RISK & HUMAN ERROR MANAGEMENT

THE NATURE OF LATENT UNSAFE CONDITIONS & FAILURES IN THE SYSTEM AND THE NATURE OF HUMAN ERROR

UNDERSTANDING HUMAN FACTORS AND HUMAN ERROR CAUSING CONDITIONS

A Guide to the Ultimate Goal to prevent Railway Accidents

By Dr. Frank Wingler, revised December 2013

FUNDAMENTS OF MODERN RAILWAY SAFETY

Modern Technology has now reached a point, where improved Safety can only be achieved through a better understanding of the Factor HUMAN ERROR and HUMAN ERROR causing Factors and Conditions. In its treatment of major Accidents, HUMAN ERROR spans the disciplinary gulf between psychological Theory and those concerned with maintaining the Reliability of Technologies with a higher Risk Potential like Railways. This is an essential reading for ENGINEERS, MANAGERS RESPONSIBLE FOR SAFE OPERATION and SAFETY REGULATORS.

Engineering and Fostering a Safety Culture with Understanding for Human Factors and Considerations of Human Factors are Key-Instruments of a Railway Safety Management.

Accidents should be investigated in a manner, that does not seek to allocate "BLAME" and to pin *"CULPRITS"*, but instead to focus on what are the latent unsafe conditions and the human error producing factors & conditions, and on what can be learned from own and others bad events for the benefit of more Safety.

Safety-critical-Staff working on the operational Railway every day, Train Drivers and their Assistants, Guards, Station Masters, Platform-Personel, Dispatchers, MA-Operators (= "Front Line Personnel"), should be incorporated in Safety- and Risk-Management Strategies. Planning's & Methodologies are involved in the continuous Development of Safety Management Processes and improved Training Concepts. Constant Training and Education in Hazard Awareness is essential.

Safety Assessments regarding Technical Measures have to be executed from the Human Factor Perspective ensuring a better response to Driver's Feedback about Track and Signal-Positioning and other Route-Shortcomings.

"Front Line Personnel" are subjected to the Psychology of Cognitive Mistakes or Errors as other human beings are subjected in all ranks up to the upper echelons of a Technical Organisation like Railways. One of the basic principles of ERROR-MANAGEMENT is that the best people, even in higher management ranks, can make sometimes the worst error; (see: J. Reason, Managing the Risks of Organizational Accidents, Ashgate Publishing Limited, Farnham, Surrey, UK, ISBN 978-1-84014-105-4, reprint 2011); J. Reason, The Human Contribution, Ashgate Publishing Limited, Farnham, Surrey, UK, ISBN 978-0-7546-7402-3,reprint 2013).

There is nowadays worldwide a consensus amongst Safety-Experts that there is plenty of evidence about the *"unhappy lot"* with top Managers and Upper Echelons of Technical Organisations with a Risk-Potential following the tendency to declare their System as *"SAFE",* and if there is a *"BAD EVENT",* it is because of *"BAD BEHAVIOUR"* of "Front-Line-Personnel", as if they are the "UNSAFE SYSTEM COMPONENTS".

Up-to-date ACCIDENT INVESTIGATIONS have to look into LATENT UNSAFE CONDITIONS and ERROR PRODUCING FACTORS (= "Failures in the System")

<> "the parents of bad events like a swamp where mosquitos bread".<>

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And Safety-Measurements have to be assessed and executed from the HUMAN-FACTOR-PERSPECTIVE taking into account the COGNITIVE PSYCHOLOGY REGARDING ERROR CAUSATION at the all-important interface:

MACHINE-HUMAN.

A GUIDE FOR UPPER ECHELONS IN SRI LANKA RAILWAYS IN RISK & HUMAN ERROR MANAGEMENT AND ACCIDENT INVESTIGATIONS BASED ON THE DOCTRINES OF JAMES REASON AND ON STUDIES & RESEARCH ON THE NATURE OF HUMAN ERROR

A survey of expert's literature in the light of SLR circumstances, a collection of 6 treatises

Derailment of Car Trailer Train with 300 Cars on 16.07.2010 at Arlberg Railway, Austria, due to excessive Speed because of Brake Failure and Laps of Train Driver

Elaborated by Dr. Frank Wingler, November 2013

The treatises had been elaborated to help SLR to find a path to more Safe Train Operation and to more Professionalism in Risk Management and Accident Investigation.

A lot can be done to make SLR more resistant and less vulnerable to Human Error.

Introduction:

Sri Lanka Railways operates at a remarkable low Safety Level. Derailments, Rear-End-Collisions and Level Crossing Collisions are frequent.

Not only that People get killed or injured, valuable Rolling Stocks get ruined.

Pict. RAIL 2012, Edition 03, July 2012, Railway Engineers Association, Sri Lanka Railways, Colombo-10, Sri Lanka

SLR has no professional Safety Advisor/Board or Safety Regulator/Commission watching over Safe Train Operation and commissioning technical Designs, as other Railways have.

The present Multi Aspect **Colour Light Signalling** dated from the 60-ties, composes over 55 Speed and Route Aspects with the three colours, Amber, Red and Green. Red is used also for other information's than DANGER or DEAD-STOP. **There are combinations of GREEN with RED and RED with AMBER.** The system has no Automatic Train Protection (ATP) and no Advanced Warning System (AWS). It does not know individual free standing Advance or Distance Signals of own design, which could not be mistaken with Main or Stop Signals. Repeater Signals as Reminders are missing, where they should be. Signals are posted without Protection Overlap.

There are many **Tricky or Risky Routes** of poor, hindered or obstructed visibility. And many Stations or Train Halts are not any more secured by Inner Home Signals.

Signals passed at Danger, **SPADS**, are presumably frequent, although there is no reliable figure available due to the circumstances, that most SPADs without a bad outcome remain unnoticed and undetected and are not registered.

To increase the Route Capacity, the Main Double lines are used en routine as twin single lines or bidirectional. On Single lines simultaneous admission for crossings without appropriate speed restrictions is allowed even on Stations of poor or hindered visibility.

Many Rail Tracks are in deplorable conditions. Concrete Sleepers had been laid without any or only marginal ballast and without any formation rehabilitation; Steel Sleepers had been laid in wet mud without any drainage and ballasting works. Fish plate bolts and nuts are missing as well rail fastenings. On some sections around 50 % or sometimes even more of the rail fastening clips are missing. There are plenty of short wave length undulations and sever geometry defects. Rail fractures are often bridged unlawful with short rail cuttings inserted between fishplates.

Rolling Stocks are in poor condition with defect bogies, dangling brakes, coming in dangerous parasitic oscillation with track irregularities. Wheels have wheel treat defects with worn roots, sharp flanges, and wheel treat spalling. Many of the new Chinese Coaches are marred with flat tyres and spallings, spoiling the rail tracks and the rail fastenings.

Train Brakes are often in poor condition and not properly serviced, maintained, repaired, examined and tested as it should be.

The Awareness for Hazards is often remarkable low in all ranks from the bottom up to the upper echelons.

Results and/or reports of Accident Investigations are not seldom blocked for political reason.

Accident Investigation in depth down to the latent unsafe conditions and failures in the system are mostly not wanted, and responsibility of higher echelons gets shirked.

The prevailing Culture can be regarded as Pathological, as a “swamp” where latent unsafe conditions can breed like mosquitoes.

Proactive measures to navigate in the safety space towards more resistance against hazards are missing.

The collection of elaborated treatises should help SLR to find a path to more safe train operation and to more professionalism in Risk & Human Error Management and Accident Investigation. A lot can be done to make SLR more resistant and less vulnerable to Human Error.

Recommendations & Lessons learnt

<> Identify the **RISKY** & **TRICKY** Routes, Sections, Spots and risky/conflictinge/hostile arranged Train Operations/Movements,

(especially when utilising Dual Lines as Twin Single Lines and/or bidirectional and when arranging Simultaneous Crossings on Single Lines);

<> educate, train and supervise properly and repeated ***“Front Line Personnel”***: Train Drivers, Dispatchers, Control Room Officers and Operators, Station Masters, Guards, to be extra vigilant and cautious on the identified tricky & risky routes, sections and locations and during tricky or risky or conflicting arranged train movements;

<> keep close and good relations to the front line personnel;

<> separate trains from conflicting situations and hostile movements at the identified tricky and risky routes, sections, spots and from identified tricky & risky arranged train operations by **TWO Signal Posts** or by an **PROTECTION OVERLAP** of adequate length and not only by the thickness of one Signal Post indicating DANGER;

<> install on routes and sections marked **Repeater Signals** of distinctive design marked **as Reminders**, where vision is poor, hindered or obstructed; not by a tiny amber spot light but by the installation of the same panel/unit as used for main signals;

<> repair, maintain, service, inspect, examine and test the **Train Brake Systems** as laid down in the handbooks: P.C. Gupta, (Compressed) Air Brake System Guide et. Vacuum Brake System Guide; Shriram Prakashan Publishers & Book Sellers, 820/9 Sita Sadan, Sant Surdas Marg., Faridabad-121006, Phone +91 129 5261773.

<> Instead of the present prevailing Pathological Culture a Generative and "No-Blame" Culture is asked, where failures lead to far reaching reforms, failures in the system are acknowledged and analyzed, communication is promoted, responsibility is shared, also in upper echelons, and where information of shortcomings and of new ideas are welcomed.

Content of the Treatises:

15.02.2012 Holmestrand, Norway; Derailment of a Stadler Flirt EMU on test run due to excessive speed: Human Mistake combined with latent unsafe condition of a track not secured by automatic Speed Control on a transition of a new 135 kmph track to an old 70 kmph bypass track

Dr. Frank Wingler

Leverkusen, August 2013

SEARCHING FOR AN ADVISABLE & SUITABLE TRAIN MOVEMENT PROTECTION SYSTEM

THE ELEMENT OF HUMAN ERRORS AND FAILURES IN THE SYSTEM

LESSONS WHICH CAN BE LEARNED FROM THE SPAINISH HIGH SPEED DESASTER

In Sri Lanka not only the TRAIN to ROAD-VEHICLE collisions on level crossings but also the frequent TRAIN to TRAIN collisions on the rail tracks are calling for a better SAFE TRAIN OPERATION STRATEGY and advanced active PROTECTION SYSTEMS/DEVISES.

When searching for an advisable and suitable higher Level of Train Movement Protection one has to analyse the role and what is the nature of the Risk Element or the Factor **"HUMAN ERROR**". One has do decide for the appropriate **"DEFENCE LAYERS**" preventing that the **"TRAJECTORY OF POSSIBLE HAZARDS"** can penetrate or creep through the loop holes of the safety devices, barriers and safeguards – like through the holes of a **"SWISS CHEESE SLICE"** – with the **HAZARD** joining finally with a **"SHARP END MISTAKE**" to an **"UNSAFE ACT"** bursting as a disaster (***"SWISS CHEESE METHAPHER MODEL"*** **by J. REASON**). The sharp end mistakes are mostly caused by **"HUMAN ERROR". A Train Protection System has to prevent, that a possible Human Error, like over speeding or disregarding and infringing signals by the Loco Driver, might lead to an accident.**

"HUMAN ERROR" is mostly "sitting" on the sharp end of a Hazard Trajectory, a chain of mishaps and shortcomings ending with the outburst of an "UNSAFE ACT" (Accident, Calamity and Disaster).

A profound **UNDERSTANDING** of the Nature of **HUMAN ERRORS** and **MISTAKES** at the so-called ***"SHARP END"*** plays a decisive role in finding the advisable and suitable technical defence layer device (Train Movement Protection Device).

Loco Drivers can make handling mistakes at the sharp end. Loco Drivers are "**FRONT LINE PERSONNELS"** and can make **"ACTIVE FAILURES"** at the end of the hazard-chain.

This means in consequence, the Signal Engineers – responsible for safeguarding the Train Movements – should develop a deep understanding for the Loco Drivers, how they might or will respond and react to the chosen **"SAFETY DEVICES".**

There is plenty of evidence in the history of Railway Accidents, that the "MOST EXPERIENCED" LOCO DRIVERS CAN MAKE THE WORST MISTAKES (ERRORS)!

The **SAFETY DEVICE** (at Santiago, Spain, ETCS Level 2) should have prevented that **HUMAN ERRORS** or **HUMAN MISTAKES** can develop its decisive role at the sharp end of a hazard Trajectory reaching a thinkable Disaster: In Spain the derailment occored, when the train entered at Santiago with 190 kmph a conventional 80 kmph restricted curve after leaving the high speed rail track. It derailed with 143 kmph. The heavy Diesel generator power coach derailed first and pulled the light weight passenger coaches from the track. They piled up at the outer curve culvert concrete wall. The heavy rear power coach catapulted the last passenger coach 5 m over the culvert wall like a ball. 79 passengers got killed and nearly nobody escaped uninjured due to the high deceleration forces of the Talgo Light Weight Construction.

To find out what might be **HAZARDS, UNSAFE ACTS** and **POSSIBLE DESASTERS** a lot of **FANTASY** and **POWER OF IMAGINATION** is asked. Fantasy and Power of Imagination can also develop in the minds an understanding for what might go wrong (especially on defined tricky spots and risky sections prone and vulnerable of conflicting and hostile train movements).

During my industrial career, involved in Safety Technology, Risk Recognition, Risk Prevention, Hazard Awareness and Disaster Investigations, we let our Fantasy and Imaginations to flow free in so-called ***"BRAIN STORM"*** **GROUP SESSIONS** under a leading coach**.** We painted thinkable and plausible **SCENARIOS,** and what will be the right counter measurements or appropriated answers and responses: ***"What to do in case if this would happen".***

Disasters reveal mostly **"FAILURES IN THE SYSTEM" or "CRACKS IN THE SYSTEM"** of far reaching history. **"FAILURES IN THE SYSTEM"** provide **"LATENT CONDITIONS"** for an accident to happen. To uncover **"FAILURES IN A SYSTEM"** need a **"GENERATIVE CULTURE"** in the organisation with openness and willingness.

My **MESSAGE FOR SRI LANKA RAILWAYS** is, that the **LOCO DRIVERS** and their Union must be incorporated and linked in search and finding processes. They should be called to participate. They must be continuously trained and as well examined in safe train operation. **TECHNOCRATES** develop their systems sometimes too remote from the **NATURE of SHARP END MISTAKES** and **UNSAFE ACTS** triggered off by **HUMAN ERROR.** Technocrats are sometimes too far away from the reactions of human natures.

In all my talks with Loco Drivers and their Union I found out, that there is not always the needed willingness in **HIGHER RANKS** of SLR to let Loco Drivers participate in decision processes. Often the Loco Drivers are regarded as the ***"CULPRITS"*** **or the** ***"BAD PEOPLE"*** for things, which went wrong at the sharp end.

To search only for **"CULPRITS AT THE SHARP END"** to be ***"severely punished***", does not alter the Nature of Human Errors and does not eliminate **FAILURES IN THE SYSTEM.**

And since **"FAILURES IN THE SYSTEM"** under a "**PATHALOGICAL CULTURE",** prevailing within SLR and the Ministry of Transport, are prevented from being analysed, Train Operation will remain unsafe as before, unless someone introduces a "**NEW CREATIVE CULTURE"** and goes for **PROFESSIONAL METHODS,** how nowadays the Risk of a Technical Organisation (Railway) can be managed, and introduces new **PROFESSIONAL Expert's TOOLS** and **METHODS.**

I hope, the Chief Engineers of the Department of Signalling and Telecommunication, who stand nearest to the **SAFEGUARD** of Train Movements, will feel challenged.

LESSON WHICH CAN BE LEARNED FROM THE SPAIN HIGH SPEED DESASTER

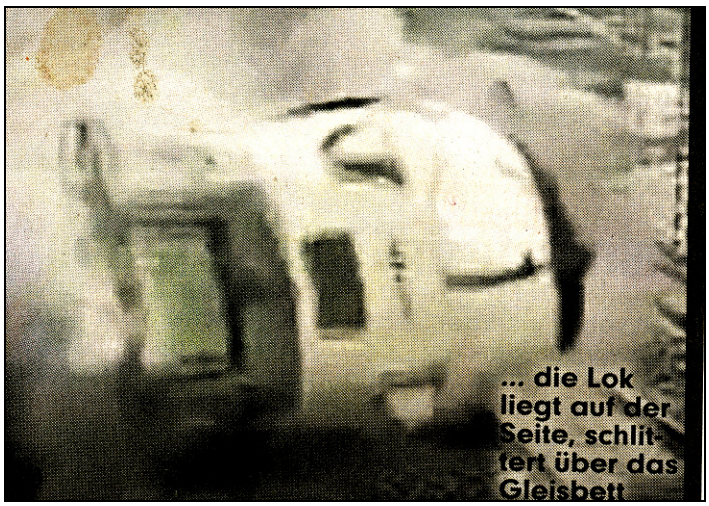
Obviously the Train Protection System ETCS Level 2 on the end of the High Speed Track allowed the high speed train to leave the end with 220 kmph on 24th July 2013 near Santiago de Compostella in North Spain. The system did not intervene and did not slow down the train automatically, so that the train set could reach the 80 kmph restricted conventional curve with 190 kmph, because it had been simply not been installed. The Loco Driver was "**experienced"** with the track situation over years and run the train on this section over a lengthy period.

Pict. taken from a video surveillance camera

The Balises for Level 2 had not been installed on the track. Only few days after the bad events RENFE installed balises to slow down the train to 30 kmph. ETTCS Level 2, although installed on the Train Set, and although compulsory for high speed, had not been in use because of shortage of funds.

Spanish Medias have reported that, as often with accidents of technical organisations, "***whistle blowers"*** have warned before about the immanent danger of this high speed track elongated by a track on a curvy conventional trace.

JAMES REASON writes in his book ***Managing the Risks of Organisational Accidents***: *"With hinsight, it is nearly always possible to identify, prior to a disaster, the presence of warning signs which, if heeded and acted upon, could have thwarted the accident sequence"*.



The history of worldwide Railway Accidents give plentiful evidence to show, that a lengthy period without a serious conflicting situation can lead to the steady erosion of vigilance. It is easy to forget to fear risks. This happened presumably to the Loco Driver of the ill-fated High Speed Train.

This tells us, one should not allow a loco driver to run trains too often over a lengthy period on the same distinguished route. By routine he might forget to be afraid of the immanent and build in RISKS of the particular route.

The **RISK** in Spain had been at the end of a High Speed Track with ending 4 km before Santiago on a 80 kmph restricted conventional route trace with sharp curvatures and conventional signalling There had not been enough money to complete the high speed track up to Santiago Railway Station.

In **Sri Lanka** the risky and tricky sections and spots of the network should be identified

together with the Loco Drivers.

The Drivers have to be trained, instructed, examined and remembered in intervals to drive on identified sections with up most care and vigilance.

= This is my message to Sri Lanka Railways!

I guess that at ***GANEMULLA***,

a tricky section with hindered visibility and no repeater and no inner home signal (Main or Stop Signal) to secure the entrance of the station and to protect halting trains,
on 09th October 2008 the ***"experienced"*** Loco Driver and his Assistant have presumably forgotten to be afraid of the Signal Aspects **AMBER** and or **RED.**

It might be easier to change the positioning of signals, to introduce additional signal posts and repeater signals, to provide troublesome sections, where conflicting train movements are likely, with an empty block in-between two signals on danger, than to change the **NATURE OF HUMAN ERROR.**

The accident investigators wanted to make out "**CULPRITS"** on the **SHARP END** to be ***"punished"***, but did not search and analysed for **FAILURES IN THE SYSTEM**, which have mostly a far reaching history.

Accident investigations should be carried out for two main reasons: To establish what occurred and to stop something like it happening in the future. Accident Investigators are required not only to establish the causes of an event but also recommend measures that will help to prevent its recurrence.

It is too obvious, that the complex multi aspect Sri Lankan Colour Light Signalling, separating a train only by the Thickness of One Signal Post from conflicting situations and hostile train movements, and this even at locations of poor, hindered and obstructed visibility without any Repeater Signal, and not securing train halts by an inner home (Stop or Main) Signal, that this system could not thwarted the recent rear end train collisions at GANEMULLA, ALAWWA and AMPEPUSSA.

THE 09th October 2008 GANEMULLA TRAIN COLLISION had not createtd the needed repercussion, because the investigation was fixed to look out for a ***"CULPRIT AT THE SHARP END"*** on the level of the Loco Drivers, and not to go for an **INVESTIGATION IN DEPTH** to search
for the weakness or even technical faults of the complex colour-light signalling arrangements, that may have featured

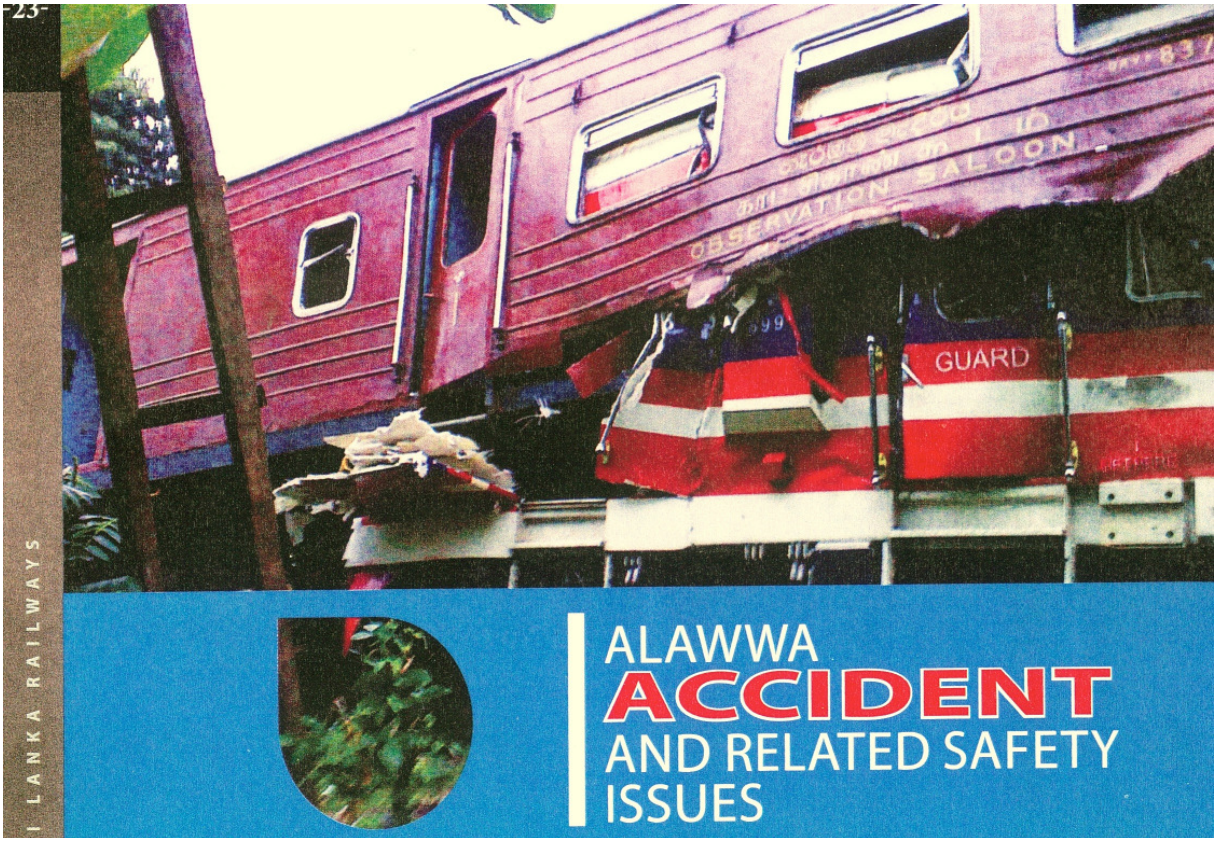
conspicuously amongst the causal factors, and which due its complexity is vulnerable by Technical Failures and Human Faults. Since it was not possible to blame a ***"CULPRIT"*** to be ***"severely punished"***, the investigation book had been closed under the tenor:

"We do not know, what caused the accident, therefore we can not take a lesson and recommend measures that will help to prevent its recurrence".

