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SAFETY MANAGEMENT IN RAIL INFRASTRUCTURE

PAUL HEIMPLAETZER*, CARSTEN BUSCH**

*) Royal Haskoning engineering, environment and safety consultancy
P.O box 94241, 1090GE Amsterdam, The Netherlands, E-mail: p.heimplaetzer@royalhaskoning.com
**) formerly employed by ProRail Inframanagement Department of Safety & Environment, currently working for Bluewater Energy Services, E-mail: carsten.busch@bluewater.com

This paper decribes the development of a safety management system for the Dutch provider of railway infrastructure ProRail.

INTRODUCTION

Safety in railway companies has mainly been managed from a technical and rule based point of view. 'Technical' in the sense that the main focus has been on robustness of infrastructure and rolling stock, and automatically functioning safety devices to eliminate the effects of human error. Rule based in this case means that the railway system was considered as a 'clockwork' where safety was guaranteed by strict adherence to iron rules with little or no room for interpretation or need for independent decision making by operators in the field, thus limiting system flexibility to a minimum (see Hale 2000).

Weick (2001) illustrates the kind of situations to which this can lead, using the case of the Pacific Union gridlock, where the complete traffic came to a stop because of lack of understanding of operational processes by management and strict adherence to rules by staff.

In Europe new developments in technology and in the railway business case are putting the technical and rule based approach under pressure. Not only is the railway network expanding in response to a growing demand, its functional and technical characteristics are also changing under the influence of technological developments: for example in the field of information and communication technology and the demand for interoperability between European national networks. On the other hand maybe even faster changes are taking place in business processes and the organizational landscape of the railway industry due to new European legislation that asks for privatization and separation of providers of infrastructure and providers of transport.

TECHNOLOGY FOCUS AND THE INFLUENCE OF ORGANIZATION AND PROCESS CHANGES

Apart from putting the technical and rule based approach under pressure these changes do not seem to be the product of a coherent master plan, and take place in a relatively autonomous way. The predominant focus is on technological developments which on one hand do not always match with changes in processes or organization and on the other prevent these to be considered as a useful alternative (or at least as a necessary supplement) to 'hardware' changes. A typical answer, when being questioned about safety incidents, still is that 'investments in systems have been tripled over the last number of years' (interview with CEO ProRail 2005). Apart from this the technological changes are characterized by different rail technology fields (such as signalling, energy, track) also developing in an autonomous way. This seems to depend in part on the fact that there is little competition between producers of railway systems and in the railway industry as a whole, and from the fact that the introduction of new concepts for example in the field of traffic management and signaling (like the European Rail Traffic Management System - ERTMS) asks for heavy investments which no single party is prepared to or able to pay for, be it railway companies, producers of systems or national authorities (van der Sandt 2006).

Only recently the railway industry has adopted new approaches in the field of design and engineering, like systems engineering and RAMS (Reliability, Availability, Maintainability and Safety) management (ISO-50126), which can bring a more transparent trade off between various types of requirements and can make it possible to consider the railway system as a whole during the design process. This approach is especially urgent when it comes to the engineering of software related systems (which are becoming more and more important also in the railway industry) as can be concluded from a study into the nature and causes of a considerable number of spacecraft and aircraft incidents (Leveson 2001). Many failures that contributed to the causation of these accidents were attributed to inadequate systems and software engineering.

Also on the side of organization and process changes the trend towards privatization and fragmentation into independent operators has produced situations that due to their 'experimental' nature have led to a number of unforeseen and undesirable effects. The case of the British railroad system is the most notorious as an illustration that a once solid system becomes fragile if important positive characteristics of the old configuration are not preserved and if the process of change itself is managed and monitored in an inadequate way.

Maybe the most vulnerable 'strongholds' of the existing systems are sound (overdimensioned) technology, the retention of experience inside the organization, and rules that work (and are partly unwritten) built up over decades. As it is clear that no system can survive without adapting to new circumstances and demands, maybe the real problem lies in the process of change itself. All too often existing systems and organizations are being dismantled, without the new being in place or functioning.

What may bother us anyhow when looking at the aspect of safety, is not the number of accidents, that may even decrease, but the often trivial causes of the accidents that still happen. In many cases loss of interest, commitment, focus and management control that are the result of poorly managed change processes seem to play an important role.

THE STARTING POINT

ProRail, The Dutch provider of railway infrastructure finds itself in the middle of the turbulence of changing technology, processes and organizational settings. In the mid nineties of the twentieth century the Dutch railways were split up into a number of companies (provider of infrastructure, maintenance, traffic control, carriers, etc.). ProRail was formed in 2004 and is responsible for capacity management, operation, maintenance and renewal of the entire Dutch railway network. This has lead to the following major changes in the characteristics of business process and position:

- The shift towards managing a railway system that is under growing political and public attention and has to satisfy ever faster changing demands. This has a number of consequences. First of all, the organization is in the process of learning to play the new game of communication with public and politics. Growing public and political attention demands a communication style which explains the company strategy in a simple way and goes beyond a strictly technological discourse. This asks for a change in the perception the organization has of its own vocation: from one where the central idea is 'providing railway infrastructure' to the idea of 'providing services to clients'. Especially when accidents occur, negative publicity may bring the company's reputation under severe pressure. The only way out is to make it clear, that the Dutch railway infrastructure wasn't built yesterday – or even the day before - and that at the same time with a limited budget available ProRail has to absorb new technological developments as well as the need to renew systems that are at the end of their economic and technical lifecycle.

