International Rail Safety Conference

1992 WELLINGTON

27 October - 30 October 1992
Park Royal Hotel, Wellington, New Zealand

Paper 9200

Index of 1992 Conference Papers

Publisher
2000 International Rail Safety Conference

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Conference Programme

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2000 International Rail Safety Conference

INTERNATIONAL RAILWAY SAFETY SEMINAR 1992

▸ PROGRAMME

WELLINGTON NEW ZEALAND

INTERNATIONAL RAILWAY SAFETY SEMINAR

27 -30 OCTOBER 1992

Parkroyal Hotel

Day/Date	Time	Sponsor/Name	Subject
Tuesday 27/10/92	08.30 09.15 - 10.15		"Registration" "Brief Visit Wellington Yard"
	10.30 - 11.00	Morning tea - 1st Floor Foyer	
Tuesday 27/10/92 Chair: Murray King Scribe: Neil Buchanan	11.00 - 12.00	1. NZRL A F Small Managing Director 2. SNCF Pierre Messulam	"NZRL as a Business" "An Historical flashback of Rail Deregulation"
	12.00 - 13.30	Lunch - 1st Floor Foyer	
Chair: Roger Gower Scribe: Russell Grigg	13.30 - 15.00	1. German Rail Dieter Metz 2. NZRL Ray Ryan/Murray King	"Development of Quality Assurance for Railway Safety "Transport Law Reform in New Zealand"
	15.00 - 15.30	Afternoon Tea - 1st Floor Foyer	

October 22, 1992

Chair: Ian Ambler Scribe: Greg Hight	15.30 - 17.00	1. British Rail David Rayner 2. Japan Toshimasa Murakami	"Cost Effectiveness of Safety Expenditure" "JR East's Investment in Safety"
	17.30 - 20.30	Cocktail Party - Rosanna Room	(1st Floor)
Wednesday 28/10/92 Chair: Garry White Scribe: Vern Herdman	08.30 - 10.00	1. SNCF M Joing 2. SRA Tony Boland/Peter Niven	"Determining the Cost of Railway Accidents" "The Costs of Safety"
	10.00 - 10.30	Morning Tea - 1st Floor Foyer	
Chair: Ed Dunn Scribe: Merv Harvey	10.30 - 12.45	1. South Africa C Labuschagne 2. British Rail David Maidment 3. NZRL Graham McDougall	"Risk Profile: A practical approach to the incident management link" "The Development of Information Systems to Support Risk Management" "The Cost of Poor Quality"
	13.00 - 14.15	Buffet Lunch with NZRL Board	Impressions Bar
Chair: Ray Ryan Scribe: Mark Fynmore	14.15 - 15.00	1. NZRL Ron Allan	"Risk Management Protection Levels at Road/Rail Crossings"
	15.00 - 15.30	Afternoon tea - Foyer	

Chair: Helen Morgan Scribe: Allan Neilson	15.30 - 17.00	1. London Underground Jack Rose 2. ANR Chris Hall	"Safety and Quality Development in LUL" "Strategy for Safety Management"
	18.00	Train Departs for Dinner at Southward Trust Museum	
Thursday 29/10/92 Chair: Graham Jones Scribe: Steve Lowe	08.30 - 10.00	1. Japan Hiroshi Nagaoka 2. SNCF Pierre Messulam	"Study and Prospect of Humanware" "Vigilance for Railway Workers"
	10.00 - 10.30	Morning Tea - 1st Floor Foyer	
Chair: Richard White Scribe: Dave Hutchinson	10.30 - 12.00	1. JR East Railway Workers Union Akita Matsuzaki 2. ANR Chris Hall	"Railway Safety for Labour Union" "Care Management of Workers Compensation & Rehabilitation"
	12.00- 13.30	Lunch - 1st Floor Foyer	
Chair: Barry Parkin Scribe: Brian Lister	13.30 - 15.00	1. SNCF M Joing 2. BR David Maidment	"Incident Investigation & Discipline Procedures "BR Human Factors Research and Application"

October 22, 1992

Chair: Ray Ryan Scribe: Ron Dobbelaar	15.30 - 17.00	NZRL Francis Small	"Seminar Summary"
	17.00	Drinks & nibbles - 1st Floor Foyer	
Friday 30 October	07.00	Train departs Wellington Station for National Park.	

International Rail Safety Conference

1992 WELLINGTON

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Paper 9202

Abstracts

Publisher
2000 International Rail Safety Conference

▸ ABSTRACTS

INTERNATIONAL RAILWAY SAFETY SEMINAR
27 - 30 OCTOBER 1992
NEW ZEALAND RAIL LIMITED

ABSTRACTS

Germany Railways- Dieter Metz

1. Development of a Quality System for Railway Safety at DB

In 1987, the European Committee for Standardisation (CEN) issued a number of standards which lay down general requirements for quality assurance in the production of products and the performance of services.

Up to now the quality-related work in the field of railway safety at DB is generally of a very pragmatic nature. A formal quality system of the type defined by the ISO standards has not been established.

The DIN ISO standards lay down new requirements which also apply to the organisation of railway safety. If the quality assurance action already taken were inadequate, management would have to justify its omissions in the event of a grave failure of safety systems due to organisational defects.

In order to meet the requirements for a quality system to ensure railway safety, a "Regional Safety Officer" should be appointed at the regional level within each directorate.

Major components of a quality system for railway safety are:

- Elements of quality system in accordance with DIN-ISO
- Safety manual
- Content of safety regulations
- audit planning and implementation

As regards the basic requirements for effective safety systems, the same standards should apply to all railways with a comparable range of services. However the intensity of quality assurance efforts made by the various railways is very different, depending for example on the occurrence of grave accidents. It would therefore be interesting to discuss the organisational structures in place and the personnel deployed by the railways in the field of railway safety. It could also prove useful to agree upon general guidelines for safety manuals and safety audits on an international basis.

French Railways - Pierre Messulam

1. Vigilance for Railway Workers

This paper has been first drafted in French by Jean George Heintz, deputy of the Human Factors section, Pierre Messulam, Head of the Human Factors Section, Dr Paul Millet, Physician, working then in the Ergonomics Division, Phillipe Muhstein, Heading then the Ergonomics Division.

The paper tries to face the issue of vigilance in railway safety.

Summary: In which way is "vigilance" a demand to handle with safety-related jobs in railway?
To face this issue, a prerequisite is to define accurately this concept which encompasses different meanings according to context. The usual meaning (moral concept) is different from its medical meaning (neuro-physiological) based on the fluctuations of vigilance following human biorhythms. Other branches use different notions, such as attention (in general psychology) and mental load (or overload) in cognitive ergonomics. A bibliographical study conducted on researches performed the last 40 years show that few convenient solutions exist to bar or to prevent human vigilance decrease. The lab systems proved to be poorly designed to run in professional context. Therefore, the study of the real working activity of the operators, on a case by case pattern, is required to improve the safety of railway systems.

New improvements paths can be drafted; although selection and monitoring of individual capacities - such as vigilance - may be of some interest, we shall broaden our field of investigation to safety loops design in the equipment's, man/machine interface ergonomics, work-organisation, quality of professional formation and training.

2. Historical Paper

How a Frenchman viewed the American railroad deregulation in 1896. Shall Europe deregulate its railroads today?

I had the chance of finding out a 1896 report of Louis Dubois accounting officer of the French Government sent on an official mission in the USA on the railroad deregulation. His comments on relationships between State and rail companies, and business practices in America are amazingly actual. A comparison between recent air deregulation and Sixth century railroad deregulation is of special interest. Finally Dubois concluded on the failures of the 'public highways' concept and of the global deregulation.

French Railway Mr Michael Joing

3. Incident Investigation and Discipline Procedures

Until recently, little was known about the phenomenon of human error. The analysis of incidents had a strong emphasis on the disciplinary aspects. This led to greater uniformisation and the increasingly systematic application of penalties to the detriment of analysis of the event itself, the circumstances which lead to it; and the professional qualities of the individual in question.

Various projects have been carried out since 1989 concerning the revision of Safety Policy which has led to a new approach based on, enriched feedback and dealing with individual cases on a personalised basis.

4. Mr Michael Joing

Determining the costs of Railway Accidents

Accidents may be usefully divided into two categories; ie those which impact on individual persons, and those of train accidents. The historical costs and how this information is incorporated into the investment choice based on SNCF exposure to risk is discussed in the paper.

Australian National Rail - Chris Hall

1. Strategy for Safety Management

Australian National has established a sound basis for improving safety through a shared recognition and acceptance of responsibility for safety. The elements in place to support this change in attitude include access to reliable, timely information, defined responsibilities, supportive and responsive management, safety training and development programs and safety management/rating system with independent assessment of AN's safety performance and professional support services.

2. Care Management of Workers Compensation and Rehabilitation

This resulted in a reduction in lost time injuries between 1988 and 1992 of 28% for the same period, total days lost reduced by 39%, the workers compensation premium reduced by 40% and the AN liability for all workers compensation reduced by 46%.

Broadly the strategy involved:

- Development of Corporate Standards and Strategic Occupational Health & Safety Plans.
- Introduction and line management of a performance reporting and rating system.
- Rehabilitation programs and management.
- Management and supervisory occupational health and safety training programs.
- Devolution of accountability for occupational health and safety accompanied by reliable, timely performance information.
- Segmentation of costs to work centres.
- An increase in negotiating workers compensation settlements outside the court system.

Australia State Rail: Tony Boland - Peter Niven

1. The Costs of Safety

State Rail embarked on a major change in the way it manages safety. To achieve impact on safety performance required substantial change in the way safety was previously addressed, while also requiring investment and workforce culture to be radically altered. Through "de mystification" of safety, establishment of specific activities and performance measures, based on a reliable data base, and a large level of commitment, major progress has occurred.

This article sets out these activities, some of the key achievements and directions of further challenge.

British Rail - David Rayner

1. Cost Effectiveness of Safety Expenditure

In October 1991 British Rail described a safety project prioritisation process, using risk assessment techniques and enabling cost/benefits to be ranked. During 1992 British Rail's risk performance has be calculated, the impact of the additional safety budget on performance evaluated and discussions on a threshold "Value of Life" for railway safety investment have taken place with UK Government and the Health and Safety Executive. Current developments include the refining of the prioritisation process to cover full loss control principles, integrated totally to BR's planning and investment processes.

British Rail - David Maidment

2. The Development of Information Systems to support Risk Management

British Rail have an accident and incident database ("BRIMS") , but risk assessment studies have identified weaknesses, especially on the reporting and analysis of "near misses" and "causality". The presentation will outline the work now being undertaken to review the accident database, especially in the light of privatisation; develop a "line of route" prototype risk assessment model for use in decision-making by line managers; and the BR policy to introduce a "Safety Case" procedure for all major changes in the system. The presentation will also refer to the 1991 "Latimer House" seminar's decision to attempt to establish some form of "International" standards in risk information including a review of the David Hyland study on Risk Performance comparisons of suburban railways.

New Zealand Rail Limited: R S Ryan and M A King

1. Transport Law Reform :

A Bill is currently before Parliament, which contains proposals for the Minister of Transport to require Railway Organisations in New Zealand to be registered and within three years of registration to have an "approved Safety System". The Bill also proposes to widen the Transport Accident Investigation Commissions role to incorporate investigation of Railway accidents.

The concept of the Bill is that it rationalises legislation which currently covers safety matters of steel wheel on steel rail operations. A quality systems approach is proposed to meet the requirements for Safety Management.

NZRL: Graham McDougall

2. Costs of Poor Quality

NZRL is committed to a Total Quality Management approach to meet customers needs.

The paper outlines the objectives behind measuring cost of non-conformance's, the strategies being used and expectations arising from the analysis and management information that is forth coming.

Risk Management: Ron Allen (Consultant to NZRL)

3. Protection at Level Crossing

This paper is about a methodology that looks at the level of resources that should be provided for the protection of road users and pedestrians at Railway Level Crossings. Guided by economic principles it seeks answers to the questions.

- how much protection is warranted
- who decides on the protection provided
- who benefits from protection
- who should pay for protection

East Japan Railway Company: Toshimasa Murakami

1. Investing in the Future to Prevent Accidents

JR East has a basic policy on safety which stresses that the most important task is to eliminate serious accidents involving loss of passenger lives. The policy is designed to enhance JR East reputation as a safe reliable Transport organisation. The policy is put into effect by taking both a "Software" and "Hardware" approach.

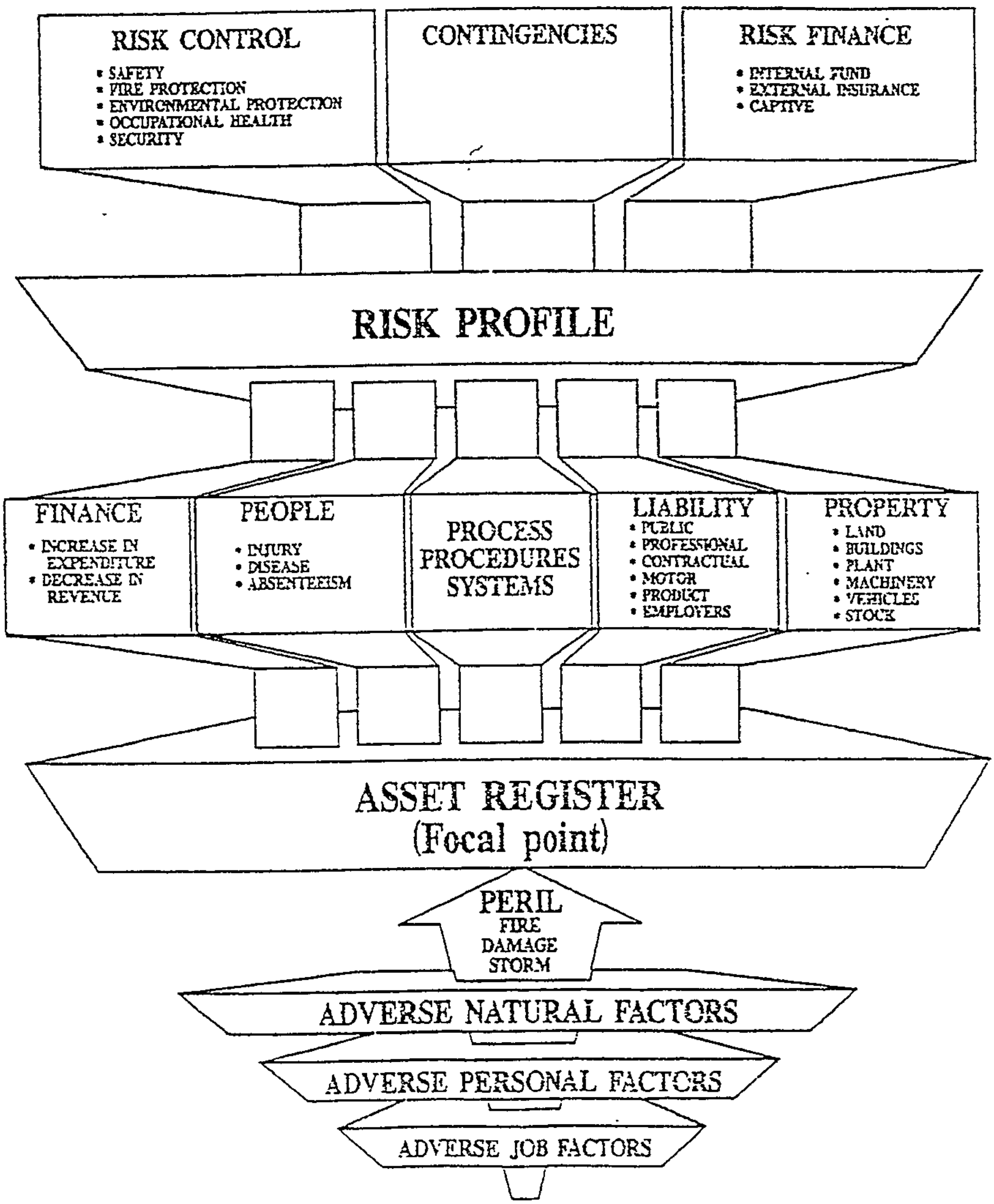
East Japan Railway: Hiroshi Nagaoka

2. Human Factors in Safety Management

JR East grew from the format Japanese National Railway. A Quality approach to customers has lead to high quality of service and improved safety. Advanced technology, training and education of staff, and the establishment of a Safety Research Institute have been three significant initiatives. The paper outlines the Research Institutes work on the three themes.

Topic: Risk Profiles - a Practical Approach
Speaker: Carel Labuschagne
Group Risk Manager
Transnet
South Africa

Objective of talk:
To suggest a practical (maybe controvertial) approach towards identifying the pure risks facing an organisation, in order to compile risk profiles and focus Risk Control and Risk Finance efforts.



New Zealand Rail

New Zealand Rail Ltd
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Wellington
New Zealand
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International Safety Seminar
Wellington Parkroyal

INFORMATION SHEET

Welcome to Wellington, the HQ of NZRL. I am proud to welcome you on behalf of the Company. I hope you find the proceedings interesting, informative and enjoyable.

These notes have been compiled to assist you. The Committee members will assist with any further information you require.

Registration

8.30am, Tuesday, in the 1st Floor Foyer

Seminar Venue

Lambton Room 2, 1st floor

Name Badges

Please wear these at all times, including social functions.

Seminar Sessions

A timetable has been included in your registration pack. To assist the Chairmen to keep to the start times as planned, please be seated five minutes prior to the commencement of each session.

Seminar Papers

If you require additional copies of these, please advise the registration desk.

Tuesday am visit to NZ Rail yard.

Please assemble in the downstairs foyer at 9.00 am. Partners welcome.

Travel Bookings

Should you require assistance with reconfirmation etc. please contact Pauline or Paulette at the registration desk.

Social Functions

Tuesday evening, Cocktail Party, Rosanna Room, 1st Floor.
This will commence at 5.30pm and will include an address by Sir Allan Wright, Chairman of the NZ Rail Board. Dress semi-formal.

Wednesday evening, 28 October, dinner at the Southward Trust Museum.
Transport has been arranged from the Wellington Parkroyal to the Wellington Railway Station. Please assemble in the downstairs foyer at 5.30 pm. The train departs from Wellington station at 6.00 pm and will return by 11.30 pm. Dress semi-formal.

Thursday evening post-seminar drinks, 5.00 pm 1st Floor Foyer.
Remainder of the evening free. Partners welcome.

Friday - Train trip to National Park - visit to Rotorua.

As the train departs at 7.00 am from Wellington Station, we have arranged for an early morning call at 5.45 am. Please have your luggage outside your room by 6.15am. Transport has been arranged to the station. Please assemble in the downstairs foyer of the hotel at 6.30 am. We suggest that you arrange to check out and settle your account on Thursday evening.

Note, we have full catering facilities on the train, and breakfast will be served en route.

Dinner has been arranged at the THC International Hotel, Rotorua, and we will need to assemble in the dining room by 7.00 pm. This is a special hangi dinner with entertainment by a Maori concert party.

Partners' Programme

We suggest all partners meet in the 1st Floor Foyer, following morning tea, Tuesday morning, to finalise details of the partners' programme with Tonya and Pauline.

All partners are invited to lunch on Tuesday , at midday, in the 1st floor foyer.

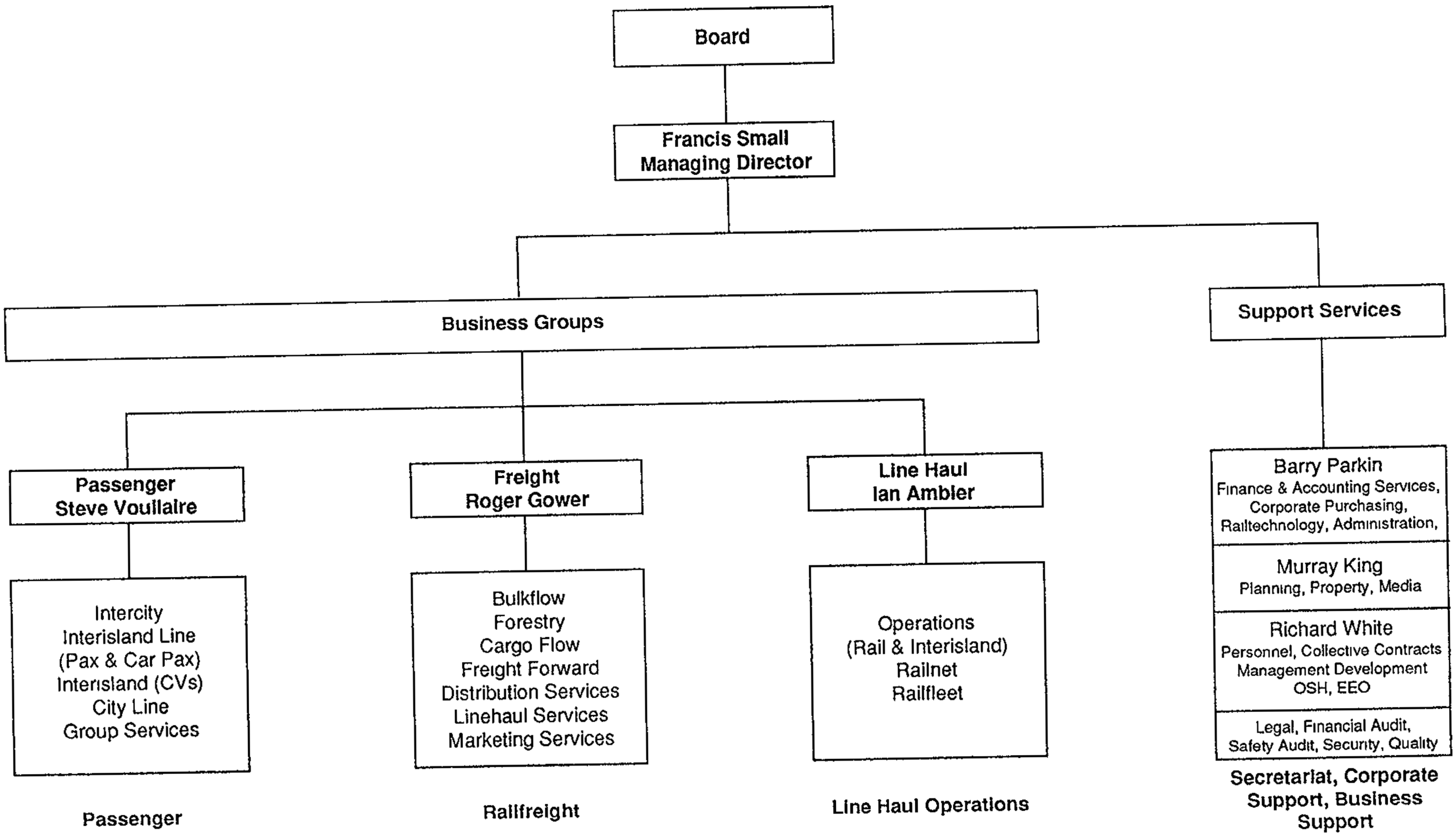
Note: on Wednesday and Thursday partners are to make their own arrangements for lunch.

Ray Ryan.

Ray Ryan
Seminar Convener

NZRL ORGANISATION CHART

1 July 1992



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Paper 9203

Pierre Messulam

An Historical Flashback of Rail Deregulation

Publisher
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International Railway Safety Seminar 1992

An Historical flashback of Rail Deregulation

Dr.P.Messulam
SNCF

Reagan versus Reagan : good and mis...fortunes of U.S. transport deregulation.

by Dr Pierre MESSULAM(**)

Again, the United States is confronted with transport deregulation : in 1887, with Congressman Reagan's proposition, a law was voted which ended several decades of wild competition between railway companies ; by a strange irony of History, his namesake, less than a century later, signed the air transport deregulation Act.

The present European Community politics for tranport is under this deregulation influence and is thinking of "liberating" track lines as if they were roads or canals.
However in 1896, L.P. Dubois, a French Account Court junior official, wrote a report about american railway transportation. He underlined the failure of full deregulation, because there was no answer for the fundamental questions : how can trains run concurrently on the same track lines which belong to different companies ? Who pays for the common understructures ?

Stakes of american railway transport in 1896.

At that time, American Railway Companies, had a capital value of 43 billions of french gold francs, (3/4 of Wall Street capitalization), employ 900,000 people. Relatively speaking, the same profitability preoccupation was found in those times in european railway, as today in all air lines Companies.

Erected without public utility proceedings, the most profitable sections were used with overcapacity, which triggered a fare war between companies This lead to the opening of a one million of gold dollar market for charters.

Impoverished companies then gathered themselves into brittle cartels, and helded to ransom local communities. In their wrestling match with big farming states, they answered the maximum lawfull fare act (proportional to mileage), either with reduced services or with bankrupty.

And Reagan I arrived !

Finally, on February 4 th 1887, a compromise solution was found with the "Reagan Bill". Leaning on "equity" and not on "common law", the Reagan Bill was unconstitutional and moreover not easy to apply ! But it allowed, without dispute, the first railway regulation.

(**) Mining Corps Chief Engineer

Technical points, structures and management in railway companies :

Companies survived thanks to several initiatives such as, insufficent safety budgets, 10 years leasing practice, cutting down in settled employees, obligatory train crews polyvalency, *a lot of firings*, wage reductions, lack of social protection policy... This pattern was taken up, after deregulation, by american air lines companies like Pan-Am and TWA !

Railways companies managed their debt with acrobatic financial performances at 80's Golden Boys way. In addition to lever mechanisms and unconsolidation, let us hold up as examples : high yield speculative obligatory emissions ('collateral trust' - the 'junk-bonds' of this time), accounts falsifications, charging common maintenance expense to "betterments item" which must only cover capacity investments. These manipulations gave "a face lift" to the balance-sheet and allow a better profit in case of raid.

L.P.Dubois. was scared with the behaviour of Wall Street; speculators which were "genuine pirates" : it was always the same small group of investors and bankers which gathered themselves to start up and reorganize bankrupted railway companies.

Accounts approval and Stock Exchange operations control were loose or inexistent, so he merely stated the generalised practice of "watering" : i.e. share emissions of fictitious capitals, free share emissions for dividend or track lines erection payment.
These behaviours brought Carl Icahan's raid on TWA, into proportion of B grade remake movie.

American railways companies in front of <<public highways>> theory.

These private companies, acting as public services, benefitted from a "charter" granted by a **legislative act** and were subjected to a "legal checking". Hence U.S. complexity of railway legislation, depending on Federal and States Administrations. How then can protection be given in a sane competitive way and to check these "chartered" companies ? May the new european structures keep us away from a similar muddle!

And yet the Brussels Commission is giving its preference to the <<public highways railways>> *doctrine* : i.e. track lines, considered as traffic roads, where trains of various companies would move together !

This old (born in 1831) doctrine keeps track line as an open road for everybody... simply subjected to a special track line code.

The Public Highway doctrine became obsolete after a first application test in New Jersey. Minnesota saw its comeback in 1871, as a weapon against exorbitant claims of companies.
J.F. Hudson took over in 1887 (the Reagan Bill year). Mr Dubois writes with irony :"... he (Hudson) suggests to return to the old bad habits, and to allow everybody to throw trains on track lines with special safety rules : Mr. Hudson thinks he finds there a very simple solution for american *railroad problem* !"

Companies assert : "the present imperatives of progress, the modern railroading practice are no more compatible with this outmoded, archaïc, obsolete theory".
So the typically american pragmatism preocupations and their legal inspection preference, carry of a doctrinaire approach of economic checking.

In conclusion : which Reagan do we choice ?

Either the man of rail regulation, or the man of air deregulation ? The deregulation problem of air or rail transports in C.E.E. may not sum up such a caricatured alternative. Today, these transports indeed haven't, in Europe a part similar to the one of american railways in 1896.

L.P.Debois analysis shows us the real complexity of this problem. We would have to meditate the various attempts at solutions acted by our american friends in the last century.

Could, America teach Europe an historical lesson ?

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Dieter Metz

Development of Quality Assurance for Railway Safety

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Development of Quality Assurance for Railway Safety

Mr.D.Metz
German Rail

International Railway Safety Seminar

27. - 30. October 1992

Wellington

Development of a Quality System for Operational Safety at DB

Dipl.-Ing. Dieter Metz
German Federal Railway

Development of a Quality System for Operational Safety at DB

1. *Basis*

In 1987, the European Committee for Standardization (CEN) issued a number of standards which lay down general requirements for quality assurance in the production of products and the performance of services.

The corresponding German standards are:

- DIN ISO 9000:
  Quality Management and Quality Assurance Standards - Guidelines for Selection and Use

- DIN ISO 9001:
  Quality Systems - Model for Quality Assurance in Design/Development, Production, Installation and Servicing

- DIN ISO 9002:
  Quality Systems - Model for Quality Assurance in Production and Installation

- DIN ISO 9003:
  Quality Systems - Model for Quality Assurance in Final Inspection and Test

- DIN ISO 9004:
  Quality System and Quality Management Elements - Guidelines

The basic principle of these standards is the use of a specific method to avoid errors at as early a stage as possibly in the development process. The later quality assurance is applied, the higher the cost of corrective action (Fig. 1).

The major emphasis of a quality system must therefore be error prevention.

2. *Ensuring Quality in the Field of Operational Safety for DB Today*

As with other railways, DB of course already makes efforts to:

- take full account of safety in the development of new systems;

- detect weak points in the field of safety;

- carry out risk analyses in the case of new projects which are planned;

- implement statistical analyses to review the success of the action taken.

However, this quality-related work is generally of a very pragmatic nature. A formal quality system of the type defined by the ISO standards has not been established (Fig. 2).

Particularly as regards the reviewing of operations, regulations concerning intervals and content are in force but there are no uniform rules for:

- *documentation of the results*

- evaluation of the results

- notification of the management in the event of critical developments.

Deutsche Bundesbahn therefore commissioned Dr. Adams und Partner Unternehmensberatung GmbH, Duisburg, to prepare a proposal for the introduction of quality assurance in the field of operational safety. This document presents the main results of this work.

3. Obligation to Implement a Quality Assurance Organization in the Field of Operational Safety

The DIN ISO standards lay down new requirements which also apply to the organization of operational safety. If the quality assurance action already taken were inadequate, management would have to justify its omissions in the event of a grave failure of safety systems due to organizational defects. Justification would prove particularly difficult in view of the relevant standards which have already been in force since 1987.

In order to meet the requirements for a quality system to ensure operational safety, a "Regional Safety Officer" should be appointed at the regional level within each directorate. The duties of the Regional Safety Officers are shown in Fig. 3.

The action required for quality assurance in the field of operational safety includes both technical and organizational elements (see Fig. 4). Whereas safety systems are generally highly developed in technical terms, this does not apply to the same extent to organizational aspects (systematic action). In order to comply with quality standards in the field of safety, priority should therefore be given to systematic organizational aspects.

4. *Major Components of a Quality System for Operational Safety*

4.1 *Elements of a Quality System in Accordance with DIN-ISO*

The standards indicate 20 elements which are relevant for quality assurance (Fig. 5).

Not all these elements apply to railways as service industries and further restrictions are required when considering the field of operational safety. The adaptations which are needed are indicated in Fig. 6 ("Optimization Elements").

4.2 *Safety Manual*

The DIN-ISO standards call for the comprehensive presentation of all action relevant to quality in the form of a quality manual. A similar manual should also be prepared for the field of operational safety. Among other things, the safety manual must include basic rules for the introduction and enforcement of safety regulations.

4.3 *Content of Safety Regulations*

In order to ensure that the system described is applied reliably and effectively, a uniform method for the preparation and revision of safety regulations must be developed.

Major elements of the structure of such a method are indicated in Fig. 7.

4.4 *Audit Planning and Implementation*

Within the field of operational safety, audits are the major quality assurance tool available to management.

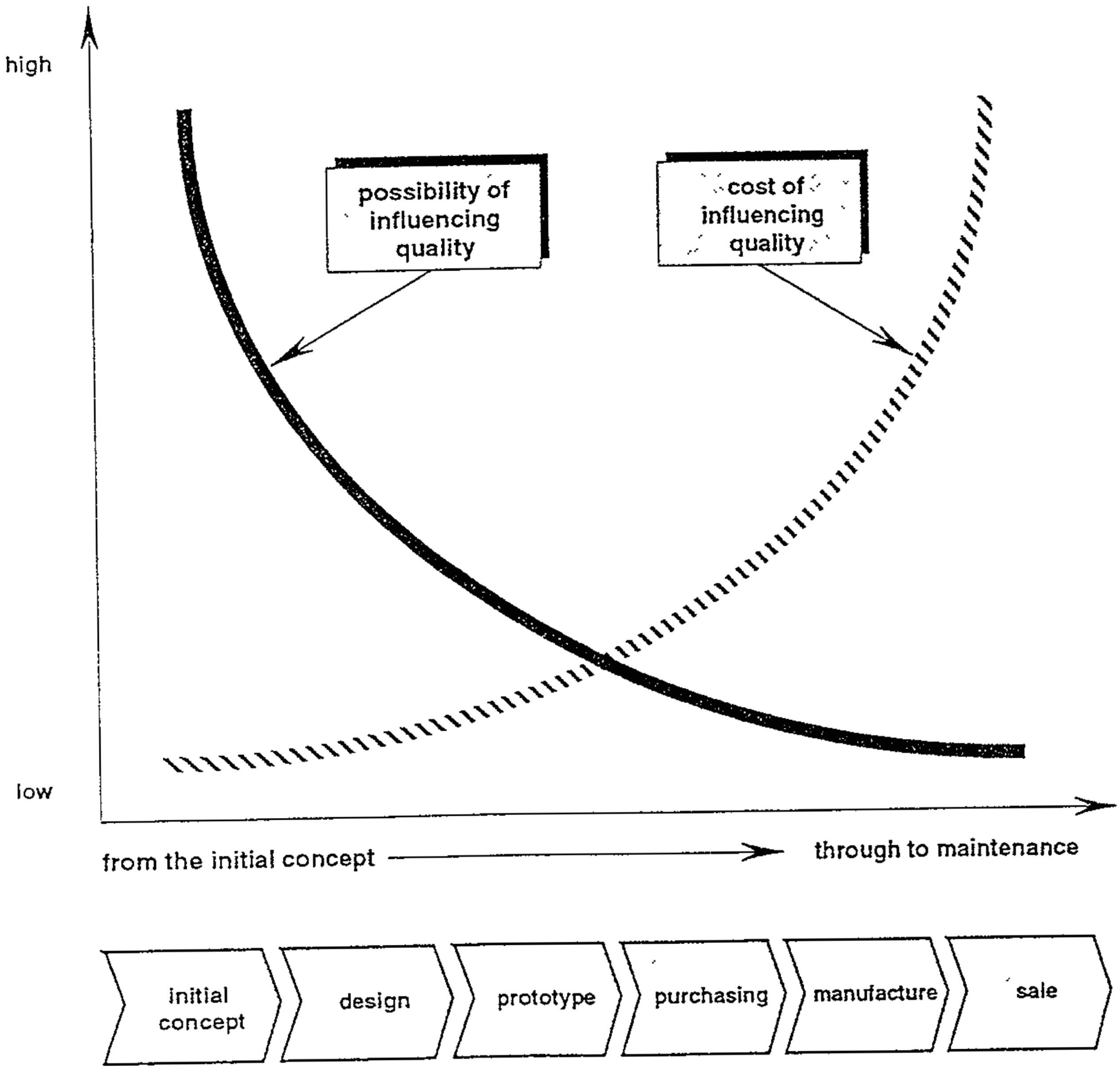
Fig. 8 indicates the definition, purpose and basis of a system audit in the field of operational safety.

An audit can only be effective if it is carried out in defined phases (Fig. 9) using defined methodology.

5. *International Agreement of a Quality System in the field of Operational Safety*

As regards the basic requirements for effective safety systems, the same standards should apply to all railways with a comparable range of services. However the intensity of quality assurance efforts made by the various railways is very different, depending for example on the occurrence of grave accidents. It would therefore be interesting to discuss the organizational structures in place and the personnel deployed by the railways in the field of operational safety. It could also prove useful to agree upon general guidelines for safety manuals and safety audits on an international basis.

Economic Reason für Quality Assurance



The Concept of Quality Assurance

Quality		

Quality is that set of properties which a product or a service needs in order to meet the requirements posed.

Quality	assurance	

Quality assurance encompasses all the organizational and technical action required to ensure quality throughout all fields and processes.
Quality assurance is a joint obligation of all units of an organization.

Quality	(assurance)	system

The quality system comprises the organizational structure and procedures established for implementing quality assurance.

Job Description for a Regional Safety Officer

Duties:

1. Advise the directorate on operational safety matters

2. Promote the safe functioning of equipment and rolling stock

3. Assist in the development and introduction of safe equipment and rolling stock

4. Supervise the application and effectiveness of the operational safety system within the area of the directorate

4.1 Conduct and supervise the evaluation of regular safety audits

4.2 Instruct operational safety reviews (non-scheduled audits) to be performed in the event of critical developments within the prouction process in the region; supervise the evaluation of the review and the corrective action taken

4.3 Supervise the satisfactory performance of surveys upon instructions from head office in the case of:
- certain types of latent risks
- certain types of actual risks
- repair of damage caused by accidents (to ensure that damage is fully repaired)

4.4 Supervise the verification of the effectiveness of central and regional safety action

4.5 Act as member of the DB "Safety Council"

4.6 Make regional proposals for the annual operational safety programme

4.7 Prepare the regional section of the annual safety report

4.8 Carry out special tasks upon instruction by the management safety officer

5. Conduct operational safety training

6. Report to the president of the directorate and head office

System-Related and Product-Related Quality Assurance

Operational Safety System

The action taken in all stages of the planning, implementation and supervision of safety work with respect to the safety system and technical systems must supplement each other in a meaningful way. This applies both to

- technical aspacts, and to
- organizational aspects

Action within Respect to Technical Systems

- Description and listing of critical subsystems (such as level crossing)
- Designation of risk areas
- Action taken to ensure safety in the event of technical defects (failsafe systems)
- Procedures for reporting line availability
- Definition of interdependences
- Keeping a safe distance

Action within Respect to Safety Systems

- Planning, implementation and supervision of audits to verify the effectiveness of the safety system
- Definition of organizational responsibilities
- Documentation
- Feedback and exchange of experience
- Purposeful staff training
- Methodology for planning action (definition of priorities)

Elements of a Quality System in Accordance with DIN-ISO

Quality System Elements:

1. Management responsibility
2. Quality system principles
3. Contract review
4. Design/development control
5. Document control
6. Purchasing
7. Purchaser supplied products
8. Product identification and traceability
9. Process control (in production and installation)
10. Inspection and testing
11. Measuring and testing equipment
12. Inspection and test status
13. Control of nonconforming products
14. Corrective action
15. Handling, storage, packing and delivery
16. Quality documentation and records
17. Internal quality audits
18. Training
19. After-sales service
20. Statistical methods

Optimization Elements

QA Element 1: Management Responsibility

- definition of duties, competence and responsibilities of persons responsible for operational safety
- procedures for conducting reviews of the DB operational safety systems
- procedures for reporting to the Board of Management

QA Element 2: Quality System Principles

- description of operational safety system
- systematic safety planning
- definition of "safety council" responsibilities
- coordination of safety work between the regions

QA Element 3: Contract review

- not applicable

QA Element 4: Development Control

- definition of safety requirements considering statutory provisions, requirements of society and internal requirements (aspects related to customers)
- definition of risk analyses and evaluations
- handling of suggestions concerning the improvement of operational safety
- definition of development requirements considering safety aspects (assistance with product specifications)

Optimization Elements

QA Element 16: **Quality Documentation and Records**

- documentation system for operational safety
- archiving system for operational safety records

QA Element 17: **Internal Quality Audits**

- preparation, implementation, documentation and evaluation of internal safety audits
- implementation of post-audits, supervision of corrective action
- definition of qualifications for auditors

QA Element 18: **Training**

- procedures for defining training needs in the field of operational safety
- performance of training in the field of operational safety
- documentation of training
- selection of external training programmes
- induction of new staff in the field of operational safety
- instruction of staff concerning new safety requirements
- motivation of staff with the objective of zero errors

QA Element 19: **After-Sales Service**

- not applicable

Structure of Safety Regulations

Contents

System Audit

Definition

Verification of the action required within the safety system with regard to the
- structure and
- functioning

of the organizational structure and procedures.

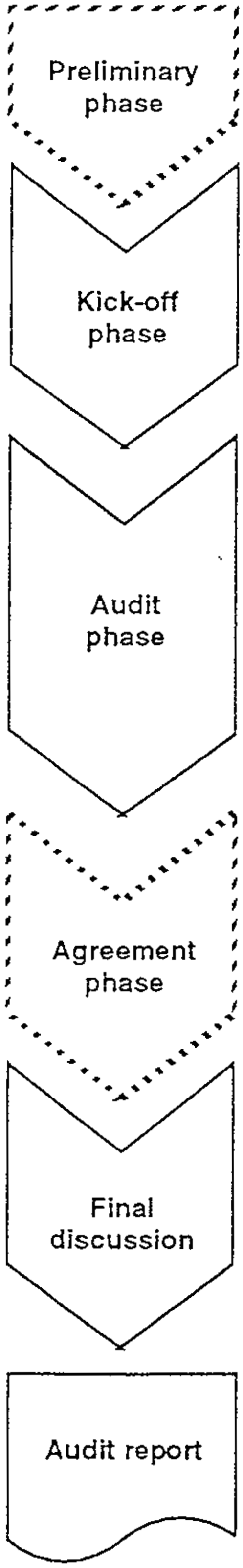
Objective

Assessment of the effectiveness of the safety system by determining whether the elements required exist and are enforced.
The audit is a preventive measure intended to ensure that the need for improvements can be recognized and corrective action taken at an early stage.

Basis

Manuals (organization manuals, quality manuals, operation manual, etc.) instructions, contract documents, management directives, checklists.
The manuals and instructions must be in force.

Audit-Phases – Typical Procedure



- preparation for the audit by auditor and auditees

- kick-off meeting
- definition of duration and content of interviews

- audit interview (auditor asks, auditee answers)
- Auditing of previously selected system elements using audit checklist
- basis: system manual, system directives, working papers and other relevant documents
- if appropriate, demonstration of procedures on site
- permanent documentation in audit protocol

- evaluation of audit by auditors
- compilation of results

- presentation of results to auditees
- discussion of joint results

- documentation of results in audit report

International Rail Safety Conference

1992 WELLINGTON

27 October - 30 October 1992
Park Royal Hotel, Wellington, New Zealand

Paper 9205

Ray Ryan
M. A. King

Transport Law Reform in New Zealand

Publisher
2000 International Rail Safety Conference

International Railway Safety Seminar 1992

Transport Law reform in New Zealand

Mr.R.S.Ryan and Dr.M.A.King
New Zealand Rail

RAILWAY SAFETY LAW

IN

NEW ZEALAND

Current Laws:

- District Railways Act 1908
- Local Government Act 1974
- Local Railways Act 1914
- New Zealand Railways Corporation Act 1981
- Public Works Act 1981
- Tramways Act 1908

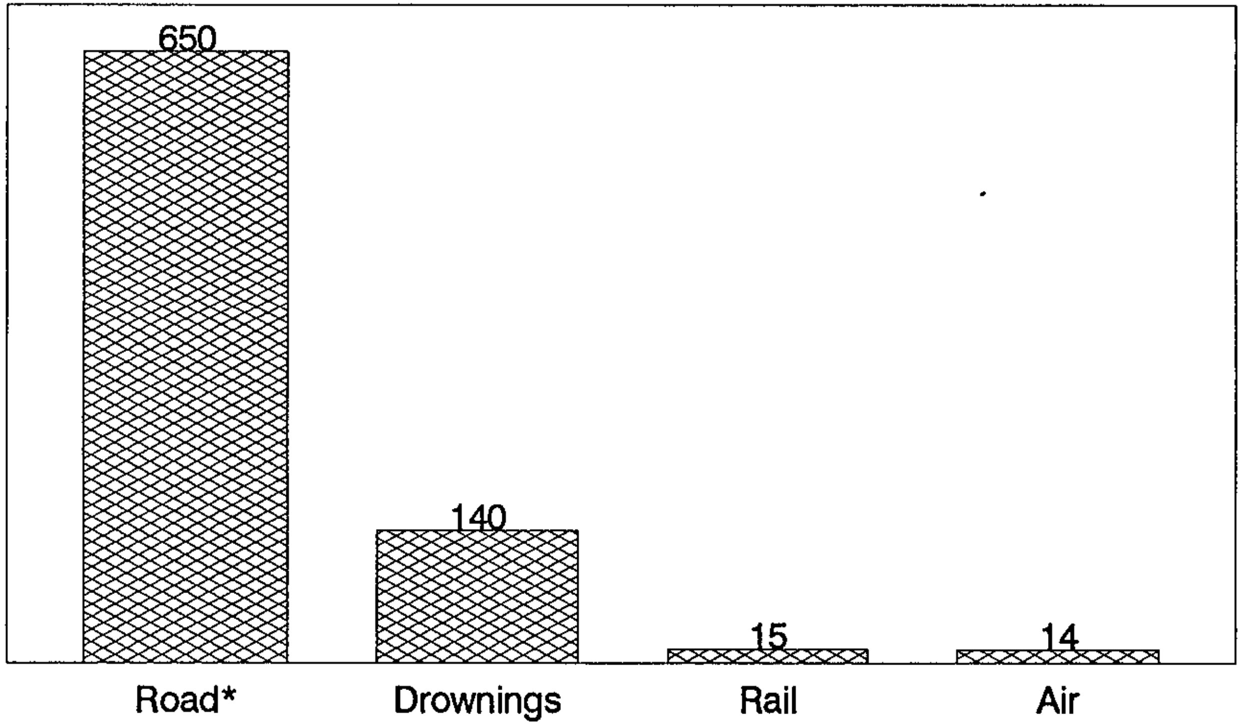
and associated Regulations

Objectives of Legislative change:

- rationalisation of existing legislation
- promote innovation
- cost effective approach to Safety Management
- entry of other Railway operators to industry
- suitability for future technologies
- protection of Public Safety interest

Fatalities in New Zealand

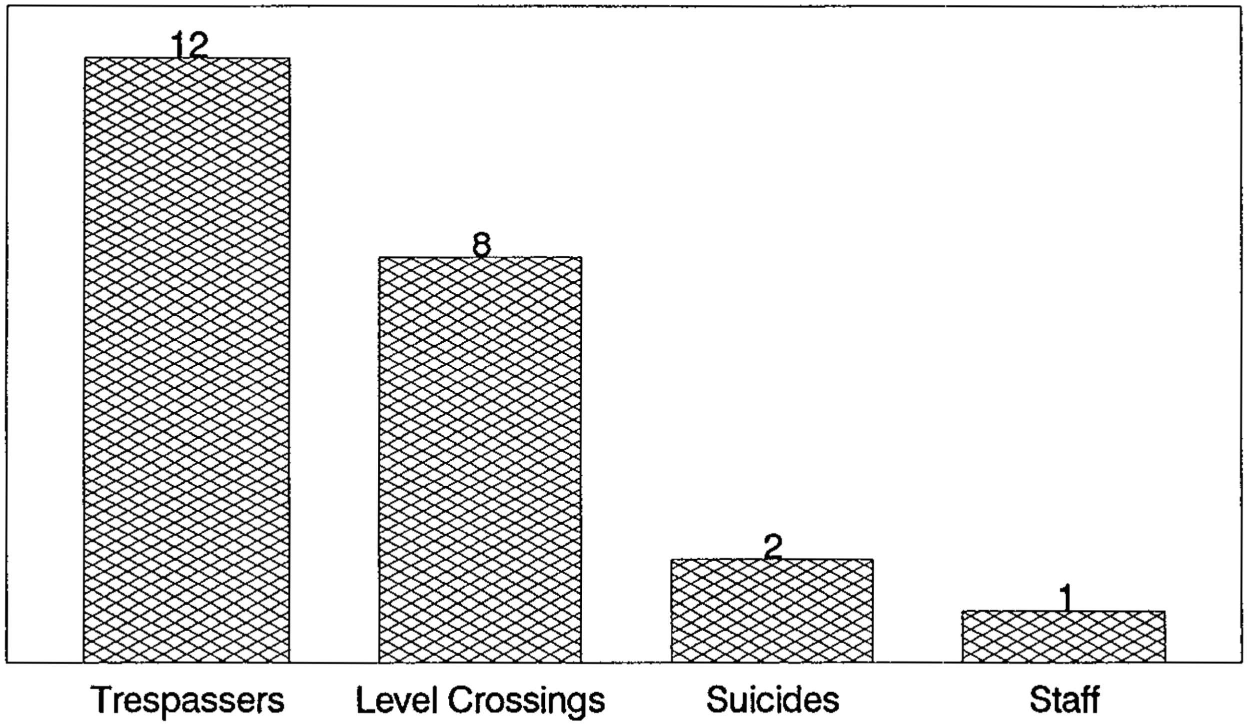
Year : 1991



* Includes Rail Level Crossings

Fatalities on New Zealand Rail

Year : 1991



Transport Bill proposes:

- operators be licenced
- Safety Audit philosophy be applied
- Transport Accident Investigation Commission's Role to cover Railways
- Safety Audit approach for existing and new technologies
- re-enactment of some existing safety clauses

  - Resource Management Act will encompass land issues

Proposed Role of Ministry of Transport:

- licensing Transport operators
- defining essential elements of Quality Safety System
- approving safety system
- auditing for compliance
- actioning remedial or penalty provisions

Role of Transport Accident Investigation Commission:

- reports directly to Minister of Transport
- conducts independent investigations
- establishes cause
- does not punish

Safety features of current Railway Laws:

- annual certification of Engineering Standards achievement
- Minister can call for Board of Inquiry
- "serious" accidents reports if Minister requests
- certification of new lines before use

Transport Safety Bill:

- Licence and System's requirements
- corridor management
- penalties
- investigations

Licence Requirements

Operators must declare:

- nature of operations
- scope of activities
- types of motive power
- name of principal officer

Licence Requirements

System to contain:

- standards
- procedures for compliance with standards
- accident/incident management procedures
- competent persons responsible for each part of safety system

Licence Requirements

System to contain:

- provisions for other operators
- Scope of Audits proposed
- Training and Qualification requirements
- other matters prescribed by regulation

Other Matters

- matters to be taken into account in considering safety system
- variations to safety system
- Appeal rights

Rail Service/MOT requirements:

- reporting accidents/incidents
- Secretary of Transport functions
- powers of the Secretary to act
- Secretary's management of the audit regime

Railway Safety:

- rules for level crossings
- level crossing management
- powers to protect railways
- offences and penalties
- unlawful acts

Issues for New Zealand Rail:

- ensure competitive neutrality
- right of way at level crossings
- accident investigation procedures appropriate for New Zealand Rail business commitments
- transitional issues
- approval strategy

Outline of New Zealand Rail Limited proposed system:

- foreword
- nature and scope of business
- role of Safety Management in New Zealand Rail business
- policy for Quality and Safety
- safety planning procedure
- management structure
- roles and responsibilities

Outline of New Zealand Rail Limited proposed system:

- system
- standards
- proactive management issues
- roles and responsibilities (specific)
- control of standards and documentation
- staff selection, training and certification
- accident/incident management
- group meetings; communication

Conclusions:

- quality system approach compatible with business objectives
- significant learning phase for all parties
- cooperative staged approval approach best strategy
- significant work load in approval phase
- innovative approach to railway safety from international perspective

International Rail Safety Conference

1992 WELLINGTON

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Park Royal Hotel, Wellington, New Zealand

Paper 9206

David Rayner

Cost Effectiveness of Safety Expenditure

Publisher
2000 International Rail Safety Conference

International Railway Safety Seminar 1992

Cost Effectiveness of Safety Expenditure

Mr D. Rayner
British Rail

BR THRUST OF ACTIVITY

TIGHT MONEY

MAJOR ACCIDENT RECOMMENDATIONS

PROGRAMME OF SAFETY LEGISLATION

£200m. p.a. EXPENDITURE

SAFETY PRIORITIES

COST EFFECTIVENESS

HIGH FOCUS BY BOARD

BOARD MEMBER, SAFETY AND STANDARDS

LATIMER HOUSE 1991

PRIORITISATION OF SCHEMES

PRIORITY OF ACCIDENT RECOMMENDATIONS

A.S.E.

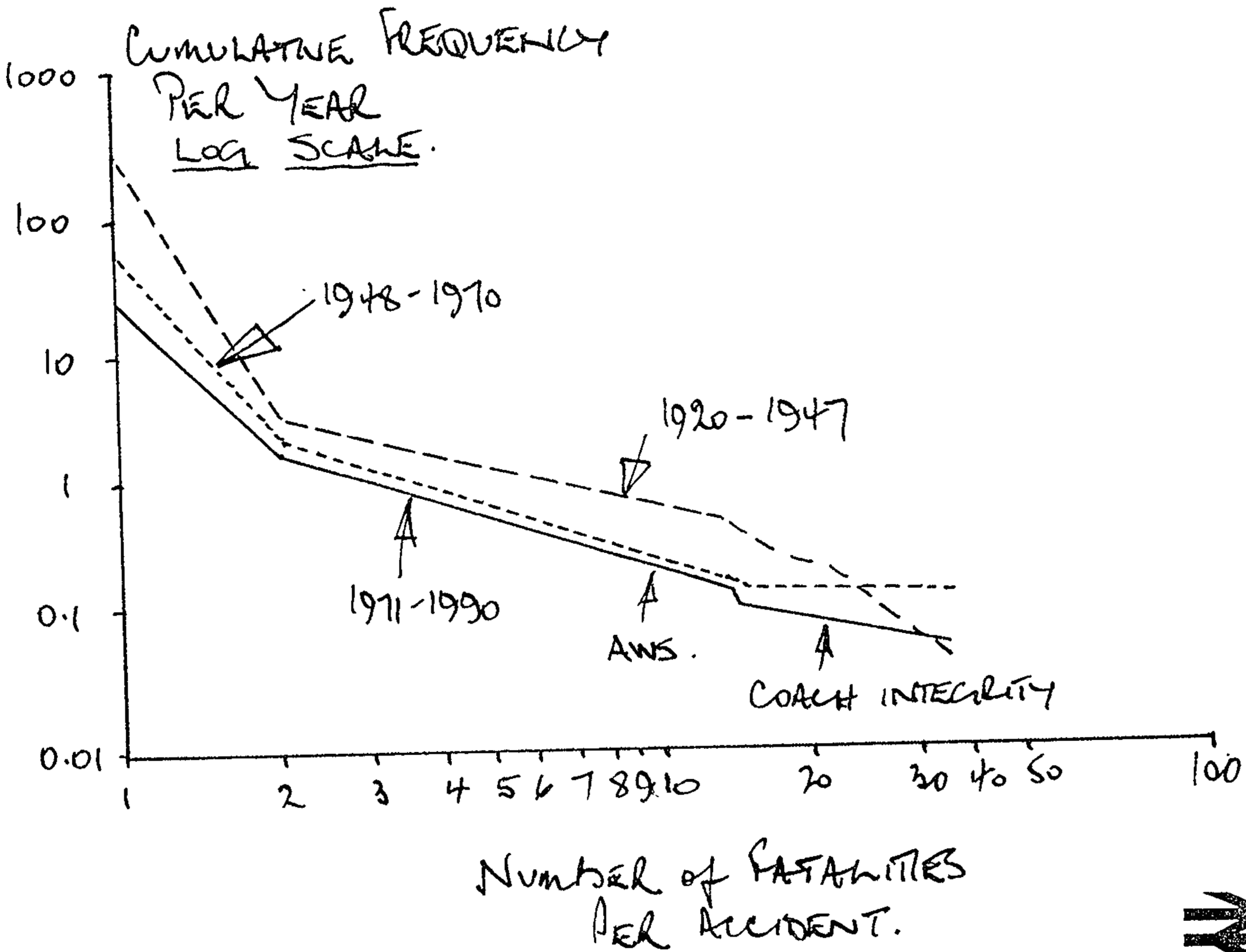
300+ SCHEMES

UNIT OF SAFETY BENEFIT PER £ SPENT

FATALITIES MAJOR AND MINOR INJURIES

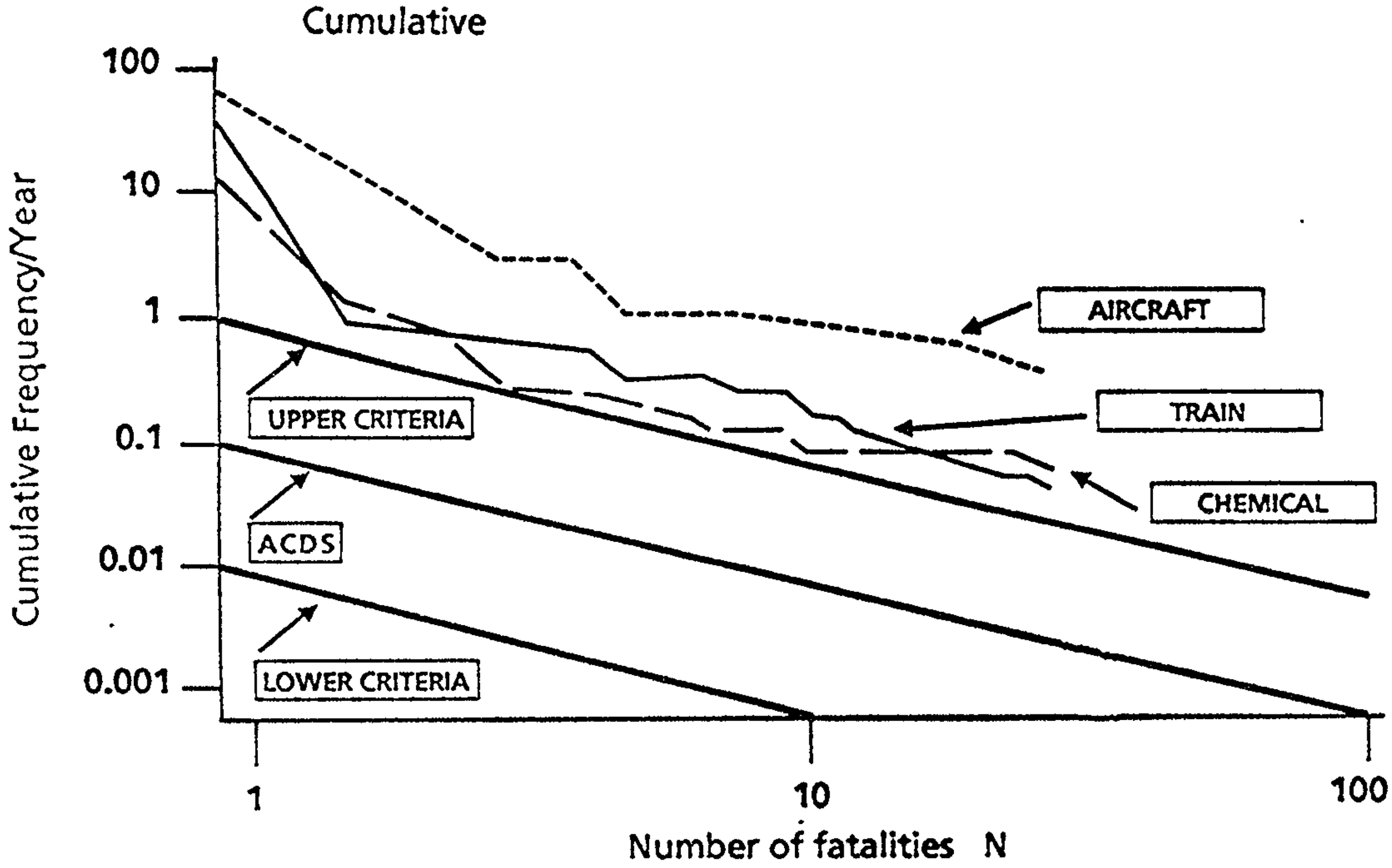
PRIORITIES.

- "SOFT" SCHEMES
- WORK FORCE SAFETY
- FOCUSSED ENGINEERING SCHEMES
- LARGE SYSTEM SCHEMES
- LEGISLATION EXPENDITURE CONCERNS


CUMULATIVE FREQUENCY
PER YEAR
LOG SCALE.
1000
100
10
1
0.1
0.01
1948-1970
1920-1947
1971-1990
AWS.
COACH INTEGRITY
1
2
3
4 5 6 7 8 9 10
20
30 40 50
100
NUMBER of FATALITIES
PER ACCIDENT.

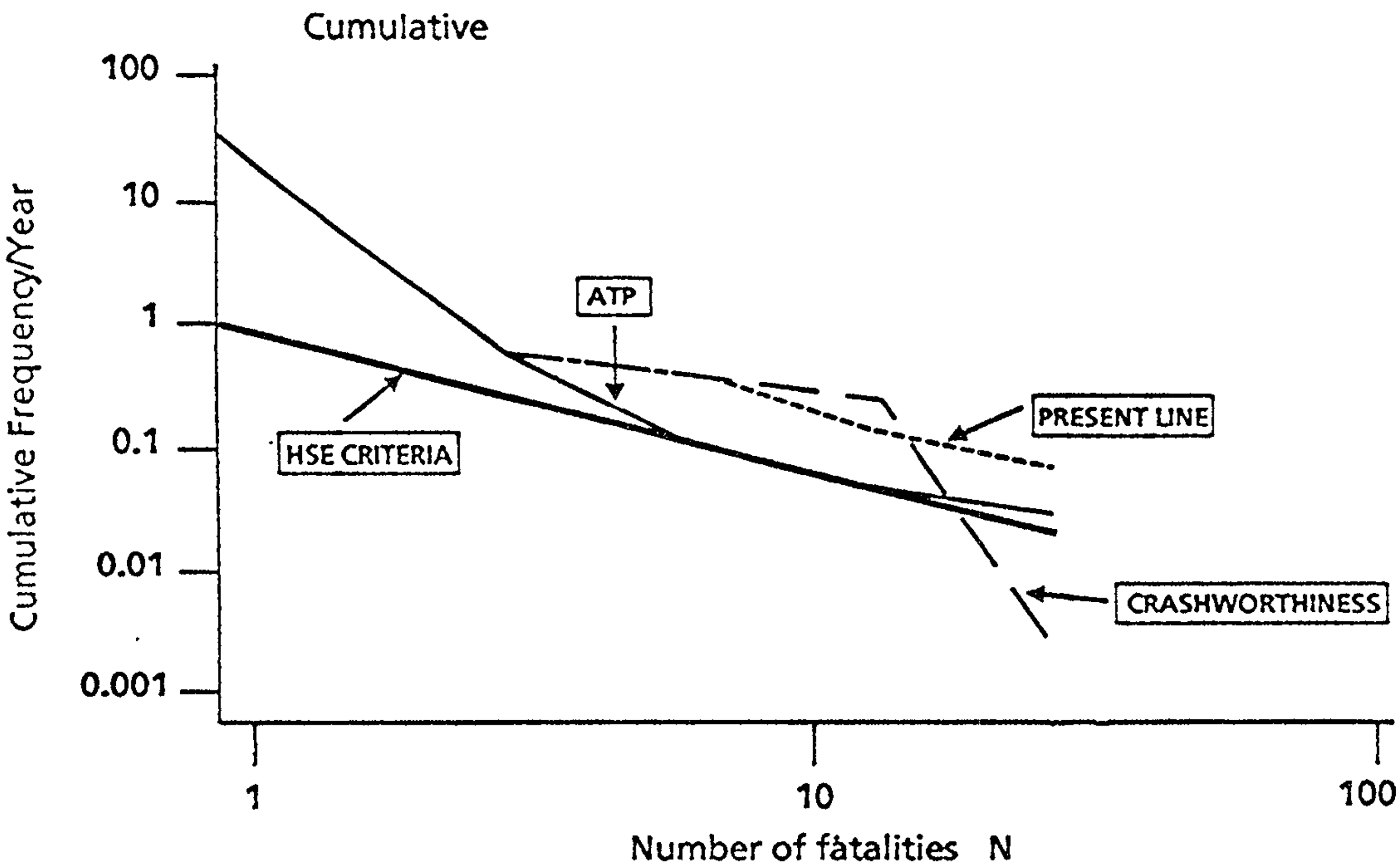
F/N CURVE COMPARISONS CIRCA 1966 - 89

4



4A

PASSENGER SAFETY PROJECTS



WORKFORCE SAFETY

130,000 WORKERS

35,000 HIGH RISK

RISK = 6.3×10^{-4} p.a.

HSE = 1×10^{-4}

DU PONT 50% IMPROVEMENT

TRACKSIDE PROJECT 1992

PASSENGER SAFETY

INDIVIDUAL JOURNEY : 5×10^{-7}

REGULAR TRAVELLER : 2.5×10^{-5}

HSE GUIDELINE : 1×10^{-5}

Health and Safe Excutive

DOORS

SLIPPING AND TRIPPING

SOCIETAL RISK

ISSUE OF IMPORTANCE

PUBLIC PERCEPTIONS : IMAGE

PUBLIC ACCEPTABILITY

"ABSOLUTE SAFETY"

ROLE OF GOVERNMENT

SAFETY REGULATION

1 IN 200 YRS
1 IN 10,000 YRS

BR 1 IN 15 YEARS

COST CONSEQUENCES

COMPETITION CONSEQUENCES

SOCIETAL RISK

BR "TARGET" - 1 IN 30/50 YEARS

RISKS: TECHNICAL
ORGANISATIONAL
HUMAN ERROR
SYSTEM FAILURES

DESIGN, BUILD, OPERATE, MAINTAIN

STANDARDS

TQM ISO 9000

COMPETENCY : ACCREDITATION : LICENCING

SAFETY VALIDATION

SAFETY CASE

AUDIT

Safety plan *1992* objectives

Overall Goal

British Rail will run a safe railway system for all its customers, public, employees and contractors.

BR will strive to eliminate all accidents that harm or damage people, property or the environment.

