# A Systems Approach to Constraining and Directing Human Behaviour


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## SUMMARY

Safety is often tackled primarily at the level of legislation, standards or technology, coupled to a regulatory regime that tends to have an internal focus, particularly with respect to Human Factors Management. It also focuses on the operators of the various elements of the modern railway system. If rail related deaths and injuries in developing nations are analysed, the underlying cause is the behaviour and attitude of people interacting with the system from without. Thus, the biggest safety gains can be made by addressing the entire rail ecosystem with particular focus on the elements outside the direct control of the operators.

We live in a world of systems that regulate our behaviour in numerous ways. Whatever we do and wherever we go we interact with, use, and are influenced by systems. Systems constrain us, direct us and affect us in ways we often don't even realise.

This paper postulates that the application of well designed systems, using a 'System of Systems' approach,, can play a significant role in constraining and regulating behaviour in the railway safety environment, particularly from a societal perspective.

When human beings are factored in with their sometimes erratic and independent behaviour; it becomes a complex, and no longer just a complicated, system that has to be dealt with. This approach recognises that while systems have evolved and technology has become more sophisticated, human beings and human nature have remained fundamentally the same.

Therefore by designing and applying a set of systems, behaviour can be affected, and later entrenched, becoming the norm.

This paper concludes, by means of a case study, providing empirical evidence, that systems do affect behaviour within the broader rail ecosystem and challenges the reader to think differently and strategically about tackling Human Factors Management.


## INTRODUCTION TO SYSTEMS

We live in a universe of interrelated systems, ranging from the biological (the brain), ecological (river systems), social (families), designed (engines) and abstract (philosophical and management systems). Whatever people do and wherever they go they interact with, use, and are influenced by systems and the way systems are applied has the ability to influence human behaviour for good or for bad. Systems constrain, direct, and affect people in ways they often don't even realise. Individuals also use systems for their own purposes, frequently without being aware that they are applying systems to whatever they have set out to do.

Social systems, in particular, have been identified in academic literature as complex, evolving systems. This is particularly relevant to this discussion around Human Factors Management.

While it can't be called a hypothesis, the position of this paper is that *'well designed and properly applied systems can constrain and direct human behaviour'*

A formal definition of a system is:

> "a set of things working together as parts of a mechanism or an interconnecting network; a complex whole". "*the state railway system*"

> "a set of principles or procedures according to which something is done; an organized scheme or method[1]". "*a multiparty system of government" or a "school system"*.

Or, to put it differently, a system is a complex whole, the functioning of which depends on its parts and the interaction between these parts.

These parts are often described as a system in itself. However, few systems can survive, or be effective, in isolation. Systems depend on each other for their survival, or their effectiveness, as the case may be.

The notion of a 'System of Systems' is therefore added to this conversation. While this has been covered extensively in academic literature the simplest explanation is that a 'system' is always a sub-system, together with other sub-systems, of some other larger system.

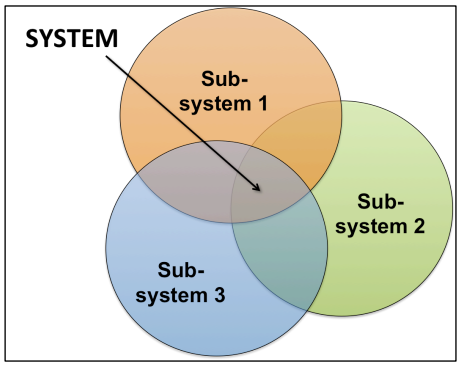



***Figure 1: Pictorial Representation of a System of Systems***

So what is a System of Systems approach? The interaction of natural systems help us understand, as well as provide an example of a self-regulating system.

**Owls, mice & snakes**[2].

As the mouse population increases there is more food for the owls, whose birth rate climbs. However, with the higher owl birth rate more mice are killed for food resulting in a decline in the mouse population which in turn lowers the owl birth rate as fewer mice are killed for food.