- This creates the need to cope on a more strategic and comprehensive level with these developments. The huge investments needed ask for a more strategic approach of technology and infrastructure development, which aims at combining short term and long term developments, because technological choices, once made, may determine and limit the direction of development for a long period and make it virtually impossible to change plans halfway. Therefore delays in technology development which may seem promising at the beginning like ERTMS can create severe setbacks in planned strategy when implementation is delayed, and bring the need for intermediary solutions like upgrading existing technologies, Intermediary solutions usually cost more in the long term. Apart from that, until recently the organizational structure of ProRail with its division into separated technology fields (like track, signaling, traction power, etc.) has made it difficult to develop an integrated technology strategy and has led to sub-optimization and fragmentation of efforts to renew technology and processes. Only recently a strategy is under development which makes it possible to combine choices in different technology fields and on different timescales, leaving more than one choice open in order to cope with unexpected setbacks in the development of specific technology or unexpected changes in demand.

- The next factor is the position of ProRail as a ‘spider’ in the network of the Dutch railway industry with many interrelations between national and local authorities on one hand and private companies which provide services in the field of transport and maintenance on the other. Here two tendencies can be observed. As a former ‘machine bureaucracy’ ProRail is dealing with a growing internal pressure towards modernization of its management style. At the same time it has to manage a growing number of interdependencies with all kinds of organizations. Once an ‘inward’ oriented organization it has had to spend a considerable effort in diverting its attention outward, realizing that many of its core business processes are directly linked to those of other organizations, primarily train operators and maintenance companies, but not only those. A very eloquent example of the start of a more ‘outward’ orientation is the renewal of management of documentation and drawings on railway infrastructure which is vital for local authorities or designers not only of railway infrastructure itself, but also of road tunnels, bridges, cable ducts, inland waterways, etc.

- Yet another important factor which characterizes the particular position and role of ProRail is the shift towards an ‘eyes on – hands off’ position, with many operations, mainly in the field of maintenance, carried out by private contractors. The main consequence of this is the need for a much more tight control of delivered services in a situation where in theory different contractors have to compete for the allotment of maintenance contracts, but in practice – given the limited number of competitors, the duration of contracts and the physical distribution of resources and equipment – the situation is far from ideal from a viewpoint of open competition. With the final responsibility for safe and reliable infrastructure remaining with ProRail, but the main tasks of inspection and maintenance as well as emergency repairs carried out by contractors, ProRail staff is just beginning to learn to play its role of landlord and of external inspectors instead of their former role as supervisors and foreman of their own colleagues. For a long time this has also obscured a clear division of responsibilities in the field of trackworker safety, where only recently a mutually agreed policy has been developed.

AIMS OF THE PROJECT

In 2002 ProRail decided to start a project for the development and implementation of a formal safety management system. The development of the ProRail SMS has the following aims:

- Satisfying the legal requirements regarding safety management in railway companies (European and national legislation).

- Upgrading safety management in order to be able to deal with the developments we have described mentioned above, and to maintain or even improve safety performance of the railway system.

The developments described bring two important requirements, which already have been indicated in the above, but need some further explanation:

First:

Dealing with public and political attention, as well as being accountable towards partner organizations in the railway industry requires the organization to have a clear (safety) strategy, performance measurement system and communication policy. ProRail must not only be able to demonstrate that it satisfies the performance requirements for safety which have been set by the State (kadernota spoorwegveiligheid) but also make it credible that it is able to maintain its performance over time. This requires a shift from working from a technical and rule based point of view - where safety is managed in an implicit way - towards one that has learned to think in terms of risk management - where safety is managed in a explicit way. It means above all changing from a deterministic and ‘binary’ point of view (things are either safe or unsafe) to a probabilistic one: thinking in terms of relative safety, defining safety as something you can be good in or even better.

Traditionally safety in the railway industry in the technical sense has been managed from an implicit and deterministic point of view. Design of equipment and infrastructure was based on design standards which were developed on the basis of sound engineering principles. These were rarely questioned from an economic or cost-benefit point of view, because railway companies were state owned monopolies with no challenge from competition. On the side of organization and processes this was reflected by a relatively comfortable situation regarding the number of staff and has contributed to a bureaucratic management style, leading to a ‘command and control’ approach with a rich culture of rules and regulations. This has created a centralized system in which there is little room for decentralized decision making and which therefore is relatively slow in responding to deviations and emergencies.

Also due to the developments mentioned earlier (growing demand and technological developments) risks can not be managed any more by a static body of rules and standards. In a dynamic situation the judgment and handling of risks must become a nearly continuous process, which requires an active involvement of workers and use of their knowledge and expertise, with continuous and systematic feed back of operational experience.

Secondly:

The split up between a number of independent organizations, some of which are competitors, brings the need to constantly monitor bottlenecks, misunderstandings and misfits in relations between functions and people inside the organisations themselves, as well as between partner organizations. The chances of mismatches in expectations grow with the number of actors the railway industry is subdivided into. Contracts on one hand may make relations explicit, but on the other hand are a poor replacement of former 'committed' and intimate working relations. This creates a growing need to periodically 'retrace' the roadmap of interorganizational dependencies, not only just after incidents, as seems to be the current practice.

