

THE ART OF INVESTIGATIONS & ACCIDENTS

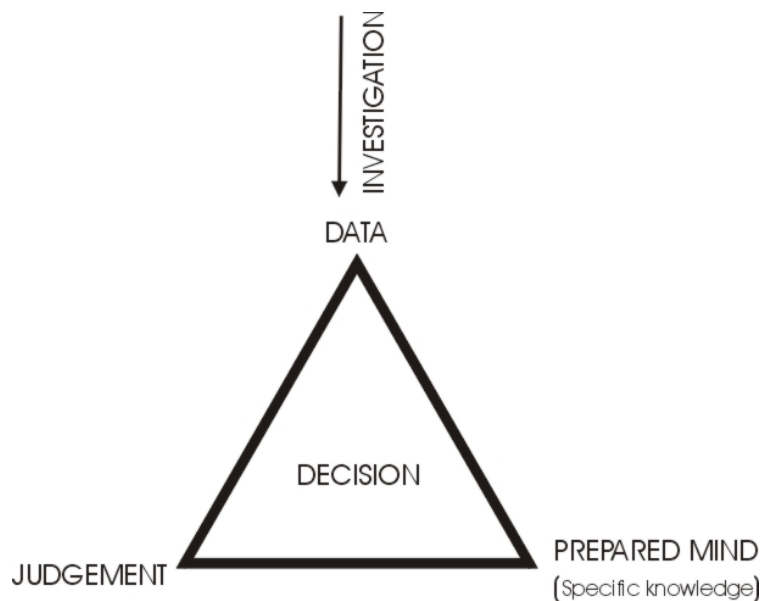
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1. HUMANITY AND INVESTIGATIONS IN THE MODERN ERA

Humankind underestimates the relevance and real power of investigations, both at work and in our everyday lives. This is no surprise because we are primarily action orientated decision makers & problem solvers, particularly at work and especially in the mining industry which is very much results-orientated. Therefore we tend to overlook the start point of a decision making process which is to always have information (preferably quality information) upon which to decide in the first place.

This essential information (data) can only be produced by an investigation, often done by ourselves, but at work just as often done for us by others depending upon our role & responsibilities. No data...no decision...no problem solving.

A bad investigation will produce bad information, the rest of the story we can easily predict.



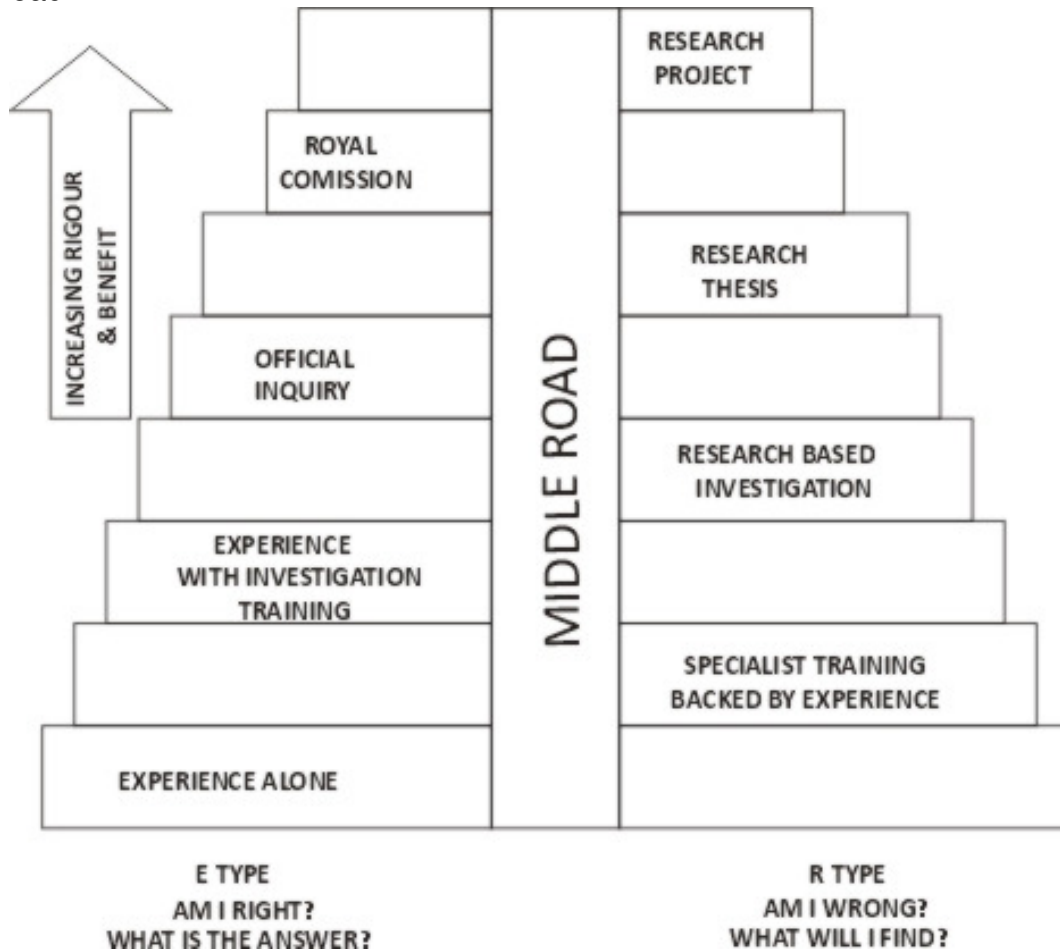
In the modern era (that is, post industrial revolution or less than 200 years ago) there are but two types of formal investigation:

