. The framework

We base this paper on the framework developed in the earlier work of Hale and colleagues (Hale & Guldenmund 2004, Larsen et al 2004, Larsen & Hale 2004). We present this framework as essentially neutral between model 1 and model 2, both of which it can encompass. This framework, set out in figure 1, is a prescriptive categorisation of the steps logically necessary for the development, promulgation, use, monitoring and modification or enforcement of rules – see also Schulman (2010). We use the framework to assess whether

rule management in practice follows this pattern, and whether the recommendations from literature are compatible with it and flesh it out with good practice.

The framework is also informed by those offered by the Labour Inspectorate (1989), the Energy Institute (2008) and Embrey (1999). In his CARMAN (Consensus-based Approach to Risk MANagement) method Embrey draws on active involvement of experienced operators in carrying out risk evaluation, drawing out best practices based on their experience, using a facilitator and translating this into training for competence and job aids as support. It also mirrors the steps proposed by Sundström-Frisk (1998) for work method change, starting with profiling of actual behaviour, its feedback to the work group to identify obstacles to safe behaviour and to propose safety measures to management for decision making to eliminate or circumvent them. Section 2.1 describes the framework and utilises it for grouping the findings of the literature review into good practice.

Figure 1. Framework of rule management. Adapted from Larsen et al (2004)

2.1. The framework applied

The framework in figure 1 has a cyclical structure, emphasising the fact that rule management is a dynamic process of adaptation of rules to the changing realities of the activity and its environment (model 2). This has the structure of Deming's 'Plan – Do – Check – Adjust' cycle and places the emphasis on the monitoring and learning part of the loop. Larsen et al (2004) is an example of the use of this framework to assess the quality of rule management in European railways, in order to come up with proposals for good practice. Bax et al (1998) argue that this sort of analysis of what they call the 'regulatory regime' is essential to understand how workers assess the legitimacy of rules. They found in their sample of Dutch workers in high risk work that legitimacy was related to the degree of control by management of the rules and the amount of consultation by supervisors about the working of the rules.

2.1.1. Monitoring and feedback

This, together with the subsequent steps in the learning and change part of the rule management cycle (2, 3, 5), forms a crucial set of steps which distinguish models 1 and 2, which is one reason why we begin with it, the other being that it is for most companies where they will start, rather than with a blank sheet and a new activity. Model 1 plays down these steps apart from enforcement (2.1.3), whilst model 2 sees this as the powerhouse of rule use and flexibility. Leplat (1998), Dekker (2005), Bax et al (1998) and Antonsen et al (2008) emphasise the need to monitor continually the gap between procedures and reality and the continuing need to adapt procedures to local conditions. However studies such as Larsen et al (2004) show that, in the railway systems studied, no formal monitoring was taking place, pointing to a model 1 approach.

Behaviour-based safety operates at this level. The classic model of it developed by Komaki et al (1978, 1980, 1982) emphasised the feedback process as a powerful influence on compliance and this has been amply proven (e.g. Krause et al 1999). Related initiatives have placed more emphasis on adding a discussion or dialogue to the feedback, on an individual basis, rather than a group one. This was more successful than just posting the figures as group feedback in evaluations conducted by Hale et al (2010a), though whether this was a reflection

of the difference in national culture and social control between the Netherlands and the United States is an interesting, but unresolved question. The successful interventions evaluated did show the companies concerned moving from model 1 cultures towards model 2, by setting up mechanisms of dialogue about working rules and safety. Behavioural observation and dialogue also give the rule-makers, or managers an opportunity to see the diversity of practice and assess whether their safety rule is indeed operable in that variety. The step from simple feedback, aimed at compliance, to dialogue, aimed at understanding reality and being open to the need for the rules to change to match its diversity, is a clear step from model 1 to model 2. Hudson et al (2000) also emphasise the need for encouraging reporting of violations, coaching by supervisors when they are reported, rather than policing and punishing, leading to optimisation of the procedures through dialogue. Model 2 suggests that, if people routinely violate procedures, it is more likely that the procedures are in need of change, than that the violations should be suppressed.

Monitoring requires not just observation by second or third parties (e.g. behavioural monitoring, Line Operations Safety Audits [LOSA] in aviation [Klinect 2005]), but also self-monitoring and reporting of deviations and surprises (situations falling outside existing rules or experience). The latter process is claimed to be relatively complete in aviation (DEGAS 2010), but is always subject to conflict in a blame culture. It stands or falls with the perception eventual reporters have of what constitutes a deviation or surprise (see e.g. Parker & Lawton 2000, McDonald et al 2005, 2006 for contrasting views on this held by doctors and nurses). Hardware to monitor rule compliance includes the black box in aircraft and its equivalents in lorries, which can provide extensive data (HFRG 1995, Roelen 2008). Davies et al (2007) suggest that it is now technically feasible to equip much more equipment using mobile sensors to record use and hence monitor rule compliance. This epitomises top-down model 1 control and as such generates anger, fear and mistrust (e.g. the spy in the cab). To cope with this it has to be surrounded by agreements about data analysis and retention and the use of individual analysis. However it has clear potential, if these problems of mistrust can be overcome, as an ingredient in the discussion of the feasibility of rules.

Schelling (1985), in a thought-provoking, if unreferenced, paper on ways of enforcing rules on oneself, places great emphasis on making deviations from rules transparent and visible and enlisting the aid of others (social control) to monitor behaviour.

The current language of monitoring, with its focus on compliance, or violations and deviations, may be in danger of reflecting solely a model 1 view of rule usage. By comparison, the language of resilience engineering, with its focus on performance variability, and learning from success and failure alike (Hollnagel 2011) offers a different perspective more in keeping with model 2; a perspective that also has implications for steps 2, 3 and 4 in the framework. Therefore, how we use language to frame what we monitor may either expand or limit what we see and what we learn.

2.1.2. Evaluate rule effectiveness

The majority of model 2 articles place this process of assessment of the adequacy of routines and written rules central to their analysis, which is not a position it enjoys in many companies (Perrin 1993), where the updating of design specifications, drawings and process documentation is often way behind the real changes. Model 2 papers see the process as going on implicitly as a part of the use of tacit knowledge, hence the failure of the documentation to keep up. Better management of this process is one of the main contributions that model 2 could make to model 1, but assessment does require that the tacit knowledge be made explicit, either for peer review or more top-down evaluation.

The need for an organisational memory and for its updating is emphasised by other writers covered in this review (e.g. Gherardi & Nicolini 2000, Holmquist 2003) and is worked out in detail by Koornneef (2000). This can preserve information about what the rules are and why they are formulated as they are, in order to function as an ‘instruction book’ for the system.

The evaluation of the existing safety rules needs to take into consideration the principles set out in the later steps (6-9) described below as criteria for deciding if the rules are good: good choice of rule as the barrier, or barrier element, good design and formulation, good training and communication. If the rules are found to be essentially appropriate and useful, we move to steps 3 and 4 which enforce them and execute them. If not, we move to step 5 to make changes or scrap them.