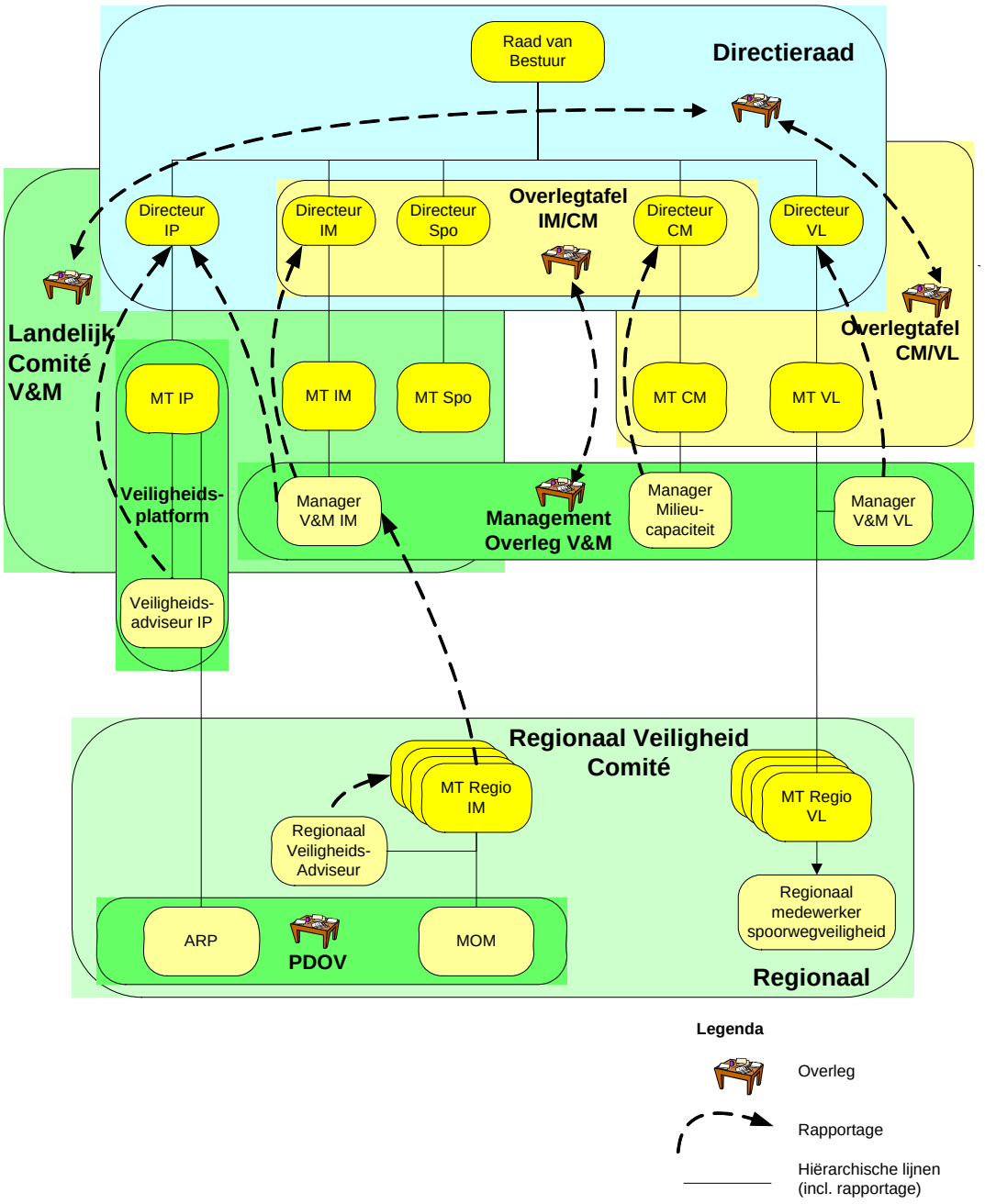

Figure 1: Communication structure SMS

METHODS / APPROACH

Managing safety in this light means going back to the 'roots', which are the risks an organization or a network of organizations is supposed to control. It means that it has to focus on those (in most cases cross functional) activities and processes that clearly and objectively contribute to the mitigation or management of risks. It also means to make and keep all actors aware of the risks they are accountable for and the lines of defense they are owning as part of the safety management process.

These principles have been at the basis of the ProRail safety management system that has been developed and implemented in the past couple of years. In short this development has followed the following steps:

In 2002 a safety committee was formed, which consisted of the director and heads of departments. On a monthly basis this committee guides and monitors the SMS development program. The main decisional structure was laid down in a 20 page booklet which described the Deming circle for safety at the management level. The first part we developed was the main structure of a performance monitoring system, based on a database of accidents, incidents and other measurements of the safety performance. By presenting monthly performance statistics to the safety committee a more complete picture and a clearer awareness grew of the actual situation regarding safety and the relative urgency and priority ranking of improvement actions. In order to take action in a consistent way a number of safety critical business processes on a tactical and operational level was identified. Because no formal safety case for the entire railroad infrastructure was available – and we had no time to develop one – a number of brainstorm sessions was held to define these processes on a more comprehensive level, using the expertise of operators and staff. In this way for each type of the five main hazards the organization is held – at least partly – responsible for (like system safety, safety of trackworkers, etc.) a number of safety critical processes was defined. Because each of these processes could be linked to one or more of the main hazards, we could monitor safety performance also in a proactive way by measuring progress in the improvement of the safety critical processes. This improvement cycle has become the main body of the development process of the SMS, as it addresses the day to day operational processes that are at the heart of safety management. By identifying and addressing these processes most of which go beyond the boundaries of single departments we also started dealing with the internal subdivision and 'technology focus' that characterizes the organizations (safety) culture.

Summarising, the development has taken place around three – strongly interrelated - actions:

1. Providing the driver: performance measurement in order to clarify 'where we stand now' and 'where we want to go'
2. Providing the structure: describing the main SMS process (Deming circle as a steering wheel for the safety committee) and the main safety critical processes
3. Influencing the culture by actions like making the organization aware of its heavy focus on technology, internal barriers and little attention for processes that go beyond the boundaries of single departments.

RESULTS

The ProRail Safety Management System came into operation in January 2004. From January 2007 it should satisfy the requirements from Dutch and European legislation regulating safety in the railway industry. Each of the actions mentioned above resulted in a set of tangible products, most of them improvements and clarifications in processes.