Specific Objectives, 1992

Within the context of the overall goal, the Board will set a number of objectives for strategic areas of safety activity across the whole system The Chief Executive will agree with individual business Managing Directors the detailed action plans necessary to support these strategic objectives, and will delegate responsibility for their achievement to nominated managers. The Board will publish these internally to its managers, staff and trade unions, and will advise the Secretary of State for Transport and the Health & Safety Executive accordingly

In accordance with this policy, and in the light of performance in 1991 and progress made during the year, the Board has set the following objectives:

1 • Employee and contractor safety

The Board will work towards the goal of 'zero accidents' for employees and contractors by·

1.1 The Route and Divisional Directors implementing the Safety Programme throughout the system by the end of 1992 through the development of the following specific objectives to be set by the Chief Executive with the Business Managing Directors:

(a) managers (including supervisors) with safety responsibilities for groups of staff to have carried out twelve safety inspection visits by March 1993, on a monthly basis

(b) all staff to have attended at least six safety meetings by March 1993

(c) all 'lost time' accidents to be entered into BRIMS within 48 hours of the accident occurring

(d) each Profit Centre to publish monthly for its own workforce details of 'lost time' accidents and appropriate comparisons

(e) within the Board's initiative to reduce excessive hours, to develop specific plans by the end of June 1992, for the achievement of the target of not more than twelve consecutive turns of duty to be worked out of any fourteen days, with costs of implementation

(f) to agree targets based on (e) above by the end of June 1992, and comply with these by end of March 1993.

1.2 Undertaking a major review of the procedures to set up and monitor safe systems of work for trackside maintenance and renewals by the end of 1992.

This will involve a high-level investigation into track-side Safe Systems of Work, covering both planned arrangements (track possessions for renewals and maintenance) and *ad-hoc* arrangements (dealing with failures and emergencies).

1.3 Developing Safety Competencies for critical 'risk-exposed staff' by

(a) completion, by January 1993, in conjunction with the Rail Industry Training Council, of the development of competency standards and assessment criteria for drivers, signalmen and permanent way maintenance staff, to enable the completion of initial accreditation of these key work groups by the end of 1993

(b) completion, by April 1993, of similar arrangements for Signal & Telecommunications' installation, testing and maintenance staff, for plant & machinery and traction maintenance staff, and for permanent way installation staff, to enable the completion of formal accreditation by mid-1994.

2 • Passenger and public safety – reduction of risk to individuals

The Board will work towards the goal of 'zero accidents' for individual passengers and members of the public by:

2.1 Continuing the programme of introducing new rolling stock that will progressively replace slam doors by power-operated doors

2.2 Undertaking an urgent assessment of the recommendations of the HSE investigation into BR 'door safety'.

2.3 Requiring businesses to produce plans by September 1992, to reduce accidents on station premises of a 'slipping, tripping and falling' type, agree target actions by the end of September, and to have implemented these by March 1993

2.4 Focusing increased attention on accidents arising from trespass and suicide to determine by the end of 1992 what effective steps can be taken to minimise such accidents and reduce the trauma on members of staff involved.

3 • Passenger and public safety – reduction of risk of multiple-fatality accidents

The Board will work towards the goal of 'zero accidents' for passengers and the public by actions to reduce the probability and frequency of accidents by

3.1 Introducing during the year the BR initiative on Supplier Accreditation (which will reduce safety risks in the design and construction/manufacture of purchased equipment) by identifying definitive proposals for accreditation by mid-year and commencing the process of accreditation of large suppliers in January 1993

3·2 Completing the pilot trials of the Automatic Train Protection (ATP) systems on the Network SouthEast Chiltern line and the Intercity Great Western line; identifying equipment specification and agreeing on implementation strategy by the end of 1992 for agreement with the Department of Transport and the Health & Safety Executive

3·3 Systematically analysing information from individual accidents and statistical data to identify underlying technical and human causes. Developing appropriate action plans to affect the causes as they become known

4 • Safety management systems and procedures

In addition to the three strategic objectives, the Board will also work towards the goal of 'zero accidents' by adopting the best industrial practices in Safety Management Systems by:

4·1a Fully implementing the agreed programme of Board Safety Audits from April 1992

4·1b Requiring the Businesses to produce their own Safety Audit plans to the Chief Executive by the end of May, 1992

4·2 Undertaking a prototype 'Safety Case' appraisal during 1992 of the resignalling project authorised for the Network SouthEast London, Tilbury and Southend line to determine appropriate 'Safety Case' procedures for major projects in the industry

4·3 To introduce by the end of March 1993 satisfactory arrangements for assessing the value for money of proposals for expenditure involving safety.

4·4 Developing safety plans for the safe introduction and operation of mega projects, in particular BR's responsibilities for the Channel Tunnel links, Kings Cross Channel Tunnel Terminal and Interchange, and the Crossrail project.

IMPROVING SAFETY PERFORMANCE

1. MEASUREMENT OF CURRENT PERFORMANCE

2. COMPARISONS : INTERNAL AND EXTERNAL

3. PERFORMANCE OBJECTIVES AND TARGETS

4. IDENTIFICATION OF PROJECTS

5. PRIORITISATION

6. PROGRAMME BALANCE

WORK IN HAND

SAFETY PLAN OBJECTIVE:-

1. SAFETY EXPENDITURE v OTHER INVESTMENT

2. SAFETY EXPENDITURE v OTHER REVENUE EXPENDITURE

3. FULL LOSS CONTROL CAPABILITY

4. "WHAT IF ?" : RISK ANALYSIS

INTERIM OUTPUT:-

NEED FOR "OUTPUT" TARGETS

IMPROVED PERFORMANCE INFORMATION FOR PRIORITISATION

LOSS CONTROL

PRIORITISATION AND RATING METHODOLOGY FOR :

- ASSET DAMAGE
- COST OF TRAFFIC DISRUPTION
- COMPENSATION
- INSURANCE PREMIUMS
- COST OF INQUIRY RECOMMENDATIONS
- PROSECUTION COSTS
- ENVIRONMENTAL DAMAGE

"SAFETY BENEFITS PER £ SPENT" WEIGHTING FACTORS

- MULTI-FATALITIES
- PUBLIC/MEDIA CONCERN
- LEGISLATION
- IMAGE AND CONFIDENCE

- SUICIDES
- TRESPASSERS

15

ANALYSIS OF BR SAFETY PROJECTS

Value of Equivalent Safety Benefit (ESB)	Percentage of Safety Budget excluding "enabling projects"		No. of Projects	Safety Benefits (Per annum)	
	1991/2	1992/3		No.	% (Cumulative)
<£0.6m	13.4%	15.3%	47	29.8	46.7%
£0.6m - 1.0m	17.4%	11.8%	30	19.6	77.4%
£1.0m - 2.0m	5.9%	21.2%	45	9.3	92.0%
£2.0m - 4.0m	4.6m%	0.7%	7	0.3	92.5%
>£4.0m	58.7%	51.0%	150	4.8	100%
TOTAL	100%	100%	279	63.8	100%

VALUE OF SAFETY

CONCEPT OF "REASONABLY PRACTICABLE"

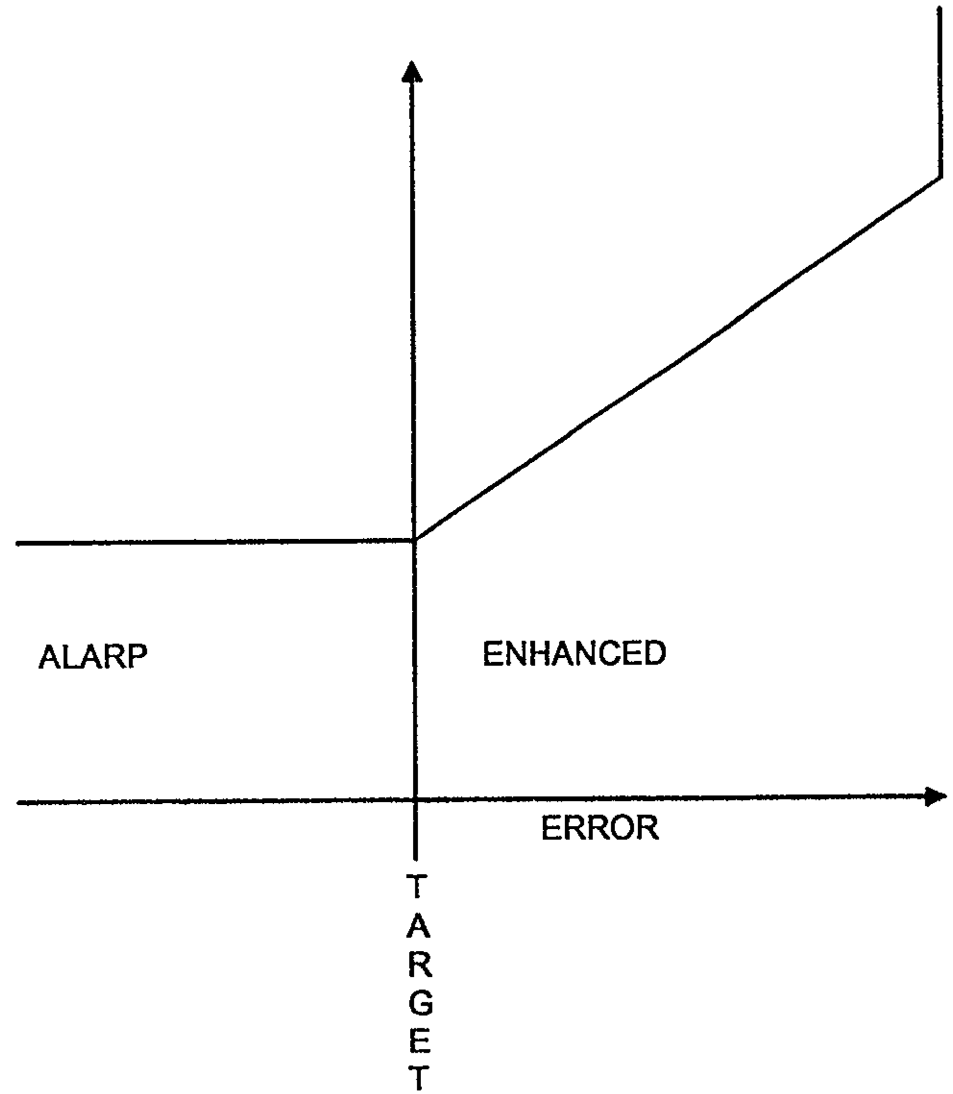
HSE

cf EUROPE

ALARP PRINCIPLES

SAFETY PERFORMANCE
CONTROL SYSTEM GAIN/SENSITIVITY

£m placed on value of predicted life saved



VALUE OF LIFE

RANKING AND RATING

WEIGHTING FACTORS

£2m BR THRESHOLD

GOVERNMENT ACCEPTANCE

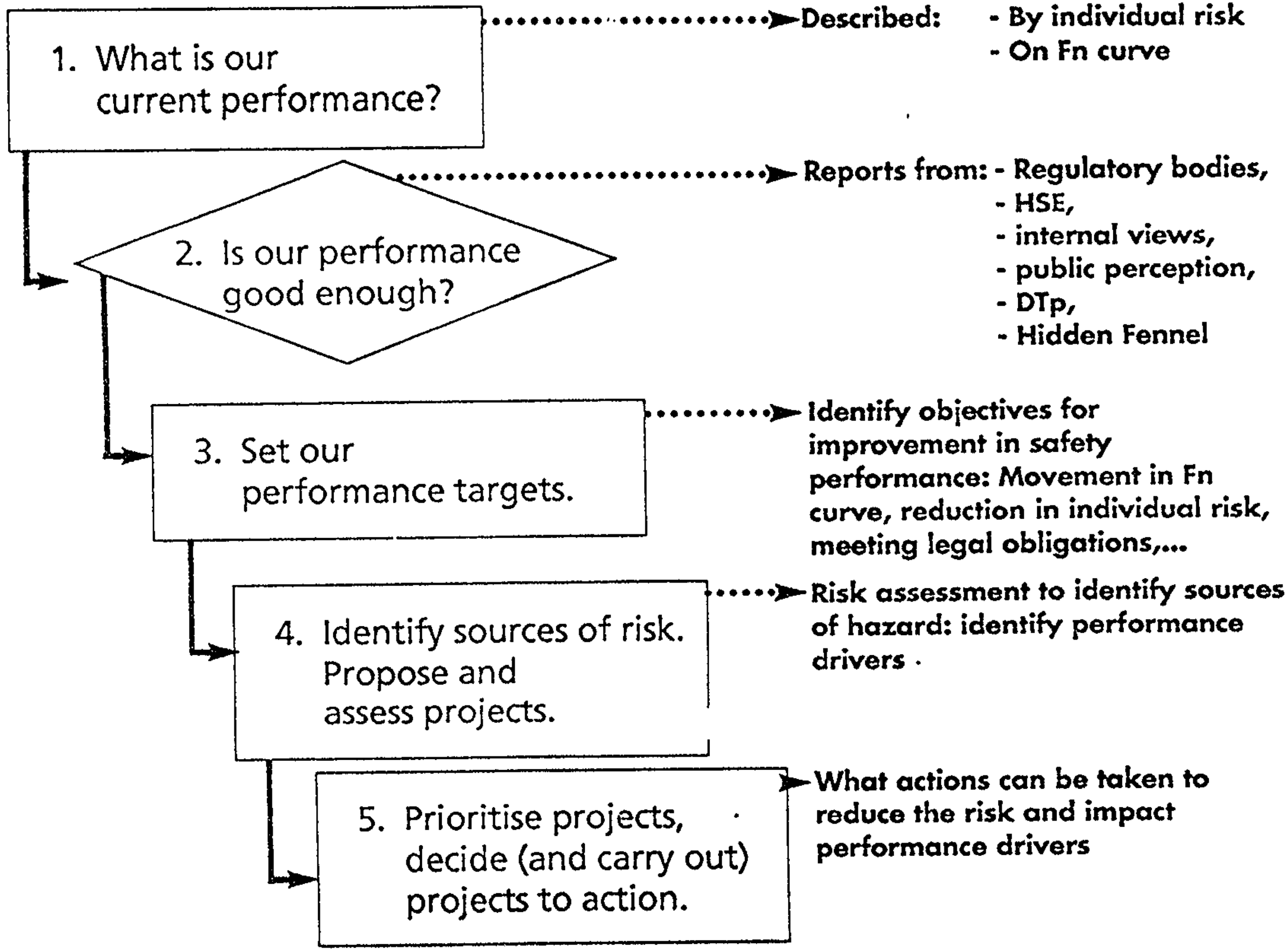
COMPARISON WITH ROAD/WITH OTHER INDUSTRIES

CONCEPT OF WILLINGNESS TO PAY

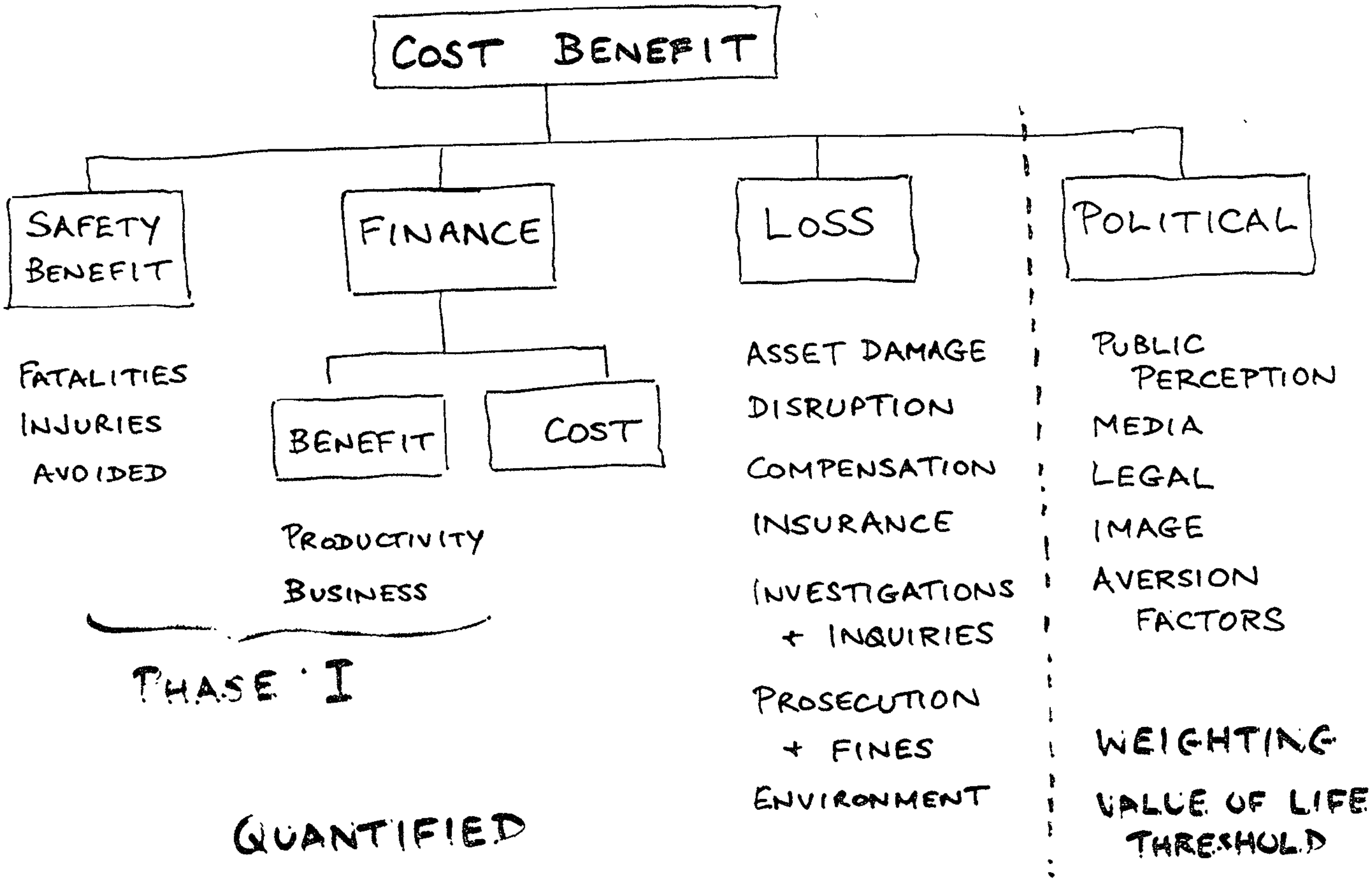
PUBLIC v PRIVATE TRANSPORT

PUBLIC ACCEPTABILITY

THE PROCESS OF IMPROVING SAFETY PERFORMANCE



SAFETY EXPENDITURE PRIORITISATION



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Toshimasa Murakami

JR East's Investment in Safety

Publisher
2000 International Rail Safety Conference

International Railway Safety Seminar 1992

JR East's Investment in Safety

Mr.T.Murakami
Japan

New Zealand Rail Limited
International Railway Safety Seminar
Wellington, New Zealand

27 October - 30 October, 1992

JR East *Safety Programs:*

Investing in the Future to Prevent Accidents

Presented by:

Toshimasa Murakami
Manager
Transport Safety Department
East Japan Railway Company
Tokyo, Japan

Draft Plan for Investment in Safety

East Japan Railway Co.

1. Basic Policy for Safety

JR East has developed a basic policy on safety which stresses that the most important task is to eliminate serious accidents involving loss of passenger lives. This policy is designed to enhance JR East's reputation as a safe and reliable transport organization. This objective can be attained by implementing specific preventive measures against accidents, as well as by building up a safer railway system.

To put this policy into effect, we have taken what we call a "software", as well as a "hardware" approach. The following is a brief description of the hardware approach:

I. Master Plan for Safety

In 1988, based upon the basic policy described above, and taking into consideration our experience from past accidents and conditions pertaining to our existing railway installations, we devised a strategy to determine which measures will best improve our safety management and control by eliminating its weaknesses.

II. Five-Year Plan for Investment in Safety

The five-year plan (1989 - 1994) for investment in safety, currently underway, was developed in accordance with the master plan described above. The total budget for the plan is close to ¥400 billion. Approximately ¥200 billion has been allocated for replacement of out-dated installations, and the remaining ¥200 billion will be used for investment in new safety measures.

2. Details of the Investment in Safety Measures and the Trend in Accidents

I. Details of the Investment in Safety Measures

The Five-Year plan envisions investing ¥200 billion in the following items:

A. ATS-P

B. Railway crossings

C. Operation control systems

D. Prevention of natural disaster

E. Others:

- Fire-proofing of internal-combustion engine cars
- Safety measures for passengers on platforms
- Establishment of a safety research institute and a safety training center

II. The Trend in Accidents

The number of operating accidents within JR East's operating area showed a steady decrease from 1987 to 1990, but there were 7 more operating accidents in 1991 than the previous year. This increase is attributed to a rise in the number of train accidents and fatal accidents during 1991 which more than offset the decrease in railway-crossing accidents recorded in the same year.

3. Future Agenda

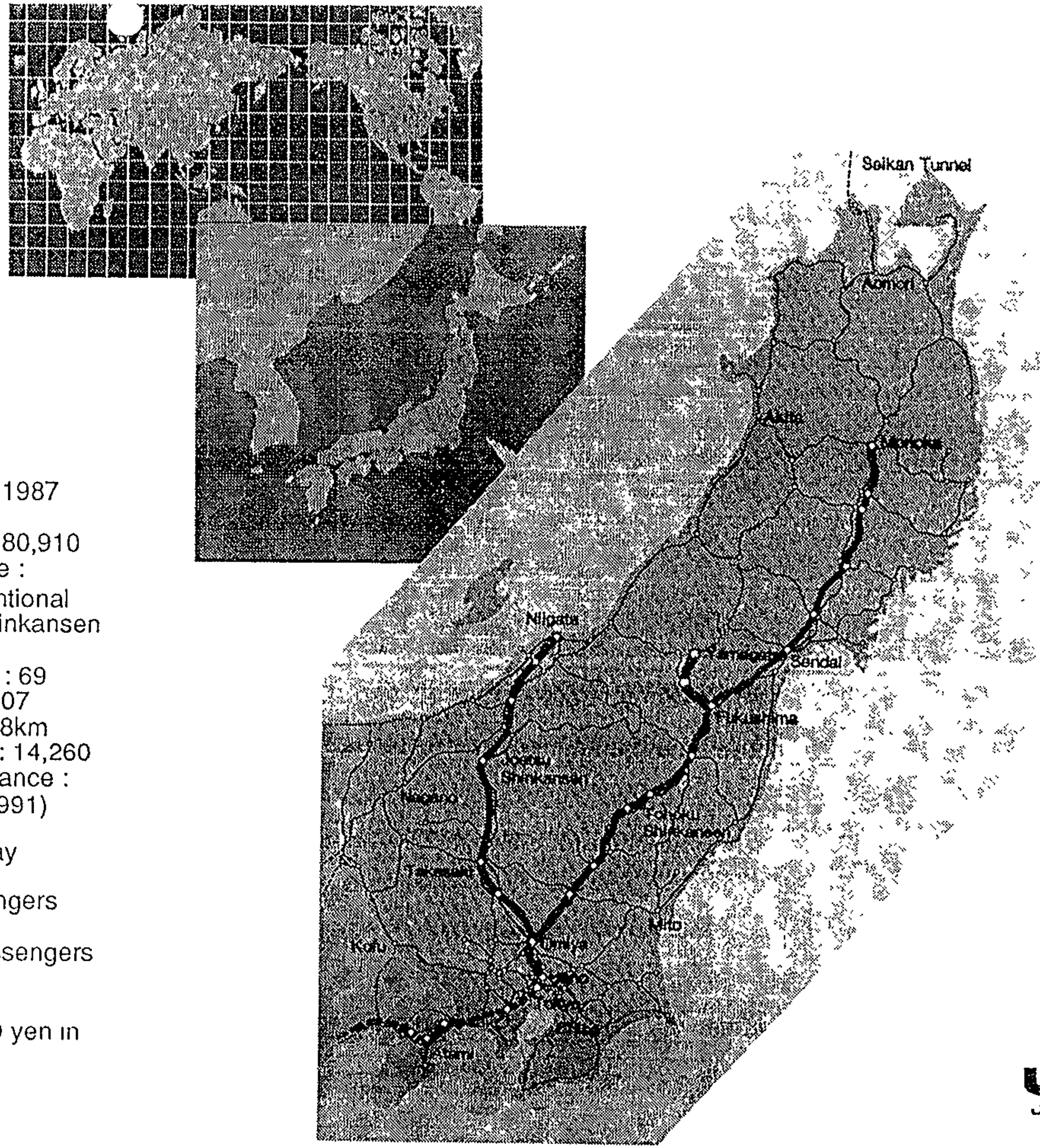
A railway system usually consists of a great variety of installations that range in age from very old to the most up-to-date. This is because new systems and equipment are usually introduced and adopted over a long period of time.

Under the circumstances, it is not necessarily appropriate to apply a single fixed concept to enhance safety. A more flexible approach is needed.

The only way to achieve complete safety, (i.e. total elimination of accidents) is to stop operating trains. As long as trains are run, we cannot avoid all accidents.

Our task, therefore, is to minimize the incidence and severity of accidents, and this is what safety management is all about. Certainly, money alone cannot solve the problem completely, but it is critical to determine how available funds should be distributed in safety management, which is an indispensable part of railway operation.

Outline and Route Map

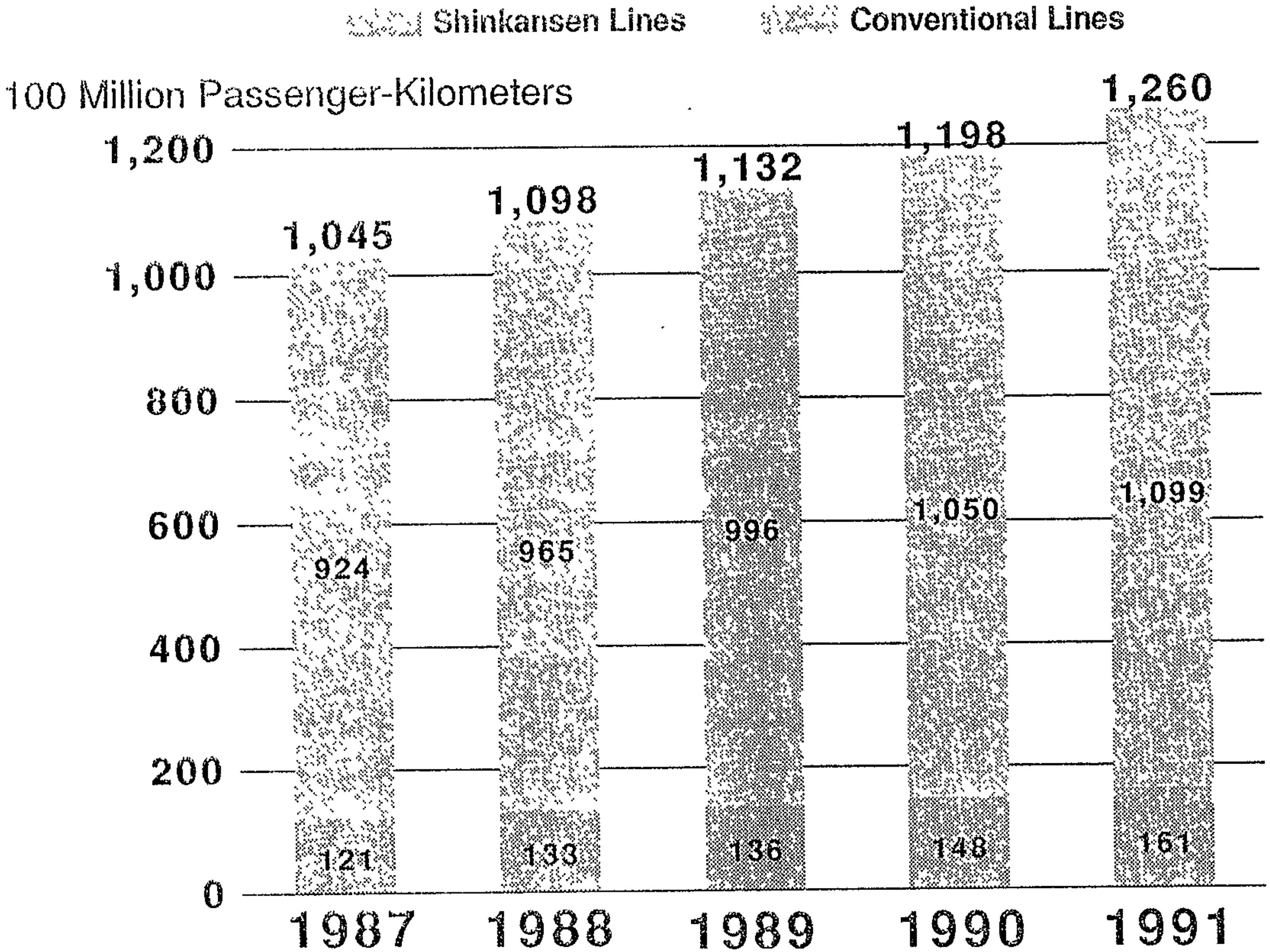


Outline of East Japan Railway Company

Founding date : April 1, 1987
Capital : 200 billion yen
Number of employees : 80,910
Length of operated route :
    7,502.0km (conventional line 6,663.1km, shinkansen line 838.9km)
Number of line sections : 69
Number of stations : 1,707
Electrified route : 5,456.8km
Number of rolling stock : 14,260
Train kilometric performance :
    272,000,000km (1991)
Number of train runs :
    12,138 runs/per day
Passenger traffic :
    16,200,000 passengers per day
    5,952,000,000 passengers in 1991
Traffic revenue :
    1,718,300,000,000 yen in 1991

JR-EAST

Number of Passenger-Kilometers



JR-EAST

JR East's Performance in Railway Operations

	(million yen)
Operating Revenue	1,875,859
Operating Cost	1,530,319
Net Profit	345,540

Note: Figures Correspond to the Period Between April 1, 1991, and March 31, 1992 .

JR-EAST

Software Approach

A. Better Understanding of Accidents

B. More Detailed Investigation of their Causes.

C. Change of Attitude From the Top Down, and From the Bottom Up

Hardware Approach

A. (To Devise a) Master Plan for Safety

B. (To Develop an) Investment Plan for Safety

JR-EAST

Master Plan for Safety

1988

Basic Concept

1. To Eliminate Fatal Accidents
2. To Implement Preventive Measures
3. To Create Safer Railway Systems

- To Identify the Nature of Each Accident and Act upon It
- To Build Up a Modern Safety System
- To Allocate Safety Investment by Priority
- To Carry Out the "Challenge Safety Action Program", In Which All Employees will Participate
- To Establish an Appropriate Organizational Structure to Prevent Accidents

JR-EAST

To Eliminate Serious Accidents Involving Injury and / or Death

Data from Past Experience (1966 - 1986)

I. Safety Systems to Be Built

A. Prevention of Train Collisions

B. Prevention of Accidents at Railway Crossings

C. Improvements in Train Operation Management

D. Disaster Prevention

E. Prevention of Accidents During Railway Maintenance Work

F. Prevention of Passenger Accidents on Station Platforms

High Priority for Safety Investment

II Participation of Employees in Safety Activities

III. An Organizational Structure That Deters Accidents

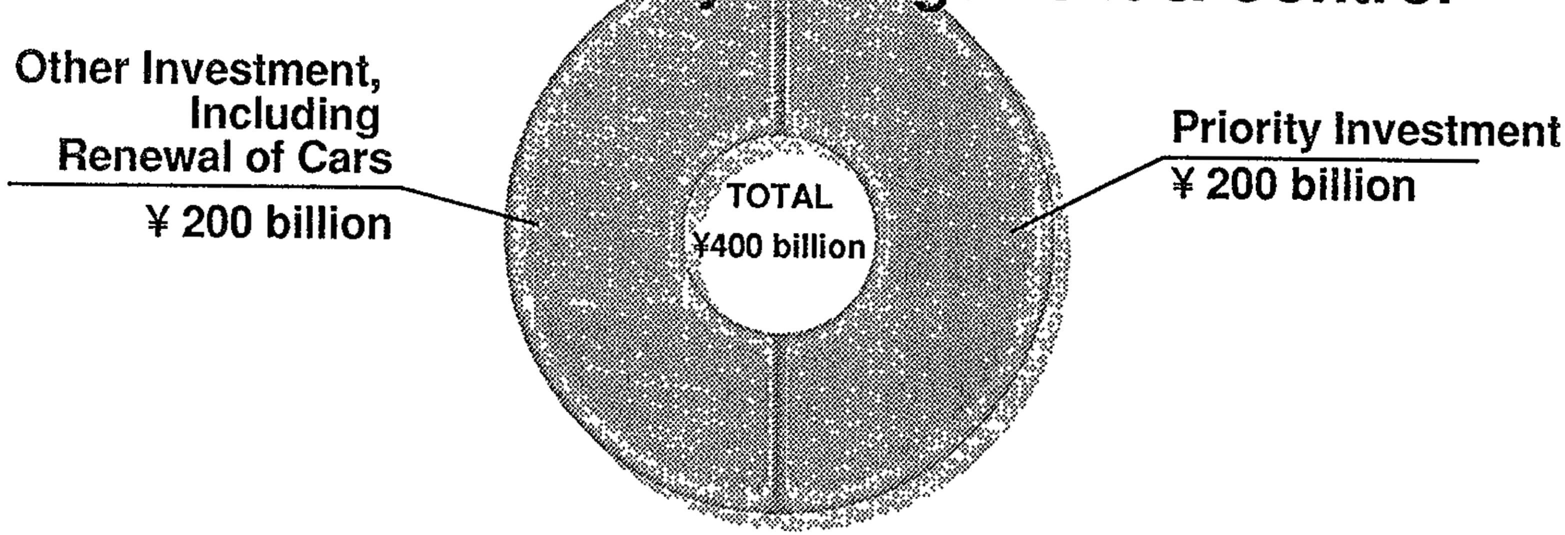
To Set Up a Safety Research Institute

To Establish a Safety Training Center

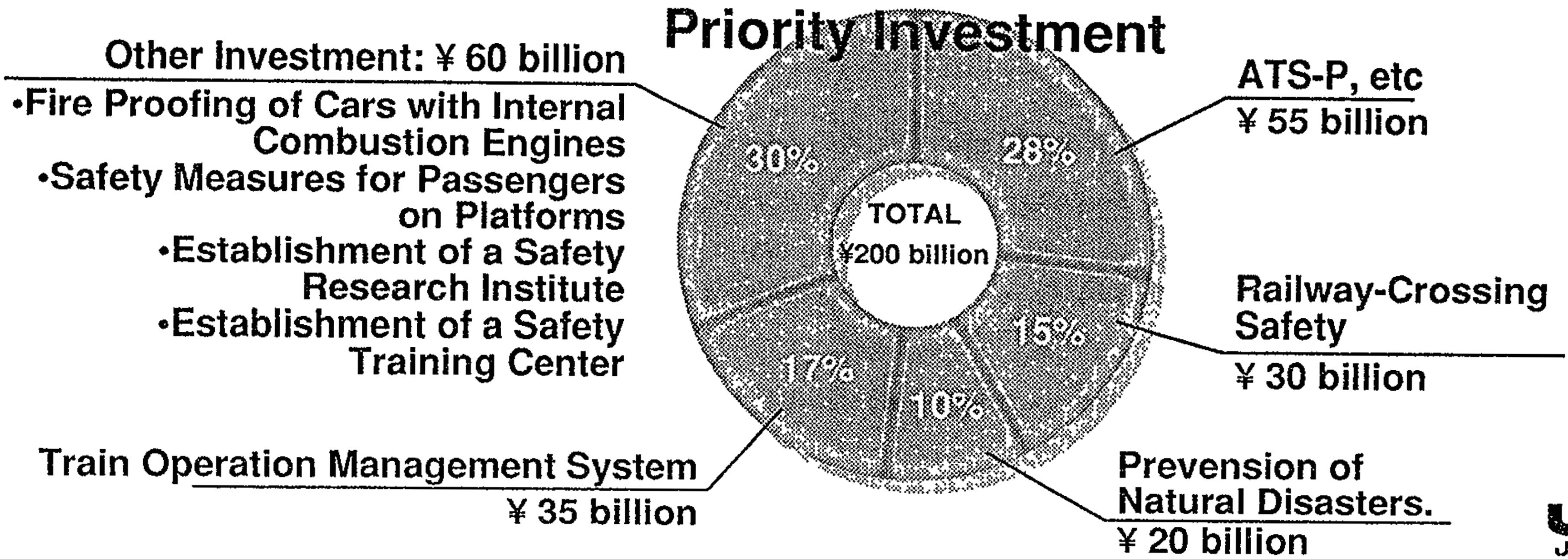
JR-EAST

Outline of the Investment Plan for Safety

Investment in Safety Management & Control

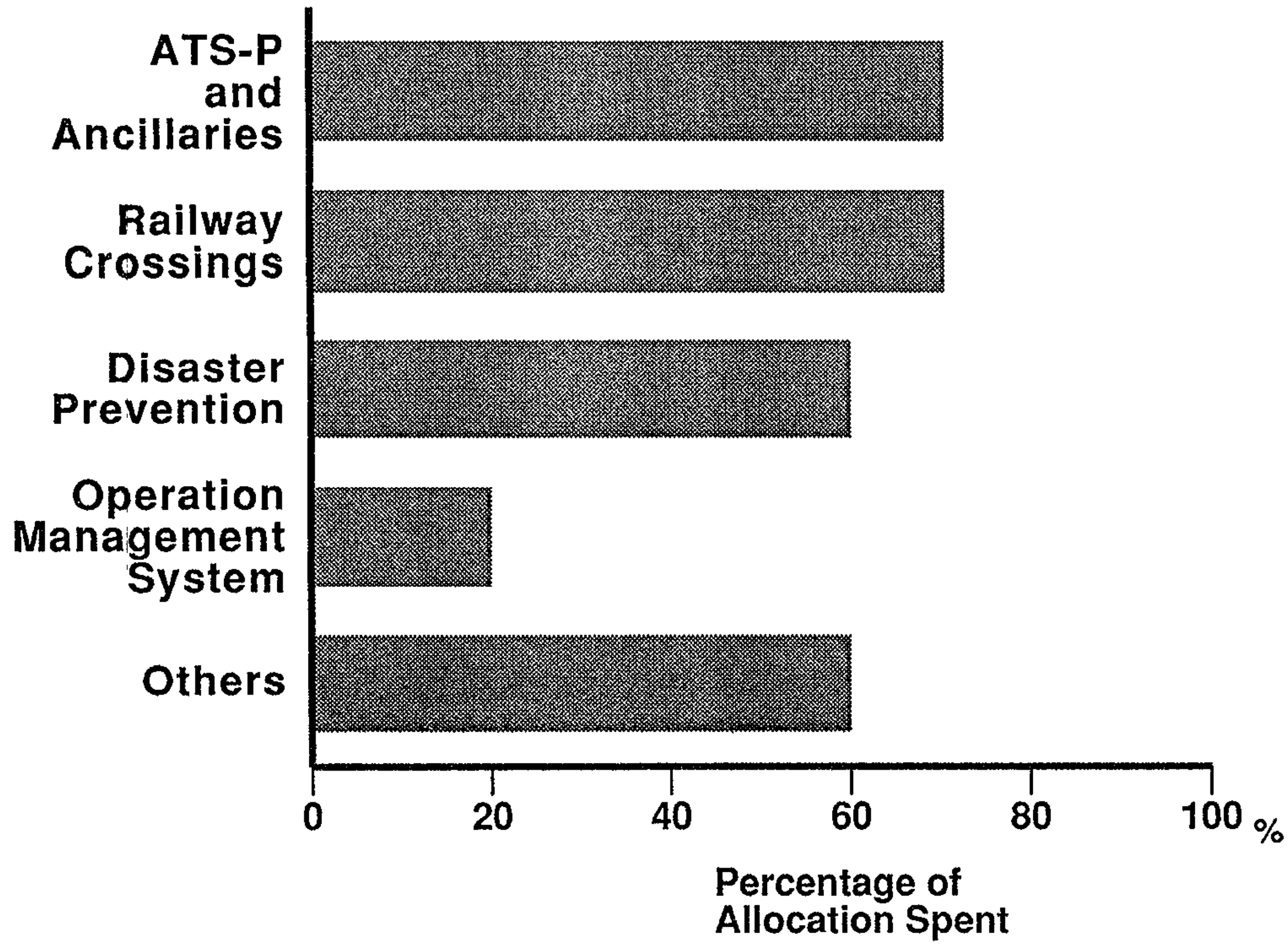


Priority Investment



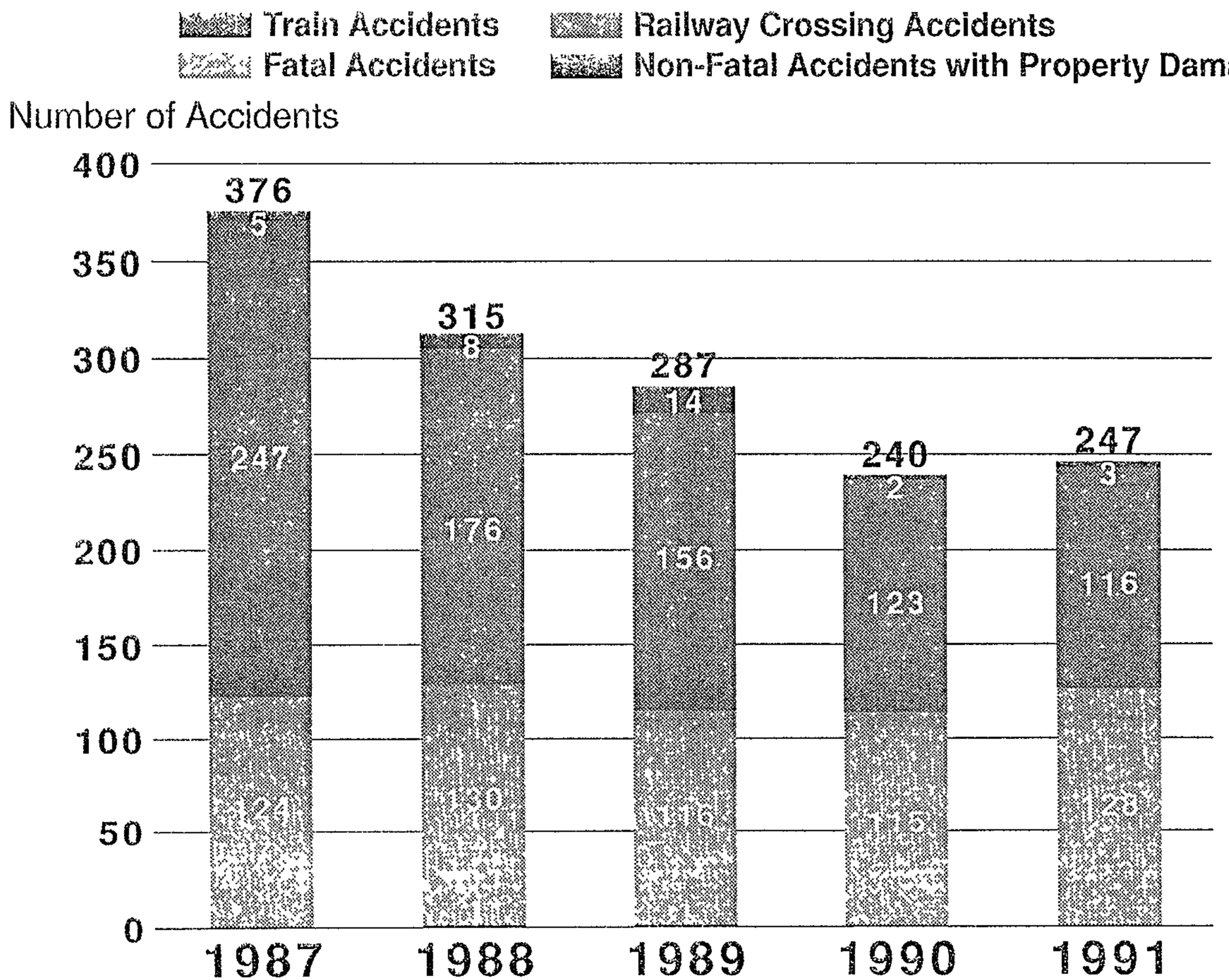
JR-EAST

Progress of the Priority Investment
(End of 1991)

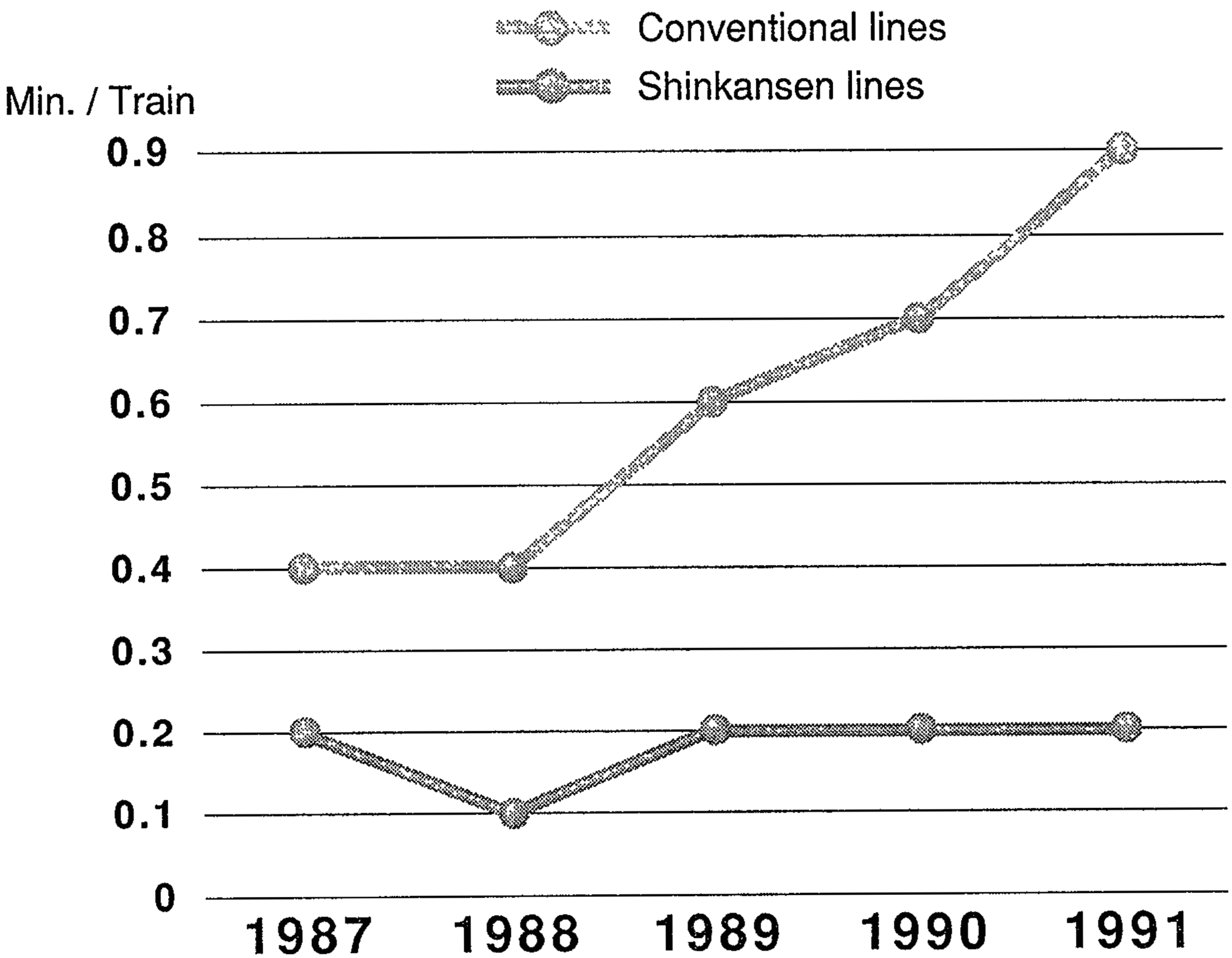


JR-EAST

Number of Operating Accidents Per Year



Average Train Delay



JR-EAST

Future Agenda

A. To Define the Role of People and that of Machines (in Railway Safety)

B. To Study how Machines can Support Railway Personnel

C. To Design an Improved Safety System

D. To Maximize the Effectiveness of the Investment in Safety

JR-EAST

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Paper 9208

Michel Joing

Determining the Cost of Railway Accidents

Publisher
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Determining the Cost of Railway Accidents

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Safety Studies Centre
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INTERNATIONAL RAILWAY SAFETY SEMINAR

Wellington New Zealand

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DETERMINING THE COSTS OF RAILWAY ACCIDENTS

Two observations should first be made:

The study focusses only on the risks to which the company SNCF is exposed, and not on risks affecting the community as a whole. This distinction takes on practical significance in the case of incidents caused by identified third parties who are financially solvent, or caused by the victim himself (this is usually the case, for example, in accidents at level crossings, suicides, and incidents in which the persons involved have not entered into a contract of carriage) Such accidents thus represent zero financial risk for the company

In the case of train accidents, the study examined accidents occurring on or involving SNCF main lines The Safety Studies Centre considers that the investment policy in relation to events occurring on secondary lines is better dealt with by adopting a "total quality" approach, rather than by initiating a research project specifically concerned with safety. It is worth noting that the transport of dangerous materials aspect is currently being dealt with in a specific project.

Accidents may usefully be divided into two categories:

- accidents to individual persons,
- train accidents

Evaluating the cost of accidents to individual persons

With this type of accident, the overall annual number of victims is relatively stable, and can be divided into the following categories:

CATEGORY	AVERAGE ANNUAL NUMBER OF PERSONS KILLED	AVERAGE ANNUAL NUMBER OF PERSONS INJURED
Passengers struck by train	12	6
Passengers fallen from train	20	58
Employees on duty	10	6
Other persons in accidents		
. at level crossings	65	28
. caused by train not at LC	85	51
Suicides	280	30

In less than 10% of the above cases does SNCF pay any compensation. The methods of calculating compensation are identical to those applied for the victims of train accidents.
Compensation of this type represents an annual cost of FFr 50m for SNCF.

Evaluating the cost of train accidents

The evaluation was based on 121 accidents recorded in the Safety Studies Centre data base for 1991, on the basis of the criteria set out above.

Costs, compensation payments and losses were broken down into the following categories:
1 – personal injury (passengers, third parties, SNCF employees),
2 – damage to rolling stock (repair),
3 – operating losses resulting from the immobilisation of rolling stock for repair,
4 – damage to rolling stock (replacement),
5 – damage to fixed installations (track, signalling installations),
6 – perating losses resulting from train delays and rerouting,
7 – re–railing costs,
8 – amage to freight,
9 – damage to privately–owned wagons,
10– costs incurred by passengers (e.g. hotel accommodation, taxi and bus fares)
11– damage to the environment.

In order to improve the statistical quality of the results:

- the loss items listed above were grouped into four main categories:
  . personal injury,
  . rolling stock (repairs + immobilisations + scrapping),
  . fixed equipment,
  . operating losses (all other items).

- complementary evaluations were made of serious accidents during 1990 of and some recent historical accidents, in order to reflect more reliably some relatively rare types of loss (particularly as regards injuries).

In all therefore, a panel of 170 accidents was subjected to the various evaluations.

- *Overall results*

  All main line accidents put together represent a cost of FFr 190m, of which around FFr 160m are met by SNCF. 8% of the most serious accidents alone account for 90% of the costs. A single accident accounts for 50% of the costs.

  One therefore needs only to consider very closely a relatively small number of serious accidents (20–30 per year) in order to take into account almost all the main line railway accidents as far as costs are concerned.

  With regard to the other accidents, a project has been undertaken to validate an estimation model based on a certain number of criteria.

- *Breakdown of losses*

  As a result of the overwhelming importance of just a small number of accidents, the relative importance of various kinds of losses is relatively variable year–on–year.

  However, if the losses are grouped into four main categories on the lines indicated above, it emerges that:
  . damage to rolling stock amounts to about half of costs,
  . damage to infrastructure and operating losses each account for a quarter of costs.

  This result confirms the usefulness from an economic viewpoint of studying types of damage excluding personal injury.

- *Breakdown of costs according to scenario*

The same observation as above applies concerning the overwhelming importance of a small number of accidents.

The breakdown of the 32 accidents of a gravity above degree 2, for which no third party was responsible, in the years 1990 and 1991, reflects the major importance of the following four scenarios:

. scenario 4: collision as a result of passing a signal in the stop position,
. scenario 1: derailment as a result of track damage,
. scenario 3: derailment as a result of rolling stock failure,
. scenario 7: collision as a result of brake failure or runaway.

These scenarios account for almost 90% of all costs incurred as a result of the accidents considered in the sample.

- *Relative importance of damage to public image*

A special study would need to be made of this kind of loss, which has not been taken into account in the above evaluations.

This kind of consideration is only meaningful in the case of catastrophes such as the one which occurred at Melun on 17 October 1991 (16 killed, 25 seriously injured).

An initial reflection to determine the maximum impact of this type of loss has been undertaken jointly with the Corporate Communication Division. The method adopted is to assimilate all reports and articles concerning the accident by all the mass media to negative advertising for the company. By assuming that to counteract the negative publicity it would be necessary to broadcast a positive message of the same duration, it is possible to advance a figure as a financial estimate of damage to the company's public image.

On this basis, the Melun accident would have resulted in public image damage (expressed as an operating loss) of around FFr 60–70m (radio: FFr 10m; TV: FFr 40m; press: FFr 16m). This figure is comparable with the total for all the other losses for this accident on which a figure has been set.

This approach can however be criticised for many reasons: in particular, the message conveyed by the media in the wake of the accident also emphasised the company's expertise in crisis management; on the other hand, the broadcasting of advertising footage equal in duration to the news coverage will have less impact on the viewer than the sight of the catastrophe.

Incorporating these costs into the investment choice method

The aim of prevention policy is to move towards zero accidents while meeting budgetary constraints. The public authorities do not at present accept the setting of an acceptable quantified objective, for example defined in the form of F/N curves.

The company is currently investing almost FFr 2bn in safety installations. This resource must be allocated as effectively as possible, and to this end the decisionmaker must be provided with information concerning both the economic aspect (which on its own is not sufficient in view of the high level of safety already achieved, and therefore the very high cost of any further improvement), and the effectiveness aspect as regards the safety of the various major investments envisaged.

As a result, the method adopted is organised around principles derived from conventional risk management techniques.

Accident risk evaluation is based on:
- a typology of causally-based accident scenarios,
- the use of evaluation methods either of a probabilistic type, or of a historic type if the perspective is considered sufficient in statistical terms,
- a study of the means of prevention, consisting of acquiring various economic and effectiveness characteristics as regards cutting the number of accidents.

For this purpose, the following data, specific to each project, must be gathered:
- investment cost,
- operating and maintenance costs,
- productivity gains,
- accident scenarios concerned,
- expected impact on accident risks, in terms of occurrence, seriousness, and reduction of repair costs for the various types of damage envisaged.

A project performance indicator can be used to relate the "human" effectiveness of the project in question (expressed in deaths avoided) to its cost (expressed in net current value).

An indicator of this sort embodies a realistic vision of safety, which lays emphasis on the safety of people (SNCF has a public service mission, and its duties to the community are primarily of a human rather than an economic nature) while taking the cost of prevention into account. What is more, it enables a comparison of the performance of projects per unit of expenditure.

Moreover, a visual result presentation medium (called a decision matrix) enables the decisionmaker:
- to assess the dominant features of each project (economic profitability, safety performance),
- to situate the projects in relation to each other.

For example, the transparency shows a comparison between six typical projects:

- transponder speed monitoring,
- simplified ground–train radio,
- the replacement of manned level crossings by level crossings with automatic light signals,
- the elimination of level crossings with automatic light signals, and their replacement by bridges or tunnels,
- maintenance–incidents–works radio,
- the bolting of high–sided open goods wagons.

The table indicates:

- the good cost–effectiveness of maintenance–incidents–works radio and its average safety–effectiveness,
- the excellent safety–effectiveness of transponder speed control and its low cost–effectiveness,
- the good cost–effectiveness and good safety–effectiveness of converting manned level crossings into automatic level crossings.

This method is only used for large–scale corporate projects (for which decisions are taken by headquarters), and is not suitable for local investments; the latter are today based on the exploitation of feedback at regional level.

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Tony Boland
Peter Niven

The Costs of Safety

Publisher
2000 International Rail Safety Conference

The Cost

of Safety

or

Quality Saves

You Heaps

SAFETY DISCUSSION BRIEF.

State Rail embarked on a major change in the way it manages safety. To achieve major impact on safety performance required substantial change in the way safety was previously addressed, while also requiring investment and workforce culture to be radically altered. Through "de mystification" of safety, establishment of specific activities and performance measures, based on a reliable data base, and a large level of commitment, major progress has occurred.

This article sets out these activities, some of the key achievements, and directions of further challenge.

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Executive Manager
System Safety
State Rail

Mr P. J. (Peter) Niven B.Sc(Eng)With Merit
General Manager
Operations
CityRail

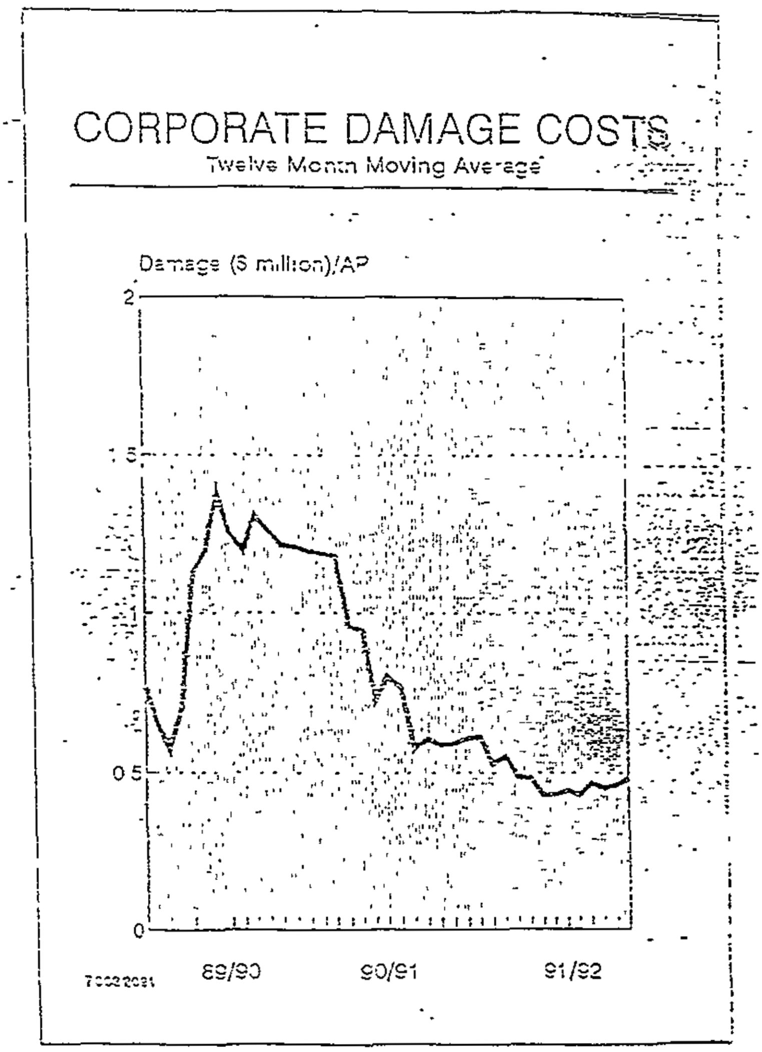
INTRODUCTION:

Most of the major industries in the world are concerned to ensure they have

"a quality product to give a quality service".

This does not mean quality at any price but requires that services and products are produced in an economical, safe condition. Some years ago "quality" was to a large extent full of "mumbo jumbo" and as such lost a great deal of credence in the community.

This paper is to show that safety is not an abstract concept but a real, vital and measurable core element of quality. It will show that the cost of safety gives quality as well as major economic benefits. These economic benefits for Railways are savings right off the bottom line.



Culture of Safety:

Safety is of course viewed by the uninitiated as a boring activity that doesn't always fit the new marketing philosophy. Further it may be seen as a burden to the commercial goals of the organisation.

To change perceptions and to ensure people are committed to safety, demands a major cultural phase shift. There has to be a major impetus to facilitate this change.

The world railway scene at the time of instituting the new profile and approach to safety within State Rail had been impacted by:

- The Kings Cross Station Fire in U.K.
- The Clapham Junction collision in U.K.
- The Coledale Embankment Failure on the N.S.W. Illawarra Rail Line.

These calamities were all followed by major judicial inquiries leading to criminal charges in some cases.

These results prompted, in many rail systems, necessary industry changes to ensure Safety could be restored to No. 1 Priority.

As far as State Rail is concerned the following activities were identified and implemented:

- Hazards were identified.
- Controls were documented.
- Establishment and maintenance of a Safety Incident Data Base (which included costing of incidents occurred).
- A Measurement Process was established.
- Data analysis became a routine activity.
- Validation of controls by Auditing was instituted.

Control Documentation and the flow on benefits:

The identification of potential hazards was relatively easy. The documentation of controls however was extraordinarily challenging. One hundred and forty years of modifications to the rules, regulations and standards existed, much of which were contradictory and ambiguous.

Some three years later with expenditure of a million dollars plus, unique and consistent rules and clearly defined procedures are in place.

But having clear procedures also allowed better working and obvious savings, since it leads to fewer derailments and other disruptions to rail services.

The safety data was easy to format and analyse, leading to substantial changes in State Rail day to day operations. A few examples of the changes involved:

- All train operation safety critical personnel are now reaccredited every two years. Previously, with the exception of some train crew, no reaccreditation program existed. This new programme involving over 5,000 State Rail staff is now an accepted fundamental policy.

- The maintenance and operating environment concerned with electric train passenger door operation readily accepted low levels of automatic door reliability performance and a high number of manual door trains were in service. This maintenance culture has been radically altered. A major program of manual door rolling stock retirement and automatic door upgrading has been substantially completed.

- People who fell from trains, fell while on stations, or trespassed on railway lines and were struck by trains were accounted as responsible for their own injury or death. No longer is this approach acceptable and initiatives to enhance passenger protection, often from their own foolish action, have been developed or substantially completed.

While a number of causal factors driving these quantum changes could be nominated, the key force is clearly the new safety management environment that has been created within State Rail.

The introduction of accepted safety performance data, audits of performance in meeting stringent hazard control standards, and cost exposure data have underpinned this new safety management environment.

The key to effectiveness in any safety system has to be measurement of inputs. For State Rail these are the total number of incidents and individual quantification of particular hazards.

IN OUR VIEW, IF A PERFORMANCE CANNOT BE MEASURED, IT DOES NOT DESERVE ATTENTION.

IMPROVED SAFETY DOES NOT JUST HAPPEN - IT MUST BE PLANNED.

Ownership of safety enhancement initiatives by the commercial business groups within an organisation is fundamental in ensuring implementation and commitment. The Group Safety Plans within State Rail address this. Within the plan, focus and priority are assured by checking initiatives against financial exposure and safety incident reduction goals. Some features from the *safety management* plan highlight this.

- Mapping of key safety enhancement activities against hazard.

- Identification of key safety programmes and their impact on hazards and safety incident level.

- Safety management process within CityRail defined.

These plans must be meaningful with simple, quantified goals. Each plan details initiatives to achieve reductions in safety incidents through hazard elimination, staff education, responsibility allocation and internal safety review.

A key measure of progress is through the level of financial exposure derived from safety incidents. Developed by an algorithm, a generic cost for each safety incident type allows State Rail to determine priorities and justification for major investment and change.

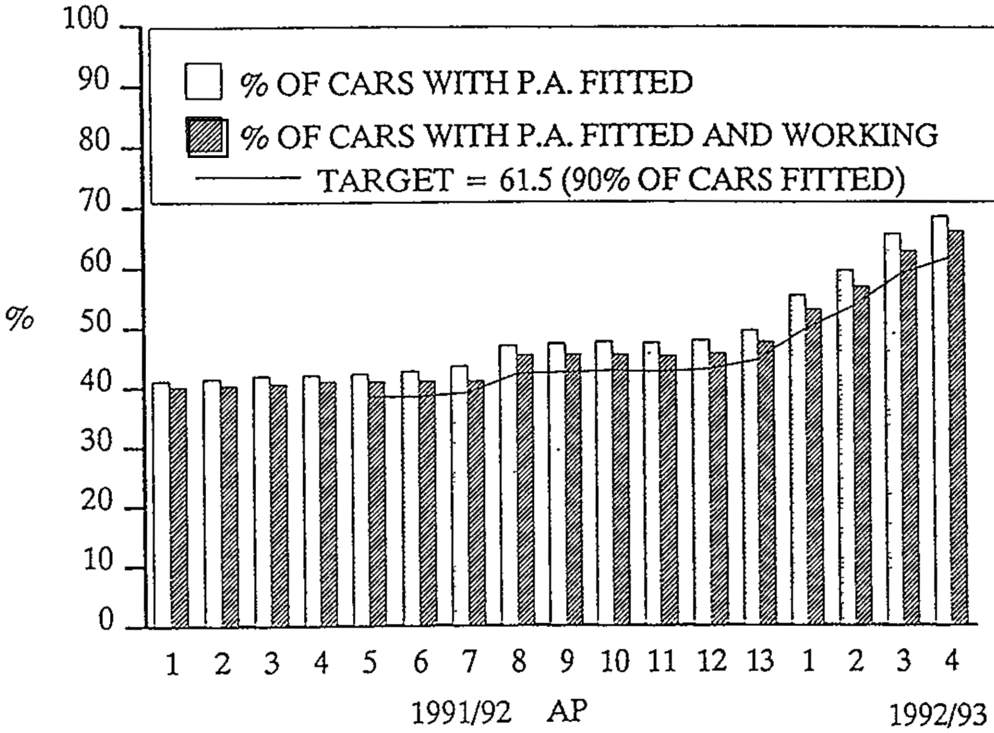
What Has Been Achieved?

Electric Train Passenger Doors: Automatic Passenger carriage train door operation must be reliable. CityRail Operation standard now established requires 98% of cars with automatic doors to have doors opening and closing to standard (including timing). Trains with failed doors are to be promptly removed from passenger service. The suburban train door system is being replaced/overhauled (774 cars at a cost of $5.4 million) and half the fleet has been completed. A new locking door system has been introduced to eliminate passenger opportunity to force doors open. The associated public address system throughout the train has also been restored and its effectiveness monitored. A crew advice system is to be installed after development to warn crew of doors held open or failing to close. The whole maintenance and operating culture within CityRail towards passenger doors has been changed. A program of accelerated retirement of 300 suburban trains with manual doors will have been all achieved by March, 1993.