Experience Based Investigations (EBI), what we can call E-Type Investigations (for example the court system, or an audit); and,

Research Based Investigations (RBI), what we can call R-Type Investigations (for example original work by specialists such as an OCE or a Gas Examiner, or, original work via higher education such as a PhD).

Both can be used in greater or lesser degree depending on the circumstances under investigation. For example, pure E-Types are ideal for document examination & investigation (legislation and written records) whereas R-Types are the preferred choice in any technical situation (machinery, equipment & processes).

E & R-Types are not mutually exclusive for workplace or work related investigations. The most productive are those that are an interactive fusion of both, what we can call the middle road.



Unfortunately, all investigative work can be affected by the same subconscious processes which often contribute to or even cause accidents. This means that investigations are at all times potentially prone to errors, sometimes severe, but in the worst case just plain wrong. To defend against these errors, E-Type investigations often use step-by-step investigative systems (or tools) to guide the investigator(s) along a “safer” course. We can call these bureaucratized investigations [their origins date from before the common era (BC) so are at least 2000 years old]. On the other hand, R-Type investigations are more resistant to errors because they are designed to self-reference against established fact, most generally in agreed science, technology and mathematics. R-Types are not proof against mistakes, however it is these investigations that put mankind on the moon (and back), underpin improvements in our living standards and one way or another drive the mining industry.

The following characteristics show how the two types of investigation nest together:

| E-TYPE | MIDDLE ROAD: APPLICABLE TO ALL INVESTIGATIONS | R-TYPE |
|--|--|---|
| Relies on experience only. | | Relies on research. |
| Seeks existing information | | Finds or develops new information |
| Searches for answers. | | Poses new questions. |
| Most popular. | | Less popular (harder). |
| Often proceeds on verbal information only. | | Discounts verbal information unless it's put to proof. |
| Can be fast, but not always effective. | | Can be slow, but is designed to be effective. |
| Lower up front cost, but generally can only save money. | | More expensive, but can also create new wealth (knowledge). |
| Less likely to advance continual improvement. | | Most likely to advance continual improvement. |
| Widely applicable, but difficult to self-check. | | More widely applicable, and more self-checking. |
| Not useful for checking results of R-Type investigations. | | Very useful for checking results of E-Type investigations. |
| Experience is personal, therefore subject to subconscious processes. | | Research tends to be impersonal, therefore less affected by the subconscious. |
| Can be influenced by emotion. | | Tends to be unemotional. |
| Differing opinions can compete for equal weight. | | Opinions are discounted. |
| Uses Tests. | | Designs Tests |
| Uses investigative systems (tools). | | Designs specific tools for the task. |
| Comes naturally. | | Requires specialist training. |

2. WHERE DO WE STAND AS INDIVIDUALS?

Everyone is a natural investigator, from infants all the way through to the most mature adult. Furthermore, we are born with an instinctive E-Type capacity and automatically use that skill to make sense of the world we inhabit. (An example is those first toddler footsteps used to investigate the sometimes painful effects of the Law of Gravity. And gravity is a most effective teacher... do it right or suffer the consequences... no exceptions.)

As we mature and personal experience grows so too our E-Type skills expand, are honed and sharpened as we constantly investigate happenings & events, all at incredibly fast speeds to provide the essential information which allows us to make snap judgements and decisions (or, just as quickly to rework previous such judgements or decisions as the case may be, because the same as the toddler, if we don't get it right then experience tells us that we'll undoubtedly suffer the consequences). We do it without conscious awareness, it's what makes us who we are.