Providing the 'drivers' or motivation for the development program:

Public concern about railway safety as well as European and national legislation and performance requirements have played a major role in the decision to develop a formal SMS. This meant above all changing from a deterministic and 'binary' point of view (things are either safe or unsafe) to a probabilistic one (thinking in terms of relative safety, defining safety as something you can be good in or even better). A safety dashboard has been developed which monitors the quality of safety performance on a number of (reactive as well as pro-active) key performance indicators (see fig. 2). The reported items reflect the safety 'iceberg', where the part above sea level represents the number of accidents which have caused injury or damage (such as derailments) and the sub-sea level indicators (from top to bottom) represent incidents (unwanted events without injury or damage, like broken rails, cattle on track, etc.) and audits and inspections (number performed, number of deviations reported, etc.) At the bottom the 'fire that has to melt the iceberg' is represented by data about close out of corrective actions and progress of improvement programs that are aimed at improving performance with respect to the type

of risk considered. This 'iceberg' report is used for each of the five main risks ProRail has to manage according to its mandate by the State: system risks, risks at level crossings (which is a specific part of system safety), risks for trackworkers, environmental risks and risks for trespassers.

System safety infrastructure	Figure	Score	Trend
Injury and/or damage			
Collision train - train	1.1.1		-
Collision train - buffer	1.1.2		0
Collision train - obstacle	1.1.3		0
Derailment	1.1.4		0
Collision with bridge or viaduct	1.1.5		0
Fire / explosion	1.1.6		0
Incidents			
SPAD	1.2.1		0
Imposed SPAD	1.2.2		0
Unexpected change in signalling	1.2.3		0
Track wrongly indicated as occupied	1.2.4		0
Irregularities in temporary speed limits	1.2.5		-
Damaged switch	1.2.6		0
Switch forced to open	1.2.7		-
Broken rails	1.2.8		0
Track subsided	1.2.9		0
Underground infrastructure damaged	1.2.10		-
Obstacle in track	1.2.11		+
Cattle in track	1.2.12		0
Audits and Inspections			
Deviations and observations	n.b.		
Projects and en programs			
Progress projects	Tabel 3		
Progress improvement measures	Tabel 8		

Figure 2: reporting structure for system safety

The cells for 'score' are colored according to the performance each specific item is showing: green for 'meeting the target', red for 'not meeting the target' and yellow for 'requiring attention'. The cells for 'trend' show if a positive (+), Negative (-) of neutral (0) trend is visible. Targets have been derived from overall performance requirements established by the state (for example individual risk for passengers has to remain below 2 * 10-9 per kilometer) or from requirements for improvement set by ProRail management itself (like % reduction in SPAD). Input for the reporting system comes from the monitoring and incident registration system PROMISE, which in the course of the project has been developed by the ProRail safety and environment department (see Wright 2006). This way of presenting performance is very much in line with the 'language' of management and directs the attention of managers towards factors that require their concern and which they can influence directly or indirectly. It has been of great help to overcome the 'learned helplessness' syndrome that characterizes many organizations that are in a more or less reactive state regarding safety. Of course this alone is not enough – management needs procedures and tools for effective intervention and steering – but it is a powerful start, especially in the case where safety performance indicators are fed into the management contract of all management layers, as is the case for ProRail.

Providing the 'system' of procedures and tools to control risks and manage safety

By monitoring performance the organization is able to measure the 'gap' between actual performance and desired performance. Overcoming this gap means the organization has to be able to influence performance indicators directly or indirectly. This requires reporting to and decision making by management and staff. In order to guarantee top management involvement in this process as a first step a ProRail management committee for safety was formed which runs the 'Deming circle' of safety management, through performance monitoring, guiding the SMS development project, initiate and guide identification and improvement of safety critical

business processes and the auditing and reviewing process. After that a management system at strategic level and 32 safety critical business processes at a tactical and operational level were identified. At the strategic level a Safety management document describes the yearly planning and continuous improvement cycle and long term safety improvement programs are documented in a yearly planning document. Safety critical business processes at a tactical and operational level were identified in a number of brainstorm sessions with management, engineers and operators. These are currently being developed and implemented (if not existing) or reviewed and improved (if they already existed). In a formal sense this process would have required the production of a overall safety case for railway infrastructure, but this would have taken too much time and in a way would have been unnecessary in order to develop the basic structure for a safety management system (meaning the top level Deming circle and the safety critical business processes). Instead of a formal safety case approach Ishikawa diagrams were developed in which for any of the five 'top' hazards we identified the major contributing causes as well as the processes that have to be in place to control these (fig 3).