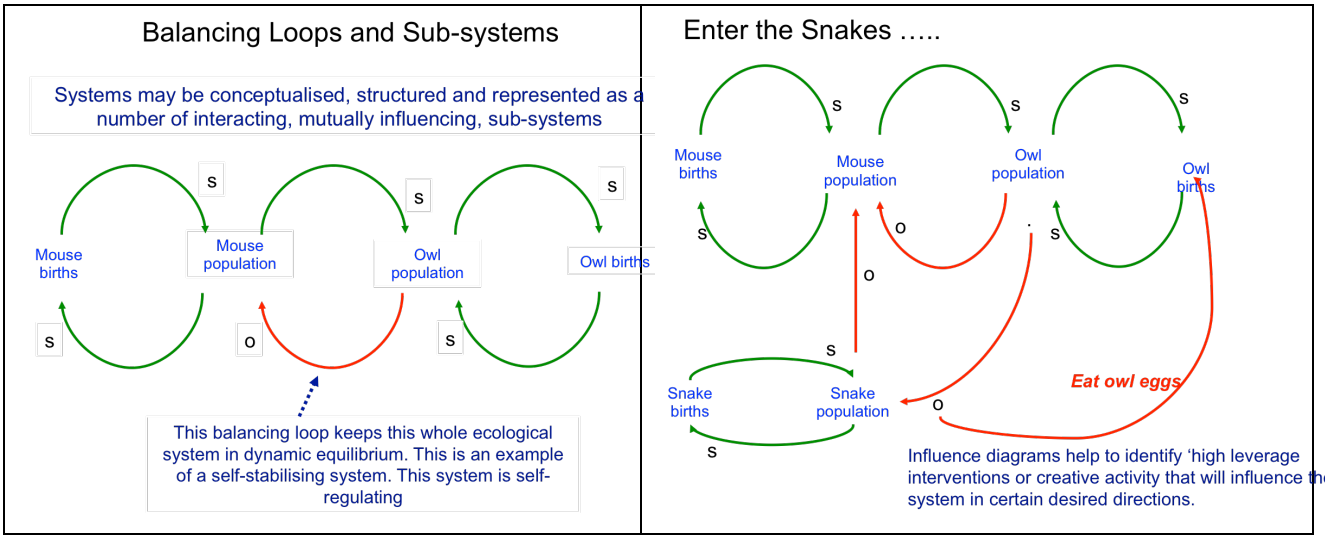



***Figure 2: Interaction of sub-systems***

However, once we add snakes to the equation it becomes more complicated. Snakes eat owls' eggs and mice, while owls eat mice and snakes. This is an example of a self regulating system, comprising numerous sub-systems.

**Complexity**

Apart from the variety of the many systems used in daily life, when human beings and their sometimes erratic and independent behaviour, are factored in, it becomes a complex, and no longer just a complicated,

1 Oxford Dictionary

2 Excerpt from Collaborative Project Design course at UCT's Graduate School of Business

system. It needs to be recognised that while systems have evolved and become more sophisticated, human beings and human nature, have remained fundamentally the same.

Within the world of systems there are also various types; ranging from 'Hard' systems (loved by engineers) to 'Soft' systems (loved by the psychologists). Sometimes systems need to be looked at from a multidimensional point of view and if it is accepted that systems are in fact a composition of sub-systems, whether they are classed as 'hard' or 'soft' or something in-between, the end result is a 'System of Systems'.

In order to apply systems effectively, an understanding is needed of the strategic application of systems, how they interact with each other and on society, and what are the potential consequences of unsuitable design.

It should be noted that while the examples used in this paper are conceptually simple, the systems applied must match the complexity of the problems encountered[3] in order to be effective..

System design is important and systems can be designed to act upon whole societies (e.g. apartheid), or focus on the individual (e.g. performance management). Both are designed to influence human behaviour.

With this basic understanding of systems the focus shifts to the issue of human behaviour and how systems can be used to influence and manage it.