2.1.3. Enforce the use of good rules

Åberg (1998) has convincing proof of the value of police enforcement to encourage drivers to use seat belts, avoid drunk driving and keep to speed limits. He points to the need for a critical mass of enforcement leading to a perception of a high chance of detection. This echoes Peters' (1999) call for a clear policy on enforcement of rules in mining, but one, in his case developed in collaboration with the supervisors and miners. Glazner et al (1999) showed that the use of disciplinary action on a construction site in all cases of violation was associated with lower injury rates for contractors on that site in the US. The question one must, however, ask is whether this action resulted in less actual accidents or only in less reporting of them. The ultimate aim is to create a climate in which the rules that are there are seen to be sensible and the workgroup uses social control to 'enforce' them.

2.1.4. Execute rules and deal with exceptions

The accessibility of the procedures for reference when required is a point mentioned by Leplat (1998) and by Antonsen et al (2008), once we have decided that the written rules are appropriate and needed. It applies particularly to emergency procedures.

In this step we arrive at a core of the difference between model 1 and model 2. Model 1 tries to minimize exceptions and may require the workforce to stop work when they come across one, waiting until management provides a new or adapted rule to follow in this exceptional situation, as Bourrier 1996 describes in her study of maintenance work in a US nuclear station (See also Dien 1998, Harms-Ringdahl 2004, Hopkins 2010). Model 2 trains the fitters and their supervisor to make the adaptations, as Bourrier found in the French station she studied where only significant changes were reported up to management. The message from Bourrier's study is that the rule management system must provide a mechanism, matched to the culture, for coping with exceptions, since the many studies reviewed under model 2 indicate that they are inevitable (e.g. Brady 1987, Besnard & Greathead 2003, Loukopoulou 2008). Fucks & Dien (2010) point out that management must define whether procedures should be followed to the letter or discretion should be used by operators, but management should accept responsibility in either case if the behaviour leads to negative consequences. Even the Shell (2009) project of 12 'life-saving rules' admits that there are rare exceptions to the rules specified and there needs to be provision for the violators to be able to present mitigating arguments before applying the heavy sanctions the project wields. Some

exceptions and rules for coping with them can be ‘pre-authorised’ (Schelling 1985), but others can only be dealt with when they occur.

Iszatt-White (2007) points to the need in road maintenance to combine rule-following related to some hazards the individual and organisation has control over, with a heightened attention (which she calls heedfulness, but Weick (1993) would call mindfulness) for unpredictable hazards which they have no control over, such as motorist invading cordoned off areas. If these times of heightened attention are limited to short periods, such as crossing carriageways to set up warning signs, this switch of attention is sustainable; but heedfulness is not something that can be kept ‘switched on’ permanently.

At the use stage many of the factors identified in table 1 come to bear, as do the insights from the cost-benefit analysis of behavioural economics (Battmann & Klumb 1993).

Rule execution needs support not only with training, but with good tools and information which make written procedures easily available when needed (e.g. DEGAS 2010, Hale et al. 2010a). Maidment (1993) analyses critically the periodic examination of rule knowledge in UK railways as requiring only rote learning, whilst undervaluing comprehension and the understanding of the context for application. The prevailing training at that time therefore emphasised the ‘what’ and ‘how’ of rules, but not the ‘why’ and ‘where’.

2.1.5. Redesign or scrap bad or superfluous rules.

Since we place rule adaptation central to our framework in order to cope with diversity and exceptions, it is important that there is an explicit mechanism to capture any change, legitimise it and incorporate it into the organisation’s memory, its master rule book. Schulz (2003) looked empirically at the growth and change in rules in a bank and a university (not related to safety, but to personnel and policy, but interesting nevertheless for its theoretical insights). He tested whether rules were static (permanent) or dynamic (impermanent) and introduced the notion of ‘life-span’ of a rule from birth through revisions to suspension. He showed that the rules in his organisations grew over time (tenfold in the university over 18 years and fourfold in the bank over 21 years) (see also Labour Inspectorate 1989, Hale 1990). He identified the search for reliability, legitimacy and efficiency, together with processes of institutionalisation as forces to keep rules unmodified, but pointed also to the growth of unofficial work-arounds, coupled with a tolerance for obsolescence as relieving pressure on

revision. Forces encouraging revision were the need to learn and update the organisational memory. He pointed to the lack of central monitoring of rules as the reason that their obsolescence was not seen or was tolerated awaiting a major revamping. The implication of this is that we need a ‘rule-destruction’ process to counter the tendency for rules to expand. Baram (2010) also emphasises the life-span of rules, in his case at the regulatory level, calling for all such rules to have a defined and limited life. At the end of that time they should automatically lapse unless extended, or renewed with modification. These are often called ‘sunset provisions’. We do not advocate that safety rules should automatically lapse, as this would send out the wrong signal about their importance, merely that they should automatically be reviewed to see if they need modification, or even replacement with more fundamental design or layout changes to make them superfluous. Such an automatic requirement for reappraisal can and does work well at company and workplace level as well, with a fixed schedule for reassessment. This can also help to guard against excessive routinisation of the old familiar routines and the consequent drop in mindfulness. This mechanism of regular reappraisal and eventual scrapping of rules can also help with the tendency that rules and rulebooks have that they grow almost autonomously, driven by accident and incident investigations, court cases, study findings and plugging the gaps found in practice (Amalberti 2001, DEGAS 2010)

2.1.6. Task & risk analysis and choice of risk controls

This issue leads us to the steps of design and redesign of rules (6-9), which are also the point of entry for an organisation which is starting up a new activity, or subjecting one for the first time to explicit (written) safety rules.

The cycle begins with an analysis of the processes, risk scenarios and potential risk control measures for the activity, being aware of the potential gap between processes as designed (and described in the manuals) and those (needing to be) carried out in practice (Energy Institute 2008). Blakstad et al (2010) set out to assess whether the process of rule change she studied in Norwegian railways would contain an explicit risk assessment step, something model 1 would require. Despite plans for that to occur, it did not materialize, and railway knowledge from experts (tacit knowledge) was used to decide what rules to modify and introduce, a reliance on model 2. The existence of old prescriptive action rules based on tacit

knowledge and experience inhibited rule-makers from going back to the first principles to decide on what rules should be made and to set up high level performance goals. The rule-makers defaulted to a more bottom-up approach of 'reverse invention', taking the trusted tacit rules based on long experience as the basis, making the tacit basis explicit and then modifying it for the new circumstances, in parallel inducing the higher level process and performance output rules. Risk analyses were found to be time-consuming and were often only conducted in parallel with the rule formulation, even in some cases being used as feedback and validation of the modified action rules. Risk analysis was not trusted as much as the long experience with prescriptive rules. Similar findings were made in Larsen et al's (2004) study of other European railways. It would appear that the rational approach set out in our model only has a good chance to be used in totally new novel activities, or perhaps in industries less suffused with tradition.