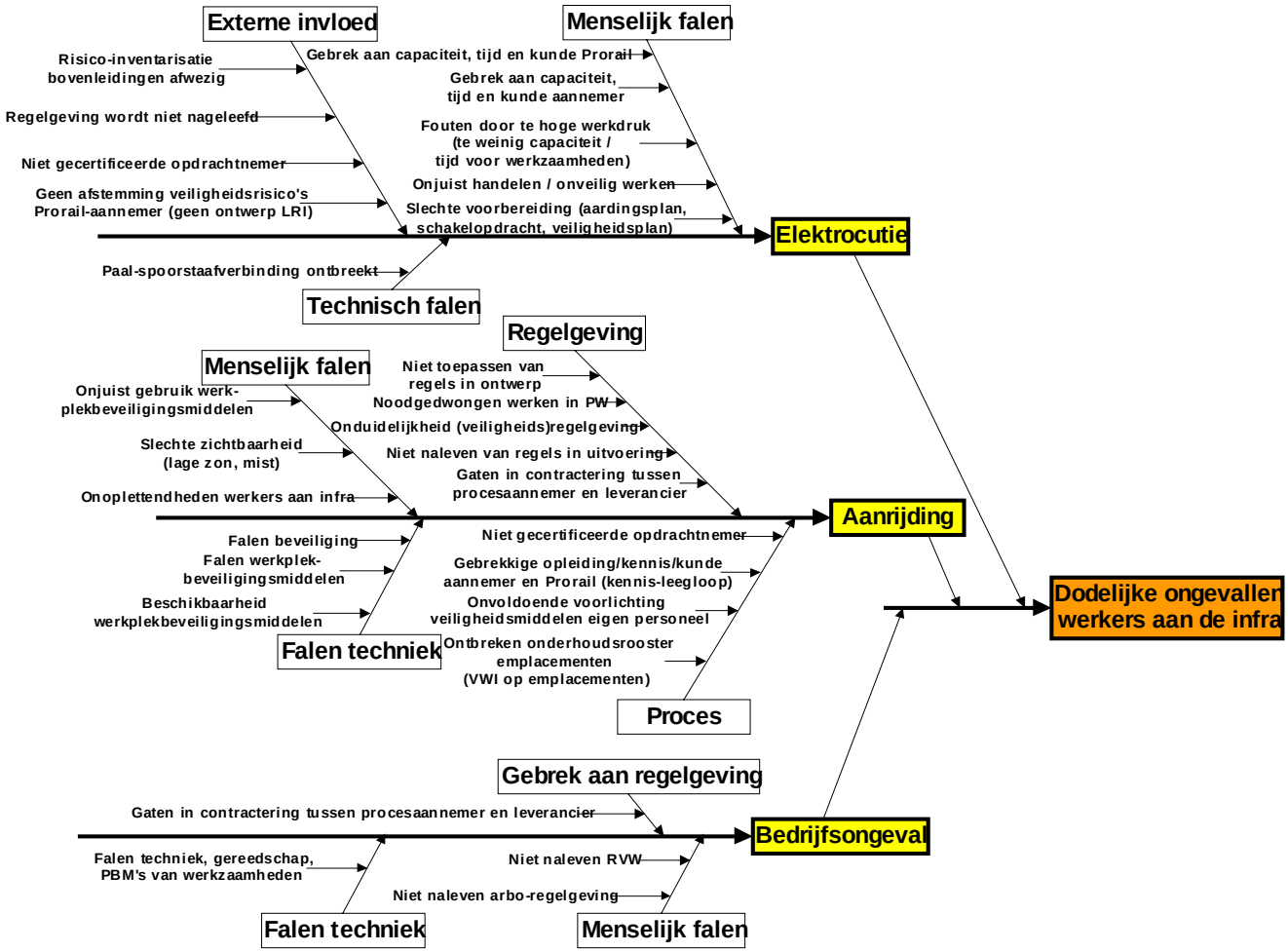

Figure 3: Ishikawa diagram for causes of trackworker accidents

After breakdown into a large number of causes and seemingly different processes we could identify 32 critical processes or organizational lines of defence, which would cover all of the contributing causes. These processes were ranked for their overall influence, which made it possible to formulate a 'top 10' of processes which have a relatively large impact on the control of hazards.

Nr.	Title
1	Quality and control of procedures and documentation
2	Auditing of conctractors
3	Management of trackworker safety
4	Contingency planning
5	Human resource management
6	Certification of contractors
7	Maintenance by contractors
8	Inspection by contractors
9	Development process of design guidelines
10	Internal quality management and auditing

Table 1: 'top 10' of safety critical processes

Of course this ranking reflects the relative importance of the different processes and in no way represents a systematic overview. However is shows that staff, going through the process of risk based prioritising, has become conscious of the need for a more systematic approach of safety management. For example processes 1, 5 and especially 10 (Quality and control of procedures and documentation, Human resource management, Internal quality management and auditing) represent processes at a tactical level which presented opportunities for improvement. Whereas more technical and operational processes, which the organization has put a focus on for a long time, have a lower position (from 11 to 32) in the overall ranking.

After identification of these processes for every process a flow diagram of the desired situation was devised together with staff which was most involved in the process. This could mean discussing with people form many different departments for it resulted that many of the processes were of a cross-functional nature. Only some of the processes could easily be allocated to just one department (like nr. 6 'certification of contractors, which was entirely under the responsibility of the procurement department and in fact was already relatively well managed). The other processes were allocated to a department which could be considered as a 'spider in the web' regarding the management of the process, although it would have to negotiate with the other departments involved in order to define or fine tune responsibilities. For example process nr. 1 (quality and control of procedures and documentation) was allocated to the department for documentation and data management, which formed a working group with other departments which had to deliver input and were responsible for the technical content of documents.

Like other large organizations ProRail tends to start up new projects for each new problem it discovers and often forgets to check if some existing action might already cover the problem. In the process of reviewing and improving safety critical business processes we discovered many 'hidden' initiatives and projects that were halfway and constantly stressed the need to build on these and on existing experience, instead of starting completely new projects. Our effort has been concentrated above all on identifying existing efforts and linking them into new alliances.

CHANGING THE CULTURE

This observation shows the impact organisational culture, seen as the system of habits an organisation has acquired over the years, may have on the process of continuous change and improvement. We can consider the concept of 'culture' as the whole of values and beliefs about how things should work which are shared by members of an organization and its environment. In this context the value 'safety' always has a special position. It seems that the trade off between safety and other values, such as economic benefits, tends to produce quite different results if compared between different social and business processes. For example there is a striking difference in values when we consider risk acceptance for different transportation modes. In terms of impact on public opinion one train collision may equal a large number of road traffic accidents with many more victims. This puts a heavy emphasis on safety in the railway industry, which tends to consider itself already as a very safe

mode of transport (which is correct if we look at the statistics of passenger safety in the EU but not when considering the safety of trackworkers - Hale 2000). This in turn has two effects: the first one is a relatively large attention from the public and politics, especially after the occurrence of accidents, the second effect is the existence of a long lasting tradition of safety engineering and regulation within the railway industry. Technology and processes are focused for a large part on securing system safety. The dominating beliefs that go with the value of safety and which determine for a large part how people think things work and should work and how they behave, are therefore based on a long lasting tradition and have produced a typical culture with regard to railway safety.