This allowed the next train collisions to occur at Alawwa and Ambepussa! And the **ALAWWA TRAIN CRASH INVESTIGATION** had been handled in the same pathological way, and revelations had been blocked for political reasons. To get to know about **FAILURES IN THE SYSTEM** is not wanted.

The weak points of the complex SRI LANKAN MULTIASPECT COLOUR LIGHT SIGNALLING, overstraining each and every Loco Drivers with its over 55 aspects, being vulnerable by technical failures and Human Errors, and not securing the train movements properly, are not wanted to be criticised. (British Rail uses only 4 aspects, and where necessary Repeaters and Banner Signals.)

RESPONSIBILITY IN HIGHER RANKS IS SHIRKED.



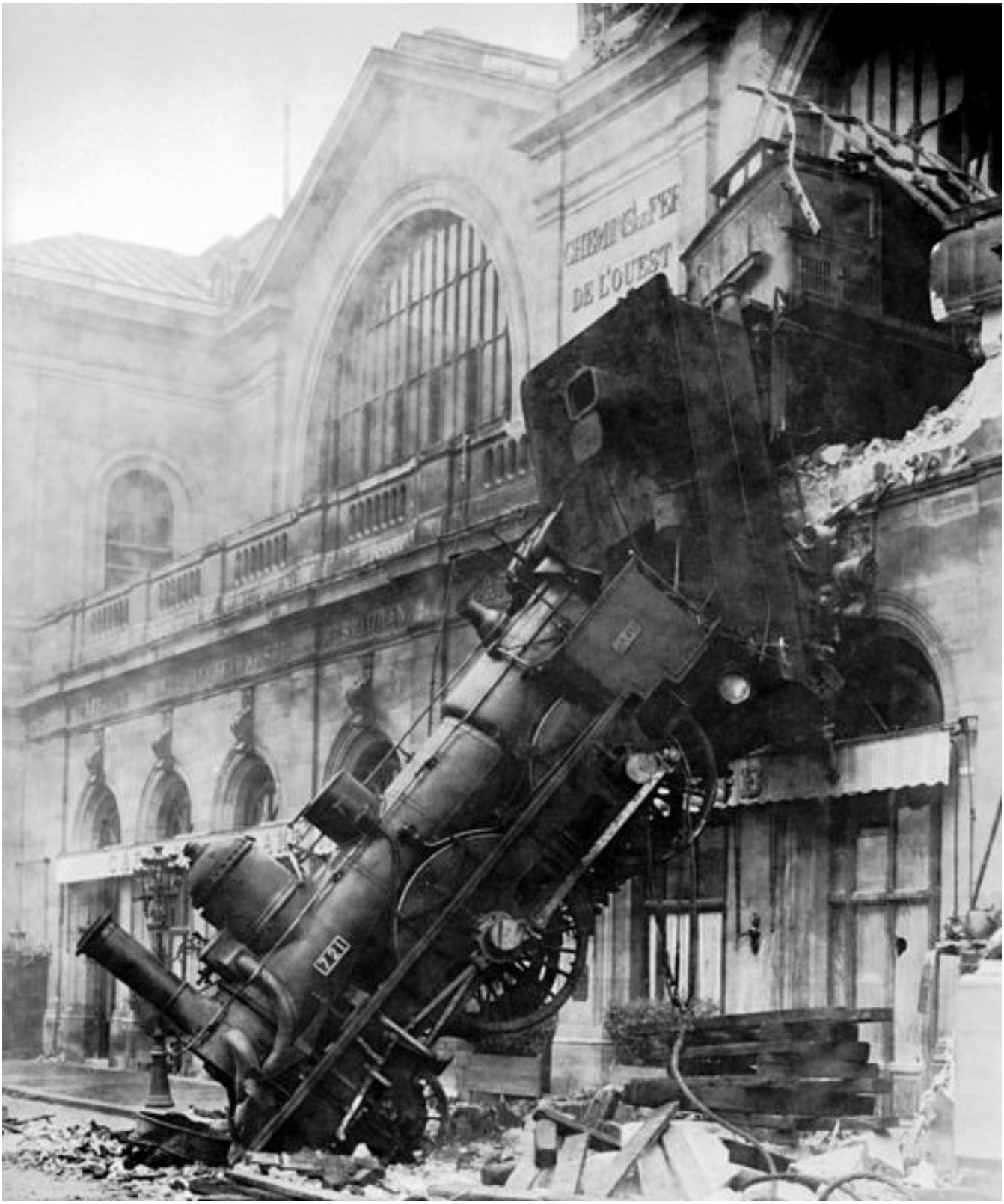
In his book how to manage Accident Risks of Organisations, **James Reason**, warns that humans on the sharp end might forget under routine to be afraid of immanent

dangers. The **AWARENESS FOR HAZARDS** gets eroded; **Lit.: James Reason, *MANAGING THE RISKS OF ORGANISATIONAL ACCIDENTS*, Ashgate Publishing Limited, Farnham, UK, 2011, ISBN 979 1 84014 105.**

And even **LEADING FIGURES, CHIEF ENGINEERS, OFFICERS, MANAGERS and MINISTERS** responsible for the well beings of Technical Organisations (Railway), sitting on the other remote end of the **HAZARD TRAJECTORY,** forget to be afraid about risks and about **FAILURES IN THE SYSTEM**, if things went well without a mishap for a lengthy period. They don't like to be remembered, that they are responsible for latent **FAILURES IN THE SYSTEM** as **ACCIDENT CAUSATION.** They are insufficient aware:

WHAT DID NOT HAPPEN YESTERDAY IS MORE LIKELY TO HAPPEN TOMORROW!

Rescue of the Light Weight Talgo Coach catapulted by the rear heavy Power Coach over the 5 m Culvert Concrete Wall like a Ball at 143 kmph Derailment Speed.



Gare de Montparnasse, Paris 1899

Accidents do not fall from the blue sky to earth, but sometimes from an upper level of a Railwaystation!

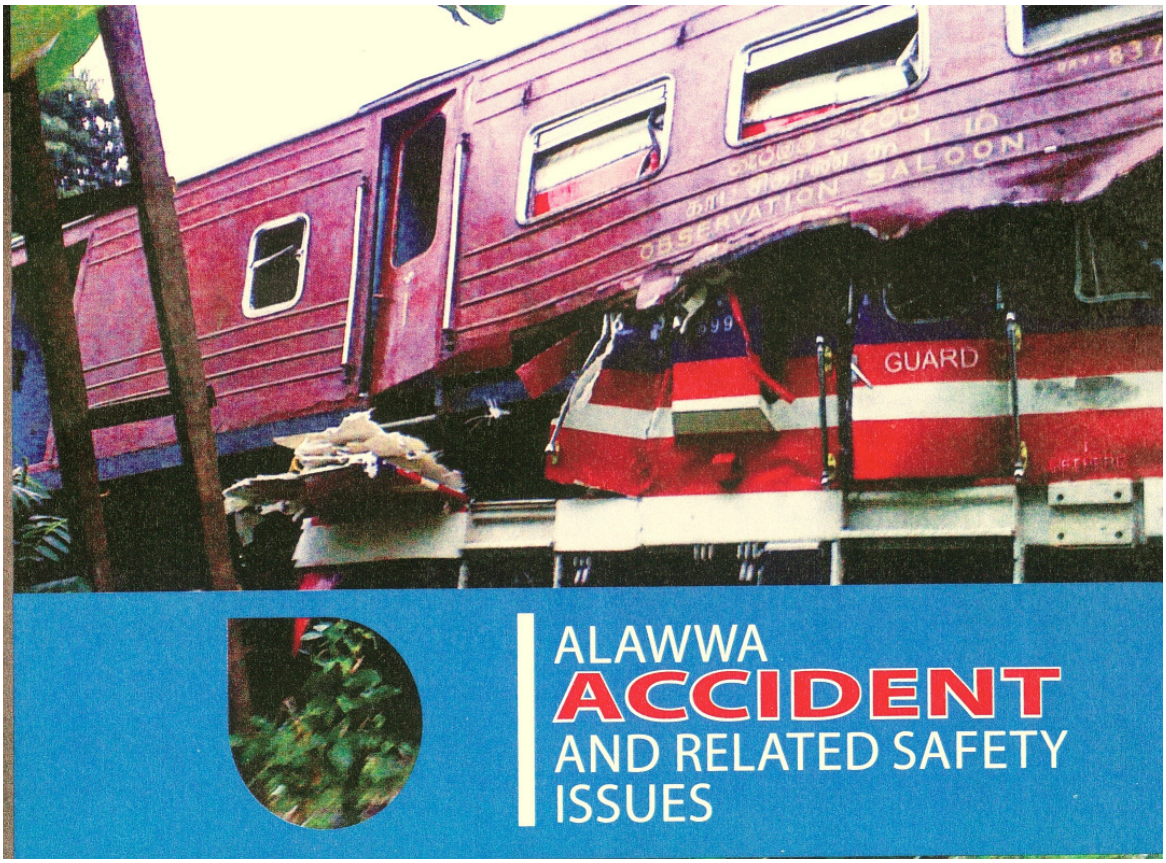
THE NATURE OF HUMAN ERROR, MALFUNCTION, MISTAKE, FAILURE and FALLIBILITY

THE SLR COMPLEX MULTIASPECT COLOUR LIGHT SIGNALLING AND THE ELEMENT OF HUMAN ERROR

LESSONS WHICH CAN BE LEARNED FROM BAD EVENTS WITH HELP OF STATE-TO-THE-ART METHODOLOGIES

Managing the Accident Risks of the Technical Organisation Railways; the Dilemma with Upper Echelons

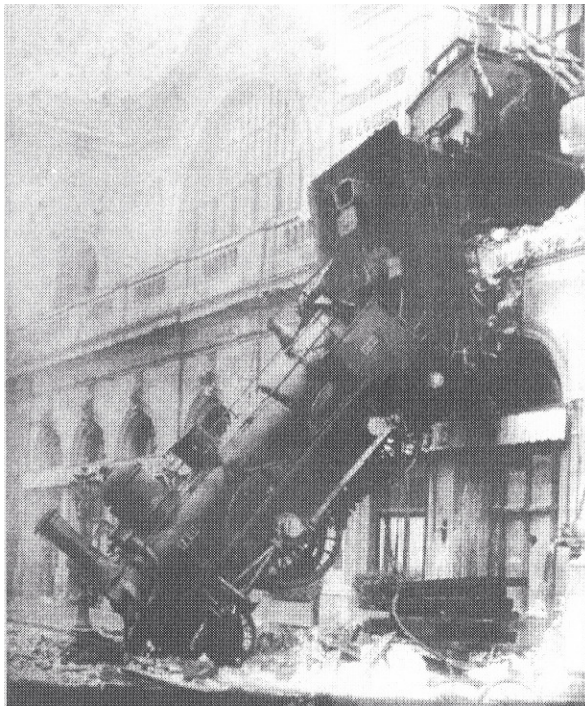
A survey on expert's literature in the light of SLR circumstances



"***Wise men learn by other's harm, fools by their own!***"

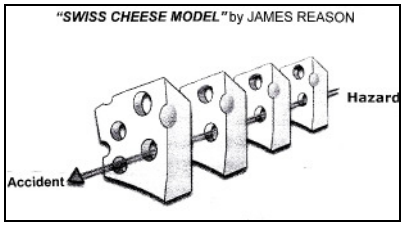
A survey of expert's literature in the light of SLR circumstances
by Dr. Frank Wingler, revised November 2013

PRELIMINARY REMARKS



Overshooting Station, Paris

Railway Signalling is a **DEFENCE LAYER** protecting **TRAIN OPERATION** from the attacks by possible Hazards. The Srilankan Colour-Light Signalling Systems have holes like a Slice of Swiss Cheese, through which **HUMAN ERROR** can penetrate (see Swiss Cheese Defence Layer Model of JAMES REASON for ***Managing the Risks of Organisations (Railways)***[1]***.***



SLR has no Automatic Train Protection or Warning (ATP; AWS) Systems to avoid Mishaps when Signals are Passed at Danger (SPADs). Even on well known defined **RISKY** and **TRICKY SECTIONS** the SLR Colour-Light Signalling separates a train from a possible **CONFLICTING SITUATION** and prevents a train from a possible **HOSTILE MOVEMENT** by the "**THICKNESS OF ONLY ONE SIGNAL POST"** indicating **DANGER (RED)**, instead by **TWO SIGNAL POST** indicating **DANGER (RED)** with an empty intersection in between or by a **PROTECTION OVERLAP** of adequate length.

A Loco Driver can make a train crash by passing the **THICKNESS of ONE SIGNAL POST indicating DANGER (RED).**

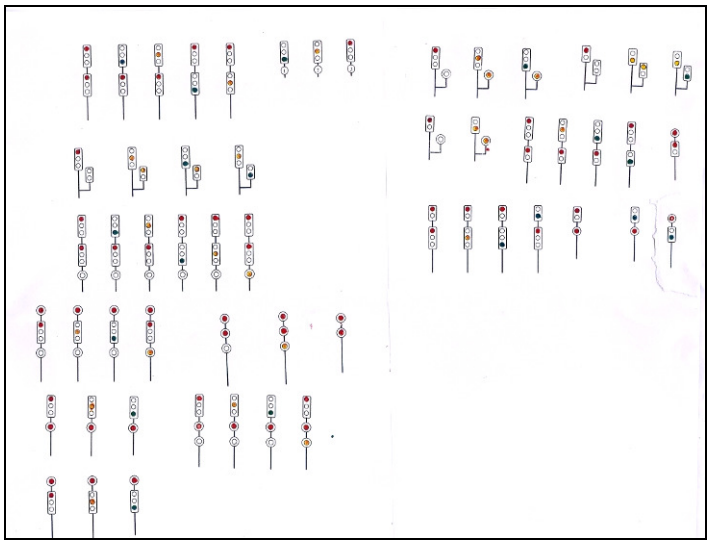
The SLR Colour-Light Signalling System does not know well marked and announced **individual standing Advance *(Vor-)* or Distant Signals** with its own distinguished design on its **own post (which can be separately posted from a Main, Block or**

Control Signal Post, which announces in advance the aspect of the next Main, Control, Stop Signal and which can be repeated and marked as thus on sections of poor or hindered visibilities) like in Sweden or Germany.

At many stations halting trains are not any more secured by an inner Home Colour Signal, and on sections of poor, hindered or obstructed visibility there are mostly no adequate and corresponding **REPEATER** Signals.

Even on **"TRICKY"** Routes there is no **REDUNDANCY** with a second defence layer in case the first defence layer (Signal AT Danger) has been passed by Human Mistake (by a socalled "SPAD").

SLR confronts its personnel with over 55 valid Colour Light Aspects in use; with 22 different aspects and combinations using **AMBER**, with 43 Aspects and combinations with other colours using **RED** and 19 different aspects and combinations using **GREEN**. There is nobody, who can interpret all the given information correctly within few seconds (3 to 5 seconds). **RED** is used to give also information's other than only **"STOP"**; this has to be regarded as "odd" and as a latent **RISK FACTOR.**



Sri Lanka 55 Aspect Colour Light Signalling

Post scriptum: Train Drivers have detected still more 4 Aspects not yet listed

There is no ***"SAFETY NET"*** installed or provided, once a Loco Driver has passed a Signal at Danger (SPAD) due to Human Fallibility. No Railway in the world is free of SPADs, but most Railways provide additional Defence Layers ***("Swiss Cheese Slices")*** to prevent that a SPAD might lead to a conflicting situation, to a hostile train movement or to an accident.

SLR leaves the fate of its passengers fully in the hands of Train Drivers with their natural fallibilities an habits.

To guide the trains safely by means of the entire complex multi aspect colour light signalling the Train Drivers must make simplifications by using his personal cognitive ability.

F.I. the British Colour-Light Signalling confronts its personnel only with **FOUR** Colour Light Aspects; with **TWO AMBEER**, **ONE AMBER**, **ONE RED** and **ONE GREEN**.
There are **NO** colour combinations. **The TWO AMBER** aspect had been later introduced in addition to the elder 3 aspects, to give at higher speed the Train Driver additional information before reaching Amber and Red:
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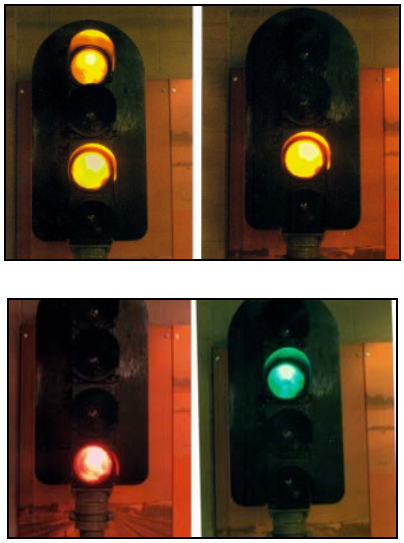


British Colour-Light 4 Aspect Signalling; (pict. by Dr. F.Wingler)

The **COMPLEXITY of SLR** Colour-Light Signalling makes Safe Train Operation and Train Protection vulnerable by **TECHNICAL FAULTS** and by the **ELEMENT OF HUMAN ERROR** and **HUMAN MISTAKES.**

The question is, how Loco Drivers process the manifold images with its information flood of the complex SLR Colour light signalling!

In the follow up some studies and research results are reported for a deeper understanding of the Human Factor in Disaster.

Here are some statements from the Dissertation of Dipl. Ing. Malte Hammerl, Technical University of Braunschweig, Germany, 21.12.2011 on

INTEGRATION OF HUMAN FACTORS INTO SAFETY ANALYSES IN RAILWAYS APPLICATION and

QUALITIVE METHODS FOR THE COMPARITIVE ASSESSMENT OF HUMAN RELIABILITY.

<> Complex Systems are error prone.

<> The Human Reliability for safety critical tasks has to be analysed.

<> The Human Factor has to be integrated in Safety Considerations and Assessments.

<> Safety Devices not adequately adapted to the Human Capabilities and Human Reliabilities can be hazardous and can cause Mistakes and Errors.

<> Engineering skills and Psychological Knowledge have to meet when designing a Safety Device.

<> The Human Reliability is as well the Technical Designs are part of the Signalling Defence Layers defending safe train movements from the attacks of hazards.

<> The Interaction of Human Ability and Psychological Behaviours have to be well understood and taken into account, when designing the Defence Layer System: Signalling.

<> For Train Protection by Signalling this should be achieved by an interdisciplinary approach of the Technocrats, Psychological Experts, Train Drivers and Train Dispatchers.

<> If an ACCIDENT INVESTIGATION TEAM is mainly focused to make out a *"CULPRIT" – "to be severely punished"* - with its HUMAN FAILURE at the so-called "SHARP END"[1] of the so-called *"HAZARD TRAJECTORY"[1],* the team will get blind to find causation attributing PREVAILING LATENT ACCIDENT PRONE CONDITIONS, the so-called "FAILURES IN THE SYSTEM", and no lessons will be learned to prevent the next similar accident on the way to come!

The Habilitation Lecture of Dr. Harald Schaub of the Institute of Theoretical Psychology of the University Bamberg, Germany from 24, February 1999, uses in his preliminary words

MURPHY`S LAW:

"Anything that can go wrong will go wrong";

"If you perceive that there are four possible ways in which a procedure can go wrong, and circumvent theses, than a fifth way, unprepared for, will promptly develop";

"It is impossible to make anything fool proof because fools are so ingenious";

"Every solution breeds new problems";

This laws got erified by many small and big catastrophes (see Journal RAIL 2012, Edition 03, p.67 July 2012, Railway Engineers Association, Sri Lanka Railways). In other words:

Leading Managers should have enough fantasy and imagination to reveal the ***"fifth way, unprepared for, to develop",*** and who might be the ***"ingenious fool".*** They should know, what might go wrong in the system, for which they are responsible.

A well known metaphor of Risk Management of technical Organizations like Railways is to say:

"If the Awareness for Hazards is low in the minds of a top hierarchy and management, than the whole system below will operate unsafe; safety can not only be delegated to lower ranks; Safety must start in the minds of the top hierarchy and management".

Applied to the prevailing culture of SLR after a calamity had occurred, there are often reluctances to look into the **LATENT CONDITIONS WITH OFTEN FAR REACHING HISTORY = THE FAILURES IN THE SYSTEM (FIS) or PARENTS OF THE ACCIDENTS; see *FAILUR WITHIN SYSTEM*, J. Hörstel, H-J. Ritzau, ISBN 3-921 304-33-4, Ritzau KG, Pürgen, Germany, 2000) as** a causation link in the chain of latent shortcomings culminating into a mishap, accident, disaster and or catastrophe. Mostly the investigators are searching predominantly for a culprit on the so-called **"sharp end"** and to declare him guilty, who triggered off the calamity by **HUMAN ERROR** as the last chain-link.

Accidents, Mishaps, Calamity, Disasters, and Catastrophes seldom occur because only one thing went wrong. Mostly they are a culmination of many shortcomings and latent **FAILURES IN THE SYSTEM (FIS)** with a far reaching history.