(See P.A. System status and percentage of sets complying to standard graphs).

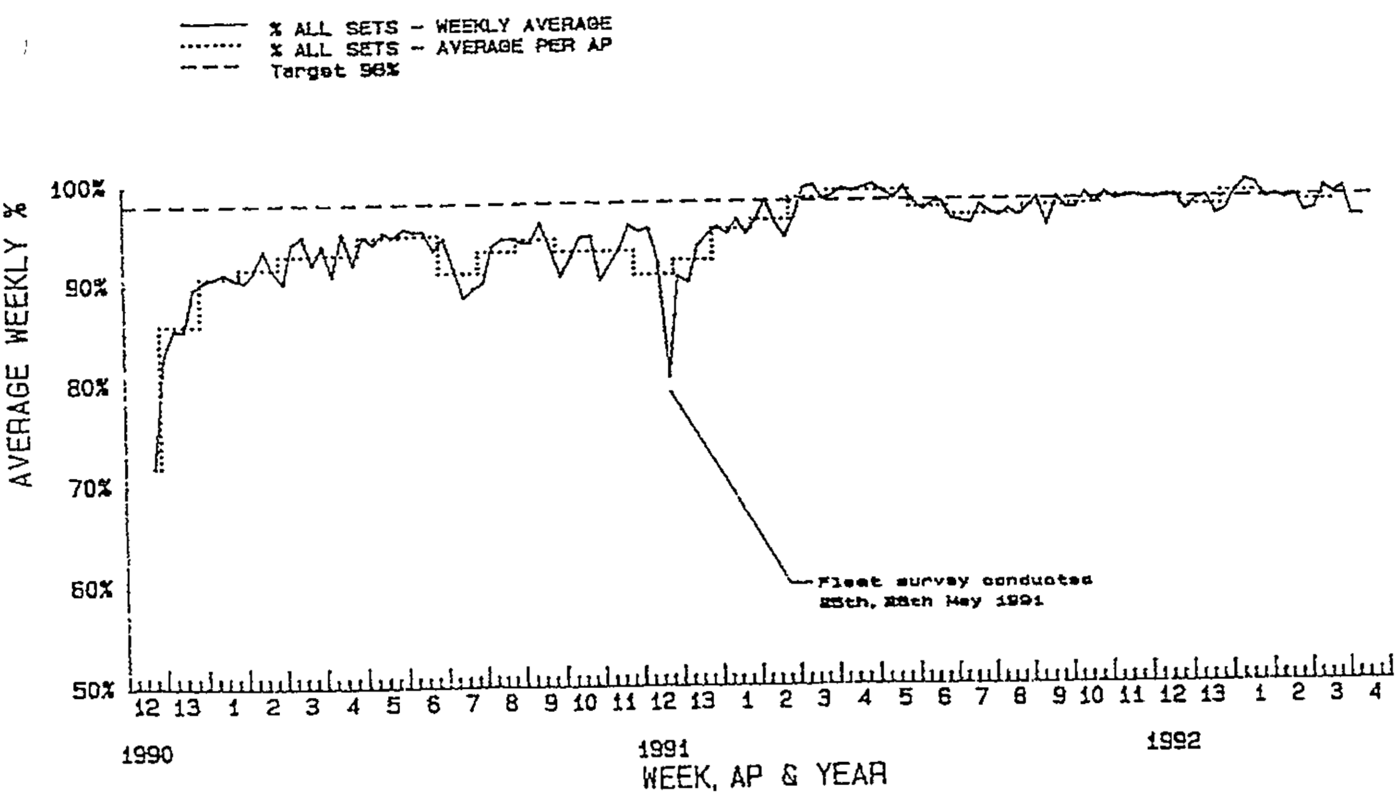
P.A.SYSTEM STATUS

Percentage Working On All Electric Carriages



Percentage of Sets with Passenger Side Doors Complying to Standard.

TREND FROM WK4 AP12 1990 TO WK3 AP4 1992



Passenger Falls: Cost exposure data highlighted the need to completely overhaul attitudes, procedures and facilities contributing to or failing to prevent passenger falls. Treating "passenger fall" incidents as merely passenger responsibility is no longer considered to be an adequate response. A passenger fall reduction strategy has commenced embracing the following:

* establishment of minimum floor friction standards
* floor cleaning and maintenance standards
* floor, step and escalator cleaning and maintenance procedures.
* passenger awareness

(See graph reference AR23).

Operating Staff Reaccreditation: Train Operation Safety staff must be reaccredited in safeworking every two years to remain qualified in their positions. This concept has been introduced to State Rail, and the first phase completed all within 2 years. The results are dramatic.

Procedural training is also being modernised. A recently contracted $3million investment in a driver training simulator is an example of the extent and level of this commitment to best staff practice and standard.

(See graph reference AR22)

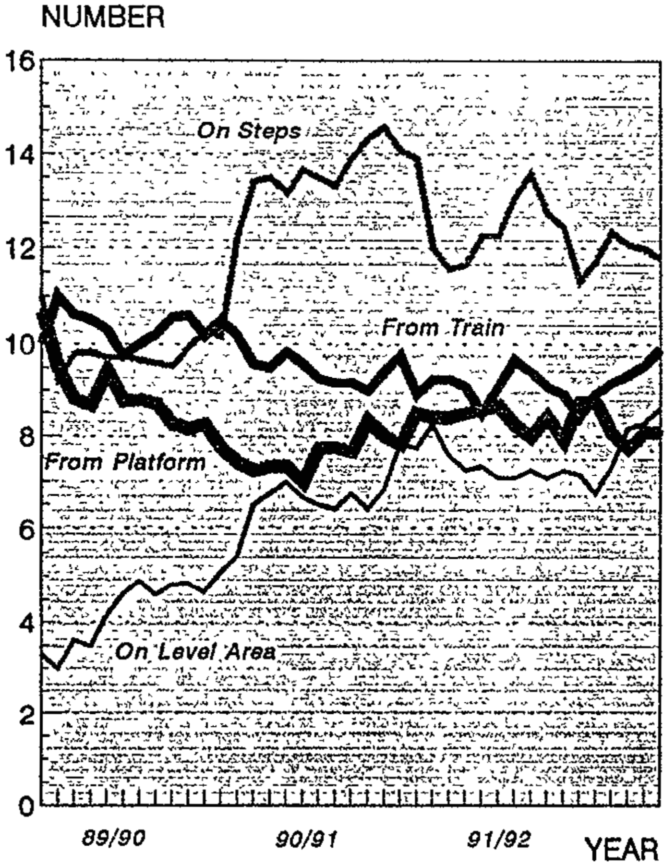
Vandalism and Trespass on the System: Increasing levels of trespass and vandalism supported the investment of almost $7 million in trackside fencing along with far greater stringency in surveillance and housekeeping with respect to trackside materials. Unfortunately, over 50% of safety incidents are still caused by agencies outside CityRail. Road motor vehicles on track, or knocking level crossing booms, and attacks by vandals represent the major elements, with bomb hoaxes also significant.

(See graph reference AR21 and AR24)

Fire retardant materials have proved the earlier wisdom of this investment as deliberately started fires on trains have been frustratingly, for the arsonist, unsuccessful. Meanwhile a program of replacement of windscreens on trains by a glass of almost double the original thickness has underscored the commitment to staff safety.

CITYRAIL: FALL MODE

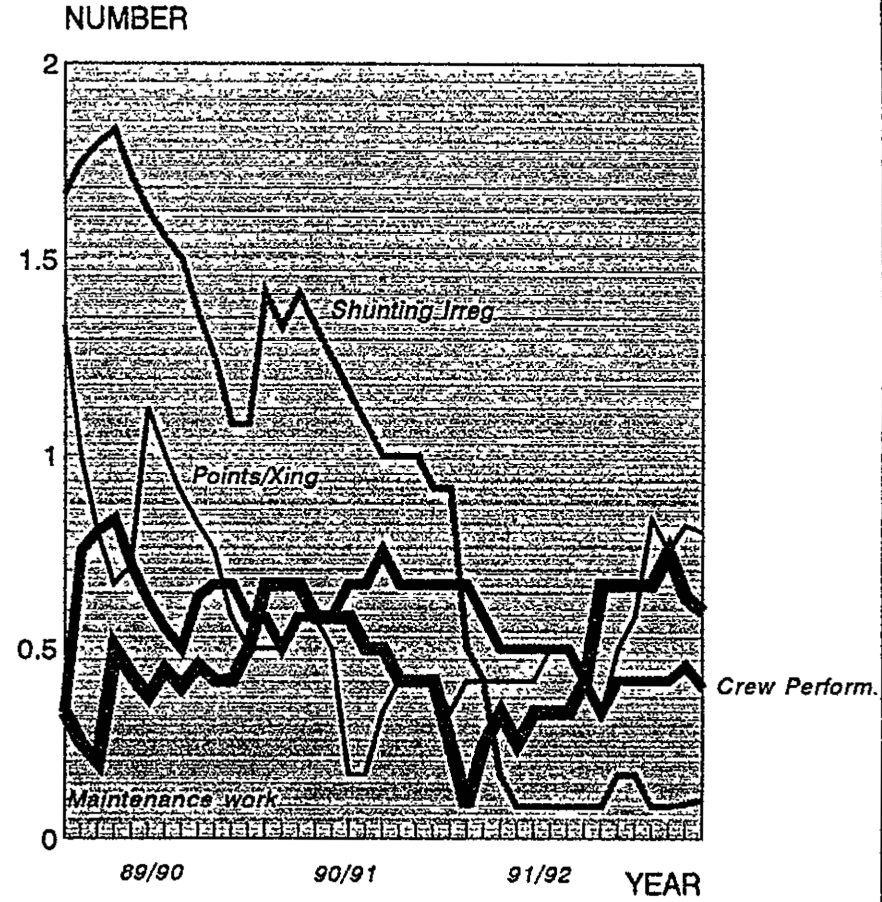
TWELVE MONTHS MOVING AVERAGE



AR23

CITYRAIL: DERAILMENT MODE

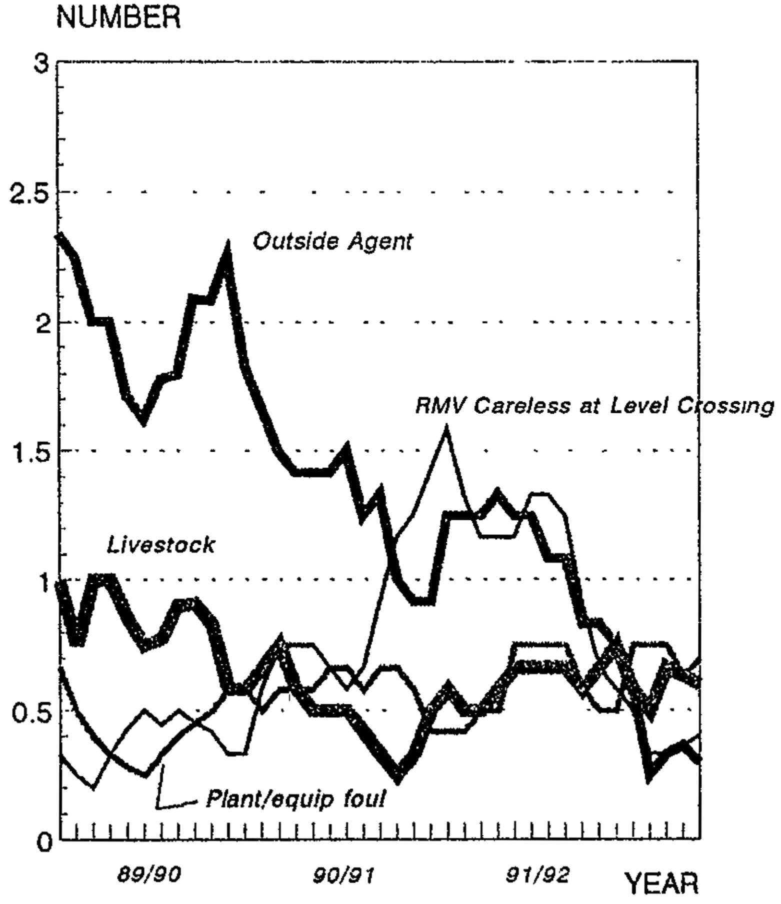
TWELVE MONTHS MOVING AVERAGE



AR22

CITYRAIL: COLLISION MODE

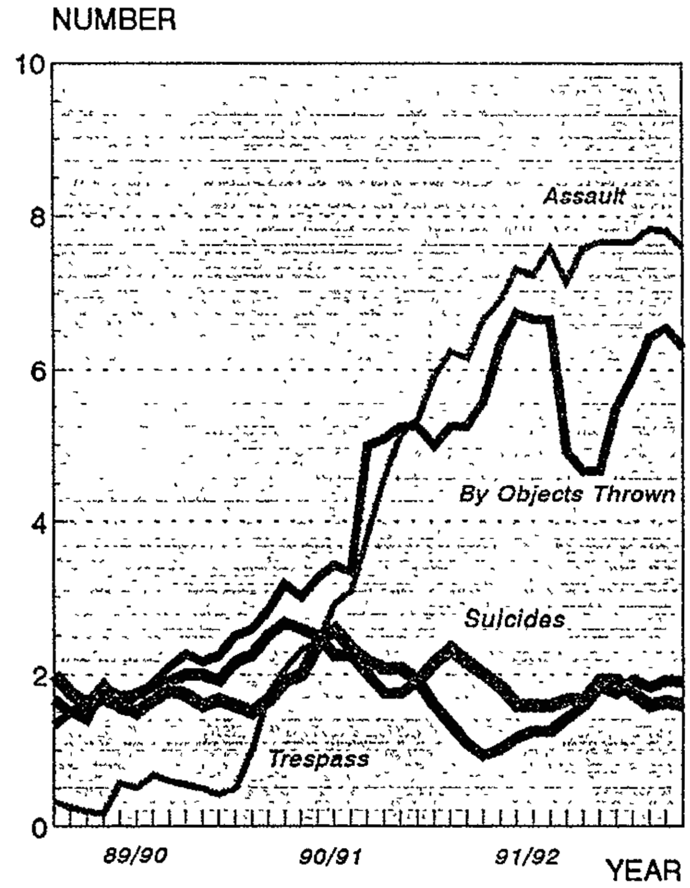
TWELVE MONTHS MOVING AVERAGE



AR21

CITYRAIL: STRIKE MODE

TWELVE MONTHS MOVING AVERAGE



AR24

Key Challenges:

While major changes to safety achievement have occurred within State Rail, there are still many substantial challenges.

> The impact of world wide trends towards greater levels of violence within communities means issues such as person to person violence and bomb hoaxes will be difficult to contain.

Trespass and system interference (particularly vandalism) will continue to require refinement of surveillance and detection measures on a widely distributed network, which a railway constitutes.

Risk Analysis:

Risk Analysis is being used as a primary safety action in a number of system safety plans. State Rail believe that Risk Analysis is very important to allocate capital works programmes where the best result for money is obtained. However, it is much more important to analyse regularly the incidents that occur to ensure that actions are taken to either eliminate or control potential hazards. In most cases hazards can be controlled quickly and efficiently without any expenditure whatsoever.

Conclusion:

The safety performance data system remains an invaluable asset to State Rail, representing vital leverage to ensure commitment and action to deliver levels of system and person safety consistent with international best practice. It has also become a means of ensuring quality service with significant savings in expenditure for the Authority.

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Carel Labushagne

Risk Profile: A Practical Approach

Publisher
2000 International Rail Safety Conference

International Railway Safety Seminar 1992

Risk Profile: A Practical Approach

Mr.C.Labuschagne
South Africa

TOPIC

Risk Management in Perspective

RISK MANAGEMENT

- Comprehensive strategy for dealing with risks
- Science that identifies methods to handle risks
- Show the independence between the available alternatives
- Management function used to plan, direct and co-ordinate activites – pure risk

OBJECTIVE

To suggest a practical (maybe controversial) approach towards identifying the pure risks facing an organisation, in order to compile risk profiles and focus risk control and risk finance efforts.

TRANSNET

RISK CONTROL

The provision of appropriate levels
and standards of protection for people
and assets to eliminate or minimise
the pure risks which have been
identified and evaluated

RISK FINANCING

The provision of funds for recovery from losses that do occur.

RISK

Risk = Chance Of Loss

The probability that the hazard potential is realised at any specified level in a given span of time.

BASIC DEFINITIONS

Pure Risk

This is a risk whose existence does not offer the person or organization exposed to it any opportunity for gain. Thus, the possibilities it offers are only loss and no-loss.

Pure risks are distinguished from speculative risks, in that the latter offer opportunities for gain

RISK IDENTIFICATION

The identification of the pure risks to which an organisation is or could be exposed.

RISK EVALUATION

The expression of identified pure risks in an organisation in financial / numerical terms to gauge the potential severity and frequency of occurrence of these risks.

TRADITIONAL APPROACH

1. Physical inspection
2. Personal interviews
3. Documentary information
4. Failure mode analysis
5. Hazard and operability studies
6. Fault tree analysis

PROBLEMS

- Expert/specialised field and availibility
- Time consuming
- Loss data unavailable
- Oversight
- Omissions
- Experience
- No line ownership
- Normally system is used for insurance purposes only

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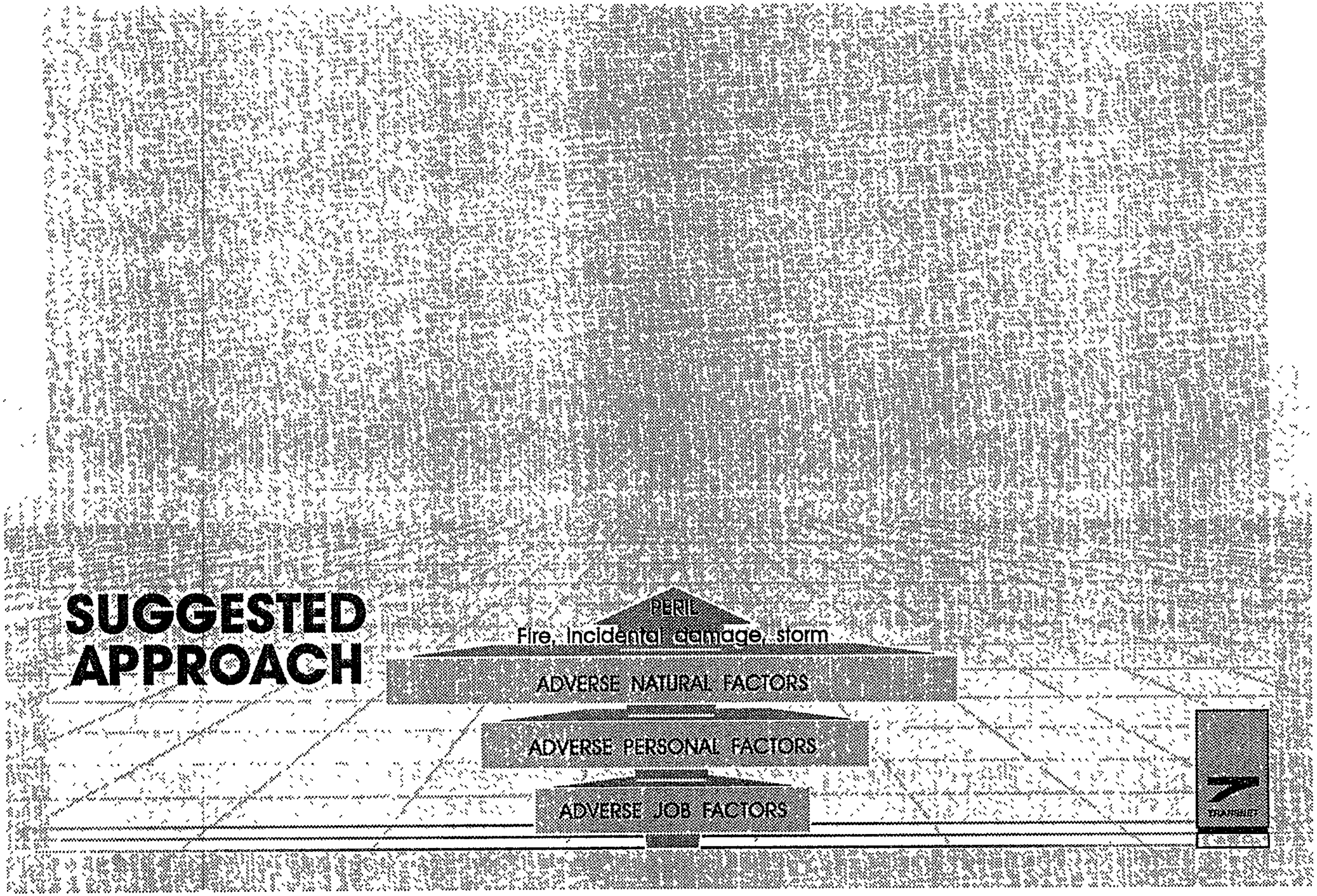
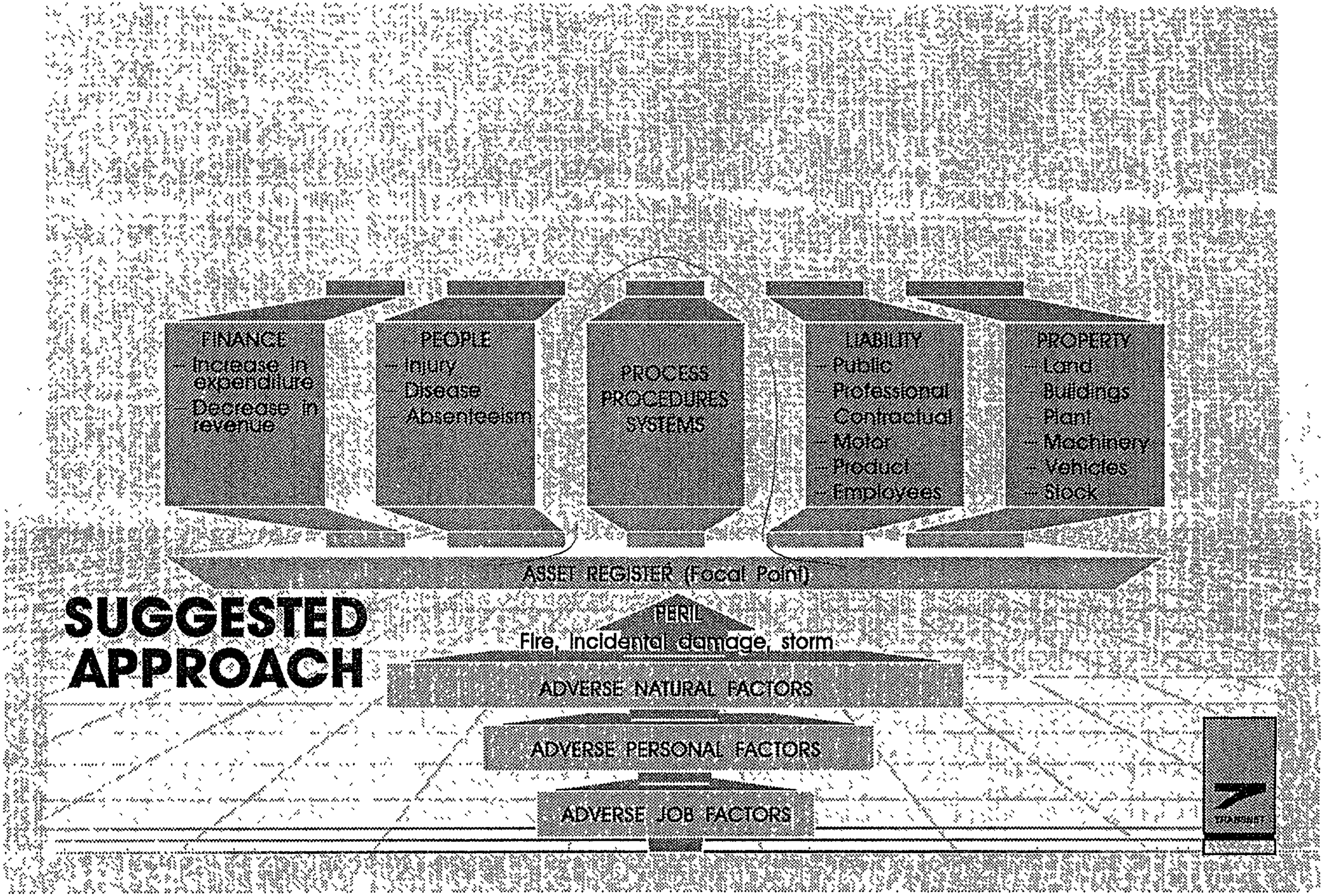
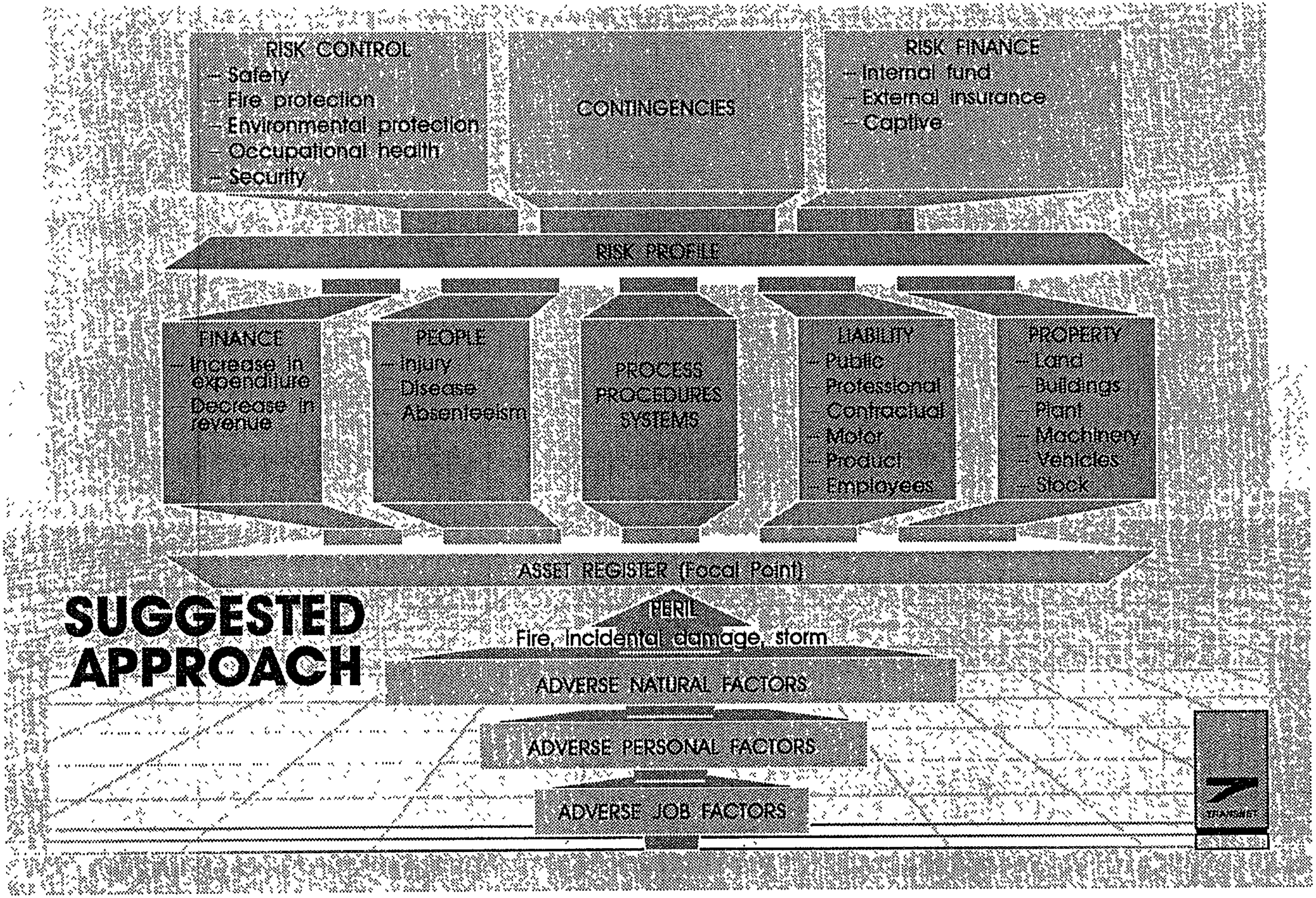




SUGGESTED APPROACH
FINANCE
— Increase in expenditure
— Decrease in revenue
PEOPLE
— Injury
— Disease
— Absenteeism
PROCESS
PROCEDURES
SYSTEMS
LIABILITY
— Public
— Professional
— Contractual
— Motor
— Product
— Employees
PROPERTY
— Land
— Buildings
— Plant
— Machinery
— Vehicles
— Stock
ASSET REGISTER (Focal Point)
PERIL
Fire, Incidental damage, storm
ADVERSE NATURAL FACTORS
ADVERSE PERSONAL FACTORS
ADVERSE JOB FACTORS


RISK CONTROL
– Safety
– Fire protection
– Environmental protection
– Occupational health
– Security
CONTINGENCIES
RISK FINANCE
– Internal fund
– External insurance
– Captive
RISK PROFILE
FINANCE
– Increase in expenditure
– Decrease in revenue
PEOPLE
– Injury
– Disease
– Absenteeism
PROCESS
PROCEDURES
SYSTEMS
LIABILITY
– Public
– Professional
– Contractual
– Motor
– Product
– Employees
PROPERTY
– Land
– Buildings
– Plant
– Machinery
– Vehicles
– Stock
ASSET REGISTER (Focal Point)
SUGGESTED APPROACH
PERIL
Fire, Incidental damage, storm
ADVERSE NATURAL FACTORS
ADVERSE PERSONAL FACTORS
ADVERSE JOB FACTORS

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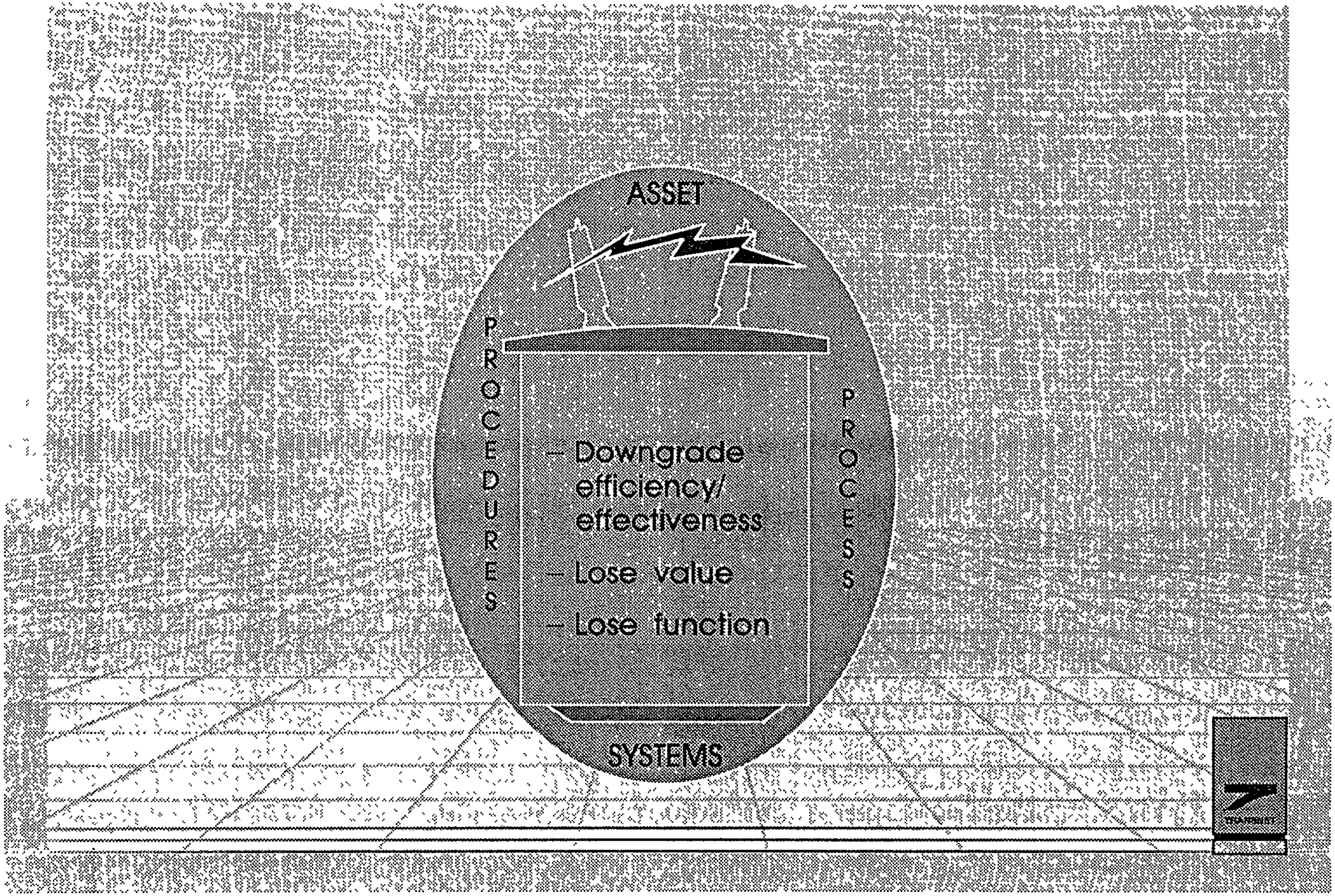

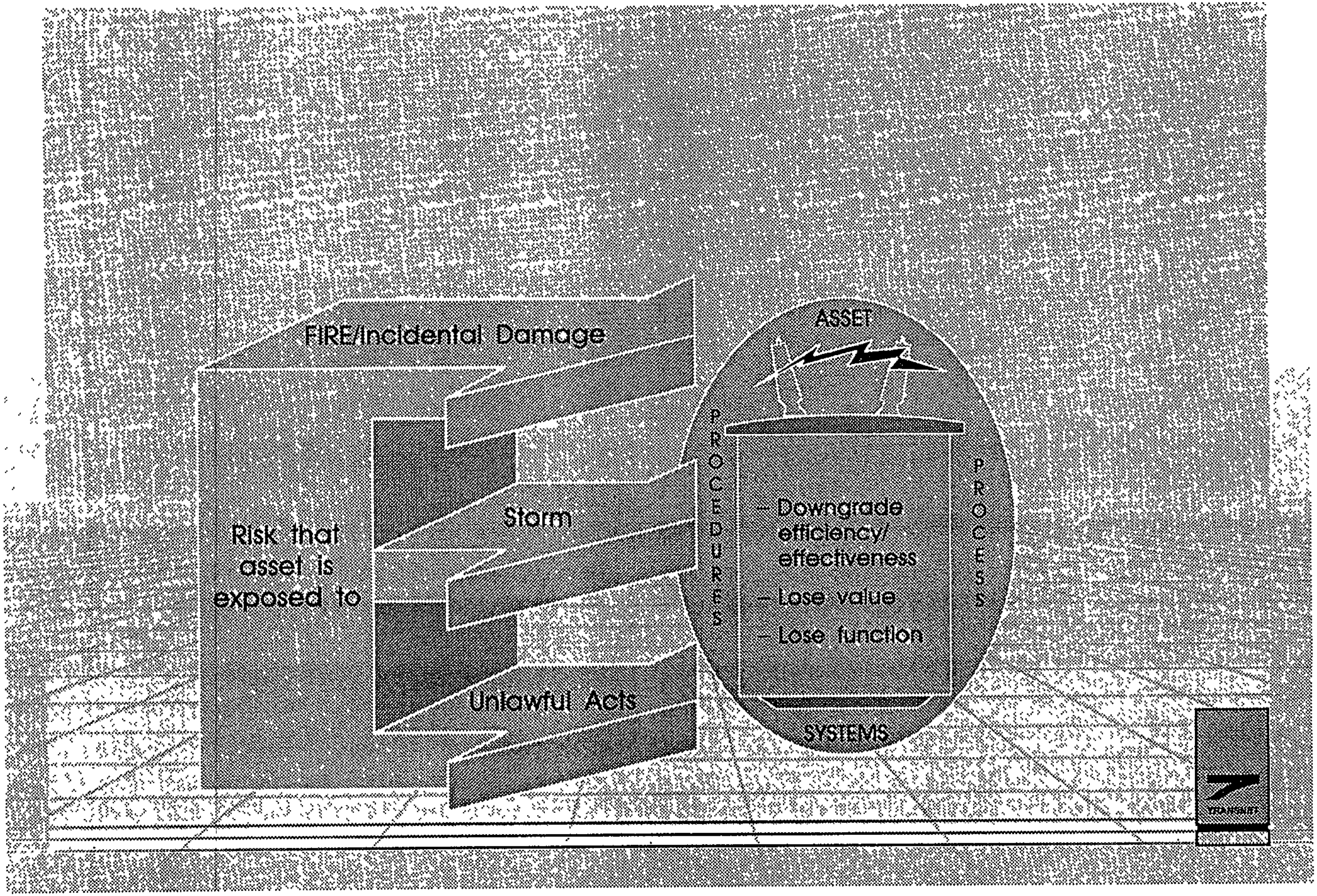
FIRE/Incidental Damage
Storm
Unlawful Acts
Risk that asset is exposed to
ASSET
PROCEDURES
PROCESS
– Downgrade efficiency/ effectiveness
– Lose value
– Lose function
SYSTEMS

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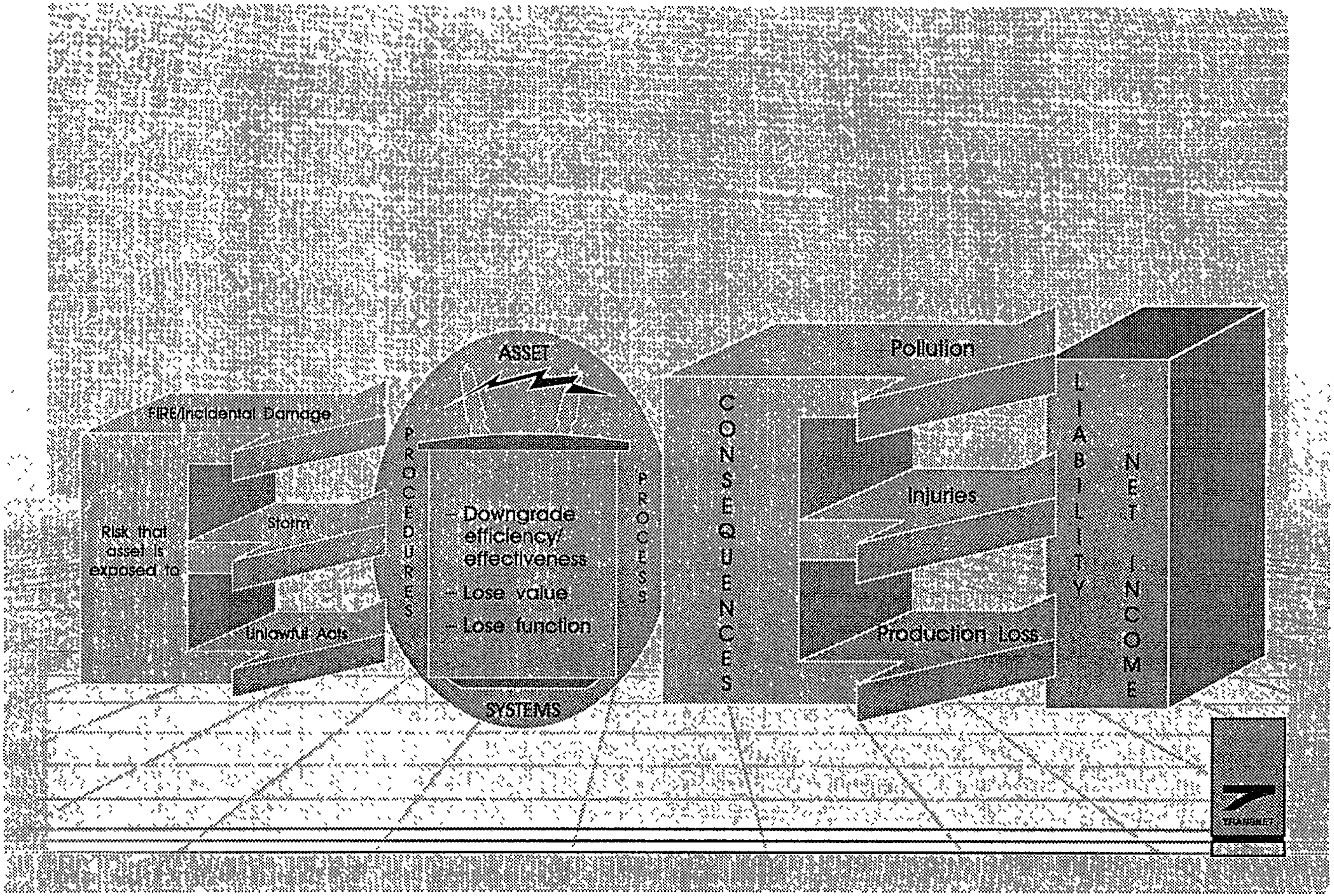

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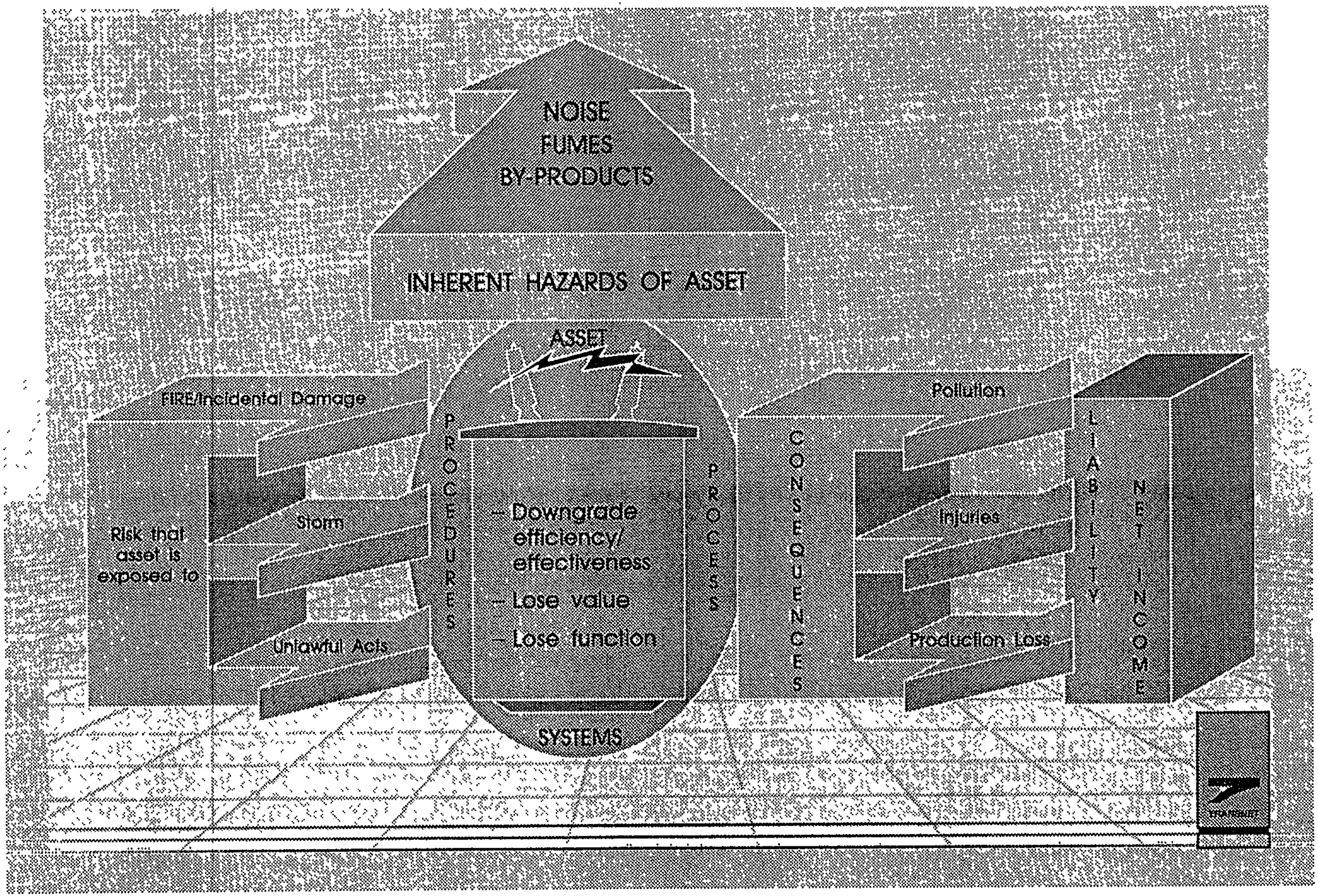
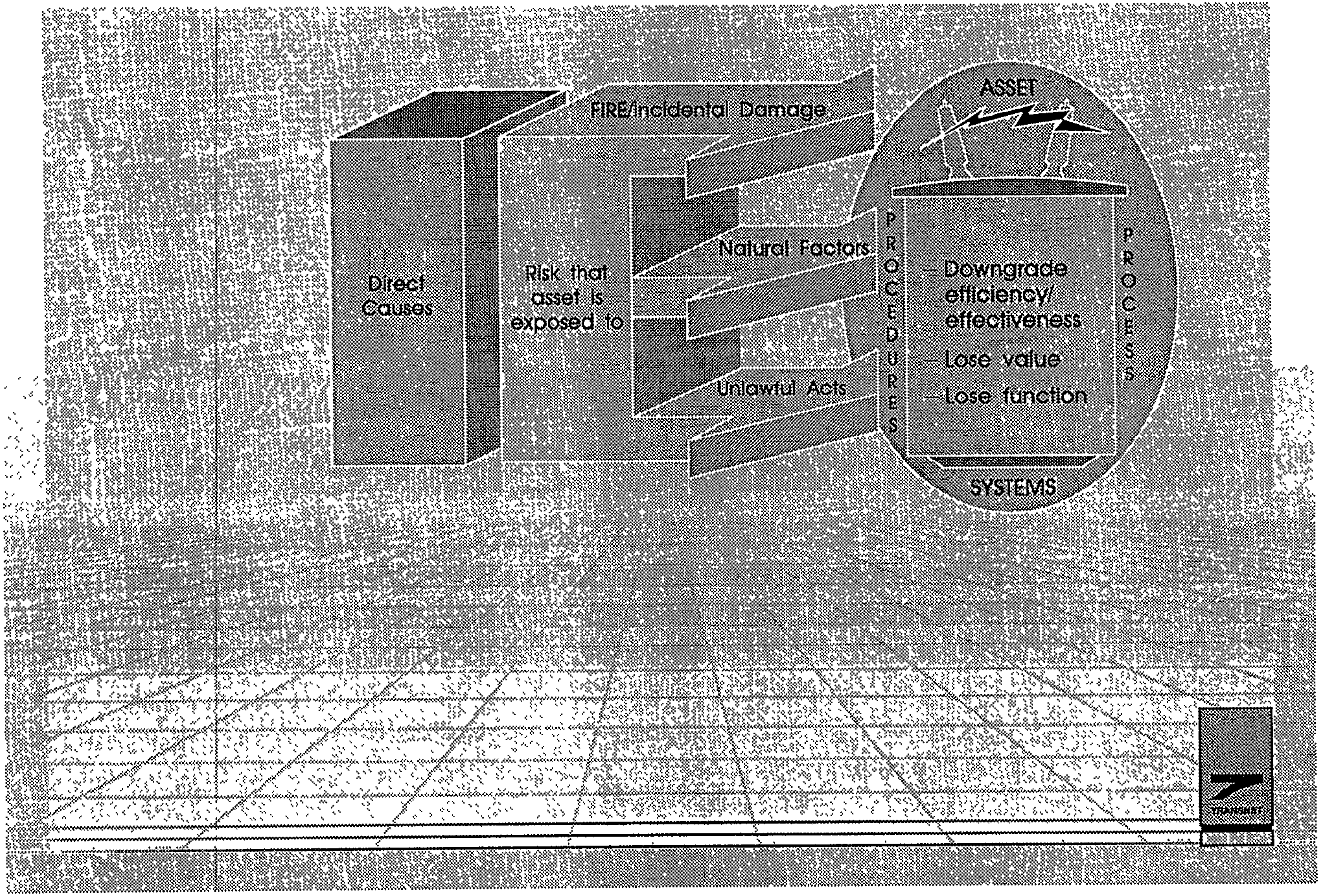
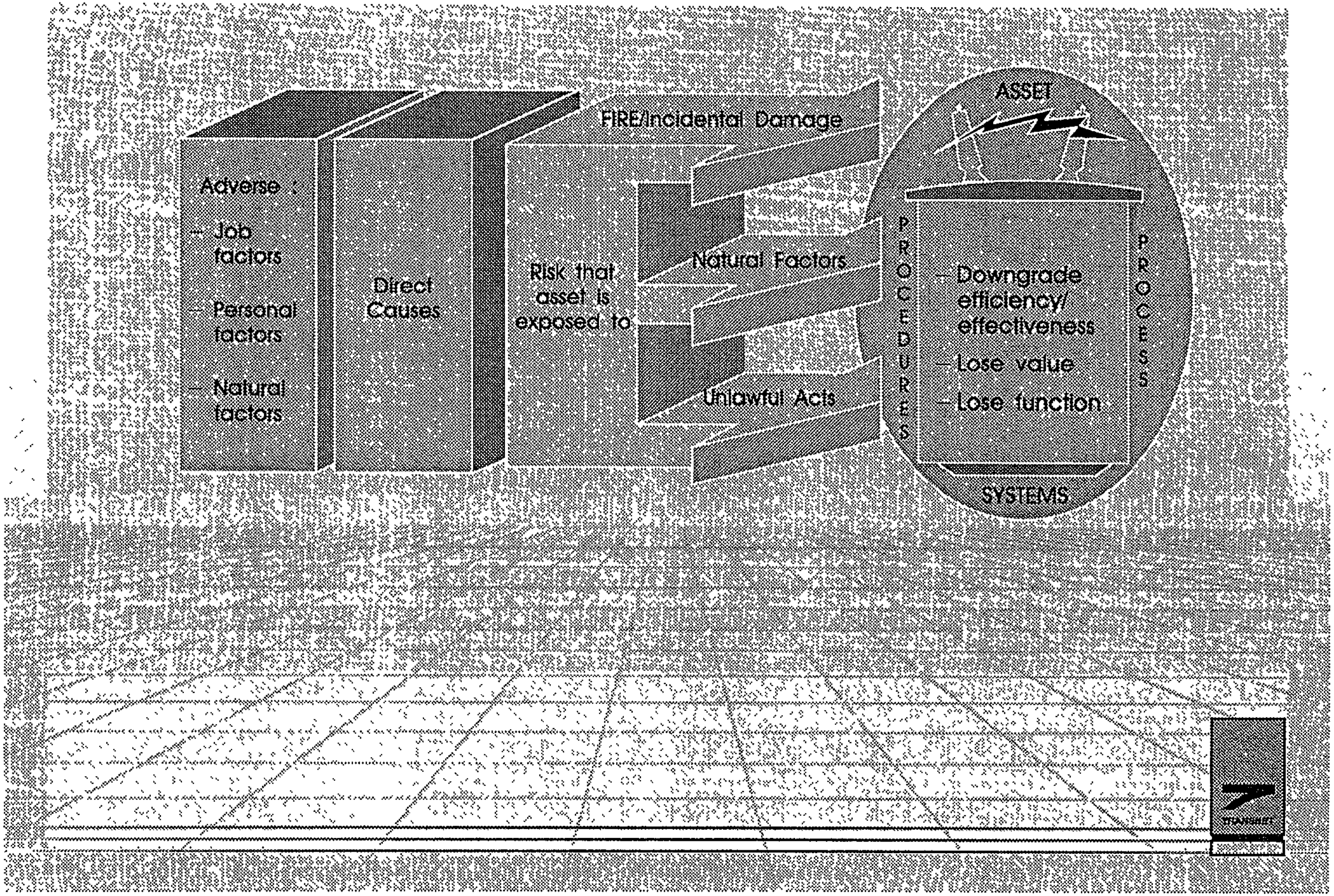


HAZARD

A physical situation with the potential for death or disablement or which may cause damage to, or the destruction of an asset, both with the possible consequential interruption of the business activities.


Direct Causes
Risk that asset is exposed to
FIRE/Incidental Damage
Natural Factors
Unlawful Acts
ASSET
PROCEDURES
PROCESS
—Downgrade efficiency/ effectiveness
—Lose value
—Lose function
SYSTEMS
TRANSNET


Adverse :
— Job factors
— Personal factors
— Natural factors
Direct Causes
Risk that asset is exposed to
FIRE/Incidental Damage
Natural Factors
Unlawful Acts
ASSET
PROCEDURES
PROCESS
— Downgrade efficiency/ effectiveness
— Lose value
— Lose function
SYSTEMS

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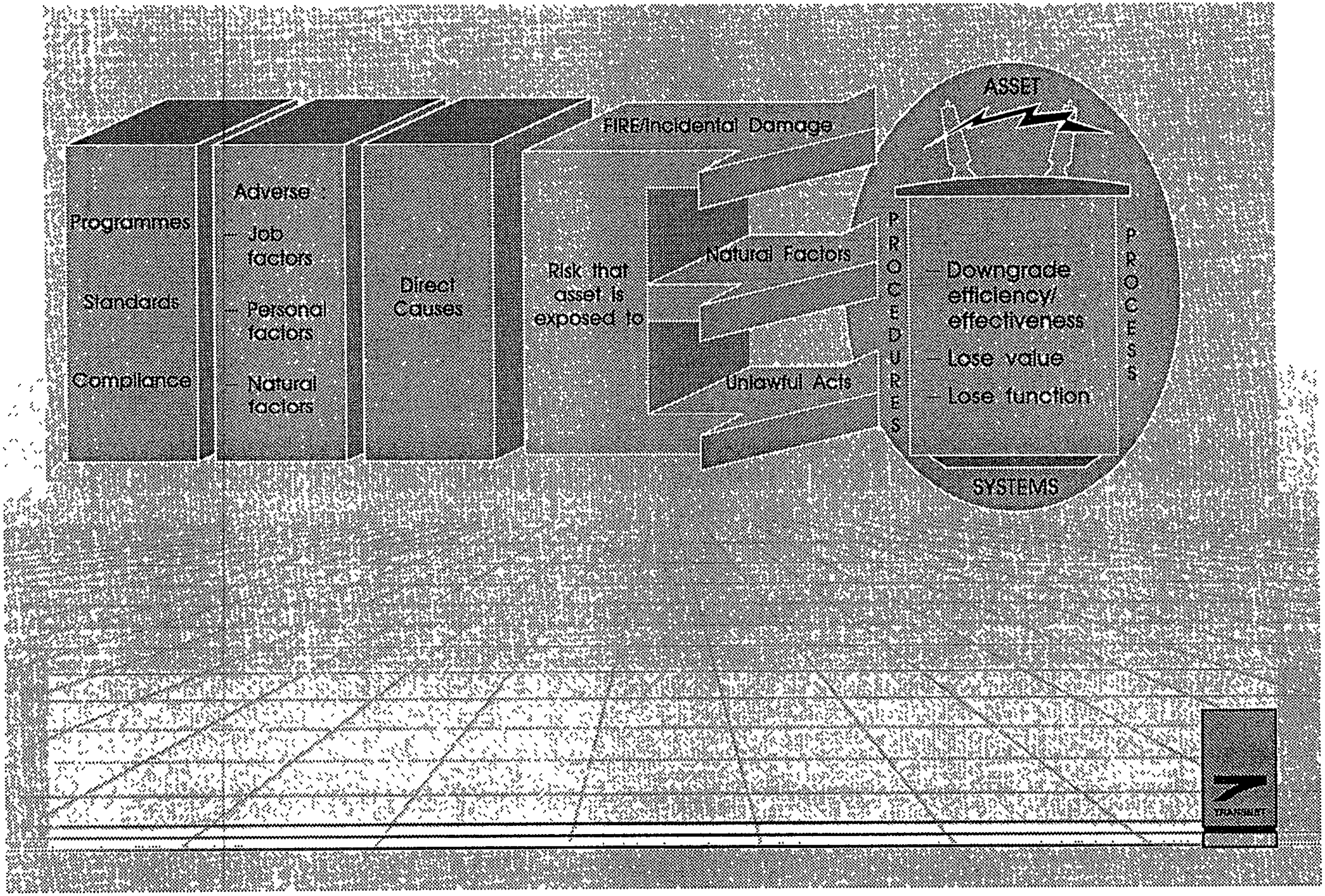

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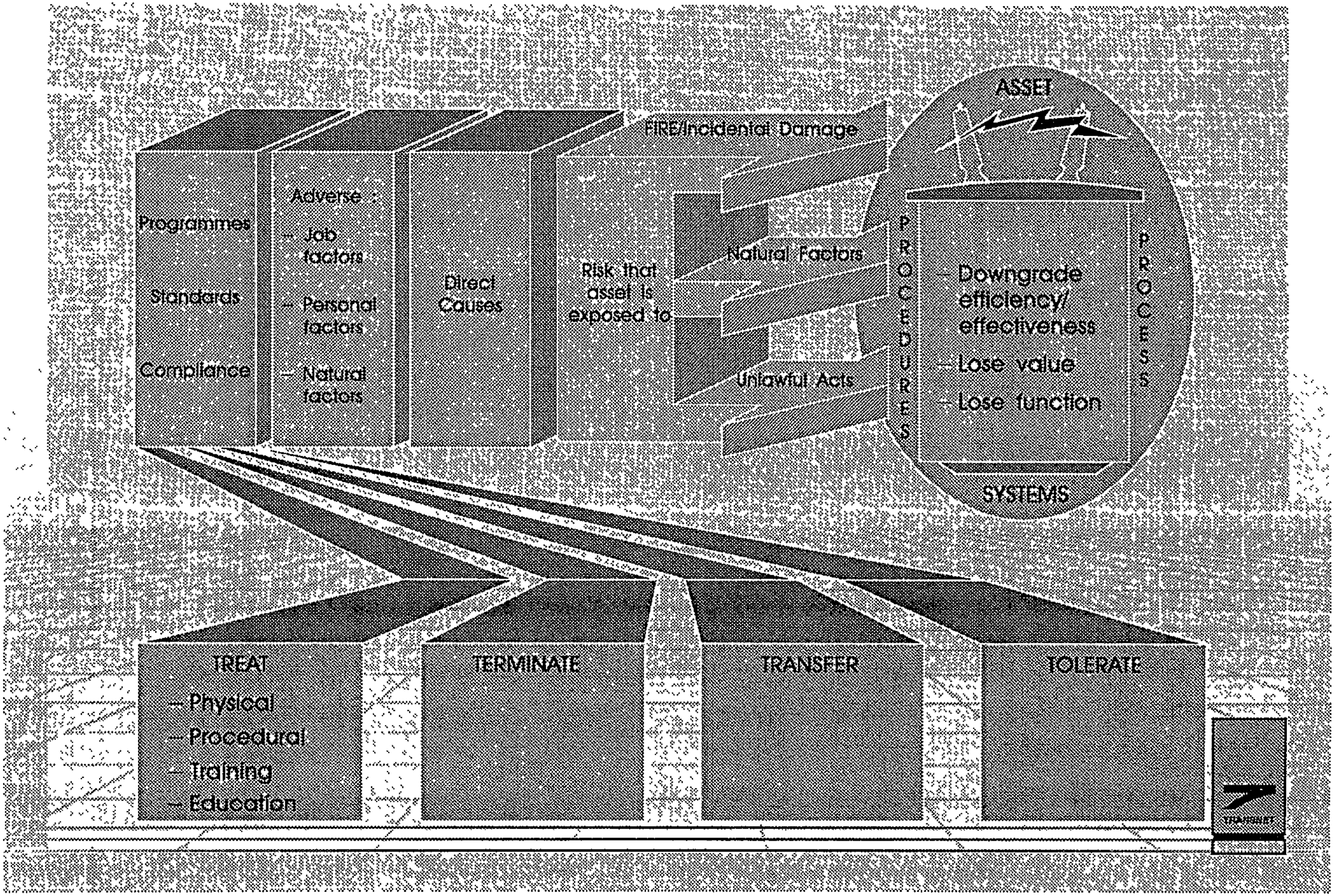

PRINCIPALS OF CRITICALITY

- Principle of systematic action
- Principle of situation control
- Principle of stress control
- Principle of forcing mechanisms
- Principle of checks and balances

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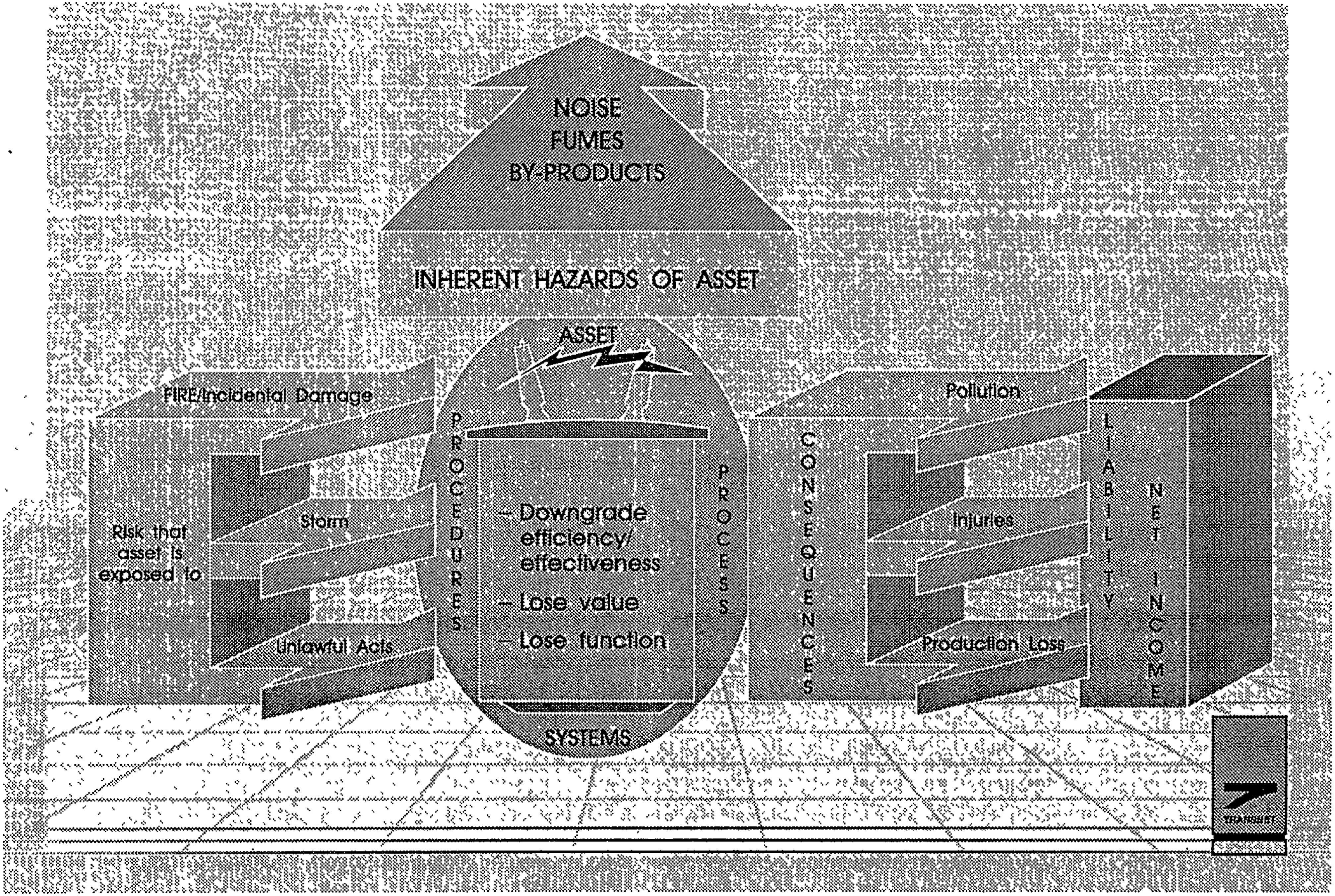

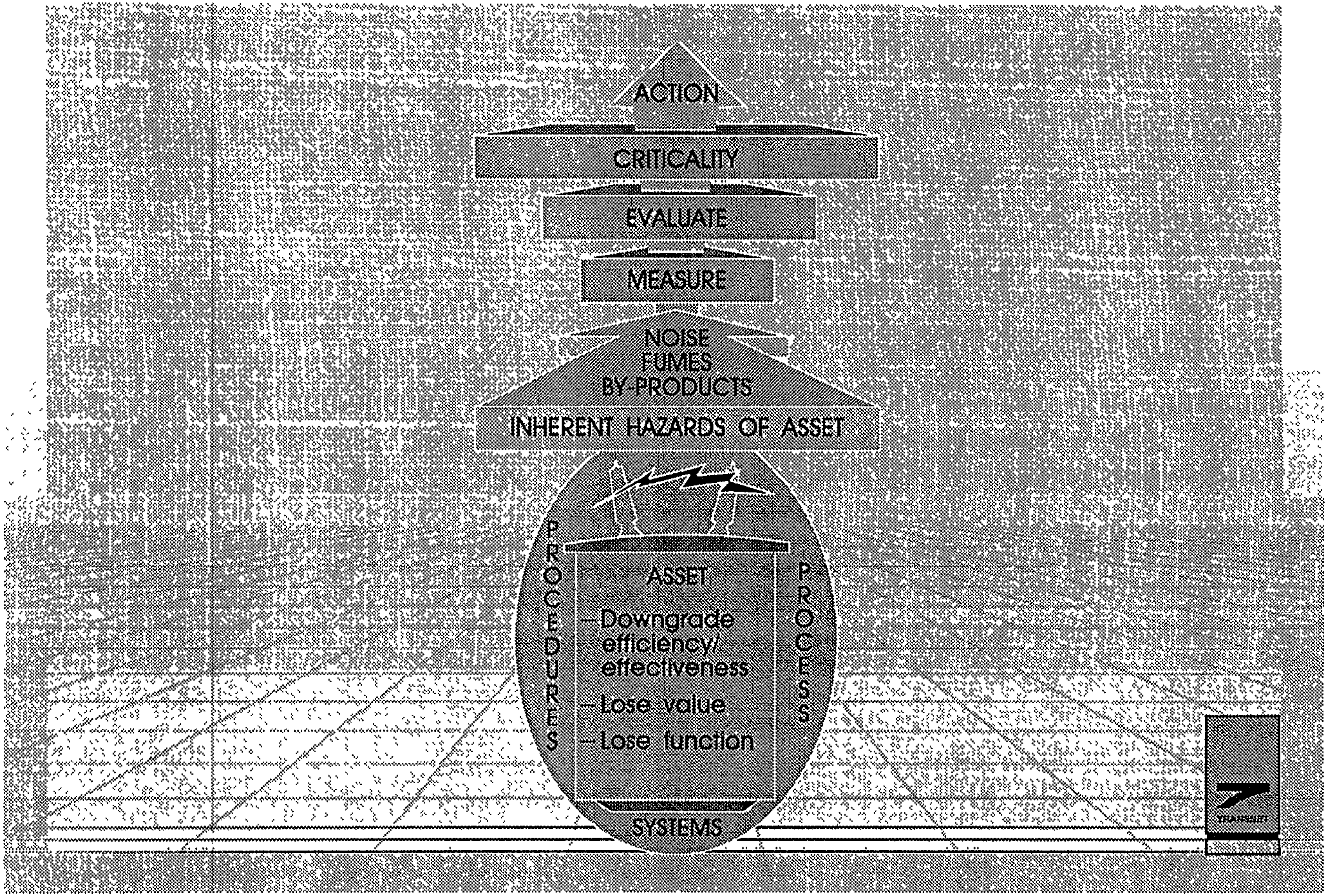
ACTION
CRITICALITY
EVALUATE
MEASURE
NOISE
FUMES
BY-PRODUCTS
INHERENT HAZARDS OF ASSET
PROCEDURES
ASSET
—Downgrade efficiency/ effectiveness
—Lose value
—Lose function
PROCESS
SYSTEMS

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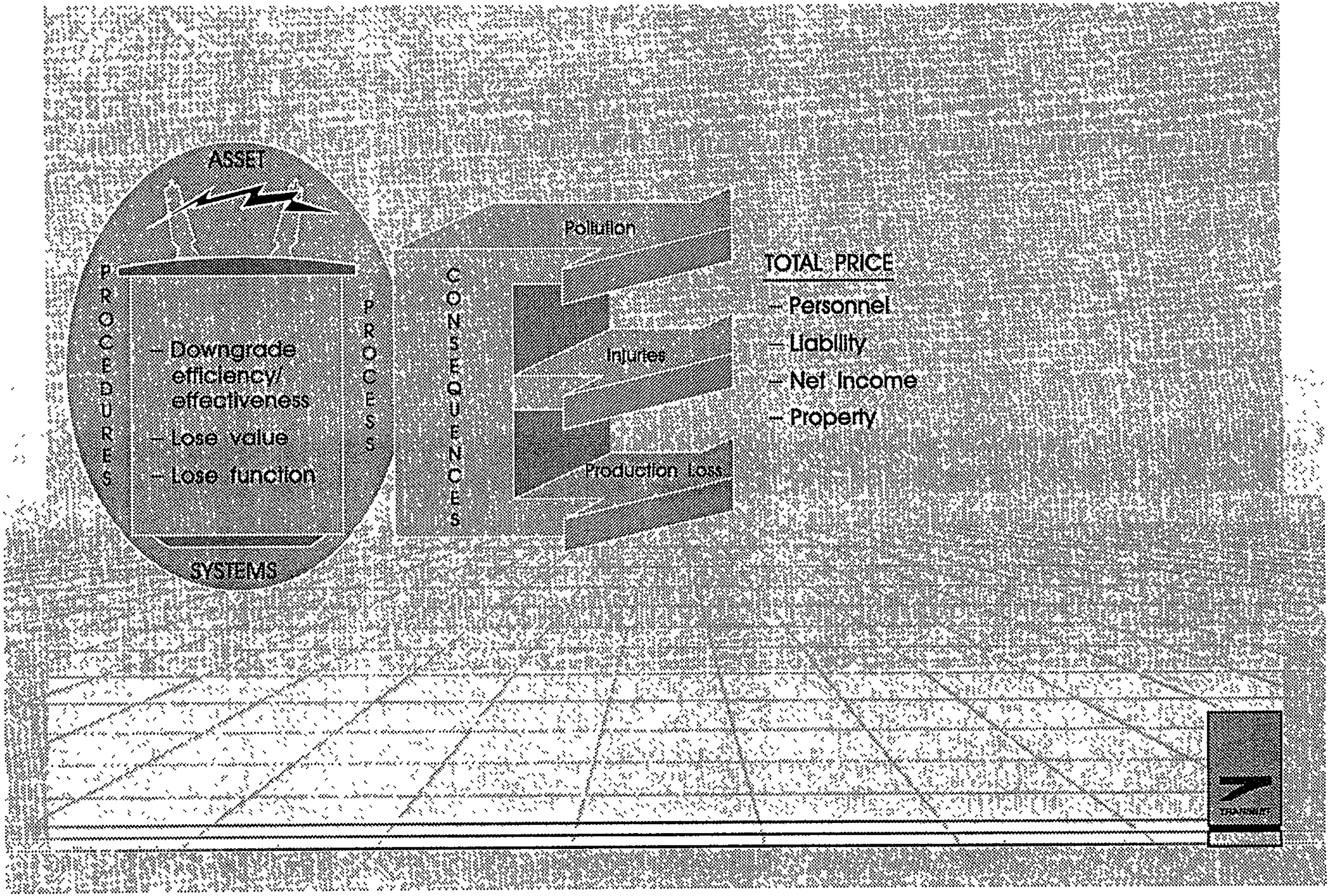
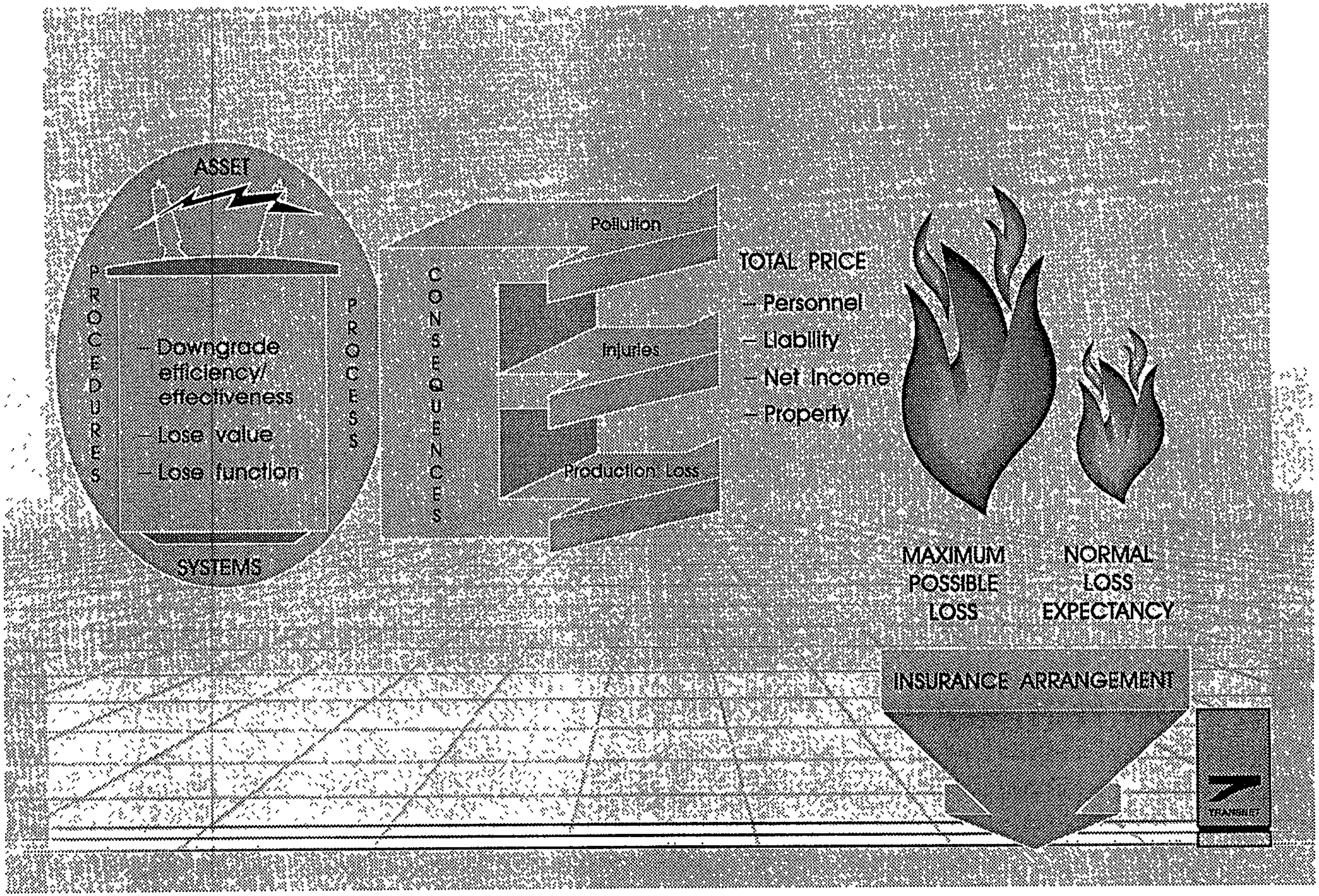



ASSET
PROCEDURES
PROCESS
– Downgrade efficiency/ effectiveness
– Lose value
– Lose function
SYSTEMS
CONSEQUENCES
Pollution
Injuries
Production Loss
TOTAL PRICE
– Personnel
– Liability
– Net Income
– Property
MAXIMUM POSSIBLE LOSS
NORMAL LOSS EXPECTANCY
INSURANCE ARRANGEMENT
TRANSNET

MAXIMUM PROBABLE LOSS (MPL)

The maximum cost of a loss that could result from a single event under unfavourable conditions.