In the scientific world much debate is going on regarding the question if and how (safety) cultures can be changed. Some authors focus on changing behaviors or attitudes directly, others believe cultures change mainly through structural or procedural / process changes (deJoy, 2005). We found that in the beginning of this process it was hard to address the topic of safety culture at all. An engineering culture – which characterizes the ProRail organization – sees itself as a purely rational system, with no 'heart or feelings', except for the pride to be part of a great tradition, which started with people like Robert Louis Stevenson. Political and social processes which – like in any organization – play a fundamental role in organizational processes and developments – and especially in safety management - , tend to be either denied or in some way 'engineered out of the system'.

As we mentioned earlier, a number of changes in business processes and position of ProRail ask for a change – not only in systems and organization - but also in the daily behaviour of groups and individuals and therefore in the beliefs and suppositions about 'how things work', that is in the culture.

These changes are:

- Growing public and political attention for system performance, which asks – as mentioned earlier - for a more explicit strategy and professional communication
- The position of ProRail as a 'spider' in the network of the Railway industry, which ask for a more outward oriented culture
- The shift towards a 'hands off – eyes' on position regarding its supervisory role

This means that the suppositions and behavior which are typical for a 'machine bureaucracy' are becoming more and more counterproductive.

As mentioned earlier much debate is going on regarding the way in which culture can be changed. One of the pitfalls in discussing safety culture is to regard this aspect as a 'shopfloor' problem, with managers complaining about workers not doing what they are told to do. The first step of improving culture is to consider it as an aspect that applies to all levels of the organization. This has been recognized by ProRail and efforts are being made to make a change to a more flexible and professional culture, by adopting the principles of the 'high performance organisation' (or high reliability organization) as described by Weick and Sutcliffe (2001). To reinforce this initiative and in order to make the organization reflect about its culture we developed a somewhat modified version of the 'understanding your culture' tool from the 'Winning Hearts and Minds' toolkit which was developed for Shell by the University of Leiden <ref>.

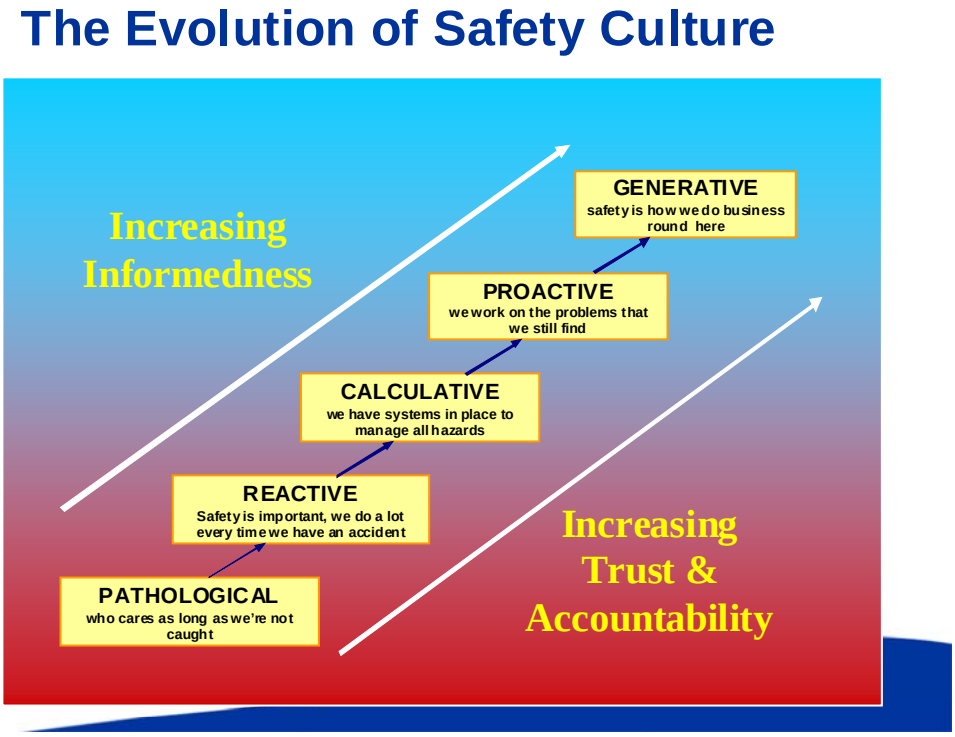

Figure 4: stages of culture maturity according to the 'understanding your culture tool'

In the 'safety maturity' ranking this methodology explicitly starts from the viewpoint that structural developments precede the development of a true – high reliability - 'safety culture'. In fact we have started form the viewpoint that structural interventions are a very good way to provoke and support cultural change and changes in behavior, even before putting the item of cultural change on the agenda in a more explicit way. These interventions have been described above. In the following the start of our intervention on safety culture is described.

- In the view of Hudson (Hudson 2001) a good safety culture (in his terms generative or 'creative', in the terms of Weick a 'high reliability culture') has five characteristics:
- Informed: everybody in the organization has to have a very clear understanding and situational awareness about the (safety) risks he personally and the organization as a whole has to cope with. A 'good news culture', where people keep the bad news for themselves, at the end will at some time provoke disasters especially if the organization operates in a high risk industry, like banking, oil and gas production or air transport. Weick calls this 'operational awareness'.
- Just: people can only be expected to report bad news and (their own) mistakes if reporting is encouraged and there is some amount of understanding about what happened. A 'blaming the victim' culture has little hope to discover what's really going on.
- Learning: once the 'bad news' is known it should be considered as a learning opportunity not only in the sense of generating knowledge, but also and especially for actually changing habits and procedures. That is not only to learn new ones but above all: forgetting the old ones – which often turns out to be the most difficult step.
- Flexible: once urgent problems have been recognized, they must be tackled in a timely and straightforward way. Management has to be able to take such decisions and calculate the risk of side effects, without being paralised by these. Changes may also be imposed by external developments such as market conditions.
- Wary: even if an organization manages to acquire all of the above characteristics, in the end it may become too confident of its own capacities to cope with any new development – even the most unexpected. Therefore some amount of 'wariness', or unease should be fostered in order to avoid 'leaning back' too much.