### An early example

An early South African example from the 1960's of a systems approach to behavioural change comes from the introduction of seatbelts in cars.

Those were the days when no cars had seatbelts. There was a big drive to wear seatbelts (only the front seats) with the concomitant hype of the safety benefits. All new cars had to have them fitted. It was almost totally ignored. A classic response of human behaviour when faced with change.

The authorities then began to fine people and immediately, albeit reluctantly, peoples' behaviour began to change. Concurrently, in junior schools, children were taught about seatbelts and why we needed them. Soon they began to influence their parents and eventually they became the driving generation. There had been a change in behaviour and to a certain extent a change in culture. Unfortunately, this system has not been maintained (behaviour regressed) and according to the Automobile Association of South Africa (AA) there is currently only 40% compliance.

### An instructive example

The introduction of electronic tolling (eTolls) as applied on the Gauteng freeways is a recent South African example of a systems approach, or maybe lack of it, that failed very publically.

In this approach, while comprising a number of systems – law enforcement, societal, political, and technical, it appears that total systems thinking was not applied to the design. In the furore that followed its introduction, very little was said in the media about the technical aspects of the system. The main focus was on the financial, societal and political elements. In all likelihood, in the development of the system, the designers focused primarily on the technical system, the actual recording of the road usage, with a concomitant failure to put enough effort into the other, and what turned out later to be, more important systems, namely the political and societal elements.

In the first example of the seatbelts a two-pronged approach was used, leading to a change in culture, while in the second it appears that the mix didn't work, or the focus was wrong, resulting in widespread resistance.

## DEFINITION OF HUMAN FACTORS MANAGEMENT

The definition of Human Factors Management used in this paper is:

> 'A scientific discipline concerned with the understanding of interactions among humans and other elements of a system'.
>
> Those who practise this discipline apply theory, principles, data and methods of design in order to optimise human well-being and overall system performance.

[3] Ashby – Law of Requisite Variety (1956). Only variety can destroy variety. For management to be able to control the operations and if the operations are to be sustainable in the environment, varieties must be balanced.

Interestingly enough, the second, explanatory part, of the definition refers to system performance and that human beings, and not technology, are an integral part of system performance.

The Civil Aviation Authority of the United Kingdom had this to say about Human Factors Management:

> 'In order to reduce HF risks in aviation safety we must influence attitudes and behaviours while embedding HF thinking into everything we do.'

While this paper is focussing on the latter, namely the influencing of behaviour, it is recognised and alluded to in this document, that changes in behaviour, together with changes in attitude lead to a change in culture. This would be the subject of another discussion. Ultimately safety is to be embedded in peoples' thinking and actions, in essence, in a safety culture.

## SYSTEM DESIGN

Design is situational, whether the design of a building, a dress or a system. You design it for the occasion, or its intended use in the specific circumstances. Take a wedding dress for example – it embodies situational design. It also needs to be realised that in situational design simple solutions are bound to fail when pitched against complex problem structures.

This paper is being presented to make the case for a systems approach to Human Factors Management and managing human behaviour, but not in isolation of other approaches and methodologies.

By designing and applying a set of systems, behaviour can be affected, but for the behaviour to become entrenched it must become a habit, and a habit, a culture. A culture is the point where people no longer think about it, it's what they do.

Furthermore, a system must be designed to fit the organisation or the situation or there will be negative consequences and resistance. While a well-designed system is self-managing (or regulating), it also provides feed back loops, contains elements of knowledge management and is self-improving.

An example of a self-regulating system has previously been covered and the following briefly touches on self-improving, as well as self-managing systems and is concluded with knowledge management systems.

As an example the figure below demonstrates a simple self-improving system that makes use of average performance.

