INTEGRATED **HUMAN** FACTORS

HF AIR™

Analyse : Investigate : Report

A guide to the technical development of HF-AIR™

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Background

HF-AIR™ is an online investigation tool that has a strong focus on understanding the human factors of an incident. The tool was developed by a team of experts from a range of disciplines and with a wide variety of industry experience. It has been tested and had input from a variety of industries including oil and gas, utilities and military defence. HF-AIR™ supports investigators in identifying the underlying Cognitive Origins™ of behaviours that have occurred. The HF-AIR™ tool also supports investigators in identifying non-behavioural root causes.

The language used throughout the tool is deliberately simple but is based on a rigorous and in-depth understanding of the research. The key benefits of the HF-AIR™ tool are:

- Upskill investigators in human factors awareness and interviewing
- Pinpoint system & cognitive origins of behaviours
- Map how Critical Moments of incidents link to the end outcome
- Develop specific & effective recommendations
- Work quickly using our streamlined & intuitive analysis process
- Produce quality automated reports
- Identify the human factors trends impacting your business
- Share industry human factors trends

This technical document was developed in order to communicate the purpose, principles and research that underpin the HF-AIR™ tool.

Guiding Principles

When developing HF-AIR™ we had in mind at all times the end user. We designed the tool so that it can be used by people with a wide range of investigation experience but who share some key requirements. For instance, the need to understand the context of behaviours and the wider impact of the system, a desire to identify HF issues without getting bogged down in complicated terminology and a need for efficiency. With our users in mind the following guiding principles were, at all times, front and centre of the HF-AIR™ design.

Simple Language

One of the core elements of the HF-AIR™ system is the simplicity of the language used within the system. The goal being that any investigator can easily pick up, use and understand the content. To achieve this, we have:

- **adapted any confusing terms.** Some terms are unnecessarily complicated and unclear. As an example, for cognitive biases such as sunk-cost fallacy, clustering illusion or planning fallacy it is not immediately clear what they mean. We have created our own terms in these cases so that they are easier to understand.
- **made our explanations short and to the point**. All of our definitions use simple and clear language so they can be easily and quickly understood.
- **developed recommendations that are specific and succinct.** As we allow investigators to choose up to 4 Cognitive Origins™ we were able to be very specific with our recommendations and limit them to no more than 3 bullet points (in most cases). The recommendations encourage investigators to think through the different reasons for the behaviour and how they will address the issues they have identified.

Intuitive & Practical Design

The design and process of completing HF-AIR™ is extremely intuitive. We have included features such as the timeline, automated report generation and analysis graphs that enable the investigator to keep an overview of the incident, avoid duplication and quickly produce reports. We have kept our categories to a manageable amount so that investigators are not overwhelmed. As an example, we have 30 contextual factors and have refined these so that they cover the key elements but not to the level of detail that will become burdensome for the investigator. The process of analysing Critical Moments is quick and intuitive.

Multiple Origins, not one root cause

We believe that there is rarely a single root cause of behaviours. Usually, there will be a number of reasons (Cognitive Origins™) that contribute to the behaviour occurring. As an example, if an individual makes a bad plan it may be due to these 3 things in combination: 1) not thinking through the possible options; 2) making assumptions about the purpose of the plan; 3) lacking the necessary experience. Therefore, we do not force investigators to select only one ‘root cause’ that caused the behaviour.

A 'systems' approach

It is widely accepted that behaviours are often a result of, or at least influenced by the system that the person is working in. Where possible (it is not always possible) we have identified the Cognitive Origin as a system-based cause (e.g. Contradicting Cues/Signals) rather than a human cause (e.g. the person was confused). This makes it easier for investigators to understand the system issues that need addressed as well as shifting blame from the individuals where it is not warranted.