NORMAL LOSS EXPECTANCY

The maximum loss that could result from a single event given that all risk control measures operate as expected.

Slide: d10 ana 20 Opid: *** DEFAULT *** Job #: 000000 DDS:0532 size: 7042 Mon Oct 12 18:30:12 1992

RISK IDENTIFICATION AND ANALYSIS FORMAT

Business undertaking: ______________ Business unit: ______________ Date compiled: ______________

Centre: ______________ Inventoried by: ______________ Date last review: ______________

Asset					Exposures					Net income								Controls
Group	S/Group	Entry/unique number	Description	Agreed value (Rm's)	Primary peril	Consequences	Agrivating factors	Mitigating Factors	Liability (1-5)	Expenses +	Income -	Humane factor (1-5)	Maximum possible loss (Rm's)	Severity	Repetitiveness	Probability	Criticality (S.R.P.)	▪ Risk finance/ Risk control ▾ T-T-T-T

Risk identification	Evaluation of potential severity	Rating	Evaluation of repetitiveness	Rating	Probability	Rating

Asset		Entry unique number	Description
Group	S/Group		
1 3	O 3 1	1	Dry dock (dry docking of vessels for maintenance/ repair)

Slide: d10 exp 22 Opid: *** DEFAULT *** Job #: 000000 DDS:0532 size: 8798 Mon Oct 12 19:39:40 1992

Exposures					Net Income			
Primary peril	Consequences	Agrivating factors	Mitigating Factors	Liability (1-5)	Expenses +	Income -	Humane factor (1-5)	Maximum possible loss (Rm's)
• Damage	• Out of commission • Ship can sink in dock • Third party ships can be damaged • Injuries • Flooding of dry dock			1	✓	✓	1	10+
• Fire	• Out of commission	• Hot work done all the time • Fuel on ships	• Fire fighting system • Hot work permit system	1	✓	✓	1	10+
		• Public access		3	✓	✓	1	10+

Risk identification

Primary perils that the assets are exposed to:

- Incidental damage
- Fire
- Natural disaster
  - Floods
  - Wind
  - Hail
  - Storm
- Unlawful acts
  - Sabotage
  - Theft

Procedure System

A S S E T

Process

What will the consequenses be. What will be affected ?

- People
- Property
- Goods/material/product
- Liability
- Procedure
- Finance
- Process
- External - natural
- External - constitution

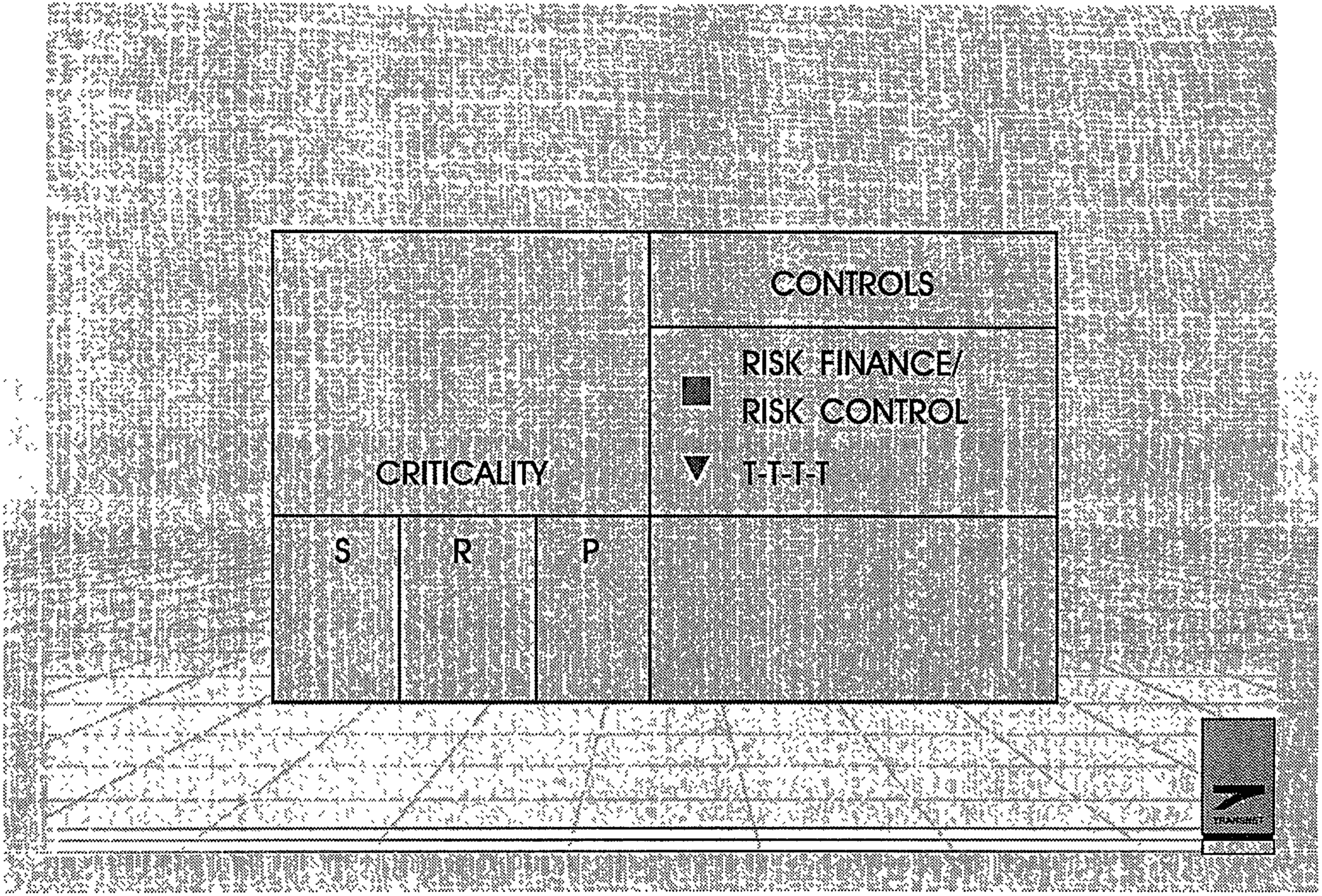
TRANSNET

SEVERITY	
EVALUATION OF POTENTIAL SEVERITY	RATING
1. Catastrophe: numerous fatalities, extensive damage, major production delays – over R10 000 000.00	100
2. Multiple fatalities: damage, quality problems, production delays R5 000 000.00 – R10 000 000.00	50
3. Fatality, damage, production delays, quality problems – R1 000 000.00 – R5 000 000.00	25
4 Extremely serious injury (permanent disability) damage & other losses of R500 000.00 – R1 000 000.00	15
5. Disabling injury: damage, production delays, quality problems of up to R500 000.00	5

REPETITIVENESS	
EVALUATION OF REPETITIVENESS	RATING
1. More than once per day	10
2. Frequently / once a day	6
3. Occasionally / once per week to once per month	3
4. Usually / once per month to annualy	2
5. Rarely / it has happened in the past	1
6. Very rarely / not known to have occured, but considered remotely possible	0,5

PROBABILITY

PROBABILITY	RATING
1. It is the most likely and expected result if the risk takes place	10
2. It is quite possible, would not be unusual, has an even 50/50 chance	6
3. Would be an unusual sequence of coincidence (it has happened here)	3
4 Extremely remote, but conceivably possible (it has never happened after many years)	1
5. Extremely remote, but conceivably possible (it has never happened after many years)	0.5
6. Has never hapened in spite of exposure over many years	0.1


CONTROLS
RISK FINANCE/
RISK CONTROL
T-T-T-T
CRITICALITY
S
R
P

Slide: d10 ana 20 Opid: *** DEFAULT *** Job #: 000000 DDS:0532 size: 7042 Mon Oct 12 18:30:12 1992

RISK IDENTIFICATION AND ANALYSIS FORMAT

Business undertaking: ____________ Business unit: ____________ Date compiled: ____________

Centre: ____________ Inventoried by: ____________ Date last review: ____________

Asset					Exposures					Net income								Controls
Group	S/Group	Entry/unique number	Description	Agreed value (Rm's)	Primary peril	Consequences	Agrivating factors	Mitigating Factors	Liability (1-5)	Expenses +	Income -	Humane factor (1-5)	Maximum possible loss (Rm's)	Severity	Repetitiveness	Probability	Criticality (S.R.P.)	▪ Risk finance/ Risk control ▾ T-T-T-T
Risk identification				Evaluation of potential severity			Rating	Evaluation of repetitiveness						Rating		Probability		Rating

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RISK NUMERICAL EVALUATION

NUMERICAL EVALUATION	SYMBOL	ITEM
A		
B		
C		
D		
E		
F		
G		
H		
I		
J		
K		
L		
M		
N		
O		
P		
Q		
R		
S		
T		
U		
V		
W		
X		
Y		
Z		

Note :

1 Minor difference in importance

2 Medium difference importance

3 Major difference in importance

SOLUTION JUSTIFICATION

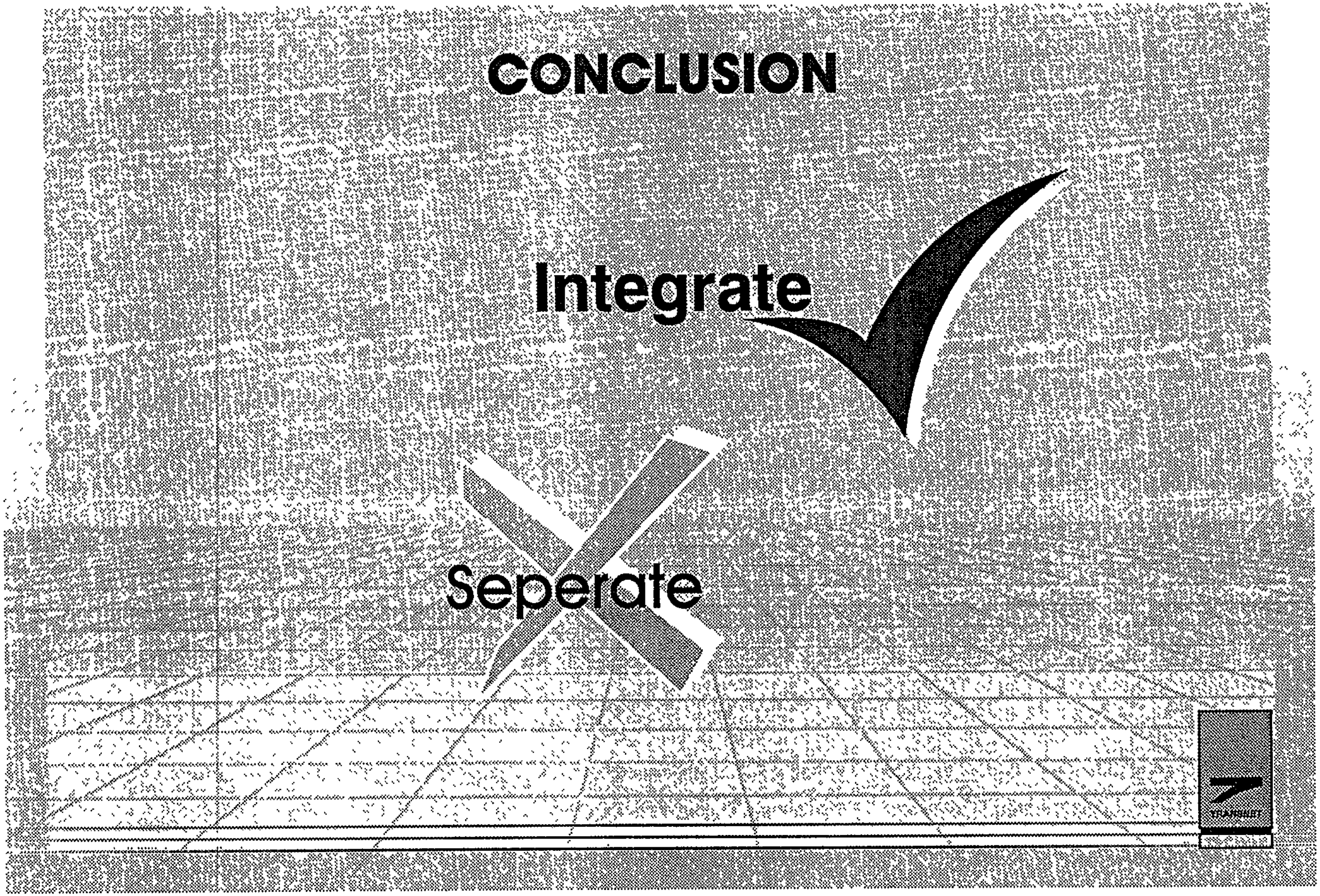
$$\text{Justification} = \frac{\text{Severity x repetitiveness x probability}}{\text{Cost factor x degree of correction}}$$

COST FACTOR	RATING
1. Over R 500 000	10
2. R 250 000 – R 500 000	6
3. R 100 000 – R 250 000	4
4. R 50 000 – R 100 000	3
5. R 10 000 – R 50 000	2
6. R 2 500 – R 10 000	1
7. Under R 2 500	05

DEGREE OF CORRECTION	RATING
1. Risk positively eliminated 100%	1
2. Risk reduced at least 75%	2
3. Risk reduced by 50% – 75%	3
4. Risk reduced by 25% – 50%	4
5. Slight effect on risk (less than 25%)	6

The chief value of risk analysis may not be the final risk figures obtained, which are certain to be open to much criticism and questioning.

The value will lie in revealing many, if not most, of the various possible damage causing mechanisms; and thereby provide better insights to effective control measurements.


CONCLUSION
Integrate
Seperate
TRANSNET

International Rail Safety Conference

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27 October - 30 October 1992
Park Royal Hotel, Wellington, New Zealand

Paper 9211

David Maidment

The Development of Information Systems to Support Risk Management

Publisher
2000 International Rail Safety Conference

International Railway Safety Seminar 1992

The Development of Information Systems to Support Risk Management

Mr.D. Maidment
British Rail

BRITISH RAIL

THE DEVELOPMENT OF INFORMATION SYSTEMS TO SUPPORT RISK MANAGEMENT

By David Maidment, Head of Safety Policy Unit, British Rail

Introduction

The purpose of this paper is to identify briefly the main developments being undertaken by British Rail in implementing revised information systems to support safety management and risk assessment.

I shall therefore give a brief outline of the main developments and attach as appendices relevant papers that may be of interest to the seminar participants.

Data Architecture Study

In British Rail's revised business structure, many responsibilities have been delegated to the new profit centres which basically cover lines of route. A major BR study is looking at the information flows and computer systems which are necessary to be retained across business boundaries as part of a national network. As well as financial information systems, the information flows concerning safety are seen as the main area of critical importance to the network as a whole and which have to be specified at Board level.

The main subject areas concerning safety information requirements are as follows:-

- developing safety policy and plans
- review safety legislation
- assess safety risks
- endorse safety case
- provide safety training
- monitor projects
- monitor safety performance
- safety audit

I attach as appendix A a flow chart of information between each of these activities and all other major organisations outside the Safety Directorate plus a brief description of what is meant by each of the brief titles above. The safety information flow chart, I am afraid, looks more like a snap shot of Heathrow's air traffic control system and it is included only to demonstrate the complexity of information requirements and the scope of the activity that we are trying to capture. There will be a major headache in deciding how to capture and maintain such information in a privatised railway situation and the extent to which it is indeed necessary. This is a subject that we are debating at present with the Health and Safety Executive.

Risk assessment information strategy

BR has a number of projects developing which integrate closely with one another. Indeed the danger is if we do not specify their input and output carefully, that they will duplicate some areas and create gaps in others. I attach a copy of a viewfoil demonstrating the inter-relationship of these as appendix B. What is important to identify at the moment is that initially one requires a reporting and recording system that includes knowledge of incidents and accidents with information about populations of equipment, passenger throughput, number of employees etc so that the incidents can be normalised against workload and risk levels measured.

With output from this database, a line of route risk model is being developed on a prototype system that will calculate event- and fault-trees and produce specific probabilities and consequences so that safety benefits of different lines of action can be established. This expert system will input data into the decision making prioritisation model under development by Cooper and Lybrand Deloitte, described to you in the earlier presentation by David Rayner.

BRIMS II - (British Rail Incident Monitoring System)

Until a couple of years ago all data about railway accidents was reported by railway operators and engineers directly to the UK Railway Inspectorate, where the data was analysed and subsequently reproduced in the Railway Inspector's Annual Report of Railway Safety. BR developed the BRIMS system to establish its own comprehensive database, including the Health and Safety Executive reportable events, lost-time injuries, and increasingly other incidents - operating and engineering - that had significant risk potential.

There are however, weaknesses in the system that has been developed - the system is not particularly user-friendly and it has been difficult for line managers to exploit the data and analyse it easily. The system is also short of "near misses" and is weak on the analysis of causality.

Whilst we are in the short term trying to address some of these weaknesses, in particular the user friendliness aspects, we are now respecifying a second generation BRIMS system and I have included a specification of the way we are going about this as appendix C.

Working hours and conditions database

British Rail are currently studying the restructuring of the hours and conditions of certain grades of staff to reduce the long hours being worked in some cases with potential safety implications. Recent work undertaken by the team considering the review of train drivers conditions have focused on the correlation between the shift patterns of the drivers and safety incidents affecting drivers, including particularly the available database on signals passed at danger. We see the opportunity to extend this work to cover other safety critical groups of staff and the safety incidents in which they are involved normalising them against their hours and patterns of duty. The work has required extensive analysis and development of the databases concerning staff hours and pay.

We are now proposing to use the work undertaken as a basis for a risk assessment of a change in drivers hours and conditions of duty and also that of other grades of staff and are likely to take part in some collaborative research work being sponsored by the UK Health and Safety Executive. A recent paper to our Board Executive outlines the scope of work that is now about to be undertaken and this paper is attached as appendix D.

Line of route study (East Coast Main Line)

It is critical that line managers have easy access to information about risks and vulnerabilities over the area for which they are responsible. We are developing therefore, a prototype system for this 80 mile section of route which brings together existing database information on incidents and accidents together with the staff, infrastructure and workload populations of the route in question. The prototype risk model will be a small expert system which will calculate event- and fault-trees and provide information on safety benefits obtainable from different safety decision options. It will therefore give an indication of the priorities implied by the different risk levels calculated by the system. The output of this system will feed into the decision making model under development by Cooper and Lybrand Deloitte.

The phase one feasibility report undertaken by the consultant on this project is attached as appendix E.

Safety case

The recent report by Sir John Cullen into the Piper Alpha disaster identified the crucial role that safety cases will have in the improvement of offshore oil installations. UK legislation now requires in that industry the production of individual safety cases for each installation to demonstrate that appropriate safety performance can be achieved.

A safety case embraces the exposition of the activity's safety management system supported as necessary by quantified risk assessment of the critical hazardous processes identified. It will compare the probable safety performance of the activity with any external or internally generated safety risk criteria and will measure performance before, during and after any major change which is proposed.

The safety case is a living document, updated so that it can demonstrate at any time the appropriate safety system in place, the risks that are identified and the preventative measures that are in place.

Proposals for British Rail's privatisation include ensuring safety through a validation process. At present proposals from the Health and Safety Executive include the provision of a railway safety case by any franchisee, privatised company or management buy-out company.

British Rail is undertaking a prototype safety case at the present time covering the major project of resignalling the commuter railway line between London and Southend. A copy of the project remit is attached as appendix F to show the scope of what is intended.

International sharing of safety data

Queensland Railways sought to collect information about safety on a comparative basis from a number of railway systems as long ago as 1990, although it is understood that many of the responding railway companies were unable to provide data in a common format or to common definitions.

At our seminar at Latimer House last year, we identified the need to attempt to develop common definitions and data supporting risk assessment and David Hyland had been commissioned to produce a comparative study of the safety performance of a number of suburban and mass transit systems.

David Hyland has now circulated his draft report to the involved railway companies. His report identifies problems in drawing conclusions because of the lack of consistency of data definition and data reporting.

In my view, also, the broad FN curves that have been drawn for each railway system are too generalised to identify any significant areas of performance difference that are helpful for analysis or decision taking.

This suggests to me that a better way forward would be to identify particular discrete areas of activity of major interest to a number of railways and exchange data about these specific areas in a way that will minimise the amount of work that has to be undertaken and will help focus on particular decision options.

I have listed in a letter sent to the Latimer House participants a number of activities in which British Rail has specific interest - in particular safety of employees at the trackside, safety of passengers on trains (passengers falling from slam doors), incident correlation with hours of duty, and finally the development of performance risk criteria for new railway projects. I am aware that other railways have specifically mentioned also level crossing safety and the transport of dangerous goods.

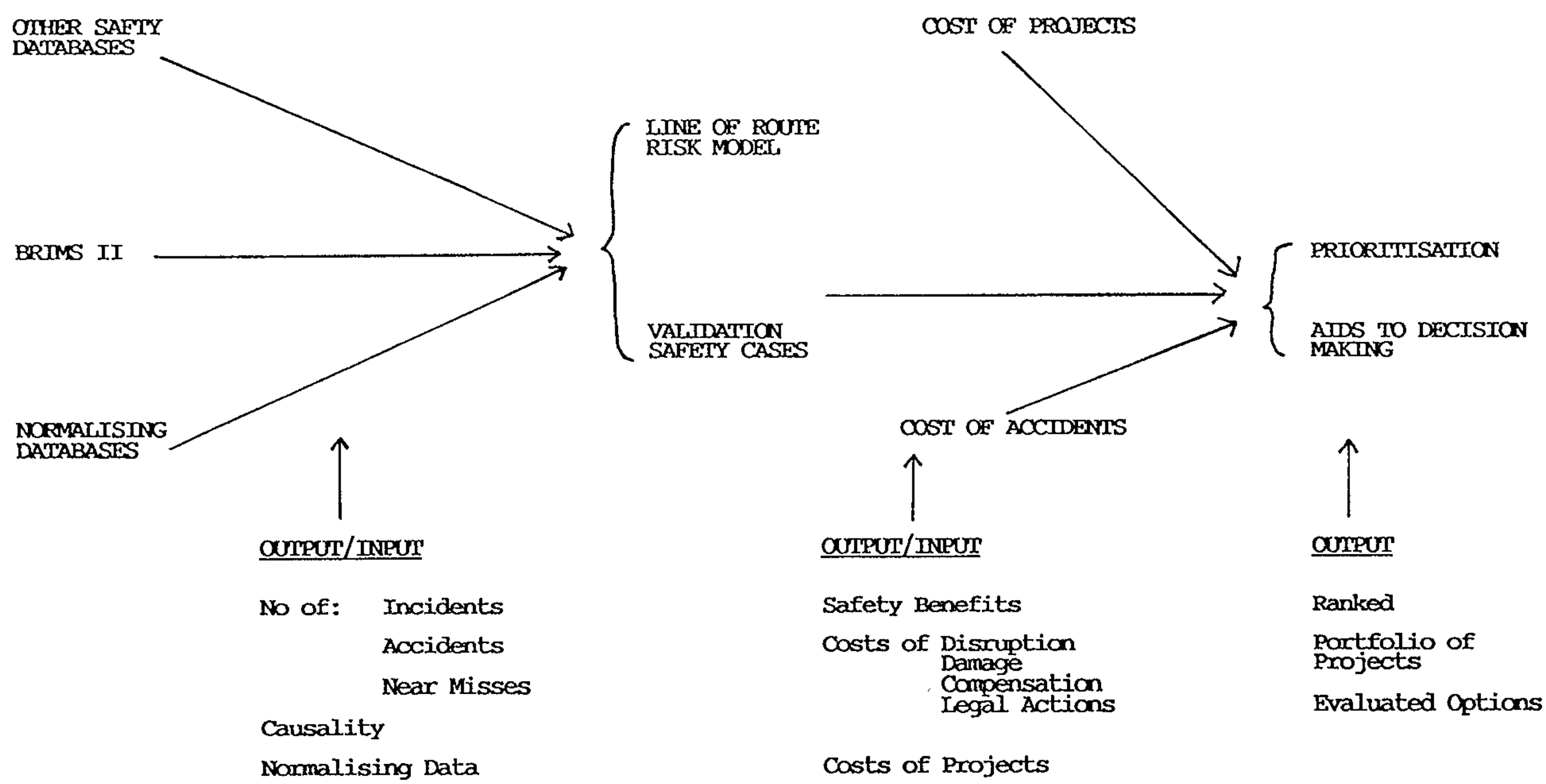
I have attached a number of relevant documents as appendices - the Queensland letter as appendix G, the notes of our relevant discussion at Latimer House as appendix H, the letter that I distributed to Latimer House participants as appendix I, an analysis of employee trackside safety undertaken as part of a major review by British Rail as appendix J and the first output of a process of developing risk performance design criteria for new railway projects as appendix K.

We have a number of options on how we take this development forward. If we wish to do this as a group, what subject or activity areas do we choose? Secondly, what resource do we use to undertake this study? Does one of the particpants at this conference wish to act as an agent on behalf of all of us in co-ordinating a definition of data required and analysing the results? Do we use a consultant on our joint behalf? Do we, perhaps in the longer term, form an international railway association, under the auspices of an organisation like the UIC for example, to collect, manage and distribute such data to the members of that association?

Other industries like the oil industry have formed such associations, setting them up as limited subsidiary companies to produce and manage such data available for all. The trend towards the privatisation of railway activities may make this sort of development essential in the medium to long term.

SUPPLEMENT TO DAVID MAIDMENT'S PAPER

RISK INFORMATION STRATEGY



International Rail Safety Conference

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Paper 9212

Graham McDougall

The Cost of Poor Quality

Publisher
2000 International Rail Safety Conference

International Railway Safety Seminar 1992

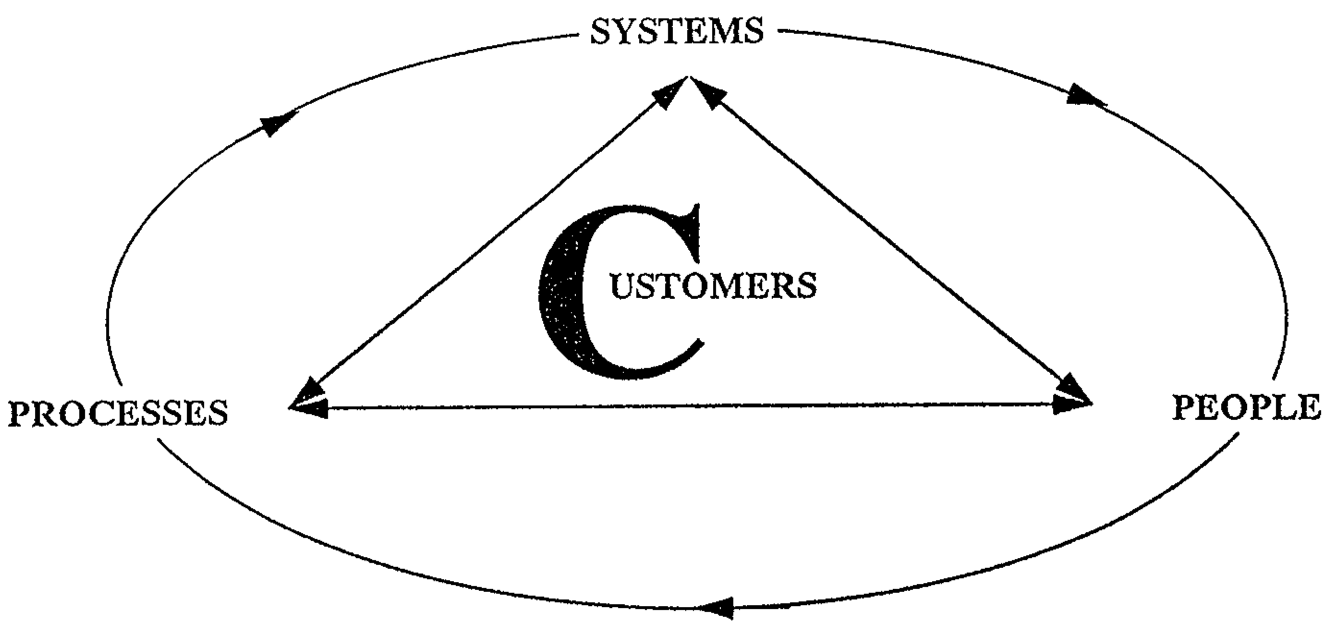
The Cost of Poor Quality

Mr.G.McDougall
NZRL

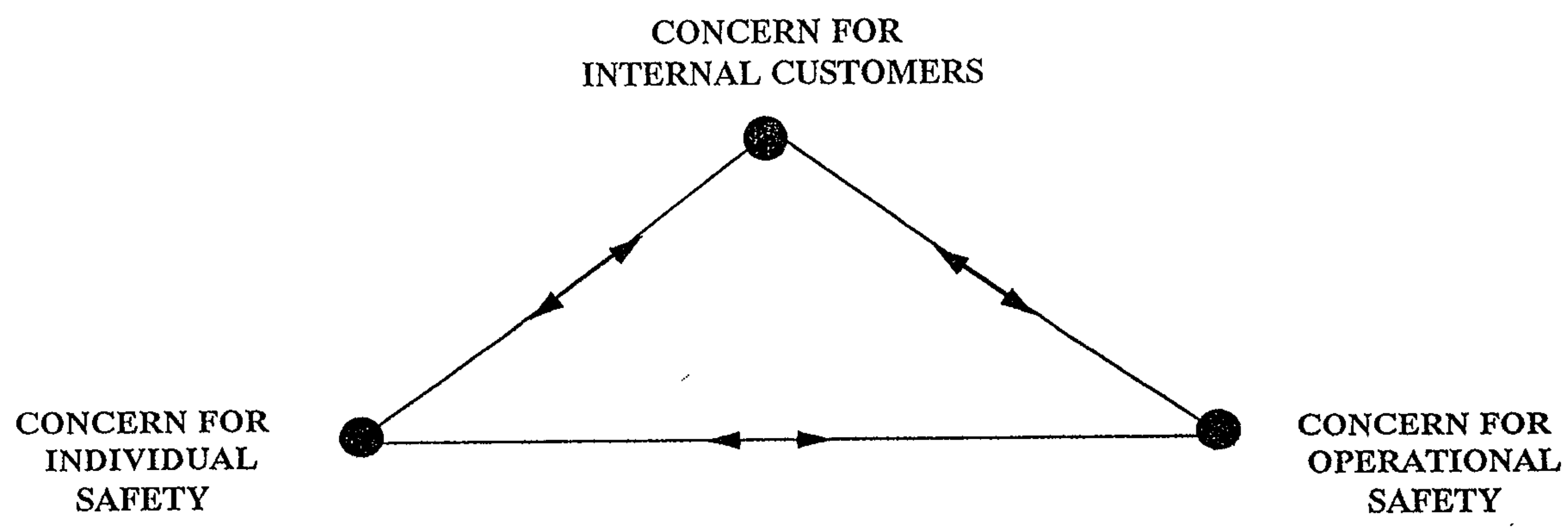
The Cost of Poor Quality

- what is 'poor quality'?
- why measure the cost?
- weighting factors
- what have we measured?
- COPQ activities
- what have we learnt

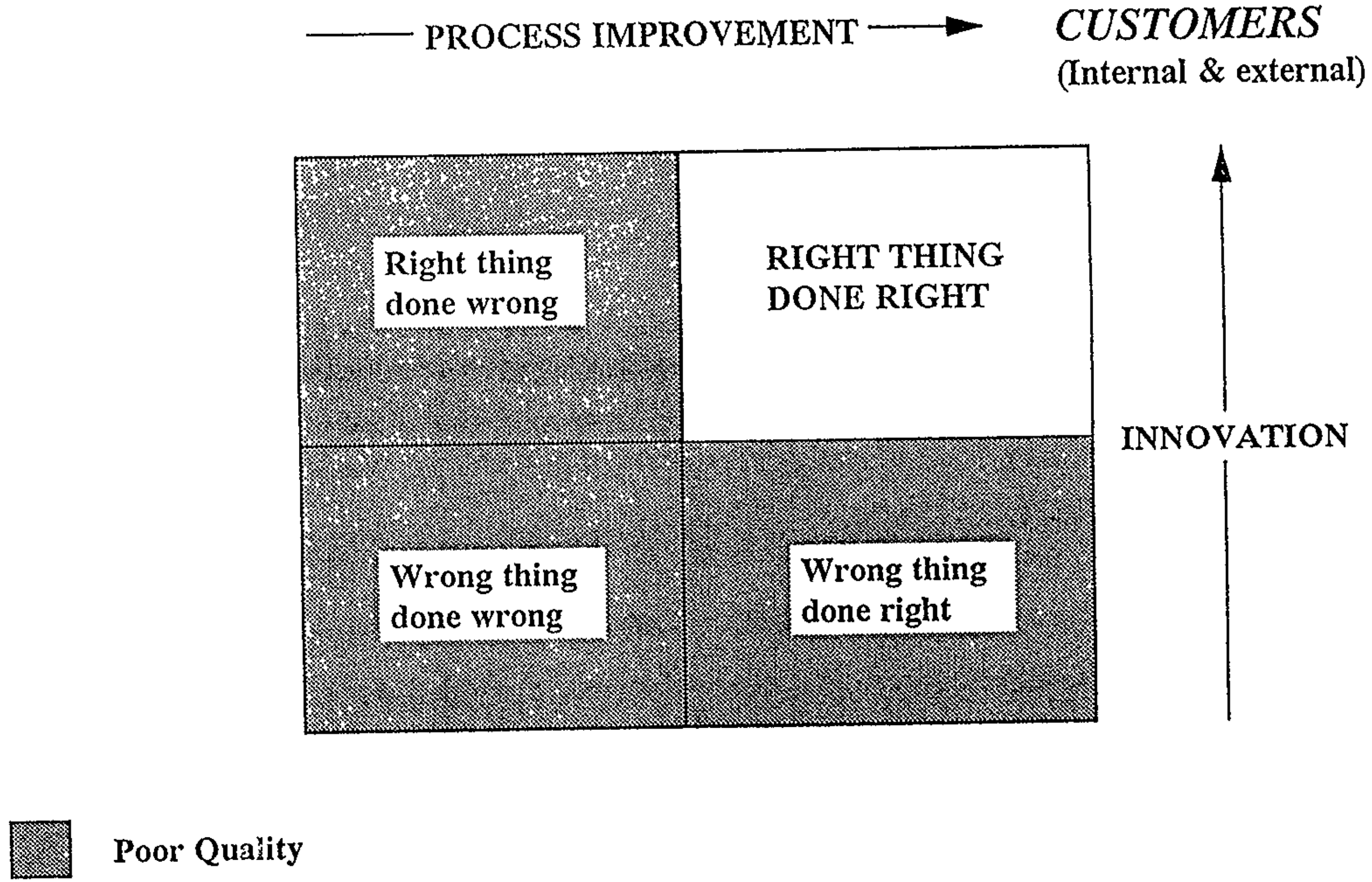
The quality improvement process



Continuous Quality Improvement ethic



What is Poor Quality?



Direct costs of Poor Quality

	British Airways Tech. Workshop manhrs.
Prevention ↓	20%
Appraisal ↓	7%
Failure	23% — DIRECT COPQ

Why we measure COPQ?

- language of management
- identify opportunity
- promote action
- a measure

Four basic questions for us?

- **how much is it?**
- **where is it?**
- **what do we do about it?**
- **how are we going to manage it?**

Weighting the costs

In analysis must consider,

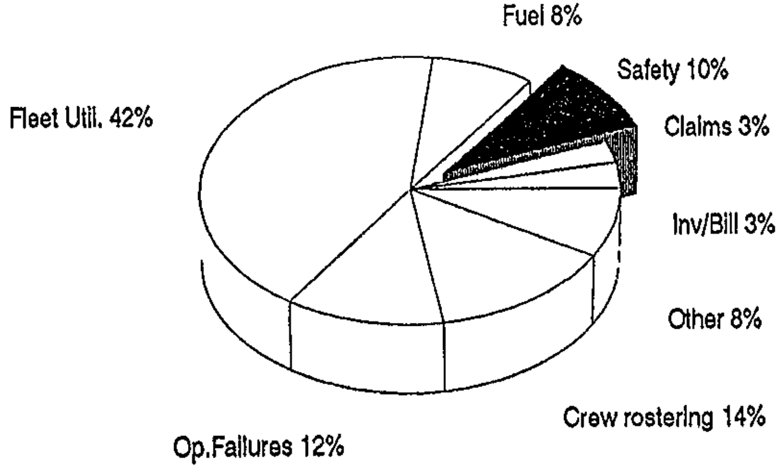
- **staff concerns**
- **customer concerns**
- **safety - risk exposure**
- **image**

Our COPQ measurements so far

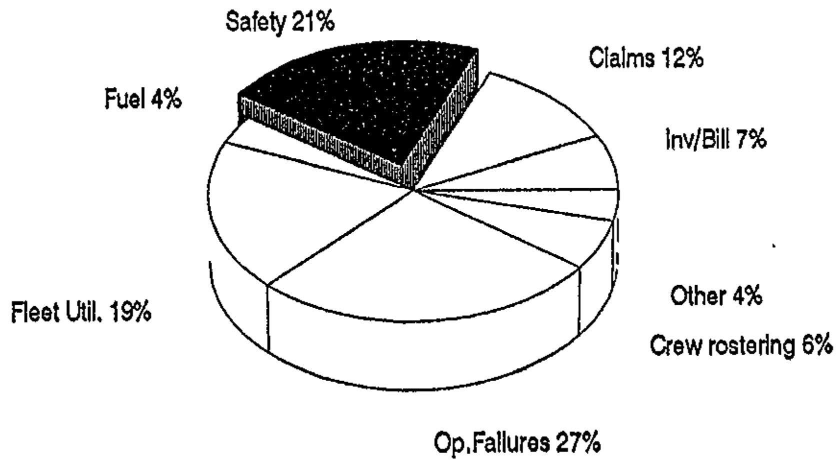
Safety (x 5)
Claims (x10)
Operational failures (x5)
Invoicing/billing (x5)
Crew Rostering
Fuel
Fleet utilisation
Other

Our Cost of Poor Quality opportunities

Actual COPQ (11% of sales)



Weighted COPQ analysis



COPQ cross-functional teams in action

- Operational failure
- Safety
- Wagon damage
- Loco & wagon utilisation
- Crew Rostering
- Fuel

What have we learnt?

- **difficult task/slow**
- **facilitator/ resources**
- **data gathering**
- **ownership**
- **constant attention**

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Paper 9213

Ron Allen

Risk Management Protection Levels at Road/Rail Crossings

Publisher
2000 International Rail Safety Conference

International Railway Safety Seminar 1992

Risk Management Protection Levels at Road/Rail Crossings

Dr.R.Allan
NZRL

RISK MANAGEMENT AT ROAD/RAIL CROSSINGS

NZ Rail System
Length 4200km

Road/rail "level crossings"

1136	Passive protection	(signs)
523	FLBs	(lights & bells)
223	HABs	(barriers)
1882		

Costs per year—
$2.3M maintenance
$0 3M capital

Collisions per year—

vehicles:	7	die
	18	injured
pedestrians.	2.6	(half fatal)

COST-BENEFIT ANALYSIS

"We can never be too safe" . *WRONG !*

"Safety at *reasonable* cost"
"Reasonable" = benefits exceed costs

To value benefits
we need a *value of life*

Not *really* valuing life . . .
valuing *risk reduction*

For NZ, "value of life" = $2M

For a typical crossing—

Annual Accident Costs

Return Period for Collisions		
20 years	30 years	40 years
$18,800	$12,500	$9,400

Compared with passive protection—
FLBs avoid 65% of accidents
HABs avoid 88% of accidents

Annual Benefits

	Return Period for Collisions		
	20 years	30 years	40 years
Passive	0	0	0
FLBs	$12,200	$8,100	$6,100
HABs	$16,500	$11,000	$8,300

EXISTING INSTALLATIONS

Annual maintenance costs

FLBs	$3,200
HABs	$5,600

Keep existing—
FLBs if *underlying* return period < 75y
HABs if *underlying* return period < 60y

Keep existing—
FLBs if *observed* return period < 200y
HABs if *observed* return period < 500y

Removing serviceable FLBs or HABs is hardly ever justified

Correct theoretical analysis shows—

Roads Most at Risk (vehicles/day)

	Train Hits Vehicle	Vehicle Hits Train
Active Protection	6000 (500 - 10 000)	3000 (500 - 5000)
Passive Protection	4000 (500+)	6000 (500 - 10 000) For *long* trains: 5000 (500 - 8000)

STATISTICAL STUDIES

Beware of
"bias by selection"
"regression to the mean"

Epidemiological studies . . .
protection is *more* effective than it seems

Before-and-after studies . . .
protection is *less* effective than it seems

"Empirical Bayes estimation" is needed.

PEDESTRIANS

Pedestrians less controllable than cars

Rational to take short cuts

Harm only themselves

Freedom to choose— "consumer sovereignty"

Responsibility to *warn* pedestrian of danger

Then up to the pedestrian to act safely

CONCLUSION

Protection methods are old and inadequate

Standardisation and reliability are the goal

Goal is *safety* . . . at reasonable cost
(and not "safety first" for the railway !)

Stop focussing on who was to *blame*

Aim to *cope* with road users' mistakes

Level crossing collisions are a *road user* issue

Traffic engineers are best to deal with it

And road users should pay for protection

RISK MANAGEMENT AT ROAD/RAIL CROSSINGS *

For NZ, "value of life" = $2M

Ronald R Allan

MSc(*Hons*) PhD(*Traffic Engineering*) FCIT FITE MRAeS MIRTNZ MIPENZ Reg Eng

McInnes Group
New Zealand

New Zealand Rail Limited operates 4200km of railway along which there are 1882 public level crossings used by road traffic. Most crossings, 1136 in all, have passive protection whilst 523 are protected by flashing lights and bells (FLBs) and a further 223 have half-arm barriers (HABs). Legislation gives rail priority over road traffic. There are also 34 pedestrian-only level crossings, 14 with passive signs, 18 with bells (some augmented by an illuminated TRAIN COMING sign) and 2 with bells and short barrier arms.

Each year level crossings cost $2.3M in maintenance and $0.3M in capital expenditure, of which half is paid by road users. Annually, approximately 7 people die and 18 people are injured in collisions between trains and road vehicles. Setting aside early 1990 as atypical, over the last decade pedestrian accidents at rail crossings have averaged 2.6 annually, half of which were fatal.

COSTS AND BENEFITS

To express the total cost of level crossing accidents in dollar terms requires a value to be placed on human life. The "value of life" about which we often hear is actually a misnomer. Suppose, for example, we expect to save 10 lives as a result of spending $10M. We can loosely think of the expenditure of *one million dollars per life saved* as the "value of life". But this does not mean we expect anyone to willingly exchange his life for $1M dollars; it is really a measure of what the population is *willing to pay for reduction in risk.* Studies of willingness-to-pay for risk reduction have establish the appropriate value of life to use in New Zealand. As a result the Minister of Transport has set the "value of life" as $2M in 1991 dollar values.

At $2M per life lost the annual cost of 7 deaths in collisions with road vehicles is $14M. Taking $50,000 as the cost of personal injury, 18 injuries add a further $1M (not to mention the cost of vehicle damage and other costs). This $15M annually is twenty-fold NZ Rail's costs of disruption, loss and damage which it estimates to be $0.75M a year. Another $5M a year is borne by pedestrians.

No one spends two dollars for an expected return of one dollar. Few would object to spending one dollar when the expected return is two dollars. Irrespective of the emotive talk "life and death" safety issues generate, this logic necessarily applies to safety expenditures. It is foolish to claim that *any* expenditure that saves a life is warranted. Funds for spending on safety are limited. That being so, these funds should spent where they achieve the greatest good.

* This paper draws mainly from two reports by McGregor & Company (now McInnes Group):
Traffic Protection at Rail Level Crossings, April 1990, and
Pedestrian Protection at Rail Level Crossings, September 1990.
The content of these reports has been updated to reflect an April 1991 directive by the Minister of Transport that economic evaluations of transport should reflect a value of life of $2 million.

ROAD TRAFFIC PROTECTION AT LEVEL CROSSINGS

For the good of the nation it is essential that *all* costs and benefits, including those of the wider public, be tallied when choosing level crossing protection. To show how cost-benefit analysis can be applied to level crossings, the following illustrates the costs and benefits of different types of protection.

	Fatal Accidents	Serious Injury Accidents	Minor Injury Accidents	Property Damage Only
Public Cost	2,242,500	78,000	16,500	$6,000
NZ Rail Cost	39,000	15,500	2,700	2,700
Total Cost	**$2,281,500**	**$93,500**	**$19,200**	**$8,700**

Suppose the relative frequency of the four types of accident are as below. The cost of the average accident is calculated to be $376,000.

15%	*25%*	*50%*	*10%*

Average accident cost:
$376,000

This collision cost can be annualised, given the expected accident frequency for a given level crossing [2]:

	Return Period of Collisions			
	20 years	30 years	40 years	50 years
Average Annual Accident Cost	$18,800	$12,500	$9,400	$7,500

We can now compare the relative benefits of the three types of protection. Taking the St Andrew's Cross (crossbucks) as a base case, American research concluded that:

(a) FLBs can be expected to avert 65% of the accidents that would occur with the St Andrew's Cross alone; and

(b) HABs can be expected to avert 88% of the accidents that would occur with the St Andrew's Cross alone.

The annual benefits of installing FLBs or HABs are then as follows.

	Return Period of Collisions			
	20 years	30 years	40 years	50 years
St Andrew's Cross	0	0	0	
FLBs	$12,200	$8,100	$6,100	$4,900
HABs	$16,500	$11,000	$8,300	$6,600

These figures give a broad guide as to the worth of FLBs and HABs. Where these safety benefits exceed the costs of active devices, their installation and/or continuance is warranted on cost-benefit grounds.

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2 "Return period" terminology is used, a five-year return period meaning that a collision occurs on average every 5 years.

Annual maintenance costs are typically $3,200 for FLBs, $5,600 for HABs and virtually nothing for St Andrews Crosses. Retention of active protection is therefore justified by the benefits if the return period is less than 75 years for FLBs or 60 years for HABs. These return periods are the *underlying* return periods, *ie* assuming passive protection. *Observed* return periods reflect the benefits of active protection. Given FLBs eliminate 65% of collisions, observed collisions are 35% of underlying rate. For HABs, observed collisions are 12% of underlying rate. In terms of *observed* collision rates, FLBs ought not to be removed unless collisions at the protected crossing will be less frequent than one every 200 years for FLBs and 500 years for HABs. As we cannot predict such rare events, *removing serviceable FLBs or HABs is hardly ever justified.* [3]

Installing new FLBs costs $45,000 and HABs $80,000, equivalent to $5,000 pa and $8,800 pa if amortised over 25 years at 10% pa (a "real" rate, *ie* 10% more than inflation). Summing the capital and maintenance costs, *new installations cost $8,200 pa for FLBs and $14,400 pa for HABs.* Comparison of costs and benefits shows installation of new FLBs to be warranted if the return period is less than 30 years.

If we find FLBs and HABs are *both* economic, *which* should be installed? To prefer HABs over FLBs we must justify the extra cost. Considering a return period of 20 years, the extra cost of HABs is $6,200 pa (14,400 - 8,200) which exceeds the extra benefits of $4,300 pa (16,500 - 12,200). Only if the return period is less than 15 years is the added cost of HABs over FLBs justified by the added benefits.

Based on the average figures used above, new installations of HABs are warranted if the *underlying* return period is less than 15 years. FLBs are warranted for underlying return periods between 15 and 30 years. A decision whether to upgrade FLBs to HABs would depend on the salvage value attaching to the FLBs removed.

These cost-benefit calculations, using illustrative figures, point to some likely conclusions regarding conventional means of level crossing protection.

- By far the greater part of the cost of level crossing accidents is incurred by the general public.
- Removal of existing active protection, in serviceable condition, cannot be justified on cost-benefit grounds.
- New installations of FLBs appear justified at level crossings with collision return periods of up to 30 years.
- If the return period is less than 15 years, the added cost of HABs over FLBs is warranted by the added safety benefit.

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3 This assumes trains continue to operate as they do now. If trains were to yield right of way to road traffic, which is not unreasonable on short spur lines used only for shunts, removal of active protection could be justified.

PEDESTRIAN PROTECTION

Pedestrians are relatively unfettered by traffic rules and regulations. This may reflect enforcement difficulties. More likely it is because walking menaces no one—whereas vehicles can inflict harm on innocent parties. Controls on pedestrians raise issues of personal freedom not aroused by controls on motor vehicles.

Pedestrians at times fail to make *any* conscious decision whether to cross or wait for an oncoming train. Pedestrians hit by trains may have been distracted, preoccupied, or otherwise unaware of the approaching train. To "see" an approaching train the pedestrian must turn his eyes in the direction of the train. The infrequency of trains on many tracks means that visual scanning for approaching trains is not as automatic as looking for cars before crossing a busy street. Auditory senses may not alert people to oncoming trains because the sound of an approaching train can be masked by background noise such as wind, road traffic, wearing portable head sets, *etc*, and the train may have throttled back and not be under power.

It is a human trait to take short cuts, even where overbridges and underpasses offer total protection to pedestrians. People take such short cuts frequently, and *almost* invariably safely. It is rational behaviour. The individual weighs his extremely small chance of mishap against the benefit of a shorter journey.

Pedestrian accidents at level crossings can be grouped with mishaps to people who participate in risky leisure pursuits: hang gliding, climbing, rugby, *etc*. Society allows individuals the freedom to choose whether to pursue risky pastimes; each individual is free to determine whether the personal benefit he derives from participating is worth the high cost of a mishap in the *unlikely* event that a mishap occurs. This is a straight-forward example of "consumer sovereignty". In everyday life no self-appointed, well-intentioned higher authority tells individuals how to live their lives or spend their money; consumers decide for themselves. Government protection of the consumer is confined to consumer legislation addressing individuals' access to the *information* needed to make informed decisions.

Pedestrians do recognise railway tracks for what they are. The pedestrian always has sufficient visibility up and down the track to determine whether a train is approaching. A pedestrian has available all the information required to decide whether to proceed or wait for an oncoming train to pass. Under the principle of consumer sovereignty, the pedestrian should be free to decide whether to proceed without waiting, or to exercise caution and suffer the attendant delay [4].

Even *without* warning devices pedestrians generally have timely and sufficient information to make informed judgements. *With* controls and warning devices (installed wherever the benefits exceed the costs) pedestrians have at their disposal all the extra assistance society can justifiably provide. If pedestrians ignore the warnings, the costs and benefits of so doing are theirs and theirs alone. *There is nothing more society should do for them.*

At railway level crossings the most elementary protection afforded pedestrians is a simple sign. The most basic form of "active" protection is an audible or visual prompt triggered by an approaching train. Further up the scale are physical barriers

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[4] In the case of a double track, the pedestrian has little chance of discerning *which* track the train is on and may well be faced with a "dilemma zone" where he has difficulty in deciding what to do. Where there are multiple tracks it is easier to justify the cost of special measures to protect pedestrians.

activated by the approach of a train. At the top of the scale is "grade separation", *ie* pedestrian overbridges and underpasses.

Pedestrian "cribs" are provided at some suburban railway stations. They are obstacle courses aimed at providing pedestrians with better views of oncoming trains. Pedestrians walking through a crib turn through 90° to face one direction of train approach then, because the crib changes direction by 180°, turn to face the other direction of train approach. The principle is sound: make the pedestrian face each direction of approach before stepping onto the track. Unfortunately, making pedestrians *face* each direction does not ensure they *look* in each direction.

To be confident a crib will be effective it must give the pedestrian plenty of time facing each direction of train approach, substantially lengthening the pedestrian's travel path. Given the size and design of cribs installed to date it would be surprising if they proved to be remarkably effective at achieving their stated purpose, *viz* getting people to look and *register* that a train is approaching. If cribs are effective it may also be due to the way they discipline pedestrian movement.

An important difference between pedestrians and motorists is that motor vehicles travel in "indian file" whereas pedestrians act independently of one another. As soon as one motor vehicle stops it forms a barrier to following vehicles. This is not the case with pedestrians unless: *(1)* they are funneled through a narrow gap before stepping out to cross the track and *(2)* they are sufficiently numerous to interact with one another. Pedestrian cribs fit this specification. If cribs have indeed caused statistically significant improvements in pedestrian accident patterns, the improvement might be due as much to the indian file effect as to the visibility effect.

Another benefit of the indian file discipline is that it reduces the danger posed by the "sheep effect". Sheep generally stay together in a mob but if one splits off others are bound to follow. The parallel with pedestrians arises because, responding to visual cues, people are inclined to think that if a person nearby steps onto the track then it is safe for them to do so too. This is not necessarily the case but, even if it is, it may set up a chain reaction that entices other people to continue to cross the track until the point is reached when someone steps out without time to reach the other side in safety. The sheep effect is most likely to be manifest when a number of people alight from a train; the larger the crowd the more likely it is that someone will set out across the track.

Active protection has a greater potential than passive protection for alerting pedestrians to imminent danger. Audible alarms (FLBs) are installed at many level crossings used by road vehicles, yet pedestrians still have accidents there. Perhaps it is connected with the short time for a pedestrian to cross the track compared with the duration of advance warning given by the bells. For pedestrians the bells may also have the perverse effect of increasing the hazard by masking the sound of the oncoming train. Furthermore, to the pedestrian, audible alarms are fundamentally contradictory: do they mean YES or NO? At signalised road intersections, buzzers signify it is *safe* to cross. At railway crossings, bells signify it is *unsafe*.

Pedestrians are demonstrably less controllable than motor vehicles. They walk around and under barriers, as do cyclists. The principle of consumer sovereignty establishes that pedestrians ought to be allowed this discretion of action at level crossings since, generally, they harm only themselves if they make an error of judgement. To the extent justified by cost-benefit analysis it is incumbent upon society to reduce the risk of misjudgment. Obviously the cost-benefit balance is dependent upon train frequency and the numbers of pedestrians using the crossing.

BEWARE! DEFICIENCIES!

Apart from St Andrew's Crosses, FLBs and HABs, almost no other form of level crossing protection is seriously considered in New Zealand, or elsewhere. The basic problem facing railways world wide is "resistance to change". There is a reluctance to consider new ways of doing things. There is an aversion to new technology which, simply because it is new, is automatically regarded as having uncertain reliability. New Zealand is not alone in this regard; it exists world wide. There is no doubt that safety is the prime criterion, but it is *safety from criticism* when something malfunctions rather than safety in the sense of *accident avoidance*.

When accidents happen the railwayman claims absolution from responsibility whenever the driver or pedestrian can be shown to be somehow at fault. This fault doctrine is negative, sterile and irresponsible. It is akin to revenge. Road users should demand that all economically justifiable measures be taken to avoid accidents— irrespective of fault.

Important traffic engineering principles are being overlooked. Insufficient recognition is being given to "Human Factors". There is poor driver compliance with the duty to determine whether or not the way is clear. One study concluded that "head movements of motorists looking down the tracks were virtually nonexistent [and] brake lights were applied on the approach to the rail crossing by only 7.6% of the vehicles". This is understandable since the use of passive signs at level crossings results in *negative reinforcement*. The St Andrew's cross bearing the words RAILWAY CROSSING is a repeated reminder to motorists that railway crossings "never" have trains on them. The St Andrew's cross is as much use as a BEWARE OF THE SHARKS sign on a New Zealand beach. The signs do have a purpose, however; they permit those who erected them to wash their hands of responsibility when accidents happen!

At passively controlled crossings the key determinant of risk is whether the motorist can see an approaching train soon enough to stop. As a motorist approaches a level crossing there is a "search time" during which he scans his surroundings to see if there *is* a recognisable danger. We should allow 3 seconds perception-reaction time before braking begins. At a speed of 100 km/h a motorist must be able to see an approaching train 12.7 seconds before he reaches the crossing; if he does not, his only option is to try and make it to the crossing *before* the train does! This means a driver travelling at the open road speed limit when still 212 metres from the crossing must be able to see any train that is within 12.7 seconds of reaching the crossing.

NZ Rail's current policy on visibility at level crossings bears no resemblance to this standard of visibility. The criteria are based on how far down the railway track a motorist can see from points 5 metres and 30 metres back from the centre line of the track. The distances specified can be interpreted thus:

> when the fastest train is 8 seconds away from the crossing it must be visible to motorists 5 metres from the track; and, when the train is 5 seconds from reaching the crossing it should be visible to motorists 30 metres from the track.