Haller & Stoelwinder (2010) found that crew resource management (CRM) training in hospitals created the space and opportunity for the whole operation theatre team to discuss risks and control procedures in such a way that a common view of them and their priority emerged, including what needed to be written down explicitly, rather than being left to this consensus to inform social control.

Other industries subject to safety case regimes, such as nuclear and chemical processes have developed explicit, rational, model 1 style models to link the scenarios they identify to decisions about the risk controls which can best be used (see for example Bellamy et al 1999, 2006, Hale et al 2004, Hale & Guldenmund 2004). Derivation from past accidents or from risk catalogues is an option even for low technology activities, such as home accidents (e.g. Peterson & Schick 1995). However, many of the studies we have analysed under model 2 point to the limits of this step and the need for alertness to unexpected risks, which can only be coped with by the use of deep tacit knowledge to cope when they occur.

Many texts, including the guidance on OHSAS 18002 advise that the use of rules as risk controls should not necessarily be a first choice, since hardware controls can eliminate hazards and reduce the reliance on behavioural conformity or problem solving (Leplat 1998). However, almost all risk controls, even if exclusively hardware, need to be put in place and suitably maintained, and all others need to be used by people in a suitable way so that they do protect against injury and damage. It is therefore axiomatic that behaviour covering all of

these activities needs to be defined and executed, in order to achieve these objectives of the risk controls. The question is who defines it (expert [model 1] or operator [model 2], or a combination) and is it committed to paper in a formal way (model 1) or does it remain in the informal sphere (model 2)?

We also have to ask here who the customers for the rules are. The regulator and the auditor flourish at the moment on written rules, since these provide a quick and easy basis for checking compliance (but see, e.g. Power [1997] for a criticism of this ‘death by audit’). The safety manager may have the same instinct to require rules to be explicit, so that they can be interrogated and improved and so that they can form the organisational memory (or instruction book) for the SMS and its risk controls (Gherardi & Nicolini 2000, Schulz 2003, Holmquist 2003). The larger the organisation and the more it seeks to harmonise across its different processes or sites, the more the need for these written rules (Labour Inspectorate 1989). Similarly the trainer, charged with putting the behaviour into the heads and limbs of those who must execute it, needs an explicit training objective and plan (Norros 1993), unless the organisation is going to rely entirely on the informal methods of apprenticeship, known in the past as ‘sitting by Nellie’ and identified with model 2. We regard these requirements for, and uses of, written rules as legitimate and needing to be met in the form of what we might call the ‘instruction book’ for the system, which is very different from procedures for front-line operators.

Therefore the main question remains whether the operator needs explicit (written) rules, or whether the rules should be self-generated, and/or internalised. The sheer volume of rules in rule books in complex technologies has been shown to be a barrier to use (Elling 1991, Norros 1993, Maidment 1993). Reason (1997), & Reason et al (1998) strongly advocates not relying too heavily on the ‘administrative controls’ of written formal rules, but using also Hopwood’s (1974) other categories:

- Social control (rules internalized and monitored by the group) such as CRM (Haller & Stoelwinder 2010, Pélégri 2010) developed in aviation, but now widely used in other sectors to encourage explicit communication and mutual control in work groups. Checklists, when used jointly were also found to produce similar effects (Høyland et al 2010)
- Self-control (rules internalized by the individual to become competence and skill).

Others (e.g. Labour Inspectorate 1989) argue even more strongly that procedures should be seen as a last resort when other equipment and work design and layout measures are not feasible. We also approach here the limits of the use of rules, in the sense that proactively made rules can never cover all eventualities, even in relatively simple tasks. At that point the only defence against the unpredictable (or unpredicted) is deep professional competence through experience, training and sharing of expertise (Amalberti 2001, Dekker 2005, Hollnagel et al 2006, DEGAS 2010).

Embrey (1999) argues that operators need a completely different set of on-line job aids than the detailed procedure manuals produced for off-line training and audit. These could resemble more the ‘little black books’ beloved of fitters, with reminders, settings, routines for coping with disturbances or infrequently used procedures, etc. He summarises the need for detailed written (or even step-by-step) procedures, often at the process rule level, as limited to high consequence, low frequency and high complexity tasks. The plea of workers and supervisors to confine detailed written procedures to high risk and out-of-the-ordinary, infrequent activities was also found in Borys’s study of Australian construction sites (2007, 2012), coupled with the recognition of young, inexperienced workers as another set of users of detailed, prescriptive action rules. The same study also found difference between operators, supervisors and managers in the purposes they saw for written procedures, operators being concerned with them as behaviour guides, supervisors seeing them also as ways of limiting personal liability in the case of accident and hence (possibly) worth the greatly expanded paperwork burden, while site and project managers cited also their role in planning as well as risk control and as tools for monitoring behaviour.

Fucks & Dien (2010) emphasise that it should be clearly defined and taught to the appropriate rule users (but also to their colleagues and supervisors) what role procedures have in a system and how much discretion people have in following them (see also Elling 1991). We have indicated in section 3.2 that a number of studies have found unrealistic assumptions among designers, planners and procedure writers about the capabilities of and constraints on operators (Norros 1993, Dien 1998, Polet et al 2003, Energy Institute 2008). These authors advocate the involvement of operators in designing and developing rules (this step and the next), in order to bridge this gap and resolve the misconceptions.

2.1.7. Develop appropriate rules

This is a step which has attracted much of the reviewed literature. The notion of the categorisation into goals, process- and action-rules described in our Part 1 paper (Hale & Borys 2012, this issue, but see also Hale & Swuste 1998) provides a means of specifying how detailed the rules should be (Knudsen 2009, Grote et al 2009), although the approach was not followed at all by the rule-makers in Blakstad's (2006) study. Much of the literature (Leplat 1998, Dien 1998, Dekker 2005, Grote et al 2009) emphasises that the level of competence of the rule users' needs to be taken into account in choosing which level to write the rules on; the higher the competence, the less action-rules are appropriate and the more process-rules will be sufficient (Grote et al 2009), since they can be phrased in terms of guidance, which is an essential element of model 2, rather than as rigid forcing functions. Dekker (2005) and Dien (1998) argue against over-specifying rules for too narrow situations, preferring to leave room for adaptation, rather than inciting violation. An elegant example of the balance between model 1 action rules and model 2 process rules is given by the World Health Organisation project to make surgery safer (Gawande 2010). To achieve this Gawande and his colleagues developed a surgical safety checklist containing a mix of process and action rules. This initiative not only established a set of critical action rules, but a process rule that codified social interaction at critical stages during the surgery, called pause points, to ensure that action rules had been followed. This approach to developing rules embraced the principles of dialogue and empowerment, and just as importantly used data to develop the few critical action rules - without specifying rules for each step in the task.