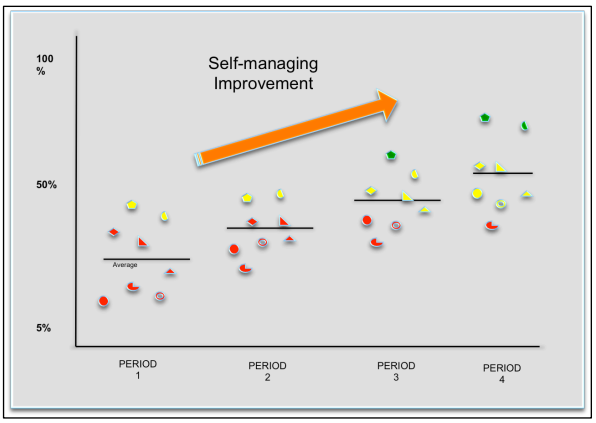



***Figure 3: Example of a Self-improving System***

Everyone who performs above the average is rewarded and everyone who performs below the average faces an ever-increasing consequence based on his or her distance below the average. There is no need to set a goal to aim for; the system sets its own goals and creates a continuous improvement cycle without much further intervention. Those who perform at the very bottom are given a chance to improve or should be released to the job market. This method also has a positive strategic consequence. The skill and performance ability of the organisation is incrementally improved with each cycle. This works best where there are the same, or similar, operations throughout the organisation. For instance, shunting yards in various locations, or ticket offices and station management. These results would need to be normalised to ensure fairness and so that alibis for poor performance can be removed – ton km, shunting movements, passenger trips, etc.. The law of diminishing returns will apply after a number of iterations.

The features of a self-managing system are different – this is where computer technology can play an assisting role. As an example we have a compliance management system and the policy states that compliance to a standard, a policy, or a procedure, should be audited every 6 months. However, if the audit does not take place, the score for each item is automatically degraded by 1 point. So those that were green become orange and the oranges become red.

*Extract from an on-line compliance auditing and managing system. Scores on the right degrade if the audits are not conducted according to the policy, or programme. These scores are summarised on an accompanying dashboard.*

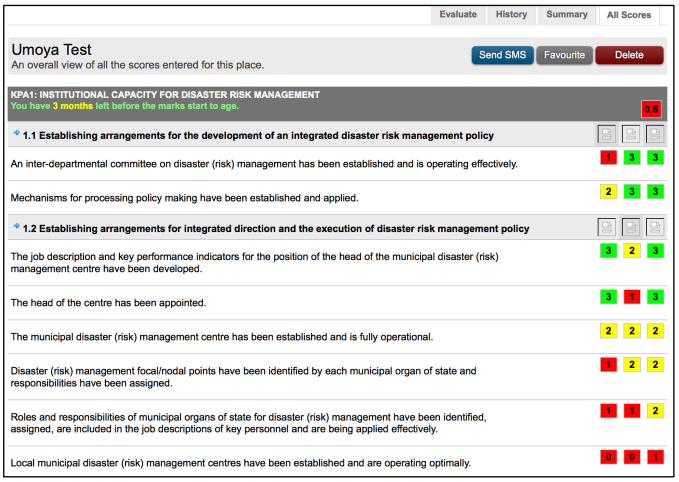



***Figure 4: Example of a Self-managing System***

The management dashboard progressively reflects the decline in score and triggers a response. The system also automatically sends an sms or email to remind the user of the upcoming audit; alternatively it escalates the lack of performance to the next level if the deadline is missed.

Finally, let's consider a Knowledge Management system – a final element of good system design is the ability of the system to learn, impart knowledge, create knowledge, or all three.

In brief, Knowledge Management (KM) is the process of capturing, developing, sharing, and effectively using organisational knowledge. It refers to a multi-disciplined approach to achieving organisational objectives by making the best use of knowledge. Knowledge Management should never be seen as a stand-alone system in itself; knowledge management principles should be applied to all systems, policies & practises.

While there are a number of formalised Knowledge Management systems, some examples of KM systems (good & bad) are part of our everyday lives, such as diaries, help functions for software, Facebook, specialist online study groups and university research libraries, amongst many others.