As we learn (the hard way) that the world contains a large measure of uncertainty, we also come to understand that it contains a great deal of regularity & repetition. Therefore when we grow and age many of our auto-investigations consistently deliver the same information and our subconscious judgements remain the same. This allows us to drop the investigative step and to adopt auto-behaviour, habit in other words (for example shoe lace tying, aspects of vehicle control, or a golf swing if we're lucky). Habits are quickly adopted because they satisfy one of humankind's prime behavioural goals which is least effort (*Reason J.T. Actions not as planned: The price of automatization*) and a powerful survival mechanism. This means that most formal investigations have a habit of becoming an E-Type or at least gravitating towards an E-Type because it's natural for us and hence least effort. A natural bias exists, but like all biases can be detrimental, therefore far better to strive for a fusion of E & R-Types, inject more R to reduce the effect of emotion and subconscious processes, in other words adopt the balanced approach of a middle way.

3. WHAT DOES LEGISLATION REQUIRE OF THE MINING INDUSTRY?

The requirement for investigations is governed by two Acts of the Queensland Parliament, one for hard rock (Mining and Quarrying Safety and Health Act 1999) and the other for soft rock (the Coal Mining Safety and Health Act 1999) both reprinted as in force on 21 April 2010. They are similar but not identical and for simplicity it is only the latter Act that is, coal, which will be addressed in this paper (hereafter called The Act).

The Act requires at least eleven (11) different investigations to be actioned by one or a combination of appointees to the coal industry's three stakeholders as follows:

Coal Mine Workers: Industry S & H Representatives; Site S & H Representatives.
Queensland Government: Inspectors; Inspection Officers; Authorized Officers.

Coal Mine Operator: Site Senior Executives (SSEs).

Only five of the eleven investigations are mandatory, that is must do, therefore the most important. Of these, three (3) relate to fatal serious accidents, or, to high potential incidents (HPIs) & serious accidents. The three are triggered by Sections 199 & 201 of The Act and require as follows:

With respect to a fatal serious accident, an investigation must be completed by an Inspector and the work must determine the cause(s), and must produce a formal report of all findings [including the cause(s)];

With respect to a HPI or a serious accident (including a fatal serious accident), an investigation must be completed by an SSE and the work must determine the cause(s), and must produce a formal report of all findings [including the cause(s)];

With respect to the cause(s) of a HPI or the cause(s) of a serious accident (including a fatal serious accident), a further investigation must be completed by an SSE and the work must investigate the already determined cause(s) for the purpose of preventing reoccurrence, and must produce a formal report of recommended measures to prevent such a reoccurrence.

4. SOME REASONS WHY INVESTIGATIONS CAN BE ERROR PRONE

Pigeon Holing: Almost every incident is unique and therefore potentially difficult to investigate, yet we invariably complete auto-investigations to come to a snap judgement or at least a very early opinion of the cause, which in spite of ourselves will often be followed by a vigorous defence of that position, tending quite easily to become entrenched. (This is because behind every opinion there is a supporting argument, and where there is an argument there is emotion, and with emotion it becomes personal so we get defensive without even knowing it.)

This long recognised effect is called diagnosis bias, or confirmation bias or alternatively cognitive bias (*Greenwald, Pratkanis, Leippe & Baumgardner, 1986; Nisbett & Ross, 1980; Lewis, 1986*). It describes a common human tendency to rely too heavily on one aspect of information when making decisions, that is, once a belief is in place we unconsciously screen what we see and hear to ensure that our beliefs are proven correct. It is a selective blindness to all evidence that contradicts our initial assessment of an incident (or of those people involved in that incident). In other words we instinctively tend to pigeon hole incidents, people and causes based solely on our first opinions, which once formed we are genuinely reluctant to reconsider. Bad luck if we're wrong.

It's a feeling, call it intuition or gut-feel if you will, in any event it's very, very powerful.

Similarities Can Be Irresistible: Incidents almost always represent (or disguise, or even hide) a very large amount of information which poses a real challenge to an investigation simply because of information overload. Clearly we have to sort “good” from “bad”, yet when making decisions concerning the relevance of uncertain information humans ordinarily rely upon a limited number of subconscious rules-of-thumb which take the otherwise complex task of evaluating probabilities & making decisions and reduces them to rapid (and therefore simple) judgement calls. In general these rules-of-thumb (psychologists call them heuristics) are quite useful, but sometimes they unfortunately lead to severe and systematic errors (*Tversky & Kahnemann, 1974; Kahneman et al, 1982*). One such powerful rule is the availability effect. This is where a thing or an event or an action is judged more likely to have occurred, or to reoccur, simply because it springs readily to mind. In other words if examples of something can be easily remembered then that something must be a common occurrence, therefore because it's common it must be an important consideration (possibly even the cause).