The only way in which NZ Rail's visibility standards could have any relevance would be to compel vehicles to cross the tracks at slower speeds. There was once a lower speed limit for vehicles approaching level crossings, but arbitrary speed limits that cannot be effectively enforced are not respected by a public that does not accept their need, given the infrequency of trains [5].

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[5] Use of the advisory speed sign might be more promising than a blanket speed limit at passively protected level crossings. Motorists are then given notice of the safe speed for each individual

WHO SHOULD DECIDE THE TYPE OF PROTECTION

Authority for installation of active and passive warning devices is conferred on the road controlling authority by the Traffic Regulations 1976. Authority for installing active devices is also vested in NZ Rail by the New Zealand Railways Corporation Act 1981, but the same Act absolves NZ Rail of any *liability* for not erecting and maintaining warning devices. By implication, there is no duty imposed on NZ Rail to do so— the Act takes a *laissez faire* approach, relying on NZ Rail's self interest to see that warning devices are adequate.

Currently, standards applied by NZ Rail are based on engineering judgment of latent accident risk. The level of protection a level crossing receives depends on its "Product Number". The Product Number encapsulates in a single number a crossing characteristics and traffic use to produce a measure of relative risk. Apart from this approach being scientificaly flawed— the next section explains why— the Product Number is only a means of *ranking* level crossings. NZ Rail's standards do not determine whether we are currently spending too much or too little on safety.

The government cannot avoid final responsibility for the welfare of the general public at level crossings. When it was a government department under ministerial direction, the railways could have been entrusted with this responsibility by delegation. As a government-owned company, expected to be privatised, this is no longer tenable.

It is illogical that NZ Rail should have power over the welfare of road users who collectively may prefer a different level of protection than that chosen by NZ Rail on their behalf. Given full knowledge of the relevant facts, road users may be prepared to pay extra for the advantage a higher level of protection than they are currently getting. On the other hand, road users may prefer to divert part of the expenditure on level crossing protection to safety measures yielding higher benefits per dollar spent (*eg* motorway median barriers, perhaps).

The people best placed to decide on level crossing protection are those who best understand the causes of level crossing accidents and the effectiveness of counter-measures. Were it not for transgressions and oversights by motorists and pedestrians, the majority of level crossing accidents would not happen. Since the consequences of accidents weigh most heavily on road users and pedestrians, should NZ Rail be particularly concerned about level crossing accidents? NZ Rail is not in a position to *do* much about level crossing accidents, especially those resulting from road users ignoring the rules. Many of the available remedies (*eg* road works and pavement markings on approaches to level crossings, driver education, *etc*) fall outside NZ Rail's jurisdiction.

Essentially the problem is a *traffic* one. Analysis of the causes of level crossing accidents lies within the province of traffic engineering, as do all the potential solutions. Even the existing measures, flashing lights and barriers, come within the expertise of traffic engineering. (And it has been demonstrated by overseas trials at level crossings that conventional traffic signals are more respected by drivers than the railwayman's flashing lights.) The Ministry of Transport's Land Transport Division should therefore be the agency responsible for standards of safety at level crossings. This is where the nation's major traffic engineering and road safety resources lie. NZ Rail does not profess to have this expertise, nor should it.[6]

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crossing and they ignore the warning at their peril. The advisory speed sign could be posted beneath the St Andrew's Cross.

6 NZ Rail can still contribute by supplying data and railway expertise to the evaluation process.

ASSESSING RISK LEVELS

The most detailed exploration of the Product Number approach was a statistical analysis of level crossing accidents published in 1982 by the United States Department of Transportation. Accident data were used to fit the following multiplicative relationship:

$$\text{Collisions per year} = k\, EI\, MT\, DT\, HP\, MS\, HT\, HL$$

where the factors in the expression are defined as:

k =	constant	HP =	Highway Paved
EI =	Exposure Index	MS =	Maximum Speed
MT =	Main Tracks Factor	HT =	Highway Type
DT =	Day Through-trains	HL =	Highway Lanes.

The three types of protection (St Andrews Cross, FLBs and HABs) were estimated separately and the results were as follows.

	St Andrew's Cross	FLBs	HABs
k constant	0.002268	0.003646	0.001088
EI Exposure Index	$(1+5c_\times t)^{0.3334}$	$(1+5c_\times t)^{0.2953}$	$(1+5c_\times t)^{0.3116}$
MT Main Tracks Factor	$\exp[\,0.2094\, mt\,]$	$\exp[\,0.1088\, mt\,]$	$\exp[\,0.2912\, mt\,]$
DT Day Through-trains	$(1+5d)^{0.1336}$	$(1+5d)^{0.0470}$	1
HP Highway Paved	$\exp[\,-0.6160\,(hp-1)\,]$	1	1
MS Maximum Speed	$\exp[\,0.0077\, ms\,]$	1	1
HT Highway Type	$\exp[\,-0.1000\,(ht-1)\,]$	1	1
HL Highway Lanes	1	$\exp[\,0.1380\,(hl-1)\,]$	$\exp[\,0.1036\,(hl-1)\,]$

where

- c = annual average daily traffic (total both directions)
- t = average daily total train movements
- mt = number of main tracks
- d = average daily through-trains in daylight
- hp = highway paved? yes = 1 no = 2
- ms = maximum timetabled speed (miles/hour)
- hl = number of highway lanes
- ht = highway type factor defined as follows:

Rural		*Urban*	
Interstate	1	Interstate	1
Other Principal Arterial	2	Other Freeway/Expressway	2
Minor Arterial	3	Other Principal Arterial	3
Major Collector	4	Minor Arterial	4
Minor Collector	5	Collector	5
Local	6	Local	6

A statistical analyses is only as good as the model used— in this case the Product Number and its exponential relationships. The above research falls down by assuming the exposure index, *EI*, to be a power relationship involving traffic volume. It fails to recognise that once a vehicle has stopped at a level crossing to let a train go by, this stationary vehicle acts as a safety barrier to vehicles behind it. Busy roads can therefore be safer than less-busy roads! From the correct theoretical analysis the following broad conclusions can be drawn.

- ***Active Protection***

  Roads carrying traffic flows in the range 500 to 10 000 vehicles a day are the most susceptible to *train-hits-vehicle* collisions, with the 6 000 vehicles a day being about the worst possible flow rate.

  For *vehicle-hits-train*, better accident records should be expected of two lane roads carrying 500 to 5 000 vehicles day, with the best performance arising at flow rates of about 3 000 vehicles a day.

- ***Passive Protection***

  For *train-hits-vehicle*, 4 000 vehicles a day is representative of a "worst case" but any road with more than 500 vehicles a day has a relatively high hazard factor.

  For *vehicle-hits-train*, higher accident frequencies are to be expected from roads carrying 500 to 10 000 vehicles day with a "worst case" around 6 000 vehicles a day. (On rail lines with predominantly long trains, the range contracts to 500 to 8 000 with a worst case of 5 000 vehicles a day.)

Scientific assessments of level crossing risk are of two generic types, epidemiological studies (such as above) and before-and-after studies.

- ***Epidemiological studies*** of accidents are like studies of diseases (epidemics). Now *passively* controlled crossings have a set of epidemiological characteristics different from crossings with *active* protection. If the level crossings receiving active protection were randomly sampled (*eg* drawn out of a hat) from the entire population of crossings, observed differences in accident patterns could be attributed to differences between active and passive protection.

  Crossings having active and passive protection are far from randomly chosen. There is "bias by selection". Since they are used at the most risky sites, FLBs and HABs appear less effective than they really are. Thus, epidemiological studies tend to underestimate the effectiveness of the protection provided.

- ***Before-and-after studies*** display the reverse effect. They tend to overestimate the effects of the upgrading of protection that took place between the "before" and "after" periods. Again the reason is a bias introduced by the selection process. In before-and-after studies, "regression to the mean" [7] makes the bias work in the opposite direction- the upgrading appears better than it really is. [8]

  Upgrading is regarded as effective if the "before" and "after" difference is large enough. "Empirical Bayes estimation" is used to judge whether the difference is "large enough".

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7 To illustrate, suppose 100 identical dice are thrown twice. Three dice throwing "6" both times are deemed "faulty" and given "remedial treatment"— a good polishing. After polishing they are again thrown twice. There are no double sixes. It is concluded that polishing cures dice of double sixes. The conclusion is obviously absurd, yet the same spurious deduction is often made in before-and-after accident studies.

8 Suppose some crossings with bad accident records are upgraded from FLBs to HABs. Even if the addition of barrier arms is totally ineffective, regression to the mean would make the barrier arms *appear* to be effective (in terms of the "after" observations). There is a danger is that someone will conclude that upgrading *had* been effective.

CONCLUSIONS

Current methods of protection are deficient. Methods of protection are old and inadequate, having remained unchanged during a post-war period that has witnessed extraordinary advances in technology. One explanation is that standardisation and reliability have become the goal rather than servants of the goal, the goal being safety. Comfortable acceptance of old technology fails to be shaken by practices in other advanced countries because they too have stood still, leaving the impression that world wide the motto is "safety first": not the safety of users of level crossings, rather the safety that gave rise to the saying "no one got fired for buying IBM".

Adherence to the fault doctrine is a major impediment to progress. Admittedly, errors by road users are a major contributor to level crossing accidents. But it is negative and wrong to rename "errors" as "faults", then use "fault" as an absolution for paying too little attention to accident prevention. Every accident is a cost to society irrespective of whether someone was at fault. Every means possible should be used to reduce road user errors— provided the benefits exceed the costs.

The railwayman's perspective is, properly, that of a rail operator. Because this is where he exercises his dominion, active protection devices are placed within the rail right of way, irrespective of whether this location is best for safety. Since collisions at level crossings are commonly caused by transgressions or failures of motorists or pedestrians, the appropriate location for installation of warning devices or carrying out remedial work is probably the road reserve, not the rail reserve.

Understandably, the railwayman's efforts at accident prevention fail to draw upon the "Human Factors" branch of traffic engineering, which lies outside his training. Counter measures derived from Human Factors often spring from new understandings, rather than new technology. The railwayman of course has his role to play in the conception of the various potential remedies; but he cannot be expected to think of all the options.

Deciding level crossing protection should be a matter for the Land Transport Division of the Ministry of Transport. Express instructions should be given that decisions are to be made on the criterion of whether the benefits outweigh the costs. Funding should be provided by agencies representing road users, as this promotes economically efficient trade-offs between rival safety expenditures. In the occasional instance when an expenditures is solely to protect pedestrians, this should be in the hands of the local body concerned.

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Safety and Quality Development in LUL

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Human factors investigation of LUL staff accidents

Prepared for J. Rose, Safety and Quality Directorate,
London Underground Ltd.

by
Human Reliability Associates Ltd. 1992

Human factors investigation of LUL staff accidents
Background (1)

- Rising trend of staff accidents in LUL
- Increase could be due to improved reporting procedures
- Increase could also reflect genuine increase in incident frequency
- Investigation into the underlying causes of incidents should identify management actions to reduce accident frequency
- HRA investigated set of incident investigation reports (IIRs) for variety of accidents, dangerous occurrences and near misses
- Study also identified strengths and weaknesses in current reporting and investigation procedures for incidents.

Human factors investigation of LUL staff accidents
Background (2)

- Accident analysis adopts a systemic and hierarchical perspective on causes of accidents. Assumes that accident can stem from actions of omissions of the individual, from the decisions and practices of their immediate line manager and from the policies of senior management.

- Wide range of incident types studied:
  Fatalities
  Major and minor injuries
  Lost and non-lost time injuries
  Dangerous occurrences

- Types of personal injuries include:
  struck by
  trips
  falls
  electrocution
  assaults

- Number of "near misses" studied. Assumed that these would have same underlying causes as accidents but occur more frequently. May also reveal possible defences.

Human factors investigation of LUL staff accidents
Aims

- To investigate a subset of IIRs to establish human factors causes of staff accidents and to develop, where feasible, generic models of causes of different types of accidents
- To produce a commentary on LUL's incident reporting system and accident investigation procedure
- To provide recommendations for management to improve the procedure and system for incident investigation
- To provide human factors input into fault & event trees etc.

Investigation of LUL staff accidents
Methodology

- 50 IIRs were analysed in detail
- Analysis consisted of:
  Construction of descriptive time/agent time line (based on STEP procedure) & identification of critical events. Causal analysis using classification tailored for LUL.
- 10% of IIRs analysed independently to ensure reliability
- Validity of information in 11 (22%) of IIRs checked by interviews with LUL manager who carried out original investigation
- Differences between LUL and HRA causal analysis established through comparison of identified causes in 10 incidents (all relating to "struck by" object)

Investigation of LUL staff accidents
Causal classification (1)

- Causal classification grouped as follows:-

- INDIVIDUAL FACTORS
  Procedures - failure to follow procedure (PF)
  - inadequate knowledge of procedure (PIK)
  - lack of training in use of procedure (PT)
  - lack of procedures (PL)
  - failure to use PPE (P.PPE)

  Training - lack of training (TL)
  - lack of refresher training (T.REF)

  Lack of experience (LE)
  Lack of knowledge (LK)
  Operator error - omission (OEO)
  - misjudge (OEM)

  Lack of attention (LA)
  Sabotage (SAB)
  Communications - communications failure (CF)
  - lack of communications (CL)

- WORK GROUP FACTORS
- Authority and leadership (AL)
  Planning and co-ordination (PC)
  Training (TNG)
  Clarity of responsibilities (CR)
  Communications failure (CF)

- TECHNICAL FACTORS
  Equipment fault (EF)
  Maintenance fault (MF)
  Design fault (DF)

Investigation of LUL staff accidents
Causal classification (2)

- PHYSICAL FACTORS
  Lack of clearance or space (LC)
  Uneven surface (US)
  Availability of PPE (A.PPE)
  Noise (N)
  Poor lighting (PL)
  Lack of guarding devices (GD)

- SUPERVISORY FACTORS
  Inadequate supervision (I)
  Control of systems of work (CSW)
  Identification of hazards (IH)
  Planning and scheduling of work (PSW)

- MANAGEMENT SYSTEMS FACTORS
  Auditing and monitoring (AM)
  Quality systems (QS)
  Safety management systems (SMS)
  Commuications and feedback (CF)
  Learning from past mistakes (LPM)
  Control of contractors (CC)
  Clarification of roles and responsibilities (RR)

- ORGANISATIONAL FACTORS
  Health and safety policy (HSP)
  Health and safety culture (HSC)
  Communications failure (CF)
  Training failure (TF)

Investigation of LUL staff accidents
Data limitations

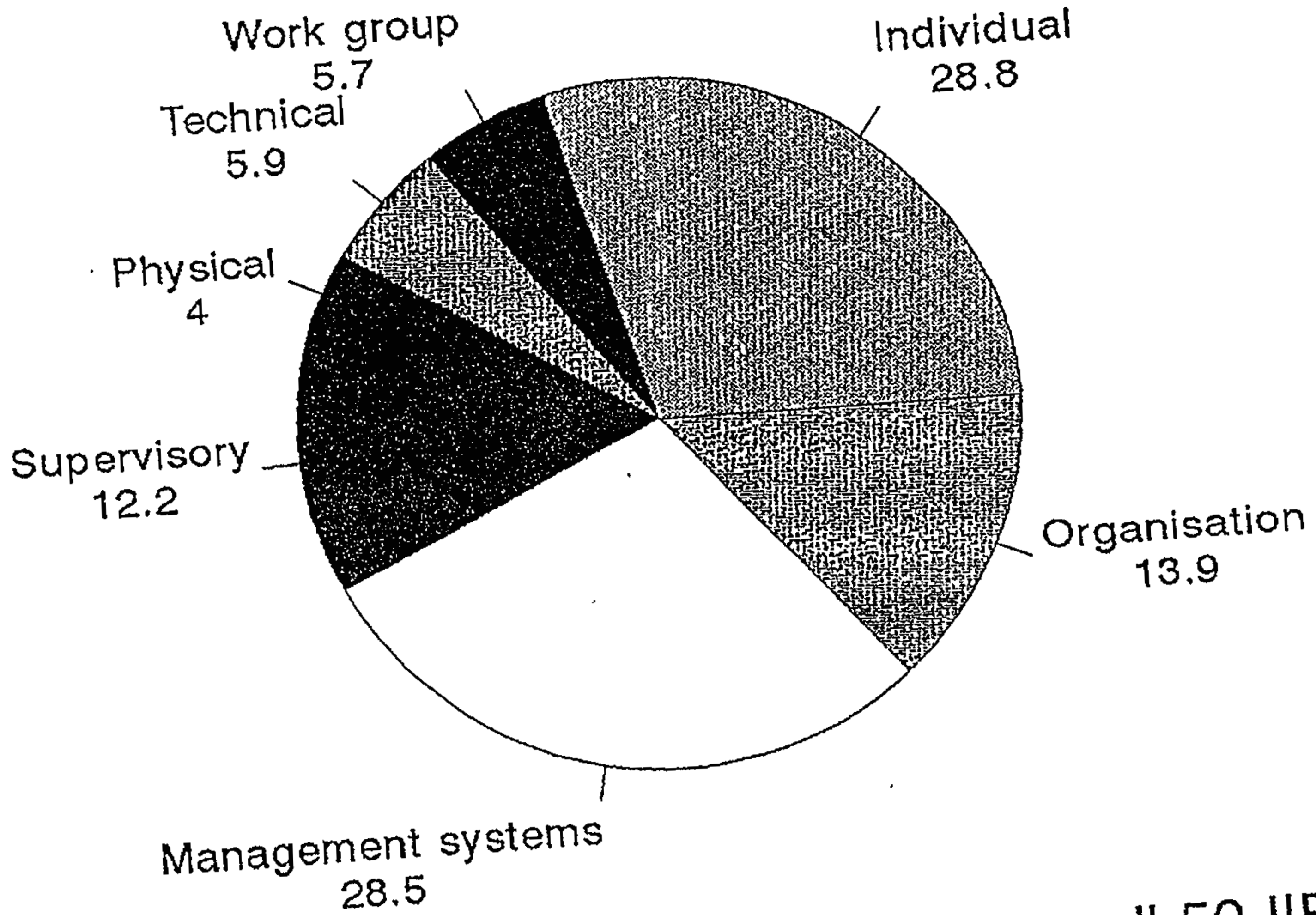
- Review of data in IIRs and interviews with LUL personnel who had carried out at least one investigation found:-

- Lack of training in investigation and report preparation
- Poor control process for actions arising from reports
- Lack of interest in carrying out IIRs
- Decision whether to carry out IIR not auditable
- No clear descriptive tool for incidents
- Overemphasis in reports on individual factors as causes and failure to look to managerial influences
- Strong bias to produce recommendations based on discipline, reinforcement of rules

Investigatic) of LUL staff accide' ts
Main results of IIR analysis

- In depth analysis of 50 IIRs identified an average of 3 critical events per incident (150 critical events for 50 IIRs)
- An average of 9.48 causal factors were identified for each IIR
- An average of 3 causal factors were identified for each critical event
- Linkages between different groups of causal factors were sought for incident types if 4 or more incidents of any type were analysed (e.g. falls, struck by)

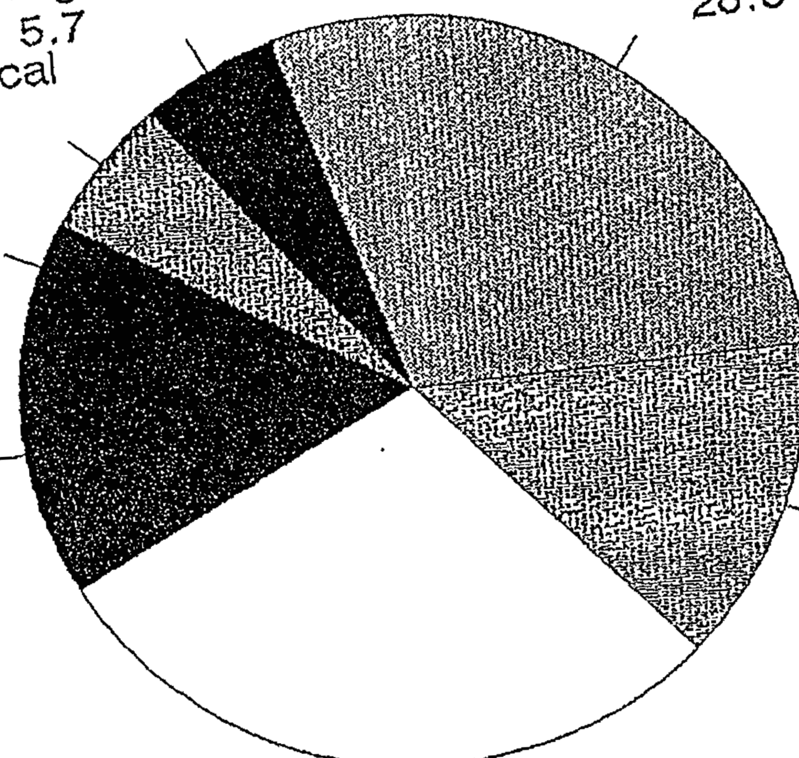
Results of investigation of LUL staff accidents
Frequency of causal categories



Distribution of causal categories across all 50 IIRs

HRA Ltd. 20/10/92 acc8

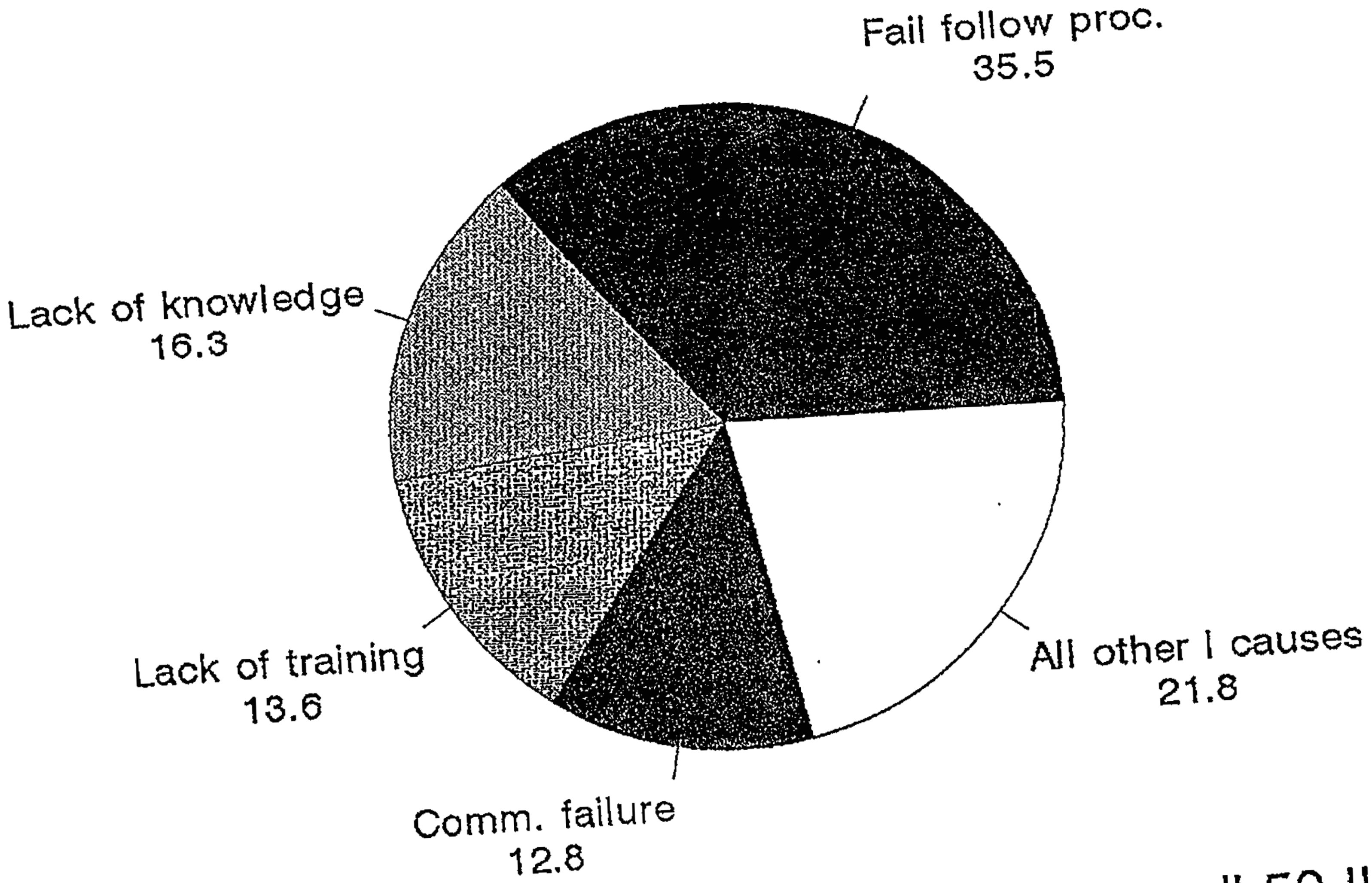
Results of investigation of LUL staff accidents
Frequency of causal categories



Distribution of causal categories across all 50 IIRs

HRA Ltd. 20/10/92 acc8

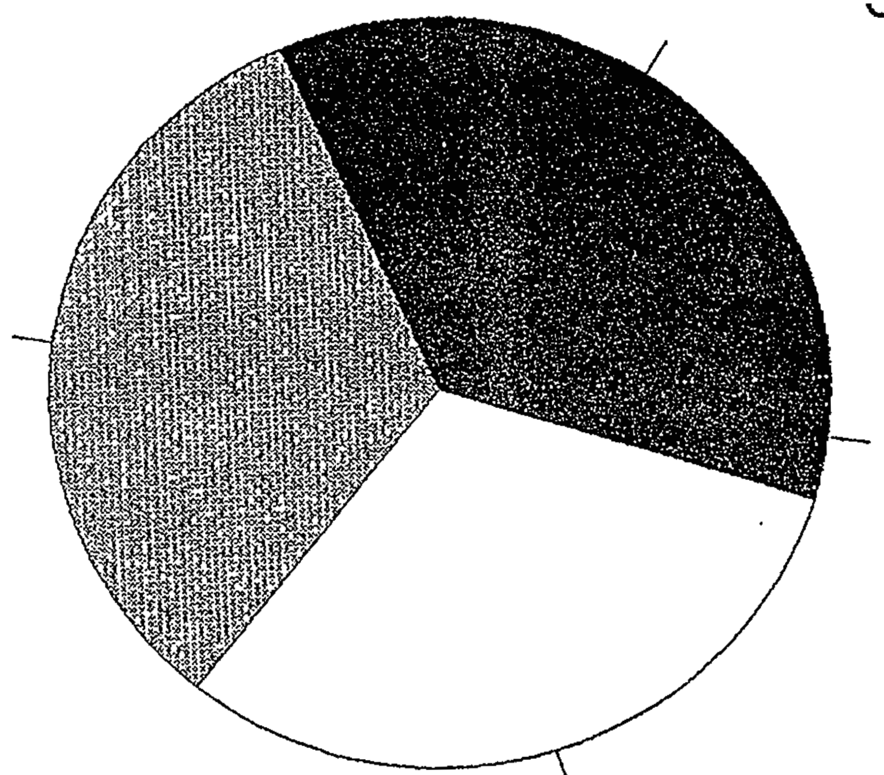
Results of investigation of LUL staff accidents
Breakdown of individual causes identified



Frequency of main individual causes across all 50 IIRs

HRA Ltd. 20/10/92 acc9

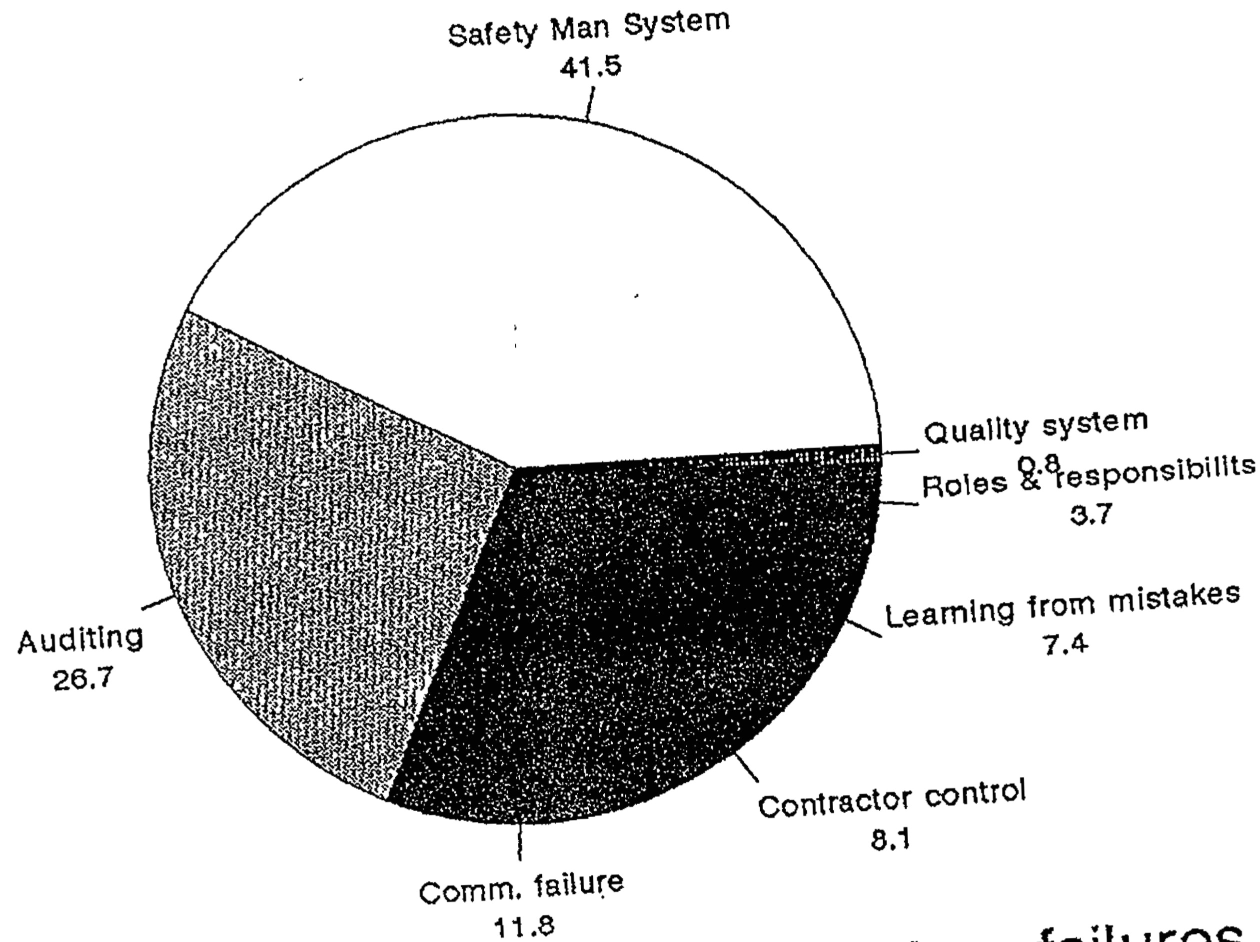
Results of investigation of LUL staff accidents
Breakdown of supervisory causes



Frequency of supervisory causes across all 50 IIRs

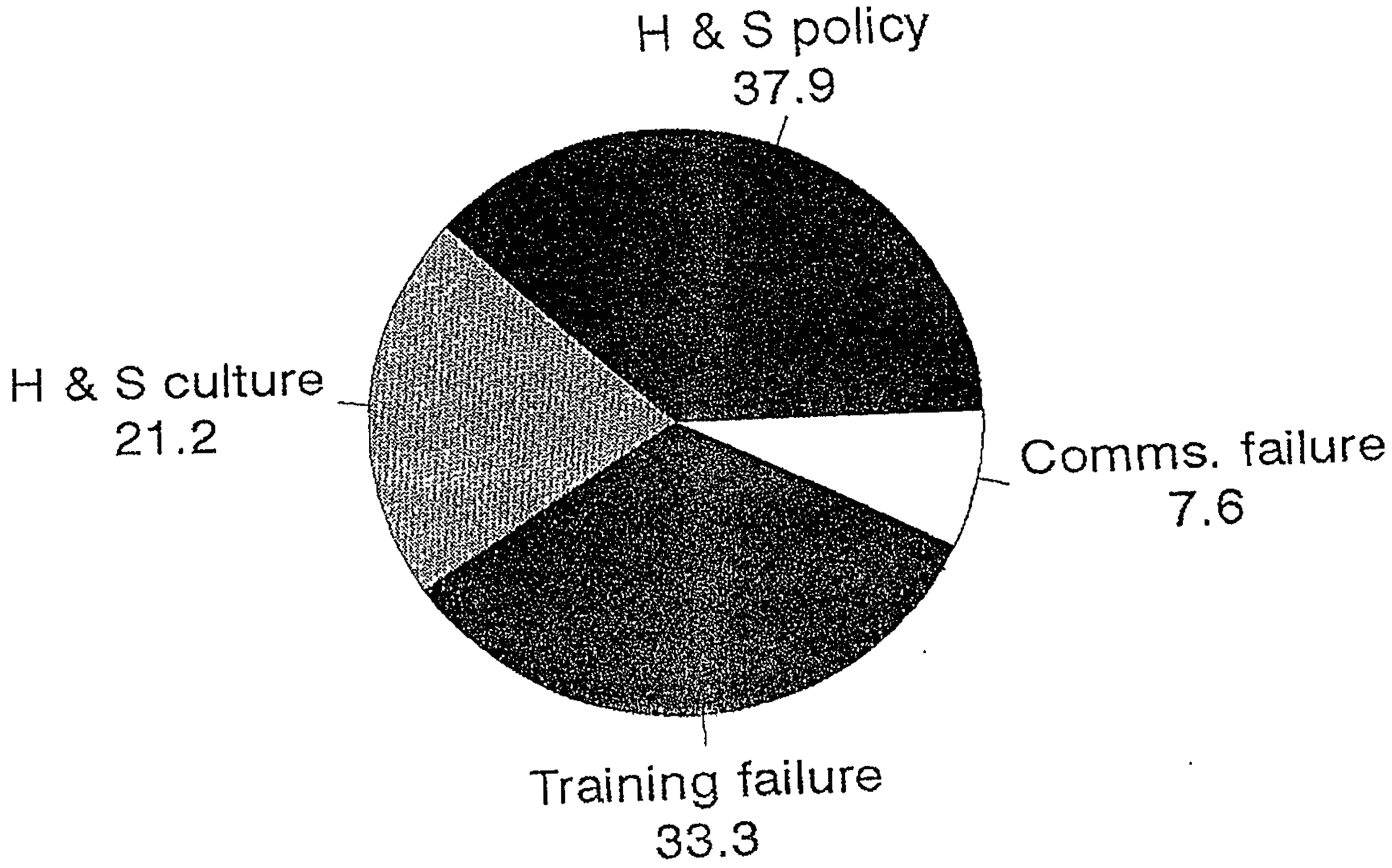
HRA Ltd. 21/11/92 acç10

Results of investigation of LUL staff accidents
Breakdown of management systems factors



Frequency of main management system failures across all 50 IIRs

Results of investigation of LUL staff accidents
Breakdown of organisational causes



Frequency of organisational causes across all 50 IIRs

HRA Ltd. 21/11/92 acc12

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Human Factors aspect of Staff Accidents: Monthly Report

Mr.J.Rose
London Underground

MONTHLY PROGRESS REPORT TO SAFETY SERVICES

Human factors aspects of staff accidents

J2486

Report for February 1992

CONTENTS

Progress on the human factors aspects of staff accidents

1. Overview

This report covers HRA's progress to date on the causal analysis of staff accidents. Such accidents are defined to include both major and minor injuries which may or may not result in lost time. Such injuries arise from the classic categories of accidents including slips/falls, handling problems, etc. as well as from assaults on employees. The set of staff accidents also includes incidents relating to contractors. This heteregeneous incident data set has been divided into three categories for the purposes of the causal analysis. The categories are as follows:-

a. Employee injuries from accidents
b. Contractor accidents
c. Assaults on employees

This classification is necessary since each category of data will show a different pattern of causes and different managerial solutions.

Progress on the human factors aspects of accidents has been restricted to date because of the concurrent work on the safety implications of the Company Plan. This report provides an overview of the progress so far and the immediate future plans in this area of work.

2. Employee accidents

2.1 Incident Notification Forms (INFs)

As mentioned in our previous report (January 1992), the INFs were found to contain sparse information relating to the causes of accidents such as trips/falls, handling errors, etc. INFs also suffered from other common problems of incident reporting systems including: variability of reporting, missing information, and lack of appropriate management actions. For the purposes of this investigation it was decided to look instead at Incident Investigation Reports and Senior Management Reviews (IIRs and SMRs).

2.2 Incident Investigation Reports (IIRs)

A listing of the IIRs covering the period June 1990 to January 1992 was obtained from Safety Services. From the short abstracts available a selection of 61 IIRs was made to cover a variety of types of incident (injuries, near misses, assaults, dangerous occurrences) (see also appendix 1). Unfortunately, not all of these IIRs were available in Safety Services although, in order to prevent the analysis of a biased set of cases, it is necessary for us to have access to the remainder of IIRs selected. However, an initial set of 25 cases was made available for further study.

2.3 Case histories

At this stage of the project two IIRs have been analysed in detail. The analysis process proceeds in three stages. Appendix 2 gives an overview of the process used for the first two stages. The stages are as follows:-

a. Development of a descriptive diagram showing the actors, critical events and times

The event diagram starts with the immediate events leading up to the incident. Future diagrams may have remote events indicated in a "pre-event" diagram.

b. Development of a causal fault tree

The fault tree concentrates on an identified critical step or failure and identifies less than adequate (LTA) conditions relating to supervision, procedures, quality assurance, etc. A number of causal fault trees may be developed for a single event line depending on the number of critical steps identified.

c. Identification of performance influencing factors

In addition, a set of performance influencing factors (pifs) is identified for each critical event. These pifs relate to three levels: policy, management/supervisory, and individual. Appendix 3 lists commonly occurring pifs for each of these three levels.

The two case histories analysed to date are presented below. The methodology for analysis may be refined as further accident case histories are reviewed. In particular, ways of linking pifs into the causal fault trees are being explored.

The two cases concern firstly a dangerous occurrence with temporary tunnel lighting. It shows the lack of a system for providing such lighting as well as violations of the procedure for track working. The second case is a near miss with potentially serious consequences which occurred in a depot. The causes relate to the provision of a safe system of work and to the nature of the equipment provided.

It should be noted that in carrying out these analyses it has been necessary to make certain assumptions in the absence of key human factors information from the IIRs. Ideally interviews with the persons concerned in the incident or its investigation should be carried out to validate these assumptions.

2.3.1 Case history 1

SUMMARY OF THE INCIDENT INVESTIGATION REPORT -
KINGS CROSS INCIDENT 18/12/1991

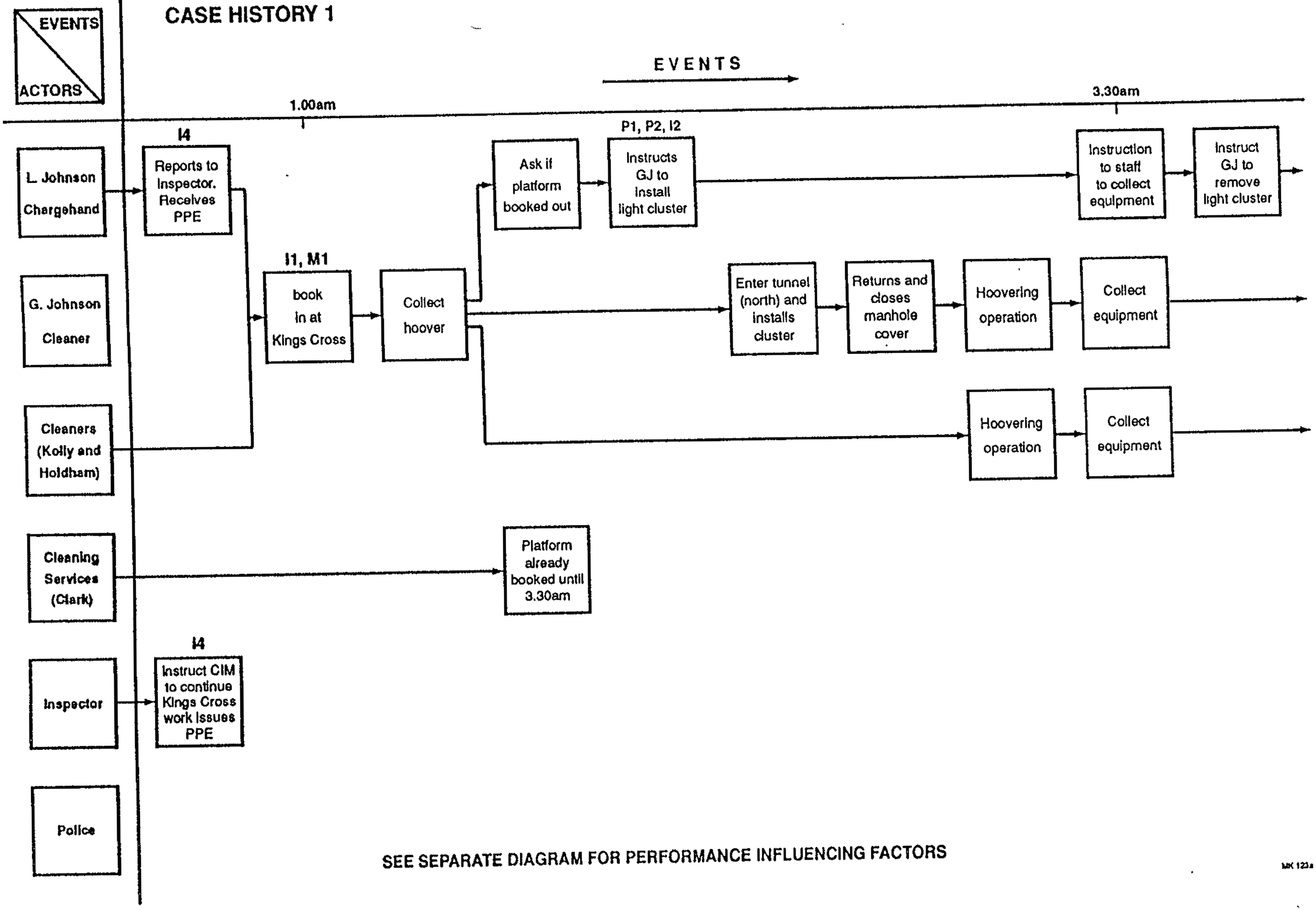
The following is a direct extract from the IIR summary sheet:-

"EVENTS

The incident was "caused" by staff making illegal connections to tunnel lighting and leaving the tunnel lighting in place at the end of engineering hours. Interviews with the staff concerned identified the fact that they had entered the tunnel without booking out with the Engineering Works Controller. Both activities are breaches of the procedures and the staff concerned are being disciplined.

The staff were working in the platform invert where there was no lighting. This is not an unusual occurrence and temporary lighting festoons have now been made available. The existence of invert lighting and the identification of a suitable supply for such temporary lighting will now be included in the site survey report prior to starting work."

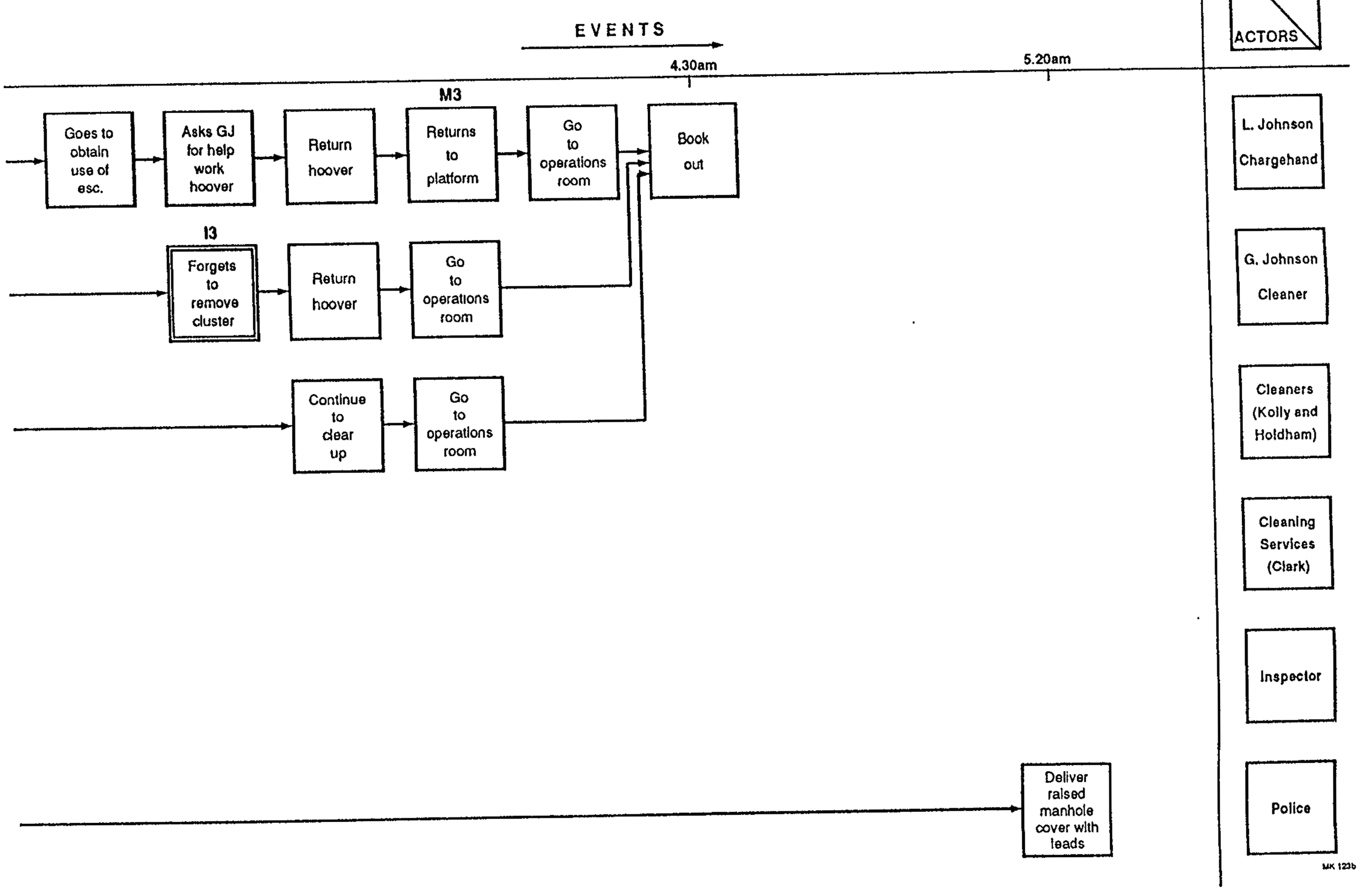
CASE HISTORY 1



SEE SEPARATE DIAGRAM FOR PERFORMANCE INFLUENCING FACTORS

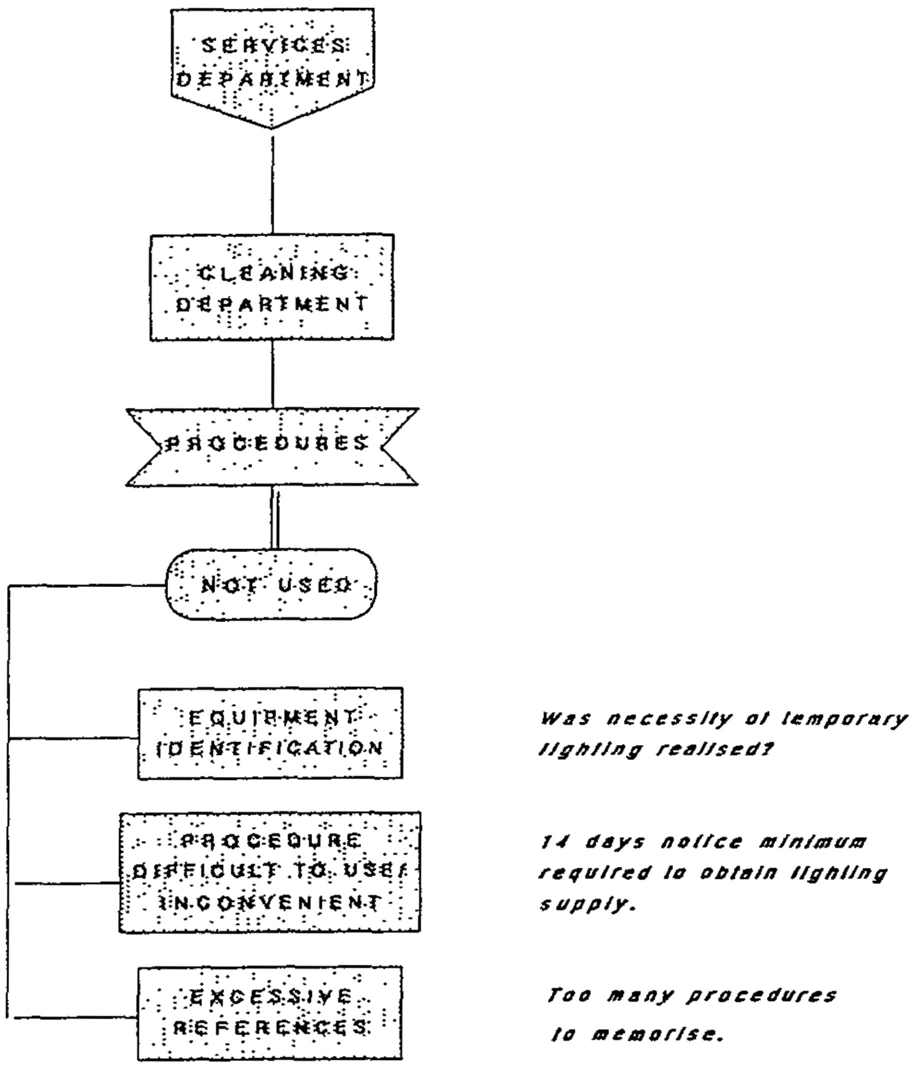
MK 123a

CASE HISTORY 1



CASE HISTORY 1 – CRITICAL EVENT TREE

EVENT : TEMPORARY LIGHTING NOT APPLIED FOR.
LIGHTING CLUSTER USED FROM
UNPERMITTED SOURCE.



PERFORMANCE INFLUENCING FACTORS

POLICY LEVEL

P1 working notice 155 not practical

P2 insufficient lighting and/or power supply

P4 Training of protection masters inadequate

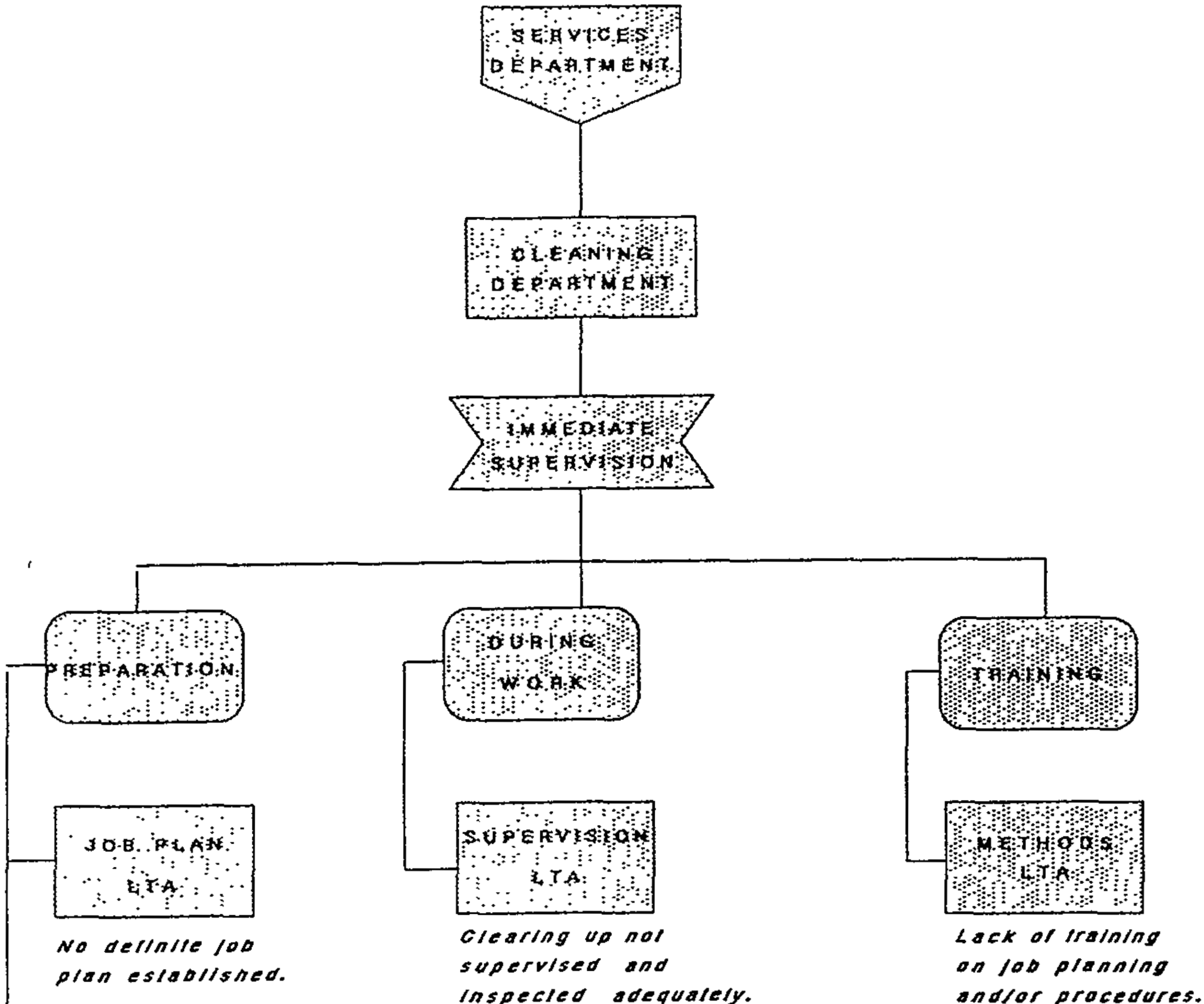
P5 Lack of procedures (system) monitoring

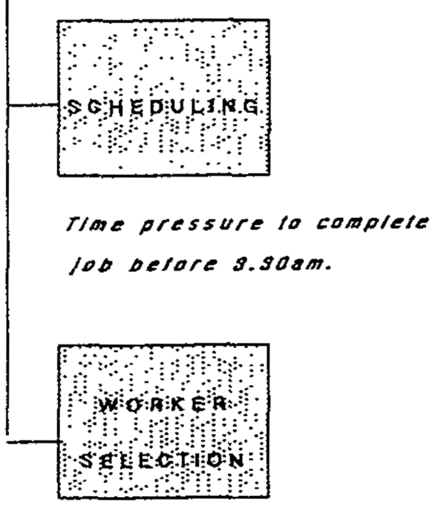
MANAGEMENT/SUPERVISORY LEVEL

M1 Chargehand lack of knowledge of works notice

CASE HISTORY 1 – CRITICAL EVENT TREE

EVENT: LIGHTING CLUSTER NOT REMOVED FROM TUNNEL SOURCE.





PERFORMANCE INFLUENCING FACTORS

POLICY LEVEL

P3 Insufficient barriers availabe for manhole

MANAGEMENT/SUPERVISORY LEVEL

M1 Chargehand lack of knowledge of works notice
M2 Chargehand fails to book out with EWC
M3 Chargehand fails to inspect adequately
M4 No monitoring of work by Station Inspector

INDIVIDUAL LEVEL

I1 Staff lack of knowledge of works notice
I2 Lack of training in use of light clusters
I3 Cleaner forgets to remove light cluster

2.3.2 Case history 2

SUMMARY OF INCIDENT INVESTIGATION REPORT -
NEASDEN DEPOT 19/11/1991

The following is a direct extract from the IIR summary sheet:-

"EVENTS

On 19/11/91 at approx. 16.30 hours, between 25 and 26 North Lifting Shop, Mr. McLeary had a problem removing jumper from car 5079.

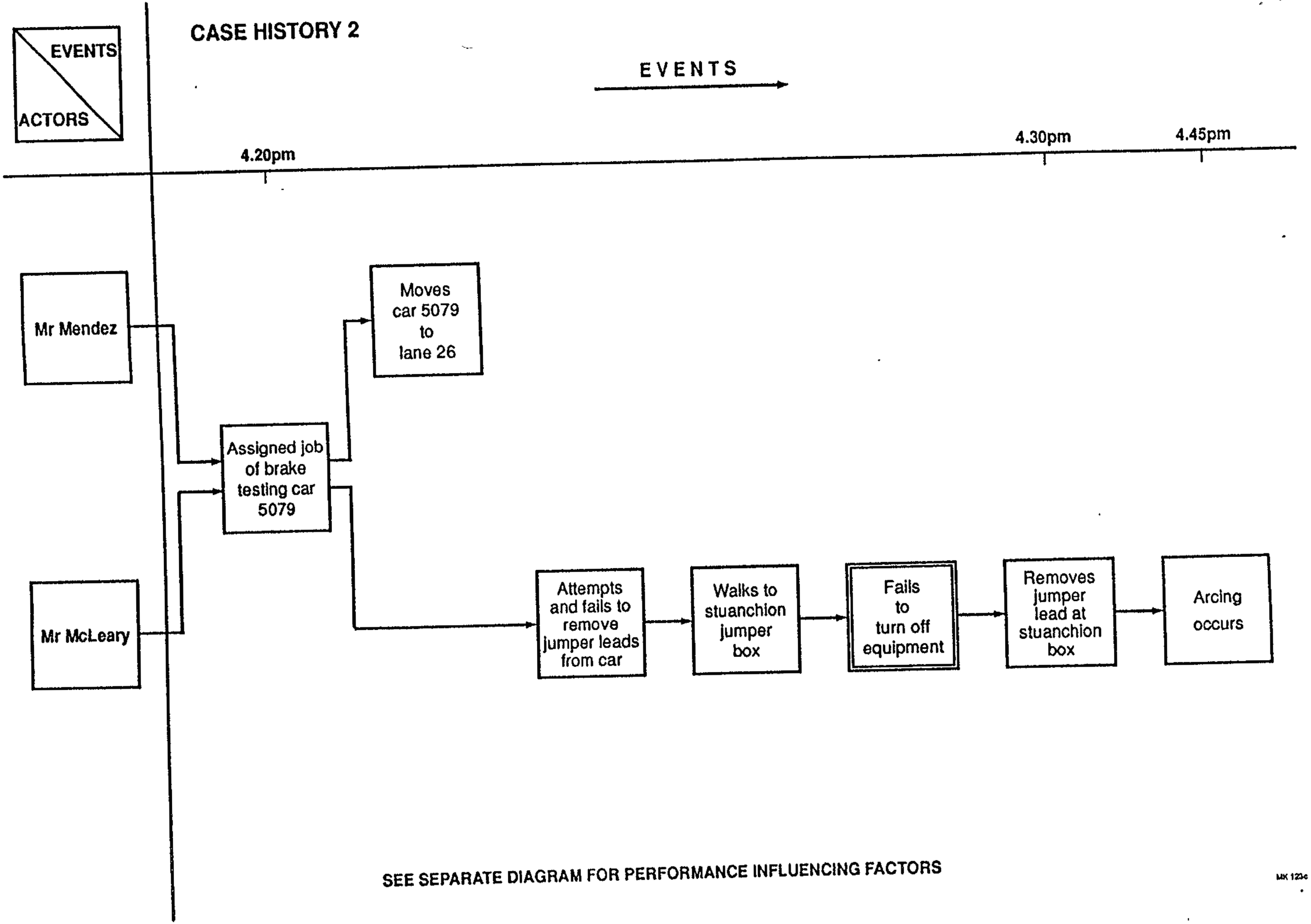
He walked back to the staunchion jumper box. In doing so there was an arcing incident at the jumper lead box causing Mr. McLeary's jacket to be scorched.

CAUSE

The motor generator and compressor was not switched off, causing a current load to be drawn through the leads.

A contributory factor was the old style B.T.H. type connection boxes."

CASE HISTORY 2

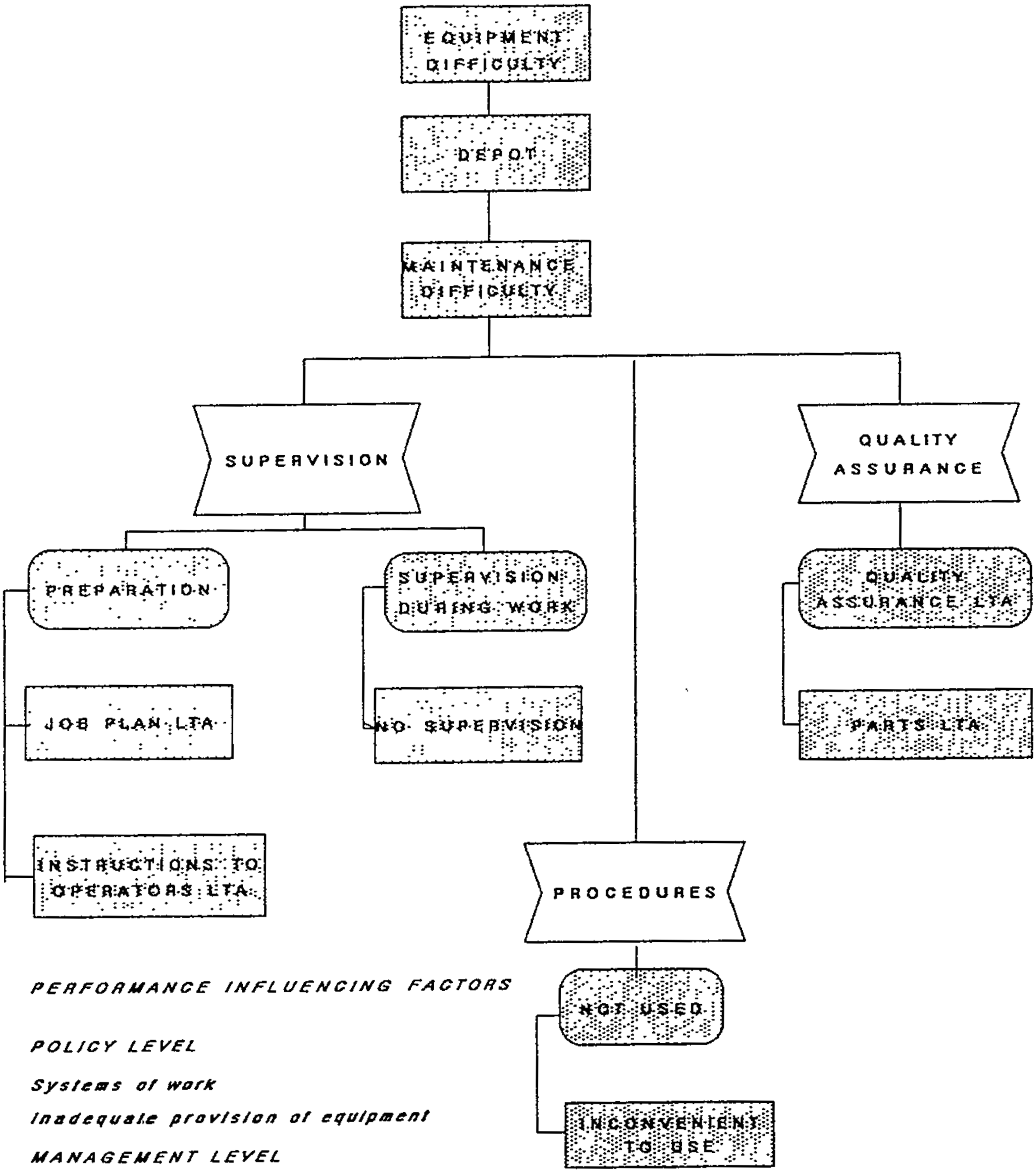


SEE SEPARATE DIAGRAM FOR PERFORMANCE INFLUENCING FACTORS

MK 123c

CASE HISTORY 2 — CRITICAL EVENT TREE

EVENT: REMOVAL OF JUMPER LEAD AT STAUNCHION BOX
CAUSES ARCING AND SCORCHING OF JACKET.



PERFORMANCE INFLUENCING FACTORS

POLICY LEVEL

Systems of work

Inadequate provision of equipment

MANAGEMENT LEVEL

Insufficient supervision

No feedback of previous similar incident

Possible time pressure

INDIVIDUAL LEVEL

Experience

2.4 Future work

a. Case history analysis

Providing that access to further IIRs can be arranged, more case history analyses will be carried out. For a subset of these incidents it would be desirable to interview the injured person and/or the incident investigators. In the process of carrying out such analyses the methodology will be developed further.

b. Causal pattern analysis

Once a set of case histories have been analysed in detail the search for common patterns of causes will commence. This should identify the most frequent causes at different levels (immediate environment, management, policy) and common combinations of factors across levels. This information will then be used in building up generic human factors accident models and in suggesting remedial actions.

c. Review of management actions

The short abstracts of IIRs and SMRs will be looked at again with the focus on the indicated managerial actions, the allocation of responsibility for these actions, and the follow up procedure on such actions. From an initial scan of the IIR abstracts it appears as though the management actions are typcially restricted to: taking disciplinary actions, warning individuals to take more care, and reviewing procedures. Allocation of responsibility for actions and lack of a timescale for such actions does not appear to be regularly addressed. This may result in no action being taken despite the efforts which went into the detailed investigation. HRA would immediately recommend that instructions to future IIR investigation teams should include the necessity of allocating responsibility and time for carrying out remedial actions. In addition the use of the term "CLOSED" on the IIR database should be restricted to cases where actions have been taken. A separate term should be employed where recommended actions have not been acted upon.

d. Repeated events

The IIRs will also be reviewed to see the extent to which similar events and causes recur. Such repetitions could be indicative of an ineffective organisational response to problems (either lack of response, or remedial actions which do not address the underlying causes).

3. Contractor accidents

3.1 Reasons for addressing separately

Accidents which occur to contractors are being addressed separately since they will have very different implications in terms of managerial control and policies. Remedial strategies such as sending contractors off site, imposing financial penalties, black listing contractors, etc. will be unique to contractor accidents. From HRA's previous experience, it is expected that the immediate human factors causes of accidentssuch as lack of training, inadequate systems of work, poor microclimate, etc. will not differ significantly between employee and contractor accidents.