## SYSTEMS THINKING

The world, and the industry, in which people operate is dynamic. Good systems co-evolve with their environments and senior management in organisations are responsible for the design and implementation, or removal, of systems. In terms of Stratified Systems Theory, developed by Elliot Jacques, Level IV[4] thinkers operate at this level.

In brief, at different levels in the organisation, tasks vary due to their complexity and become more unstructured and complex at the higher levels in the organisation. "Cognitive complexity"[5], as one type of conceptual skill, includes the ability to use environmental indicators to make distinctions, classify things, identify complex relationships and develop creative solutions to problems[6].

[4] Level IV: Strategic development: underpin the future of the organisation by achieving overall strategic intent in the designated sector of the market-place in light of competition and changing social and business environment. On this level one would agree and set goals for operating units; supply and co-ordinate resources for established practices and systems; design and develop new systems, practices and relationships e.g. with suppliers, customers needed to meet changes; integrate new and current systems; terminate practices, systems, units that can no longer realise strategic intent; provide framework for projects with maximum two year time horizon. One would however, not be responsible for making decisions about the reallocation of resources to provide services/ products, working relationships outside defined market sector, but encouraged to offer input regarding the positioning of the enterprise as a whole.

[5] Cognitive complexity, as managerial competency, relates to the cognitive power, or the innate mental ability to organize information. A manager with high cognitive complexity would easier develop a better mental model of the organisation and identify the critical factors and their relationships within the organisation and the environment it operates in.

[6] Yukl G. 2002: Leadership in organizations, 5th edition. New Jersey: Prentice- Hall Inc.

The application of 'Systems Thinking' is part of this skill set in order to effectively create, or remove, systems. A definition of this type of thinking is;

> "Systems thinking is the process of understanding how things, regarded as systems, influence one another within a whole."
>
> *Wikipedia*
>
> "Systems thinking is a holistic approach to analysis that focuses on the way that a system's constituent parts interrelate and how systems work over time and within the context of larger systems."
>
> *Techtarget.com*

The following case study looks at an application of basic systems approach in the rail environment.

## CASE STUDY – STATION ADMINISTRATION

In about 2002, Metrorail in the Western Cape had serious problems with station management, particularly the administrative management at the ticket offices and all it entailed. Internal audit was highlighting serious issues.

The answer was deceptively simple. All that was done was the application of a simple systems approach, linked to common sense psychology.

A very visible, colour coded and very basic scorecard was published each month in the internal staff newsletter and intranet. Apart from early interventions, very little other action was taken. Results were aggregated upwards so that management's performance was also highlighted. There was no place to hide for the poor performers.

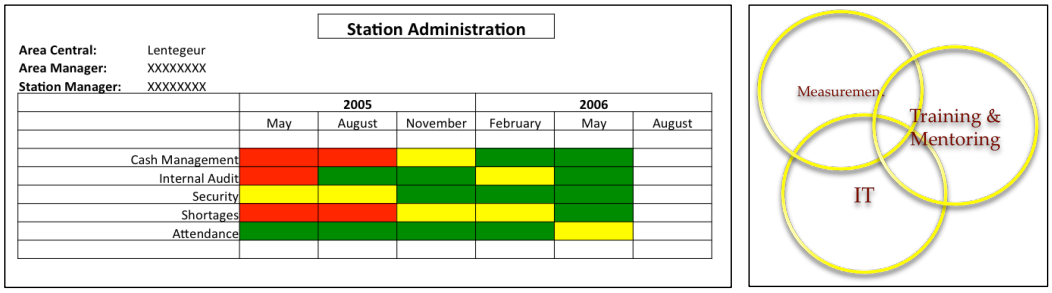



***Figure 5: Extract from Regional Scorecard & Interaction of the Systems Influencing It.***

Within 16 months all stations were scoring above 95% with most of the stations above 98%, as measured by internal audit.

