Investigating accidents as an expert witness

Biases in investigations: how these can be minimised with analytical methods
An iconoclastic and partisan analysis of the 2005 Buncefield explosion

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Theme of the talk

“We can be almost certain of being wrong about the future, if we are wrong about the past”
G.K. Chesterton (1874 – 1936)

Preconceptions bias: ‘traditional’ investigations

- Preconceptions (confirmation)
  - Causality – who to blame: jump to conclusions; and rationality of behaviour
- Hindsight – part of “availability”
  - Bad events seem more likely and more preventable in the aftermath – and errors more culpable
- Role of (company) investigators and expert witnesses
  - Partisan support in an adversarial legal system
- How Events & Causal Factors Analysis (ECFA) can reduce biases, and promote full investigations

So ‘traditional’ investigators are likely to:

Hindsight: heightened risk perceptions graph
inspired by Tversky & Kahneman (1973) “Availability” theory

Enforcement notices and prosecutions

Rules and safeguards devised here may be violated when perceptions decay over time

Serious accident

Perception of risk

Injuries

Investigate accident - steered by the preconceptions of the investigator

Rule derived forbidding unsafe acts

Technical solution to make conditions safe

Injured person

Organisation

The ‘big name’

Unicausal ‘world view’

No multi-causality

‘Fundamental attribution error’

‘Stop rule’: blame the...

Attribute primary cause to unsafe acts

Attribute primary cause to unsafe conditions
**Preconceptions (confirmation) bias**

- Cherry pick (or worse) the evidence to confirm preconceptions
- Blameworthiness magnified (and mistaken conclusions) if investigators think fallible decisions inexplicable and / or irrational, so:
  
  “Go on collecting and analysing data until you feel that you too, in the given circumstances, would have made the same decision which proved in practice to be wrong”

  Prof Andrew Hale; Chair, Hastam

**Hindsight bias**

Prof James Reason FRS (2008)

“There is a universal tendency to perceive past events as somehow more foreseeable and more avoidable than they actually were

Our knowledge of the outcome unconsciously colours our ideas of how and why it occurred”

**Hindsight: Fischoff (1975 / 2003)**

“Consider a decision maker ... caught unprepared by some turn of events ... he can do little more than berate himself for not taking the action which his knowledge seems to have dictated

... When ... second guessed by a hindsightful observer, his misfortune appears to have been incompetence, folly, or worse”

**Hindsight: Fischoff (1975 / 2003)**

“Given knowledge of outcome, reviewers will tend to simplify the problem solving situation that was actually faced by the practitioner. ... Possessing knowledge of the outcome, because of the hindsight bias, trivializes the situation confronting the practitioners and makes the correct choice seem crystal clear”

**Hindsight: Fischoff (1975 / 2003)**

“... what passes for the wisdom of hindsight often contains heady doses of sophistry” - that the perceived inevitability of outcomes is imposed upon, rather than legitimately inferred from, the available evidence”

* “The clever use of arguments that seem true but are really false, in order to deceive people” https://dictionary.cambridge.org/dictionary/british/sophistry

**Hindsight bias – key points**

- Research has uncontested authority
- People who think that they can ‘factor out’ bias are wrong
- Fallible decisions and unintended human errors look ‘incompetence, folly, or worse’ (decisions may not be fallible at all)
- Scapegoating individuals & organisations
- Sophistry: cherry picking & distortions
- Important ‘other’ preventive work appears ‘misdirection of effort’
- (Outcomes – violations leading to ‘disasters’ condemned; ‘good’ outcomes: violations condoned)
The Buncefield explosion


Buncefield explosion
06:02 Sunday 11 December 2005

- HOSL: Oil Storage Depot JV owned by Total UK Ltd 60%; Chevron 40%
- Total the employer and also contractually responsible for safety
- Overflow of 250,000 litres of petrol from storage tank T912
- Vapour ignited by spark from fire-pump motor
- Devastating ‘unconfined’ vapour cloud explosion (UVCE) and major fire
- Epicentre of explosion meant that no HOSL staff or tanker drivers were fatally injured

Buncefield from the North

Fire pump

Tank T912

The explosion

Graham Nash (Pipeline supervisor):
“The windows of the control room were blown in and I was thrown across the room”

Mark Foorde (Terminal Supervisor):
“There was orange everywhere. I either fell or was blown to the floor. The other drivers were as well.