3.2 Availability of data

One problem that has emerged with contractor accidents is the lack of documented data. INFs may not always be completed for contractor accidents (presumably since the contracting organisation will have its own incident forms and will notify the HSE's RIDDOR data base where appropriate). Following on from the lack of INFs, only a few IIRs have been found which cover contractor accidents. An alternative strategy other than case history analysis will therefore be necessary for the study of such accidents.

3.3 Future work

Useful interviews relating to control of contractors and hence to contractor accidents have been held with the Central Line project team and with the Cleaning Services manager. Further work could look in more detail at either or both of these areas with particular emphasis on actual incidents which have occurred.

4. Assaults on employees

4.1 Identification of risk factors

Assaults are being analysed as a separate class of injuries (both lost time and non-lost time) since they will have a different pattern of causes to individual accidents.

From the data base of INFs and the summary graphs provided by Safety Services it is possible to identify a number of "risk factors" for assaults. These cover who, where and when assaults occur and are as follows:-

a. Who: Grade of staff

The grade of staff most likely to be assaulted are the leading railman (barrier), the station foreman B, and the reliefs for both of these positions. By the nature of their roles, these staff are the ones most likely to come into contact with members of the public. This is also borne out by data showing the numbers of assaults suffered by employees over an 16 month period. 22.5% of those employees assaulted had suffered two or more attacks. One can only feel extreme sympathy with those 12 individuals who were assaulted between 3 and 8(!) times over this relatively short period of time.

b. Where: Location of assault

Assaults are most frequent in stations, that is, in the booking hall, at the ticket gate or on the platform. Figure 1 below gives a further breakdown of location including lifts/escalators and station entrance for a 6 month period during 1991. Note that relatively few assaults occur on trains.

Certain stations are high risk locations for assaults particularly those at mainline stations and at main interchanges where the volume of passengers must be a contributing factor.

c. When: Time of day

Assaults occur at most times of the day with the exception of the early morning between 2.00 to 7.00 approx. (presumably this coincides with engineering hours when stations are closed). The majority of assaults on staff occur in the evening/early morning between 16.00 and 1.00. There are also smaller peaks between 7.30 and 10.00 and between 13.30 and 15.00. To a certain extent the distribution may therefore partly be a reflection of the volume of customers travelling at different times of the day. Figure 2 shows the peak incidences of assaults occurring at 5-7pm and 9-11pm for a set of 102 assaults during six months of 1991.

The data supplied also provides some information about the consequences of assaults. The statistics supplied by Safety

FIGURE 1: LOCATION OF ASSAULT

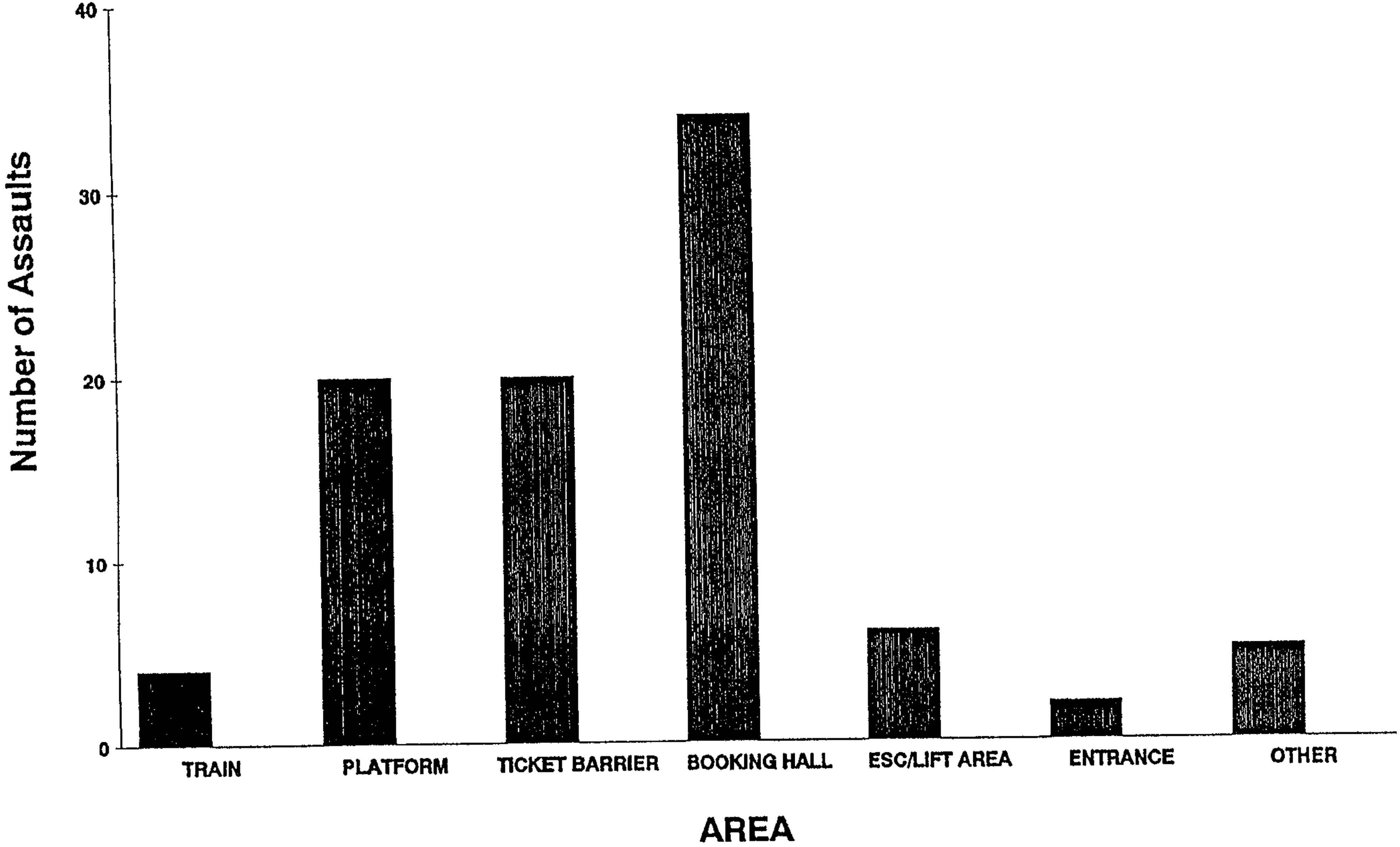
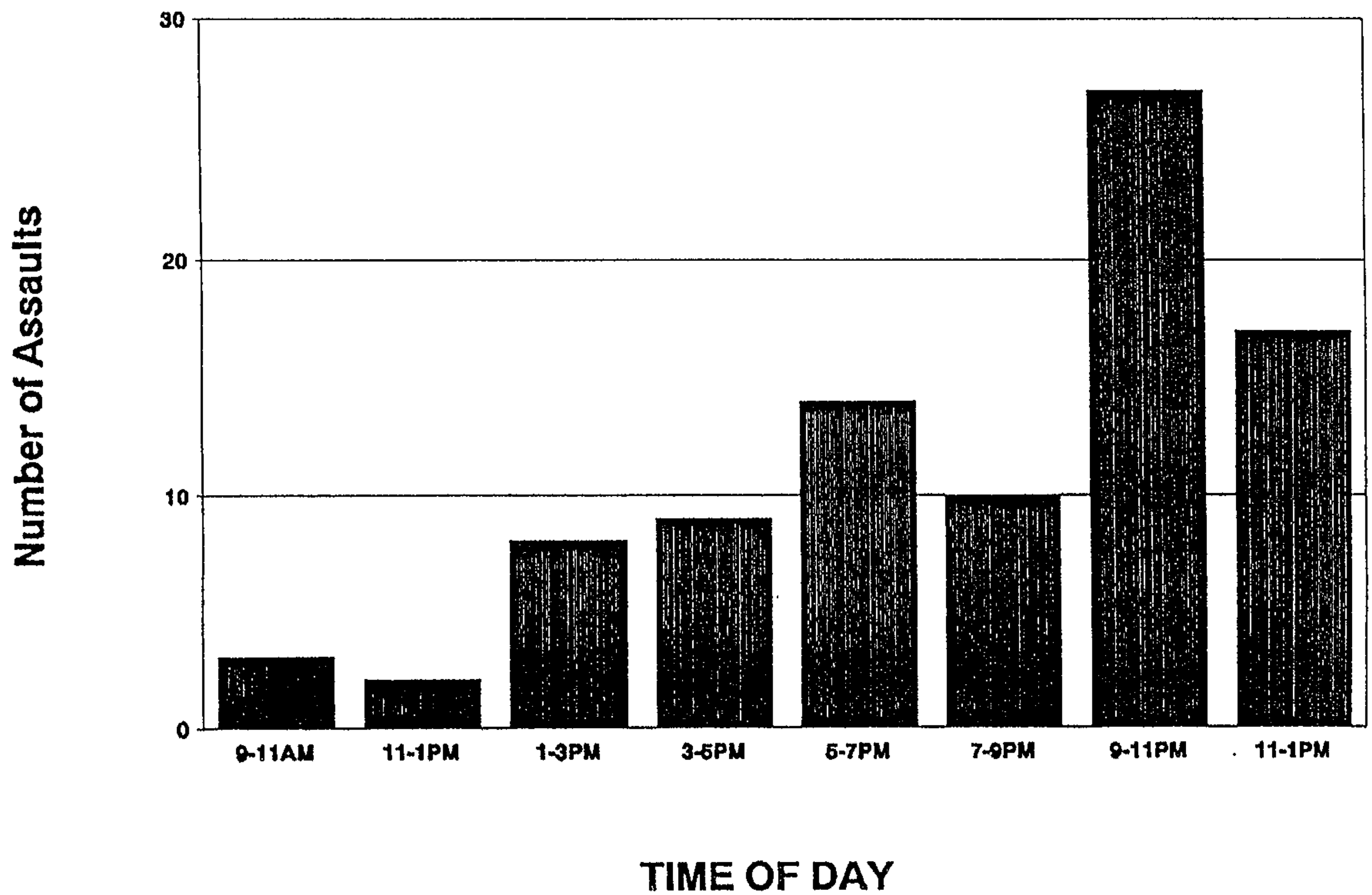


FIGURE 2: TIME OF ASSAULT



Services show that for each assault resulting in a LTI the average number of days sick leave is 29. Extrapolating from the figures supplied, in 50% of cases where an assault leads to time off work this will total at least 15 days. The assault is most likely to injure an employee's head or upper body (see figure 3) and the injury will most often be pain or a surface wound.

4.2 Initial causal analysis

Since the available statistics did not produce much information about why the assaults were occuring HRA looked again at the INF records for assaults over a six month period during 1991. 102 records of assaults were reviewed and a search was made for causal factors such as mention of alcohol, moving vagrants, robbery, etc. For each assault one "reason" was identified. Figure 4 below shows the pattern of cited reasons for the assault. Of interest is the high percentage attributable to fare evasion (33.3%). This raises issues concerning the costs (probability of an assault) versus benefits (increased revenue) of challenging customers travelling without a ticket in identified high risk situations (see section 4.1). 12% of the cases studied involved persons who had been drinking. 9% of the reasons relate to situations in which the LUL employee would have had to caution a member of the public (e.g. to stop smoking, to stop abusing LUL property, or to move off LUL property). A third of the assaults reviewed did not identify any reason for the attack. This could be due to poor or biased reporting (e.g. perhaps the victim of a racial attack is reluctant to report all the facts) or to the nature of certain assaults.

From this analysis it is clear that there are a variety of situations which may potentially lead to assaults on station staff:-

FIGURE 3: Type of Injury

- All classed as MINOR injuries

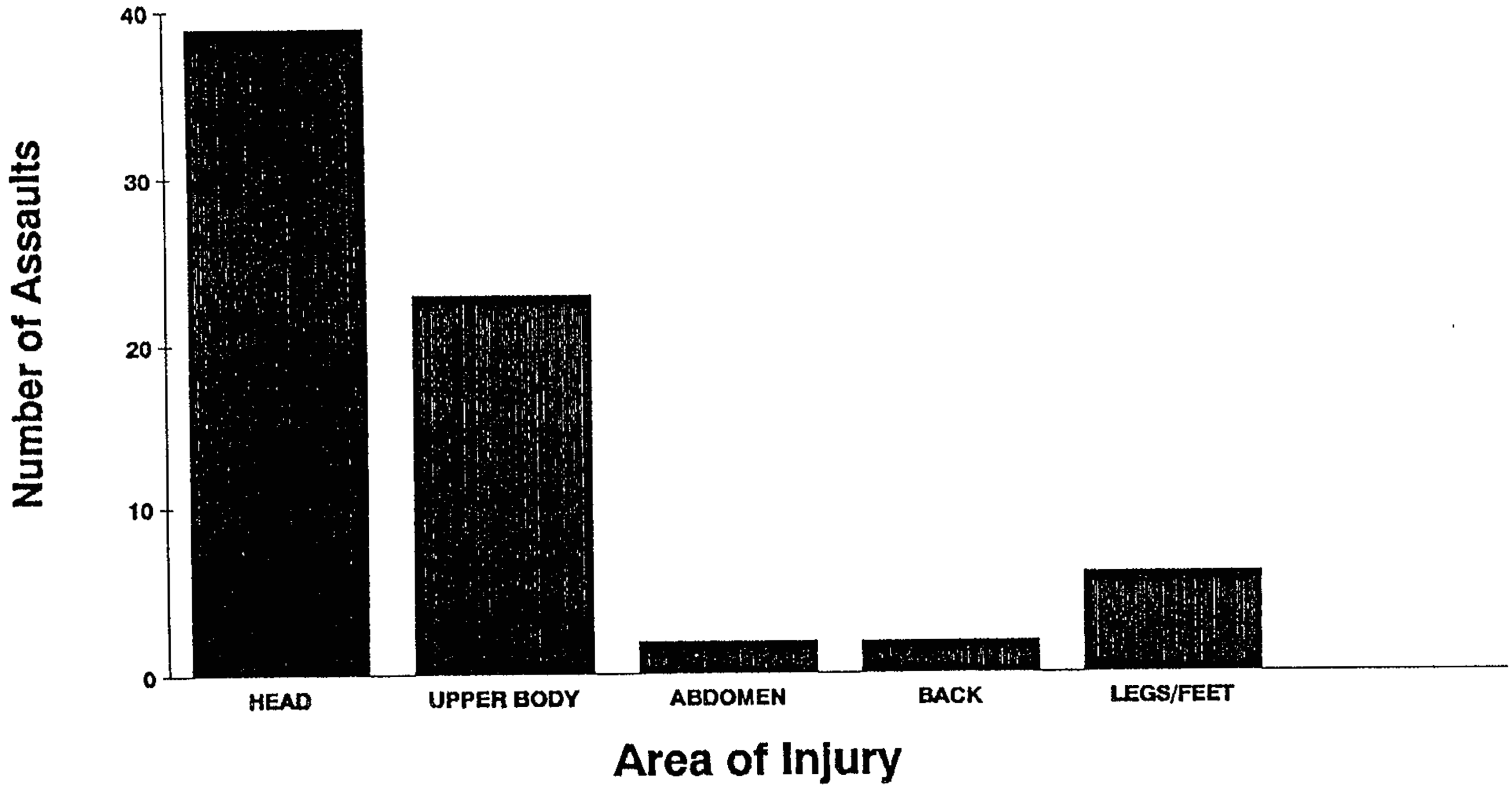
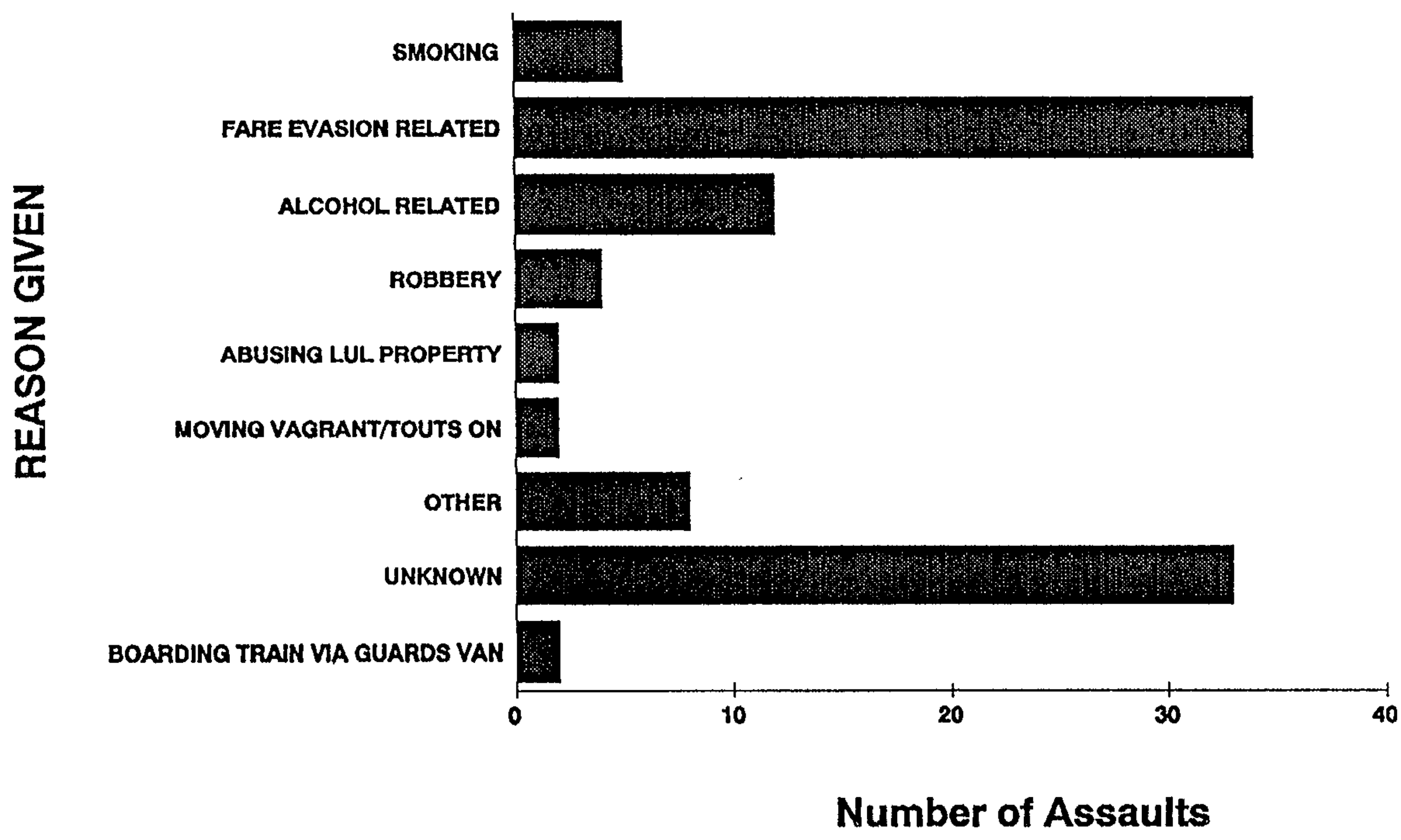


FIGURE 4: REASONS FOR ASSAULT



- a customer being challenged after deliberate fare evasion
- a customer being told to desist if smoking/damaging LUL property
- vagrant/tout being moved on
- customer substance abuse (principally under the influence of alcohol)
- robbery/mugging

In addition there could be a further set of causal situations which currently reside under the "unknown reason" label.

The review of INFs has provided an initial starting point for classifying assaults however the data content in INFs is limited and hence there is a need to move to other data sources.

4.3 Future work

The next stage of research into assaults is to take a broader perspective regarding information gathering.

a. HRA would like to talk to the LUL counselling service who counsel victims of assaults. This would be useful in order to gain insights into potential causes not apparent from the INFs (e.g. racial attacks) as well as understanding the psychological impact of being assaulted which may delay the return to work. It would also be useful to establish the level of use of the counselling service after an assault and the publicity methods of the service in order to find out if this service is being used as effectively as possible.

b. It could prove useful to examine in more detail the cases where specific employees receive repeated assaults looking for common patterns of location, time of day, nature of injury, etc.

c. A further line of enquiry is to consider the training received by high risk grades of staff in coping with difficult customers in order to avoid a potential problem escalating into an assault. An initial review of the Leading Rail Person Induction Course Information Book (Elliman, 1990) found no mention of strategies to cope with difficult members of the public, however this type of information and even role playing exercises may be carried out during the training course.

d. An interview with an area business manager would also be useful in clarifying management's attitude to the cost of assaults versus the benefits of collecting all fares. The goals (explicit or implicit) which are set by such managers could have a significant impact on day to day issues such as the criteria used by station staff concerning when to insist on collecting a fare and when to leave well alone.

e. The human factors case history method (presented in section 2.3) will also be used on a limited number of IIRs which involve assaults in order to see if any additional causes are revealed.

5. Summary of progress

a. The analysis of individual case studies of employee accidents is proceeding well. A preliminary methodology has been selected and two cases have been analysed. Providing that access to further IIRs can be arranged it is anticipated that this aspect of the project will proceed according to plan. It is intended that managerial actions given in IIRs will be reviewed during the next phase of this work.

b. Analysis of accidents to contractors will be carried out through further interviews and through a study of incidents to contracted cleaners and to contractors on the Central line project.

c. Risk situations for assaults are beginning to be identified. It is felt that INFs contain no further clues concerning causal factors. The next stage of the work in this area is to consider training of station staff, to look at the work of the counselling service for assault victims, and to discuss policy issues for revenue protection with an area general manager. It would also be useful to look in more detail at those cases where individuals have been repeated assaulted over a relatively short period of time. A limited number of IIRs will be analysed using a similar method to that for employee accidents.

Appendix 1:

List of IIRs required for analysis

LIST OF IIRS REQUIRED FOR ANALYSIS

No.	Date	Location	Incident	Issuing name (where given)
91/001765	31/12/91	Stockwell,Victoria	DO	DTM Simmons
91/001680	9/12/91	Pimlico,Victoria	DO	Mr. J. White
91/001628	5/12/91	Euston/Warren St.	DO(Pway)	
91/001569	26/11/91	Kings Cross/C&H	Passenger in doors	Mr. T. Jones (19/12/91)
91/011083	17/11/91	Heathrow T1,2,3,Picc	Escalator	Mr. G. Taylor
91/001448	6/11/91	Wimbledon, District	Door irregularity	Mr. G.R.Simpson
91/010978	5/11/91	Ruislip Depot,Central	Employee fatality	DTM Smith
91/010870	23/10/91	Hillingdon, Met.	Employee incident	Mr. A. Munro
91/010846	17/10/91	High St.Kens.,Distr.	Employee assault	Mr. R. Thomas
91/001316	2/10/91	Victoria,Victoria	Collision	Mr. P. Neal
91/001293	25/9/91	Hammersmith, Picc.	Passenger in doors	Mr. A. Tofis
91/001329	18/9/91	St. Paul's,Central	DO(evacuation)	Mr. L.Murray
91/001223	12/9/91	Putney Bridge,Distr.	Signal defect	Mr. R.A. Davy
91/001442	12/9/91	Cockfosters Depot,Pic	Passenger incident	Mr. A. Harvey
91/010715	11/9/91	Liverpool St. Eng.Ops	S&E Contractors	Mr. M. Appleby
91/001273	9/9/91	Angel, Northern	Lift defect	Mr. I. Harley
91/001296	6/9/91	Camden Town,Northern	Gas release	Mrs. Lopez
91/001147	31/8/91	Ruislip Depot,Central	Employee fatality	Mr. B. Richardson
91/001153	30/8/91	Hyde Pk Corner,Picc	Fire category A	Mr. P. Jesset
91/001145	29/8/91	Hammersmith Depot,C&H	Bomb alert	Mr. L. Seviour
91/001133	20/8/91	Edgeware Rd,Bakerloo	DO	Mr. T. Cock
91/001050	13/8/91	Bank, Central	Fire category A	Mr. J.H. James
91/001225	9/8/91	Embankment,District	Signal defect	
91/000987	30/7/91	Acton Works,EOW	Employee injury	Mr. C. Leach (6/8/91)
91/000955	25/7/91	Wembley Pk/Neasdon,Pic	Near miss	Mr. M. Bull (9/8/91)
91/001104	23/7/91	Covent Gdn.,Picc	DO	Mr. R. Joy
91/001056	19/7/91	Dagenham East,Distr.	DO	
91/000922	16/7/91	Angel, Northern	Serious congestion	Mr. E. Stuart
91/000910	15/7/91	Earls Crt, District	Lift defect	Mr. D. Simpson
91/010161	12/7/91	Greenford/Perivale	Central line project contractor incident	J. Alton
91/010070	10/7/91	Greenford	- ditto - employee	Mr. D. Westerburg

91/000889	7/7/91	Amersham, Met.	DO	Mr. D. Sexton
91/000828	30/6/91	Goodge St., Northern	Lift defect	
91/000839	27/6/91	East Putney, District	Signal overrun	Mr. R. Simpson
91/001536	12/6/91	Liverpool St.,Central	DO	A.J. Porton
91/000750	9/6/91	South Harrow, Picc	Collision in depot	D. Morley
91/009768	5/6/91	Acton Works, EOW	Employee injury	J. Merkelt
91/000730	2/6/91	Edgeware Rd. C&H	Staff absence	J. Staples
91/009697	29/5/91	Ruislip depot, Centrl	DO	M.P. Trotter
91/000642	22/5/91	Cockfosters, Picc	Collision in service	A. Tofis
91/000643	20/5/91	Marble Arch,Central	possession overrun	M. Smith
91/000640	14/5/91	Perivale,Central	DO	J. Przednowek
91/000600	10/5/91	Paddington,Bakerloo	DO	M. Sharp
91/000538	2/5/91	Leicester Sq, North	Pway defect	A.G. Lane
91/000541	1/5/91	Willesden Grn, Met.	Near miss	J. Doyle
91/000571	25/4/91	Frank Pick Hse, Scientific Research Lab.	Fire category A	R.K. Brans
91/000513	24/4/91	Preston Rd.,Met.	Near miss	D. Mould
91/001199	24/4/91	Northumberland Pk. depot,Victoria	DO	
91/000497	23/4/91	7 Sisters, Pway	DO	R.Taylor
91/000439	15/4/91	Liverpool St., Met.	Station closed	
91/009497	12/4/91	Wembley Pk/Neasden	Pway employee inc.	
91/000495	6/4/91	Northolt, Central line project	Contractor incident	J.O'Connell
91/000395	2/4/91	Rickmansworth, Met.	Near Miss	T. Bowdery
91/000406	22/3/91	Clapham Nth, Pway	DO	F.L. Hammond
91/000335	16/3/91	White City depot, Central		
91/000404	13/3/91	Holborn, Central	Near miss	B. Middleton
91/009139	26/2/91	Neasdon Depot, Pway	Employee injury	P. Meads
91/008853	23/2/91	Lillie Bridge Yd. Depot	DO	J. Whittington
91/000197	8/2/91	Oxford Circus/Picc. Circus, Bakerloo	DO	Fay Luckhurst
91/008998	8/2/91	Ealing Common Depot District	Employee injury	
91/000123	1/2/91	Euston Sq., Pway	DO	M. Allen

Appendix 2:

Description of methodology for case studies

Mr. Andrew D. Livingston
Mr. Mark Green

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Dalton, Lancashire, England.

Evaluation of Incident Investigation Techniques and Associated Organisational Issues

1. Introduction

Typically an incident report will provide an organisation with a description of events which principally focuses on the status of the plant at discrete times along a timeline. Reports usually also place the emphasis of any analysis on developing a description of the consequences rather than causes of the incident. Essentially they tell an organisation what happened, but not why it happened. Such analyses are almost invariably technically orientated involving detailed descriptions of plant, equipment, reactions and their governing logic systems. To human factors practitioners such bias appears strange when one considers the pervasive nature of human error in a range of recent disasters in the chemical, nuclear, aerospace and transport industries.

Such incidents typically involve complex socio-technical systems with highly automated production and protection functions. Many such incidents involve a mismatch between the people and technology in the system. However, what typically happens in the majority of investigations is not the identification of such a mismatch but a sequence of events which, once human error is implicated, duly assigns responsibility and closes the investigation. Such a sequence is a reflection of the attitude that human error is both an acceptable cause and explanation of incidents. Consequently any recommendations relating to the human component in the system tend to be vague and ineffectual. For example: provide more training, exhortation to follow procedures or work more safely, and most typically reprimand of the individual(s) involved.

It has been our experience that in the majority of incidents deeper investigation identifies latent failures at the senior management and organisational level. Rarely, however, do incident investigations attempt to identify these root causes of operational error and link them with specific preventative recommendations. It is only by adopting investigation techniques which explicitly identify root causes, that organisations can hope to learn from past failings and avoid similar incidents in the future.

2. Limitations of Investigative Approaches

Different industries and individual companies within the same industry often have different approaches to incident investigation, some of which are more formalised than others. All too often the approach is rather ad hoc and those leading the investigation frequently have minimal professional training for the task. Companies, particularly in the chemical process industry, rely heavily on the investigator's professional knowledge and experience of the system under investigation. It is assumed that these are an adequate substitute for investigative knowledge and the application of a systematic and structured approach. As previously stated, this leads to reports that contain a great deal of technical information, but which do not necessarily describe the true complexity of the incident and the contribution of human actions and omissions to it.

Lacking a structured investigative framework and clearly defined procedures, many incident reports fail to identify the incident process as being multicausal, that is involving a complex set of interacting events, with one or more root causes being critical to the evolution of the incident. The lack of a standardised methodology for incident investigation is demonstrated by the variable quality of many incident reports in terms of: the description of the facts, the attempted investigation of underlying causes, and the nature of recommendations produced.

The consequence of the above failings will inevitably be a succession of repeat failures, the financial costs of which, notwithstanding the safety and environmental consequences, can be enormous. For example, in 1983 incidents cost West Germany $15 billion, with indirect costs estimated at a minimum of three times this amount (Hoyos and Zimolong, 1988).

3. Incident Investigation Techniques

A variety of investigation methodologies are used in industry, each with its different merits and drawbacks. For example, Benner 1985, offers a comprehensive review of methodologies used in US Government agencies. The three methodologies to be briefly evaluated here represent fairly structured approaches, all of which have been used extensively in industry. These evaluations will focus primarily on how effectively the techniques represent the incident process and to what extent they facilitate the identification of root causes.

3.1 Tree of Causes

This investigative method was developed by the Institute National de Recherche et de Sécurité (Leplat, 1987). The underlying principle of the method is that an accident results from changes or variations in the normal process. It is these variational antecedents which the analyst must identify, list, and finally organise into a diagram in order to define their interrelationship. Unlike a fault tree the method starts with a real accident and results in a representation which only includes the branches actually leading to the accident. Thus no "OR" gates are represented. The construction of the diagram is guided by simple rules which specify event chains and confluence relationships.

It should be noted that the completed diagram is not a diagram of causes, as the variations are the active factors necessary to generate an accident but only in conjunction with other latent factors already present in the system. The method does recognise that there may be permanent factors in a system which need to be represented in order to improve diagram comprehension, and it is by representing these "state antecedents" that one moves towards a diagram of genesis which is deemed to constitute the ideal arrangement. The goal of the method is to identify those changes which can be introduced to break the flow of events in the diagram.

The finished diagram is used to identify nodes representing inappropriate acts and abnormal physical states in the system and to extract a list of factors involved in the accident with a view to improving the conditions for human decision-making and action, hence improving the work environment and system design. Also, the sequence of events is analysed with the objective of breaking the causal relations between nodes by either making physical changes or providing operator-feedback concerning the risky course of events. Both of these interventions act as barriers against the flow of events.

Although the diagram is easy to construct and represents the incident process in an accessible manner, the method provides little guidance on how to collect all the relevant incident information or identify the main events involved. The method also relies heavily on the analyst's knowledge of the system's conditions. Without this in-depth knowledge, it is necessary to perform a task analysis of the system in order to identify all the deviations. Finally, the ability of the method to identify the root causes of incidents is poor, as it provides no explicit structure for the analyst to determine these factors. The root causes may remain undiscovered if the analyst is not experienced in incident investigation, as the method deals mainly with identifying direct causes, trigger events and prevailing conditions, but not the underlying causes which lead to these.

3.2 The Management Oversight and Risk Tree (MORT)

The development of MORT was initiated by the U.S. Atomic Energy Commission (AEC), and is described in Johnson (1973). Mort is a comprehensive analytical procedure that provides a disciplined method for determining the causes and contributing factors of major accidents. It also serves as a tool to evaluate the quality of an existing safety programme.

MORT is designed as an investigative tool with which to focus upon the many factors contributing to an accident. A unique feature of the method is a logic diagram which represents an idealised safety system based upon the fault tree method of system safety analysis. The diagram comprises specific control factors and general management factors. Detailed consideration of the former is accomplished by reasoning backward in time through several sequences of contributing factors. This analysis ends when the question posed by the MORT statements is answered "yes" or "no". The analyst must focus upon the accident sequence when evaluating the specific control factors and, when evaluating the management factors, must consider the more global or total management concept. The diagram is supplemented by the MORT text which is a commentary on best concepts and practices found in the safety literature. It contains criteria to assist the analyst in judging when a factor is adequate or less than adequate. In short, MORT provides decision points in an accident analysis which help an analyst detect omissions, oversights or defects.

However, MORT does not aid in the representation of the accident sequence which must first be determined before the method can be effectively used. Although MORT provides a comprehensive set of factors which may be considered when investigating an incident, it can easily turn an investigation into a safety programme review as no guidance is provided on the initial investigative process.

MORT excels in terms of root cause identification, as factors such as functional responsibilities, management systems and policies are well covered, but this strength of the method requires an accurate description of the incident process, and an experienced MORT analyst who is knowledgeable and well-practised with the methodology.

3.3 Sequentially Timed Events Plotting Procedure (STEP)

STEP, described by Hendrick and Benner (1987), developed from a long research history on incident investigation methods centred on event and causal factor sequencing. STEP is based on the multiple events sequence method and is an investigative process which structures data collection, representation and analysis.

The method distinguishes between actors, actions and events. Actors can be people, equipment, substances etc., while actions are anything which is brought about by an actor. Events are the unique combination of one actor plus one action during the incident process. The method's primary aim is to help the analyst identify the main actors and their actions and map the relations between these events along a flexible time line.

Based on a description of the end state of the incident the main actors are identified and their condition noted. The initial state is determined by identifying the first event in the incident which is an unplanned change by an actor within the planned process. The method proceeds by developing a multilinear events sequence diagram which involves listing the actors down a vertical axis and establishing a time line on the horizontal axis. Each actor's actions are traced from the start of the incident to the finish. Actions which initiate changes of state in other actors are also identified which functions to reveal new actors previously not implicated in the incident. Events are positioned relative to one another along the time line and causal links are represented. Figure 1 represents the conceptual structure of the STEP worksheet.

As the diagram develops, a necessary and sufficient test is applied to pairs of events, and checks for completeness and sequencing are made. One-to-many and many-to-one relations can be represented in the diagram. If data cannot be found to verify the relation between an event pair, then a technique called backSTEP can be used to explore gaps in understanding. Essentially backSTEP is a fault tree which uses the event with no arrows leading to it as the top node. The analyst then develops possible event flows which could describe what happened during the gap in events in order to cause the top node.

When the STEP diagram is complete, the analyst proceeds through the diagram to identify event sets that constitute safety problems, as determined by the effect the earlier event had on the later event. The safety problems are evaluated in terms of their severity and recommendations for corrective actions made. These recommendations, similar to those produced by Tree of Causes, tend to focus on how to break the sequence of events by placing barriers between events and also on how to lessen the effects of one event on another.

The method is well-structured and provides clear, standardised procedures on how to conduct an investigation and represent the incident process. Also the method is relatively easy to learn and does not require the analyst to have knowledge of the system under investigation. However, the method alone does not aid the analyst in identifying the root causes of the incident, but rather emphasises the elimination of event relations and weakening the propagation of event sequences.

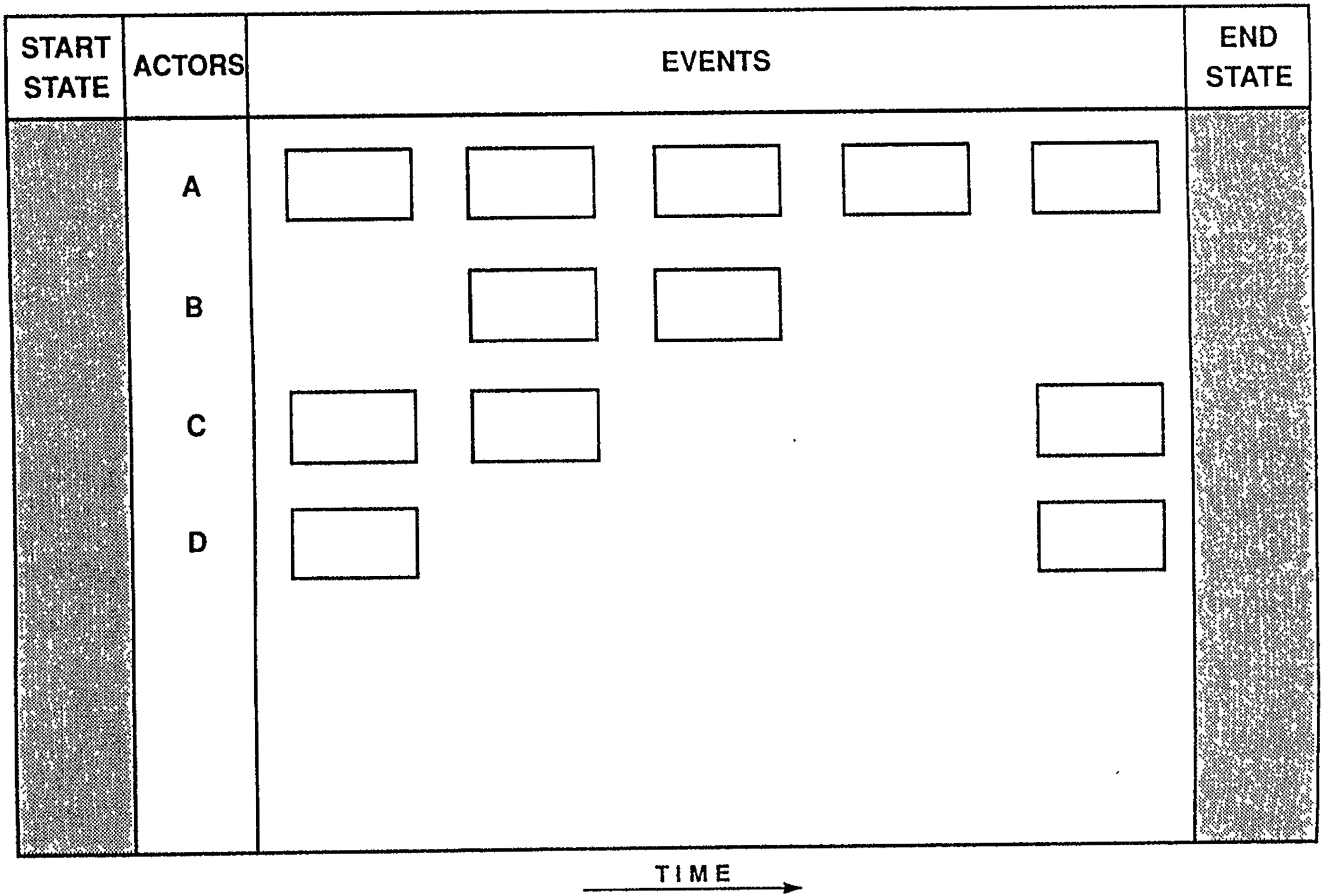

Figure 1: A STEP Representation of an Incident Process

MK-88

4. Hybrid Model of Incident Investigation

Based on the brief review of methods above, the STEP method provides the analyst with the most useful guidance in performing an incident investigation. Most importantly STEP consists of a set of well-defined procedures for collecting information, then structuring and representing it in a manner which is consistent with a systems view of incident causation. The resulting diagram is easy to understand and enables logic testing of the incident process, thus highlighting any gaps in understanding.

If one has the objective of identifying root causes, the complete STEP diagram identifies the causal events but only represents the first stage in the investigation. The second stage is to identify the critical actions and events in the incident process. This involves identifying the events which have significantly influenced the course of the incident, i.e. those events which acted as triggers rather than events which were a reaction to other events. The STEP diagram, by representing the flow of events and providing the analyst with a structured understanding of the incident greatly aids the identification of these critical actions/events.

The final stage in the investigation aims, via a decision tree, to identify the root causes which led to the critical events. The root cause tree was originally developed in the U.S. nuclear industry and has close links with MORT. See Armstrong, 1989, and Armstrong et al, 1988, for fuller descriptions of its development and construction. It consists of six levels covering equipment failures, quality failures, management systems failure and human error. The decision tree codes critical actions and events. By entering the top level of the tree the analyst has to determine whether the critical event involved an equipment difficulty, operations difficulty or technical difficulty. Based on the answers to these general questions the investigator branches down to more specific levels of the tree which relate to: functional area, equipment problem category, major root cause (such as training and management system), near root cause (such as procedure wrong and training methods less than adequate), and finally root causes themselves (such as procedural facts incorrect and decision made not to train). This root cause coding allows the investigator to be specific about the underlying reason for a given critical event. The stages of analysis are presented in figure 2.

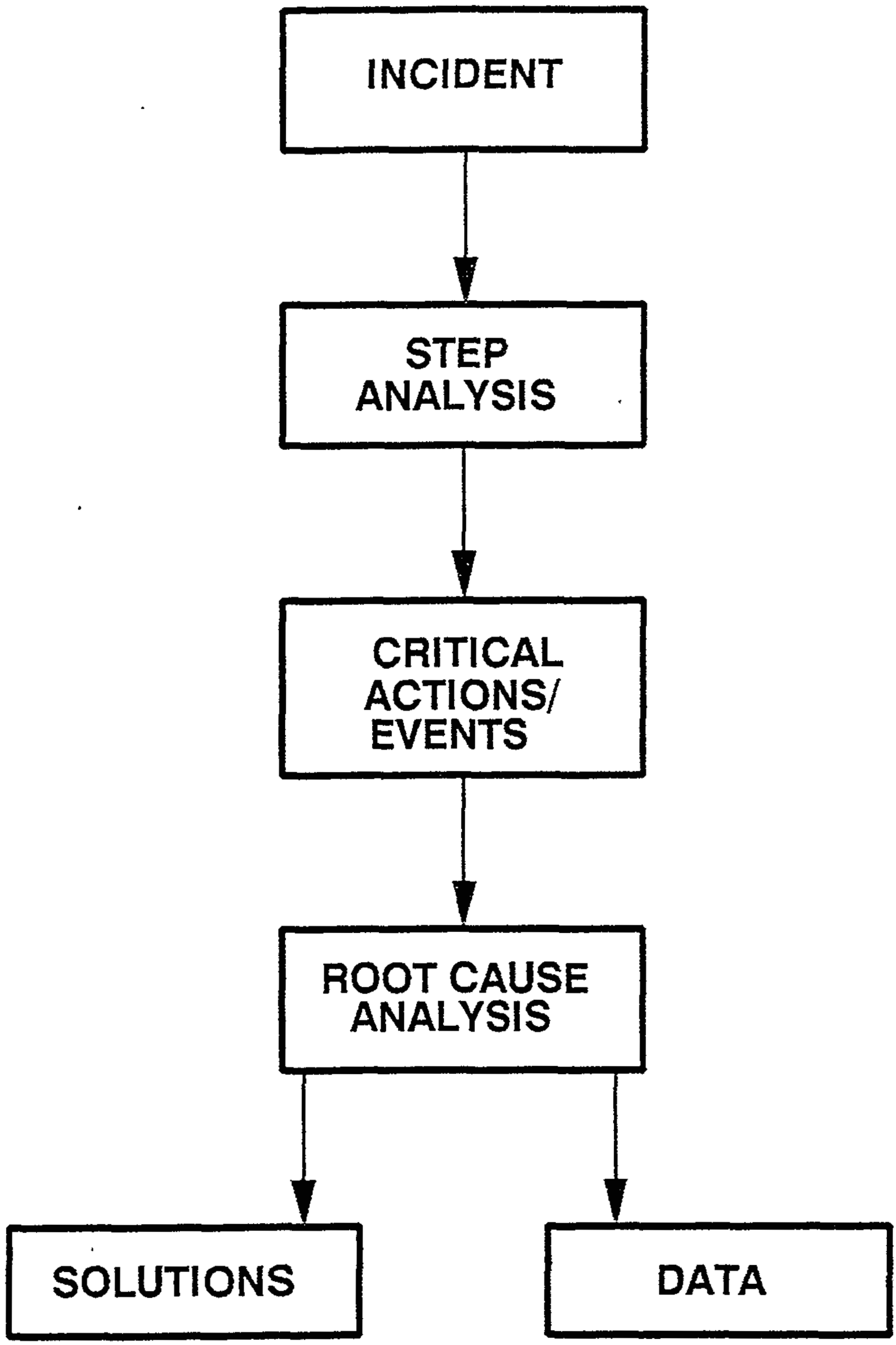

FIGURE 2: HYBRID MODEL OF INCIDENT INVESTIGATION

5. Conclusion

The investigative process outlined in section 4 is currently on trial in a major oil refinery in the U.K. The development of the technique involves tailoring the root cause tree to the requirements of an organisation, taking into account the organisational structure / functional departments and the company's activities. Training course material also needs to be developed for company practitioners and in-house courses presented.

This root cause analysis approach provides a systematic and structured method acceptable to non-specialists, which enables the identification of causal factors and their root causes. Both the STEP procedure and the root cause tree provide consistency across investigations and lead to better quality incident reports. The standardised approach also enables an organisation to develop a database of root causes which address human, equipment, technical and quality failures. Consequently, rather than merely being event driven, the approach enables the identification of root cause trends and the development of effective preventative recommendations which not only prevent repeat failures but will also serve to circumvent many related incidents.

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1. Error inducing factors/immediate accident preconditions

a. stress

high workload
high time pressure
high level of distractions
high level of anxiety (e.g. emergency situation)

b. experience/training

ignorance of system
lack of experience
inadequate training
high task complexity

c. equipment/microclimate

wrong/inadequate equipment for task
poor MMI
poor work environment (heat,light, etc.)

d. morale and fatigue

motivational difficulties
fatigue (workhours/shift patterns)

e. risk taking

inappropriate perception of hazards
inappropriate balance of production/safety goals

f. job design

inadequate definition of responsibilities
inadequate system of work
poor instructions/procedures

g. supervision/communications

poor supervision
poor communications

2. Line management factors

a. Operations

manning levels
procedures
scheduling
general working methods
SSW/PTW

b. Training

induction training
safety training
skills training

c. Maintenance

planning/scheduling
quality of work

d. Design and procurement

quality of equipment
design of MMI
design of instructions and procedures

e. Personnel

selection procedures
industrial relations

f. Other management factors

management training in safety
responsibility and accountibility for H&S
management appraisals
safety auditing
management skills

3. Policy aspects

organisational health and safety policy
organisational health and safety culture (production goals/safety trade off, risk taking)

monitoring and feedback systems (accidents, near misses, LTI, DOs)
rules and procedures (specifications)
auditing
sanctions and enforcement

communication systems

design factors and ergonomic standards for equipment
- same for instructions/procedures
task design/SSW design
standards/procedures for job analysis/description

training policy (induction, safety, skills, management skills)

personnel selection policy
costing and allocation of human resources

risk management e.g. hazard analyses, safety plans
assignation of responsibilities for safety

control of contractors

external influences e.g. economic situation

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Chris Hall

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Strategy for Safety Management

Mr.C.Hall
ANR

STRATEGY FOR SAFETY MANAGEMENT

Australian National has come a long way in the last five years in relation to the handling of safety in the workplace and still has some way to go.

To understand the change process in context, a brief description of AN as an organisation is useful. Formed in 1978 through the amalgamation of two State/one Federal rail systems, AN is a rail freight and passenger service organisation. It is also a vertically integrated organisation with workshops and perway maintenance gangs, as well as operational staff. The formation of AN presented enormous problems to be overcome by staff and management. The combined workforce had disparate conditions of employment, different cultures and in the safety arena a poor record.

During the development years of AN from 1978 until the mid 80's many basic issues had to be addressed. Cost reduction, workforce reduction and rationalisation of services had to be vigorously exercised before true development could commence. It was the early stages of the OMELET; breaking the eggs and blending the mixture had commenced.

Safety management was not high on AN's agenda until about 1987 when some indications of the cost of safety emerged through the increasing workers compensation liability.

However from a bureaucratic and ineffective approach to safety AN has moved to a position where safety is a responsibility in every job and the majority of the workforce and certainly all management levels are involved in accident prevention and creating a healthier workplace.

The attached statistics reveal the improvements achieved since 1988/89. Prior to that time, statistics were collated manually and are not considered valid.

To arrive at AN's current situation we had to identify our starting position, plan carefully a significant change in the approach to managing safety and of course from the beginning create a clear picture of where we wanted to be.

It is true that you must be careful if you don't know where you are going, because you might not get there. At first our goal was not clear but the only way was up. It would have been difficult to get worse.

The starting position was not even clear at first. Information systems were manual, unreliable, cumbersome and provided a limited picture of the situation. Certainly there were some factors that were clear however.

Safety management, along with many human resource management functions was centrally controlled and administered. Responsibility, authority and accountability were remote from the workplace. This was not an uncommon situation resulting from the growth of centralised human resource departments.

The centralised approach was rigid and bureaucratic. Issuing of rules and policing through safety officers was the approach. This was negative, adhoc and alienated both managers and employees. Attitudes ranged from indifference to contempt for the safety function.

The unions took little interest in safety apart from the occasional point scoring exercise brought about by delayed workers compensation payments or an obvious breach of safety rules.

In such a dangerous industry it was surprising that the workforce treated safety with contempt. The 'macho' railway workers often ignored hazardous situations and worked in a dangerous manner. At the same time however, because of the 'government railway' attitude, workers compensation provisions were abused making it difficult for genuine cases to avoid the stigma attached to claimants.

The change strategy involved the following elements. Firstly, the development of reliable information to analyse the situation and define the extent of the problem. The true cost of poor safety management had to be identified along with the specific causes of accidents.

At first, only high level analysis was possible. From this analysis education and training programs were developed to address organisation wide issues of safety concern.

The second element was to shift responsibility and accountability for safety back to line management. To do this it was necessary to acknowledge that managers were not equipped to take on the responsibility. They needed information, training and a change in attitude. The high level analysis of costs was sufficient to gain the attention of executive management. Better information systems revealed a serious situation that was getting worse. The cost consciousness of top management was a key to gaining support to pursue the strategy further.

Further improvements to the information systems were supported and endorsement was given to a program of management education to prepare them to take back responsibility for managing safety. The next phase however, coupled with education, involved changes to the accounting/reporting systems.

The costs of workers compensation and lost time injuries were allocated to each division and then further segmented to departments and sections. This move made managers accountable for reducing such costs and motivated them to accept training opportunities.

As attitudes changed and accountabilities were included in all management job descriptions, the demand for more detailed information increased.

Throughout the early stages of the strategy the maintenance of centralised support through the Human Resources Division was vital. As managers began to grapple with the problem they needed additional expert resources to assist in accident investigation, education, training and the development of accident prevention programs.

To develop appropriate support the Human Resources Division had to change from a policing role to a supportive, advisory role. This required changes in personnel. New safety advisers were brought in at senior levels and those remaining employees in the safety area were given training to support their changed role.

There was also an ineffective safety committee structure set up in the early establishment of the safety management bureaucracy. The Committee role and structure was given more emphasis and support. Managers were given better information and training support as well as access to investigatory and advisory services. However in time that committee structure would also disappear to be replaced with more direct employee involvement.

To develop a more complete approach to safety management the next phase required the introduction of a comprehensive safety management system. The systems available cover all aspects of safety management including training, information systems, workplace facilities and controls, housekeeping, policies and procedures, emergency planning requirements as well as performance standards.

Through such a system managers would be guided through a structured approach and audited or rated annually on their performance. The rating process prompted goal setting and encouraged incremental change and improvement through extensive and detailed feedback following the annual reviews.

The reviews were conducted by the external provider of the management/rating system. These reviews were however supplemented by six monthly reviews by internal advisers to assist and encourage managers and supervisors to improve their performance.

Throughout the change process some outstanding champions of safety management emerged and at the top level we were fortunate in having a Managing Director and General Managers who were visibly committed to improving AN's safety performance. This sent a clear signal to all that safety was a vital issue. Similarly, through regular reporting to our Board, their support was given and made visible.

Safety was now well and truly on the management agenda.

Feedback from managers however suggested that whilst helpful, the management/rating system selected was considered to be administratively burdensome, not focussed on the most important issues. Generally our now, better informed, more committed managers had assessed the system as inappropriate for our organisation.

In response an alternative system was adopted that focussed less on administration issues and more on workplace arrangements and safety performance. This change has received a positive response and encouraged managers to share their concerns and seek support.

The next step on the strategy was to introduce safety responsibilities at the workforce level.

During the past three years AN has restructured its awards, redesigning all jobs to develop a multiskilled workforce with accountability at all levels for quality performance. Throughout this process extensive participation and consultation at the work group level was encouraged. Over forty employee working parties reporting to joint union/management co-ordinating committees were set up to redesign jobs and develop training programs and curriculum.

Safety training and responsibilities were included for all jobs. In addition employees were not only made more aware of their responsibilities, they were given better feedback on performance and an understanding of their rights. Management support was one of these rights and this made them aware that they could control the safety of their jobs and their working environment.

During this phase the codes of practice and other policies and practices that had been produced centrally to assist managers were rewritten and consolidated into one reference manual. A working party consisting of managers and employees at all levels undertook this task and resulted in greater ownership throughout the organisation. That Manual - 'AN's Corporate Safety Standards' - has been distributed to all first line supervisors and, through them, is available to all employees.

At this stage the need for extensive centralised support was reducing and it was appropriate to reduce and decentralise such support arrangements. Information systems were decentralised, safety advisers/co-ordinators were allocated to the line divisions and a small core of three safety specialists were retained in the Human Resources Division. The dismantling of the central function was vital to prevent a drift of responsibilities back to that area, as can be the tendency.

The above changes have resulted in a culture of safety consciousness in AN. Good safety management is recognised as a win/win and it is one area in which management, employees and unions have very limited disputation and generally work together in a positive way to resolve problems.

AN's results reflect this positive change. The improved safety performance and attention to both rehabilitation and worker's compensation liabilities have reduced AN's outstanding liabilities by 60% since 1988.

In recent times we have reviewed and changed the committee structures to facilitate work group involvement in policy development and workplace change. Managers will continue to support these committees. Externally and internally provided training programs will continue to be developed to respond to emerging issues of concern.

Safety suggestion and award schemes have been developed and give special recognition to individual achievements. Implementation of safety suggestions has been of significant commercial benefit to AN. Results from rating reviews are widely distributed and engender a healthy spirit of competition.

The next stage is to establish key performance indicators for each work group and improve our information systems to provide timely and detailed performance feedback against these indicators.

In summary, the strategic approach taken by AN over a five year period progressively introduced the elements necessary for incremental change at a pace and in a way that achieved a change in attitude which above all is the key to safety management.

The responsibility was not dumped onto managers and the workforce. The problem was identified and shared, accountability was progressively assigned and support through training, information, advice and appropriate systems development was put in place at each stage. Through this approach resistance was minimal and encouragement was emphasised.

AN's workforce as a whole now recognises and accepts its responsibilities for safety management and collectively has achieved a turn around in our safety performance.

Good information systems and participative training that reviews real issues and is relevant to the workplace must be continually reviewed and improved. Participation in goal setting and self monitoring is essential to self management.

Continued support, recognition and visible interest at the highest levels in the organisation must be maintained to serve as encouragement and a demonstrated commitment to safety.

In this paper I have concentrated on safety management and AN's strategic approach to sharing responsibilities throughout the workforce. To put this approach in context however the level of participation in all change processes in AN is increasing and this area is one of the best examples. In addition a major change in the handling of workers compensation claims and rehabilitation has occurred in parallel.

Health services were also improved to demonstrate a commitment to not only prevention of accidents but to caring for injured employees and an acknowledgment of our responsibility to help support our people.

This aspect will be the subject of my next paper.

Thank you.

Strategy Safety Management

AUSTRALIAN NATIONAL SAFETY PERFORMANCE
CALCULATED RATES FOR FINANCIAL YEARS 1988/89 - 1991/92

	DURATION RATE				LOST TIME FREQUENCY RATE				LOST TIME ACCIDENTS				TOTAL DAYS LOST			
Division	88/89	89/90	90/91	91/92	88/89	89/90	90/91	91/92	88/89	89/90	90/91	91/92	88/89	89/90	90/91	91/92
Rail Transport	15.4	12	11.3	8.5	86	84	74	76	797	740	595	530	12789	9244	6822	4636
Freight Management	18	16.1	19.8	9.1	72	88	73	95	31	26	29	37	569	592	574	369
Passenger & Travel	35.1	48.4	27.2	10.7	73	61	47	71	60	56	45	55	2126	2730	1236	592
Tasrail	11.2	12.1	16.8	12.6	59	59	53	74	98	94	73	71	1346	1165	1236	1047
AN Total	17.9	14.7	13.4	9.4	76	73	64	70	1005	943	769	705	17979	13875	10343	6673
	NUMBER OF EMPLOYEES				WORKERS COMPENSATION CLAIMS				LOST TIME ACCIDENTS % OF WORKFORCE				TOTAL DAYS LOST PER EMPLOYEE			
Rail Transport	4621	4428	4010	3505					17.2	16.7	14.8	15.1	2.8	2.1	1.7	1.3
Freight Management	215	205	199	195					14.4	17.6	14.6	19	2.6	2.9	2.9	1.9
Passenger & Travel	410	459	479	389					14.6	12.2	9.4	14.1	5.2	5.9	2.6	1.5
Tasrail	825	790	694	482					11.9	11.9	10.5	14.7	1.6	1.5	1.8	2.2
AN Total	6348	6436	5965	5041	1731	1220	1071	971	15.1	14.7	12.9	14	2.7	2.2	1.7	1.3

	COMPENSATION PREMIUM $/EMPLOYEE						WORKERS COMPENSATION / % EMPLOYEES					RATIO WORKERS COMP CLAIMS/LOST TIME ACCIDENTS			
	88/89	89/90	99/91	91/92	92/93		88/89	89/90	90/91	91/92		88/89	89/90	90/91	91/92
AN Total	N/A	1693	1507	1163	1064		26	19	18	19.3		1.7:1	1.3:1	1.4:1	1.3.1

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Hiroshi Nagaoka

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Japan

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JR East *Safety Programs:*

JR EAST AND HUMAN FACTORS IN SAFETY MANAGEMENT

Presented by:

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East Japan Railway Company
Tokyo, Japan

JR EAST AND HUMAN FACTORS IN SAFETY MANAGEMENT

We have entered the final decade of the 20th century, a critical period to prepare ourselves for the next millennium. The 90s have already been a turbulent decade and several critical and historical developments have taken place. So far, notable events in the 90s include the Gulf War, the collapse and the fragmentation of the former Soviet Union, and the EC's determined progress towards a unified Europe. Many things, especially political and economic issues, have emerged from a tight gridlock of narrow ideas into the open air to be discussed, scrutinized and re-evaluated in an attempt to determine the future course of human society.

Railway transportation has also felt the winds of change. In 1987, shortly before the start of this historic decade, a major restructuring divided the former Japanese National Railway —— burdened by a large and mounting debt that reached ¥37 trillion —— into several privately-operated railway companies.

As a result of this restructuring, six passenger railway companies and one freight railway company were established, each of which has since operated its business as a private enterprise, forging its own unique management policies and strategy.

All of the newly-established companies have since experienced reasonably good operating results. At JR East, our profit and passenger traffic has grown steadily.

We believe this improvement in operating results is due to the efforts of both our management and our employees. Privatization has fostered more initiative and higher levels of productivity among all of our personnel. Continued support from our passengers, who have appreciated our greater efforts, has also contributed to our improved profitability.

There are several reasons why we were able to earn the support of our passengers. These are:

First, we have provided them with high-quality service, worthy of a private enterprise. We think one of the critical factors in the improved quality of our service is the changed attitude each of our employees has displayed, as their status changed from being a public servant to becoming an employee in the private sector.

The second reason is that we have achieved a substantial improvement in safety. The stimulus for our renewed commitment to safety was the commuter train crash which occurred at Higashinakano on December 5, 1988. This accident resulted in a heavy toll: two people including the driver were killed, and over 100 passengers were injured. We took this accident seriously and decided to take the necessary steps to raise our safety standards to an even higher level than we had achieved at that time.
I must add that the JR East Trade Union also contributed to this effort with their understanding and co-operation.
One of the significant measures we took after this decision was to invest ¥400 billion in safety over the following 5 years. This investment included introduction of advanced signal systems such as ATS-P connected with ATS-S through a transponder, improvement of level-crossing safety systems, introduction of an operating control system, introduction of a natural disaster prevention and information system, purchase of new cars, adoption of safety measures on station platforms, and improvements in infrastructure. By this year, the fourth of the five-year plan, we have invested a total sum of ¥260 billion in safety.

This investment program lets us achieve the first step towards the planned modernization of our safety systems by allowing us to introduce advanced technology. This is an area in which we have lagged behind current trends in this era of advanced information technology.

The second step we took was to address the human factor. For example, take the training and education of our drivers. In the past, this task took place either in the classroom or on actual trains in operation, with experienced drivers as instructors. With such a system, no systematic training in driving is possible, much less training in corrective measures in accident situations, since trainees are unlikely to experience an accident. With the intention of improving our training system, we have set up 10 training centers equipped with train-operation simulators, each of which is an exact replica of a real train cockpit. Our drivers, instructors, conductors and other train-crew members are now routinely trained at these centers to refresh their knowledge and test their skill and reactions during simulated accident conditions.

The third step we took was to establish the Safety Research Institute where I work.

At the Institute we have 52 researchers, some of whom undertake basic research in their respective speciality. Others assess safety systems by analyzing data to determine how we can improve them, simulate accidents, study applied technology to be introduced, and so on.

Our major R&D topics are as follows:

1. Safety systems: The main R&D themes in this area include improvement of existing signal systems and development of next-generation signal systems.

2. Safety analysis: Themes in this area are simulation of train motion, assessment and analysis of level crossings, and analysis of all types of accidents.

3. Natural disaster prevention: Research on wind behavior and natural disasters, such as snow avalanches, which affect railway safety, are conducted by our natural disaster prevention teams. They also carry-out research on predicting problems such as landslides and rock falls based upon studies of mountain geology.

4. The level-crossing teams are working to formulate, based upon empirical data, a program of safety measures for level crossings and proposals for their improvement.

5. We also have research teams assessing the safety performance of railway cars and other rolling stock, investigating accidents that have arisen from unknown causes, and so on.

6. The Human factor: R&D in this area is now our top priority.

I believe we have achieved a substantial decrease in accidents due to the effectiveness of safety measures we took following the accident at Higashinakano in 1988, and because of the positive attitude of our employees in carrying out their assigned tasks in making JR East a safer railway system.

Now I want to talk about the relationship between railway operation and technology, and address our philosophy on future research involving the human factor.

Chapter 1. The Human component in safety

Technology is the mainstay of railway safety, but it's people who develop, operate and maintain the technology. Technology to support safety systems can be used effectively only when these people complete their assigned tasks with pride and professionalism, while also improving their skill and knowledge. So we consider the human component an important subject to study along with technical development.

The first point to address in this area is how to make the corporation a place people can be proud to work in. We are fortunate in this respect, as all of our employees have good cause to be proud of JR East, with its reputation as one of the leading railway companies in the world during our brief history as a private enterprise.

Reasons for JR East's exemplary performance may include our sound management, along with the pride and self-confidence that comes from our personnel's knowledge that they helped establish the company. There is also our pride as railwaymen in maintaining and nurturing our tradition in technology. The moral of all this is that the first step towards safety is to make the corporation a place that people are proud to work in.

The second point is that safety must have priority over all other management issues, and management must act accordingly. At JR East, safety has always been the most important part of our management policy. Therefore we have done our utmost to improve our safety installations and to develop new safety technology. As always, we will keep working on improving safety, with our management leading the way.

The third point concerns the interaction between men and machines. New technology enhances safety. But, it also brings about a great change in the working environment. When new technology is introduced and is either difficult for people to handle or unfriendly to them, they usually lose their willingness to work with the technology. Under such circumstances, people not only fail to take full advantage of the new technology, but also lose confidence in the management that imposed the technology upon them. Therefore, whenever new technology is adopted, it is essential to develop a system that is user-friendly, and to provide adequate training in its handling, to those who will operate it.

Most successful companies have grown by effectively adapting to technological change.
However, it is just as important for the company to provide an appropriate follow-up program that helps employees adjust to the new technology.

The fourth point is to make front-line staff participate in safety. Safety issues should not be studied and discussed only by management and dictated in a top-down fashion. Discussion of safety should also include "hands-on" input from front-line staff. For a safety program to succeed it is important that these people take part, that they propose safety measures based upon their daily experiences and that they help put safety measures into effect which will achieve the desired result. The "Challenge Safety" campaign we have undertaken at JR East since 1988 is an action program that encourages such participation by all personnel.

The fifth point is to develop a corporate culture based upon mutual trust and respect between all levels of the organization, while encouraging all personnel to think of the company's success as their own personal achievement. This will help strengthen the foundation upon which the corporation is laid and offer its employees an opportunity to enrich their working lives. The basis of this concept may be related to cultural factors, or perhaps it can be thought of as harmony among people who share a common goal. However, for our practical purpose, it can be summarized by the following adage: A corporation that nurtures its people, will in turn be nurtured by those people.

Chapter 2. Meeting the human component challenge

At our Railway Safety Research Institute we have conducted studies on the human component using various approaches so we can better advise our top management on railway safety.

The primary problem that the Institute must deal with is the interface between man and machine. For example, the Institute is now developing a new concept for designing the driver's cockpit. Until now, research focused mainly on the layout of different devices in the cockpit to minimize the chance of human error in their handling. Our current research is aimed at developing a new type of integrated driver's cockpit that combines components such as a digital display, character display, and advanced communication systems into a single unit. The Institute is now manufacturing a model of this driver's cockpit for new Shinkansen lines and is working to improve the controller through simulator training. One of our criteria for the new type of integrated cockpit is that it be simple enough to be operated by every member of our front-line staff. Accordingly, the Institute is focusing its efforts on determining how the cockpit design can achieve this goal.