What had happened? A systems approach, aided by human psychology, had changed the behaviour of the staff. This was not a system in isolation but was coupled to training and mentoring, as well as IT systems. It was not even part of the admin officials' performance evaluation system, nor was the disciplinary system involved, except where fraud was identified. This all happened within the broader context of the region's Quality Management System.

It must be stressed that all that has been discussed in the above example focuses on behavioural change. However, in isolation of other interventions, it does not change attitude or 'culture'.

## A STRATEGIC FOCUS

Most often when addressing safety and human factors management thinking tends to focus on those safety critical occupations such as train driver, guard, train control officers, staff who work for the organisation and for whom the organisation is responsible.

However, if the objective is to positively affect the injury and death rates within the rail ecosystem, those grades/occupations should not be the primary focus of effort and resources. The word ecosystem is used deliberately as the safety management zone goes beyond the trains, rail reserves and station domains. It covers the neighbourhoods and societies that interact with rail in any way.

A strategic view and a System of Systems approach would need to be taken if significant change is to be effected. Energy and resources need to be focussed where it can make the most difference, changing the behaviour, and hopefully the culture, of the rail users and the societies/communities that interface with the

rail operations. Systems, as will be highlighted in the following case study, can be applied to both individuals and societies.

## CASE STUDY – FARE EVASION

This case study looks at Metrorail Western Cape over the period 2005 to the early part of 2007.

While this case study could be broken up into many examples of behavioural change brought about by the application of systems, for brevity's sake it focuses only on one element, fare evasion.

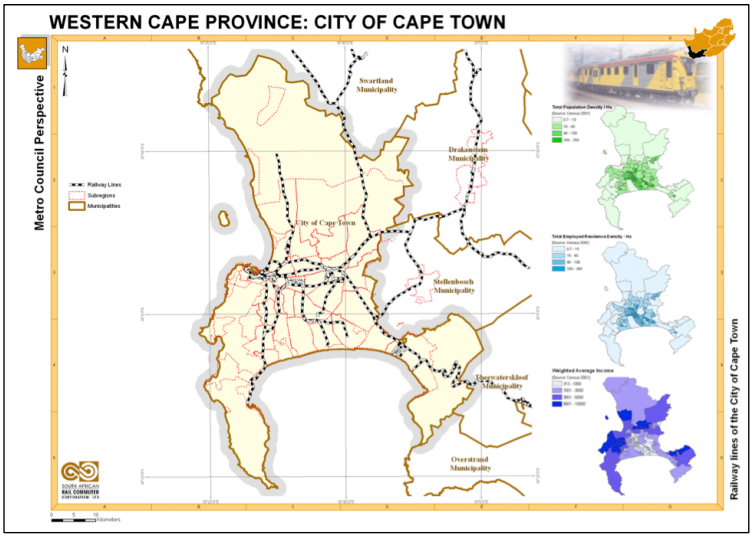



***Figure 6: Main Rail Links in the Cape Town Metro***

### Setting the scene.

By 1998 Metrorail in Cape Town could be described as in bad shape.

In the early 90's through to the turn of the century the service was under threat with significantly reduced budgets, political violence of every sort, aging fleet and a loss of skills. Pre 1994 saw significant attacks on the trains with derailments, arson and vandalism.

Over this period, vandalism was rife with over 10 000 windows being stolen for their aluminium scrap value while internal fittings – grab poles, door handles and light fittings were targeted by vandals and signal cables were cut and burnt for copper content. 3000v live electrical power cables were being stolen at night at least twice a week. Graffiti was a significant problem

The culture of the organisation was still that of the old 'Railways' and was not focused on the customer, nor was it business oriented. The service had lost customers steadily since 1992 with the low point being around 1999. Government subsidy was, in real terms, reducing each year with the result that fares had to be increased disproportionately.

Fare evasion, at its worst, was in the order of 38%. The fare evaders were being encouraged by Metrorail's own access control staff who, for the handover of R2, would allow them through the gates, that is, if there were staff at all to check tickets.

Morale was so low that staff would cover up their uniforms or Metrorail logo when off duty in public.