When reading this, one may realize that cultural changes will require considerable effort and will be time consuming. Experts in the field state that any of the five steps in figure 1 may take 2 to 3 years. Stepwise management will have to shift from a 'controlling' role to a supporting one, workers at the same time should be stimulated to grow form a 'obeying' role to a initiating and sometimes deciding one. It is a process of growing consciousness, sense of urgency and search for new balances between the actors within an organization, both management and staff.

As a first step a modified version of the 'understanding your culture' tool from the 'Winning Hearts and Minds' program (table 2) has been used by the ProRail HSE staff to sharpen their own view of the organizations safety culture. Their conclusion is that ProRail finds itself somewhere in between the reactive and bureaucratic stages, in some cases a proactive level has been reached.

	Pathological	Reactive	Calculative	Proactive	Generative
Principles of risk management	Small amount of rules and procedures	Procedures are developed after accidents have taken place	There are procedures for nearly everything, which makes it hard to keep the system up to date and consistent	Shift in emphasis from procedures to training and learning form experience	Focus on critical processes, which makes the set of procedures manageable
Incident reporting and analysis	Only for serious cases, aimed at establishing who is guilty	Analysis aimed at direct causes and avoiding repetition	Procedure for reporting and analysis, emphasis on monthly statistics, little scope in improvement actions	Reporting also of near misses is stimulated, 'no blame' culture, complete learning and follow up, management is personally involved in analysis of serious accidents	Active search for links between incidents and failures at management system level or flaws in organizational awareness; reporting directly and by line management
Management of change	See what happens'	Ad-hoc monitoring of unwanted effects of changes in hardware or processes	Check of systems integrity for larger changes in processes, technology or organisation	Periodical check on systems integrity	Ongoing control systems integrity
Management of Contractors	Contractors judgement is based on time & expenses, safety criteria are absent	Safety performance of contractors is considered but does not count in the selection process	Prequalification of contractors also for safety, standards are lowered if no contractor can meet them	Contractors must have a safety management system, may get help in training of staff	No bargaining regarding meeting of safety requirements, collaboration in problem solving, no start of work before safety requirements are met

Table 2: Some examples of culture characterizations for different aspects of safety management

Next step will be applying this tool in a management workshop to define a more explicit approach towards cultural changes. Firstly by making the concept of safety culture more tangible and then by defining realistic ambitions and action paths for each of the aspects of safety management considered.

PERFORMANCE IMPROVEMENT

The most important aim of implementing the safety management system is to maintain and improve safety performance. The establishment of targets for improvement has made it possible to measure progress in the safety performance of the railway system. Although it is difficult as to this moment – given the short period of time the safety management system has been operational - to speak of a general improvement in safety performance, there are two examples where a clear improvement can be seen, which is closely related to a risk-based and systemic approach which has been adapted over the last couple of years.

Case 1: Level crossings

One of the earliest, and so far most successful examples of benefit of safety management for ProRail has been the improvement of safety at level crossings. The Dutch Department of Transport has set a goal for a 50%

reduction in the number of fatal accidents on level crossings to be reached by 2010 [Kadernota]. The risk-based safety program (Programma Verbetering Veiligheid Overwegen, PVVO), which partly preceded the introduction of the formal ProRail Safety Management System and has served as an important 'source of inspiration' for the introduction of the 'risk based management' approach is aimed at identifying and prioritizing high risk level crossings and has made it possible to distinguish between a number of alternatives for the improvement of safety, such as

- closing level crossings (e.g. by replacing them by tunnels);
- replacement of automatic flashing light installations by automatic half level crossing barriers;
- improvement of existing automatic half level crossing barriers.

The programme has proven to be very successful, meeting the 50 % reduction target as early as 2004.