The second subject being studied at the Institute is CAI (Computer-Aided Instruction). Until now, driver training has been done mainly by our experienced drivers. But, because of the diversification in the types of cars we use, as well as the introduction of various types of new technology, such a system has only served to widen the difference in skill levels among our trainees. To overcome this problem, we developed an interactive, computer-assisted instruction system with related software.

The CAI uses a NEC 9800 series computer. It can easily be used for on-site training and to program software. The Safety Research Institute is now developing a more effective instruction system than the existing CAI, along with its basic technology. We'll be able to expand this new system by modifying its software to accommodate new situations that may arise in the future, such as the introduction of a new type of car or changes in regulations. Members of our front-line staff are expected to contribute to this development with their practical knowledge in relevant areas.

The third research theme is focused on determining a new approach to driver aptitude testing. The aptitude test has been one of the traditional technical fields involving human factors. Until now, the Krepelin test, which mainly focuses on a driver's physical ability to operate a train, has been used. However, because of diversification in the types of train operation and changes in the nature of each operation, such a test has become inadequate. To deal with this situation, we are conducting research to design a method to test driver aptitude more precisely from a wider perspective, including incorporation of a multiple reaction test. Part of the results from the new test will be shown to individuals who undergo the test so they can recognize how their personality and aptitude can improve. Counseling to help each individual overcome his or her weak points is also being studied.

The purpose of these studies is to help design the best possible method for *training and instruction.* To accomplish this objective, we are doing research on ways to accurately evaluate an individual's ability, personality, and attitude towards safety, during interviews. We are also doing research on formulating an integrated training and instruction system that incorporates effective counseling and improved communications to foster better human relations within the work place. Further studies are being conducted to develop an ideal human-centered environment within the corporation which will let its people work with more freedom, to better themselves and help better the company.

The Institute is also involved in the area of crisis management, which concerns the handling of various types of accident we may face in the future, particularly natural disasters such as earthquakes, typhoons, floods, and other serious accidents. Research subjects include such issues as: how the corporation and its employees should deal with such events, what actions should be taken by staff members in these situations, and what sort of information should be given, for their benefit, to our passengers and to people in the area affected by the accident or disaster.

The human component is multi-faceted. We realize, however, that our efforts would be useless if they were not *human-centered. That is, if they were not* based upon respect for every individual as a person. JR East is dealing with the human component by forging a philosophy of human-resource management that will nurture both the corporation and its personnel. The Safety Research Institute for its part, is now undertaking studies to determine how JR East can realize this goal of helping all individuals within our organization achieve their fullest potential.

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Vigilance for Railway Workers

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Vigilance for Railway Workers

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Relevance of Vigilance and attention for railway safety

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Summary:
1 Let's pay attention to vigilance!
2 Vigilance as a physiological substratum
3 multiple significations of vigilance
4 a complementary concept: attention
5 few convenient solutions to railways problems
6 vigilance in french railway context: the drivers example
7 Inadequacy and limits of the vigilance concept to face all the demands of the driver's job.

Introduction:
More and more, rail experts agree on the importance of human factors for railway safety.

Vigilance is widely regarded as a basic demand for safety actors. Therefore, SNCF Direction commissioned an internal task-force(1) to define precisely the meaning(s) of the concept. The first conclusions were published in Informations Médicales, the SNCF internal medical review. As members of the taskforce, we wished to explore further the paths surveyed by the taskforce.

Exhorted everyday to be vigilant to quality while purchasing, to moral obligations in civil life, vigilance sounds for us as a familiar and intuitive concept. Specifically for railmen used to safety, vigilance is a familiar demand. Think about the vigilance expected from track maintenance lookout-man while monitoring incoming trains to alert his colleagues, or about vigilance expected from drivers. In this later example, 'vigilance' is quoted(++) as a job-word referring to the technical system monitoring the driver's acquitting knowledge of yellow signals.

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(1) This taskforce met in 1990, and was composed of specialists concerned with human factors: Psychologists, Ergonomists, Human factors specialists, physicians, raimlen from different technical backgrounds including driver's managers.
(++) in french railways

Vigilance carries then different meanings for railmen, both common and specific to rail jobs.

1 Let's pay attention to vigilance!

According to the Robert french language dictionary, vigilance used to mean in 1380 'insomnia' and evolved to the meanings of 'watchful monitoring, without any fault' in 1530.
Relationship between vigilance and awakeness started only at the beginning of the 20th century with the physiological studies on sleep and drowsiness.
Quoting Vigilance today refers to different fields:
- sleepiness and awakeness
- stressing the capacity of monitoring watchfully and faultlessly a task
- standing attention to face a moral obligation.

Emmanuel KANT signaled as early as 1796 in its 'Anthropology from a pragmatic viewpoint' the complexity to the phenomenon (Kant 1796):
" Distraction is mood when attention looks away from certain dominant representations, and is scattered among others different representations from various character. When intended it is called misbehaviour; when involuntary, it is to be absent-minded."

Following Kant, we could define vigilance in opposition to misbehaviour.

More recently, Raymond Duval, a contemporary french philosopher, explained in his book 'Time and Vigilance' that:
" Being vigilant is to keep ready to react to an event without knowing when, how, and under which circumstances it would happen, even when ignoring whether it would happen. Being vigilant is to be ready to an uncertain event in order not to be surprised: 'thou know it: would the master of the home know the time in the night when robbers would come, he would stay awakened and would bar him drilling the wall. Therefore, you too, get ready, for you ignore the time His Son will come" (Matthew 24, 43-44). Vigilance is demanded when the meaning of what would or could happen can only decided before and not when it happened: if not ready, we would fail to grasp a too quick, lightning, undistinguishable event, occurring too quickly for our slow detection and replying capacities. When it would occur, it will be already too late for us if we were nor prepared to watch it. Just like being ready, on the road, to face driving hazards."

Vigilance is here connected with the capacity of anticipating an event which may or may not occur.

However, being ready to face events demands being awakened and fit for feeling, thinking and acting without sleeping! One shall be awakened. Vigilance stands here no longer for insomnia but for what physiologists name 'conditions':

'optimal conditions when brain receive informations from external word, assimilate them, and transmit them to other organs through sensor-motor coordination.'

These specialists link very often vigilance with awakeness, as defined :

' active awakeness is the humane operator's maximal capacity (hypervigilance) to handle in the best way a specific job. Active awakeness is characterized by presence of beta rhythms. Diffused awakeness is the humane operator's minimal capacity (hypovigilance) to handle properly to a specific job. It is characterized by presence of alpha rhythms." (2)

When used by neurophysiologists, vigilance points to all body adaptative phenomenons including nervous system functional answers or linked behaviour modifications such as variations during sleep-awakeness cycle.

2 Vigilance as a physiological substratum

The etymological meaning of vigilance is "awakeness". Awakeness characterizes one of the stages in the sleep-awakeness cycle. Study of cyclic organisation of sleep and awakeness and of other 'nycthermeral' cycles(3), and research on polygraphy(4), neurophysiological structures, and neurotransmitters combined to define vigilance as a physiological clue.

Main humane physiological functions and physiological parameters evolve on cyclic patterns: they characterize the humane chronobiological rhythms. These rhythms can be regarded as sinus function of time, and scientists use to define:

- period (T) defined in time units,(or frequency as 1/T)
- amplitude(C)
- phase (Q) referred to origin or reference phase, inside or outside the biological system.
- mean level (mesor) corresponding to the adjusted rhythm level during the considered epoch.

Biological rhythms are hereditary. Bur different environmental factors, the 'synchronizers',can influence and modify period and/or phase. Synchronizers don't create rhythms but do alter them.The rhythmic evolution of physiological parameters and functions build a time-basis in the body. Most of biological rhythms can be classified in three types, according to frequency:

-'ultraday' rhythms with high frequency: period from one second to 30 minutes
- mean frequency rhythms period from 30 minutes to 2,5 days; one good example is circadians rhythms with a 24 hours period.
- low frequency or 'infraday' rhythms, with period going from 2,5 days to very long ones such as one year.

The same biological parameter may present simultaneously 3 different rhythms, like the humane temperature:
the first circadian, the second monthly, the third yearly.
Then, several different cyclic variations with their own frequency can be observed in the same bilological parameter.

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(2) ergodatabank, Laboratoire d'anthropologie appliquée de l'Université de Paris V, Ed 1985
(3) chronobiologists define 'nycthemeral' as the lapse of time including one day and one night, which corresponds to a biological cycle.
(4) simultaneous graphic recording of several physiological parameters such as EEG (brain) and ECG (heart).

One of the most powerful synchronizer is the daily alternative shift between light and darkness, combined with socioeconomical organisation... <u>Chronobiology</u> studies these periodic variations of body functions.

Body time structure may be modified harmoniously: such modifications occur for healthy people isolated for a long time from their usual synchronizers. In that case, gaps in circadians rhythms can be observed from the usual 24 hours pattern, although phase relations remain on a stable pattern.

But disharmonious time structures changes can also affect human body: modifications of periods, and/or phase synchronisation can also be observed. Such modifications may be induced by:

- specific socio-ecological conditions including synchronizers-phase changes exceeding 5 hours (such as repeated schedule changes, transmeridian flights,...)
- specific illness
- specific cures (REINBERG, 1974).

Sleep-awakeness activity-rest alternations are among the more obvious cyclic body functions. In working conditions, the sometimes perturbed rhythms of these alternations have been regarded as one of the main factors of stress and tiredness of weekly shift-rotating workers.

Authors agree on the decreasing of stamina and mood average levels during the period between 9pm and 5 am. Important desynchronisation occurs during this time lapse corresponding to delayed synchronizers phasage of 6 hours (like a transatlantic flight).

Observations on 5am-1pm shifts workers, show fewer desynchronisation than perverse consequences of early awakening (at 3 to 4 am) cutting drastically paradoxal sleep which happens precisely during night ends. Tiredness felt] by workers would result more from sleep perturbations than from body time-structure changes.

<u>Chronopharmacology</u> proved the existence of cyclic productions of chemical substances and the reactivity of their nervous system targets.

"Consequently, tiredness or stamina expressions and their physiological or pathological variations can be coupled with alteration of time structures. They could result from some secretions desynchronisation (cortisol, catecholamines,...) or from some nervous structures desynchronous reactivity to substances they usually react to." (REINBERG, 1974).

Vigilance, as used originally by neurophysiologists, points to <u>all body adaptative phenomenons</u>, including nervous system functional answerings or behaviour modifications, specifically when coupled with alterations of sleeping cycles.

For a pragmatic point, we shall separate:

- activation level
- attention
- consciousness field mobility

Activation level represents quantitative aspects of vigilance.
It is partly linked with unspecific systems activity, and can be estimated through physiological measures (quantified EEG).

Attention is the aptitude to focus on useful information.

Consciousness field mobility provides the capacity to move the attention focus point and to draft a strategy adapted to a ever complex reality. Working man processes information according to the well-know single line model, with limited compiling capacity and saturation risks.

Physiological and psychological methods can both deal with these problems. Psychological testing, using simple or complex tests, seeks to evaluate regularity levels or missing ratios when facing rare signals...

Physiological testing try to point out reliable and repeatable criteria for vigilance (and more specifically activation) levels decreases. Therefore, brain electro recordings (EEG) are used to study the variations of the ratio:

(rate of alpha waves)/ (rate of beta waves).

As a matter of fact, Alpha waves point to lowered vigilance level. Numerous research teams recorded variations of heart frequency, eyelid moves, spontaneous reactions (actometry), variations of breathing frequency.

Any of these methods delivers reliable, valuable and sensitive measures in laboratory which proved very unfortunately far less accurate and risky when applied in working environment, namely in milieu disturbed by electromagnetic fields. Furthermore, tracking down hypovigilance phase may be useful, but the very point, safety men would be interested by, is predicting them before hazards may happen.

Vigilance is subject to cyclic variations, even after a normal night sleep. Twice a day, mainly between 3 and 5 pm and between 2 and 5 am, vigilance decreases significantly. Awakening arises through the complex combination of different interregulated systems characterized by positive or negative answers to some neurotransmitters.

Psychopharmacological studies explore possibilities of maintaining vigilance on a very long time and enabling sustained attention. Among the numerous tested chemical substances, the best known are caffeine and amphetamins. Although great progresses have been already performed, results in this field remain yet reserved to specific applications far away from day to day operations.

As a conclusion of this short review of bio-psycho-physiological components of vigilance and of structures underlying sleep-awakeness alternation, let us not forget that the man's happiness with thinking and information processing relies on his fondness for sleeping and dreaming.

3 multiple significations of vigilance

We just saw how wide were the fields referring to vigilance. Even restricted to scientific domains, this concept refers to different meanings, according to applied psychological, cognitive psychological, general psychological, psychophysiological fields.(5)

General psychology and numerous connex fields also use the notion of 'attention' to improve our understanding of problems posed by the common signification of vigilance.

Ergonomists use the "mental load" concept, although its definition remains quite fuzzy, varying along the numerous authors, and along the considered reality levels:

- physiological parameters,
- answering to psychotechnical testing,
- results and performances in information processing (but do they apprehend vigilance or processing capacity?)...

Through our bibliographic screening, appeared limited approaches of vigilance...., but not a single one could encompass comprehensively the various aspects already quoted previously in our review!

Various meanings of vigilance from 'attention', 'job processing capacity', 'lack of distraction', 'awakened state' build all the power and the ambiguity of this notion. To grasp its precise signification, one shall first fix both the references of the scientific method and of the reality level considered. Nevertheless, the confrontation of different theories could set more insights, if indeed no concept confusion occurs and scientific contexts remain clearly stated.

Remarks on laboratory conditions:

Many experiments run in laboratories all over the world are often based on restricted sampling. Though some of them do reproduce some of the real working conditions, their results shall still be regarded cautiously, for many recorded or unrecorded internal or external parameters can alter the measures.

Scientists, such as Michael W. Eysenck [1989], have noted significant differences in performance levels between 'outwards-oriented' or 'inwards-oriented' people. Further on, J.C. Sperandio, a leading french ergonomist, declares that physiological vigilance level is in no way the single factor conditioning the monitoring efficiency. He stresses that 'inwards-oriented people' achieve 'better' performances while EEG (brain electrical recording) show no noticeable differences with 'less performing' 'outwards-oriented' people.

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(5) Numerous publications on vigilance could be quoted. We reviewed some of them, such as works by T. Akerstedt (Sweden), R. Amalberti (CERMA, France), A. Chapon (INRETS Lyon, France), A. Coblentz (Laboratoire d'Anthropologie Appliquée, Paris, France), F. Lille (Salpétrière Hospital, Paris), A. Muzet (Strasbourg, France), A. Paty (Groupe de Psychophysiologie Cognitive, Bordeaux II University, France), J.-C. Spérandio (Paris V University), J.F. Richard (Paris VIII University), and also J.A Adams, D.R. Davies, J.C. Miller, R.G.C Fuller, R.R. Mackie in english speaking countries and K. Hashimoto in Japan...

Recent studies [Amalberti, 1989] confirm older researches (1972, 1969, 1951) in stressing both the importance of the concept widely labelled as 'vigilance' and difficulties to address its precise meaning. For instance, routine behaviour and lack of attention would be evoked in analysis of some incidents or accidents , as worktime organisation and job monotony, could be regarded as 'causal factors' of 'human errors'.In other accidents analysis, error may result from over-focussing on a single aspect of the job (while 'forgetting' the others), over-cautiousness, over-vigilance (up to stress) or from informations delivered to the operator.... Without forgetting to cite events where errors have nothing to do with vigilance or attention, but are due to inadequacy of procedures (which may be throughout un-readable and fuzzy) , lack of training, vocal information gap,....
Most present specialists or research workers regard definitions usually proposed of 'vigilance' as either too narrow or too sketchy. As a matter of fact, the notion of vigilance as observed by psychologists in behaviour studies do have connections with whole organic symptoms observed by physiologists. In this context the key-notion is 'activation' of the central nervous system, from which arises the 'reactivation' notion (through job, external stimuli such as bips or bell ringing, appropriate drugs,...).
Causes of activation level decrease are well-known: long and monotonous shifts, rare signals detection, sleep deprivation, certain drugs or medicines consumption...
Nevertheless, researchers, and namely 'cognitive psychology' specialists stress the inadequacy and inaccuracy of known physiological methods to comprehend activation. As a matter of fact, fine correlations between performances and slight activation level variations (awakeness, active watchfulness) are too fuzzy to be reliable. These slight variations seem to occur more frequently than broad variations (sleep, or hypovigilance). Therefore, psychologists re-introducted another notion, used a long time ago: attention.

4 a complementary concept: attention

Attention points to both ideas of:

- mind- focussing
- control and guidance of mental activity.

We already mentioned its definition as the aptitude of focussing on useful information. Vigilance stands then as a necessary but not a sufficient condition for appearance of attention mechanism. Issue shifts from physiology to psychology, and focuses on the understanding of how attention works and what could alter or promote it.
Following some highly regarded experts' opinion, such as REASON, ANDERSON, RASMUSSEN, attention is conditioned by the very kind of knowledge stocked in memory (procedures, diagrams, technical knowledges or know-how...). Any operational manager is familiar with the different kinds of knowledge mobilized and used by operators on duty, according to

- their experience, and how long they have practicing the job,
- the 'normal' or "unusual" context or situation.

Some knowledges are considered as:

-1) declarative when they deliver descriptions

of systems, such as, in railways:
switching posts systems
onboard systems in locomotives cabs (like TVM 300 and TVM 430 cab-signalling systems on TGV).
or of descriptions of environment, such as, in railways:
lateral signalling (opposed to cab-signalling)
electrical diagrams,...

-2) procedures, when they are used for action.

Declarative knowledges are a prerequisite for procedure knowledge, but are not sufficient to build up the 'professional know-how'.

Jens Rasmussen, researcher of the Danish Riso National Laboratory, separates several different functioning levels in worker's activity:
- beginners' behaviour is based on declarative knowledges
- in unusual situations, behaviour is based on production rules, which are knowledges linking expected facts (when A occurs, B shall follow)
- in usual situations, behaviour is based on know-hows; a very much 'automatic' behaviour may occur without any mental control, characterizing the trained worker.

What about the ergonomists' approach? Their records of on-line variations of worker's performance in real working conditions, clearly show that the more complex the job, the less significant and relevant the relationship between performance variation and physiological vigilance. As a matter of fact, other factors may modify the performance:
- nature of signals (stimuli)
- ways of performing the activity
- physiological conditions of the worker
- working environment.

Considering the importance of those different factors, ergonomists build up the concept of "mental load" which refers to the worker's global mobilisation on task achievement. Nevertheless, contrary to physical load, 'mental load' has no direct clue, and therefore cannot be measured, but only estimated and used to compare different working conditions for the same job.
Ergonomists do not reject the two notions of vigilance and of attention, but, as cognitive psychology specialists, consider they should not be mixed.

Furthermore, according to JC Spérandio [1984] quoting Piéron (1934, in 'Nouveau traité de psychologie' of Dumas) attention has a twofold characterization:
" an increase of the level of apprehensive, mental and motor activity" and "overrule of one form of activity on any other form available right on the spot."
Attention would require first some vigilance level and some mobilisation of nervous processes (Neither too few, nor too much).

5 few convenient solutions to railways problems

The reviewed bibliography(*) confirm Robert R. MACKIE ' s statement (1987): although theoretical progresses have been achieved in vigilance and attention fields, " few practical measures have been implemented to counter lack of vigilance", only classical and quite inefficient measures:

- work control and psychotechnical testing
- "safety nets", such as interlocking systems for switching posts, or other technical systems.

It's of peculiar interest for railmen to note that technical systems used in our operation were set up and improved regardless of any theoretical reference to vigilance. Very few references apart, documents facing the vigilance and attention sustaining issues fail to propose any convenient solution in working conditions.
According to R.R. MACKIE, this persistent failure can be explained by the gap between theory and experience due to:

1) researchers 'choice and appeal for 'esoteric' simulation testing
2) researchers' appeal towards generalisation.

Results from applied or theoretical researches on vigilance are more dependant on a specific working activity than usually acknowledged by research workers.
Theory lays down the choice of the considered variables, far much than real problems facing operators do. Therefore, we do know few about the real interest of the variables studied.

According to R.R. MACKIE, the researches conducted during the last forty years could enable us to set up "engineering principles" to put the finishing touch to verifiable and testable systems to cope with lack of vigilance effects.
J.A. ADAMS (1985), quoted by Mackie, considers as an error the idea endorsed for many years that fundamental research could step by step resolve these problems. He thinks the control of vigilance related phenomenons requires still studies during decades or centuries! According to Adams, scientists are prone to follow classical models derived from physical sciences, where identifying variables is the first step before inducing general laws. An other american researcher, A. Craig (1984), is sceptical towards applications of these different models, for psychology would, on his opinion, 'invent' its own experimental tasks. Without questioning quality or quantity of existing results, one can still be much disappointed when comparing the amount of time and money spent and the poor practical results achieved.

Regarding railways, Japanese studies on vigilance seemed to have been stopped since the end of the 60's. A SNCF/UIC study exploring in 1965 the different kinds of vigilance and attention testings concluded on the difficulty to elucidate whether they were actually testing attention or vigilance. It suggested that **vigilance could be a softened kind or even may be a radically different form of attention; vigilance would embody the perceptiveness, the psychomotricity of the operator.**
Furthermore, the SNCF/UIC study stressed how arbitrary were the definitions of these concepts. Anyway this study collected a great

(*)and quoted at the end of this paper

deal of valuable insights on statistical elucidation of signals collected through testings, and on physiological modifications: electro-brain-recording, electrocardiogram, electro-eye-recording.

More recently, researches conducted in France since the beginning of 1980's by Laboratoire d'Anthropologie Appliquée (LAA) on behalf of SNCF, on the VACMA system (vigilance control system with sustained bearing for trains' drivers) concluded also on the limits of an approach focussed on the measure of a single physiological parameter.

As a *conclusion*, most of specialists agree on the great difficulty of understanding the 'inner mechanisms' of vigilance and of attention, all the greater when studies are limited to tests in laboratory. Some scientists suggest a greater use of ergonomics to enlighten the notions *of vigilance and attention*: their relationships with knowledges required in different jobs, and the way automatised systems affect behaviour could give good insights on these notions. In order to achieve, at last, practical solutions, studies could be specifically targeted at:

- error possibilities
- analysis of incidents or accidents

6 vigilance in french railway context: the drivers example

All the notions previously developed in our review are of a significant relevance for railway operation and for railmen in charge of safety activities, whenever they act only partly in safety jobs, or are implied in full time jobs related with crew safety or train safety.

As previously noted, the relevance of vigilance problems may vary with the different jobs, according to specific working environment and risks faced by operators.
We choose here to restrict our attention on the very specific issue of drivers' vigilance, for at least two reasons:
- among safety jobs, the drivers work is the most time-constricted without or with few safety loops to recover mishaps
- the driver may face sting and sudden intensity variations of his(μ) activity following long periods of monotonous low-activity tasks, specifically on freight night trains, where sleeping-proneness may occur.

These reasons induced all over the world numerous studies on the so-called *'vigilance problems of train drivers'*. Our understanding of the problem is that we should address rather the "attention sustaining in monotonous situation" issue, instead of the solely physiological vigilance problems.

As previously noted, we do not question the quality of studies already performed, but we think that their operational accuracy could have been better focussed. We believe, that the definitions of the 'qualities' (among them, of course vigilance is of tremendous importance) expected from a driver can only be drafted

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(μ) his or her, though the overwhelming majority of drivers are male: only 3 female drivers on more than 16000 drivers in SNCF.

in consideration with the real working conditions, and not in general and global terms. Our first step shall therefore be towards a more accurate definition of what we expect from a driver in his real driving conditions.

Without developing here a comprehensive study of driving activity, let us list some of the most representative 'qualities' needed by a driver:

- quick mobilisation of prerequisites
    - training to prescribed task,
    - safety regulations,
    - technical knowledge of the locomotive(s) and or of rail-car(s)
    - practical experience
    - driving know-how

- ability to identify properly or to look for, relevant information at a specific timing during his task-handling; these information may be scattered and present:

    either in the driving cabined (pictorials, dials, indicators, written instructions, Facia, pips, radio messages, signified noises coming from the engine ...)

    either all over in the environment (signals, other tyrants, track surroundings, road vehicles nearby crossing levels, people on the verge of falling on the track...)

- capacity of processing these information, or of memorising them for a connex process, to build up a diagnosis which could lead to further information investigations.

- frequent time-stress (speed of trains, braking distances, punctuality), which demand adaptative action processing.

- capacity of instant reaction, at any time, to face the unforseen, sudden, hazardous events as soon as they are detected. This capacity induces very strong and sudden cognitive activity variations. (information identification and processing)

In this working situation, beyond the job strictly prescribed by regulations,
" the operator shall use individual on-line strategies to manage his activity; these strategies demand a maximal integration of available data in a model encompassing all the hazards processing; the construction of this model is part of the operator's domain". (FAITA and VALLORANI, 1986). (!)
Starting from an analysis of the driver's behaviour while facing signals (specifically the single red, which in SNCF rules demands stop, and proceed at caution 'marche à vue'), Faita & Vallorani stressed that drivers were not only complying "passively, and immediately" to signals orders(#), but were compelled to develop a an active identification/analysis of signals shown. (think about temporary speed limits due to track works combined with direction changes demanding speed restrictions). Uncoding complex and

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(!) M. Vallorani is a member of one of the drivers trade-unions, and used to represent workers in SNCF Board meetings.
(#) the first SNCF safety rule expects 'every railman to comply passiveley and immediately to signals' (and of course as Nelson would have said, to do his duty...)

interfering data, which could be shown one after the other and combine in composite information, is one of the main feature of the driver's job.

We agree with these authors when they concluded: "Beyond a regulatory corpus demanding integral and passive regard to coded information and prescriptions, driver shall sustain a faultless mental activity to conduct instantaneous analysis of any normal, exceptional or un-normal context."

7 Inadequacy and limits of the vigilance concept to face all the demands of the driver's job.

It is time now to wonder whether vigilance, defined here as 'sustained attention', is a prerequisite enabling drivers to handle their job.

Dr A. Ombredane and Pr J.M. Faverge answered this question as early as 1955 in their book "l'analyse du travail" (job analysis). Specifically, A. Ombredane recalls in the foreword, his experience of job-analysis for metro-drivers conducted on behalf of RATP (Paris urban transports authority) to devise psychotechnical testing for drivers selection. Although metro driving used no automatic system, his team conclusions are still of great relevance for railmen today; let's quote A. Ombredane:
" I was said that the railcar-driver's job in tunnels demands attention, and that he shall pay attention to signals. Here is, labelled in terms of worker's psychological attitude, a demand arising from the job. But what shall we understand by attention? Its own etymology points to a state of watchfulness, tensed towards something which may happen, inhibiting current concerns, ready for possible reactions, with somekind of stress and anxiety rate specific to alert situations. Early overreaction and erroneous anticipations may be feared in this situation. Fresh new drivers unquestionably show such dispositions, which are subdued up to disappearance with routine. The 'old' driver turns over freely in his mind his worries and glees, brakes and starts again unconsciously, reacting to signals without hurry or delay. He would be at odds to say whether he actually paid attention or not(+). But he could reasonably confirm that he actually obeyed to signals. It is quite obvious to understand the impossibility to define a permanent demand on a job through the worker's reaction capacity while this capacity may fluctuate so much and be absorbed so dramatically. What job demands is not attention(£) but compliance with signals under an optimal pattern between some tolerance boundaries, regardless of the driver's disposition, as far as he complies. Arising from these signal compliance, significations must be drafted to precise the definition of compliance. How many different signals types? How can they be discriminated? How are they scattered along the track? Do they show redundance (repeated signals)? Are they temporary of permanent? expected or not? How long is the delay left to react after signal occurrence? Do their time-space structure fits with the space-time structure of the

(+) we could say 'whether he was vigilant...'

reaction ? (|) What is the seriousness of neglecting them and which sanctions would trigger this neglect, probably or surely ?..."

Dr Ombredane's statement makes clearly the point: through his relevant insistence on task and on the role of disposals guiding the operator's actions (we would speak today of "man-machine interface quality"), he stresses rightly that optimum safety level doesn't depend solely on individual physiological or psychological parameters, but results also from the global technical and organisation complex. A. Ombredane showed us the way to a long neglected human factors approach of human work, aiming at context clearing and adapting it to physical and cognitive capacities of operators.

As a conclusion, our review of the relevance of the vigilance concept in railway safety shows that no-one can pinpoint hypovigilance as a relevant factor of occurrence of accidents. The single conclusion on physiological vigilance needs no big studies but common sense: we shall not tolerate sleeping drivers in our cabs!

Conclusion

None of the single notions of **vigilance, attention, mental load** can encompass alone an operator's performance, but each has its relevance in a specific context, and may reflect the operator's activity in some respect.
Bibliography shows that mechanisms managing the vigilance and attention may fluctuate, and are based both on a physiological substratum and on knowledges, know-how, and know-how-to-be used by operators in real working conditions. Progress achieved in theoretical studies on vigilance and attention, sustained very few practical solutions, lest for railways.
Meanwhile SNCF does feel concerned by this issue, and decided as a first step to conduct this review of the topic to guide new efforts towards improved efficiency. Ways of progress shall use practical results in any relevant scientific domain, while taking care of their social acceptability both by managers and workers.
Improvements of man-machine interfaces ergonomics, and construction of new safety nets (such as KVB, presented by M. Joing in these conference), and of new safety loops, are already on course. But we shall not neglect managing methods which today remain well-suited to face this issue:

- crew's training
- plain and pragmatic information on factors crippling vigilance and attention such as day to day life hygiene, risks provoked by some medicines,....

Simulator training seems a very promising way, when used by crew for improving their weak points.

(|) think about speed limits signals for instance!

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International Rail Safety Conference

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Paper 9219

Akita Matsuzaki

Railway Safety for Labour Union

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International Railway Safety Seminar 1992

Railway Safety for Labour Unions

Mr.A.Matsuzaki
Japan

Railway Safety for Labour Union

Akira Matsuzaki
President
East Japan Railway
Worker's Union (JREU)

Thank you, Mr. Chairman.

Ladies and gentlemen, together with the company management of 2 years ago, I speak as a representative of the JREU, which sponsored the International Railway Safety Conference in Tokyo.

In Spring of this year, our JREU was criticized by a journalist who called it a "Mafia". The criticism is that we intervened in the operation of JR-East Company and are controlling it from inside. He based his censure on the idea that "labor and management consult with each other on everything including industrial facility investment".

It is true that the labor and management of JR-East Company hold various discussions associated with facility investment. Starting with the installation of the ATS-P safety device, the results of these discussions include improvement of the platform facilities, based on the opinions of the conductors and station masters, the development of the approaching train alarm device, reflecting the ideas of the trackmen, and improvement of the motorman's cab based on the opinions of the motormen.

This journalist criticized these measures as unfair labor union intervention into management. We believe, however, that they are absolutely necessary and indispensable for safety. It is unfortunate, but this episode shows that the old way of thinking, which will not allow labor unions to set foot within the sacred domain of management, has strong roots that still remain in Japanese society.

There are many examples that can be taken from recent events in Japan to illustrate what happens when business managers ignore proposals from labor unions and workers on the spot. One year ago, there was an accident involving the Tokaido Bullet Train, in which the train was going at a speed of over 200 km/hour with the axles in the locked position. Fortunately, for reasons of good luck, the train did not derail, but about 6 kilograms of steel was thrown off in sparks and the wheel edge touching the rail became flat for a length of 300 millimeters and 30 millimeters in depth.

During a spot check the previous night, the inspector noticed that the lubricating oil of the gear case was boiling, and he reported the revolution stoppage, but his opinion was ignored. On the day in question, the motorman reported the occurrence of damage based on the alarm in the motorman's cab, but the control section instructed the driver to continue. This accident occurred as a result.

This year, the new Tokaido Bullet Train has started to run at a maximum speed of 270 ~~340~~ km/hour. It appears that trouble has occurred repeatedly, including the dropping off of machinery under the train right after it starts moving. On May 6, the bolt attached to the main motor fell off. The violent shaking of this motor caused the WN joint to come off, which in turn caused great damage to the machinery under the train. As a result, the brake hose cut off, causing the train to be stopped for a five hour period. In this case as well, the accident occurred because the ideas from the labor union to improve the train cars, based on people working on the spot, were ignored.

The JR-Tokai Company is responsible for running the Tokaido Bullet Train. The management at this company felt a strong hostility towards the existence of the labor union, which strongly voiced its opinion representing the workplace, and it decided to infiltrate the union with people from management. Thus, the labor union was changed into a controlled union with the total support of management. I strongly warn that tragic accidents are likely to occur due to this kind of management attitude. Case in point is what happened to a train of the JR-West Company, which, believing that safety only the concern of management, did not participate in the International Railway Safety Conference held in 1990. A short half year later, the Shigaraki-Kogen Railway was the site of a head on collision that claimed the lives of 42 people. The over confidence of management in terms of safety will lead to big losses.

Fortunately, the JR-East Company is undertaking both earnest as well as frank consultations between management and labor for the sake of safety. Recently, an accident occurred in which a large truck entered a railroad crossing directly in front of an oncoming passenger train, killing the motorman. Just by saying that the accident was caused by the truck driver's reckless driving will not bring the motorman back to life. Therefore, we made a request to management concerning the immediate improvement of the motorman's cab, asking them to make further investigations in order to save the life of the motorman in a similar kind of accident and to adopt a new train car design.
Railway safety is being protected by the joint effort of management and front line workers in the field. From this matter of fact reality, it is absolutely necessary for the railroad industry that the problems raised by labor unions, based on workers in the field, are heard through face-to-face consultations. This fact has been established by the Japanese experience, including several tragic accidents, in the 2 years since the International Railway Safety Conference.

We greatly appreciate the attitude of the JR-East Company management which faithfully responded to the problems raised by the JREU. Of course, there are many points of confrontation between management and labor in the JR-East Company. Intense debate associated with the working environment of the one-man driver motorman and how to deal with the aftermath of accidents that have occurred is continuing. We think that these kinds of confrontations do not go beyond a difference in the points of view of management and labor, and that they will definitely not go away.

The problem is not that confrontation exists, but that there is no place to earnestly discuss and resolve the points of confrontation. It is the workers in the field that know the most about safety.

I believe that we will continue to strongly voice our opinion to management from now on for the sake of the safety of laborers working on trains and railways. I think that this is necessary at all costs to raise the standard of railway safety another notch.

At the same time, we have actively accepted opinions from management concerning the necessary education needed by workers for safety and other problems associated with safety. The reason why is because although safety is not something that can be guaranteed unilaterally from above, the opposite of that statement is also true.

In the majority of the cases, it is indispensable for the labor union to raise grievances and opinions from below, that is, from the front line, and to build towards theories and policies that have adjustability as a labor union. In other words, I do not think it is fair to hit the company directly just with feelings and opinions from the front line. The problem here is that these feelings, grievances and opinions have some sort of basis and that they are formed according to the specific circumstances of each workplace.

Therefore, efforts and abilities that constantly improve the quality of labor union leadership and uniformly construct, as much as possible, the various grievances and opinions according to each set of circumstances, are necessary.

Labor unions cannot neglect or remain idle concerning this issue.
The reason why is that labor unions must have fixed medium and long term views and strategies to move towards the future, not only to cope with the present, and they must attempt to solve problems by promoting their integration.

If the labor unions were only to emphasized the straight opinions of union members, there is a danger that this would only contribute to the growth of the confrontation between labor and management. Many policies associated with safety have been based on the experience of various accidents that occurred in the past. At the same time, it aims at absolute value in terms of safety and zero accidents, which seems to be very difficult to realize.

For example, there are 80 railroad crossings in the operating area of the newly built Yamagata Bullet Train "Tsubasa" line, but it is not possible to actually have them all abolished or solidified due to budget and other considerations. In addition, it is not possible to obstruct the force of a

30 or 40 ton dump truck that comes flying in after the gate mechanism of the crossing has gone down (blocking the entrance to the crossing with a 10-centimeter thick steel bar would be a different story though...).

If both labor and management have the attitude to advance consultations and discussions energetically, decisively and responsibly, then the possibilities for reducing the number of accidents down to zero will be endless. The idea that there "have to be" accidents for there to be safety will disappear. For that very reason, the road towards "0 accidents" or absolute safety must be earnestly, scientifically, and passionately pursued above all else, but it is also necessary for labor and management to discuss their differences humanely and to promote bilateral policy.

In the history of the Japanese railroad industry, sadly it has not been possible to liberate ourselves from the situation in which accidents occur one after the other while, in terms of safety, management sees things only from its point of view, labor sees things only from its own point of view (because the points of view of labor and management are necessarily different to begin with), the assertions increase mutually, the conflict intensifies, and no points of agreement can be found. Within the process that achieves national railway reform through division and privatization, in the JR-East company, labor and management get together at least once a month to really talk, confront each other, and exchange opinions on all aspects of running the business, and above all, to aim at discussions that will lead to understanding concerning safety problems. ... not every thing will be agreed on of course, but...

Also, in addition to the management conferences participated in by the heads of both labor and management, sectional meetings are held with the union president and the company vice president associated with safety problems in charge. At these meetings, resolution measures are thoroughly discussed after watching on-location videos concerning the cause of as well as measures concerned with the accident that occurred.

This directly advances the discussion of accidents and safety problems, but at the same time, labor and management will overcome each specific

barrier through discussions to reduce the number of accidents to zero, while building a mutual feeling of trust.
The vice president of JR East company in charge is not only a technically related authority, but also possesses superior talent to promote the discussion of safety problems based on human engineering and human respect.

In this way, the JREU, with its unique style of confrontation between management and labor, but not infiltration (nearly equal) is radically and therefore progressively promoting this movement. (Still, it cannot be denied that the bureaucratic structure of national enterprises continues to depend on separate labor and management). So it is steadily moving forward.

I think it is truly a shame that, not all of the labor unions participated in this conference, considering it was held in Japan. I strongly hope that cooperation between labor and management will continue in the future and that an international labor and management conference for safety will be held soon. Thank you very much for your kind attention.

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Chris Hall

Care Management of Workers Compensation and Rehabilitation

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Care Management of Workers Compensation and Rehabilitation

Mr.C.Hall
ANR

CARE MANAGEMENT OF WORKERS COMPENSATION AND REHABILITATION

The AN experience in this area of Human Resource management is best described as shifting from an uncaring approach to one of caring. The caring however is not purely a moral caring but more a concern for sound management of an issue to support those motivated toward the goals of the organisation and managing the issues for those who are pre-disposed to taking advantage of the system.

In the early days of AN, workers compensation was not identified as a specific cost or issue. Like many public service organisations the rail systems that formed AN were not directly accountable for workers compensation. The cost was treated as an overhead that was administered rather than managed.

For example, a security guard injured at work who was not able to perform that job was returned to work in the Signals and Communications area. He was employed by the Signals and Communications Branch, but was paid through the budget of the Security Department. For Security, even though he was on their budget he was out of sight and out of mind. To Signals and Communications he was a 'free' employee up to a point. However they regarded him as a liability because if re-injured or if he aggravated his injury the cost and his wages would then be picked up by Signals and Communications.

Consequently life was difficult for injured employees. They were not wanted in light duties positions and rehabilitation was not contemplated. This was largely due to a need to reduce staff numbers.

As the workforce numbers reduced and the organisation became leaner there were fewer positions in which injured people could be accommodated. The question of how to use these people was put in the too hard basket. Costs increased through workers compensation and lack of management.

The total cost of AN's workers compensation liability was not known until a review was requested in 1985/86. This action was taken as a result of the increasing number of employees on AN's payroll who were either at home and never likely to return to work or at work on 'light duties'.

The other issue that alerted management to the need to identify the true cost was the increasing amount of litigation. Under the arrangements in Australia prior to 1988 employees could, in addition to claiming workers compensation, claim damages at common law, with no limitation on the amount and with no effect on compensation paid to date. These claims were often in the order of $100,000 up to $300,000. Lawyers were becoming better at it and courts more generous.

In 1985/86 the liability was estimated to be around $110m. However this figure was not accurate. It was not until 1990 that a valid actuarial assessment was made because information systems could define the costs. Estimating of claims was also based on a management approach that did not make provision for cost reduction through rehabilitation or case management.

Once the costs were known, the task of separating the components was necessary to define the problem. These components were common law claims, long term claimants (at home and not likely to return to work), light duties employees and general claims for minor injuries.

In parallel with the review of workers compensation the accident prevention and safety management in AN was being focussed on to handle the problem at the cause.

The liability however could only be reduced slightly and over a very long period of time if the post injury situation was not better managed.

A key component in the strategy of handling the workers compensation problem was and is rehabilitation. Rehabilitation however, to be successful, required not only professional support but also a change in attitude to claimants. The stigma attached to workers compensation had to be removed.

As early as 1988 a policy of rehabilitation was endorsed. It was an approach promoted and administered by the Human Resources Division with significant resistance throughout the workforce for the reasons mentioned above.

The policy identified the need for AN to commit itself to a rehabilitation program for injured employees. It also identified the responsibilities of all involved in the process ie:

Australian National believes that a planning rehabilitation program will:

- minimise time away from work
- maintain good employee relations
- reduce uncertainty and restore productivity of the injured worker
- maintain self esteem
- be ultimately cost efficient for Australian National and the wider community

Rehabilitation Unit Responsibilities Include:

- identifying rehabilitees
- informing Managers as necessary
- arranging early contact with employees
- reducing anxiety caused by financial or domestic problems
- developing Case Management Plans
- arranging work trials and securing co-operation of supervisors and staff
- arranging adjustment of work station if necessary
- educating supervisors and managers
- assisting by referral to professionals
- following up work trials.

If all attempts at rehabilitation are unsuccessful, recommending other appropriate action eg medical retirement.

Line Manager/Supervisor Responsibilities Include:

- identifying rehabilitees and taking an early interest in their welfare
- referring rehabilitees to the Rehabilitation Unit
- assisting professionals as required in assessment of job placement and design
- actively supporting and encouraging an employee undertaking a rehabilitation program.

Rehabilitee Responsibilities Include:

- communicating regularly with Rehabilitation Unit supervisor
- taking an active part in the rehabilitation program

Whilst the introduction of legislation in Australia in 1988 assisted and supported this approach by making rehabilitation mandatory, its success relied on a complete attitude change in the management and workforce ranks.

Successful rehabilitation is defined as 'the combined and co-ordinated use of medical, psychological, social, educational and vocational measures to restore function or achieve the highest possible level of function of persons at work following injury or illness'. (Australian College of Rehabilitation).

Key players in the process therefore had to be the supervisors, managers and rehabilitation staff. One of the first steps taken was to design and run professional rehabilitation management and supervisory training programs, develop and co-ordinate return to work programs, establish a rehabilitation information system to track and assist in case management and to actively support managers and supervisors in handling the return to work of injured/incapacitated employees.

It was also recognised that the most essential ingredient in AN's rehabilitation program was motivation. Motivation toward rehabilitation on the part of the injured worker and his manager, supervisor and co-workers. A shared concern for the individual and a positive attitude to returning to work is a guarantee of success. Without it of course there is limited success.

The change required in AN can be represented as follows:

COMPARISON - COMPENSATION VS REHABILITATION

OLD	NEW
Emphasis on compensation rather than rehabilitation, increasing common law payouts, medical/legal conflict emphasis (compensation neurosis).	Emphasis on and incentive towards rehabilitation, limits on common law payouts, vocational consensus emphasis on work return.
Employer encouragement rather than responsibility for work return (consultative basis).	Employer responsibility as well as encouragement (workplace based).
Lack of co-ordination; medical/vocational employer/employee, etc.	Co-ordinated procedure involving case manager.
Focus on cost containment through retirement (partial/total disability) work return not a priority.	Focus on cost containment through rehabilitation, earlier work return.
Attitudinal barriers - negative 'compo' mentality, light duties.	Attitudinal challenge 'problem solving' mentality alternative duties/retraining.
Lack of individual access to rehabilitation, delayed referral.	Clear access, specific mandatory referral.

An education program for managers and supervisors informed them about the issue. AN's situation was made clear and in a seminar format real cases were discussed and later followed through. Through professional support an increasing number of successes were experienced and these encouraged all involved as well as workers and managers in other areas.

Top level support was required from executive management for flexibility in approach and in putting aside budget issues, taking an AN view and demonstrating respect and care for the individual.

The results to date are indicated through these statistics.

eg: Average working days lost by long term injured ie greater than one month absence -

Pre December 1988	=	171 days
Post December 1988	=	71 days
December 1990	=	60 days
June 1992	=	27 days

Return to work rate -

1988/89	52%
1989/90	70%
1990/91	75%
1991/92	88%

The approach clearly has been successful. Responsibility and a positive attitude is shared and the culture has changed.

Of course not all employees could be rehabilitated. The long term employees left at home for years were often beyond return for various reasons. Some were injured to the extent that they were permanently incapacitated, some had become set in this situation with a mental block to change and some were 'playing the system', ie accepting payment yet working elsewhere without declaring it.

There were also the $25 million worth of Common Law claims to be dealt with and long term light duties employees not willing to participate in further rehabilitation.

In brief the long term cases were reviewed. In cases of suspected fraud investigations were made and even surveillance employed. Similarly in relation to some Common Law claims similar approaches were employed.

With Common Law claims another approach adopted was negotiated entitlements rather than seeking resolution through the courts. The approaches taken in this area have reduced this liability by $20 million in three years with claims being settled on average for less than 50% of the amount under the court system.

Long term light duties employees were given increased medical review as were long term workers compensation cases. Through this assessment, opportunities were revealed and pressure was put on individuals to consider work-related options

One option taken by a significant number of such people was that of retrenchment with a severance payout based on AN's redundancy scheme provisions. This 'payout' relied on demonstrated rehabilitation and return to work and therefore an end to the employer-employee relationship on termination retrenchment, eliminating all future salary and wages costs.

Those approaches to manage the problems caused through the 'old culture' and successful rehabilitation today and for the future have resulted in AN's liability for workers compensation reducing significantly:

1989/90	$92m
1990/91	$60m
1991/92	$46m

In conclusion I can only stress the importance of the role of managers in the rehabilitation process. Caring for injured workers is not optional and the managers role does not end when a worker is injured; it intensifies.

If managers do not participate in rehabilitation only two stand to lose, the injured worker and the company. There can be no better reason to care.

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Michel Joing

Incident Investigation and Discipline Procedures

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Incident Investigation and Discipline Procedures

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INTERNATIONAL RAILWAY SAFETY SEMINAR

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INCIDENT INVESTIGATION AND DISCIPLINE PROCEDURES

Until relatively recently little was known about the phenomena of human error, and the analysis of incidents laid strong emphasis on the disciplinary aspect. This led to greater uniformisation and the increasingly systematic application of penalties to the detriment of analysis of the event itself, the circumstances which led to it, and the professional qualities of the individual in question.

This observation was underscored by the various projects carried out in 1989 concerning the revision of the safety policy in the light of the catastrophes which occurred in 1988.

A new approach has been defined based on:
- enriching feedback,
- dealing with individual cases on a personalised basis.

A full and detailed knowledge of incidents and irregular situations, and a close analysis to reveal their origin and the processes set into motion make it possible to deduce the actions required to prevent their re-occurrence. This has made it necessary to implement specific tools (data bases) to gather and analyse a substantial mass of information. But if such an approach is to be successful, a state of mind and a climate of trust must be built up, overcoming any hesitation on the part of an employee with a safety responsibility to express himself, by making him aware that his errors and difficulties could be instructive to others, provided they are made known and exploited.

To move towards this objective, it proved essential to modify the previous corporate approach regarding penalties. An error is now no longer considered systematically as misconduct, for which a penalty should be imposed, but as a deviation from the norm, whose causes must be found to prevent it arising again, or to reduce its possible consequences The search for causes is dissociated from the apportioning of responsibility.

The new approach implemented in 1989 had the following objectives:

- to enrich our knowledge of the events which in fact caused the incidents,

- to favour a positive approach:
  - . by analysing what happened with the employee involved in an incident or a case of apparent misconduct,
  - . by devising an action programme in conjunction with the employee if a refresher course proves necessary;

- to recognise and take into account the concept of human error,

- to distinguish clearly and explain the various stages of incident processing, namely:
  - . immediate corrective measures (if necessary),
  - . analysis, and the devising of an action programme,
  - . penalty (if necessary),
  - . suspension from duty for safety reasons.

- to use a discipline procedure adapted to the individual cases in which this approach seems useful to rectify the situation,

- to assert the importance the company attaches to certain "golden" safety rules by introducing a system of penalties devised as a collective communication tool,

- *to assert the responsibility and autonomy of the local division.*

The new system put into place is shown in diagrammatic form on the table in the appendix. It comprises the following stages.

Analysing causes

If the local manager, after being informed of a case of apparent misconduct or a breach of safety rules, harbours a doubt about the overall capacities of the employee, or observes a succession examples of of apparent minor misconduct which could amount to a safety risk, he undertakes – in liaison with the unit headquarters and with the employee in question – a full analysis of the causes.

This analysis can be based on a document listing all the relevant parameters:

- events leading to the incident or case of apparent misconduct,
- entries indicating the technical data relating to the incident,
- similar cases recorded earlier, particularly through feedback;
- human parameters: age, work schedule, working conditions, environmental particularities...
- work organisation: structure in place, instructions for application...
- conditions relating to the training, qualification and continuous training of the individual in question.

Assessment balance–sheet

Once the analysis of causes has been completed, a balance–sheet should be drawn up with the employee concerned, to determine the underlying reasons for the anomalies observed. If necessary the balance–sheet can be backed up by medical or psychological examinations if these seem relevant to the final diagnosis.

If necessary, the balance–sheet is used as a basis for the definition, in conjunction with the employee, of an appropriate action programme if a refresher course is needed to enable the employee either so that he can obtain the safety qualification required to occupy his previous post, or be transferred to a post which is better adapted to his abilities.

The action programme could be:

- a refresher course,
- temporarily adapted duties,
- a medical procedure.

Preventive measures

If the analysis of causes, or the assessment balance–sheet, leads a manager to doubt the overall capacity of an employee to fulfil his safety functions, he must relieve him temporarily of his duties.

This measure should enable:

- the employee to regain the balance which he may have lost following an incident or accident,
- the local manager to wait, without taking any safety risks, before making his definitive judgment, after an interview with the individual concerned, and after the results of the additional examinations requested have been obtained;
- the activation of the action programme decided during the assessment balance–sheet phase.

The suspension from duties is of limited duration, and ceases as soon as the local manager has come to his verdict.

This procedure is provided for in the staff regulations, and does not constitute a penalty.

Penalties

Apparent cases of minor misconduct and of clear but isolated professional error result in the implementation of a minimum concerted action programme and a feedback–type analysis.

The most serious types of misconduct, which give rise to the heaviest penalties, are those committed wilfully or deliberately. In view of their nature they result in the immediate temporary withdrawal of an employee from his duties and suspension. The employee will not be allowed to return to his duties until the action programme agreed between him and the head of his unit has been completed. The following cases fall into this category:

- alteration of mechanisms or use of means to overcome interlocking devices effected for such mechanisms,
- fraudulent use of devices,
- drunkenness,
- train driving without due care and attention...

Other types of misconduct can be classified under the heading "professional environment misconduct". These are serious cases of apparent misconduct or serious professional errors. In this case it is necessary for the company to clearly indicate that certain breaches of rules, whatever the circumstances, could potentially have serious consequences and cannot be tolerated.

In addition to the imposition of a penalty, which could be as serious as suspension, an action programme is devised, and the conditions in which the error occurred are analysed in detail at local or regional level.

This category includes breaches of rules such as:

- the authorisation of wrong–line or wrong–direction running without first having ensured that the part of the track concerned is free and will remain so,
- failure to follow the fundamental rules of single–track running,
- agreeing to works without ensuring the protection of the track,
- passing an absolute stop signal,
- serious irregularities concerning the application of measures specific to electric traction (catenary protection)

The local hierarchy is responsible for determining the nature of the misconduct in each case.

Penalties as a whole should therefore be considered as corporate communication tools, and should have:

- individual impact: indicating that the incident has been recorded and dated,
- collective impact: emphasising the absolute necessity of not going beyond certain limits.

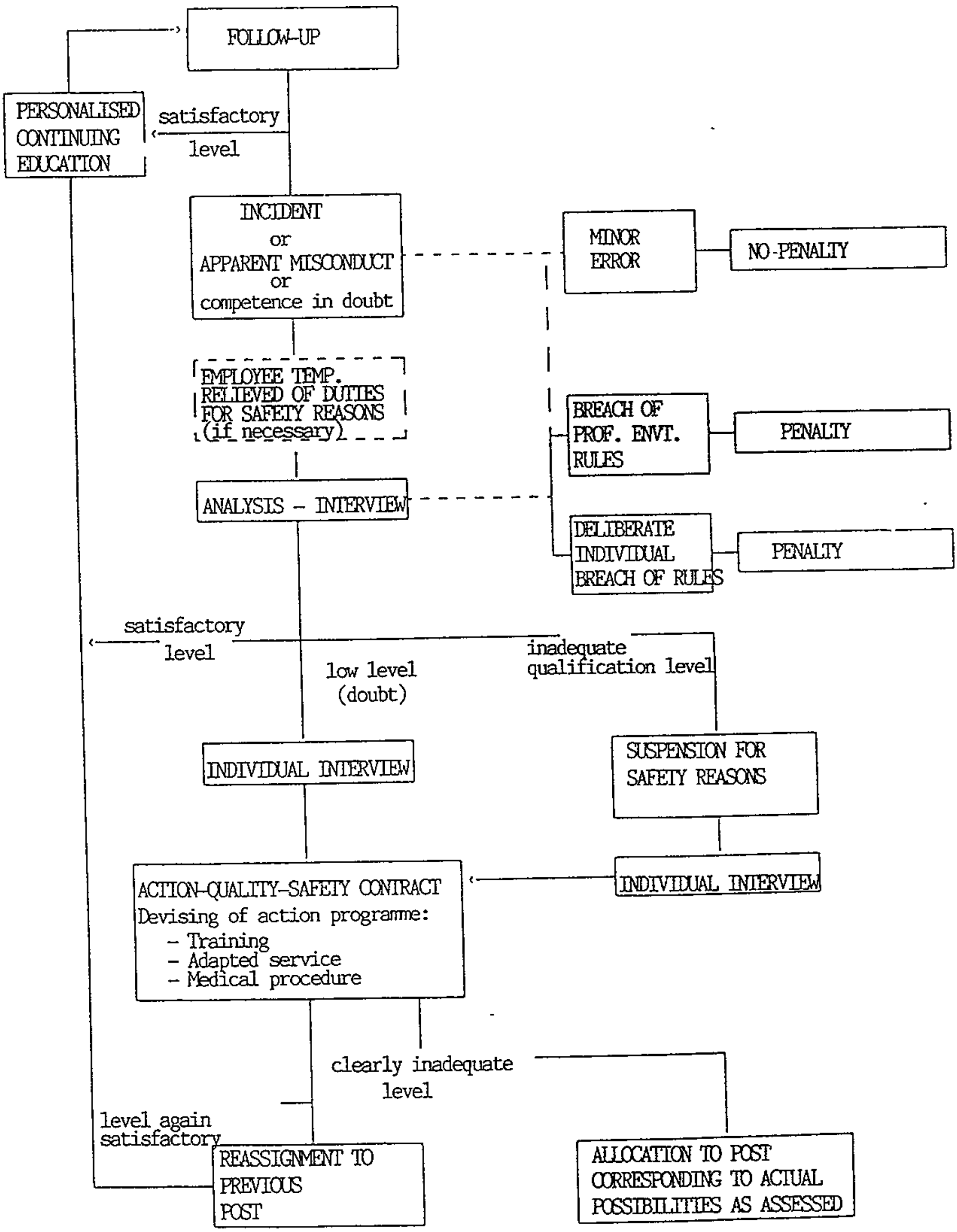
This new policy seems to be bearing fruit, as for example in the case of passing stop signals, the following have been observed in recent years:

- a strong increase in the number of incidents reported, which are then analysed,
- no significant variations in the number of near–accidents.

What is observed therefore is not a deterioration of the safety level, but in fact a better knowledge of what is actually not functioning correctly.

This approach, adopted 3 years ago, is long and difficult. It must be conducted tenaciously and with perseverance, as it represents a major dimension of corporate culture.

FLOW DIAGRAM OF NEW SYSTEM



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David Rayner

British Rail
Human Factors Research and Application
An Update

Publisher
2000 International Rail Safety Conference

International Railway Safety Seminar 1992

B.R.Human Factors Research and Application

An update of work being done by Roger Taylor
Head of Human Factors Unit,
Research Division
British Rail

Mr.D.Rayner
British Rail

BR HUMAN FACTORS RESEARCH AND APPLICATION

Introduction

It is now widely accepted that the performance of people is the major factor in determining the safety of a railway and all of its activities. Human factors are increasingly the focus of attention both in accident investigations and in the development of strategies towards safety improvements. The purpose of this paper is to describe progress by BR in its research programmes building on the work reported by Taylor (Ref 1) at the 1991 International Railway Seminar.

The emphasis placed on this activity by BR is illustrated by reference to the 1992 Safety Plan:

> "It is British Rail's policy to be in the vanguard of research to understand and apply the lessons of academic research into the causes of error and the often misguided and well intentioned misuse or neglect of rules and instructions."

The paper will briefly outline research into human behaviour, perceptions and attitudes covering three key railway occupational activities - driving, shunting and track work.

Resources

The study is being conducted within British Rail through its Research Centre and benefits from an academic link with the University of Manchester. The in-house Human Factors Team works closely with the University's department of psychology, with post graduate researchers working under the guidance of Professor Reason.

Approach

Fundamental to meaningful research in each of these areas is the need for the researchers to understand the true nature of the appropriate job and to establish a relationship with the workers to promote a free flow of information.

This has been achieved through a number of actions including the researchers joining induction courses for new entrants, joining gangs and carrying out the same tasks as the other members of the gang, talking to local Trade Union officials and freely answering questions raised about their research.

Information was gathered in a number of ways including observation, interview, general discussion and quantitively through questionnaires.

Driver Study

The first phase of this study concentrated on evaluating the perceptions of drivers compared with those of their managers and more senior managers.

Subjects from each of the three levels of the organisation were asked to give their views on the relative importance of a number of factors on the safety of the railway. In addition they were asked to indicate how they thought people in the other two levels would rate the same issues.

It revealed the existence of misperceptions between different levels of the organisation.

The second phase of this study is exploring the link between misperceptions and communications. Regular safety meetings have been introduced by BR as part of the safety programme, as a means of establishing a two way flow of information on matters affecting safety. Views of drivers on this process and other communications links and management were collected by questionnaire at the end of their first attendance at a safety meeting. Their views will be sought following attendance at several such meetings to see how they might change.

The first round of safety meetings for drivers were conducted by the Train Crew Leaders in a manner which encouraged two way discussion. All those attending were encouraged to contribute their views to the discussions. The success of the meetings was reflected in the drivers' views (Fig 1), seeing the process as useful (mean 4.06) and feeling those conducting the meeting listened to their views (mean 4.06).

In contrast communications are seen as poor (mean 1.94) and managers are not seen as doing a good job (mean 2.22). Further analysis of the driver responses reveals that of all the factors noted their view of communications is the most significant predictor of driver attitudes towards managers.

<u>Shunting Study</u>

Shunting is a high risk activity on BR, resulting in 19 fatalities between 1982 - 1990. An initial phase of this study was the analysis of shunting accidents statistics investigating the relationship between causes and the consequence of the accident. It showed (fig 2) that the most common cause of minor injuries (collisions) was different from the most common cause of death or major injury (caught coupling).

The next phase concentrated on the way the shunting activity is performed on a daily basis rather than the circumstances surrounding accidents. Opinions of shunters were sought in confidence to establish which rules were violated and the reasons for the violations.

Using the rules identified by the shunters themselves as being most frequently violated, the reasons for the violations fall into three categories best described as competence, attitude and conditions.

Factor 1 - Competence - Inexperience
- Laziness
- Management turn a blind eye

Factor 2 - Attitude - Skilled shunters can work safely
- It's a macho way
- Management turn a blind eye

Factor 3 - Conditions - Design of sidings
- Rule is impossible to work to
- Inexperience

There is strong correlation between the rule broken and the factor, in most cases a single factor, causing the violations.

The next phases of the work will concentrate on establishing when people violate high risk rules and investigate the link between violations and compliance and conformity.

<u>Track Work Study</u>

The research in human factors in track work activities formed the basis of the paper at the 1991 Seminar (Ref 1). It showed that many of the day-to-day problems encountered on the railway originate in the decision making process at the strategic management level and are brought about by a lack of awareness of the implications of those decisions. The decision making process might be considered as the first step in the accident causation process, which introduced general failure processes which in turn lead to error enforcing conditions.

Building on the earlier work, a programme of concentrated research was centred on discovering more about the error enforcing conditions and their origins. It involved the use of knowledge elicitation techniques with infrastructure supervisors to obtain their view of the relative influence of 28 factors or conditions on the likelihood that staff would make errors or commit violations.

Although the difference between errors and violations was explained to the supervisors the responses suggest they were rated as one (Fig 3). Thus "tight time constraint" and "ambiguous/complex rules" were in the top four for both error and violation enforcing conditions.

There was good agreement between supervisors from different activities (civil engineering, overhead line equipment, plant and signal and telecommunications) and by averaging all the results, the relative influence of the workplace conditions on unsafe acts is obtained (Fig 4).

The General Failure Processes derived from earlier phases of the research, were profiled using the "Problem Based Profiling" technique. This technique is part of PRISM (Proactive Railway Instruments for Safety Management) which is being developed by the research team. Supervisors were asked to list safety related problems which they had encountered and then to rate the contribution of each General Failure Process to the problems.

The differences in profiles obtained for different activities confirmed the technique as a measurement tool for General Failure Processes. Training and communication were seen to provide the most problems for S&T (Fig 5) and OLE whilst planning was the major influence for civil engineers (Fig 6). The high scores for inadequate defences and environment among Plant Staff (Fig 7) is probably due to those profiling supervise an area where tunnel work forms a significant part of the job.

The Problem Based Profiling technique offers a means of obtaining information about the safety health of different activities relatively quickly. Other profiling techniques being researched as part of PRISM, such as indicator profiling, appear susceptible to technological and operational change. The advantage of Problem Based Profiling is that it utilises information about activities that individuals hold in their heads and this is constantly updated.