Everything was building up to a crisis. Something had to give. The region could have tipped either way.

### Jumping Ahead

Jumping ahead to late 2006: In spite of the shortage of funds, the aging fleet and public perceptions about safety, Metrorail Western Cape was virtually a new organisation. There was a new spirit amongst the staff, business was booming, so much so that the region could not cope with the numbers flocking to rail.

In comparison with the other Metrorail operations in the country, the Western Cape accounted for 24% of the expenditure but 34% of the income. In terms of systems and processes it was about two years ahead of the rest and in 2006 it held 56% of the public transport market in Cape Town, with about 600 000 passenger trips per day.

In tackling the problem of fare evasion Metrorail took a Systems of Systems approach and identified all the then, current subsystems that should be brought to bear, as well as those that would still need to be developed.

The philosophy that drove the system design was to make it too expensive/costly to be caught without a valid ticket. It was also coupled to elements of New York Mayor Rudi Giuliani's 'broken window' strategy, namely, deal with the little things and the big ones come right.

This is what was done.

- Stop and ticket check operations were carried out extensively at random times and stations. Teams also operated on the trains and tickets were checked.
- Metrorail reached agreement with the National Prosecutions Authority to hire and pay for Metrorail's own dedicated public prosecutor.
- Agreement was reached with the local SAPS (police) Provincial management and well trained Grade A security guards were used as force multipliers so that only two SAPS officers were needed per team. They were augmented by 4 – 6 security guards from Metrorail's specialist security contractor. This allowed for the police presence to be 3 – 4 times more effective than using SAPS only teams on trains and stations. They were also used effectively for weapons & drug searches on the trains.
- The Metrorail management team (HR, IT, engineering, etc.) set the example for the staff and had to check tickets on trains or stations at least twice per month.
- Station precincts were closed off, both physically and with staff. Community volunteers were used under the Provincial Government's Bambanani programme.
- Ticket offices had to be open on time and at times that allowed people to buy tickets.

The crux of the operation was that any person caught without a valid ticket before 12h00 was arrested, charged, appeared in court, and sentenced all before 17h00 on the same day. The region used its weekly commuter newspaper (60 000 copies), Commuting Times, to publish the number of arrests and convictions each week. Station announcements reinforced this.

At the same time that fare evasion was being targeted, there was a commensurate improvement with service delivery. People had to have a reason for wanting to pay their fares. Interestingly, the region had, through innovative security strategies, completely eradicated overhead cable theft over the two-year period of this case study.

Metrorail also had to work on their own staff. Money was being accepted at the access control points to evade paying fares. It started with well advertised random 'system integrity tests'. These were undercover operations with camera and audio recordings. After the first few dismissals the incidence of allowing fare evaders through, dropped significantly.

A number of systems were integrated, to bring this about.

- Firstly, the operational group of systems needed to work together for the stopping and searching of trains for fare evaders, namely, train operations, station management and safety systems.
- Then there was the security as well as the South African Police. This was linked to the justice system and the courts. A minor role was played by the internal disciplinary system.
- Then of course, the overall management systems that became the glue that held them all in balance.
- A final innovation was that passengers themselves volunteered to check tickets, and did so with great success.

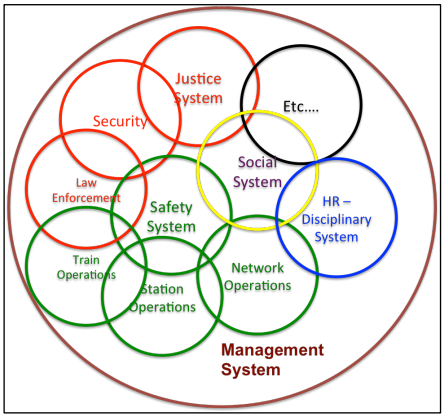



***Figure 7: Pictorial View of Systems***

Commuters were so hemmed in by these systems that they had little choice but to change their behaviour.