As I was running towards the control room there was not much left

All the windows had gone and the ceiling was hanging down. I thought Graham was dead, but as I got there he popped up large as life on the phone”
HOSL tanks burning following the explosion. The epicentre was adjacent to the office building on the left foreground.

Immediate events: technical
10 & 11 December

- Failure of an endemically-unreliable automatic tank gauge (ATG) and consequential non-operation of ATG high level alarms, and:
- Failure of an apparently-functioning independent high level switch (IHLS) - but with a crippling latent defect
Storage tank — fuel level monitoring and safety devices

Immediate events; procedural
10 & 11 December 2005

- Day shift log error (tank T915 & ‘slow’ flow-rate Total pipeline), and cursory shift handover
- Graham Nash (night-shift pipeline supervisor) multiple tasks & concerns
- No T912 (T915) level checks by Graham, so ATG seizure (and resulting non-operation of alarms) not detected
- Mr Nash scapegoated by Total; despite:
  - ‘It is unrealistic to expect an operator to watch a level when a trip (or alarm) is provided’ (Kletz; 1987 / 2009)
  - Nobody knew of IHLS defect
  - Graham responsible for overfill NOT overflow

Precursors: suppliers

- Motherwell Control Systems (MCS) supplied and maintained ATGs and (TAV) IHLSs.
- MCS failed to effect robust ATG repairs
  - Faults corrected, NOT corrective action (14 ATG failures in three months)
- Crucial IHLS locating pins (actually padlocks) not fitted by MCS engineers – presumed only for security!
  - No instructions supplied by TAV (manufacturer)
  - I have not read MCS evidence that might explain how this happened – looks superficially like ‘folly’

The Major Incident Inquiry Board: purpose and challenges

- Tasks: thorough investigation to establish root causes (and Prior Role of CA)
- Inquiry nominally led by MIIB but hijacked by HSE – in role as prosecutor
- Many organisations in the causal chain: BPA; BP; Chevron; DNV; HOSL; HSE (CA); MCS; Shell; TAV; Total – and their staff
- The crucial issues for the MIIB:
  - How the explosion happened
  - Failible decisions by the parties
  - How these failible decisions interacted and came together on 11 December 2005
  - Lessons for prevention

The MIIB – how the prosecution of Total impeded its work

- Total the ‘fall guy’ from the outset; all the opprobrium for overfill [from all parties] (prosecution WAS appropriate)
- Others written out of the story or errors excused
- Witnesses cherry-picked and ‘cut off’
- As a result, HSE investigation did not help MIIB draw the salient lessons from the incident – ‘wrong about the past’
- The signal to the industry was that Total were incompetent
- Not that good / best practice safety management systems were insufficiently robust to detect degradation of ‘preventive resilience’

Shortcomings of process

- Prior role of HSE criticised objectively (by HSE)
  - Contents known to the prosecution in 2008
  - Only disclosed to Total in 5/10 a year after guilty plea decided (7/09) – ‘may have assisted defence’
  - Should have been published at latest in January 2011 (as promised) – but NOT yet published
  - COMAH CA (2011) published

Note that this report was written for the MIIB by HSE / EA staff not involved in COMAH regulation or in the prosecution

MIIB (Crown copyright 2008) “The Report of the Buncefield Major Incident Investigation Board into the policy and procedures of the Health and Safety Executive’s and the Environment Agency’s role in regulating the activities on the Buncefield site under the COMAH Regulations”
**MIIB Final Report (paraphrased)**

- “The regulatory conduct of the CA ... was examined by the [criminal] legal team.... The purpose was to see whether the prior role of the CA had any bearing on the events ... which might undermine any prosecution or support a defence ... It is rightly the task of those conducting the criminal investigation to examine whether any acts or omissions of [the CA] had any bearing on the Buncefield incident.”