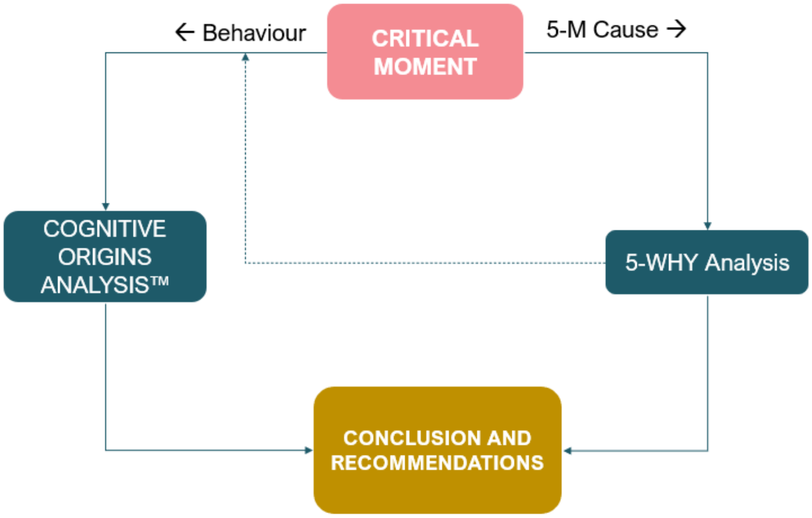
In addition, the COA™ does not refer to violations, but to Planned Deviations and seeks to understand why the planned deviation made sense at the time. Many times, this is to do with the individual trying to manage a situation as best they can (Situational Resilience) or reacting with instinct under considerable pressures (Exceptional events).

Critical Moments

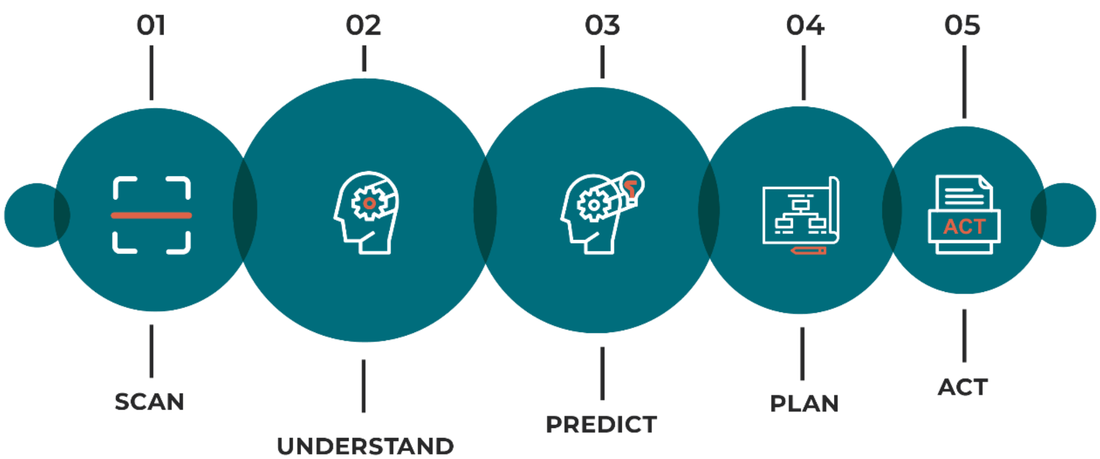
The Critical Moments (CM) of an incident are those that contributed to the negative outcome. This includes moments in the past that may have set up the (latent) conditions that allowed the incident to occur. The CM's can either be 5M Causes (Machinery; Methods; Materials; Mother-nature; Measurement) or Behaviours.

The investigator enters the Critical Moments (CM) into the system which will allow the investigation team to see at a glance when events have occurred. Users can zoom in and out on the timeline, view CM descriptions and associated photographs. This is also where they select a CM to analyse.

CM Behaviours are then analysed using Cognitive Origins Analysis™ which includes using the SUPPA™ model and identifying contextual factors. 5M causes are analysed using the 5-why analysis. The following pages outline the background to these approaches.



Cognitive Origins Analysis™



At the centre of our approach in understanding human behaviour is our SUPPA™ (Scan – Understand – Predict – Plan – Act) model. The SUPPA™ model is an operational model of Situational Awareness. Situational awareness describes a dynamic process where an individual takes in information from the outside world (Scan), makes sense of it (Understand) and then uses this information (in combination with their own knowledge) to predict and plan for what will happen next. The process is dynamic as the individual's awareness and knowledge of the situation and environment (their 'mental model') is being continually updated.

