safety theories, models and metaphors

Paul Swuste
safety science group
Delft University of Technology

<table>
<thead>
<tr>
<th>safety beliefs</th>
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<tbody>
<tr>
<td>safe behaviour (safety first movement-1906)</td>
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<tr>
<td>safety culture (Chernobyl-1986)</td>
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<tr>
<td>safety management (Robens-1972, Piper α-1988)</td>
</tr>
<tr>
<td>safety leadership</td>
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<td>safety indicators (BP Texas-2005)</td>
</tr>
</tbody>
</table>

links with (major) accident/disaster scenarios?
**from data to knowledge**

**DATA**, raw facts

classification based on metaphors, models of accident processes

**INFORMATION**, explanation

theories

**KNOWLEDGE**, prediction

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**topics**

*long before, acts of God*

1840-1910
- safety technique: engineers
- external causes: sociologist

1900-present
- unsafe acts: engineer
- behaviour, human factor: psychologists

1950-present
- hazard-environment-victim: physicians
- safety management: engineer
- men-machine interactions: ergonomist
- compound & human failure: engineers, psych.

1985-present
- complexity
- systems are unsafe: sociologist
- safety culture: anthropologist
- manage the unexpected: psychologists
acts of god

Leyden, explosion
gunpowder ship
1807

Delft, explosion
gunpowder storage
1654

1800 manufacturing
direct feedback

MEN

RAW MATERIALS
topics

long before, acts of God

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**19th century manufacturing machine feedback**

- MEN
- MACHINES
- RAW MATERIALS
‘.. much of current hazardous labour is very stupid, and monotonous. It kills all energy of workers, and turns a worker into a machine’

Heijermans (1905). Gezondheidssleer voor arbeiders
Pittsburg survey

accidents
- incidence accidents educated white Americans ≡ uneducated immigrants
- accidents are unique events ≠ prevention
- opinion workers, foreman: 95% is victim
- repeated accidents, are preventable

responsibility
- foremen, superintendents have authority over work, not workers
- inexperienced workers are send to dangerous places

consequences
- financial burden is for families of victims
- consequences of accidents are a big social waste. Social justice legislation is needed to prevent, manage financial consequences
topics

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unsafe acts
US safety first movement 1906
unsafe acts & behaviour

Fig. 22.

SYMBOLICAL HEAD
ILLUSTRATING THE
NATURAL LANGUAGE OF THE
FACULTIES.
unsafe acts & behaviour
accident proneness theory

Greenwood & Woods 1919,
there are clumsy workers, causing accidents, and careful workers

unsafe acts & behaviour
Beyer 1916

STAIRWAY ACCIDENTS

Many Persons are Killed or Injured Every Year by Falls Down Stairways

Keep Your Hand On The Rail!
<table>
<thead>
<tr>
<th>Year</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>1931</td>
<td>industrial accident prevention, a scientific approach</td>
</tr>
<tr>
<td>1941</td>
<td>industrial accident prevention 2nd ed</td>
</tr>
<tr>
<td>1950</td>
<td>industrial accident prevention 3rd ed</td>
</tr>
<tr>
<td>1959</td>
<td>industrial accident prevention 4th ed</td>
</tr>
<tr>
<td>1980</td>
<td>industrial accident prevention 5th ed</td>
</tr>
</tbody>
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<tr>
<td>1927</td>
<td>the “incidental” cost of accidents</td>
</tr>
<tr>
<td>1928</td>
<td>the origin of accidents</td>
</tr>
<tr>
<td>1929</td>
<td>a message to foremen</td>
</tr>
<tr>
<td>1929</td>
<td>the foundation of major injury</td>
</tr>
<tr>
<td>1932</td>
<td>the safety engineer aids the life underwriter</td>
</tr>
<tr>
<td>1935</td>
<td>the use of accident records in prevention</td>
</tr>
<tr>
<td>1938</td>
<td>accident cost in the construction industry</td>
</tr>
<tr>
<td>1938</td>
<td>it’s up to the foreman!</td>
</tr>
<tr>
<td>1942</td>
<td>men in motion</td>
</tr>
<tr>
<td>1942</td>
<td>the foreman’s place in the safety program</td>
</tr>
<tr>
<td>1945</td>
<td>key men in industry: part 1-3</td>
</tr>
<tr>
<td>1950</td>
<td>the human element in the cause and control of industrial accidents</td>
</tr>
<tr>
<td>1951</td>
<td>the safety engineer and home safety</td>
</tr>
<tr>
<td>1956</td>
<td>recognition of safety as a profession</td>
</tr>
<tr>
<td>1956</td>
<td>the accident cause ratio, 88 : 10 : 2</td>
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</tbody>
</table>
timeline 1900s till 1920s

1906 safety first movement, US
1910 external causes, US
1926 hazard Ó energy, US
1927 costs 1:4, US
1929 mechanism 1:29:300, US
Heinrich’s axioms 1941

1. injury is the result of a **sequence** of events, one in the accident
2. accidents are caused by human errors and physical hazards
3. **human errors** are by far the most important cause
4. not all human errors are leading to accidents
5. motives for human errors are starting points for prevention
6. the severity of injuries are coincidental
7. control of accidents also controls costs and quality of production
8. **management** is responsible
9. the **foreman** is the key to prevention
10. indirect costs of accidents are also costs
3 oorzaken van ongevallen

Ik ZAG het niet.