Reference

1. Presented at the 1991 International Railway Safety Seminar at Latimer House, UK.

"Human Error Research - Individual and organisational safety culture"

RKT1-S29
(JL)

Figure 1 MEAN DRIVER RATINGS
Information flow and communication

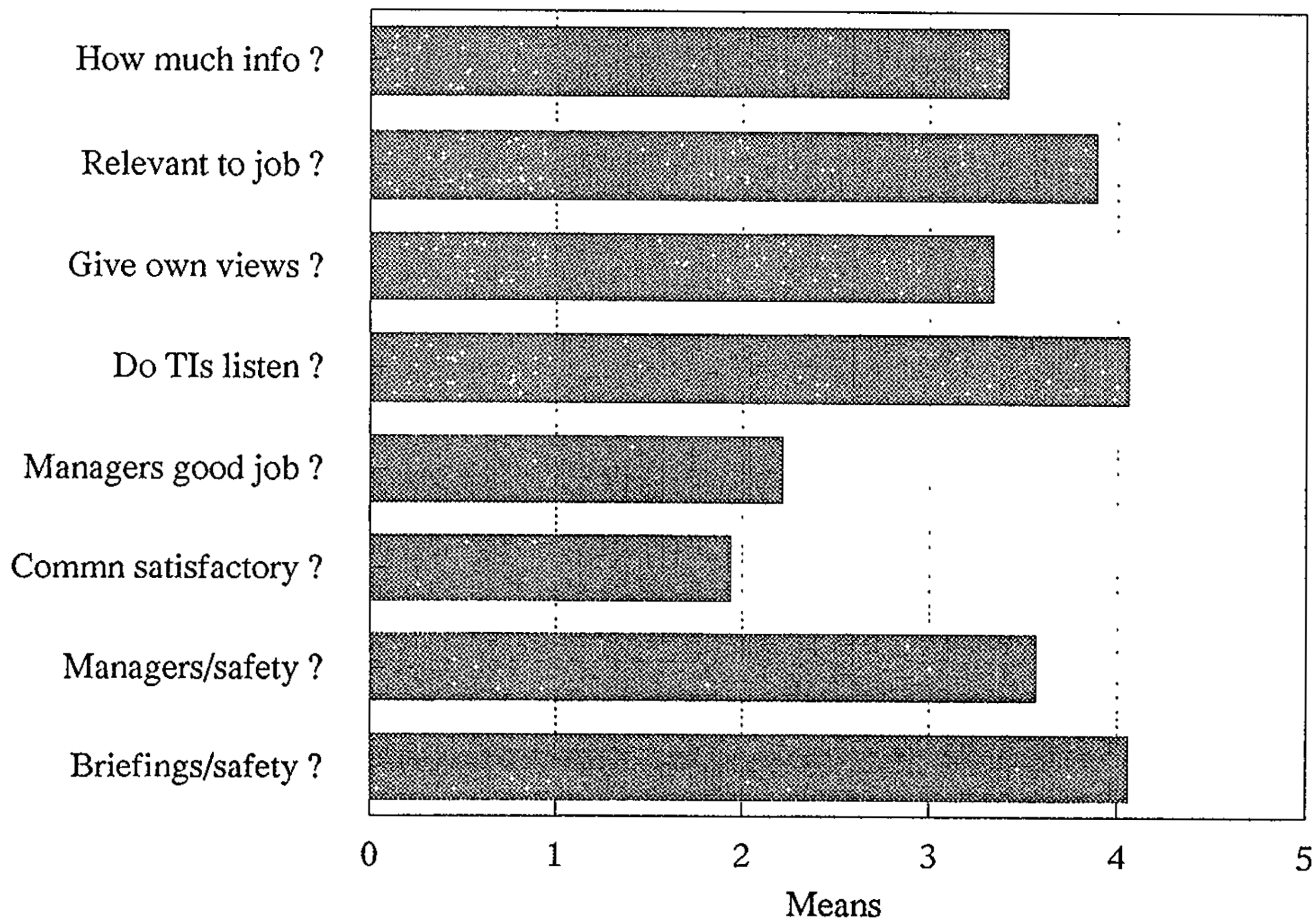


Figure 2 CAUSES OF ACCIDENTS 1986-1990

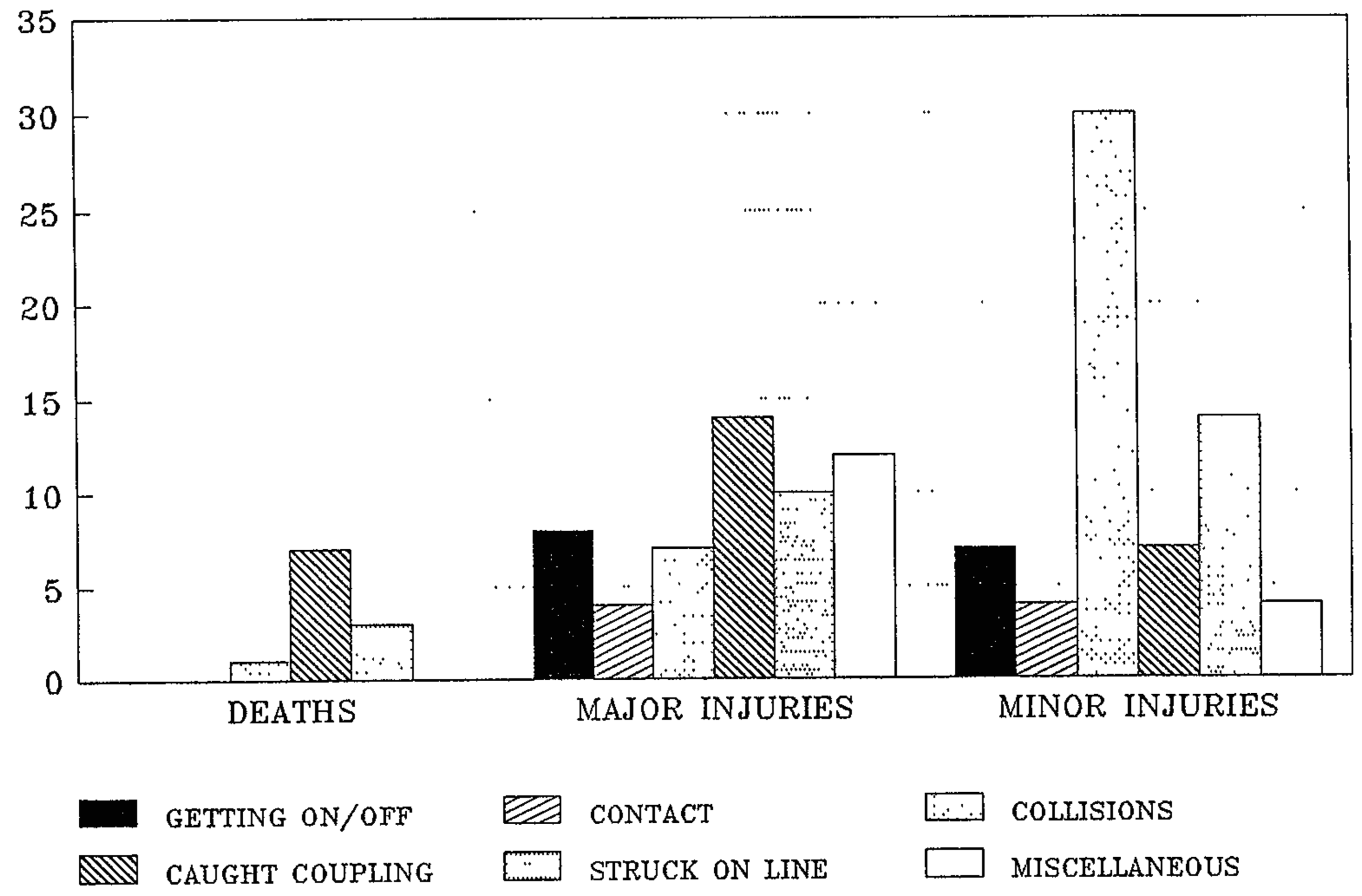


Figure 3
Error and violation enforcing conditions

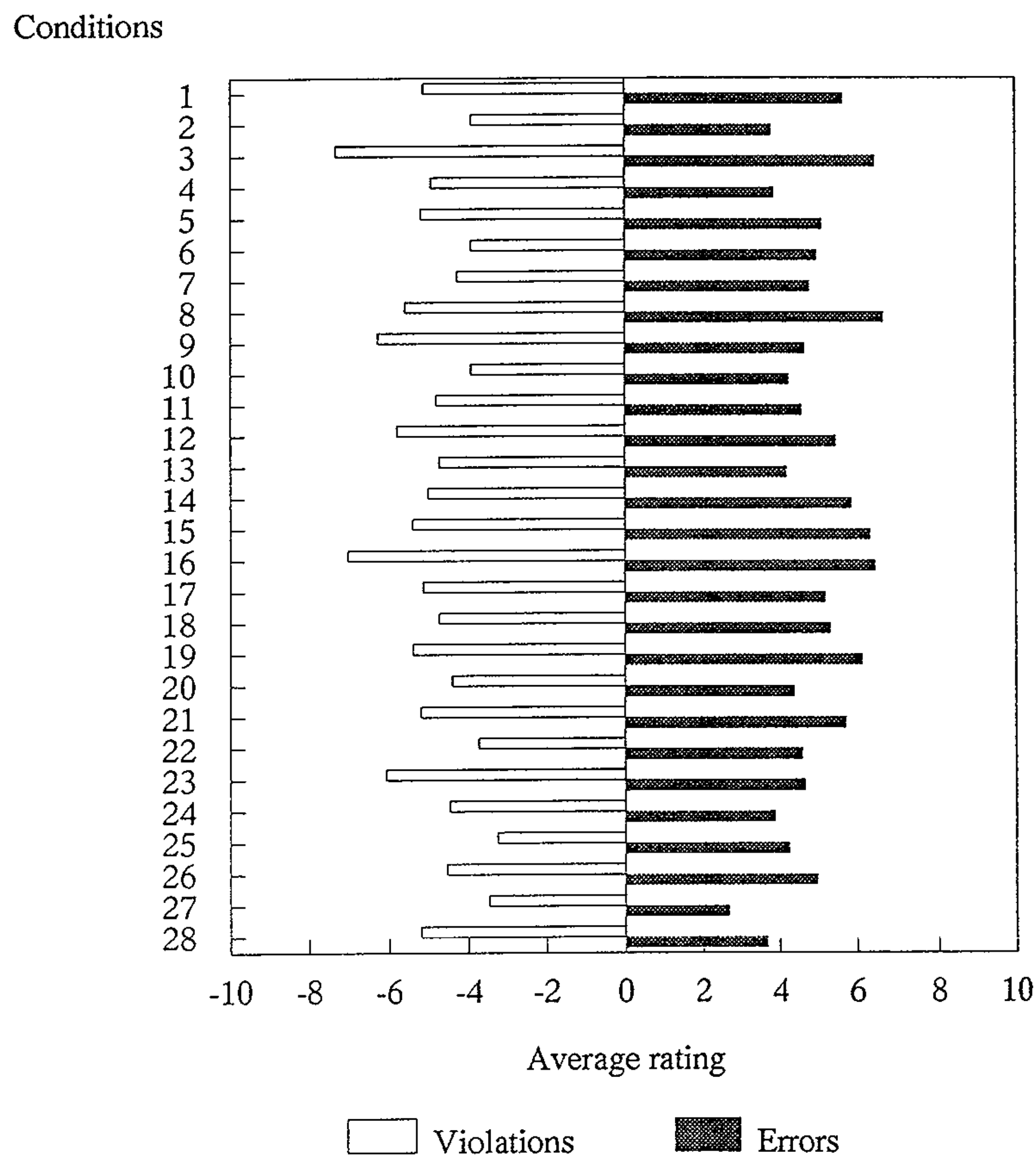


FIGURE 4

Condition	Increased likelihood of unsafe act occurring
Tight time constraints	6.9
Ambiguous/complex rules	6.735
Inexperience	6.135
Lack of awareness of hazards	5.865
Poor departmental communication	5.765
Low morale	5.635
Lack of supervision	5.47
Fatigue	5.465
Last minute planning changes	5.435
Unfamiliar with task or equipment	5.4
Beliefs that bad things will not happen	5.37
Manpower fluctuations	5.165
Poor communication through the line	5.165
Poor communication among staff	5.165
Boredom and monotony	4.765
Constant changes in line of command	4.7
Equipment that is difficult to use	4.535
Frequent changes in team members	4.465
Poor social relationships within/between teams	4.465
Belief that managers will turn a blind eye	4.435
Onerous environmental conditions	4.4
Lack of equipment or materials	4.4
Lack of reward and thanks for performing the job	4.17
Unpredictable workloads	4.165
Lack off clear lines of responsibility	4.1
Lack of written procedures for performing job	3.86
Poor design of equipment worked upon	3.77
Lack of confidence in management's ability	3.07

Figure 5

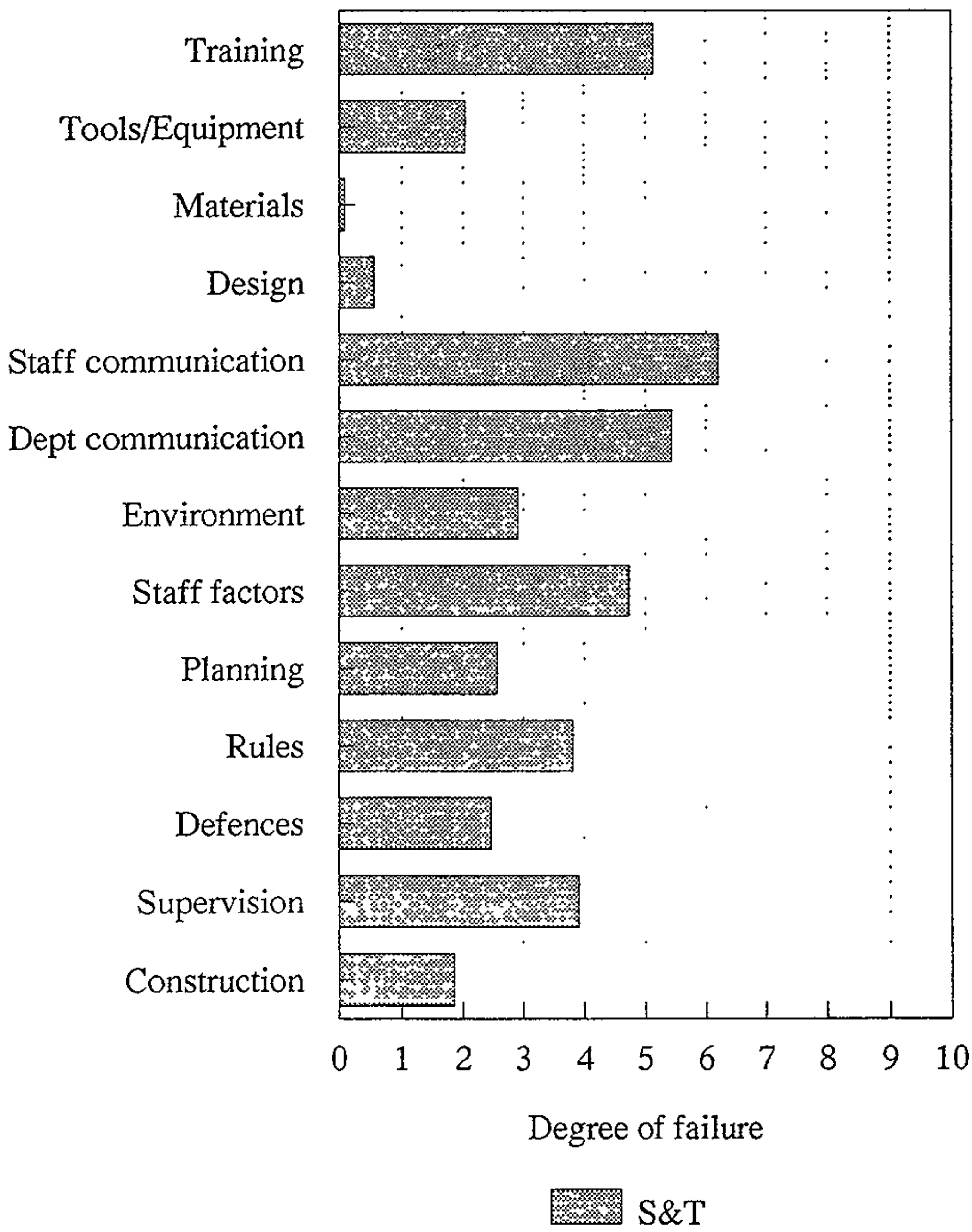
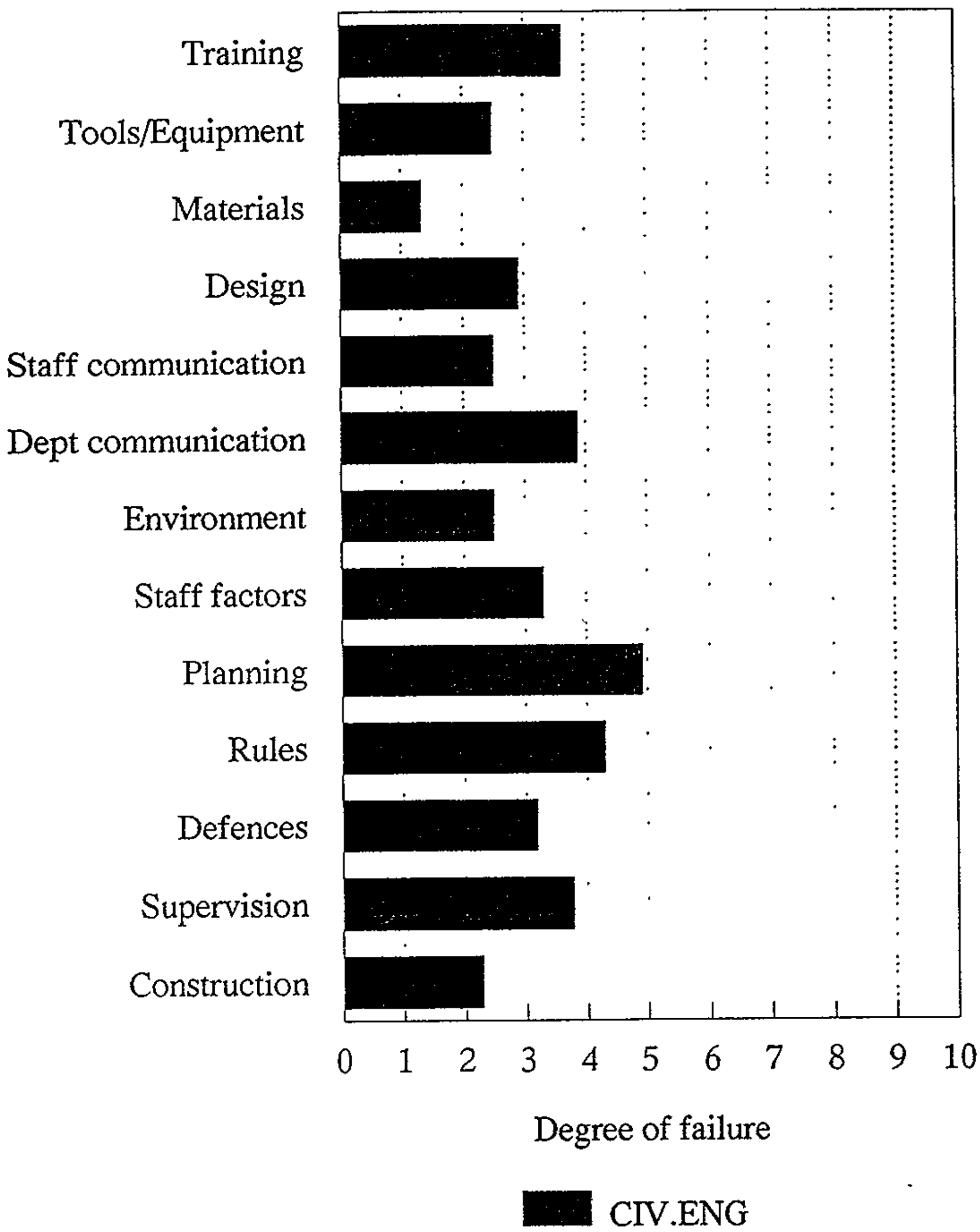
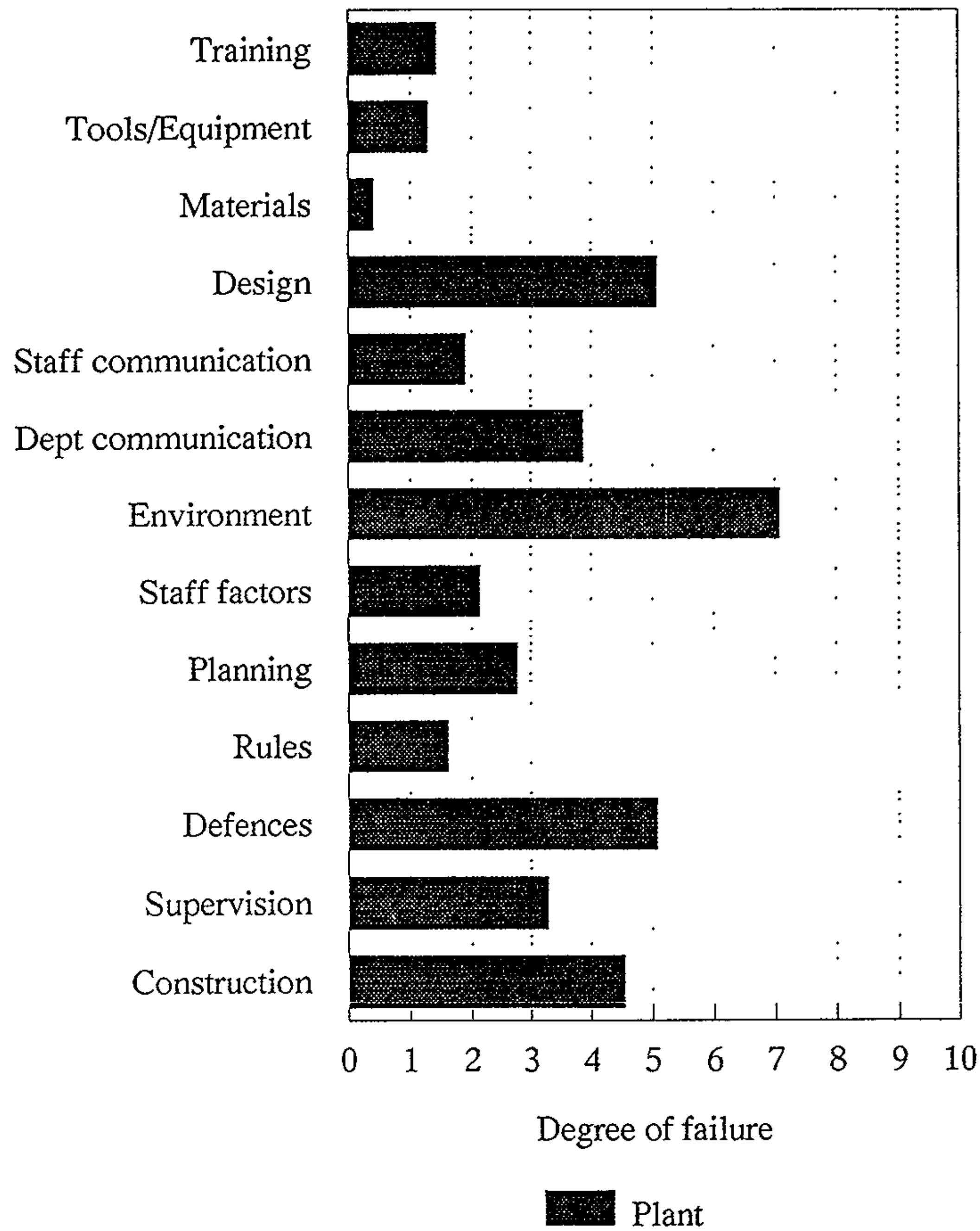

Training
Tools/Equipment
Materials
Design
Staff communication
Dept communication
Environment
Staff factors
Planning
Rules
Defences
Supervision
Construction
0
1
2
3
4
5
6
7
8
9
10
Degree of failure
S&T

Figure 6



Training
Tools/Equipment
Materials
Design
Staff communication
Dept communication
Environment
Staff factors
Planning
Rules
Defences
Supervision
Construction
0
1
2
3
4
5
6
7
8
9
10
Degree of failure
CIV.ENG

Figure 7



Training
Tools/Equipment
Materials
Design
Staff communication
Dept communication
Environment
Staff factors
Planning
Rules
Defences
Supervision
Construction
0 1 2 3 4 5 6 7 8 9 10
Degree of failure
Plant

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Michael Jones-Lee
Graham Loomes

Monetary Value of Underground Safety Relative to Road Safety

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Monetary Value of Underground Safety relative to Road Safety

Mr.M.Jones-Lee and Mr.G.Loomes

THE MONETARY VALUE OF UNDERGROUND SAFETY RELATIVE TO ROAD SAFETY: AN EXPLORATORY ASSESSMENT (THE "PHASE 0 REPORT")

Michael Jones–Lee

Graham Loomes

This report has been prepared under contract to London Underground Limited

June 1992

CONTENTS

INTRODUCTION

Protection of the safety of human life and limb is unquestionably one of the most important considerations in transport investment and regulatory decision–making. If such decisions are to generate an efficient allocation of scarce resources it is therefore clearly essential to have *explicit* monetary values of safety and costs of risk so that safety effects can be weighed directly against other costs and benefits.

The fundamental question is then *how* monetary values of safety and costs of risk are to be defined and estimated for any particular transport mode. In the case of road safety, there is now widespread agreement, both in this country and abroad, that the *willingness–to–pay* (WTP) approach provides the appropriate valuation and costing methodology (see, for example, Jones–Lee et al [1985], Department of Transport [1988], Dalvi [1988], Miller et al [1988] Persson and Cedervall [1991] and Miller and Guria [1991]). Essentially, this approach seeks to capture the amount that a safety improvement is *worth* to those that are affected by it. More specifically, under the WTP approach, the value of a particular safety improvement is defined in terms of the aggregate amount that those who benefit from the improvement would be willing to pay for it. Defined in this way, values of safety clearly act as vehicles for the expression of individual preferences over competing objects of expenditure in the face of scarcity and, as such, play precisely the same rôle as monetary values determined by the interaction of the forces of supply and demand in a market context.

Because most safety improvements afford any particular individual a *very small* reduction in the probability of his or her own death or injury, the WTP approach typically focuses upon the (usually quite modest) amounts that affected individuals would be willing to pay for these small probability reductions. In fact, in order to standardise the results that emerge, in practice WTP values are normally estimated on the basis of small individual probability reductions that are such as to entail the expected prevention of *precisely one* fatality (or injury) in a large group of people during a forthcoming period – the resultant aggregate individual willingness to pay being referred to as the value of preventing one "statistical" death (or injury) or more succinctly as the "value of statistical life". Thus, suppose that 100,000 people would, on average, be willing to pay £10 per head for a safety improvement that would reduce the risk of death during the coming year by 1 in 100,000 for each and every individual in the group. The value of statistical life for this group would then be £10 x 100,000 = £1m.

Clearly, the prevention of death and injury not only reduces individual risk but also avoids various "direct" economic costs, such as loss of output or income, medical costs and – in the case of transport risks – the costs of vehicle or system damage and disruption. To the extent that individuals typically do not take account of the avoidance of such costs in determining their personal willingness to pay for risk reduction (and there is evidence that they do not – see Jones–Lee et al [1985]), it is necessary to add an allowance for them to the aggregate individual willingness–to–pay figure.

In the U.K., the Department of Transport (DTp) currently uses a WTP based value of statistical life of some £700,000 in 1992 prices in its cost–benefit analysis of proposed new road schemes. Of this figure, £620,000 is a pure aggregate individual willingness–to–pay component, the balance of £80,000 consisting principally of avoided net output losses, but also including an allowance for medical and ambulance costs. The output loss is "net" in the sense that it is average output per capita *minus* average consumption per capita, this being the average amount of output that the rest of society "loses" when a productive individual dies prematurely. In the case of non–fatal injuries, the DTp is currently in the process of deciding upon the appropriate level at which to set WTP values in the light of work undertaken by the authors. While no firm decision has yet been taken, it seems probable that the WTP–based value of preventing a statistical serious[1] non–fatal road injury will be set in the region of £60,000 – £80,000 (of which some £55,000 – £75,000 is the pure willingness–to–pay component) while the corresponding figure for a slight non–fatal injury will be between £1000 and £6000. In the case of the value of preventing fatal and non–fatal *accidents* (as opposed to casualties) the DTp adds a further allowance for the avoided costs of damage to vehicles and property and avoided police and administrative costs.

1. VALUING SAFETY ON LONDON UNDERGROUND : ISSUES OF PRINCIPLE

Given that the DTp and other public sector and related agencies in the U.K. and abroad have now adopted the WTP approach to the valuation of safety, two key questions arise for LUL, namely :

- Should LUL also employ WTP based values in its safety expenditure and investment decisions?
- And if so, how should the magnitude of such values relate to those currently used by DTp?

In the light of LUL's business objective of "maximizing net social benefit within available funds and subject to a defined gross margin target" the answer to the first of these questions is unequivocally in the affirmative. The reason is quite simply that in the context of conventional social cost–benefit analysis and social welfare

[1]A "serious" injury is defined by the DTp as "an injury for which a person is detained in hospital as an 'in–patient', or any of the following injuries whether or not he is detained in hospital: fractures, concussion, internal injuries, crushings, severe cuts and lacerations, severe general shock requiring medical treatment, injuries causing death 30 or more days after the *accident*" (*Road Accidents Great Britain* 1989). In turn, a "slight" injury is defined as "an injury of a minor character such as a sprain, bruise or cut which are not judged to be severe, or slight shock requiring roadside attention" (*Road Accidents Great Britain 1989*).

maximization, "net social benefit" is *defined* in terms of individual willingness–to–pay *precisely in order to ensure that social choices reflect the preferences and wishes of the people who will be affected by those choices.*

This having been said, it is important to bear in mind that LUL's business objective involves maximization of net social benefit *subject to the constraints of available funds and the gross margin target.* This means that in addition to a pure WTP component, LUL's costs of risk and values of safety should also take account of the effect of accidents upon LUL's financial position. *Prima facie*, this suggests that while DTp and LUL values should both contain a pure WTP component, they will differ with respect to the financial impact referred to. However, when one considers the categories of financial consequences of accidents for LUL, it becomes clear that there are close parallels between the accident costing and valuation procedures appropriate for the roads and for the Underground, at least in principle. Thus, it will be recalled that the DTp's value of preventing a fatal *accident* comprises the sum of :

- A component reflecting avoided damage to vehicles and property
- A component reflecting avoided medical and police costs
- A component reflecting avoided output loss, net of consumption
- A pure WTP component

If it is to take account of net social benefits, *as well as* effects upon its own financial position, then LUL's value for preventing a fatal accident should clearly comprise the sum of

- A component reflecting avoided costs of damage to the Underground System, including loss of revenue due to disruption and/or adverse customer reaction
- A component reflecting avoided medical and police costs

- A component reflecting the avoided cost of legal compensation (or, equivalently, the cost of insuring against claims for compensation)
- A pure WTP component

Clearly, in qualitative terms there is a direct parallel between the first, second and fourth components of the LUL value and the corresponding components of the DTp value. Furthermore, in the case of legal compensation for death or injury, English courts award damages on an essentially *compensatory* (rather than penal or deterrent) basis. In the case of a fatality in particular, the sum awarded to the surviving dependents of a deceased victim is intended to be reflective of their financial interest in his or her continued survival[2] and such a sum may broadly correspond with the victim's "net output", as defined by the DTp.

There are several other (possibly controversial) issues which may also have a bearing on the value used by LUL to appraise projects involving safety improvements, and we shall draw attention to these in Section 4. But first we consider the more straightforward aspects of the four components identified above, and for each in turn we discuss whether, and in what ways, the values used in decisions about Underground safety might differ numerically from those used in the context of road safety.

[2]Though apparently in some recent cases an additional sum has been awarded in respect of the "subjective losses" associated with loss of companionship and the distress arising from bereavement.

2. *THE RELATIVE VALUE OF UNDERGROUND AND ROAD SAFETY*

2.1 *Material Damage and Lost Revenue (MDLR)*

Within the timescale of this report, we are not in a position to quantify the costs to LUL of MDLR relative to the number of fatal and non–fatal injuries. If LUL does not already have an estimate of this figure (or at least the range within which it is likely to lie), we believe that an appropriate figure (or range) could be derived from some combination of historical data and elements of the fault tree analysis already undertaken. At this stage, we confine ourselves to two conjectures :

- It seems likely that, on average, the MDLR associated with an Underground fatality (or other injury) will be substantially higher than the corresponding costs associated with a road accident fatality (or comparable injury).
- It may well be that these costs increase disproportionately with the number of fatal and non–fatal injuries resulting from any particular incident.

So, for example, even if one disregards for the moment *all* the costs involved in implementing the recommendations of the Fennell Report[3], the MDLR associated with the King's Cross fire, which resulted in 31 deaths and at least two dozen serious non–fatal injuries, may conservatively be estimated at more than £20m. By contrast, the damage to vehicles and infrastructure associated with road accidents resulting in a similar total of deaths and injuries is unlikely to exceed £1m on even the most extreme assumptions – and could well be less than half that figure.

[3]We shall come back to this point in Section 4.

2.2 Medical and Police Costs

We do not have the data necessary to determine whether the medical and police costs associated with deaths/injuries resulting from "small scale" Underground incidents are appreciably different from the costs involved in road accidents of similar scale. However, as in 2.1 above, we suspect that the costs associated with larger–scale incidents, which tend to make abnormally heavy demands on the emergency services, may be disproportionately high.

2.3 Net Output Loss/Legal Compensation (NOL/LC)

On the face of it, there is no obvious reason to expect the costs per fatality/injury under this heading to differ greatly between Underground and road accidents. However, certain possibilities may repay further investigation. We highlight two :

- NOL/LC depends to a considerable extent on the age, employment status and expected future earnings of the victim. If there are significant differences in these respects between the population at risk on the Underground and the population at risk on the roads, there would be a case for an appropriate differential under this heading.
- Certain kinds of non–fatal injury (e.g. permanent brain damage, paraplegia and injuries resulting in permanent inability to follow chosen occupation) may entail particularly large NOL/LC. So if the frequency of such injuries relative to others differs greatly between the Underground and road contexts, some account should be taken of this. However, firm estimates of these relative frequencies are not yet readily available even in the case of road transport, due to problems of classification and under–reporting of the less serious injuries. We

suspect that similar problems are present to an equal or greater extent for LUL, so that it may be difficult to argue strongly for a significant differential one way or the other under this heading.

2.4 The Pure WTP Component

Both introspection and more formal studies in cognitive psychology and economics indicate that people tend to be markedly more averse to the prospect of being killed or injured in one set of circumstances rather than another (see, for example, Slovic et al [1981], Jones–Lee et al [1985] and Mendeloff and Kaplan [1990]). Given this, it is clear that many people will *quite rationally* be willing to pay different amounts for a given reduction in the risk of death (or injury) by different causes – in which case, (as one of us has argued elsewhere, see Jones–Lee [1990]) the logic of the WTP approach clearly entails the necessity to specify different values for avoiding death or injury in different contexts.

How, then, are people likely to view the prospect of being killed or injured in an Underground accident vis–a–vis the prospect of sustaining a similar degree of injury on the roads? In what follows, we identify a number of relevant factors whose combined effects point to the conclusion that the pure WTP component for the Underground will be *substantially larger* than its road transport counterpart.

- *Heightened Aversion to the Prospect of Underground Injuries*

  As indicated above, there is ample evidence that people regard different ways of dying (or being injured) with differential degrees of distaste. We do not know of any existing study which provides *direct* evidence for comparisons between road and Underground, but we can think of three potentially significant considerations. First, the time taken for rescue and medical services to gain access to Underground casualties will typically be substantially greater than in most road accidents, so that Underground accident victims may well have to endure a more protracted period of suffering immediately following the accident than is the case on the roads. Second, most people will almost certainly view the prospect of sustaining a given degree of injury in a confined space "deep in the bowels of the earth" with particular dread. Finally, given that two of the more prominent potential causes of Underground fatalities are flooding and fire, and given that most people view the prospect of death by drowning or fire with considerable horror, this is also likely to lead to a heightened aversion to potential Underground accidents, relative to their road counterparts.

- *Controllability of Underground Risks*

  A second reason why people may display greater aversion to physical risk on the Underground than on the roads relates to the question of the *controllability* of risk and the related distinction between "voluntary" and "involuntary" risks.

  Many drivers perceive that the risks that they face on the roads are to a considerable degree under their own control. To a somewhat lesser degree, the same can also be said for car passengers, in that they can communicate directly with the driver. By contrast, the risks faced by Underground passengers are almost entirely *out* of their control and, at least once passengers have entered the Underground system, essentially involuntary.

  As a result, one would expect that most people's aversion to Underground risks would be substantially greater than to corresponding road risks so that, quite apart from their differential distaste for the prospect of Underground injuries vis–a–vis road injuries, they would be prepared to pay more for a given reduction in Underground risk than for the same reduction in road risk. A further consequence of the uncontrollable and involuntary nature of Underground risks is that passengers will almost certainly feel that LUL has a markedly greater responsibility for the provision of safety than does the DTp in the case of road safety.

- *Catastrophe Risks*

  While fatal road accidents do occasionally lead to large scale loss of life, the vast majority of such accidents involve only one or two fatalities. On the Underground, however – as Moorgate and King's Cross remind us – there is considerable potential for loss of life on a catastrophic scale. Indeed, major flooding or system power failure could result in the loss of several hundreds, or even thousands of lives.

  Given that many people appear to view the prospect of death or injury in a catastrophe with even greater distaste than a corresponding injury incurred in an accident involving only one or two fatalities, a number of authors have advocated that the prospect of the loss of one life in a catastrophe should be weighed more heavily in the decision making process than the loss of one life in an "everyday" accident on the roads or in the workplace (see for example, Bodily [1980], Keeney [1980] or the Royal Society [1983]). Indeed, the Health and Safety Executive [1989] has proposed that physical risk should be thought of as comprising two dimensions, namely : "*individual*" risk (the risk of death or injury for any particular individual) and "*societal*" risk (the risk to society of large scale loss of life or injury).

  However, we suspect that it is not simply the scale of the loss of life, as such, that provides the grounds for setting the value of statistical life for catastrophe risks at a premium, but rather the element of uncertainty and ambiguity that derives from the relative rarity and uniqueness of catastrophic events. After all, one can predict with some confidence the approximate number and nature of road accidents and (though perhaps with less precision) the number of small–scale Underground accidents for the coming year. But who knows when, and on what scale, and under what circumstances the next train, plane or Underground catastrophe will occur? We consider that it is the aversion to the uncertainty and ambiguity associated with catastrophe risks that justifies the addition of a premium to the value of statistical life in the case of such risks. This seems to accord with the findings of Slovic et al [1981, 1984], and more recently, Kunreuther et al [1992].

3. BEGINNING TO QUANTIFY THE DIFFERENTIAL BETWEEN VALUES OF UNDERGROUND AND ROAD SAFETY

In the previous section we have identified four possible reasons why it might be appropriate to set WTP–based values of Underground safety at a premium in relation to their road counterparts, namely :

- The material and system damage component of Underground values will almost certainly exceed the corresponding component for road values by a substantial margin.
- People may well be markedly more averse to the prospect of incurring any particular severity of injury in an Underground accident than on the roads.
- Passengers almost certainly regard Underground risks as being largely beyond their control. In addition, these risks are essentially involuntary, whereas road risks are to a far greater extent both controllable and voluntary. This will tend to further increase people's

willingness to pay to reduce Underground risks vis–a–vis road risks.

- Aversion to the uncertainty and ambiguity associated with catastrophes such as occurred at Moorgate and King's Cross may well justify setting the value of reducing catastrophe risks higher than the value appropriate for risks of accidents involving smaller numbers of casualties.

Thus, there appears to be a case for setting the values of preventing *all* severities of Underground injuries at a premium in relation to their road counterparts; and there also appear to be good grounds for increasing the size of this premium when considering safety measures intended to reduce the risk of incidents involving large–scale loss of life. But if, for the time being at least, LUL wishes to work with a single value of statistical life that does not differentiate between catastrophe and other risks, we suggest that such a value should consist of a *weighted average* of the value appropriate for accidents involving small numbers of fatalities and the value appropriate for catastrophes, with the weights reflecting the expected proportion of fatalities occurring in the two types of accident.

However, safety measures are not concerned exclusively with fatalities. In order to have a comprehensive approach it is therefore important to be clear about the way in which *non–fatal* injuries are to be dealt with in LUL's safety expenditure and investment decision making. In fact, there would appear to be *two quite distinct* ways of proceeding, and while there is something to be said in favour of each of these two possibilities[4], it is *absolutely essential that LUL should explicitly adopt one or other and then employ it consistently.* More specifically, the alternatives are :

[4]Though later we give reasons for preferring one, rather than the other.

- To focus only on the number of *fatalities* that will be prevented by a programme of safety expenditure, but to recognise that, on average for each fatality prevented there will also tend to be a number of avoided non–fatal injuries. Under this approach, the value accorded to the prevention of one fatality will *really* be a value for preventing a "*package*" of one fatality *and* a number of non–fatal injuries.
- To deal with fatal and non–fatal injuries *explicitly and separately.* Under this approach it would be necessary (a) to predict the number of fatalities and/or non–fatal injuries of varying severity that would be prevented by a particular safety countermeasure and (b) to have (at least) two distinct values : one for the prevention of a fatality; and (at least) one for the prevention of the corresponding array of serious and slight non–fatal injuries.

3.1 The Value of Preventing a "Package" of One Fatality and Associated Non–Fatal Underground Injuries

Under this approach it is necessary to convert non–fatal injuries into "fatality equivalents". For this purpose one needs to know (a) the number and severity of non–fatal injuries avoided per fatality prevented and (b) the "conversion rate". At present, we can do no better than to employ the F–N/FMECA curves specified in DOO5–ESHM–91–Z and DOO6–ESHM–91–Z "extended" back into the area of non–fatal injuries, with the value of preventing a serious non–fatal injury treated as being 10% of the value of statistical life and the value of preventing slight injuries as 1%. While it is clear that a great deal of empirical work would be required to put such percentages onto a firm foundation, it should be said that the figure of 10% for a serious non–fatal Underground injury is not grossly out of line with corresponding figures that have emerged from our work for DTp, although we should be surprised if the pure WTP component of the value for preventing a *slight* non–fatal Underground injury were anywhere near as high as 1% of the value for preventing a death. Still, for convenience of exposition, let us accept the 1% figure for the time being.

On this basis, it would seem appropriate to proceed as follows. The F–N curves specified in DOO5–ESHM–91–Z and DOO6–ESHM–91–Z all take the form $F = \frac{a}{N}$, $a > 0$, with N further restricted in DOO6–ESHM–91–Z to lie in the interval $0.01 \leq N \leq 100$. This implies that the expected annual number of Underground fatalities is given by :

$$\int_{0.01a}^{a} \frac{a}{F}\, dF = 4.6a,$$

while the expected annual number of "fatality equivalents" for non–fatal injuries is given by :

$$\int_{a}^{100a} \frac{a}{F}\, dF = 4.6a.$$

It is clear, therefore, that given the assumptions that underpin the F–N curves in DOO5–ESHM–91–Z and DOO6–ESHM–91–Z, the non–fatal injuries associated with each fatality amount to exactly *one* fatality equivalent. Under these circumstances, the "package" of one fatality and associated non–fatal injuries is equivalent to precisely *two* fatalities.

If one then defines a catastrophe as an event involving ten or more fatalities, the expected proportion, ρ, of fatalities occurring in such events in relation to *all* fatalities is given by :

$$\rho = \frac{\int_{0.01a}^{0.1a} \frac{a}{F}\, dF}{\int_{0.01a}^{a} \frac{a}{F}\, dF} = 0.5.$$

Denoting the WTP premium for Underground casualties in relation to road casualties of corresponding severity by α, the premium for "catastrophe" casualties by β, the pure WTP component of the value of statistical life for road risks by v and the pure WTP component of the value of preventing a "package" of one Underground fatality and associated non–fatal injuries by u, it follows that :

$$\begin{aligned} u &= 2[0.5\,(1 + \alpha)v + 0.5\,(1 + \alpha)\,(1 + \beta)v] \\ &= (1 + \alpha)\,(2 + \beta)v. \end{aligned}$$

Setting v = £620,000, the implied pure WTP component of the value of preventing a "package" of one Underground fatality and associated non–fatal injuries for various illustrative values of α and β will therefore be as shown in Table 1 overleaf :

Table 1 : The Pure WTP Component of the Value of Preventing a "Package" of One Underground Fatality and Associated Non–Fatal Injuries (£)

β / α	0.0	0.2	0.6	1.0	1.5	2.0
0.0	1,240,000	1,364,000	1,612,000	1,860,000	2,170,000	2,480,000
0.2	1,488,000	1,637,000	1,934,000	2,232,000	2,604,000	2,976,000
0.4	1,736,000	1,910,000	2,257,000	2,604,000	3,038,000	3,472,000
0.6	1,984,000	2,182,000	2,580,000	2,976,000	3,472,000	3,968,000
0.8	2,232,000	2,455,000	2,902,000	3,348,000	3,906,000	4,464,000
1.0	2,480,000	2,728,000	3,224,000	3,720,000	4,340,000	4,960,000

While the "package" approach appears to have the appeal of simplicity, it is important to appreciate that it has three significant drawbacks.

First, it effectively assumes not only that half of all *deaths* will occur in catastrophic incidents, but *also* that half of all serious and slight injuries are expected to occur in similar circumstances. This latter assumption appears to us to be very dubious : from the returns we have seen, it seems likely that the (great) majority of non–fatal Underground injuries occur in small–scale incidents, many of which involve no fatalities at all. Thus, to apply the catastrophe premium to half of all non–fatal injuries, as in the "package"–based Table 1 above, is likely to result in a (substantial) overestimate.

Second, there is a danger that, if it were used casually or at second–hand, Table 1 might be misconstrued and/or lead to double–counting. As stated earlier, the figures in Table 1 relate to a "package" which is equivalent to *two* fatalities. However, if this *caveat* is overlooked, and the figures come to be thought of simply as the value of preventing one fatality, as such, then there is a risk that a *further* amount might erroneously be added for non–fatal injuries, neglecting the fact that the value of preventing these injuries is already "built–in" to the figures in Table 1.

Third, having a "package" involving some particular ratio of fatal : non–fatal injuries seems to us to be too crude an instrument for use at the level of individual project appraisal, where some projects may be targetted more at preventing fatalities in catastrophic incidents, while others may be designed to reduce the frequency of smaller–scale accidents predominantly resulting in non–fatal injuries.

For these reasons we therefore incline towards the alternative approach outlined below.

3.2 The Explicit and Separate Valuation of Preventing Fatal and Non–Fatal Underground Injuries

If we again define a catastrophe as an event involving ten or more fatalities, then the expected proportion, ρ, of fatalities occurring in such events in relation to all fatalities is, as before, 0.5.

Once again denoting the WTP premium for Underground casualties in relation to road casualties by α, the premium for catastrophe casualties by β, and the pure WTP component of the value of statistical life for road risks by v, the pure WTP component, $\hat{u}$, of the value of preventing one Underground fatality, as such, is given by :

$$\begin{aligned}\hat{u} &= 0.5\,(1 + \alpha)v + 0.5\,(1 + \alpha)\,(1 + \beta)v \\ &= 0.5\,(1 + \alpha)\,(2 + \beta)v.\end{aligned}$$

Again, setting v = £620,000 the implied pure WTP component of the value of preventing one Underground fatality, as such, for various values of α and β will therefore be as shown in Table 2 :

Table 2 : The Pure WTP Component of the Value of Preventing One Underground Fatality, As Such (£)

α \ β	0.0	0.2	0.6	1.0	1.5	2.0
0.0	620,000	682,000	806,000	930,000	1,085,000	1,240,000
0.2	744,000	818,000	967,000	1,116,000	1,302,000	1,488,000
0.4	868,000	955,000	1,128,000	1,302,000	1,519,000	1,736,000
0.6	992,000	1,091,000	1,290,000	1,488,000	1,736,000	1,984,000
0.8	1,116,000	1,228,000	1,451,000	1,674,000	1,953,000	2.232.000
1.0	1,240,000	1,364,000	1,612,000	1,860,000	2,170,000	2,480,000

It is important to appreciate that when considering a programme of safety expenditure which is expected to prevent non–fatal injuries as well as deaths, under this approach an appropriate pure WTP component for injuries must be added into the calculations, presumably in the form of the value of preventing the number of "fatality equivalents" corresponding to the non–fatal injuries concerned. However, as indicated in Section 3.1, we think it unlikely that half of all serious and slight injuries could be expected to occur in catastrophic incidents. We have therefore constructed Table 3, whose columns show how the WTP value for preventing one "fatality equivalent", denoted by w, varies when we assume that the proportion, π, of non–fatal injuries occurring in catastrophes ranges from zero to 0.5. The six rows give the appropriate values for six illustrative pairs of α and β. Other values can be derived from the formula :

$$\begin{aligned} w &= (1-\pi)(1+\alpha)v + \pi(1+\alpha)(1+\beta)v \\ &= (1+\alpha)(1+\pi\beta)v \end{aligned}$$

Table 3 : The Pure WTP Component of the Value of Preventing One Underground "Fatality Equivalent" (£)

$\{\alpha, \beta\}$ \ π	0.0	0.1	0.2	0.3	0.4	0.5
0.2,0.2	744,000	759,000	774,000	789,000	804,000	818,000
0.2,0.6	744,000	789,000	834,000	879,000	924,0001	967,000
0.6,0.2	992,000	1,012,000	1,032,000	1,052,000	1,072,000	1,091,000
0.6,0.6	992,000	1,052,000	1,112,000	1,172,000	1,232,000	1,290,000
1.0,1.0	1,240,000	1,364,000	1,488,000	1,612,000	1,736,000	1,860,000
1.0,2.0	1,240,000	1,488,000	1,736,000	1,984,000	2,232,000	2,480,000

So, for example, if it is thought that serious and slight non–fatal Underground injuries amount to one "fatality equivalent" for every actual fatality, the total WTP component for preventing death *and* injury is arrived at by adding the appropriate figure from Table 3 to the relevant figure from Table 2. Thus, if we assume $\alpha = 0.2$, $\beta = 0.6$ and $\pi = 0.1$ (that is, 10% of all non–fatal injuries occur in catastrophes), we combine w = £789,000 with $\hat{u}$ = £967,000 to give a total of £1,756,000.

Separating out fatalities from non–fatal injuries in the way implied by the explicit and separate valuation of preventing fatal and non–fatal Underground injuries seems to us to have several advantages.

First, besides being less vulnerable to misinterpretation and double–counting, it is also more straightforward to vary the ratio of fatalities to "fatality equivalents". We have assumed that ratio to be 1 : 1, but if further consideration suggests that 1 : 2, or 1 : 0.5, or some other ratio is more appropriate, the total WTP component for preventing death *and* injury can be readily computed as $\hat{u} + 2w$, or $\hat{u} + 0.5w$, etc. And, of course, there is the extra degree of freedom provided by detaching the estimate of π from the estimate of ρ.

Second, it may make it easier to combine the pure WTP component with the other components – MDLR, police and medical costs, NOL/LC – that enter into the *overall* value for preventing death and/or injury. It seems quite possible that the total figure for these "other" components associated with a "fatality equivalent" set of serious and slight non–fatal Underground injuries might be quite different from the corresponding figure associated with an actual fatality. Separating $\hat{u}$ from w facilitates the construction of an overall value for preventing a fatality *and* a (possibly rather different) overall figure for a "fatality equivalent" set of non–fatal injuries. When further evidence has been collected. it may be possible to extend this process further – as DTp are doing – to arrive at an overall figure for a serious injury *and* an overall figure for a slight injury. This should be the medium–term objective. In the meantime, the kind of analysis represented by Tables 2 and 3 provides a first approximation.

4. CONCLUSIONS AND RECOMMENDATIONS

The terms of reference for this report are to consider the value that might be used by LUL for preventing death (and injury) on the Underground *relative to* the value used by the Department of Transport in the context of road safety.

In Sections 1 and 2 we discussed how one should decompose the overall figure into broadly comparable components, namely : material damage and lost revenue (MDLR); police and medical costs; net output loss/legal compensation (NOL/LC); and a pure willingness–to–pay component.

Focusing for the moment on the case of a fatality, we saw no obvious reason to expect any significant differential under the headings of police and medical costs, and net output loss/legal compensation – although further study may reveal a case for some differential.

However, we suggested that there *were* good grounds for expecting that the MDLR figure would be considerably higher for the Underground vis–a–vis the roads. In arriving at that conclusion, we took into account the weight that should be given to the damage and lost revenue resulting from occasional catastrophic incidents, but we explicitly disregarded the costs of implementing a battery of recommendations such as those contained in the Fennell Report. We indicated that we would return to this point, and we shall deal with it later in this section; but at present we continue to set those costs on one side.

There does not appear to exist any very firm estimate of what MDLR, police and medical costs, and NOL/LC might amount to in the case of the (weighted) average Underground fatality, but for the sake of argument let us work with a figure of £500,000.

This means that if LUL wishes to justify an overall figure of £2 million per avoided fatality – this being the figure referred to in DOO6–ESHM–91–Z, p.2 – the pure WTP component should amount to £1,500,000. Since we are here focusing on a single actual fatality, as such, (rather than a "package" of one fatality and associated non–fatal injuries), the appropriate table to consult is Table 2 (or for greater precision, the formula for û which generates that table). To produce a figure of approximately £1,500,000 would require combinations of $\{\alpha,\beta\}$ such as {1.0, 0.4}, {0.75, 0.75}, {0.6, 1.0} or {0.2, 2.0}. How plausible is it that α and β should take values such as these?

Without the benefit of research directly targetted on eliciting values of α and β from members of the population of (potential) Underground customers, we can only draw on indirect evidence tempered by judgement. For example, Mendeloff and Kaplan (1990) conducted a survey in which they kept the number of avoidable deaths constant but varied the nature/context of those deaths. There we no Underground (nor even railway/boat/plane or "bowels of the earth") scenarios, but there were three road safety scenarios, and even within these there were noticeable context effects. In fact, what Mendeloff and Kaplan did was something like (but not precisely analogous to) holding β constant and looking for variations in α. Their conclusions, based on their own work and the work of others, was that context *does* have an impact, although a much more modest one than is often supposed. Nevertheless, *two–fold* aggregate differences were by no means out of the question. This would translate to a possible value of up to 1.0 for α.

However, our judgement at this stage would be to take a more cautious view, on the grounds that Mendeloff and Kaplan's study, and others to which they refer, do not use an explicit willingness–to–pay approach, and do not directly address the particular factors we highlighted in Section 2.4. Nevertheless, it is not at all implausible to contemplate values of α in the range 0.2 to 0.6.

Let us now consider β, the coefficient representing a catastrophe premium. As indicated in section 2.4 there is a body of literature suggesting that it is appropriate to place special weight on reductions in the risk of catastrophic incidents. However, there is no consensus about the threshold for introducing such a premium, nor about whether and how it should vary with the magnitude of the catastrophe.

Some authors have argued that the pure WTP component should increase as some *power* of the number of lives lost – see, for example, Wilson [1975], Ferriera and Slesin [1976] and The Royal Society [1983]. Wilson, for instance, suggested that a power of 2 should be used, implying that 10 lives lost simultaneously should be regarded as the equivalent of 100 lives lost separately. We would find this size of differential impossible to defend, and we are dubious about whether the "power" approach – even when the power takes more modest values – can be sustained over large numbers of fatalities. Nevertheless, it has exerted some attraction, and it is clear that, if implemented, it would produce larger figures than those shown in Table 2. An illustration of the sort of values that might emerge under this approach is given in Appendix 1.

Instead, we have adopted a relatively simple approach which takes a threshold of ten simultaneous fatalities and sets a *fixed* premium per catastrophe death prevented, relative to the value per death prevented in smaller scale incidents. Moreover, we have emphasised the importance not only of the number of fatalities, but of the ambiguity and uncertainty associated with such low probability/high consequence events.

At present, there is very little relevant data to guide us on plausible values for β; but the results reported by Kunreuther et al [1992] are of some interest. In one part of that study, professional underwriters were asked to quote financial premia for various scenarios involving quite small risks – 0.01 or 0.005 – of substantial (but not huge) financial losses – $1m or $10m. When given *precise* information about both the probability and the size of loss, quoted premia exceeded the expected values of losses in a way that reflected underwriters' aversion to "pure" risk. However, when presented with essentially the same scenarios but with some *imprecision or ambiguity* about the probabilities and some *uncertainty* about the possible magnitude of losses, the average difference between premia and the expected values of losses frequently *trebled*. This kind of differential seemed quite robust across three different contexts – earthquake, leakage of toxic chemicals, and a "neutral" scenario involving an unnamed hazard.

Clearly, one should not place too much weight on any single study; but it was clearly the case that professional underwriters (and other insurance professionals, including actuaries) appeared quite consciously to inflate premia by a β–like factor when faced with ambiguity about probabilities and uncertainty about losses.

One might suppose that when it is life and limb that are at stake, rather than purely financial losses, the premium might be even larger. However, once again – bearing in mind the limited and indirect nature of the available evidence – we shall take what seems to us to be a cautious stance, and suggest that β may lie in the range 0.5 to 1.5.

Others may form a different judgement – and in due course, further research may clarify the issue – but let us consider the implications of assuming that α lies between 0.2 and 0.6, and that β lies between 0.5 and 1.5. Taking the lower end of *both* ranges would produce a WTP component of £930,000 for an avoided fatality, as such, on the Underground – a figure exactly 50% higher than the DTp's £620,000. Taking the upper end of both ranges produces a figure of £1,736,000, while the two mid–points interact to generate a figure of £1,302,000. If we then add the sum of £500,000 for all "other" components, we arrive at an overall value for avoiding a fatality on the Underground somewhere in the range £1,430,000 to £2,236,000, with a mid–point figure of just over £1,800,000. Thus the figure of £2m quoted from recent LUL documents lies inside this range, albeit towards the upper end – and would (just) continue to do so even if the sum for "other" components were reduced to £300,000.

It may be thought that at various stages of the analysis we have been relatively conservative. Possibly that is true. There is so little firm direct evidence to go on that we have had to exercise a degree of judgement and – being somewhat averse to uncertainty ourselves – we have tempered that judgement with caution.

We have also quite deliberately restricted ourselves so far to considering components which closely parallel those which enter into the DTp's road safety values, and *on that basis alone* we have come to the conclusion that it would not be unwarranted for LUL to use an overall "value of a statistical life" which is at least

1.5 times, and possibly as much as 3 times, the size of the figure used by DTp in relation to road safety.[5]

However, before concluding this report, we wish to draw attention to two other issues which may bear on the relationship between the value of safety on London Underground and the value used by DTp for the roads.

We also wish to raise the question of whether and how to discount the benefits of *future* expected reductions in deaths and injuries attributable to current safety investment. However, although this question has substantial implications, it is a somewhat separate matter, and we therefore deal with it in more detail in Appendix 2.

So let us now turn to the two further arguments which seem to us to be pertinent to an assessment of the level at which values of Underground safety should be set vis–a–vis their road counterparts. We refer to these as the "externality" argument and the "excessive reaction" argument.

Essentially, the "externality" argument is based upon the idea that in addition to the costs and benefits of Underground travel perceived by passengers, there are further "social" costs of pollution and congestion associated with road travel that will be avoided if road journeys can be diverted to the Underground. Since a fully worked social cost–benefit analysis ought to take account of these avoided costs, the value of anything that is likely to lead to substitution of Underground travel for road travel – such as Underground safety improvement – should be accorded its contribution to this avoided cost. Of course, precisely the

[5]It should, of course, be borne in mind that all of our monetary estimates have been made on the basis of the DTp's current WTP value of statistical life of £700,000. To the extent that the DTp has chosen to set its value at the bottom end of the range of available empirical estimates, one could argue that the figure of £700,000 is itself *too low a base.* However, we believe that any attempt to justify LUL's value on these grounds would not be fruitful and that the central issue for present purposes is the appropriate *relativity* of the Underground and road values.

same argument applies to any other kind of improvement that makes Underground travel more attractive – such as improved comfort and convenience or punctuality. Nevertheless, to the extent that improving safety – and in particular, reducing fears of catastrophic accidents – helps to divert travellers from road transport (and especially from private cars), it constitutes a positively valued social benefit which is consistent with LUL's business objective, and should be recognised as such.

More controversially, perhaps, the "excessive reaction" argument is based on the premise that formal enquiries set up in the wake of major accidents tend, in general, to result in a host of "belt, braces *and* safety–pin" recommendations. Reading through the lists of such recommendations, there seems to be little evidence that the authors have seriously considered how the marginal benefits of many recommendations compare with the costs of implementing them. Nevertheless, it is not unusual for the managements concerned to be required by the political process to implement the bulk of these recommendations without further ado, even if it means undertaking many projects which could not be justified under normal appraisal procedures.

The sums involved are far from negligible, as an example will illustrate. Suppose that LUL's *status quo* position is that an incident on the scale of the King's Cross fire can be expected to occur, on average, once every 25 years (a supposition entirely consistent with the F–N curve analysis used earlier). And suppose each such incident is followed by a report such as the Fennell Report which requires expenditures amounting (at a conservative estimate) to £150m more than would normally be justified on the grounds of a "value of life" in the range arrived at earlier in this section. If (also on the basis of the F–N curve analysis) LUL expects, on average, 9 or 10 fatalities/fatality equivalents each year for the next 25 years, the excessive expenditures average out at £600,000 per fatality. If this figure is added to our earlier estimates, it shifts the *lower* end of the "value of statistical life" range to slightly *more* than £2m, and the upper end to more than £2,800,000.

It may appear somewhat paradoxical that by (quite rationally) anticipating the risk of having to undertake excessive expenditure, the value of safety may be raised to an extent which encourages LUL to undertake some projects that would not otherwise be regarded as justified.

But what is the alternative? Ideally, it would be to persuade those who commission or sit on enquiry panels to adopt good project appraisal practice when formulating their recommendations. In the absence of any such welcome developments, LUL's business objective leaves little choice but to build in an additional component to allow for "Fennell effects".

Under these circumstances, our considered judgement is that a figure of £2m per avoided fatality seems entirely acceptable – and possibly even slightly on the low side. Pending further research yielding more direct evidence, we recommend the (continued) use of that figure in appraising safety programmes on London Underground.

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APPENDIX 1 : THE "POWER" APPROACH TO DEFINING THE VALUE OF STATISTICAL LIFE FOR CATASTROPHE RISKS

As in Section 3, let v denote the pure WTP component of the value of statistical life for road risks. Taking the "power" approach, the pure WTP component of the value of *each* statistical life saved by preventing an event that would involve N fatalities is then given by vN^{θ}, $\theta \geq 0$. Under the "explicit and separate valuation" approach to dealing with non–fatal injuries, the pure WTP component of LUL's average "cost of a fatality"/"value of statistical life", û, for the F–N curve, $F = \frac{a}{N}$, $0.01 \leq N \leq 100$, would then by given by :

$$\hat{u} = \frac{(1+\alpha)\int_{0.01a}^{a} vN^{\theta}\,\frac{a}{F}\,dF}{\int_{0.01a}^{a} \frac{a}{F}\,dF}$$

where, as before, α denotes the premium for Underground casualties in relation to road casualties of corresponding severity. In order to simplify matters, consider the case in which a = 1, so that $F = \frac{1}{N}$. The above expression for u then simplifies to :

$$\hat{u} = \frac{(1+\alpha)\ [(0.01)^{-\theta} - 1]v}{4.6\theta}.$$

Hence, setting v = £620,000, with $\alpha = 0.2$ and $\theta = 0.1$ for example,

û = £946,000,

while with $\alpha = 0.2$ and $\theta = 0.2$

û = £1,223,000,

and in turn, with $\alpha = 0.2$ and $\theta = 0.4$,

û = £2,147,000.

Under the alternative "package" approach to dealing with non–fatal Underground injuries, these figures would be £1,892,000, £2,445,000 and £4,293,000 respectively.

Clearly, then, under either approach to incorporating non–fatal injury effects, the pure WTP component of the value of statistical life is very much more sensitive to variations in the parameter θ than it is to variations in the fixed catastrophe premium, β, used in Section 3 of the main text.

APPENDIX 2 : DISCOUNTING AND SAFETY

Discounting for futurity is a central feature of commercial project appraisal. This reflects the fact that nominal (and real) interest rates are typically positive and that revenues and costs are generally subject to more uncertainty the further in the future they are likely to arise.

In turn, albeit for somewhat subtler reasons, it is generally held that future benefits and costs should also be subject to discount rates in public sector project appraisal and cost–benefit analysis.

Does this mean that LUL's costs of risk and values of safety for various severities of injury should be subject to discounting for those projects whose safety effects can be expected to manifest themselves over a number of future years? We believe that the answer depends upon *which component* of the WTP based "cost of risk"/"value of safety" is being considered.

In the case of those components that relate directly to LUL's financial position and gross margin target (ie the costs of legal compensation and system damage), there seems to us to be every reason for proceeding in precisely the same way as with other factors that impact upon LUL's gross margin. That is, these components should be discounted at LUL's standard rate of 8.5%.

As far as medical and police costs are concerned, we are not clear how these affect LUL. If these costs are ultimately borne by LUL, then they should plainly be treated in precisely the same way as legal and system damage costs. If, by contrast, these costs fall upon (and "stay with") the public sector then they should, in principle, be treated as having a direct impact on "net social benefit" and hence be subject to the prevailing *public sector* discount rate.

When we turn to the pure WTP component of LUL's "cost of risk"/"value of safety" however, matters become altogether more controversial. As far as we are aware, those U.K. agencies that employ WTP based values of safety currently subject these values to discounting in their project appraisal procedures. However, we believe that such discounting is *unwarranted* and we are, apparently, not alone in this view – see Broome and Ulph [1991] Ch. 3, Spackman [1991] and Parsonage and Neuburger [1991]. Essentially, the issue is this. If LUL's discount rate of 8.5% is applied to the pure WTP component of the value of statistical life then the current "net social benefit" of preventing a fatality in the year 2012 will be treated as being about *one fifth* of the corresponding benefit from preventing a fatality in 1992. We can think of no persuasive moral or ethical principle (other than one founded upon severe doubts about the continued survival of the human race beyond a twenty year horizon) that would treat the death of someone selected at random from the population existing in the year 2012 as being only "one fifth as bad" as the current death of a randomly selected person. *Yet such differential treatment is an inescapable consequence of discounting.*

Of course, it might be argued that since individual willingness to pay for safety will rise with income (and there is ample evidence that it does – see Jones–Lee et al [1985], Persson [1988] and Miller and Guria [1991]), then given growing real incomes, the pure WTP component of the "cost of risk"/"value of safety" will tend to increase with futurity so that, in real terms, the (undiscounted) WTP value of preventing a fatality in twenty years' time will be *substantially larger* than the corresponding value for a fatality now. In the unlikely event that LUL's project appraisal procedures were to take explicit account of this phenomenon, then some sort of discounting would undoubtedly be called for. However, we cannot escape the strong moral intuition that, under these circumstances, the discount rate to apply to the pure WTP component of a "cost of risk"/"value of safety" should be chosen so as to *offset precisely* the real–income elasticity of individual willingness to pay for safety.

Thus, if our arguments concerning discounting are well–founded, it is not only essential that LUL should have well–specified WTP based costs of risk and values of safety but it is also vital that LUL should be clear about the way in which these costs and values break down into their component parts.

We illustrate the point with an example. Suppose an investment in safety this year (t_0) is expected to prevent exactly one fatality next year (t_1) and each year for 19 years after that – at which point, it ceases to have any further effect. To keep things simple, suppose also that the safety investment requires only a lump–sum expenditure this year i.e. disregard maintenance costs etc.

Working with an overall value of £2m per avoided fatality, discounting *all* 20 lives saved during the period t_1 to t_{20} by applying the 8.5% discount rate to the full £2m in each case would generate a total present value of the benefits of £18.93m.

But suppose instead that the £2m per life were decomposed into £500,000 of discountable costs and £1,500,000 due to pure WTP which should *not* be discounted. The total present value of benefits under these assumptions would now be £34.73m – almost *twice* the figure calculated the other (and we would argue, *wrong*) way.

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Human factors investigation of LUL staff accidents
Assaults

- Assaults on employees substantial contribution to LTIs
- Previous research already carried out for LUL & HSE in this area (Poyner and Warne, 1988)
- Previous research was updated using recent INF data to identify models for 7 assault situations:-
- Assault whilst excluding drunks and vagrants from stations
- Fare evasion leading to assault
- Assaulted whilst trying to stop passengers entering/ leaving train via guard's door
- Armed robbery at booking offices
- Asssulted whilst cautioning passengers for smoking/ abusing LUL property
- Assaulted whilst dealing with non-routine situations (e.g. detraining, flow control)
- Mugging

Human factors investigation of LUL st .ff accidents
Outline of recommendations

- Based on the analyses carried out for the study a number of recommendations have been produced
- Process of incident investigation should be made a higher priority with specific training for dedicated investigators
- Methodology used to investigate IIRs for this study should be adapted to improve data collection and clarification of causal factors. This will also focus attention on management and organisational factors
- There needs to be a shift of health and safety culture away from individual blame and reliance on documented rules and regulations. This must stem from management and may be achieved with a greater focus on the new Safety Management System.
- More pattern analysis of causes should be carried out to build up generic models for different incident types. An initial start in this area has been made in the present study This type of analysis should be carried out by the SQD.
- A formal system of action tracking has been introduced. The present study supports the need for this system. In addition, other methods of communicating potential problems, causes of incidents, etc. and feeding these back to the lines needs to be developed in order to improve learning from operational experience.