On the face of it this appears quite reasonable, however the effect has two faces. Not only does it give excess weight to information that is seemingly recalled with ease, but also it ignores anything that is not immediately present (*Fischhoff & Coauthors, 1978; Reason J.T. Human Error, 1990*). It is the ease of recollection not the substance & relevance of what's recalled that drives the intuition. This means it is a double edged sword, and when applied to information sorting can just as easily throw the baby out with the bathwater.

Group Think: Group dynamics are very relevant because many investigations in the mining industry use investigative teams which in turn rely on E-Type investigative tools (documented, step by step investigations). In the first instance, teams are a good choice because they are both versatile and diversified, however they can unknowingly slide into serious error (and this in spite of management consultants' silly view that “nobody is perfect but a team can be”). Two such examples are as follows:

Research into human mind function has established that people will ignore vital evidence in order to comply with a group opinion [*Solomon Asch, 1958 (peer pressure to conform)*]

A typical psychology experiment is to ask someone to fill in a form in a waiting room full of other people. Apart from the person being tested all participants are actors. Screams are heard, a fire alarm goes off, and smoke enters. None of the “in-group”, that is, the actors, responds. An astounding one out of three people tested this way will ignore the evidence of their senses to comply with the group.

Decades of other research has proven that tight knit groups usually come to more extreme decisions than the average view of the individuals within the group (*Moscovici and Zavalloni, 1969 Group Polarisation*). The effect is called group polarisation. It appears counterintuitive, even irrational, however the effect means that when like-minded people interact, their existing views become more extreme, therefore to the extent individuals can form forceful and persistent mental models, groups have the potential to do so on an even much greater scale. The results of such group think can be seriously wrong as demonstrated by *Dixon 1976* in his analysis of military incompetence.

5. INVESTIGATIVE SYSTEMS (Bureaucratised investigations)

There exists a multitude of models/tools purporting to guide the investigative process, some of which date from before the common era (BC). All seek to cut through our deep seated behavioural biases & preference for “least effort”. (Many are in fact decision making devices, therefore even as a tool they try to satisfy our desire to cut straight to the problem solving stage, rather than waste too much time on further investigation.)

In general all such systems have at their core someone’s belief that an investigation is amenable to step by step methods, that is, investigation can be bureaucratised and our minds tamed. This is an odd perception, particularly as experience has taught that in all forms of scientific & engineering enquiry, hard facts and strong explanations are built up slowly and then only after a great deal of effort. There’s no free lunch.

A number of tools are randomly listed as follows:

| Tool | Source | History/Origin | Type |
|---|--|--|---------------------|
| Accident fault trees, AFT diagrams, Fault tree analysis | The Fault Tree Handbook. Vesely, Goldberg, Roberts and Haasl, 1981 | Was originally developed in 1962 at Bell Laboratories by H.A. Watson | Combined E & R type |
| Barrier Analysis | Svenson - Risk Analysis, | 1991 | E with R type |
| Cause Consequence Analysis | Neilson | 1970s | E type |
| Causal factor tree analysis | Purdue University | | E Type |
| Cause and effect Diagram (Fishbone diagram) | The cause & effect diagram is the product of Kaoru Ishikawa, | 1982 Root Cause | E Type |

| | | | |
|---|--|---|---------------------|
| Cognitive Reliability and Error Analysis Method (CREAM) | Erik Hollnagel Human factors only. | 1999 | Pure E Type |
| Current Reality Tree | Goldratt E. Theory of Constraints | 1984 | Pure E Type |
| ECFA - Events and Causal Factors Analysis | Buys and Clark, | 1995 Runs in parallel with investigation | N/A |
| Expert Analysis | | Relies on the knowledge and experience of “field experts” | Combined E & R type |
| Failure mode and effects analysis (FMEA) | US Armed Forces | Late 1940s for military usage Pre-emptive method not related to investigation of accidents | N/A |
| Five Whys? | A question-asking method formalized by Sakichi Toyoda, Founder of Toyota | ~1930 | Pure E Type |
| Management Oversight and Risk Tree (MORT) | The Noordwijk Risk Initiative Foundation | 2009 | E with R type |
| Safety Case Analysis | Dept of Computer Science, University of Virginia | 2003. Pre-emptive method not used to investigate accidents | N/A |
| Hypothesize, then test. | Princeton University. Wikipedia | 300 BC Aristotle | E Type |
| Taproot® Analysis | System Improvements, Inc | Commercial version 1991 | E with R Type |
| Tree Diagram | One of 7 Management and Planning Tools described by Shigeru Mizuno | Post war Japan | E Type |
| Petri nets | Carl Adam Petri | 1962 Maths based analysis. Not used for failure investigation | N/A |
| Who? What? Where? When? How? Why? | Hermagoras of Temnos. Rhetorician. | 1st century BC | Pure E Type |
| Why-Because-Graphs/Analysis | Research group of Prof. P. Ladkin, Ph.D. | 1975 Analysis not investigation | E Type |