Ik DACHT er niet aan.

Ik WIST't niet!

causes of accidents

Onwetendheid • Onoplettendheid • Onvoorzichtigheid • Onwellevendheid

GRUP nog vandaag die vier O's bij de kraag!
timeline 1930s till World War II

1935 external factors, UK

1941 domino’s, US

operational research, UK

topics

long before, acts of God

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  manage the unexpected: psychologists
Mondriaan
Victory Boogie Woogie 1944

unsafe acts & behaviour
Bird and Germain 1966

INTRODUCING
COMMON DENOMINATOR PERSONALITIES
INVOLVED WITH
PERSONAL INJURY AND PROPERTY DAMAGE

- "CARELESS CARL"
- "RASHY RONN"
- "HECULESS HARVEY"
- "PREOCCUPIED PAUL"
- "FORCEFUL FRANK"
- "INATTENTIVE INN"
- "IGNORANT IDA"
- "EGORIOUS EDDY"
- "HORSEPLAY HARRY"
relation between unsafe acts, damage, and injury
Bird and Germain 1966

Bird and Germain 1966

ACCIDENT RATIO STUDY

SERIOUS OR DISABLING
Includes disabling and serious injuries.

MINOR INJURIES
Any reported injury less than serious.

PROPERTY DAMAGE ACCIDENTS
All types.

INCIDENTS WITH NO VISIBLE INJURY OR DAMAGE
(Near-miss accident)
<table>
<thead>
<tr>
<th>Safety Management (Period before 1950 - Precursors)</th>
<th>General Management Approaches</th>
</tr>
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<tbody>
<tr>
<td>Roosevelt 1908: manage production scientifically</td>
<td>behavioural management 1930s</td>
</tr>
<tr>
<td>Taylor 1911: the principles of scientific management</td>
<td>rise of industrial psychology</td>
</tr>
<tr>
<td>redesign tasks, working methods</td>
<td>behaviour, motivation, leadership</td>
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<tr>
<td>Gilbreth 1917: time-motion studies</td>
<td>modern management 1950s</td>
</tr>
<tr>
<td>insurance companies: safe production is efficient</td>
<td>company is an open system</td>
</tr>
<tr>
<td>classical management 1900: top manager is the centre</td>
<td>managing = decision making &amp; information</td>
</tr>
<tr>
<td>of decision making</td>
<td>Deming, Juran 1980s</td>
</tr>
<tr>
<td></td>
<td>quality control from product to process</td>
</tr>
<tr>
<td></td>
<td>the problem is management</td>
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Heinrich 1950

The foundation and the five steps of accident prevention.

deming circle
Deming quality management

Accidents are complex

- Agent is not clear (~ occupational diseases)
- For a long time, distinction between cause and consequence was vague
- Fatalistic attitude: ‘shit happens’, ‘acts of God’
- Low quality of scientific safety research
unsafe acts, behaviour, dominance of psychological explanation

- Freud, rise of industrial psychology
- Accidents are preventable, insurance companies, industry;
- Causes are workers and education: prevention ≡ education, training, selection
- ‘Blaming the victim’ is popular, risk taking is rewarded, failure (accidents) punished

epidemiological triangle
Haddon 1949
Gibson 1961. The contribution of experimental psychology
Haddon 1963. A note concerning accident theory and research

hazard – barrier – vulnerable object

prevention strategies
Haddon 1973

1. prevent build-up of E;
2. reduce amount E;
3. prevent emission E;
4. reduce rate and distribution E;
5. separate E of host (time, space);
6. place physical barrier between E & host;
7. limit contact surface host;
8. strengthen resistance host;
9. evaluate damage asap, take action;
10. stabilise host.
Willem Winsemius (1917-1990)  
men-machine interactions

An accident is a sudden physical ‘event’, causing damage.

Task dynamics, acts to complete a task.

If a ‘fast way’ creates greater risks, and a safer way takes longer, the fast way is preferred.

At high task dynamics, during process disturbances, the fastest way will be chosen.

Prevention strategies according to Winsemius 1951

Safe way should not be devious;

Safety ≡ reduce process disturbances;

Create comfortable workplaces, importance of ergonomic design.
**timeline after World War II - 1950s**

1949  epi triangle, US

1950  management, US

1951  task dynamics, NI

**human factors and ergonomics**

US:  human factors, quantification of human faults, comparable to reliability assessments van pumps, valves

safety  failures of components, and workers

UK:  ergonomics, information processing

control panels look like clock shops

Singleton 1967. ergonomics in system design (UK)
Hale & Hale 1970. accidents in perspective (UK)
Swain 1964. problems in measurements of human performances (US)
<table>
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<th>Powell ea 1971</th>
<th>topics</th>
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<td>long before, acts of God</td>
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<td>o apathy of the workplace</td>
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<td>o safety is too much paperwork</td>
<td>safety technique: engineers</td>
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<td>o redesign equipment and workplaces safely and ergonomically</td>
<td>external causes: sociologist</td>
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