The notion of the safe envelope also set out in our part 1 paper (Hale & Borys op.cit) provides another language for talking about the place within the safe envelope picture that is taken by the rule. Is the safe operating zone (SOZ) defined very narrowly, with the risk that violations will be encouraged to occur in the name of productivity, and the operators will come into uncharted territory for them, where they cannot 'feel the edge' (the controllability or viable boundary) (Reason et al 1998, Leplat 1998, Howell et al 2002)? Are rules needed for strict optimization within the SOZ, or can navigation in this area be safely left to the competence of the operators? How can rules for operation outside the SOZ (abnormal or emergency procedures) best be formulated, given that they will (or should) be less frequently used and so will be less practiced? These and other categorisations of rule functions (e.g.

Schelling 1985, Hale 1990, Elling 1991) can provide the basis for discussion with rule users about what types of rules are useful. If performance variability (Hollnagel, 2011) and adaptation (Rasmussen 1997, 2000, Dekker 2003) are at times desirable and inevitable, then the discussion may well centre on controlling adaptations (Rasmussen 1997, 2000) or constraining performance variability (Hollnagel); within a SOZ as appropriate to the circumstances. The aforementioned surgical safety checklist (Gawande 2010) achieves this “goldilocks compromise” by getting the balance “just right”. Once again, how the language of rules is framed will influence how rules are discussed and designed. Studies such as those for British Rail (Maidment 1993) point to the pressure from some regulators and from legal cases to use prescriptive rules, because of their unambiguity, rather than giving discretion to operators and using process rules or performance goals. This pressure can be hard to resist, even when it produces rules which create problems.

Related to the last point is the question of the status of a given rule: is it an absolute requirement or specification, or is it a piece of guidance from which an expert operator can deviate by using an action that is equivalent or better in the level of safety achieved (Elling 1991)? Formulating the rule as guidance has been shown to work well for experts in complex technologies (see section 3.3.3). There are often only a few ‘golden rules’, which have (almost) no exceptions and can be promulgated as true specifications.

Vital for the success of rules, according to the literature, whether from the criticisms of model 1 or the advocates of model 2, is the participation of the rule users in formulating the rules. This is endorsed by almost all of the studies reviewed (e.g. Leplat 1998, McCarthy et al 1998, Dien 1998, Embrey 1999, Dekker 2005, Antonsen et 2008, Polesie 2009). However, authors from the organisational disciplines (e.g. Perrin 1993, Hofstede 1986) warn that introducing such participation in rule-making in organisational cultures which values hierarchy and has a high power-distance score, is not an easy task. Bax et al (1998) found that workers in high risk jobs believed that rules were more legitimate if they were consulted regularly about them, but not if they were involved in writing them, which directs us to think carefully about what participation should entail. Model 2 gives the domain expert user the central role by definition, given its bottom-up orientation. However, it is not difficult to adapt the top-down approach of model 1 to incorporate their participation, displacing the subject expert to a supporting, organizing, writing and polishing role (see also Hale et al 2010b), instead of being seen as the fountain of all wisdom, despite their lack of hands-on experience and of

awareness of practical constraints (Embrey 1999). Borys (2007, 2012) found that the workers on his construction sites did not see it as their job to write the safe work method statement (SWMS), which usually came down from higher levels in the hierarchy, but did value the opportunity in toolbox meetings and informally to have their say in adapting them. Above all, this process of producing procedures needs to be seen as an important and high status one, not drudgery inferior to the interesting activity of technical design and development (Perrin 1993).

At a more basic level this step is concerned with the more mundane criteria for appropriate rules set out for example by Wagenaar (1982), Elling (1987, 1988, 1991), Labour Inspectorate (1989), HFRG (1995), Leplat (1998), or Energy Institute (2008). An important question is how much explanation of the rule needs to be given within it (or as commentary/training on it) about why it is formulated as it is, and to which situations it does and does not apply, with what preconditions before it is valid, and with what prerequisites for the use of safety equipment, competence, (additional) manpower, etc. (see also Hale 1990, Iszatt-White 2007, Fucks & Dien 2010) Too little explanation favours violations out of ignorance and does not equip the user to adapt the rule if meeting situations outside the definition; too much makes the rules complex and impenetrable. A failure to write down the reason for the rule and how it fits with prevention principles can lead in complex systems to the organisation forgetting why some of the rules were made as they were (e.g. Larsen et al 2004, Blackstad et al. 2010). This makes them very vulnerable to change which cannot easily go back to first principles of the role of the rule.

Decisions also need to be made about whether to keep safety rules integrated with work rules so that they do not get treated as separate and second-class, or separate so that they are emphasised and prioritised. Waszink et al (1995) emphatically favour the former on the basis of their research, as this allows for a significant reduction in the bulk of rules and improvement in their relevance to each person's specific activity. This requires aligning the rules with the company's primary processes, to emphasise for each user the whole set of rules governing their specific activity. This has great advantages for the rule user, but makes the rule set less transparent for the safety auditor only interested in rules about risk control.

Leplat, Elling and Wagenaar (op.cit) all emphasise the importance of completeness, specificity, readability and understandability in formulating the rules. Maidment (1993) cites

an internal British Rail study which found that the reading age required to understand its rules was 16-18, whereas the average measured reading ability of the staff needing to apply the rules was 8. Readability and understandability are subsumed by Embrey (1999) under the heading of 'Accessibility', which he offers alongside 'Accuracy', 'Practicality', 'Optimisation', 'Presentation', 'Policy', and 'Usage', as headings for optimizing the content and presentation of procedures. Embrey emphasises that 'best practice' consists of two elements, that the procedures work and that they are acceptable to those using them. Without either one they will not be used. Elling (op. cit.) warns that improvements to rules too often concentrate on surface characteristics such as readability, rather than on the content, its clarity, specificity, comprehensibility and appropriateness. He also advocates the ordering of the procedures by task, to assist the operator in finding them, rather than by the system functions they deal with. Wagenaar (op. cit.) points to the need to have check points to monitor (both by self and outsiders) whether the procedure is progressing correctly, and also to check the mutual compatibility of different, simultaneous, contiguous or overlapping procedures. He also advocates explicit instructions on how to cope with unforeseen situations, specification of the discretion allowed to the procedure users and the priority to be given where any conflict with other objectives than safety are to be met. These are all worthy requirements, but implementing them can make procedures extremely complex and unusable.

Antonsen et al (2008) carried out a study in offshore supply bases to try to close the gap between work as imagined and work as done. The main changes they made were to reduce the number of procedures and to simplify and clarify their language, using workers as informants. They also prioritised procedures on importance and implemented a weekly discussion of procedures at HSE meetings. The workers felt that there had been an improvement in safety, but this was not borne out by the number of accidents, and 44% still felt the procedures were being violated after the changes. Borys (2007, 2012) studied the use of written 'safe work method statements'² (SWMS) in two Australian construction sites and found a rather small (perceived) gap between the SWMS and the real procedures, which seems to be explained by the relatively informal methods of supervisors on the spot allowing modifications of standard SWMS, prepared in advance, to cope with local situations. These modifications were often not made to the formal issued SWMS, but only incorporated later

² These are required by law as written statements for dangerous activities, setting out the hazards identified and the risk control measures to reduce the risks to acceptable levels.