**HSE as prosecutor – unfounded (biased) allegations and let offs**

- Total should have included UVCE from tank overflow in COMAH Safety Case and preventive plans; latter LTA as ‘what was at stake’
  - MIIB: “UVCE not realistically credible” – HSE & Industry mind-set
  - DNV quantitative analysis fundamentally wrong
  - HSE told HOSL not to include overflow as a MAH (HSE role air brushed out)
  - HSE guidance complacent HSE (1998) HSG176
- Total Safety Case: feet dragging and hopeless
  - In fact generally excellent
  - HOSL COMAH training too legalistic
- HSE told HOSL to remove conditions on UVCE (HSE role air brushed out)
- Total’s role as a customer
  - Rumbled MCS generally
  - Nick Toone (HSE HID) MSc evidence that Total following good industry practice
  - ‘Applied their minds’ to IHLS testing; BUT
    - MCS widely used in other OSDs
    - DID consider IHLS testing thoroughly; HSE involved
    - No other OSD had detected IHLS fault
  - HSE as prosecutor
    - unfounded (biased) allegations (and let offs)
    - Critical HSL report on fatigue based on 2006 guidance; insecure, and irrelevant here
    - Glaring errors in HSE expert’s report not checked
    - HSE must reasonably have known that many of their criticisms of Total unfounded or exaggerated
- The PCS “is misleading, inaccurate, unethical and substantially marred by the biases of hindsight ... Its occasionally polemical, intemperate and sarcastic tone did not rise to the level of events”

**Hastam evidence to HSE Triennial Review July 2013**

**How Events & Causal Factors Analysis (ECFA) can help**

- **Promote** thorough investigations
- **Reduce** net bias and challenge bias by others
- **Tell the ‘story’** as objectively as possible
- For each event in ECFA put oneself in position of people involved – the challenges they faced
- Show where best to intervene to prevent repetitions - and incidents generally
- Review repeated failure types: human; procedural; technical (and comparisons with other incidents)
**Investigation techniques:**
*Events and Causal Factors Analysis (ECFA)*
- Chronology of discrete events leading to an incident – the timelines for each part of the ‘story’
- Ask ‘why’ (maybe more than ‘five times’) to determine:
  - The conditions (explanations) relating to the events
  - The causal factors - eg ‘less than adequate’ (LTA) ....
  - The links between the stories
- Leads to an accessible map of incident causation
- See ‘Supplementary material’ – also includes Fault Tree Analysis (FTA)

**Buncefield ECFA ‘Map’**
- Coves
  - Only part of the story (lots of secondary events ‘stories’ omitted eg HSE prior role)
  - Drafted six months before all evidence studied
  - Lots of gaps and errors

**Buncefield ECFA**
*Primary events:*
- The timeline of events on 10 & 11 December 2005
*Secondary events:
- CA decision whether overflow a ‘major accident hazard’ (precursors ignored)
- Preparation of HOSL / Total Safety Case
- Role of HOSL Board
- DNV audits
- Reliability issues: ATGs and IHLSs
- HOSL senior staff activities (lack of focus)
- Throughput challenges (role of JV partners)
- HOSL ownership history

**The generic learning points – informed by gathering data for the ECFA**
*Some issues not mutually-exclusive*

**UVCE ‘Not realistically credible’ and COMAH safety cases**
- Corporate memory – learning from ‘disasters’
  - Regulator’s fallible decisions and their dominant impact
  - Overflows (undesirable on any terms) ‘fell below the radar’
  - DNV quantified risk assessment findings flawed: prediction of % vapour with ‘waterfall’ from overflowing tanks not considered
  - Satisfying the regulator not enough
  - Generic reliability data almost worthless
**Management of HOSL / JVP subsidiaries**

- Vulnerability of JVPs - conflicting pressures
  - Shell / Chevron took throughput scheduling decisions; HOSL staff not consulted; Total powerless – 50% increase in Chevron throughput 2002 - 2004
  - Chevron veto on expenditure / staffing levels
- Parent companies should manage subsidiaries with a ‘light touch’ (a management ‘mantra’)
- Fingers on the pulse
- Best practice audits miss resilience decays
- HOSL Board minutes show high focus
- Good news swamped bad news

**Intelligent customers and change management**

- How should clients evaluate expert suppliers?
- What expertise required ‘in house’?
- What is a ‘material change (COMAH)’ – a ‘like-for-like’ replacement?
- Fault correction hopeless if not combined with corrective action

**Shifts and control room operations**

- Weak shift record keeping and handovers – a generic problem – a lesson of several major accidents; but not acted upon
- Supervision of shift work; checks on shift logs by managers essential
- Shift scheduling (fatigue)
- Vigilance reduced where automated systems; exacerbated here by personal preoccupations
- Coping with high risk challenges perceived as essential skill of experienced staff: continual work on a knife-edge part of the job
- Weekends vulnerable

**Preventive resilience: the slippery slope**

- Several organisations’ resources inadequate, notably HSE, HOSL and MCS
- Tensions between staff working under unreasonable pressure and some suffering domestic challenges
- No ‘spare capacity’, including
  - Lack of storage tanks (thus no realistic IHLS test)
  - Violations committed to get the job done: everyone doing there best, but ‘working around’ constraints
  - HOSL staff sent to Colnebrook OSD (Heathrow) at critical time
- OSDs not profit centres and faced penalty charges
- Key people did not know what was going on

**Pastiche conversation: Total HOSL Chair and Site Manager – 4 weeks before explosion**

Nick: ‘Bob. We’ve got big problems at Colnebrook. Contractors have screwed up … Can you get down there pronto with Steve and Phil?’