The so-called **PATHALOGICAL INVESTIGATION CULTURE** of SLR, who is its own **SAFETY REGULATOR,** can be compared with the Investigation Culture prevailing during the investigation of the 28. March 1979 Three Mile Island Harrisburg, USA, Nuclear Power Plant mishap: Nobody was really interested in clearing up the causation. Everybody blamed the other to be guilty but never oneself, although there had been actually serious shortcomings in the Management, Maintenance, Rules, Constructions, Designs, Education, Training, Supervision in conjunction with a prevailing Pathological Culture and a far reaching Sloppiness. Those shortcomings can be summed up under **FAILURES IN THE SYSTEM (FIS). The HUMAN ERROR CAUSATION has only been the last link in the long chain leading to the disaster.**

The same causation chain or so-called **HAZARD TRAJECTORY,** we find at the 1986 Tschernobyl Nuclear Power Plant Explosion in Ukraine, and at the 1986 Space Shuttle Challenger Crash.

But what is actually **HUMAN ERROR, HUMAN MALFUNCTION, HUMAN FALLIBILITY or HUMAN FAILURE?**

There is no human being free from failures. One only has to wait long enough until even the most reliable human makes a mistake. Human Error is not unusual. Even the most experienced operator can make the worst mistake.

Important is to consider the interface between Human and Technical Device. The inadequate designed interface is mostly the background or breeding ground of many accidents and catastrophes.

Psychological Aspects lead in the end to a mishap or calamity. Latent Failures in the System (FIS) with a long lasting history mostly add up with the insufficient Interface between Human and Technical System towards the outburst of a catastrophe.

Humans are given by nature an appropriate tool against mistakes of any kind: This is

ROUTINE.

But **ROUTINE** has two sides. **TOO MUCH ROUTINE** can also become **HARMFUL.** Most of serious mishaps in technical organizations (Railways) are caused not by beginners but by experts with many years of experience. They are the operators, who mostly infringe safety rules. By their routine they often forget to be afraid of risks. They have the fallacious and jugglery feeling that thanks their experience they can not make a mistake.

A so-called ***"experienced Loco Driver"*** might forget to see a risk in a Signal Aspect with Amber or Red. He might regard an aspect with **Amber** or **Red** not any more as serious enough in order to get afraid of the risk to make a train crash. He might think, that thanks his ingenuity and experience he can handle any conflicting situation. Mistakes find their way into daily routine. Mistakes and as well infringements of rules will be repeated. Faulty behaviors worm in daily practices and habits.

Besides **FAILURES IN THE SYSTEM (FIS),** overestimation of skills and experience and too much routine has been the causation for the **24th July 2013 High Speed Train Crash near Santiago de Compostela in Spain of the Alvia Train 4155 Madrid – Ferrol:**

The ill-fated Train Set is a Talgo-Hybrid 730 012, which can run as well by Diesel generator (installed in a Power Car behind the electric Locomotive) as by electricity under overhead wire. It is an articulated engineering construction with aviation technology for 250 kmph with light weight coach shells with a low centre of gravity and only one axle per rack. The wheel sets are adjustable as well for Broad as for Standard Gauge. The transition from high speed track to conventional track with sharp curvatures track 4 km before Santiago had been known to be **tricky and risky**. The high speed line is controlled by ETCS Level 2, but the programmed balises (transponders) to control the speed reduction at the end of the high speed line have not been installed. This had been done only few days after the accident with automatic speed reduction in steps from 160 over 60 to 30 kmph. The consecutive conventional track is equipped with the Spanish ASFA automatic train protection system, which can stop a train passing a signal at danger, but can not control the speed. It renders also no deceleration brake curves.

There have been previous warnings about this **tricky transition** from high to conventional speed without appropriated automatic balise protection, which should have been installed together with the ETCS Level 2 System. But the warnings have either been not taken as serious or played down by higher levels, responsible for safe train operation.

There had been also previous criticism about the safety of the train set design with Light Weight Passenger Coaches clamped between two heavy push-pull Locomotive unites with Diesel Generator Power Cars.

ARTICULATED LIGHT WEIGHT TALGO HIGH SPEED TRAIN

The ETCS Level 2 although installed on the train had not been used for whatever reason. This enabled the train to leave the high speed track and to enter the conventional track with 179 kmph.

The permissible speed of the curve is 80 kmph. The train derailed with 153 kmph. The Diesel Generator Power Car with its high centre of gravidity behind the Locomotive derailed first and pulled the consecutive Light Weights Coaches from the track smashing them against the culvert concrete wall. The derailment sequence had been monitored by a surveillance camera. One Light Weight Coach jumped over the 5 m high culvert concrete wall and came to stand behind the wall.

The Locomotive Driver obviously forgot to be afraid of this tricky transition not properly secured by Signalling. He made a phone call to the movement authority in Madrid asking to be sent on a special platform at Santiago on the previous phone request by the head guard. The Loco Driver had been well ***"experienced"*** and run on this section continuously for a longer period.

So what caused this tragedy?

Is it the Human Error of the Train Driver, who made an official phone call to the MA in Madrid; is it the routine; the overestimation of skills; the negative outcome of too much "experience" and routine? Is it the well known tricky section, for which no adequate train protection system had been installed or put in use;

the authority, which put this train driver for a longer period on duty on the same section, the management, who had not been aware of the possible hazards on this section in order to undertake counter measurements?

Had the Train Driver not been properly trained and advised by his seniors, how to handle this tricky section without the usually prescribed back-up by automatic speed control protection, and how to be extra vigilant?

Had it been a mistake to send the same train driver always on duty on this section for a longer period?

If it had been well known, that this tricky transition is not properly protected by Signalling and that the ETCS Level 2 compulsory for velocities higher than 160 kmph had not been in use, why did the relevant responsible authorities not provide other safety counter measurements by special operational rules, optical speed indicator panels and by training of the train drivers for extra vigilance?

For Safety Experts it is incredible, that for a high speed line, per definition a line for trains over 200 kmph, there had been no installed Speed Control Devices, in this case no balises for the a limited train control ETCS Level 1 or unlimited train control Level 2, although the train set had been ready for the latter.

It is incredible, that 79 passengers had to loose their lives and that over 100 had to be injured, before the RENFE Authorities installed the missing balises.

The safeguard of passengers in High Speed Trains (> 200 kmph) can not been left only in the hands of one Train Driver and his reliability.

What is the participation on this accident by the relevant authorities, who have either not taken the previous warnings as serious or played the warnings down?

Had there been political pressure to open the line for high speed, although there had been not enough funds to finish the high speed track and to install the prescribed train protection systems?

Who might be responsible, that such a **tricky** transition from high to conventional speed had been installed without proper Automatic Train Protection with Speed Control? Who can be made responsible as the culprit that ETCS Level 2 had not been in use!

Are the engineers of this Light Weight one axle Talgo shells responsible for the high death toll with 79 killed passengers and the unusual fact, that nearly nobody escaped uninjured, that on crash the travelers inside the coaches had to face a too high deceleration forces due to the low weight and short deceleration distance (one rack jumped like a ball over a 5 m high wall and landed abrupt upright with an intact shell on the ground with nearly all insiders killed or injured or thrown out of the coach). The heavy power cars at the rear had catapulted the last Light Weight Coach 5 m over the concrete culvert wall like a ball. Only the train driver escaped the crash slightly injured in the heavy power coach, which scraped along the culvert concrete wall over a longer distance with a lower deceleration rate.

The Dilemma with Upper Echelons

Probably the **General Manager** of RENFE can be made responsible for all those latent conditions and failures in the system, the parents of the accident, for which he cares the responsibility.

But mostly **Senior Managers** are not trained, educated and studied how to manage risks, about the nature of accidents and about the latent conditions, the failures in the system, which are the background of bad events and for accident producing conditions. **Top Managers** come and go. A common believe of Managers and Politicians is that the main threat to safe operation and to the assets comes from "bad" behaviours in lower ranks and from motivational shortcomings of their subordinates and as well from personnel's at the "sharp end" (Train Drivers, Train Dispatchers, Head Guards, Station Masters, Movement Authority Officers and Operators). But such an attitude runs counter to the message of the state-to-the-art knowledge and philosophy how to manage risks of accidents and how risks are managed in technical organizations in the Transport Sector, Railways, Aviation, Space Technology, Nuclear Power Generation, Oil Exploration.

It is much easier to "pin" the responsibility for an accident or an unsafe act on those sharp end personnel than on the prevailing latent conditions, the **Failures in the System**. **Managers** tent to uncouple their own individual fallibility from the corporate fallibility. By their nature and primary tasks those, who manage the technical Organization Railway, process productive and organizational skills rather than protective capabilities. They want the trains running thinking less of how safe they run. Only after an accident they awake up for a short period.

In Germany the **GMR** had to quit his position for all the technical and organizational shortcomings **(FAILURES IN THE SYSTEM; FIS)**, which caused the 03.06.1998 High Speed ICE Crash at Eschede, Germany, where 101 people got killed and 119 seriously injured.

The train derailed on a point, not designed for high speed, due to a faulty wheel tire, and half of the train set coaches crashed with 200 kmph against a pillar between the double tracks of an overhead road bridge. The bridge collapsed and 5 coaches plus the power car behind piled up at the bridge debris. The front part of the train set, which had already passed the bridge, came after 2 km to a safe halt.

Neither the engineering wheel design nor the point and the track clearance with the pillar bridge structure had been suitable for high speed over 160 kmph. And in addition there had been sloppiness in train (wheel) inspection and maintenance. And even the Safety Regulator, the Federal Office for Railway Safety in Braunschweig, can be declared as a ***"culprit"*** for commissioning the fragile wheel design, unfit and risky for high speed trains. And who is responsible for that this line had been commissioned for velocities over 160 kmph despite the unfit points and the obstacle of the bridge pillar between the two tracks!

High Speed Train Crash, Germany 1989, Eschede

<u>The lessons which can be learned</u> is: If the GMR is not fit in up-to-date and state-to-the art Methodology how to mange the Risks of the technical Organization Railway, and if he is not fit in the Methodology (used nowadays worldwide by Transport Undertakings) how to defend safe Train Operation against the hazard attacks, he should keep at least a professional consulting expert as a Safety Advisor, who knows his onions and who is fit in the mentioned methodologies. Aviation Industries and Transport Undertakings use such expert's consultancies or advisory boards worldwide.

The **CATASTROPHE** of a technical organization like Railways is mostly the **FINAL RESULT** of a woven chain of latent and active Failures. This chain is also called ***"HAZARD TRAJECTORY".***

<u>But what is actually a FAILURE</u>?

The example of the Spanish 24th July 2013 Alvia Train 4155 Madrid - Ferrol Talgo High Speed Train Crash shows, how **HUMAN FAILURES** and **MALFUNCTIONS** are dominant on all levels in the **SYSTEM RAILWAY, and that even the responsible management can be blamed to have made mistakes and misjudgements, which can be summed up as latent conditions or FAILURES IN THE SYSTEM (FIS), the parents of Accident.**

One can define a **FAILURE**, if one aims at a certain goal, but by mistake does not reach this goal. If Accident Investigators search for causation in depth, they mostly find that Human Failures had been made on all levels contributing finally to the outburst of the calamity. Human Actors stand behind of Technical Organizations, Engineering Designs, Planning, Maintenance, Repair, Training, Education, Managements, prevailing Cultures, Organizational Practices and Modes, lack of Supervision, behind Safety Rules and Procedures ect. One can estimate that nearly 100% of a catastrophe is caused by **HUMAN FAILURES and MISTAKES.**

Even the 26th December 2004 SLR Tsunami Train Disaster has a link to FAILURES IN THE SYSTEM as well to HUMAN FAILURURE, FALLIBILITY and MALFUNCTION.

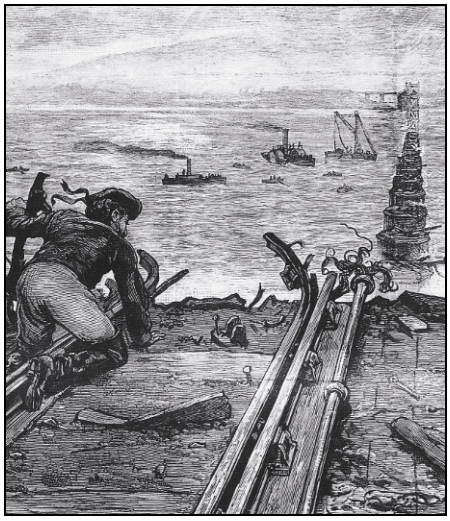
26th December 2004 Tsunami Disaster; the worst Railway Accident in History?

This is the worst ever TRAIN ACCIDENT in the world history of Railways!

It has to be classified not only as a NATURAL CALAMITY but also a MAN attributed ACCIDENT due to prevailing SLOPPINESS in the Stations of Ambalangoda, Madampe and Kahawe, and because of the missing technical link of the Signal Control to the Central Moving Authority in Colombo. The fact that the train could not be stopped and therefore got trapped by the Tsunami

wave and swept away, had been enabled by HUMAN FAILURES & MALFUNCTION and TECHNICAL SHORTCOMINGS. If not of the Malfunction of the personnel and the station master on duty at the Ambalangoda Station, selling curd on the platform instead of attending duty at the local control panel and taking the phone call from the GMR, the tragedy could have been averted. Therefore this calamity can be classified as a RAILWAY ACCIDENT, although those responsible for the Human Failure and Technical Shortcoming will not confess their responsibility. They want to be praised as saviors rather than blamed as culprits!

This mixture of **NATURAL CALAMITY** with **TECHNICAL SHORTCOMINGS** and **HUMAN SLOPPINESS and MALFUNCTION** is comparable with the cause of the famous **TAY BRIDGE DISASTER** of 28th Dec. 1879 in Scotland. Nobody survived this accident, when the train plunged in a stormy night with the bridge into the fiord.



TAY BRIDGE DISASTER 1879

There is no technology without mankind; therefore there exists also no technical failure without direct or indirect human influence or involvement. There is nothing ***"FAIL SAFE"*** or **"SAFE TO FAIL"** in this technical world!!The roots of failures are based on the functioning of **PSYCHOLOGICAL MECHANISM.**

The functioning of our mind is determined predominantly by two processes, by ***"similarity matching"*** and ***"frequency gambling"***.

If we have to decide between two different actions, we have the tendency to do things, we did already in previous similar situations or under comparable circumstances.

This called ***"similarity matching".***

But if we can not find in our mind a matching previous action, we will do, what had delivered us in the past mostly success.

This is called ***"frequency gambling".***

"Similarity matching" and ***"frequency gambling "***support us to fulfill routine handlings. This helps us to agitate with prefabricated handlings or actions and makes for us the world easier.

"Similarity matching" and ***"frequency gambling"*** help in Sri Lanka the Loco Driver to digest and interpret the manifold and complex Colour-Light Signal Aspects with its Colour-Light combinations, when he has to find to the right action within few seconds. This helps him to simplify the manifold information's.

The way our brain works when processing information's on the way to an appropriate handling is according the so-called ***"FUZZY LOGIC"***. This is a natural methodology of our brain to sort out and handle inprecise or diffuse data to be used for problem solving. Fuzzy logic helps to come to precise outputs from inprecise inputs. Our brain works with such a process control methodology. The method processes inprecise information's or only few information's, processes those information's with experiences of the past and thus comes to a tangible and precise output for process control.

The operator sticks to his experience and long-standing tradition. He will do automatically without many considerations, what he has done frequently earlier successfully without negative experiences or even punishment, even if his actions have violated safety rules. Failures can find their way into routine behaviours.

But there rests also a **DANGER**. A slight change in the circumstances or situation can thwart the success and turn the process towards a catastrophe. Experience and Routine based action, which went well in the past, may become the source for a hazard. This is a part of error causation in conjunction with cognitive psychological behavior. **The danger is that faulty behaviors, which had previously no negative effect or result and which went on unpunished for a longer period, but made the world easier, will penetrate, loop, creep in or worm into routine habits!**

At Ganemulla presumably it had occurred, that faulty behaviors, which had previously no negative effect or result and which made the world easier, had wormed into the routine of the train driver when he approached Amber and passed a signal on danger and hereafter crashed, after negotiation the curve with obstructed visibility, in the rear end of a halting train, not secured by an inner home signal with corresponding repeaters in the curve.

The that time GMR jumped out of his responsibility by declaring, that the causation

(hazard trajectory, which penetrated through the loop holes of the Signalling defense layers ; see the methodology of James Reason[1], how to lower the probability of risks)
is unknown, thus preventing that this incident could have had the needed repercussions to avert the next rear-end-train collisions at Alawwa and Ambepussa.

A professional investigation procedure would have constructed a likely scenario as working hypotheses, a HYPHOTHETICAL RECONSTRUCTION OF THE BAD EVENT. A likely scenario of a plausible causation has been painted by the author in the Technical Paper: "Ultimate Goal to prevent Railway Accidents".

The lessons which can be learned from the Ganemulla incident is: If the GMR is not fit in up-to-date and state-to-the art Methodology how to mange the Risks of the technical Organization Railway and if he is not fit in the Methodology (used nowadays worldwide by Transport Undertakings) how to defend safe Train Operation against the hazard attacks, and if there is no independent Safety Regulator, he should keep at least a professional advisor or consulting expert, who knows his onions and who is fit in the mentioned methodologies. Aviation Industries and Transport Undertakings use such expert's consultancies worldwide; but SLR NOT!

09th Oct. 2008 Ganemulla Rear-End-Collision; what had been the Cause? No Lessons learned?!

There are certain cognitive functioning's, which proof that we can process only relatively little information at a time. Our mind tries to come to the correct conclusion mostly only on basis of two or three information's and processes the information's according the so-called ***"fuzzy logic***". The modern technological world produces manifold information's and aspects. To tackle with this complexity, we have to make the world for us subjectively easier. We must reduce the complexity. It becomes obvious, that also **FAILURES** and **ERRORS** can be produced by this mental reduction loops.

If two persons are sitting in the cab of a loco, there is also the danger that the Driver might boost or show-off with his longlasting COMPETENCE in the presence of his Assitant.
This danger is well known in aviation between Pilot and Copilot and had led on 8th Jan. 1989 to a crash of a Boeing 737 on a flight from London to Belfast. 47 Passengers had been killed and 79 had been seriously wounded, when the plane crashed on a highway in Leicestershire.

What can be done to mitigate the RISK BY HUMAN ERRORS, FALLIBILITY, FAILURES and MALFUNCTIONS; what help renders PSYCHOLOGY?

First of all we have to accept, that wherever there are humans there are also errors and failures. It is not possible to avoid by 100 % risks and hazard caused by human error or mistakes. ***Fools are so ingenious!***

HUMAN FAILURE MANAGEMENT is an indispensable tool to manage risks of a technical organization (Railway).

A comprehensive guide for the railway industry in **UNDERSTANDING HUMAN FACTORS**, developed by the Bristish Rail Safety & Standards Board from June 08, one can find in the publication ISBN 978-0-9551435-3-3 or as PDF under http:// www.rsb.co.uk. This guide gives answeres to the question, what practical advice can a HUMAN FACTOR APPROACH offer to railway staff without requiring them to be experts in the subject.

Already in the preliminary stages in the forefront not only the technical devise had to be designed and optimized but also the **PSYCHOLOGICAL FACTOR taken into consideration:** How will the human operator react on the system, how will he process the exposed information's, what will be his handlings and actions as the result of the cognitive process?

TECHNICAL DEVICE - HUMAN INTERFACE has to be adequately designed.

Many efforts are undertook to make a technical system more safe (signalling). But are those systems also user friendly coordinated with the psychological behaviours of the operator?

Constant and repeated **EDUCATION**, **TRAINING** and SUPERVISION in handling the technical

system in any predictable situation and even under **ODD SITUATIONS** (see Murphy`s law) under **PSYCHOLOGICAL ASPECTS** is essential. During the training of Train Drivers and their Assistants, they have to be confronted about routine failures, which can loop in, creep in and or worm into routine behaviors. Failures can find their way into routine actions. Training about the danger of too much routine is essential.

European Railways use **SIMULATOR TRAINING FOR TRAIN DRIVERS** to increase Security and Safety. On the simulator all errors and failures, which might worm into the habits of Train Drivers, can be addressed. **SIMULATOR TRAINING** helps to increase the train drivers **PERFORMANCE STRENGTH and to eliminate bad behaviours.**

Essential for a successful **TRAINING** is the knowledge of its own strength and weakness, and the coaching of alternative reactions under stress in emergency, unexpected and odd situations.

HUMAN ERROR has to be met human friendly with human psychological behaviour adaptation and not the other way round. If not the case, this might become in crisis situation an enormous hazard (see frequent rear-end-train-collisions in Sri Lanka).

Man and Technique must match. They meet at the Interface of Technical System and Human.

It is obvious that in **SLR COLOUR-LIGHT SIGNALLING** and **PSYCHOLOGICAL PROCESSING BY LOCO DRIVERS** are not in compliance as it should be.

Human Psychos can not be changed, but technical devices and designs can be adapted to the Psychos.

SLR SIGNAL ENGINEERS MUST KNOW AND TAKE INTO ACCOUNT, HOW HUMAN PROCESSES THE MANIFOLD ASPECTS OF THE COMPLEX MULTI ASPECT SIGNALLING BY MEANS OF THEIR INDIVIDUAL MENTAL CAPABILITIES.

Signal engineers can not creep out of the responsibility for safe train operation by their argument, they have installed a *"falil-safe"* device.

Together with the Train Drivers the RISKY routes and sections with insufficient Signalling Protection, where conflicting situations and hostile train movements can happen or are likely, have to be identified and assessed. Loco Drivers have to be trained to be on those routes most vigilant. Train Drivers have to be prepared to be aware of the specific risks and hazards on those routes.

Standards of Human Factor Management

This is an issue of the South African National Railway Safety Regulator.

SLR is marred by the lack of a professional Safety Advisor, a professional Safety Advisory board, be the lack of an independent Safety Regulator, Institution or Commission with professional experts in Safety Technologies, Risk Recognition, Hazard Awareness, Risk Management and Hazard Prevention knowing about state-to-the art methodology and tools of **ACCIDENT INVESTIGATIONS and PREVENTIONS. There is no proper PROFESSIONAL SAFETY MANAGEMENT SYSTEM within SLR.**

As defined by the South African National Safety Regulator Act,

"HUMAN FACTORS" means factors which include the perceptual, physical and mental capabilities of people and the interactions of individuals with their job and working environments, the influence of equipment and system designs on human performances, as well the organizational characteristics that influence safety-related behaviors and at works.