(if at all) as modifications for future use. These sites seemed not to be typical of Australian sites in that respect, according to the findings of a WorkCover (2001) study.

2.1.8. Trials with and approval of the rules

A trial use of any proposed rules is always desirable (Energy Institute 2008). To evaluate this there needs to be a set of criteria for accepting rules and giving them a formal status (see section 2.1.3). Model 2 suggests that this ‘approval’ resides in the consensus of the group of domain experts using the routines and sees it as an essentially informal process. Model 1 sees it as needing to be formalised. Larsen et al (2004) found that the railways studied did not have such criteria and relied, as with so many other issues, on the expertise of the rule writers and checkers. Leplat (1998) provides a number of attributes (see previous section) and warns that, as rule sets get larger, the danger of internal inconsistencies becomes greater and these need to be deliberately checked for. McCarthy et al (1998) come up with a longer list for hospital guidance protocols: validity (evidence based), cost-effectiveness, reproducibility, reliability, developed with all interests (including patients), clinical applicability and flexibility, identification of exceptions, clarity, meticulous documentation and wording and presentation as guidance and learning resource and not as imposed control. Antonsen et al (2008) focus on comprehensibility, accessibility and accuracy.

2.1.9. Communication and training in rule use

Training has to produce the balance between internalization of the rules as tacit knowledge and the remaining reliance on consulting written rules or checklists; the balance lying towards internalization for normal operations, but more to consultation of paper in emergency situations (provided time is available) or other unexpected situations. The training step is also the point at which any of the individual factors identified in the literature (see table 1 of the Part 1 paper (Hale & Borys op.cit.), can be identified and attempts made to counter them, particularly in relation to underestimates of risk and poor knowledge about the reasons for specific rules and the consequences of violating them (model 1). The importance of good mental models of what rules are trying to achieve is emphasised by Besnard & Greathead (2003), whilst vivid and convincing demonstration of the risks is underlined in Bell & Fogler’s (1999) suggestion for using accident simulations, and the emotive training using victims of injury in the evaluation study in Hale et al (2010b). In pursuit of model 2, this is the step which could provide the knowledge and understanding to be able to adapt rules to the

diversity of situations to be faced (Dekker 2005, DEGAS 2010) especially complex ones involving multiple failures of hardware or of other operators, which can produce unpredicted interactions. The studies reviewed emphasised that this learning takes place over a long time of experience and of meeting different situations, but formal training and refresher retraining can structure this learning and alert people to the need for it, and also make explicit the processes by which it occurs and monitor its progress.

When rules are changed, prompt information to users is vital to avoid them violating the new rule by continuing to use the old one. Larsen et al (2004) found problems here in many railways. However, Drach-Zahavy & Somech (2010) in their study of nurses cite studies showing only minor effects of training and enforced compliance on accident rates, because these interventions were not translated into practical implementation.

In summary we can indicate the various options under this set of steps as follows, drawing particularly on the summaries of HFRG (1995) and the Energy Institute (2008):

1. Monitor and analyse violations as a participative activity, in order to understand them
2. Audit violation potential
3. Redesign the job or equipment to remove the need for procedures or violations, or to support procedure use
4. Rewrite procedures with a well-designed process and to adequate criteria
5. Involve/consult/inform the workforce during the rewriting
6. Train and retrain in risk perception, the procedure and its use and adaptation
7. Anticipate the need for, and provide authority and a system for, varying procedures
8. Promote a learning and sharing culture around compliance
9. Enforce where the procedure is the agreed and appropriate best way of proceeding.

3. Conclusion

The rule management framework can accommodate the vast majority of the insights provided by the literature of both model 1 and model 2. Some guidance is also available to indicate which of the models should be chosen at each step, given the type of activity, the rule-users and the levels of risk involved in the behaviour, but the literature is not conclusive in helping us to decide between the models. It does highlight where in detail the models differ. Our review has also shown that the two models have their own strengths and weaknesses. Model 1 is more transparent and explicit than the tacit knowledge and emerging set of routines

characterised by model 2. This makes it more scrutable for trainers, assessors and improvers, but at the cost often of creating the gap between work as imagined in the rule set, which has to be written to achieve that scrutability, and work as carried out in practice. The quality management and auditing industry favour written procedures for these reasons of transparency, and hence create major incentives for companies to write weighty procedure manuals, but tend then to be blind to the gap with reality which a paperwork-based system audit does not pick up.

The stages of developing appropriate rules, their use, including dealing with exceptions, and their monitoring and adaptation are steps where there are conflicting recommendations from the two models, implying that choices have to be made, or at the very least that work has to be done to arrive at a compromise which encompasses both standardisation and flexibility. Rules may be imposed from above, but they must be at least adapted from below to meet the diversity of reality. As DEGAS (2010) says, ‘a rule is fit for purpose because it works, not because it is written’. Model 1 fits best with routine work with few exceptions, conducted by lowly skilled people (the classic machine bureaucracy of Mintzberg (1983) (see also Haller & Stoelwinder [2010]) but even there the rule management system can benefit from their greater participation based on trusting them as domain experts in defining rules and tempering the top-down nature of model 1.

This view coincides with the ‘telling and directing’ leadership style of Hersey et al (2007) which they characterise as appropriate for workers with low competence and commitment. The ‘participating and supporting’ and particularly the ‘delegating and observing’ leadership styles are suitable for a workforce with high competence and variable or high commitment, such as pilots, surgeons, and possibly seamen and fitters working in a professional bureaucracy, though even here there is a need for a safety net of agreed action rules covering the crucial checkpoints in safety critical processes (Gawande 2010). Detailed written procedures are also appropriate for learners, for high risk situations and for infrequently conducted tasks, provided that these risks can be and have been predicted. If they have not been predicted, the situation requires the opposite approach of deep tacit knowledge and the ability to improvise. Here lies one of the biggest question marks of rule use, since these two approaches appear to contradict each other.

Model 2 fits best with complex, high uncertainty, high risk domains with great variety and need for improvisation. The work on proceduralisation of health care, aviation and other candidates for this grouping does, however, show that there is scope for making guidance and protocols more explicit, usable and used, by specifying them as process-rules rather than as action-rules. Models 1 and 2 also fit together better if we see 1 as the producer of written rules and 2 as the producer of enacted routines. The task then is to how to articulate the two and derive one from the other. It would appear that it is very often more productive to start with the enacted routines and derive the rules from them and not vice versa. The literature does point clearly to the advantage in this respect, if not the necessity of greater participation in rule-making and modification by the rule-users, and the need for monitoring and change to be a central plank in rule management. These can be easily grafted on to model 1 to take away some of its elitist image.