There were also unexpected results

Because of these interventions, crime had dropped to less than 0.03 incidents per 100 000 passenger trips. After the initial few months, train timekeeping averaged at 92%. All of these improvements, coupled to the enforced 'systems' change of behaviour in paying fares, resulted in a tentative change in culture of the commuters.

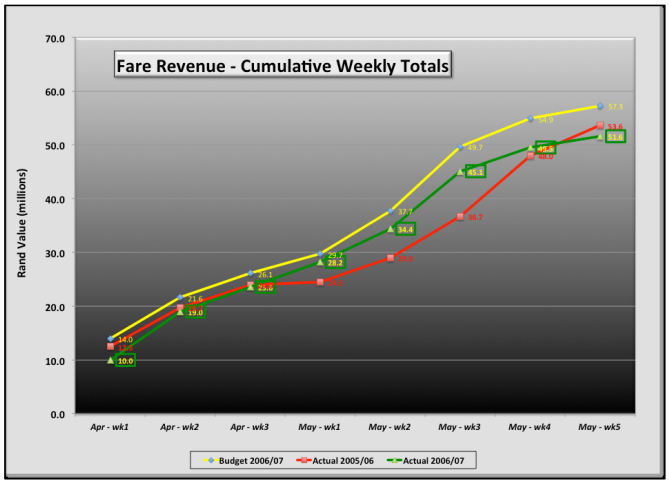
### Changed Behaviour Resulting in Fare Evasion Below 3%

While behaviour changed and fares were being paid, fare evasion dropped to below 3%[7]. It got to the point where regional management was so confident, that local critics were being challenged to get on any train at any time and find a person without a valid ticket.

All this took place before the deployment of the current Railway Police. People began paying for their fares out of their own.

### Evidence

The evidence for this was during a 3-month security officers' strike in 2006 (March – June)




Apart from a few specialist security contractors most of the security support disappeared from the system for 3 months and because of staff being assaulted, facilities torched, and general intimidation, access control staff were withdrawn from all stations in the Central Area.

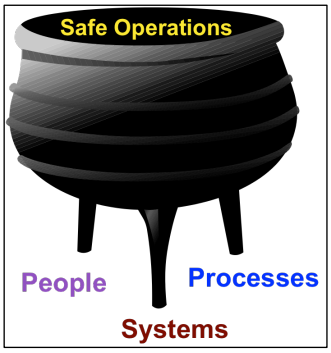
The effect on fare evasion and income was counter-intuitive. Income continued to improve over the previous year (without a fare increase). It was only after two months that commuters realised that they could get away with not paying and the growth levelled off. Unfortunately it took another 4 months to recover the situation. The graph below was taken from a presentation on 7 June 2006 at the debriefing session after the security strike.

***Figure 8: Extract from Report on Security strike***

The first tentative steps to a culture of payment had been realised. Unfortunately this was undermined by the security strike.

The case study demonstrates that the behaviour of communities, in this case the community of rail users, can be constrained and directed, even in the tough area of fare evasion.

## CONCLUSION




While the proper application of systems play a significant role in constraining and managing human behaviour, systems in themselves are not the long-term solution, they are, however, the quickest way to respond to a critical situation. Lasting change is brought about over time with both behaviour and attitude being dealt with. It is here that the so-called 'Soft' systems play a larger role. A systems approach coupled to a well thought out change management strategy, with a strong focus on training and motivational input, will bring about, and entrench, the desired behavioural change in a new culture.

It is hoped that with the argument presented, backed up by the case studies, it has been demonstrated that by using a systems approach, as a minimum, people's behaviour, whether individually, or in communities can be constrained and directed. Furthermore, it is strongly suggested that this approach can be effectively applied in the area of railway safety management, and in particular in the field of Human Factors Management.

The challenge is to creatively apply our minds to the current safety challenges we each face as operators and regulators and determine how we can bring this about through the effective design and application of systems.

END/

[7] This was measured independently by Metrorail's head office through a passenger census