The purpose of **HUMAN FACTO MANAGEMENT** is to reduce occurrences attributed to **HUMAN ERROR** by optimizing human capital and by mitigating the risk and hazard associated with human factors to an acceptable level.

The **MANAGEMENT OF HUMAN FACTORS** shall form an integral part of the operators' safety management system.

The requirements of these standards have to overlap with other components such as recruitment, selections, training, fitness for duties, health and medical issues.

The concept of **DUAL RESPONSIBILITY** together with the **DUTY OF CARE PRINCIPLE** between employer and workforces is emphasized. This is regarded as crucial to ensure **SAFE RAILWAY OPERATION** with lowered risks. The **TOP MANAGEMENT OF A RAILWAY WITH ITS GENRAL MANAGER IS CHALLENGED. He should know, what might go wrong in the system he is responsible for and should organize in time appropriate counter measurements.**

HUMAN RELIABILITY IN RAILWAY OPERATIONS

Based on the theory of **COGNITIVE PSYCHOLOGY** regarding **HUMAN ERROR CAUSATION** the German Aerospace Centre, Department for Traffic Technology in Oberpfaffenhofen, Germany, has developed a methodology to appraise **HUMAN RELIABILTY IN RAILWAY OPERATIONS**, published in Eisenbahn Technische Rundschau, ETR, November 2010, No. 11, p 762, Eurailpress, Hamburg, Germany, ISSN 0013-2845.

The probability on approach to a signal indicating danger to pass this signal at danger is in the range of 1 in 10.000 to 1 in 100.000 as evaluated by several Railways. This mean, that an average train driver will not pay heel to one signal

out of 10.000 to 100.000 Signals indicating danger. I guess, in Sri Lanka the failure rate is much higher due to the complexity of the system and due to the fact that **RED** is also used for other information's than to bring the train to a dead stop. **RED** is not any more taken as serious as it should be. Train Drivers have been used not to be any more afraid of the Aspect **RED.** Often Passing of Signals at Danger (SPADs) goes unnoticed. SLR has no proper tools to register and monitor cases of SPADs.

Not seldom trains overshoot Signal on Danger due to **weak or defective brakes**, or because of Human Error of the train driver in wrong estimation of the braking distance influenced by the train brake power. Several Train Drivers have developed the BAD HABIT not to take the Warning or Caution Aspects with **AMBER** serious as they should do. They slow the train down too late and try to come to the next Signal at Danger as close as possible. An AMBER Caution or Warning Aspect does not only mean "be prepared to stop at the next Signal at Danger (**RED**) but should also mean:

"SLOW DOWN NOW AND NOT LATER. LATER MAY BE TOO LATE".

A comprehensive brake power test with a brake certificate, before a train is send on a run or after coupling a locomotive, as in India, is unknown in Sri Lanka; see format

of a Brake Power Check Certificate in ***COMPRESSED AIR BRAKE SYSTEM GUIDE***, P.C.Gupta, Shiram Prakashan Publishers, Faridabad, India, 2004, p.125 ff.

In the **CENTRE** of the modeling of the working system stands the interacting human-technical system **INTERFACE**. The train driver has to interact with the signalling and the train driving on his working place. This **INTERACTION** can be influenced by technical, physiological, personal and organizational factors. Motivation and **SAFETY CULTURE** – it may be ***PATALOGICAL*** or **GENERATIVE** – are also of great influence.

INPUTS for this **INTERACTION INTERFACE CENTRE** are **PERCEPTIONS** of **SIGNAL ASPECTS** and **TRACK IMAGES** ahead. By a so-called **COGNITIVE LOOP PROCESS** the **PERCEPTIONS**

- in Sri Lanka for example the perception of 22 different aspects and combinations using **AMBER**, 43 Aspects and combinations with other colours using **RED** and 19 different aspects and combinations using **GREEN** -

have to be mentally processed and brought into line (synchronized, adjusted, collated, equalised, aligned, adjusted, harmonised, reconciled) with rules, concepts, experiences, action-schemes, of which the train driver has to be aware, before coming to the **OUTPUT** with a handling or action, for instance to reduce the train speed or to bring the train to a halt starting from a certain brake point and ending up at a certain stop point (brake distance). SLR has no automatic Train Protection System, which controls this task. This task is left to the **HUMAN RELIABILITY** of the train driver.

The over 55 Aspect Srilankan Colour Light Signalling can be assigned to be of a category of **weak speed signalling mixed with elements of route signalling.**

For a train Driver in India or England it is much easier to process in his mind the **AMBER** Aspects, because there are only two and not 22. For a Train Drivers in other countries **RED** means only, come to a dead stop, and nothing else. And there should be no other colour combinations with **RED;** **see *International Comperitive View on Aspects of Light Signals* by Claudia Machner and Göran Unzner in DER EISENBBAHN INGENIEUR, EI, 10/13, p. 12.** But Not so in Sri Lanka!

The classical arrangement of the **LOOP PROCESS** is

"PERCEPTION – INFORMATION PROCESSING – DECISSION - ACTION".

If the train driver detects a whistle board, the loop process is simple. He knows and is trained to press with his hand the whistle button. The **LOOP PROCESS** is initiated by only one perceptive, and there are no other feed back information's to be mentally processed. The probability, that the train driver might make a mistake is marginal.

But if the train driver gets confronted with one of the 55 Colour Light Aspects in use in SLR, the situation becomes very complicated and conflicting, and therefore much more **FAILURE PRONE.** If the train driver in Sri Lanka gets confronted with one of the 22 aspects using **AMBER,** the situation becomes as such: First he must recognise within few seconds the aspect picture and keep the picture in his mind,

than he has to interpret the given information and process it. Mostly he will make his world easier by reducing the **INFORMATION FLOOD** to one or two simple information's: ***"be cautious and be prepared to stop at the next signal ahead",*** regardless what the multi aspect system want to tell him precisely. Out of ***the big multi aspect picture*** he will make in his mind an **smaller picture** and will process the reduced information by **fuzzy logistic behaviour**. Otherwise he can not come to an **OUTPUT** or result within few seconds. He can also not store the full information picture in his mind. He might come to the result **(OUTPUT)** that he has now to reduce the speed of the train to be prepared to bring the train to a safe halt in front of an approaching Signal on Danger with **RED,** or because he might be send to a deviation ahead. But one can not exclude by 100% that he might make a failure in such a complex situation.

There is plentiful evidence that The FAILURE RATE INCREASES WITH THE COMPLEXITY OF THE TECHNICAL SYSTEM! It is a well known rule that higher complexity leads to a higher rate of HUMAN FAILURES (besides to a higher rate of Technical Faults).

By our nature, we humans are not prepared by evolution to estimate higher speeds than approx. 40 kmph exactly. The maximum speed we experienced in our evolution had been when riding on a horse. To detect a higher speed we have to look at a speedometer. This speedometer information has to be fed back in to our brain for another **LOOP PROCESS**. Mostly the train driver has to repeat this feed back process several times and has to pass in his mind several consecutive Loops. When applying the compressed air brake he has to process feed back information's from the pressure gauges of the Brake Pipe (BP) and the Brake Cylinder (BC) and as well from the relation of reciprocal pressure increase (BC) and pressure decrease (BP). One can understand that under this constellation the probability for the **OUTPUT** to be faulty is much higher than in the simple case of the Whistle Board.

In SL the situation is mostly worse, since on most of the locomotives the **SPEEDOMETER** are not functioning and the Loco Driver gets **NO FEED BACK ABOUT THE ACTUAL SPEED** and of the **SPEED DECREASE (DECELERATION-RATE, actual BRAKE CURVE) in order to control his action, to come on the right point to a halt.**

The situation also worsens by the fact, that mostly the Train Drivers are not trained to watch the pressure changes of the BC and BP. **And in addition on the new S12 the BC Gauge is wrongly marked**. And nobody worries about this mistake. Often the Train Drivers are not properly instructed and do not exactly know, what is the difference of Vacuum and Compressed Air Brake functioning's and how the brake application has to be performed accordingly. They are not trained to watch the BC and BP pressures when applying the brake.

One of the main reason, why despite the low traffic density there are relatively many severe accidents on the new **Colombo-Galle Highway** is, that the road vehicle drivers are not used to control their speed by looking on the speedometer. After going 100 kmph for some time, they loose the feeling for the actual speed and than mostly they over speed when coming to the exits.

I always train my Sri Lankan friends, when driving on the new highway, to have always a glance on the speedometer, especially when slowing down for an exit.
But who trains and coaches the Sri Lankan Train Drivers to watch the speedometer – if there is any - and to watch the BC and PB pressures when applying the compressed air brake.

The SLR Multi Aspect Colour Light Signalling is of HIGH COMPLEXITY and therefore associated with more HUMAN ERRORS than the simple British 4 Aspect System, also used in India.

INFLUENCES ON THE FACTOR HUMAN ERROR, FAILURE , MISTAKE, FALLIBILITY & MALFUNCTION

The Institute Journal No. 32 from October 2004 of Institute for Railway Performance of the Technical University Vienna, Austria, deals with aspects of influence on the **FACTOR HUMAN ERROR** in its studies about **SAFETY IN RAILWAY OPERATION.**

The authors emphasize that mostly **HUMAN ERROR** leading to a mishap is enabled by **FAILURES IN THE SYSTEM**. Investigation on what had been the kind of Human Error or Human Malfunction should be performed independent from **Apportioning of Blame or Guilt**, independent from the search for the ***"CULPRIT TO BE BLAMED GUILTY AND SEVERELY PUNISHED".*** The verdict of guilt can be left to the jurisdictional court.

Important is to get to know how the Human Failure had been possible to trigger of a mishap and how this had been sponsored or enabled by the **FAILURE IN THE SYSTEM (FIS). FIS** are the stage for **HUMAN ERROR & MALFUNCTION** in nearly **all RAILWAY ACCIDENTS**. To avoid the next accident on the way to come, such **FAILURES IN THE SYSTEM** had to be detected and dealt with. What can be learned from **HUMAN ERROR & MALFUNCTION** and what enabled it, is important to get to know, not to punish a culprit.

FAILURES IN THE SYSTEM

can be Weaknesses in the Safety Culture (Pathological Culture, "*criticism not wanted"*); too much Trust, Confidence and Overestimation on Technical Safety Systems, Measurements, Rule Works; general low Awareness for Hazards in the minds of all level especially of the top management; insufficient Knowledge in the Methodology of how to manage risks of technical organisations (Railway) and how to investigate accidents in depth; missing of state-to-the-art Experts Knowledge and Skills; insufficient Supervisions; ineffective Communication Structures; ineffective or unsuitable Technical Measurements, Specifications, Designs, Technical Systems and Devices overstraining the Human Capability (Information Processing of the 55 SL Multi Aspect Colour Light Signalling!); ineffective or insufficient Training to handle difficult situations and odd problems; insufficient Teaching and **Controlling**; prevailing Sloppiness in the System; Overestimation of own skills; ineffective or

insufficient Cooperation between the Disciplines (Departments); Free-for-all Scramble for Priority; unprofessional Decisions; Mismanagement; faulty Concepts; Missing of Tools and Instruments (f.i Speedometers on locos); poor Maintenance, Repairs, Services, Tests, Examinations of viable Safety Devices (Train Brake Systems); high Complexity of the Colour Light Signalling;

"TRICKY" **Routes not adequately secured by Signalling Systems.**

The dilemma of **SLR** is, that there is no **Safety Advisor, Safety Advisory Board**, no independent **SAFETY REGULATOR or SAFETY COMMISSION**, watching over Safe Train Operation and responsible fo**r COMMISIONING and CERTIFICATIONS.**

A system does not need to be perfect. Important is, that not too much accident prone failures come together. Often an accident can be averted, if only one contributing factor of the **HAZZARD TRAJECTORY**[1] can be eliminated. One has to learn lessons from failures. There must be a willingness to confess and to acknowledge that there are **FAILURES IN THE SYSTEM (FIS)** to be tackled with and to be addressed.

Accident Investigations should be performed under a so-called "GENERATIVE CULTURE"[1]. Investigation in depth[1] must be allowed. Investigations should have the needed repercussions beyond the individual case (to search only for culprits to be blamed guilty and punished) with advices and recommendations to avert similar accidents already on the way to come. The investigations had to be carried out by independent experts. Railway Authorities and Politicians should not be allowed to interfere or to micromanage in the investigations or block results for political reasons as it is mostly the case in Sri Lanka

"Wise men learn by other's harm, fools by their own"

– see paper ***"Organizational barriers to learning the lessons from major accidents"*** given by D.A .Lucas to the Safety & Reliability Society Symposium on "Safety and Reliability in the 90-ties", 19/20th September 1990, Altrincham, Manchester, UK; see also D.A.Lucas "***Understanding the Human Factor in Disasters***", Interdisciplinary Science Review, **17**, 1992. p.185ff.

One can come to the conclusion:

"SAFE TRAIN OPERATION IN SRI LANKA IS IN A SORRY STATE OF AFFAIRS."

SIGNALS PASSED AT DANGER (SPAD)
"HUMAN ERRORS ARE A CHANCE FOR LEARNING"

Feature Article by Dr F.A. Wingler

Leverkusen: 15-03-16

The above headline is the motto of the independent British Rail Safety and Standards Board (RSSB) established to speed-up **SAFETY** in the system BRITISH RAIL; see: Interview with George Bearfield, Safety Director of Rail Safety and Standard Board, UK, in ETR, March 2016, No.3, eurailpress, Hamburg Germany, ISSN-0013 – 2845.

British Rail has made in the last decade an enormous improvement of its **SAFETY RECORDS** utilizing modern methods based on the RISK and **HUMAN ERROR MANAGEMET** methodology developed by James Reason; see: James Reason, ***MANAGING THE RISKS OF ORGANIZATIONAL ACCIDENTS***, Ashgate Publishing, Farnham, UK, ISBN 978 1 84014 105 4; ***THE HUMAN CONTRIBUTION***, Ashgate Publishing, Farnham, UK, ISBN 978-0-754-7402-3; ***A LIFE IN ERROR***, Ashgate Publishing, Farnham, UK, ISBN 978-1-472 418418, 2013;
See also Frank Wingler, ***RISK AND HUMAN ERROR MANAGEMENT, a Guide for upper Echelons of Sri Lanka Railways in RISK & HUMAN ERROR MANAGEMENT and ACCIDENT INVESTIGATIONS, based on the DOCTRINS of J. REASONS and Studies & Researches on the NATURE OF HUMAN ERROR***, private publication, 2013, email: drwingler@web.de

RSSB has published February 2016 a study on the **HUMAN FACTOR** leading to **SIGNALS PASSED AT DANGER (SPAD);** see: "Helping improve investigations into signals passed at danger (SPADs)", www.rssb.co.uk. Despite there had been in GB no fatal accidents caused by Signals passed at Danger in the last years due to improved train control systems, there are still every year in GB about registered 300 SPAD cases – a hint that things do not work as planned.

In worldwide railways the contribution of the **FACTOR HUMAN ERROR** and **HUMAN FALIBILITY** on unwanted bad Railway Events is still in the range of 30 to 40 %. The fundamental attribution **ERROR** is basic to the **HUMAN ERROR**. It should be the aim of all operators to reduce this contribution on the way of an overall reduction of accidents and near missed accidents for the ultimate goal to prevent Railway Accidents; see: Aryan Bhushan, M.M. Agarwal, ***INDIAN RAILWAY SAFETY – Ultimate Goal to prevent Railway Accidents,*** revised Edition 2015, Bahiri Brothers Publishers & Book Sellers, Delhi, 2015.

In early years under a prevailing so-called ***"PATHOLOGICAL SAFETY CULTURE"*** the so-called ***"PUNITIVE METHOD"*** had been in the foreground to "pin the culprits to be severely punished" or to blame ***"bad people"*** rather than the situation. Nowadays Safety Experts around the globe have understood, that the punitive method is a blunt weapon of nearly no effect on the way to improve the safety margin. It works even counterproductive. Such an approach leads, that people on all fronts will do everything to avoid detection of what really had happened. Failures in the System or latent unsafe Conditions with often far reaching history, the parents or breeding ground for accidents, are overlooked.

Since then a ***"NO BLAME CULTURE"*** had been established. Nobody should be discouraged to participate at the discovery, uncovering and detection and nobody should be discouraged to provide information.

Learning and taking lessons from own and others bad events are key instruments for improving Safety Records.

Discipline and adherence strictly to the safety rules and procedures has to be trained and constantly watched, monitored and controlled.

In collaboration of all ranks in a technical organization with a high risk potential one has to find out, what are the "***HUMAN ERROR PRODUCING FACTORS".***

It is rear for Railway Accidents to result from a single error, almost always there will be a chain of contributing factors starting often from ***"LATENT UNSAFE CONDITIONS***" and missed opportunities. Watching out for precursors of unwanted bad events (unsafe acts, unsafe conditions), sharing the details and learning from them can help to prevent the build-up of a chain of contributing factors, which might one day result in a real disaster; see: Christopher Jackson, editorial/comment in Railway Gazette International, March 2016, page 3, Sutton, GB.

A well functioning **SAFETY INFORMATION SYSTEM** under a so-called "***GENERATIVE CULTURE",*** where information are actively searched, messengers are trained and rewarded, responsibility is shared, failures lead to far reaching reforms and new ideas are welcomed, is an important error management tool.

A well functioning **SAFETY INFORMATION SYSTEM** depends on the willingness of individuals to report events in which they themselves may have played a significant part.

There is also an important lesson for those, who think that simply installing more advanced technology like Positive Train Control (PTC) or European Train Control System (ETCS) will eliminate all accidents. It won`t. Technical advances will undoubtedly continue to improve railway`s safety records. But they have to be considered and treated as a part of an overall risk reduction strategy, which embraces so much more.

James Reason quotes:

> **EFFECTIVE SAFETY MANAGEMENT** is like a long-term fitness programme. Rather than struggling vainly to exercise direct control over incidents and accidents, managers should regularly measure and improve those processes
>
> − design; hardware; constant and repeated teaching, training, education, coaching and
>
> examination & supervision especially of the so-called ***"FRONTLINERS"*** as there are: Train Drivers and their Assistants, Dispatchers and Control-Room (Movement Authority) Operators, Station Masters, Guards, Platform-Personnel; procedures, maintenance, planning, budgeting, communication, goal conflicts and the like –,
>
> that are known to be implicated in the occurrence of accidents. These are the processes, which managers are hired to manage. In this way, safety management is not an add-on but an essential part of the system`s core business in order to navigate the organization of high risk potential towards an **INCREASING RESISTANCE** against hazards.

In recent times **Sri Lanka Railways** faced several fatal train crashes, several unwanted hazardous events and several near missed accidents, where **SPADs** had been obviously been involved.

The SLR Color-Light Signallng is the most complex and complicated Signalling System around the globe with over 55 valid Aspects. It does not know any automatic train protection system and no protection-overlap behind most of the main or stop signals. This system

separates trains from conflicting situations or hazardous arranged train movements only by ***"the thickness of one signal post".*** Overshooting of a Signal at Danger can lead to unwanted hazardous situations and even to accidents. This system does not use distinguished and marked Repeater Signals for Warning Aspects on sections of poor or hindered visibility. There are 22 different valid Warning Aspects with **AMBER**. SLR has no official comprehensive hand-book of their complex Color-Light Signalling for its "frontliners". In addition train brake system are often not properly maintained, checked and tested leading sometimes to weak train brake-power or brake failures.

The author has discovered that several SLR train drivers are not any more afraid of **AMBER** Aspects and take them not as serious and threatening as they should do. Some train drivers have the bad habit, before slowing down to come as near as possible to the next Signal at Danger in the expectation that the signal will turn to clear the moment when reached.

Railways all over the globe have experienced that the so-called "experienced train drivers with routine" are more likely to be entangled in an accident than less experienced. "Experienced" people are less afraid of "**RISKY"** and "**TRICKY SITUATIONS".** Mostly such Signals are passed on danger, which usually show a clear aspect.

Routine has two sides. Most of serious mishaps in technical organizations (Railways) are caused not by beginners but by experts with many years of experience and routine. They are the operators who mostly infringe safety rules. By their routine they often forget to be afraid of risks. They have the fallacious and jugglery feeling that thanks their experience they cannot make a mistake.

There is no technology without mankind; therefore there exists also no technical failure without direct or indirect human influence or involvement.

The roots of failures are based on the functioning of **PSYCHOLOGICAL MECHANISM.** The functioning of our mind is determined predominantly by two processes, by ***"similarity matching"*** and ***"frequency gambling"*** (J. Reason).

If we have to decide between two different actions, we have the tendency to do things, that we did already in previous similar situations or under comparable circumstances.

This is called ***"frequency gambling".***

"Similarity matching" and "frequency gambling" support us to fulfill routine handlings. This helps us to agitate with prefabricated handlings or actions and makes for us the world easier.

"Similarity matching" and "frequency gambling" help in Sri Lanka the Loco Driver to digest and interpret the manifold and complex Color Light Signal Aspects with its manifold Color Light combinations, when he has to find to the right action within few seconds. This helps him to simplify the manifold information's.

The way our brain works, when processing information's on the way to an appropriate handling, is according the so-called ***"FUZZY LOGIC"***. This is a natural methodology of our brain to sort out and handle imprecise or diffuse data to be used for problem solving. Fuzzy logic helps come to a precise output from imprecise inputs. Our brain works with such a process-control methodology. The method processes imprecise information's or

only few information's, processes those information's with experiences of the past and thus comes to a tangible and precise output for process control.

The operator sticks to his experience and long-standing tradition. He will do automatically without many considerations, what he has done frequently earlier successfully without negative experiences or even punishment, even if his actions have violated safety rules. Failures can find their way into routine behaviors.

But there rests also a **DANGER**. A slight change in the circumstances or situation can thwart the success and turn the process towards a catastrophe. Experience and Routine based action, which went well in the past, may become the source for a hazard. This is a part of error causation in conjunction with cognitive psychological behavior. **The danger is that faulty behaviors, which had previously no negative effect or result and which went on unpunished for a longer period, but made the world easier, will penetrate, loop, creep and worm into routine habits!**

A faulty behaviour of Train Drivers (which got routine) is, not to be afraid any more of Amber Warning Aspects and not to take such aspects serious.

On invitation the author has given several seminars to SLR Train Drivers on the topic "Signalling and Human Error" and has given the following message:

Take Warning Aspects with Amber **SERIOUS** and slow down now and not **"LATER"** when reaching the next main signal. **"LATER"** may be too late.

The Starting point or birth-place of a SPAD is mostly the preceding Amber-Warning Signal, when not taken seriously.