We would hypothesise that model 1 is probably still the dominant model in the majority of industry among top managers, particularly in small companies and certainly among regulators and auditors. Whether that is also the case with safety advisors is an open question. Model 2 is somewhat hidden from view, either deliberately by the work-floor to retain their autonomy, or because management and supervision turn a blind eye to it. As indicated above, there is room for mixing some of the best features of each model, but we believe that there is still a need for a significant culture-shift, perspective change or paradigm shift for many of those individuals and organisations operating under a pure model 1, to accommodate the ideas of the flexibility implied in model 2.

As we have shown, the framework in figure 1 can be used to structure both model 1 and model 2 approaches and to offer valuable compromises or combinations between the models to use their strengths and repair their weaknesses. In order to move the emphasis in rule management from rule-making to rule monitoring, adaptation and modification, the cultural assumptions of top managers, supervisors and regulators need to be explicitly challenged. In particular, the dead hand of the last group needs to be faced. The more rule sets come under the scrutiny of legal or quality management and auditing processes, examining compliance to detailed provisions, the less likely is it that organisations can preserve the flexibility of their own sets of rules to deal with the diversity of work as actually performed.

The discussion of the papers reviewed has also emphasised that all situations, all rules and all users are not alike. Detailed rules written by head-office experts may be appropriate for a novice group with low levels of training working on complex, high-risk technology or coping with emergencies. On the other hand, experts with long experience and deep knowledge may only need advisory protocols for off-line browsing to refresh their minds about complex skills and procedures that may have become too automatic to be monitored and reviewed, plus a few critical checkpoint action rules to guard against inattention and distraction. This ‘horses for courses’ approach needs to be worked out in detail in future research (see also Rosness 2010, Schulman 2010 for some first attempts at defining dimensions).

We would also repeat the call that we made at the beginning of the paper for more field research into actual use of rules in a broad range of circumstances. Such research has been conducted in the model 2 paradigm, but mainly for complex, professional jobs. The model 1 paradigm has tended not to do such in-depth studies, stopping at labelling all deviations as negative, rather than trying to understand the reasons for them. A more even-handed attention to actual field practice from both paradigms would help us to become better at betting on which horses for which courses.

4. Coda

Interesting questions arising from our review, but not articulated here include the following, which we recommend to other readers:

1. Does this analysis of rule following and rule management at the level of the work-floor or primary process have anything to offer for the analysis of regulations imposed by regulators on companies, or by companies on their managers as part of the SMS, where violation is just as prevalent? See also Hale et al (2011)
2. If evaluation and improvement and the demands of an organisational memory require rules to be made explicit, how can we do this without going to the expense and trouble of making all rules formal and written down? How can we reliably interrogate and audit tacit knowledge and implicit rules? What does this have to say about the knowledge and domain competence of auditors, but also of the top managers of organisations?
3. What is the role of national culture and its influence on the image and use of rules in explaining the differences found in the literature reviewed?

5. References

- Åberg L. (1998). Traffic rules and traffic safety. *Safety Science* 16 (1) 205-216
- Amalberti, R. (2001). The paradoxes of almost totally safe transportation systems. *Safety Science*, 37(2-3): 109-126.
- Antonsen, S., Almklov, P. & Fenstad, J. (2008). Reducing the gap between procedures and practice – Lessons from a successful safety intervention [Electronic version]. *Safety Science Monitor*, 12 (1): Article 2.
- Baram, M. (2010). Personal communication
- Battmann, W & Klumb, P. (1993). Behavioural economics and compliance with safety regulations. *Safety Science* 16 (1) 35-46
- Bax, E. H., Stejn, B. J. & De Witte, M. C. (1998). Risk management at the shop floor: The perception of formal rules in high-risk work situations. *Journal of Contingencies and Crisis Management*, 6: 177-188.
- Bell, J. & Fogler, H. (1999). Virtual laboratory accidents designed to increase safety awareness. *Proceedings of the 1999 American Society for Engineering Education Annual Meeting* (Session 3613). Charlotte, North Carolina.
- Bellamy L.J., Ale B.J.M., Geyer, T.A.W., Goossens, L.H.J., Hale A.R., Oh J.I.H., Mud, M., Bloemhoff, A., Papazoglou I.A., & Whiston J.Y. (2006). Storybuilder: a tool for the analysis of accident reports. *Reliability Engineering & System Safety* 92 (6) 735-744
- Bellamy L.J., Papazoglou I.A., Hale A.R., Aneziris O.N., Ale B.J.M., Morris M.I. & Oh J.I.H. (1999). I-Risk: Development of an integrated technical and management risk control and monitoring methodology for managing and quantifying on-site and off-site risks. Contract ENV A-CT96-0243. Report to European Union. Ministry of Social Affairs and Employment. Den Haag.
- Besnard, D. & Greathead, D. (2003). A cognitive approach to safe violations. *Cognition, Technology and Work*, 5(4): 272-282.
- Blakstad, H.C (2006). *Revising rules and reviving knowledge: Adapting hierarchical and risk-based approaches to safety rule modifications in the Norwegian Railway System*. Unpublished doctoral dissertation, Norwegian University of Science and Technology, Trondheim.
- Blackstad H.C., Hovden J., & Rosness R. (2010) Reverse invention: an inductive bottom-up strategy for safety rule development: a case study of safety rule modifications in the Norwegian railway system. *Safety Science* 48 (3) 382-394

Borys D. (2007). Exploring risk awareness as a cultural approach to safety: an ethnographic study of a contract maintenance environment. PhD thesis University of Ballarat. School of Science & Engineering.

Borys D. (2012). The role of safe work method statements in the Australian construction industry. *Safety Science* 50(2) 210-220.

Bourrier, M. (1996). Organizing maintenance work at two American nuclear power plants. *Journal of Contingencies and Crisis Management*, 4 (2): 104-112.

Brady, F. (1987) Rules for making exceptions to rules. *Academy of Management Review*, 12 (3): 436-444.

Davies, N., Efstratiou, C., Finney, J., Hooper, R., Kortuem, G. & Lowton, M. (2007). Sensing danger - Challenges in supporting health and safety compliance in the field. Proceedings of the Eighth IEEE Workshop on Mobile Computing Systems and Applications, pp. 34-38. Washington DC: IEEE Computer Society

Dekker, S.W.A. (2003). Failure to adapt or adaptations that fail: Contrasting models on procedures and safety. *Applied Ergonomics*, 34(3): 233-238.

Dekker, S.W.A. (2005). Ten Questions about Human Error: a new view of human factors and system safety. Lawrence Erlbaum. New Jersey.

DEGAS. (2010) Regels als gestolde ervaring (Rules as concentrated (solidified) experience). Dutch Expert Group Aviation Safety. Advice 2010-053. <http://www.adviescollege-degas.nl/>

Dien Y. (1998). Safety and application of procedures, or 'how do 'they' have to use operating procedures in nuclear power plants?' *Safety Science* 29 (3) 179-188.