Bob: ‘Well, I’m up to my eyes in completing the COMAH report; Chevron are playing silly buggers again …; Steve’s having a wobble about the critical parts list …; Phil’s about to resign … Supervisors are threatening strike action – oh and we haven’t even started preparing the ISO 14000’

Nick: ‘You think you’ve got problems … Well forget the ISO – You must be there first thing tomorrow’

Rob: ‘Um … OK … I’m … sure we can fit everything in; We’ll be there at 7.30’

**The full investigation process**

ECFA aids data collection (identifies gaps in knowledge)

ECFA & FTA aid data analysis
Recap: Biases in investigations – inter-related with synergy

- **Preconceptions (confirmation):**
  - Uni-causality or multicausality
  - Who to blame; rationality of behaviour
- (‘Availability’ – people more influenced by recent or particularly vivid events)
- **Hindsight** – bad events seem more likely and more preventable in the aftermath
- **Role** of investigators – partisan support for the protagonist who engaged investigator; potential ethical challenges

**Biases – training suggestions**

- **Biases of outcome (ie, hindsight)**
  - Two teams review causal factors of an event (eg, emergency services) from the same ‘neutral’ narrative
    - Team 1: Conclusions based on ‘bad’ outcome
    - Team 2: Conclusions based on ‘good’ outcome
  - Later in course (after ECFA explained)
    - Team 1: Conclusions based on ‘bad’ outcome but with ECFA
    - Team 2: Conclusions based on ‘good’ outcome but with ECFA
  - Compare and contrast team reports at end of both exercises

- **Biases of role**
  - Two teams review causal factors of an adverse event from the same ‘neutral’ narrative – but including prior role of regulator
    - Team 1: Conclusions: prosecutor
    - Team 2: Conclusions: defence
  - Later in course (after ECFA explained)
    - Team 1: Conclusions: prosecutor but with ECFA
    - Team 2: Conclusions: defence but with ECFA
  - Compare and contrast team reports at end of both exercises

**Concluding remarks**

**Supplementary material**

- Events and Causal Factors Analysis (ECFA)
  - Set out each part of the story:
    - Next the events leading to a missing section of guard rail (secondary events line)
    - And show how each part of the story is linked via conditions and causal factors
    - But still not the whole story:
      - Why was SUK on Refurb’s approved contractors list? *Were Refurb’s contractor appraisal systems LTA?*
      - Does this support uncertain evidence that Refurb undocumented PPE procedures were LTA?
Methodology illustrated here with a job from a scaffold
First the Primary events; with three conditions and one possible causal factor
(Not a real case)

A simple explanation of ECFA and how lessons can be learnt:

- Methodology illustrated here with a job from a scaffold
- First the Primary events; with three conditions and one possible causal factor
- (Not a real case)

Investigation techniques:
Fault Tree Analysis (FTA)

- Identify combinations of faults that resulted in an adverse TRO event (incident)
- Cascade tree downward to establish underlying and if possible root causes / faults
- Use ‘Boolean’ algebra: ‘AND’ gates; ‘OR’ gates to identify faults relevant to incident
  - AND: two or more faults must be present together
  - OR: two or more faults, but where only one needs to be present
- Logical map of incident causation
- Example – fall from a scaffold (as before)
Example of a simple FTA

FTA Symbols

- **Failure or Event** caused by a combination of contributory causes.
- **Basic Fault or Event** caused by a component or human factor.
- **Unusual Event**. This symbol represents an unusual or acceptable situation, not a fault condition.
- **Fault or Event** that is not developed further due to lack of information or importance.
- **OR gate**. The output exists if any (or any combination) of the inputs are present.
- **AND gate**. The output exists only if all the inputs are present.

**Transfers**: These symbols (N & C/L/T) are used to duplicate an entire port of a tree location on the Tree.

Symbols with dashed contours indicate that the information is incomplete or non-existent.