The defense against SPADs is comprehensive teaching, training and coaching of Train Drivers to eliminate the ***"bad habits"***, which have sometimes wormed into their mind under their daily routine.

Past experience from many countries suggests that out-of-course running can create a pressurized situation, where mistakes may be made. Therefore it is essential to train and prepare the ***"frontliners***", especially the train drivers, how to tackle safely with unexpected out-of-course running situations as well with so-called ***"tricky"*** and ***"risky"*** situations and sections with upmost vigilance.

Repeated Teaching, Education, Coaching, Training, Examination and Supervising especially of "Frontliners", are effective tools to minimize the contribution of the factor **HUMAN ERROR** and **HUMAN FALIBILITY.**

Four-Aspect CL-Signalling in GB

In his article in the Journal Signal und Draht 102 (2010) Heft 7/8, p. 24ff, H. de Raad explains ***Why Loco Drivers pass sometimes Signals on Danger.***

See for more understanding of **SPADS** also:

H. Schlatter ibid, 102 (2010), Heft 3, p.12ff ***Theoretical Considerations for Passing Signals on Danger***;

B.Ryan at al. ***An Analysis of the Content of Questions and responses in Incident Investigations: Self Reports in the Investigations of Signals Passed on Danger (SPADS)***, Safety Science 48, 2010, 3, p.372ff;

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E. Hollnagel et D.D. Woods *JOINT COGNITIVE SYSTEMS ENGINEERING*, Boca Raton Fl: Taylor & Francis, 2005.

M. Arenius et O. Sträter *COGNITION ON TRACK – A NEW MODEL for HUMAN RELIABILITY ASSESSMENT (HRA) in the RAILWAY DOMAIN* in Gestaltung nachhaltiger Arbeitssysteme, 58th Congress of the Association for Work Science, GfA Press, Dortmund, Germany, 2007, page 601ff.

J. Gilroy et E. Grimes *THE DEVELOPMENT AND APLICATION OF A RAIL HUMAN RELIABILITY ASSESSMENT TOOL; PEOPLE AND RAIL SYSTEMS - HUMAN FACTORS AT THE HEART OF RAILWAYS*, 2007, p.455ff.

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“Old Warriors” ; Semaphore Signalling and GM G12 in Argentina

SUMMERY:

This feature article describes **HUMAN ERROR, HUMAN FAILURE, HUMAN MALFUNCTION, HUMAN MISTAKES, HUMAN FALLIBILITY** in Railways, and what enables Human Error, Failure and Malfunction to trigger off Mishaps, Calamities, Accidents, Disasters, Catastrophes, Conflicting Salutations and Hostile Train Movements at the so-called ***“Sharp End”*** of the so-called ***“Hazard Trajectory”***[1].

One has to understand the Nature of Human Errors and the Human Error Causing Factors.

There is nearly no Railway Mishap without a root in **FAILURES OF THE SYSTEM.**

The Malfunction is mostly **SIGNAL PASSED AT DANGER, SPAD,** on the so-called ***“sharp end”*** of the Hazard Trajectory penetrating through all Defence Layers (Signalling).

In Sri Lanka one can detect a connection of **SPADs** with the **COMPLEXITY** of the Multi Aspect Colour Signalling with its manifold extra Aspects, which can be assigned to a ***mixture of Route Signalling and Speed Signalling or Weak Speed Signalling***, not adequately securing **“RISKY and TRICKY ROUTES”.**

Train Drivers have often the **BAD HABIT** not to take Warning or CautionAspects with AMBER as serious as the should do. Not seldom they slow down later when coming close to the next Signal at Danger. "Later" may be sometimes **"TOO LATE"**.

The elaboration is based on studies of available expert’s literature & research studies, which describe the Methodology and the Physiological Aspects utilised by experts of worldwide Railways, respectively by Safety Advisors, Regulators, Safety Commissions, Safety and Standard Boards to mitigate the negative effects on **SAFE TRAIN OPERATION**.

Let’s hope, that this will be a valuable tool to

develop **DEFENCE STRATEGIES** against **HAZARD ATTACKS** on **SAFE TRAIN OPERATION within SLR,**

and to design **DEFENCE LAYERS by SIGNALLING SYSTEMS and DEVICES.**

The recent Train Crashes and Bad Events on the Main Line reveal again that the SLR Colour-Light Signalling has holes like a slice of "Swiss Cheese", through which Hazards can penetrate, and that the Train Movements on Tricky or Risky Routes are not properly secured by the Colour-Light-Signalling.

The challenging task of upper echelons is, to make the system Railways less vulnerable by bad events, and to amke the system increasing resistant to hazards by proactive process measures with Commitment, Competence and Cognisance; see James Reason[1] and H. Mintzberg, ***Mintzberg on Management; Inside Our Strange World of Organisations,*** Free Press, 1989, New York, USA.

SLR have to overcome its dilemma, that it has no professional Safety Advisor or Advisory Board or Regulator, skilled and trained with up-to-date knowledge and methodology, how to manage the risks of accidents in technical organisations (Railways) and how to investigate accidents as well near-missed-accidents (narrow escapes) in depth in a modern professional way. There is no independent Safety Regulator, Commission or Board, which could not be overruled by either the Railway Management or by Politicians and the Government. The dilemma is, that SLR is its own Safety Regulator and that governmental Politicians can block fact findings of investigators like in the case of the Crash-Worthiness Investigation by the Moratuwa University of the Indian build S11.

Smashed Glasfibre-Polyester Front-Part of crashunworthy India build DMU, Class S11, SLR; Crash at Pothuhera 30th April 2014

HOW MUCH SAFETY, HOW MUCH PROTECTION, HOW MUCH DEFENCE AGAINST HAZARDS

Abergale England, 1868

By Dr. Frank Wingler, November 2014

This chapter is based on the Thesis of J. Reason[1]

SAFETY means **FREEDOM FOM BAD EVENTS**. There is a relationship between **HAZZARDS, DEFENCE** and **LOSSES** in all technical Organisations**.** To implement safety costs money for technical devices as well for operational issues, training and teaching, supervision, proactive measures and needed corrections. There is a relation of spend money (input) and incurred losses by bad events. Not enough spend money leads to higher losses by bad events. Whereas the input – the invested money – can be precisely measured, the losses are not directly measurable.

It comes to an economical question as well to a humanitarian and ethical question, how much should be invested into Safe Operation and Protection of assets, environment, in avoidance of aggregated hindrance costs and in intactness of human lives. It is also a question, how much money the Organisation has at disposal and can afford to invest in Safety and Safety Culture.

After Railway Accidents in Sri Lanka Politicians and Managers lament louder about the damage incurred to the assets than about the humanitarian losses. Thy are quick to pin ***"culprits"*** at the so called "sharp end" of the Hazard Trajectory (see theorem of James Reason[1]) to be severely ***"punished",*** instead to look into the latent prevailing unsafe conditions of far reaching history, into the Failures in the System (FIS), the parents, which enabled the outburst of the calamity or of the bad event, as

if the ***"severe punishment of sharp end personnel"*** can thwart the next accident already on the way to come.

Losses of assets, damaged, ruined, wrecked rolling stocks and damaged tracks and infrastructure hurt SLR directly. Loss of lives and aggregated costs hurt SLR less.

But how to evaluate the losses of lives, the costs of injured people, the aggregated losses for society and economy? Killed or injured people by Railway Accidents comes relatively "***cheap"*** for the Organisation SLR, since only marginal compensations are paid, which even often do not cover the funeral costs.

In this respect the 26th December 2004 Tsunami Disaster had been relatively ***"cheap"*** for SLR but highly **"costly"** for the economy and society. SLR lost some written-off already corroded Rumanian Coaches and had to spend some money to recover the ill-fated M2 No. 591, Manitoba, and to refurbish this locomotive. SLR lost the revenues for some month. The aggregated costs for the lost lives of far over 1000 people had been left to the economy and society.

The Government stepped out of the responsibility by declaring this catastrophe as the outcome of a "***Natural Disaster"***, although this bad event could only happen because of Malfunction of Railway Personnel with incredible Sloppiness at Ambalangoda Railway Station, when the Railway personnel where engaged with their private ***CURD BUSINESS*** and not attended the phone in the local control room.

Curd Business **is still going on at ABA Station September 2013**

An even nowadays every morning around 9 am, when the Matara bound express-train 8050 has arrived, this private "***CURD BUSINESS"*** of Railway Personnel is unabated going on.

And on 26th Dec. 2004 morning, when this CURD DISTRIBUTION ON THE PLATFORM was going on, at Ambalangoda and the following stations Madampe and Kahawe nobody could be reached to stop the ill-bound train:

The washed away track sections could be restored within a relatively short period with the help of the Road Development Authority. There had been enough sleepers and rails at hand to rebuild the track grid. To restore the Signalling was more difficult and needed more time.

If one leaves the humanitarian and ethical issue aside and if one omits the damage incurred to society and economy, it comes to the question, why to invest more money in safety than lost by the accidents.

The compensation by SLR, which has no insurance for lost lives, is only a minor alleviation. The compensation offered for the French National killed at the Alawwa crash had been less, than the costs to transport the coffin to France.

It is more a question of **COMMITMENT** for **CULTURE, PHILOSOPHY and ETHICS** or even of **POLITICAL STRATEGIES and PUBLIC PRESSURE** how far Human Lives should be protected under any circumstances by proactive safety measures.

After a bad event or in times of unlucky events as during the recent period of level crossing incidents, the value of Human Live might comes on a higher agenda. But within a longer lucky period of no bad events the commitment, the humanitarian and ethical issues are loosing their values, and investment in safety gets sacrificed.

To keep the Railways at high Safety Standards needs constant capital investment (input). Workforces from the top to the bottom have to be regularly trained, educated supervised and exanimate. Loopholes in the defense layers have to be detected, identified and closed and new defense layers inserted where necessary. Regular checks are required. Procedures, working rules, operational modes, safety procedures, safety laws and schedules, working manuals have to be constantly and continuously revised. Information, Communication and Detection Instruments have to be introduced and kept at high level;

<> see **TRIPOD DELTA** (developed by a research team from the University of Leiden and Manchester for Shell in 1988: P. Hudson, J. Reason et al., ***TRIPOD DELTA, Proactive Approach to enhance Safety*** in Journal of Petroleum Technology 40, p. 58-62, 1994) = a Safety Program utilized nowadays worldwide in Oil Riggin/ Exploration based on a widespread information and loop hole detection technology; and **REVIEW, a Practical Guide to Error Management in Railways**, developed at the University of Manchester in Collaboration with British Rail Research; see J.Reason, ***REVIEW***, I. Overview & II. Theory, Derby, British Railway Board, 1993; S. Tozer, ***REVIEW SUMMERY OF PILOT STUDY***, Railtrack Safety & Standards Directorate, 1994, London, UK.

British Rail has learned its lesson. With each invest of 20 to 30 million Pounds in Safety Measurements and further Signalling and Train Protection on identified TRICKY **SECTIONS** British Rail managed to reduce the number of casualties to one killed passenger per year with tools and methodologies developed by J. Reason1).

Bad habits have to be detected and eliminates and discipline drilled. Drilled Discipline is a major element of Safety in USA and Japan Railways.

But SLR is far away from such GOOD PRACTISE.

1) James Reason: ***MANAGING THE RISKS OF ORGANIZATIONAL ACCIDENTS***, Ashgate Publishing Limited, GU9 7PT Farnham, Surrey, England, ISBN 978 1 84014 105 4.

THE UNHAPPY LOT OF GENERAL MANAGERS AND TOP MANAGERS OF RAILWAYS

by Dr. Frank Wingler
November 2013

This elaboration is based on the book of James Reason *MANAGING THE RISKS OF ORANISATIONAL ACCIDENTS*[1].

Senior Managers are not specially trained, educated and studied how to mange accidental risks, about the nature of accidents, the latent conditions or **Failures in the System (FIS)**, which are the parents or background of bad events and the accident producing conditions. FIS are the PATHOGENES in the System. Managers have not studied the state-to-the-art safety subjects. There is no procedure setting for the nomination of a GMR or CEO if he is trained in the methodologies how to achieve the Railway's goal for safer train operation and less mishaps. They follow mostly, what they personally believe is good or bad.

Top Managers come and go. Commitments and Professionalism fluctuate with them in short periods.

Top managers only seldom fully understand the ***"true nature of the safety war"*** and they are mostly not aware that according the Nernst Theorem of Physics ***"Entropy wins in the end"*** telling: ***Over a lengthy period without bad events Safety Culture and Awareness for Hazards deteriorate.***

Failures in the System, FIS, for which the top Management is responsible, are the "parents of bad events". But not all Managers get grip on this "evil" in the system. Top Managers need therefore professional Safety Advisors or Safety Boards/Regulators at hand, who are fluent in the methodologies and techniques and acquainted with the tools utilised nowadays worldwide by Technical Organisations with high Risk Potential in Transport, Shipping Companies, Aviation, Space Technology, Nuclear and Thermal Power Generation, Oil Exploration, Chemical Industries.

Such Advisors should help the Management or GMR or CEO to understand the technical organisational as well the human factors, and the safety culture, that determine the safety state of affairs of the Organisation Railways as a whole system in its entity.

The GMR or CEO should be skilled by help of Advisors in the methods and its tools to drive the Organisation towards a state of maximum resistance to its operational Hazards in order to limit the numbers of bad events, accident as well of “near miss events” (narrow escapes).

“Near miss events” are as bad as occurred mishaps, but mostly they do not lead to the same repercussion or consequence as outbursted calamities. There had been several narrow escapes of trains coming out of control on the down gradient Balana Incline, leading to no consequences to prevent that finally an Intercity could jump with faulty brakes together with the rails in the last curvature before Rambukkana from the planum and crash into a paddy field, killing nearly 50 passengers (the exact number of killed passengers had been hidden).

The common believe of Managers and Politicians is that the main threat to safe operation and to the assets comes from the “bad” behaviour and from motivational shortcomings of individuals and personnel at the so-called “sharp end” of the Hazard Trajectory (see metaphor of James Reason[1]). But such an attitude runs counter to the message from state to the art knowledge, how to manage the Risks of Accidents, of technical Organisations worldwide of high risk potential in the fields of Transport, Shipping Companies, Aviation, Space Technology, Nuclear and Thermal Power Generation, Oil Exploration, Chemical Industries.

Safety, the Freedom from Bad Events, can not be only delegated to lower ranks.

It is much easier to “pin” the responsibility for an accident or unsafe act on those personnel at the “sharp end” than on the prevailing Latent unsafe Conditions or Failures in the System, with often a far reaching history, than to bare the responsibility. They do not like to be remembered when people got killed. They like to be called the “saviours” like after the dreadfully 26th December 2004 Tsunami Disaster near Telwatte, the worst Railway Accident and Disaster in the history of Railways, a combination of natural calamity with human malfunction.

Managers tent to uncouple individual fallibility from the corporate fallibility and from own responsibility for what is going wrong and for what had produces and provided the latent conditions, the FIS.

Top level **COMMITMENT, COMPETENCE and COGNISANCE** (Awareness for Hazards, for what might go wrong) are essential.

By their nature and primary task those who manage the technical Organisation Railways posses productive rather than protective skills. Managers want to see primarily the trains running and ask less, how safe the trains are running.

Managers mostly well understand the information given to them relating operational and economical issues, but not so the information and signs for latent unsafe conditions, which suddenly lead to the outburst of a bad event or can combine with other unsafe acts ending in a catastrophy. It is therefore only after a bad accident of frightening “near miss accident” or “narrow escape” that protection comes only for a short period, uppermost in the minds of those, who manage the organisation.

Mostly it is acknowledged that in the long term production and protection necessarily go hand-in-hand. But it is the short term that inherits conflict occurrence. Management tents to decide for “short cuts”. For most parts such “short cuts” bring no bad effects due to the chaotic nature in the occurrence of accidents. The option for short cuts can become so a habitude part of manager’s routine work practices. But unfortunately this gradual reduction in the system’s safety margins (“Entropie wins”) renders the organization increasingly vulnerable to particular combinations with other unsafe acts.

Often a top Manager gets subjected to the fallacy believe that the non-occurrence of a bad event in the past proofs the safety of the organisation. This is the worst mistake or error one can make

“What did not happened yesterday is even more likely to happen tomorrow”
due to the chaotic nature of accident occurrences.

There is plentiful evidence to show that lengthy periods without serious accidents can lead to the steady erosion of protection as the productive demands “keep the trains running” on whatever safety level, even on the threshold to the next calamity, gain the upper hand in the this already unequal relationship. For top Managers it is easy to forget to fear things, that really happened as a result defence declines. One can say that accidents are needed to make top managers and politicians in higher echelons awake, that more has to e done.

Safety has to start in the minds of top managers. It is a principle rule

that if the awareness for hazards is not properly developed in the minds of the upper echelons, the whole system below operates unsafe. Safety can not only be delegated to lower ranks.

The Objective of Higher Echelons in a technical Organization, Railways, is to lower the probability for bad outcomes and the number of mishaps and accidents as well of “nearly missed accidents” or “narrow escapes”. They have to look for Proactive Measures to navigate the system towards more Safety and less vulnerability to Human Errors, Failures, Malfunctions, Fallibility. Their task is, to identify those conditions most needing correction, leading to steady gains in resistance or fitness against bad events. They have to organize regular checks, reveal where holes exist now and where they are most likely to appear next allowing hazards to penetrate the defense layers.

Managers are responsible for a Generative Culture, where informants and messengers of deficits, shortcomings and loop-holes are trained and rewarded. They are resposnible that Responsibility is shared, that Failures lead to far reaching Reforms and New Ideas are welcomed.

Managers need hindsight to identify, prior to a disaster, the presence of warning signs which, if heeded and acted upon, could have thwarted the accident sequence.

Steady and repeated advanced training and further educating of all levels in Hazard Awareness and Accident Avoidance have to be organized by them.

Managers do not like to be remembered when people got killed. They like to be praised as “saviours” like after the dreadful 26th December 2004 Tsunami Disaster near Telwatte, the worst Railway Accident and Disaster in the history of World Railways; the outcome of a combination of natural disaster with human malfunction.

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1) James Reason **MANAGING THE RISKS OF ORGANIZATIONAL ACCIDENTS**, Ashgate Publishing Limited, GU9 7PT Farnham, Surrey, UK, ISBN 978-1-84014-105-4, 2011.

THE CHAOTIC NATURE OF THE OUTBURST OF ACCIDENTS

SRI LANKA RAILWAYS ACCIDENTS

SLR-MULTIASPECT COLOUR-LIGHT SIGNALLING – AN UNSAFE LATENT CONDITION FOR AND HUMAN ERROR PRODUCING FACTOR

An unpredictable chaotic Turbulence

By Dr. Frank Wingler, November 2013

Accidents are subjected to the so-called **Chaotic Law of Nature.**

Chaos Theory is a field of study in mathematics with applications in several disciplines including meteorology, physics, engineering, economics, biology as well in Accident Occurrences. Chaos theory studies the behaviour of dynamical systems and happenings, that are highly sensitive to initial conditions; an effect, which is popularly referred as the ***BUTTERFLY EFFECT***. A turbulence caused by a butterfly in South America might determine the weather pattern in Europe. Small differences in initial conditions yield widely diverging outcome for such dynamic systems, rendering long-term predictions impossible in general. This happens even although these

systems are deterministic, meaning that their future behaviour is fully determined by their initial conditions, with random elements involved. In other words, the deterministic nature of these systems does not make them predictable.

Referred to the occurrence of accidents one can say that the initial conditions are of such a nature that once a specific accident will outburst, but one can not predict the location, date and time.

Chaotic behaviour can be observed in many natural systems, such as weather or pattern on waves at a sea shore. Insects follow a chaotic flight route, which makes it difficult to catch them.

If you hang up two pendulums, they show mathematically determined swinging behaviours. This is used to regulate the time of a tower clock. But if you couple both pendulums by a rope with a weight, both pendulums start to make chaotic unpredictable movements. It comes to chaotic solutions.

Chaotic laws are part of the universe natural laws ruling the cosmos. Occurrences subjected to the Chaotic Laws have their distinguished pattern. But this pattern can only be described macroscopically, but not microscopically. You know, when and under what conditions insects come into your house, but you can not describe their flight route in your house.

In other words, a forward exact calculation or process control is not possible because of the manifold disturbances by reverse coupling effects. Only after an event has happened – like an accident – one can follow backward in retro perspective the process and describe, what has caused the event.

ACCIDENTS are unwanted **BAD EVENTS**, which can incur a lot of losses and aggregated high expenditures for economy and society. Accidents should be avoided because of economical as well humanitarian issues. Zero elimination of accidents is not possible. There is always a rest-risk for the occurrence of unwanted bad events, even in the best defended technical organisations like, Aviation, Space Technology, Nuclear and Thermal Power Generation, Oil Exploration, Transport Railways.