Drach-Zahavy A. & Somech A. (2010) Implicit as compared with explicit safety procedures: the experience of Israeli nurses. *Qualitative Health Research* 20 (10) 1406-1417.

Elling, M.G.M. (1987). Veilig werken volgens geschreven procedures: illusies en werkelijkheid (Safe work according to written procedures: illusion and reality). Communicatie in bedrijf en beroep (Communication in company and profession) Toegepaste Taalwetenschap 2: 133-143

Elling, M.G.M. (1988). Duidelijkheid, bruikbaarheid en effectiviteit van werk- en veiligheidsinstructies (Clarity, usefulness and effectiveness of work and safety instructions). Tijdschrift voor Taalbeheersing 10: 1-13

Elling, M.G.M. (1991). Veiligheidsvoorschriften in de industrie (Safety rules in industry). PhD Thesis. University of Twente. Faculty of Philosophy and Social Sciences Publication WMW No.8. Netherlands.

Embrey D. 1999. Preventing human error: developing a best practice safety culture. Paper to the Berkeley Conference International conference Achieving a step change in safety performance. Barbican Centre, London, February.

Energy Institute. (2008) Managing rule breaking: the toolkit. www.energyinst.org.uk/-/heartsandminds.

Fucks, I. & Dien, Y. (2010). “No rule, no use”? The effects of overproceduralization. Paper to the 27th New Technology and Work Workshop on How desirable or avoidable is proceduralization of safety? Sorèze, France.

Gawande, A. 2010. *The Checklist Manifesto: how to do things right*. London, Profile Books

Gherardi, S. & Nicolini, D. (2000). To transfer is to transform: The circulation of safety knowledge. *Organization*, 7 (2): 329-348.

Glazner J.E., Borgerding J., Bondy J., Lowery J.T., Lezotte D.C., & Kreiss K. (1999). Contractor safety practices and injury rates in construction of Denver International Airport. *American Journal of Industrial Medicine* 35: 175-185

Grote, G., Weichbrodt, J., Gunter, H., Zala-Mezo, E., & Kunzle, B. (2009). Coordination in high-risk organizations: The need for flexible routines. *Cognition, Technology & Work*, 11 (1): 17-27.

Hale A.R. (1990). Safety rules OK? Possibilities and limitations in behavioural safety strategies. *J. Occupational Accidents*. 12 3-20

Hale, A.R. & Borys, D (this issue) Working to rule or working safely? Part 1: a state of the art review. *Safety Science*

Hale A.R., Borys, D. & Adams M. (2011). Regulatory overload: a behavioral analysis of regulatory compliance. Mercatus Center. George Mason University. Arlington, Virginia.

Hale, A.R., Goossens, L.H.J., Ale, B.J.M., Bellamy, L.A., Post, J., Oh, J.I.H. & Papazoglou, I. A. (2004). Managing safety barriers and controls at the workplace. in Probabilistic Safety Assessment & Management. 608 – 613. Springer Verlag. Berlin.

Hale, A.R. & Guldenmund F.G. (2004). Aramis Audit Manual. Safety Science Group, Delft University of Technology. Version 1.3.

Hale A.R., Guldenmund F.W., van Loenhout P.L.C.H. & Oh J.I.H. (2010a). Evaluating safety management and culture interventions to improve safety: Effective intervention strategies. *Safety Science*, 48 (8), 1026-1035

Hale A.R., Jacobs J. & Oor M. (2010b). Safety culture change in two companies. Proceedings of the International Conference on Probabilistic Safety Assessment & Management. Seattle. Washington

Hale, A. & Swuste, P. (1998). Safety rules: Procedural freedom or action constraint. *Safety Science*, 29 (3): 163-177

Haller G & Stoelwinder J. (2010). Teamwork management by the 'crew resource management' method used in civil aviation: an alternative to procedure-based strategies to improve patient safety in hospitals? Paper to the 27th New Technology and Work Workshop on How desirable or avoidable is proceduralization of safety? Sorèze. FonCSI. France.

Harms-Ringdahl, L. (2004). Swedish case study - Safety Rule Management in Railways (Report). Stockholm, Sweden: Institute for Risk Management and Safety Analysis.

Hersey P., Blanchard K.H. & Johnson D.E. (2007). Management of Organizational Behavior: leading human resources. 9th Edition. Prentice Hall.

HFRG. (1995) Improving compliance with safety procedures: reducing industrial violations. Human Factors in Reliability Group. Published by Health & Safety Executive. HMSO London

Hofstede, G.R. (1986). Werken aan de organisatiecultuur. (Working on the organisational culture) *Bedrijfskunde* 58(2), 102-106.

Hollnagel, E. (2011). Prologue: The scope of resilience engineering. In Hollnagel, E.; Pariès, J.; Woods, D. D. & Wreathall, J. (Eds). Resilience Engineering in Practice: A Guidebook. Surrey, Ashgate.

Hollnagel E., Woods D.D. & Leveson N (Eds). (2006). Resilience Engineering: concepts & precepts. Aldershot, Ashgate

Holmqvist, M. (2003). Intra- and inter-organisational learning processes: An empirical comparison. *Scandinavian Journal of Management*, 19 (4): 443-466.

Hopkins, A. (2010). Risk Management and Rule Compliance Decision Making in Hazardous Industries (Working Paper 72). Canberra: National Research Centre for OHS Regulation

Hopwood A.G. (1974). Accounting Systems and Managerial Behaviour. London Paul Chapman.

Howell, G., Ballard, G., Abdelhamid, T. & Mitropoulos, P. (2002). Working near the edge: A new approach to construction safety. *Proceedings IGLC-10*, August 2002, Gramado, Brazil.

Høyland S., Aase K., Hollund J.G. & Haugen A. (2010). What is it about checklists? Exploring safe work practices in surgical teams. Paper to the 27th New Technology and Work Workshop on How desirable or avoidable is proceduralization of safety? Sorèze, France.

Hudson, P., Parker, D., Lawton, R. & van der Graaf, G. (2000). Bending the rules: Managing violation in the workplace. International Conference of the Society of Petroleum Engineers. Retrieved 4th April, 2010, from: www.energyinst.org.uk/heartsandminds/docs/-bending.pdf.

Iszatt-White, M. (2007). Catching them at it: An ethnography of rule violation. *Ethnography*, 8(4): 445-465.

Klinec, J.R. (2005). Line Operation Safety Audit: A Cockpit Observation Methodology for Monitoring Commercial Airline Safety Performance. Doctoral Dissertation, University of Texas

Knudsen, F. (2009). Paperwork at the service of safety? Workers' reluctance against written procedures exemplified by the concept of 'seamanship'. *Safety Science*, 47 (2): 285-303.

Komaki, J., Barwick, K. & Scott, L. (1978). A behavioral approach to occupational safety: Pinpointing and reinforcing safe performance in a food manufacturing plant. *Journal of Applied Psychology*, 63(4): 434-445.