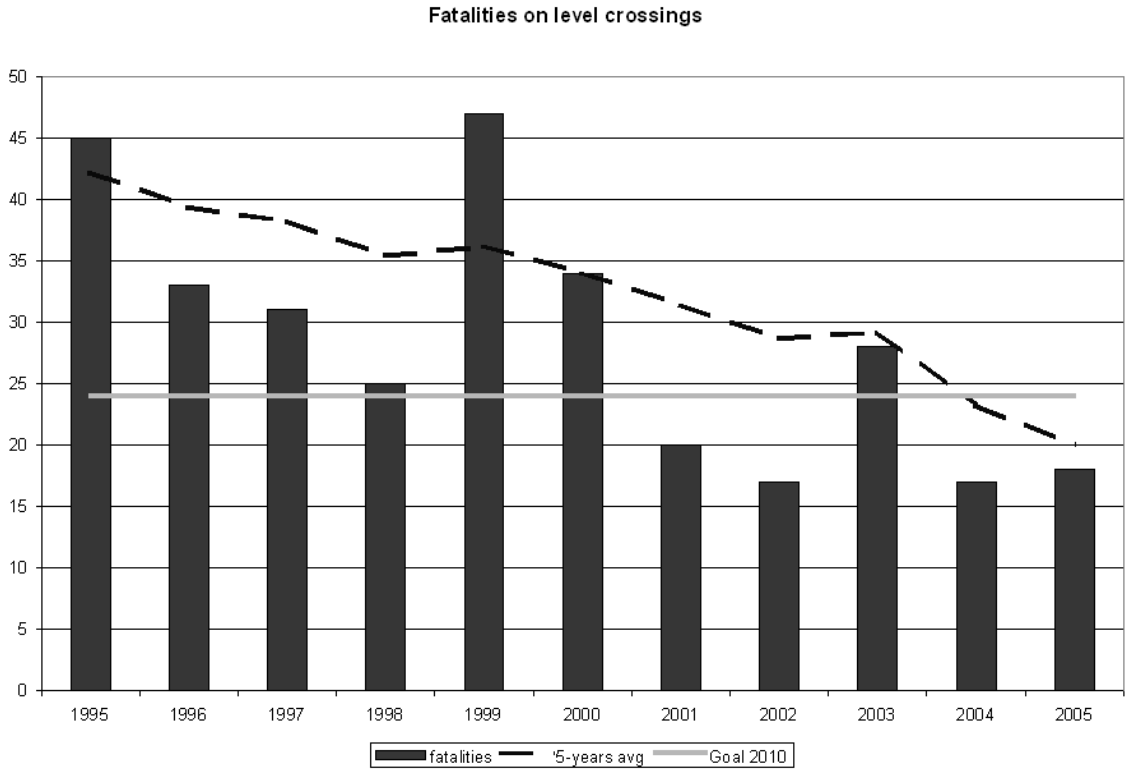

Figure 5: Development of fatal accidents on level crossings from 1995 to 2005

Case 2: Third party incidents

Another example for successfully applying principles of safety managment is the programme aimed at the reduction of so called third party incidents, which includes accidents like collisions with people walking on or along the tracks, trespassers, acts of vandalism (like throwing objects on the tracks or towards trains), and the like. Of all disruptions in train traffic, over 10% are caused by 'third parties'.

In 2003, ProRail started a project in one region in order to reduce these problems and incidents. Meanwhile the approach first tested as a project has now been adopted as a standard way of working.

Actions for the reduction of third party incidents include:

- identifying hotspots: locations where many incidents occur, and/or location with a higher risk (near schools, discotheques, etc.);
- security officers patrolling along the tracks;
- placing fences along the lines;

- placing cameras at hotspots;
- cleaning up along the tracks to reduce material that can be ‘used’ for vandalism;
- an information campaign, especially directed at schools and communities.

The figure below pictures the reduction of the condensed Safety-KPI on third party incidents for ProRail over the past three years, showing a decrease of incidents of 5 to 10% a year.

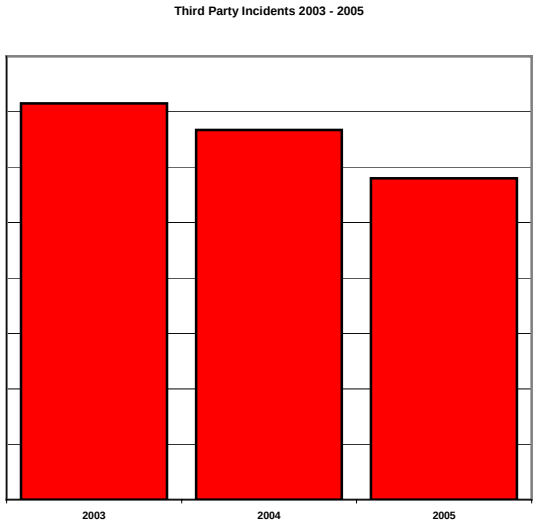

Figure 6: Decrease of third party incidents 2003-2005

DISCUSSION

The development of a safety management system especially in large organisations means you will have to take into account many internal and external aspects of the organisation as well as its history. Starting from our work for private industries in different sectors (oil and gas, chemistry, steelmaking) our group has had to ‘learn by doing’. Apart from engaging in a time consuming process – and having to restart again at some moments – we have been able to introduce new concepts into a traditional world. In this process we have had to revise our time schedules constantly to keep pace with the many organisational and process changes the company has been undergoing in the same period. In this process we have identified some learning points regarding the process of change itself, which are:

- Setting up an SMS is not a question of providing new tools alone, but first and foremost the acceptance by management and staff of new insights and of the tools themselves by using them in practice. This asks a lot of energy of managers and employees which have to change habits and working patterns and at the same time have to keep daily operations going.
- ’The medium is the message’. The form one chooses to communicate is fundamental for the acceptance and understanding of new concepts. Engineering cultures are used to communicate with the use of drawings, pictures and graphs, therefore we have chosen as much as possible to use this language, avoiding the use of extensive written explanations.
- ProRail as a part of the Dutch railway system has to either adapt to ways of thinking and communicating of its partners or create a standard that is appealing to them. This requires much attention for the development and use of a common ‘safety management’ language, definitions and even systems within the railway industry. Despite the fact that train operating companies had to have safety management systems, long before this has become an obligation for ProRail, we found that other parties are looking at the ProRail SMS as a blueprint for their own approach to safety management. For example departments of the Dutch Ministry of Transport are considering to give its own SMS the same form and style, apart from the obvious functional differences between the organisations.

CONCLUSIONS

This paper describes the process of introduction of a safety management system for ProRail the company which operates the Dutch railway network. We have described the starting point and goals of the project, explained the strategy chosen for the implementation program and given some insight in results in terms of performance improvement and actual implementation of the system.

The main challenges for this project have been to create a breakthrough towards risk based management, to overcome internal organizational barriers and to create a more 'outward' orientation. These are challenges the organization finds on its path towards implementing and fully benefiting of the advantages a systematic approach of safety management. Each of these challenges has been confronted in a particular way.

In order to develop a more risk based management approach performance measurement and defining quantitative targets were introduced as 'drivers'.

Organisational barriers were overcome by focusing developing a management system that is focussed on cross functional business processes. And the path towards a more external orientation has been led by surfacing the cultural aspects which characterise the organisation and which distinguish it from its surroundings. Explicitly addressing the value of 'safety' as one of the main achievements of rail transport, and being aware of the importance to demonstrate what efforts are being made to maintain this high level performance may be crucial to gain and keep the 'spider in the web' role ProRail ideally should have in the context of Dutch and European railway industry.

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