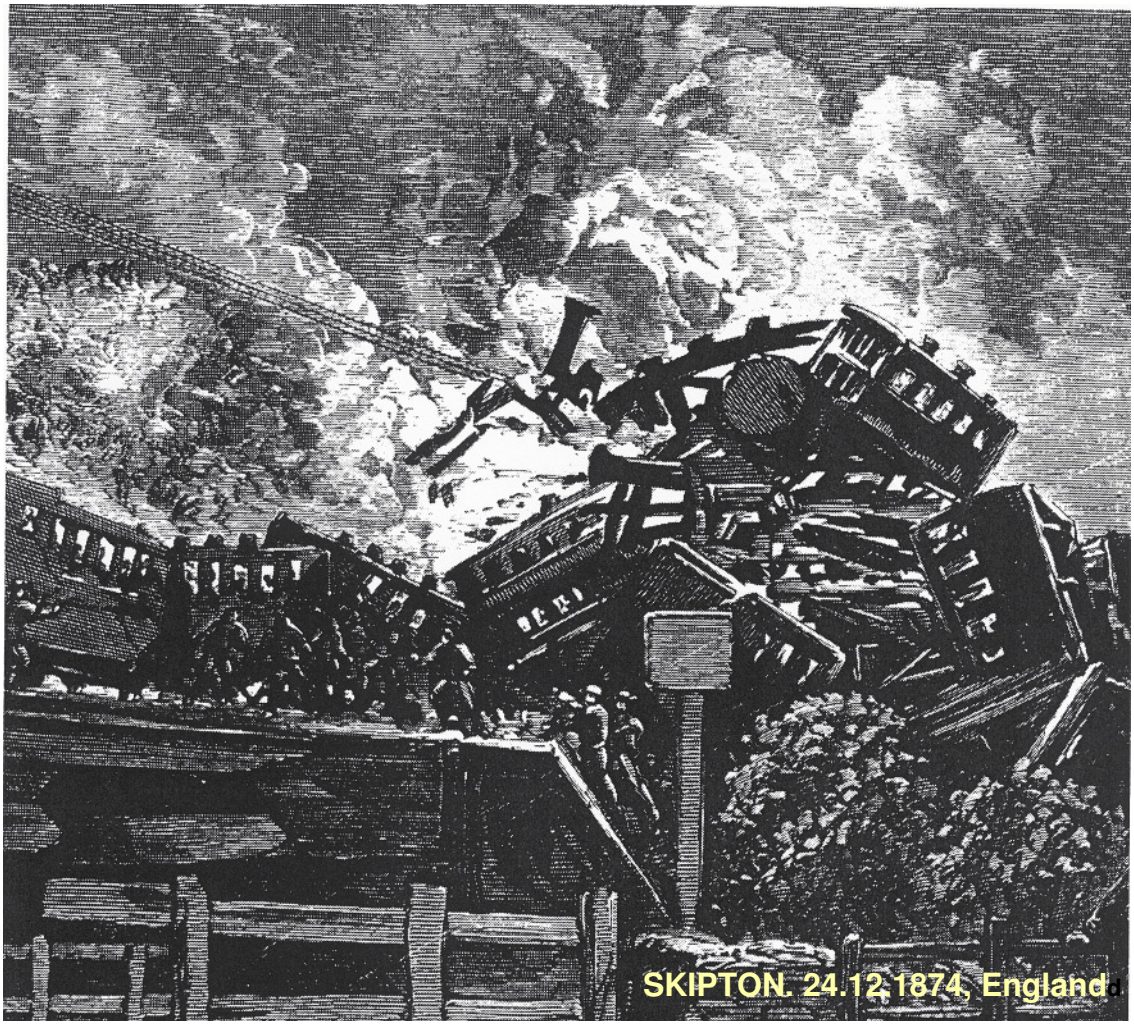
RISK is a function of both the **LIKELIHOOD OF AN EVENT** occurring and of the possible extent of its bad outcome.

Small events can combine with latent unsafe latent conditions to have disproportional large effect.

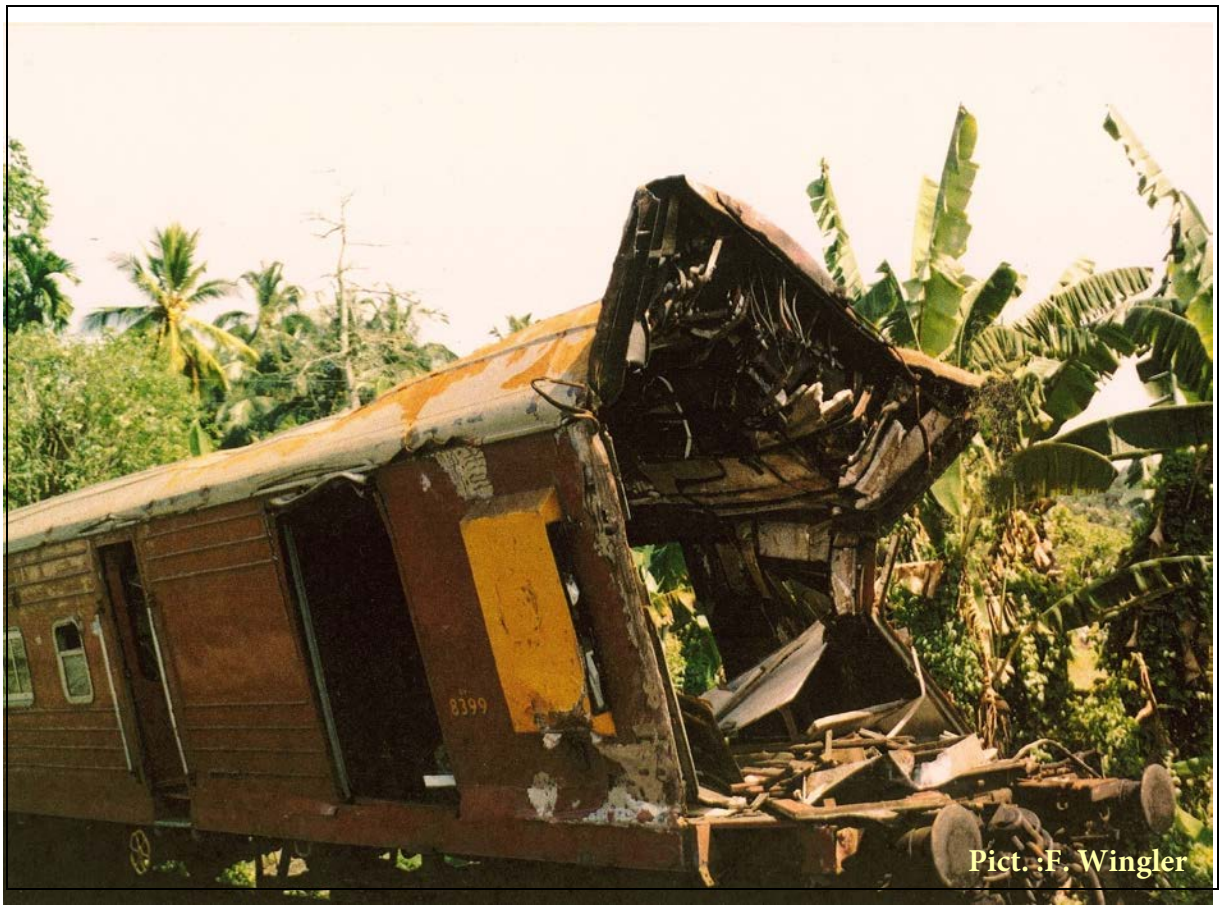
In a Railway System one can detect unsafe latent conditions, often of a far reaching history, so-called **FAILURES IN THE SYSTEM, FIS**[1], which can combine or add-up with other unsafe acts to the outburst of a calamity. But one can not make a precise prediction, when and where this might happen. One can only make statements of the likelihood of an accident to happen and about the latent contributing hazardous factors, the parents of a mishap. Latent unsafe conditions or **FAILURES IN THE SYSTEM RAILWAY**[1] are **HAZARDS** and like a bomb, which not yet has exploded.

Small factors can combine and bring the bomb to an explosion. Managing the Accident Risks by modern Methodologies as used nowadays worldwide in Aviation,

Aviation Industries, Space Technology, Nuclear and Thermal Power Production, Transport, Shipping, Oil Exploration and Railways can defuse the **BOMB**.



The **Jan. 2002 RAMBUKKANA** down gradient run-away train disaster had been such a typical bad event, where many unsafe latent conditions combined suddenly and unpredictable to an outburst:



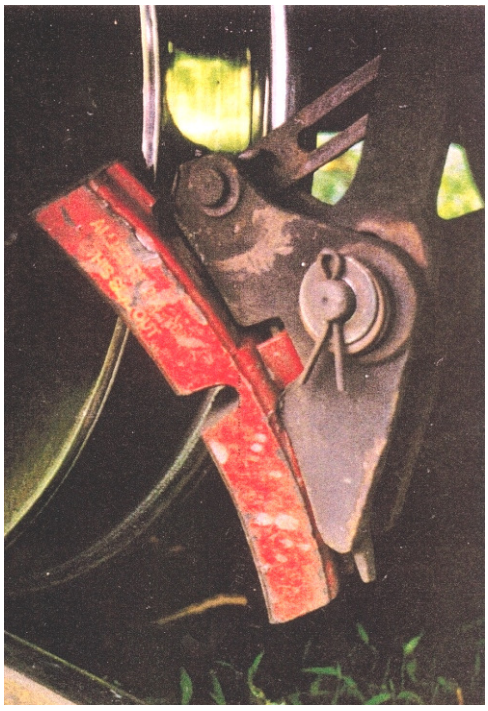
By the well known bad state-of-affairs of the poorly maintained, repaired, serviced and examined train bake system it had been very likely, that once a passenger train will gain such a momentum down gradient, that the train will leave the track together with the rails and crash into the surroundings. And in dead there had been several incidents, where trains got out of control and had a narrow escape. In the professional terminology we call such events **"NEAR MISSED EVENTS"**. But since

the outcome had been lucky, such events have not been taken as serious and they had been no consequences for better brake maintenance and brake checks and inspections/examinations.

A **"Near Miss Event"** with a lucky outcome is as bad as an event with a bad unlucky outcome. The boarder between both events is often only gossamer-thin.

All ingredients for the recipe of such a tragic event had been well known prior to the Rambukkana disaster, and nothing has been undertaken to eliminate them; in other words: *TO DEFUSE THE BOMB:*

Faults in the vacuum brake system like leakages, turned brake shoes, blanked brakes, weak Loco exhauster, defective dynamic loco brake, faults in the loco friction brakes, untrained head guards interfering on down runs in the vacuum brake system, badly trained and inexperienced train drivers, bad and weak track without proper drainage and ballasting, no proper brake check, examination and tests as in other countries with down gradient hill lines or at least as in India on so-called Ghat Sections. If only **one** ingredient had been missing, the bad event would probably not have happened.



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The danger of all those individual elements had been misjudged until suddenly they combined to this sad Jan. 2002 event.

The tracks leading to GANEMULLA, ALAWWA and AMPEPUSSA are TRICKY ROUTES, not properly secured by the SLR Colour-Light Signalling, by a Signalling System, which can give manifold information(over 55), but does not secure properly risky routes and risky Railway Stations. Recently the latent hazardous conditions with perhaps a technical faulty signal have combined with Human Fallibility to outburst in a rear-end-train collisions. But lessons have not been learned and no changes of the signal positioning have been arranged. No repeaters have been intalled.

To give another example of the risks of **TRICKY ROUTES:**

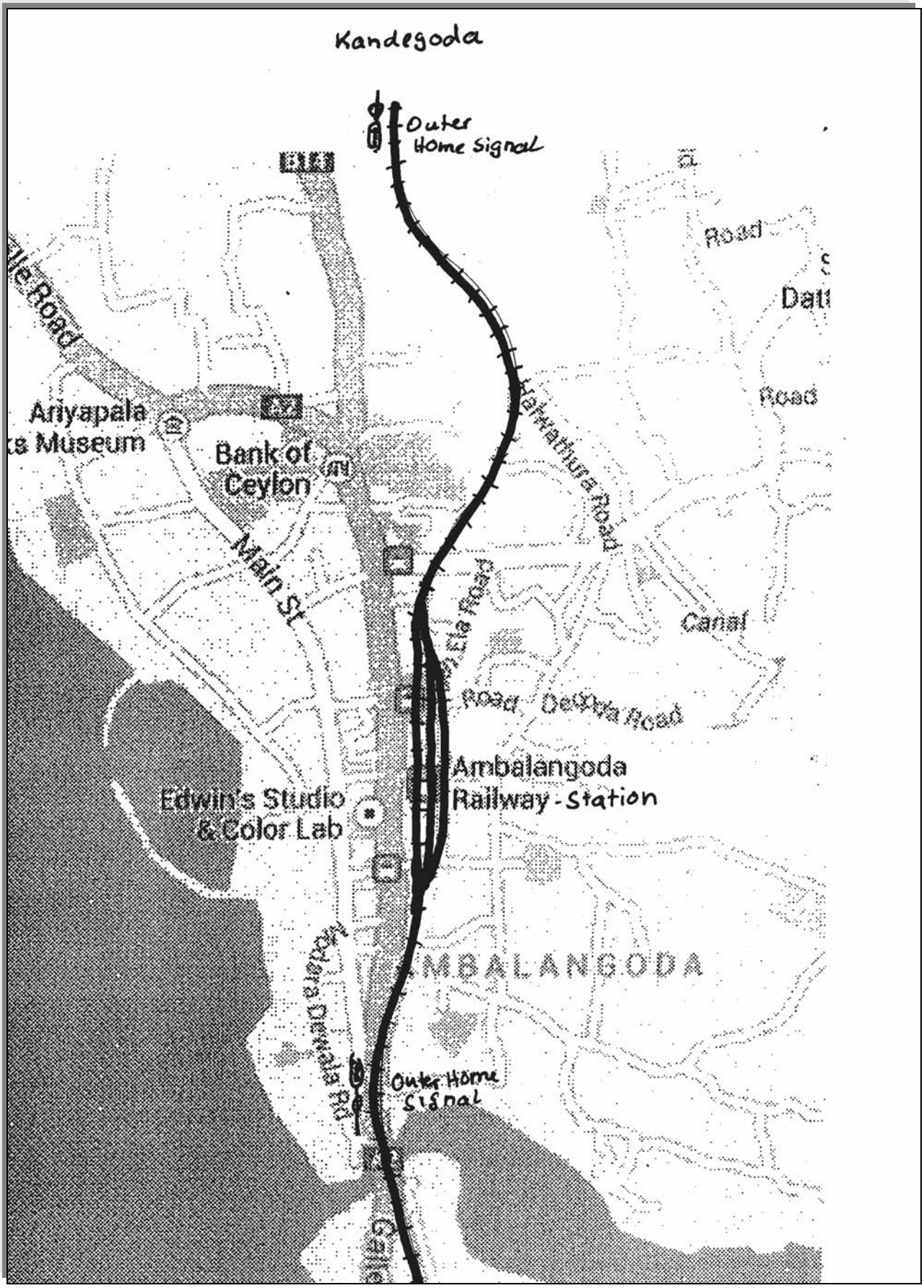
Both reverse curves leading to **AMBALANGODA (ABA) RAILWAYSTATION** are typical **TRICKY** and **RISKY SECTIONS**. After the IRCON Upgrade trains are now allowed to negotiate the 6 Degree curves with 60 kmph although a train driver can not see, what will be the situation at the platforms. There are no inner home signals to protect train movements at the Station and there are also no corresponding Distance Repeater Signals in the curvatures on both approach sides of the station, so that also no empty intersection between two signal posts can be arranged for redundancy.

ABA Railway Station is only protected by the **THICKNESS OF ONE OUTER HOME SIGNAL POST** on each side. And there is no speed restriction for the curvatures, as it should be on such a tricky route, in steps from 40 to 15 kmph! In addition simultaneous crossing is allowed.

The present Signals are only lit few seconds, before a train enters. The south control signal on platform 1 had been shifted few yards north to prevent trains entering the longer fouling zone, since IRCON had exchanged the 1 in 8.5 turnout to the leaner 1 in 12 Indian standard switch and addid a 4 m curve-transition. The fouling zone has become extended. Nevertheless since the platform on the north entrance had not been accordingly elongated, incoming trains are allowed to overshoot the south control Signal and park with the loco in the fouling zone; see picture Sept. 2013. And nobody within SLR understands, why this “odd” procedure should not be allowed.

ABA Station, Train 8050, 26th Sept. 2013

Such things one can not find in other countries. In this respect SLR is unique.



TRICKY SECTION NOT PROPERLY SECURED BY SIGNALLING AT ABMALANGODA (ABA)

In contrast to ABA Station one can assert, that KAHAWA Railway Station is far more resistant to bad events than ABA Station. The visibility from both sides is good and the station is protected by inner home signals.

Since the outburst of an accident is subjected to the chaotic pattern, one can not determine when a likely bad event caused by such hazardous latent conditions (bomb) will happen also at Ambalangoda.

One can only say:

"WHAT DID NOT HAPPEN YESTERDAY IS MOR LIKELY TO HAPPEN TOMORROW".

An accident at ABA Station under those latent conditions or Failures in the System is likely, but it may perhaps outburst tomorrow, in 10 years or never at all in the next 100 years.

And nobody within SLR really understands why this constellation of risky elements should be unsafe. The Signal Engineers, Train Dispatchers, Station Masters, Movement Authority Personnel persist in the jugglery fallacy that nothing bad will happen, because nothing bad had happened in the past.

SLR had been lucky that so far nothing happened at ABA Station. But this tells nothing about tomorrow and the safe state of affairs.

Unsafe Organisations like SLR can escape severe accidents a longer period or in other words:

"GOOD LUCK CAN PROTECT THE UNWORTHY"; "HAPPY and UNHAPPY CHANCES ARE UNFORSEEABLE".

Latent unsafe conditions or Failures in the System (FIS) can lay for a longer period dormant. Only a small or tiny **DISTURBANCE** can trigger off a catastrophe.

Likely train accidents are Rear-End-, Head-to-Head and Flange- Collisions due to SPADS and insufficient protection of tricky sections by the present Colour-Light Signaling system without any AWS or ATP, and poor and faulty train brakes and or risky arranged train operations by officers in the control room, which in the air conditioned control rooms are often remote from the rear live field realities and the track conditions. Derailments are likely due to bad tracks with a quality not matching the traffic load, rail defects and due to over-speed not heeding the imposed speed precautions. Derailments are likely due to defect rolling stocks, bogies with loose parts, worn dampers, worn wheel profiles. Derailments can occure on week upcountry tracks due to sudden emergency brake application, interferences by head guards, especially on downgradient runs. Derailments can occur due to short transitions of curve-superelevation, especially with the long Indian DMU cars with the short secondary air-cushion suspenion.

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Latent accident sponsoring conditions are poor training, education and supervision especially of front-line personnel, poor awareness for hazards in all ranks, inadequate operational rules and procedures especially when using the double tracks as twin single tracks or bi-directional, common sloppiness, smart alike, corruption, inadequate and too complex colour-light signaling, missing speedometers on locomotives.

SRILANKAN MULTIASPECT COLOUR-LIGHT SIGNALLING – AN UNSAFE LATENT CONDITION FOR TRAIN MISHAPS

Already 1932 German Signal Experts criticized the North American Daylight Light Signal System, which with the Americans wanted to give too many information (14 aspects) making the system unclear for the train drivers and hence hazardous.

And what is with the over 55 valid Aspects of the Sri Lankan System, where one can detect North American Route Signaling features and British Speed Signaling elements, brewed together from 1962 onward in Sri Lanka by Srilankans and Ericson to a Signal System without any AWS or ATP, which one can not find anywhere in the world. SLR Colour-Light Signaling (sans ATP or AWS) gives manifold information, too many, but has the deficit, that it does not properly protect several TRICKY SECTIONS. Inner home signals got lost on tricky routes. The system does not know individual free standing distance or approach signal with a distinguished own design, which can not be mistaken as a Main- or Stop-Signal. This Signal system does not protect properly the use

of dual lines as twin single lines or bi-directional. This system can be regarded as a system inviting to make mistakes, mostly rear-end-crashes.

The that time designers of this Multi Aspect Colour Light Signaling, which resulted until nowadays with over 55 Aspects, wanted too much without any ATP or AWS in the intention, to increase the route capacity of dual lines, not taking account of the cognitive psychological error causation of Loco Drivers, the increasing traffic density and train speed. Not the doubts over the Safety of this System without ATP or AWS render train operation unsafe as uttered by some Signal Engineers. The System itself has deficits, which can turn into hazards under certain conditions. Train operation is not as safe as it should be because of the inherent latent unsafe conditions in this Signaling System.

The Srilankan Multiaspect Colour-Light Signaling without any ATP or AWS is not enough resistant against Hazards Attacks by Malfunctions and vulnerable to Human Error and Technical Faults. It has holes like a slice of Swiss Cheese, through which Hazards can penetrate.

The 31-01-13 **Pallewela incident** shows the weakness of this Signaling System, when a goods train with empty tank cars in the middle of the formation overshoot a signal without a Protection Overlap short before a cross over already set for an opposite running Intercity, due to SPAD and presumably poor brakes. The goods train overshot the Signal and burst the switch already set for the approaching intercity to trail from the right (wrong) track to the left up track (bidirectional use of the double main line). Without checking the full release of the vacuum brake up to the last brake van, on request of the Movement Authority the Train Driver reversed the train set with full power over the burst switch (cross over, turnout). Part of the empty tank cars trailed in the wrong direction and tumbled, blocking the line for two days. Loco Driver and Control Room Officer violated the rule, that a train which has come from the opposite facing direction to a halt on a turnout should never be reversed and especially not on a burst turnout. They violated also good practice, not to allow the north-east bound intercity to come near the crossover, before the goods train had come to a safe halt clear of the cross over.

In regard of the worst possible scenario of a train accident this is a "**NEAR MISS EVENT".** Luckily the approaching Intercity could be brought to a halt; otherwise it would have crashed into the overshot freight train and cached fire. Between "near miss event" and the worst scenario of a disaster there had been only a thinly gossamer.

Luckily the **"WORST SCENARIO"** could be thwarted the last moment. The **"WORST SCENARIO"** would be a crash of a passenger train in the debris of another derailed train on the Main Line, and catching fire.

As already revealed in my previous papers, the worst Railway Accident of mankind caused by a natural disaster in combination with human malfunction, the 26th Dec.

2004 Tsunami train catastrophe, could have been thwarted, if someone had been in the local ABA control room to take a phone call from the Movement Authority in Colombo, instead to go for a private **CURD BUSINESS** on the platform. And even nowadays this private curd business by railway employees is going on. Pot by pot the curd is taken out of the Guard-Van behind the ***"Rajadhani AC Car"*** and distributed well organized on the platform. This procedure upholds the train several minutes.

ABA Station, Train No. 8050, 26th September 2013

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1) FAILURES IN THE SYSTEM (FEHLER IM SYSTEM) by Jürgen Hörstel and Hans-Joachim Ritzau, Ritzau KG, 2000, ISBN 3-921 304-33-4, Pürgen, Germany.

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HOW TO MANAGE THE ACCIDENT RISKS OF TECHNICAL ORGANISATIONS; THE JAMES REASON "*SWISS CHEESE SLICE*" DEFENCE LAYER METHAPHOR;

THE LATENT UNSAFE CONDITIONS OF SLR AND THE COLOUR-LIGHT SIGNALLING; WHAT SLR CAN LEARN!

06. July 1988 PIPER ALPHA OIL RIG CATASTROPHY off-coast of ABERDEEN, UK;
167 out of 228 personnel working on the rig got killed. The financial loss incurred had been over 2.5 billion $ not included the losses for 167 lives.