Komaki, J., Heinzmann, A. & Lawson, L. (1980). Effect of training and feedback: Component analysis of a behavioral safety program. *Journal of Applied Psychology*, 65(3): 261-270.

Komaki, J., Collins, R. & Penn, P. (1982). The role of performance antecedents and consequences in work motivation. *Journal of Applied Psychology*, 67 (3): 334-340.

Koornneef F. (2000). Learning from small-scale incidents. Ph.D. thesis. Safety Science Group. Delft University of Technology.

Krause, T.R, Seymour, K.J. & Sloat, K.C.M. (1999). Long-term evaluation of a behavior-based method for improving safety performance: a meta-analysis of 73 interrupted time-series replications. *Safety Science*, 32 (1) 1-18

Labour Inspectorate. (1989) Procedures in the Process Industry: examples and proposals concerning development, introduction and control of procedures in the process industry. Directorate-General of Labour. Ministry of Social Affairs and Employment. Voorburg NL.

Larsen L. & Hale A.R. (2004) Safety rule management in railways. Proceedings of the European Transport Conference. Strasbourg, 4-6 October. Association for European Transport.

Larsen, L.D, Petersen, K, Hale, A.R , Heijer, H, Parker, D, & Lawrie, D. (2004). A Framework for Safety Rule Management. contractno:GMA2/2001/52053. Lyngby: Danish Traffic Institute.

Leplat J. (1998). About implementation of safety rules. *Safety Science* 16 (1) 189-204

Loukopoulou, L. (2008). *Pilot error: even skilled experts make mistakes*. Paper presented at WorkingonSafety.Net, 4th Annual Conference: Prevention of occupational accident in a changing work environment, Crete, Greece, 30th September – 3rd October.

Maidment, D. (1993) A changing safety culture on British Rail. Paper to the 11th NeTWork Workshop on ‘The use of rules to achieve safety’. Bad Homburg 6-8 May.

McCarthy, J., Wright, P., Monk, A. & Watts, L. (1998). Concerns at work: Designing useful procedures. *Human-Computer Interaction*, 13 (4): 433-457.

McDonald, R., Waring, J., Harrison, S., Walshe, K & Boaden, R. (2005). Rules and guidelines in clinical practice: a qualitative study in operating theatres of doctors’ and nurses’ views. *Quality and Safety in Health Care*, 14: 290-294.

McDonald, R., Waring, J. & Harrison, S. (2006). Rules, safety and the narrativisation of identity: A hospital operating theatre case study. *Sociology of Health & Illness*, 28(2): 178-202.

Mintzberg, H., 1983. Structures in five: designing effective organisations. Simon & Schuster, Englewood Cliffs, New Jersey, USA

Norros, L. (1993) Procedural factors in individual and organisational performance. Paper to the 11th NeTWork Workshop on ‘The use of rules to achieve safety’. Bad Homburg 6-8 May. VTT Espoo, Finland,

Parker, D. & Lawton, R. (2000). Judging the use of clinical protocols by fellow professionals. *Social Science & Medicine*, 51(5): 669-677.

Pélegrin, C. (2010). The story of proceduralization in aviation. Paper to the 27th New Technology and Work Workshop on How desirable or avoidable is proceduralization of safety? Sorèze, France.

Perrin, C. (1993) The dynamics of safety: the intersection of technical, cultural and social regulative systems in the operation of high hazard technologies. Paper to the 11th NeTWork Workshop on ‘The use of rules to achieve safety’. Bad Homburg 6-8 May. MIT. Sloan School of Management.

Peters, R. (1999). *The challenge of enforcing safety rules in remote hazardous work areas*. Paper presented at Work, Stress, and Health '99: Organization of Work in a Global Economy Conference, Baltimore, March 13.

Peterson, L. & Schick, B. (1993). Empirically derived injury prevention rules. *Journal of Applied Behavior Analysis*, 26(4): 451-460.

Polesie, P. (2009). *Valuing freedom and standardization when working at the construction site* (Building and Real Estate workshop paper). Hong Kong: The Hong Kong Polytechnic University.

Polet P., Vanderhaegen F. & Amalberti R. (2003). Modelling borderline tolerated conditions of use (BTCU) and associated risks. *Safety Science* 41(2-3) 111-136.

Power M. 1997. *The audit society: rituals of verification*. Oxford University Press. Oxford.

Rasmussen, J. (1997). Risk management in a dynamic society: A modelling problem. *Safety Science*, 27(2): 183-213.

Rasmussen, J. & Svedung, I. (2000). *Proactive Risk Management in a Dynamic Society*. Swedish Rescue Services Agency, Karlstad, Sweden.

Reason J.T. (1997). *Managing the Risks of Organisational Accidents*. Aldershot. Ashgate.

Reason, J., Parker, D. & Lawton, R. (1998). Organizational controls and safety: The varieties of rule-related behaviour. *Journal of Occupational and Organizational Psychology*, 71: 289-304.

Roelen A.L.C. (2008). *Causal Risk Models of Air Transport: comparison of user needs and model capabilities* PhD thesis, Delft University of Technology, Safety Science Group.

Rosness R. (2010). *The proceduralization of traffic safety and safety management in the Norwegian Rail Administration: a comparative case study*. Paper to the 27th New Technology and Work Workshop on How desirable or avoidable is proceduralization of safety? Sorèze, France.

Schelling, T. (1985). Enforcing rules on oneself. *Journal of Law, Economics and Organization*, 1 (2): 357-374.

Schulman P. (2010). *Procedural paradoxes and the management of safety*. Paper to the 27th New Technology and Work Workshop on How desirable or avoidable is proceduralization of safety? Sorèze, France.

Schulz, M. (2003). Impermanent institutionalization: The duration dependence of organizational rule changes. *Industrial and Corporate Change*, 12(5): 1077-1098.

Shell. (2009). *Guidance for employee and (sub) contractor front-line staff*. Version 2. (12. Life-saving rules). Shell. The Hague

Sundström-Frisk C. (1998). Understanding human behaviour: a necessity in improving safety and health performance. *Journal of Occupational Health & Safety – Australia & New Zealand*. 15(1) 37-45

Wagenaar, W.A. (1982) Checklist voor de evaluatie van geschreven procedures (Checklist for the evaluation of written procedures). TNO Instituut voor Zintuigfysiologie. Soesterberg. NL

Waszink, A.C., Meyer, F.O. & van der Pelt, A.C.W. 1995. Integratie van zorgsystemen (Integation of management systems). *Sigma* 1. 4-7.

Weick, K. E. (1993). The collapse of sense-making in organizations: The Mann Gulch disaster. *Administrative Science Quarterly*, 38, 628-652.

WorkCover New South Wales. 2001. Priority issues for construction reform: safe building New South Wales, report summary. WorkCover NSW. Sydney.