Unfortunately these are all fallible. No one method has come to dominate, there is no universal application, no “one size fits all”. The mere existence of so many systems, the end result of so much focused attention by humankind over a period of at least 2,000 years, undermines the value of any.

There is an emphasis on data processing, and in the case of accidents the focus is often upon human (mis)behaviour and preventing recurrence.

All are subject to foibles and can be corrupted by the same subconscious processes (some already dealt with) that justified their development in the first place.

6. CONCLUSIONS

We instinctively and continuously investigate the world around us for the purpose of getting essential information to feed into rapid, subconscious decision making processes as we negotiate daily life and work.

Alternatively, formal (that is, conscious) investigation is the deliberate, and slow distillation of the often complex & sometimes conflicting information evidenced by uncommon incidents (or events) for the purpose of applying that distilled data to a specific problem solving process. The better we investigate, the better the information produced, the better we can problem solve, then the better our private or work lives can become.

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E & R-Types are not mutually exclusive for workplace or work related investigations and the most productive are those that are an interactive fusion of both. The middle road. For formal investigations to achieve their required goal they themselves must complete multiple decision making and/or problem solving tasks. Herein lies the opportunity for error because this is where our instinctive investigative approach, also an E-Type, can exert influence without us knowing.

It is a fact of life that flesh and blood decision making consistently falls short of the ideal, often caused by distraction, inattention and the difficulty of absorbing the entirety of a particular situation. There is a tendency to settle for satisfactory rather than best courses of action, and that's true for both individual and group decision making. Sometimes, near

enough can be good enough as long as it gets the job done.

How people conclude upon “evidence” is largely governed by a willingness to accept information which is positive to their view whilst finding it exceedingly difficult to accept negative statements, or, to show an often overwhelming tendency to affirm generalisations rather than negate or disprove them, or, to unknowingly bias their findings because of reliance upon a limited number of subconscious principals (heuristic rules-of-thumb). Therefore in order to strengthen decision making in formal investigations, a large number of step-by-step investigative systems (or tools) have been developed to introduce discipline and to tame the human mind, however these tools are subject to foibles and can be corrupted by the same subconscious processes that justified their development in the first place.

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Mistakes arise because of a restricted view of the outermost boundaries of an investigation, an innocent over reliance on least effort mental shortcuts, and a gut-feel reluctance to engage in the labour intensive (but otherwise powerful) processes involved in hard, unemotional reasoning (*Reason J.T. Human Error, 1990*). Often times this means being attracted to intuitive strategies including following clues that have proven useful in the past, or well tried problem solutions, all of which directs our thoughts along familiar and comfortable paths rather than new ones (the new ones which are often required to truly solve an incident or an event that’s only being investigated in the first place because it’s uncommon).

Any mistakes, even small ones, restrict exploration of the entirety of an incident, act to the detriment of available options, muddy the prospect of optimum problem solving, and of course reduce the likelihood of profiting safely.

7. WHAT ACTION CAN WE TAKE?

Beware our natural bias to do pure E-Type investigations only. Tread the middle road. Use an interactive fusion of both E & R-Types.

Get training in research methods. Every investigation can be improved with a bit more research.

Apply quality control to investigation reports by having a statistically significant percentage independently reviewed using a different approach, then compare results.

If there is an external investigation (by others) run an independent R-Type or middle road investigation to counteract subconscious biases and keep everything fairer.

Use triggers as a useful tool to remind ourselves that every investigation stands to benefit from research. For example:

Fires & explosions require specialist training backed by experience.

Incidents involving unusual, or sudden failures.

After every n^{th} E-Type investigation, independently check the results by means of an R-Type comparison. There is no point in having a system if you don't test it.

Loss of production or high cost incidents are great opportunities for R-Type investigations to unearth safer profits.