Elaborated by Dr. F. Wingler, November 2013

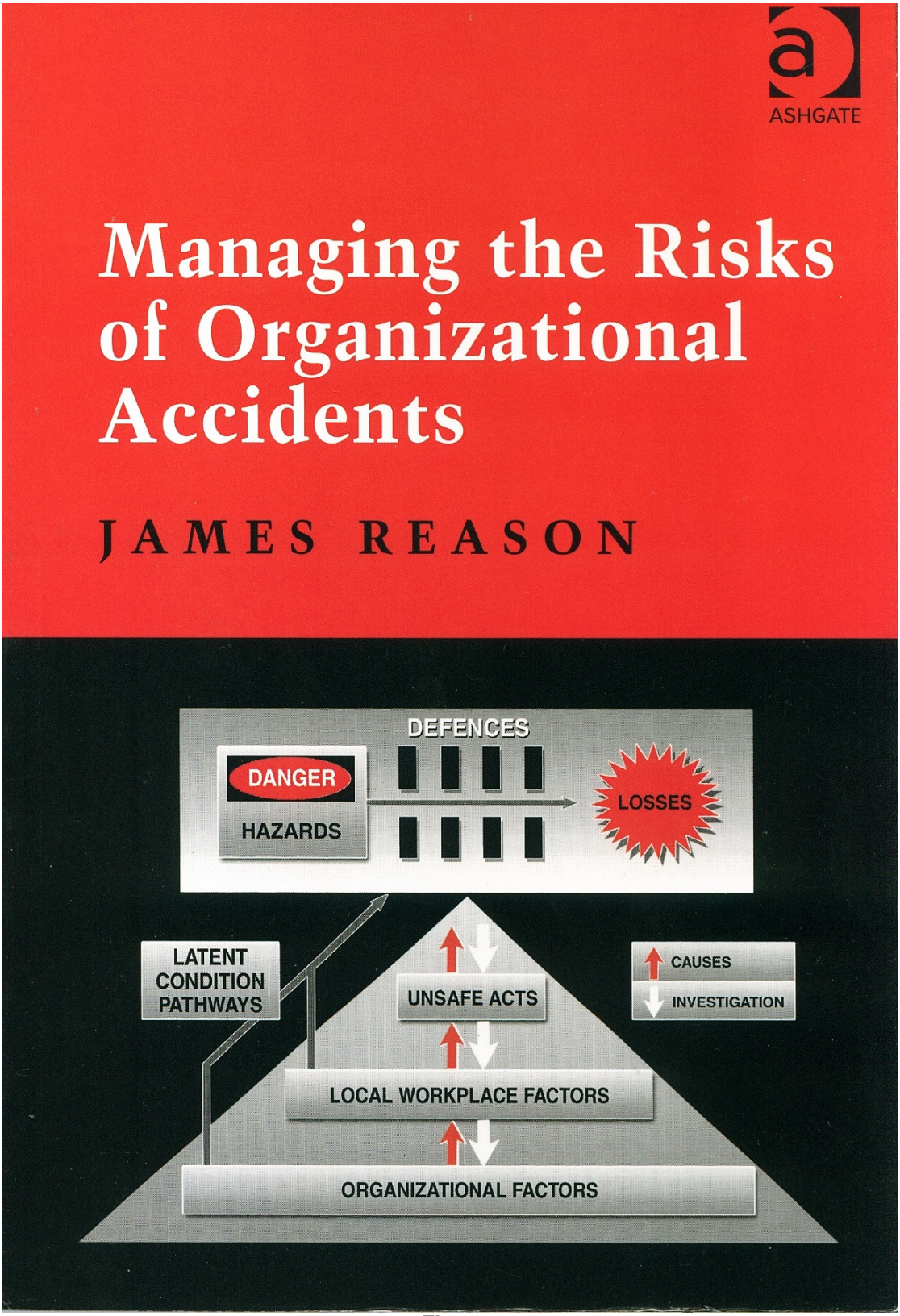


Fig. 1

In his book **JAMES REASON** shows ways how to uncover potential hazards and risks of technical Organisations. Accidents are **"bad events"** which include the wide field of Mishaps, Calamities, Catastrophes, and Disasters. Potential Risks are buried in latent unsafe or hazardous conditions. In the Germany Safety Technology and Accident Investigations, the term **"FAILURES IN THE SYSTEM"** is used.

The Principles, Methodology and Doctrines of James Reason[1], how to manage the Accident Risks of Technical Organisation is based on Military Defence Strategy. James Reason is one of the best known Safety Expert worldwide; his Methodology, Doctrines, Methapers and his approach, to bring more safety into a technical organisation and to make the organisation more resistant and less vulnerable, are nowadays used worldwide by high risk technical Organisation in **TRANSPORT (RAILWAYS) AVIATION, SPACE TECHNOLOGY, SHIPPING, MARINE, CHEMICAL PRODUCTION, NUCLEAR and THERMAL POWER GENERATION, and OIL EXPLORATION/RIGGING to prevent bad events to occur and to make the Organisation more resistant and less vulnerable to Hazards. The metodology is used and as well in Accident Investigations.**

Each accident has its own individual pattern of cause and effect. But when it comes to an investigation in depth one find mostly out, that they have common under-laying structures and are based on latent unsafe conditions or so-called **FAILURES IN THE SYSTEM (FIS).** FIS is a **condition.** It is present in the System regardless if bad incidents happen or not. Every Technical Organisation (Railway) has more or less latent unsafe conditions. A mishap can make the latent unsafe condition or FIS manifest. FIS creates the conditions, that promote, sponsor or exacerbate unsafe conditions resulting in unsafe acts and accidents.

FIS are detectable parents of accidents. The war against **FIS** is a **proactive** step.

The more exhaustive the inquiry of Accident Investigations, the more such latent unsafe conditions (FIS) it will recover. FIS undoubtly can combine suddenly and unexpected with local factors or Human Failures to break through safety defences.

The Task of Risk Management is to remove **PROACTIVE** such latent unsafe conditions, such **PATHOGENES** before a bad event as far as possible, although it will not be possible to eliminate FIS to zero. One should be aware that other latent unsafe conditions might spring up instead.

"THERE IS NO FINAL VICTORY IN THE SAFETY WAR!"

But some Management behave only **REACTIVE.** They order changes only after a bad event already has occurred.

The **PROACTIVE** type of navigating the technical Organisation toward more resistance and less vulnerability to Risk is to

<> identify those conditions most needing correction, leading to steady gains in resistance or to gains in fitness, and not to react only, when the unlucky event has already outbursted.

<> Regular checks reveal, where holes exist now and where they are most likely to appear next.

To identify measure, confirm and control FIS is a general method to bring more safety into a system. Such considerations are core issues of Railways worldwide,

especially in Canada, Germany, England and Austria. Those organisations lay core emphasis on **AUDITS on FIS. INR** is also nowadays using such a path for more safety.

The success depends on the prevailing **CULTURE** of the Organisation. The “culture” is like a swamp where the mosquitoes bread. The up-to-date Technique of **ERROR MANAGEMENT** demands a **GENERATIVE CULTURE**, where **INFORMATION** AND communication play a key role. Messengers are trained and rewarded. Responsibility is shared and not only pushed to lower ranks. Failures and detected unsafe latent conditions (FIS) lead to far reaching reforms. New ideas are welcomed.

The prevailing **SLR CULTURE** is far from this. Messengers, who report about failures and shortcomings, get discouraged, because they do not see any result for betterment. Their information, messages and reports are running into emptiness, f.i

<> about flat tyres, defect couplers, leaking brake systems, worn or defective brake shoes, not working or missing instruments like speedometers, pressure gauges, electric instruments, indicators, track and rail defects ect..

Critics and messengers of risky conditions are seen by seniors as ***“red cloth”***. They often react angrily and emotionally. Responsibility gets shirked. Things even might get ***“perverted”***, when the spreading of doubts about the safety of the SLR colour - light signalling is regarded as the unsafe act. The messenger becomes the “bad people” and the latent unsafe condition of the signalling system is concealed. The blame is driven away from the unsafe condition or act to the messenger.

The informants learn that their effort to bring in more safety or to eliminate unsafe conditions is fruitless, so that they simply will give up. Their willingness to resolve problems drys away.

Experts call this **“LEARNED HELPLESNESS”**. This is characteristic for a **“BAD”** or **“PATHOLOGICAL” CULTURE.** Such pathological culture discourages new ideas.

How to engineer a **GENERATIVE CULTURE** I refer to the Chapter 9, p.191ff of the J. Reason Book[1].

A well functioning **INFORMATION and COMMUNICATION SYSTEM** are a core elements of the Engineering of **SAFETY CULTURE**. A well protected Organisation needs **THE WILLINGNESS OF ALL WORKFORCES** in direct contact with shortcomings to report the shortcomings, unsafe acts, near missed events, as well latent unsafe conditions. Well protected Organisations have nowadays engineered an effective **REPORTING and INFORMATION CULTURE.**

Another key tool of **ERROR MANAGEMENT** (see J.Reason[1] p. 125ff) is the establishment of the constant, repeated and consecutive **LEARNING, TEACHING, TRAINING, EXAMINATION and SUPERVISION** in order to increase on all levels, also in higher echelons, the **AWARENESS FOR HAZARDS** and the capability of **RISK RECOGNITION.**

Those who are interested in ERROR MANAGEMENT or are engaged with SAFETY MEASUREMENTS should study well the PRACTICAL GUIDE to ERROR MANAGEMENT in the J. Reason Handbook, Chapter 7, p 125 t0 155 and the cited literature.

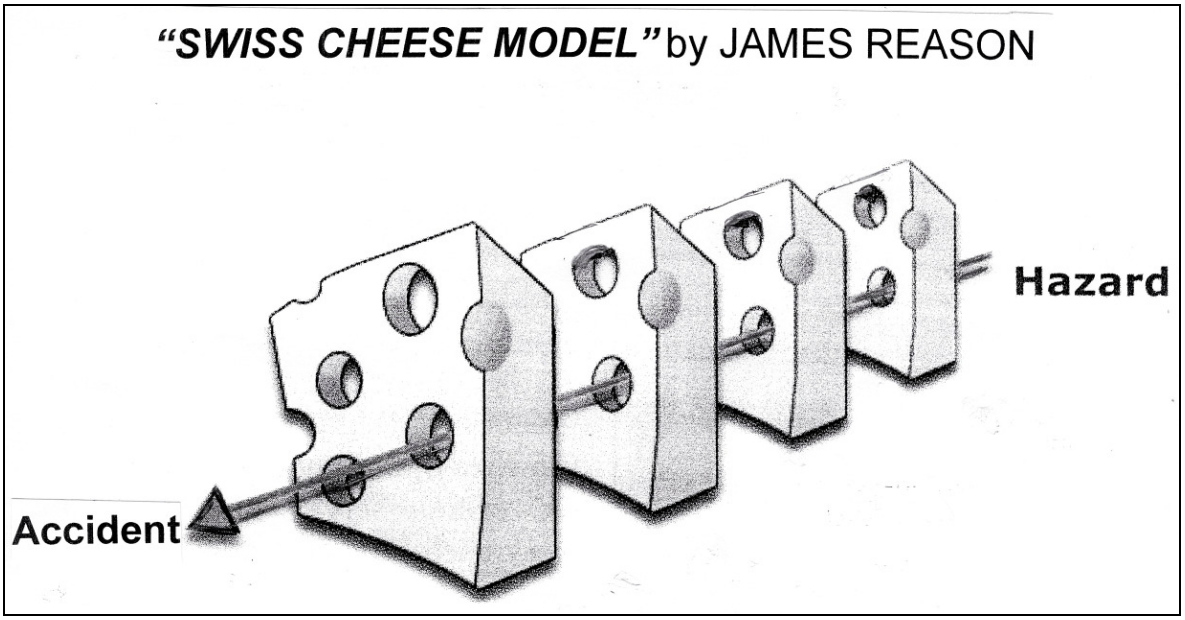
A practical guide to **ERROR MANAGEMENT IN RAILWAYS** is **REVIEW**, developed at the University of Manchester, UK, in collaboration with British Rail Research; see J. Reason, ***REVIEW, I. Overview, II. Theory***, Derby, British Railway Board, 1993; S. Tozer, ***REVIEW Summery of Pilot Study***, Railtrack Safety & Standards Directorate, 1994, London, UK.

REVIEW is based and derived from **TRIPOD-DELTA**, developed by a research team from University Leiden and Manchester for Shell in 1988; see P. Hudson, J. Reason et al. ***TRIPOD-DELTA: Proactive Approach to enhance Safety***, Journal of Petroleum Technology 40, p. 58-62, 1994. **TRIPOD-DELTA** is nowadays utilised worldwide by Oil Exploration Industries. The basic instrument is a computerised online information system to identify and confirm daily the safety related weak points, spots, events and happenings of so-called **GENERAL FAILURE TYPEAS (GFTs).** GFTs are measured constantly.

The Piper Alpha Oil Rig Disaster had been investigated on basis of J. Reason's doctrines and his approach for more safety. The recommendations have also been established on basis of the doctrines laid down in the J.Reason handbook[1].

ACCIDENTS are **BAD EVENTS** incurring high costs for the Organisation, for Economy and Society. Possible Risks are Hazard or **DANGERS,** which can penetrate the **DEFENCE LAYERS,** the Safety Procedures, safeguards ore Safety Barriers like an Arrow with its so-called **"Sharp End".**

DEFENCE LAYERS have their weakness like holes in a slice of Swiss Cheese. If the holes come in line, the Hazard Trajectory can penetrate through the holes of the defence layers, the weak spots, and culminate in the outburst of a Misevent, Bad Event, Calamity, Mishap, Accident, Disaster and Catastrophe. Each slice presents a **DEFENCE LAYER** preventing individual shortcomings or unsafe acts to combine and to culminate in the outburst of an accident.



Since no one can foresee all the possible scenarios of disaster, it is therefore inevitable that some defensive weaknesses will be present from the very beginning of a system's lifespan, or will develop unnoticed – or at least uncorrected – during the subsequent operations. Such deficits, latent conditions or **FAILURES IN THE SYSTEM (FIS)** can take a variety of forms.

The more exhaustive the inquiry, the more **unsafe latent conditions** – the error and bad events producing conditions - it will be uncovered:

The latent unsafe CONDITIONS provided by the SLR CL-SIGNALLING:

The SLR Multi Aspect ColourIlght Signalling has deficits, inherent latent weaknesses, like a slice of Swiss Cheese with holes, through which hazards can penetrate and can outburst in a calamity.

This system has a far reaching history, now more than 50 years. The parents of this Signalling System, which developed up to now over 55 aspects, wanted that time too much to increase the route capacity, especially on dual lines, by using the tracks bi-directional or as twin single tracks en routine, and this without any Automatic Train Protection or Automatic Advanced Warning System and without Protection Overlap of adequate length.

The Signal System does separate a train from a conflicting situation or from a hostile movement ONLY by the THICKNESS OF ONE SIGNAL POST INDICATING DANGER, and this without any ATP or AWS. SLR does not use axle counters, which could detect, if a second train enters an occupied section.

This system has no tool to monitor and registered SPADS (like other Railways have), and if a train enters due to SPAD a section, which is already occupied by another train. Only after a bad event or a near missed event the SPAD is noticed. The actual number of SPAD cases in SL is unknown.

The System takes not appropriately account of the poor state of affairs of the badly maintained, repaired, serviced, tested, examined train brake systems and of risky or conflicting operations arranged by the Movement Authority and dispatchers, like 31th Jan. 2013 at Pallewela.

The aspect RED is not only used for DANGER, but also for other information, to mark a control signal post or that there a non existing deviation like at Alutgama. GREEN in COMBINATION with RED can tell that the track ahead is clear.

The System does not know free standing individual advance or approach Signals of an own design, which could not be mistaken as a Main- or Stop Signal and which could be repeated on tricky and risky routes with poor, hindered or obstructed visibility as a Reminder for the aspect to be expected on the next Main- or Stop Signal, and could warn about the next information ahead on tricky routes of poor visibility.

This system, which one can find nowhere in the world and which is unique with its over 55 aspects, combines RED with Amber or Green Aspects. It has features of the North American Route Signalling and elements of the British Speed Signalling.

The SLR System does not take fully account of the psychological cognitive ability of Train Drivers, to process in their minds all given information within seconds. The System, providing too much information but not protecting properly risky routes and operations, is not tailored appropriately to the cognitive strength and weaknesses of human front line operators. The system is vulnerable to Human Fallibility and Technical Failures. It demands high personal skills and training levels of the Train Drivers. The creators and the present engineers underestimate the latent hazards.

This System is a parent of the bad events of recent time's rear-end-collisions: Twice at Veyangoda, at Kalutara, Ganemulla, Alawwa, and Ambepussa and for the "near missed disaster" recently at Pallewela. The system, despite of the over 55 aspects, does not properly protect TRICKY ROUTES or SECTIONS and des not secure risky or conflicting arranged train movements, when setting routes for cross-over for bi-directional or twin single line use.

In Sri Lanka trains a send en routine over tricky routes, and risky train movements are arranged, when utilising dual lines as twin single lines or bi-directional, with inadequate safe Signalling and Train Movement Protection.

The Higher Echelons and the Signal Engineers are subjected to the jugglery FALLACY, that what they do and have arranged is correct and safe. They say: *The Signalling is "fail safe". A*nd if a bad event has occurred," it is because of the *FAULT* of the *"bad"* people, who breach the Signal Defence on the front line or so-called "sharp end" of the hazard trajectory. They denie the possibilities of technical failures or socalled technical "wrong Signal Aspects".

<u>RECOMMENDATIONS and MESSAGE FOR SLR:</u>

The Train Drivers must be informed about, what are the deficits and weak points (the holes in the Swiss Cheese Defence Layers) of the SLR over 55 Aspects Colour-Light Signalling. They must be well trained how to react and act accordingly with up most care and vigilance upon the given information especially on TRICKY or RISKY ROUTES and when risky train movements had been arranged by the Movement Authority or Dispatchers. Dispatchers, Movement Authority co-workers, Station Masters, Head Guards have also be informed about the weakness and loop holes in the defence layer COLOUR-LIGHT SIGNALLING, and their vigilance had to be trained accordingly.

Collaboration and Harmony between Signal Engineers and Train Drivers is essential for SAFE TRAIN OPERATION. The present terrible disturbed relation of Signal Engineers with Train Drivers has to be regarded as an unsafe latent condition.

Before SLR is migrating to higher Train Protection Levels – a thorny and costly adventure – the **HAZARDS** on the present **TRICKY ROUTES OR SECTIONS** have to be defused by introducing extra signal posts, by arranging Protection Overlaps of sufficient length, by implementing warning repeater signals (reminders) of the corresponding information given ahead by the next main or

stop signal and by keeping an empty intersignal space between two signal posts indicating **DANGER**.

SLR should go for **axle counters like nowadays INR**. This will help to detected, if a second train enters unauthorised an already occupied section and when SPADS are committed. **INR** took a lesson from an accident two years back, when near Mathura by a signal failure a second train entered an occupied block. Both trains where running towards Delhi in the same block. In the first train a prisoner guarded by police on the way to Delhi for a court case pulled the chain and the train stopped, the police tried to catch the fugitive prisoner. The second train crashed at the rear. 4 People in the last coach got killed.

The next step should be, to implement a GSM-R network (ready for LTE) and Track Balises. Anti Collision Devices and GPS assisted Systems have still too many bugs.

So why not learn from British Rail, how they have managed the risks and hazards after the series of bad events, what methodologies they use and how they defuse the risks and hazards (the latent unsafe conditions) on identified TRICKY or RISKY ROUTES, SECTIONS and SPOTS.

One can not change the Human Condition, but one can change the conditions under which Human work. One can insert additional defence layers, Slices of Swiss Cheese (more redundancy) to make the system less vulnerable to the factor of **HUMAN ERROR** (extra signal posts, repeater signals, keeping one intersignal section empty or protection overlaps).

The additional Slices of Swiss Cheese have been missing in UK, when on 19th September 1997 the Swansee Great Western Train crashed with 125 mph near Southall with a freight train, due to SPAD committed by the Train Driver. The AWS has not been in function and the ATP has been switched off. Both systems could have thwarted this disaster. Under the light of the violation of safety procedures by the operator the case against the Train Driver Larry Harrison had been dropped. The company had been fined to pay 1.mi £ :

Southall,UK, 19th Nov. 1997

Southall, UK, 19th Nov. 1997

British Rail has learned its lesson from recent accidents. With each invest of 20 to 30 million Pounds in Safety Measurements and further Signalling and Train Protection on identified **TRICKY SECTIONS (input)** British Rail managed to reduce the number of casualties by one killed passenger **(output)**. The investment input for the much smaller SLR network will be far less. British Rail has nowadays far less bad train accidents than f.i. Switzerland. The strategy to implement extra defence layers had paid off.

Leaving aside legal concerns for responsibility, **ACCIDEN INVESTIGATIONS** have to be carried out to establish, what occurred, and has to stop something like it happening in the future.

To ***"pin" "Culprits"*** to be punished, might render personal satisfaction, but should be left to the judiciary. There is plentiful evidence, that to blame people rather than the error producing situations and the **FAILURES IN THE SYSTEM** - the latent **UNSAFE CONDITIONS or PARENTS OF BAD EVENTS -** has little or no effect upon error-producing factors, and so errors continue to be involved in the forthcoming bad and unlucky incidents and accidents. Bosses are doubly aggrieved: People have been punished, but they persist in making errors. The history of modern technology is rich in instances of risk mangers are being caught with their eyes on the wrong ball. It is much easier to pin legal responsibility for an accident on the unsafe acts on those at the "sharp end" of the Hazard Trajectory, which breached the system's defence layers (penetrated through the holes of the Swiss Cheese Slices), than to acknowledge the **FAILURES IN THE SYSTEM, FIS and the own Responsibility for what is going on in the Technical Organisation.** Punishment has only a doubtful effect. Experts agree this nowadays worldwide.

Even **Indian Railways** (INR) have learned that **punishment** of ***Front Line Personnel*** having committed a Human Error has little or even no effect in making the Organisation safer and less vulnerable by Errors. Therefore INR has adopted **PSYCHO TECHNICAL METHODS how to deal with the COGNITIVE** Process of "Front Line Personnel" to come to more suitable practical guides for **Error Management.**

In its programme to enhance safety, "***the ultimate Goal to prevent Accidents"*** INR have taken the Initiative of developing and adopting number of new Technical Devices in supporting Human Effort like Axle Counters on the tracks, AWS Systems, Anti Collision Devices, Micro processed Speed, Time and Distance Recorders on Locos, EMUS and DMUS, recording also events.

Train Drivers in India with higher educational qualifications are far better selected, recruited and trained than in SL. They have to undergo Aptitude Tests and Refresher Courses. INR started training Train Drivers on Simulators. INR makes regularly **SURPRISE INSPECTIONS** to enhance strict Discipline. **Maintaining Discipline** is regarded as essential. Regular **SAFETY AUDITS** are undertaken at several levels to make in depth assessments of Safety Systems.

INR have understood that strict rules can not take control over all events. Increased **Safety Consciousness and Awareness for Hazards** have to be developed by training at all levels to prevent the loss of valuable human and material recourses.

SIGNAL PASSED AT DANGER, SPAD, but not causing any accident with lucky outcomes, is nowadays taken as serious as a SPAD resulting in a bad event. **Near Missed Events** have to be treated with the same seriousness as occurred bad, unlucky events.

"In case of Railways Accidents, however it is the Railway Organization that has to take the Blame" = ARIYAN BHUSHAN, a member for the Commission of Railway Safety for 17 years; **see A. Bhushan and M.M. Agarwal, INDIAN RAILWAY SAFETY, Prabha and Co., Delhi, India, 2005, ISBN 81-900613-3-x.**

INR has adopted the doctrines and principles of **ACCIDENT CAUSATION** laid down in the handbook of James Reason, which should in all hands of Accident investigators and Safety Experts.

Measures that involve sanctions, threats, fear and the like have only very limited effectiveness unless the latent error producing conditions and failures in the system are addressed.

Substantial developments have occurred over the last 25 to 35 years in understanding the nature, varieties and causes of **HUMAN ERROR.** But some **GMR** even ignore this nowadays. Safety Experts and Managers have learned from the Disasters like ***PIPER ALPHA, CHALLENGER, CHERNOBYL, ZEEBRUGGE, CLAPHAM, KING`S X, BRUEHL, ESCHEDE, SOUTHALL, EXON VALDEZ.***

But this does not mean that some human unsafe acts are egregious, for example substance abuse, reckless non-compliance, sabotage and so on. A blanked amnesty on all unsafe acts would lack credibility in the eyes of workforces. What is needed is a balanced **JUSTICE CULTURE**, an atmosphere of trust in which people are encouraged, but in which they are also clear about, where the line must be drawn between **ACCEPTABLE or UNACCEPTABLE** behaviour.

Strict discipline has to be trained but can not be reached by punishment and by driving the ***"BLAME CYCLE"***. Front line operators can not be made the victims in order to conceal **ORGANISATIONAL DEFICIENCIES, ERROR ENFORCING CONDITIONS and FAILURES IN THE SYSTEM.**

The more exhaustive the inquiry, the more latent conditions – the error producing conditions - it will be uncovered:

The **PIPER ALPHA DESASTER** is such another case. The disaster had been caused by a massive fire, which was not the result of an unpredictable ***"ACT OF GOOD***" or did not fall down to earth from the ***"BLUE OF THE SKY"***, but caused by an accumulation of Errors and questionable Decisions to increase productivity on the expense of Safety. Most of the Disaster Causations are rooted in the Organisation and its Structure, Procedures and Culture. There can be also flaws in inspection procedures, technical designs, guidelines and practices. The oil exploring company ***OCCIDENTA***L and its higher echelons have been finally blamed by Hon. Lord Cullen for the disaster. In the first row, the investigators wanted to put the blame on an inspector, who failed to spot many of the shortcomings, that contributed to the disaster few days later.

Safety experts of worldwide Railways followed, how the German Judiciary decided in the case of the **06.02.2000 Train Crash at BRÜHL**, Germany.

BRÜHL, Germany; 06th February 2002: FAILURE IN THE SYSTEM

A 28 year old Train Driver had been send with the Express D 203 from Cologne to Bonn over a ***tricky*** arranged deviation to bypass a blocked section under repair in the night, by using the left down track bi-directional, although for bi-directional use there had been no clear Signalling and no Indusi Magnets (ATP, PZB) to monitor the speed. There had been beforehand warnings, not to send trains over such a ***TRICKY***

ROUTE without appropriate safe Signalling. The lady dispatcher in Cologne did not consider it as necessary to give a warning attest to the Driver. Before the crossover to the left track a Signal had given the Caution Aspect, GREEN OVER AMBER, which means in this case 40 kmph. The rule is, to keep the 40 kmph speed up to the next Main Signal with a clear information. On the track there had been sign posts left from the previous day without a bypass deviation for a temporary speed restriction of 120 kmph. Since the Driver did not found a Signal for the next 4 km, he thought the temporary speed restriction left from the previous day is an invitation to accelerate to 120 kmph. He had not been informed in Cologne, that he will be send in Brühl over a siding, arranged, to manage bi-directional service and crossings with north bound trains on the left down track.

The Train negotiated the turnout with 122 kmph instead with 40 kmph. The Locomotive managed to take the turnout with 122 kmph but pushed in the counter curve the rails from the planum and crashed in a house without causing too much damage. The coaches crashed transverse into the station platform with the result that 8 passengers got killed and over 50 serious injured.

The Medias have been quick to blame the Train Driver as the **"culprit"**. He had been charged of manslaughter, but later the public prosecutor dropped the case against him for a penalty of some month salary. **His fault had been regarded as minor** against the severe **FAILURES IN THE SYSTEM,** when arranging this **TRICKY ROUTE** without securing it appropriately by Signalling and ATP, and against the negligence of the Lady Dispatcher in Cologne, not to issue a warning attest.

There had been a series of front-to-front, rear-end and flange collisions in Germany, Netherlands and Switzerland due to **Human Error**, which combined with **latent unsafe Conditions** by risky and tricky arranged train movements on sections not adequately protected by Signalling, Interlocking and Train Protection Systems:

29.01.2011, Hordorf, East-Germany

07.08.2010, Geldern, Germany

24.11.2009, Rotterdam, Netherlands

28.04.2006, Thun, Switzerland

Such bad events can happen, if Dispatchers and Controllers in the Movement Authorities (MA, Control Room) are too remote from the track realities when arranging risky or tricky train movements.

In my previous papers on the nature of Human Error and SPADs and Signalling, the Chaotic Nature of Accidents, the Lot of Higher Ranks in Management, the economical, human and ethical Aspects of Accidents (– how much safety?) and the main Doctrines of James Reason have been laid down. The following pages deal with some of his important Assertions:

Accidents doe not fall from the ***"Blue of the Sky***" (like the steam locomotive 1899 at Gare de Montparnasse, Paris: see page 81). Mostly accidents have a far reaching history of **latent unsafe conditions**. Seldom has an accident occurred because only **ONE** thing went wrong. Mostly it is a combination of several latent unsafe conditions which combine and outburst suddenly to a bad event.

200 years before, when a horse carriage driver made a mistake and the carriage tumbled, the damage effect had been limited to the few passengers and not much damaged occurred to the spot of the mishap.

If nowadays a Train Driver or a Dispatcher makes a mistake and if there are no additional defence layers any more to thwart the mistake, the damage of an outburst on the so-called ***"SCHARP END"*** of the hazard trajectory can be disastrous:

On 02.08.1999 286 passengers got killed and 358 injured when at **GAISAL**, Katihar Division of the North Frontier Railway in India the down Dibrugarh-Delhi Brahmaputra Mail 4055 collided front to front with the up Delhi-Assam Express 5610 due to the disregard to the non interlocked station working rules by the traffic staff working at Kishanganj East Cabin, which resulted in the diversion of the north bound Assam

Express on the wrong down Main line, already occupied by the opposite south running Brahmaputra Mail..

The stations between Kishanganj and Alubari Road are not interlocked. “Line Clear” is given from station to station. The interlocking at Kishanganj Station had been out of working order due to repairs. The East Cabin Crew of Kishanganj has sent the up Assam Express Mail, which was already 8 hours late, on the wrong up track, already occupied by the down Brahmaputra Mail. Neither at Gaisal nor at Gunjaria have the cabin crews been aware, that the up Assam Express was coming on the wrong track. They have granted each other for both trains to set the line clear. Obviously nobody noticed that the up Assam Express had been send at Kishanganj on the wrong track. After setting the line clear there had been no instrument any more to stop the Assam Exp. on the wrong track or the down Brahmaputra Mail on the correct track.

The cause had been **HUMAN ERROR** combined with the latent condition of a not properly secured Station and a double line with old mechanical three aspect upper quadrant Semaphore Signals without interlocking. This out-of-date Signalling had been not fit any more for a dense traffic with trains running 100 to 110 kmph. Additional defence layers, radio communication or track occupation devices could have thwarted the tragedy.

“Defence-in-Depth” is the IDEA of laying successive layers of protection, one behind the other, each guarding against the possible breakdown of the one in front, when understanding, awareness, safety rules, procedural guidance fail to keep potential victims away from hazards. At Gaisal those additional defence layers, Swiss Cheese Slices, have failed, and rules in the Kishanganj Cabin broke down. The train passengers got caught by the hazard of running a train bi-directional on a double line without proper defence signalling. There had been no escape and rescue by a track occupancy device once both trains on the same track had left the Kishanganj and Gunjaria stations. The System had not been proof against a **SINGLE FAILURE** that of the so-called ***FRONT LINE PEOPLE*** at Kishanganj, who displaced the interlocking defence in order to do some repairs. The latent unsafe condition of this section has lain dormant for a long time doing no particular harm until it interacted with the local circumstances at **KISHANGANJ**, where the interlocking system had been out of order and the cabin crew disregarded the working rule in case the interlocking system is not working.

The latent unsafe condition had been undiscovered and uncorrected for nearly 100 years. But since the installation of the mechanical system the traffic density and train speed have increased drastically. The “**GAISAL”** bad event had been an

ORGANISATIONAL ACCIDENT rather than only the outcome of **ONE INDIVIDUAL HUMAN FAILURE or MALFUNCTION.**

"GAISAL" proves, that bad events mostly not occur during routine procedures but with preference during or after off-normal conditions of repairs, services, testing, assembling, as revealed by several examples in the J. Reason Book.

There are similarities with the above mentioned "**BRÜHL**" Disaster. And the careful reader will find similarities to the recent bad events of **SLR** at **GANEMULLA** and **ALAWWA. Investigations in depth have been blocked by higher ranks. To reveal the unsafe conditions, the organisational factors or the FIS, has not been wanted. Investigations in depth down to the roots of the latent unsafe conditions would have revealed the responsibility of higher echelons. But this had been not wanted. No lessons had been learned and the accident had no repercussions for further safe train operation.**

If one tracks down the root causes of the worst Organisational Accidents of the last 35 years, of Railways, of Aviation Industries, Space Undertakings, Oil Explorations, Nuclear Power Productions or Marine and Shipping Organisations, one always finds severe unsafe latent conditions or FAILURES IN THE SYSTEM, FIS. Radical improvements of the Technical Organisation's Safety can be only achieved through a better understanding of the nature of the involved bad ingredients of the Accident-Brew. From the System Manager one can expect to exercise some control.

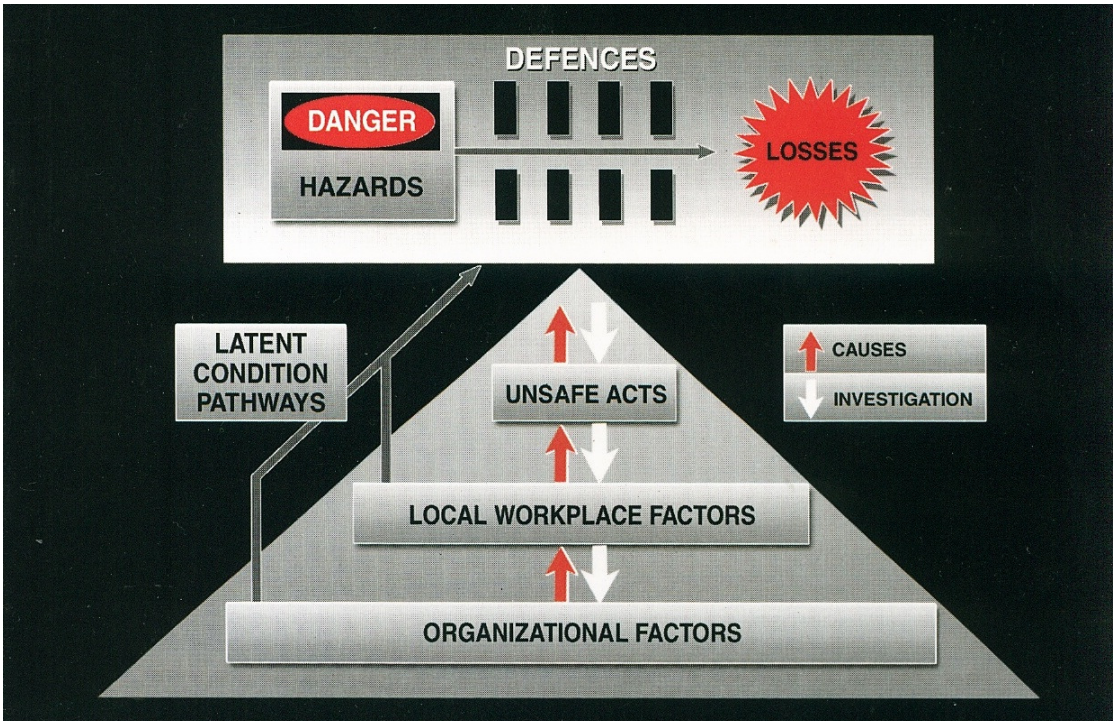


Fig. 1; Stages in the Development and Investigation of an Accident.

The principal stages involved in the development of organisational accidents are shown in Fig. 1 on the cover of the James Reason Book[1]. This model links the various contributing elements into a coherent sequence, that runs bottom-up in causation and top-down in investigation.

The rectangular block at the top represents the main elements of an event, while the triangular shape below represents the system producing it. This has three levels: The unsafe Act (f.i. by **HUMAN FAILURE** or **MALFUNCTION** of a Cabin Crew, Dispatcher, Control Room or Movement Authority Officer, Train Driver), the Error-provoking Conditions or local workforce factors (f.i the Track Conditions, Signalling) and the Organisation (Railways). The red and grey upward arrows indicate the direction of **CAUSALITY** and the white downward arrows indicate the **INVESTIGATION STEPS.**

ACCIDENT INVESTIGATORS have always to go down to the root of ORGANISATIONAL FACTURES and FAILURES IN THE SYSTEM (RAILWAYS)! But in SL the revelation of the organisational factors, for which higher echelons are responsible, are not wanted. They are kept dormant.

Railway Accidents are nowadays unacceptable in terms of their human and commercial costs; see my treaties on "HOW MUCH SAFETY".

In Sri Lanka one could detect a trading off of protection for the advantage to keep the trains running on the lowest possible investment level, leading to the gradual deterioration of defence in a period in which the absence of bad events created the impression that the system might operate safely.

Discipline and Awareness is asked:

Every Railway has its rules, procedures, practices, and operational modes to make the operation safe, to defend the system against the attacks of hazards. There are defence systems, devices. Most important are Signals and Interlocking Systems to prevent conflicting situations and hostile train movements. But this alone can not make the Technical Organisation to operate 100 % safe without the occurrences of bad events. The Safety Instruments can not cover all possible unsafe acts and conditions. There might be always situations occur, for which the safety procedures are not prepared for. There are sometimes odd or the unthinkable situations propping up, for which the staff had not been trained properly to be handled in a safe way.

It needs phantasm and imagination to paint all possible scenarios, for what might go wrong, and to plan carefully in advance what to do, how to react, if what happens.

During my career in Industry we came together in groups under a mediator for a **BRAIN STORMING GROUP SESSION** to find out all thinkable, even the "unthinkable" scenarios, and what will be the remedies; **"what to do if what happens";** in other words: **"BE PREPARED FOR THE WORST".**

Most important is the AWARENESS FOR HAZARDS. This can be sharpened by Education and Training.

Strict **DISCIPLIN** in all ranks, also in upper echelons is another prerequisite for safe operation. In other Railways, especially in North America, one can find much more and stricter discipline than within SLR. Under strict Discipline at the Railwaystation

Ambalangoda, Madampe, Kahawe the 26th Dec. 2004 the Tsunami Train disaster could have been averted.

Some Active Latent Risks and Hazards of SLR:

Collisions due to arranged risky train movements, risky operational modes, procedures especially when utilising dual tracks en routine as twin single tracks or bi-directional; insufficient protection by signalling especially on tricky or risky routes and sections; human error, malfunction, mistake, fallibility; due to weak or faulty brakes, not properly repaired, maintained, serviced, inspected, examined, tested brake systems (leakages in the brake system, faulty capacity of vacuum exhausters or pressure pumps, not enough vacuum or air supply, angle cock valves not opened, loose, dangling and turned brake shoes, blanked brakes; collisions with road vehicles on unsecured level crossings.

Derailments due to bad tracks not properly ballasted and drained; loose fishplates, loose fishplate fastenings, loose rail fastenings, loose brake blocks – which might fall between rails and check rails or in V-crossings of points, missing rail fastening clips, rail kinks, hogging joints, rail fractures, risky rail fracture repairs by inserted rail cuttings in fishplates, worn-out rails, faults in geometry parameters; mud dancing sleepers due to inferior rail track engineering works, botched up repairs and missing drainages; excessive speed; worn wheel treats (flat tyres, worn root, sharp or steep flange, wheel treat spalling); defect bogies; train jerks; sudden brake application especially on down gradient runs on warped tracks; collisions with mud slides, rock and bolder slides, falling trees on not properly maintained cuttings, tunnel entrances, hill sections and unsecured culverts; weak or defect bridge abutments (f.i. at Ambalangoda).

Some latent Unsafe Conditions, Failures in the System SLR:

Related to Phatalogical instead Generative Culture, frustration of employees, shortcomings related to basic organizational processes, rules, designing, constructing, operation, maintaining, communication, selecting, qualification, training, teaching and education, supervision, managing;

related to unprofessional risk management, unprofessional accident investigations, blocking of results by higher echelons and politicians;

related to lack of awareness for hazards, missing routine inspections, holes in the safety defence layers, disastrous decisions, incorrect running of the economy, common smart alick, sloppiness, low pay, low status, macho-culture, pressures on station masters, Train Drivers, Control Room Officers to breach safety rules in order to keep the trains running on time, poor or disturbed human-machine interface, under manning, poor supervision, poor guidance by seniors and top managers, corruption, political interference, dangerous micromanaging by politicians, disturbed relations between disciplines, especially between signal engineers and train drivers;

related to inadequate operational rules, procedures, shortages of funds, manpower, spares and tools;

related to not advisable rolling stocks, tracks not matching the traffic load it has to carry, complex signal system not in line any more with train speed, traffic density and operational procedures by the movement authorities;

related to tricky routes and section not properly secured by signalling, deficits of the Multiaspect Colour-Light Signalling.

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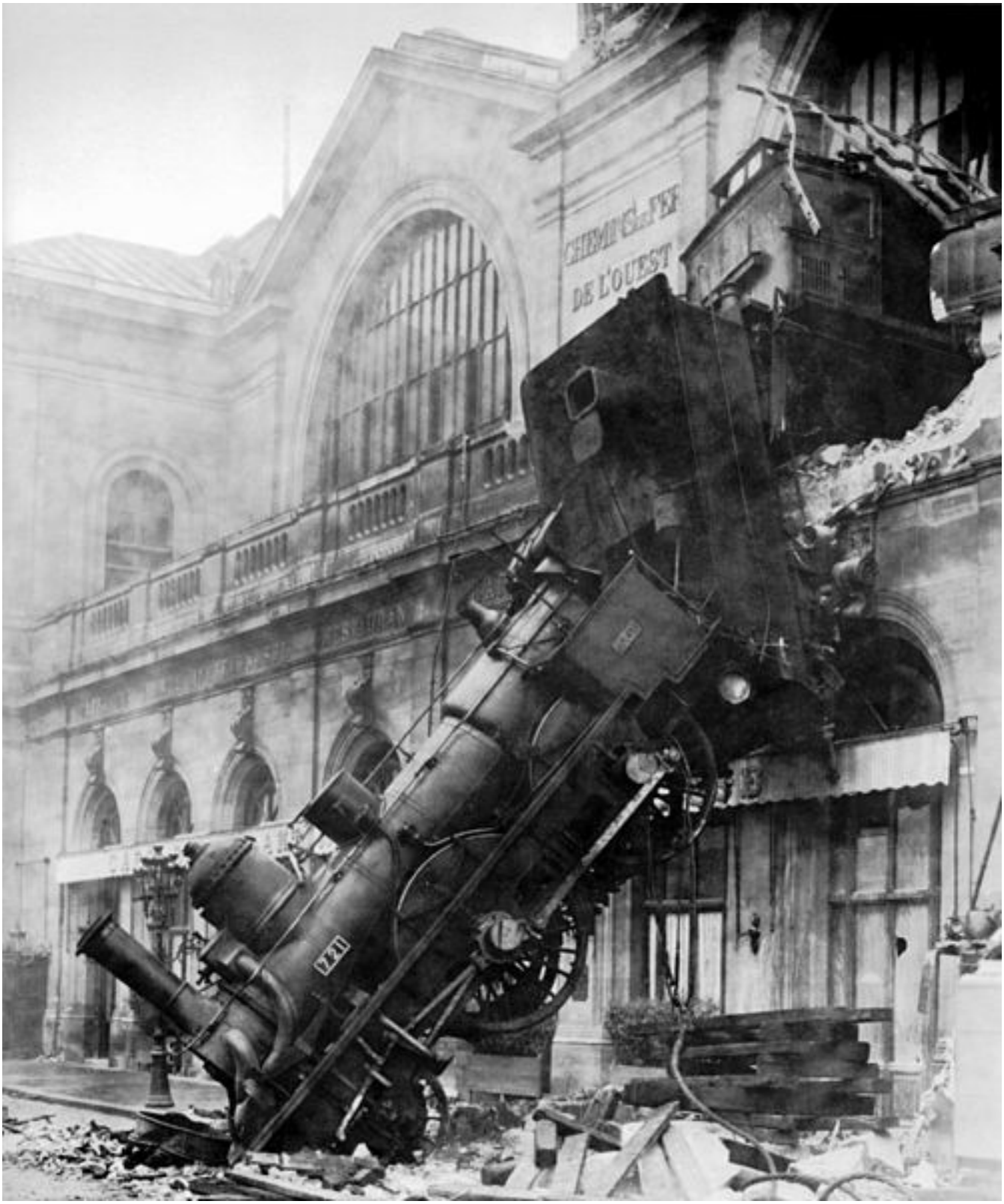
1) James Reason ***MANAGING THE RISKS OF ORGANIZATIONAL ACCIDENTS***, Ashgate Publishing Limited, GU9 7PT Farnham, Surrey, England, ISBN 978 1 84014 105 4; **see also the ibid. cited literature for further information.**

Versaille 1842



Gare de Montparnasse, Paris 1899