The most well-known model of situational awareness was developed by Endsley (1995a) where she highlighted the importance of factors such as workload, ability, experience, training, memory, preconceptions, culture and procedures on each stage of the situational awareness process.

We chose the concept of 'situational awareness' as the basis for our model as research has continually highlighted that it is often the main causal factor in incidents (Hartel et al., 1991; Endsley, 1995b; O'Dea & Flin, 1998). Through identifying the stage of situational awareness that a failure has occurred we can go on to look at the factors that influence that particular step of the cognitive process and pinpoint specific Cognitive Origins™.

Various authors have highlighted the reasons why we might fail at different stages of situational awareness. Reason & Takano (1999) outline the role of working and long-term memory as well as the impact of cognitive biases on cognitive tasks. Endsley (1995a) highlights the importance of external factors such as 'data being difficult to detect/perceive' contributing to scanning failures. Research has identified that external factors are often coupled with internal mental processes. For instance, research has shown that individuals can become so fixated on a task that they miss other (sometimes obvious) information. Or individuals recognise familiar situations and then selectively perceive information, filtering out information that is not expected. We have reviewed the available research and identified the key external and internal causes of failure. Not all of these high-level causes will apply at every step of the SUPPA™ model. For instance, the *Understand* step is impacted by only Cognitive bias, Rigour, Knowledge and Unpredictable situation/system.

Table: High Level Causes of Failure

External Causes of Failure	Internal causes of failure
Clarity of signals/cues	Vigilance
Confusing signals/cues	Recall
Unpredictable situations/systems	Cognitive Bias
Distraction (external)	Knowledge
Equipment/workplace	Rigour
Social Influence	Zoning out
Situational resilience	Communication slip
Exceptional events	Physical slip
Planning context	Routine gains

Cognitive Origins™

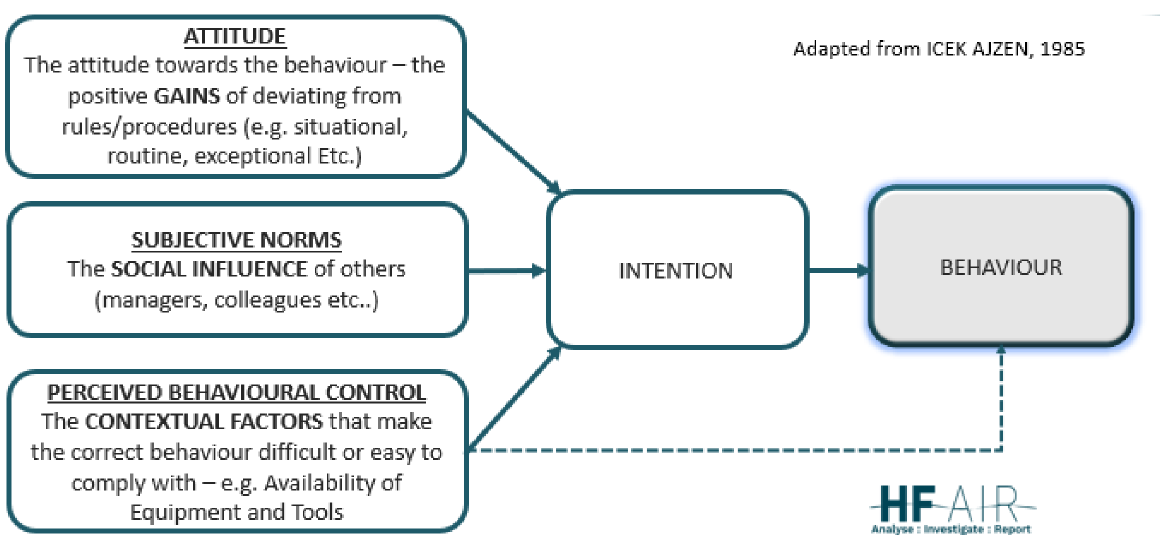
Each of these high-level causes contains a number of Cognitive Origins™, which are the underlying specific reasons for the behaviour. For instance, Knowledge can be broken into specific areas such as risk awareness, experience and base knowledge. The Cognitive Origins™ displayed under the high-level category are different depending on which step of the SUPPA™ model the failure occurred at. For instance, the cognitive biases that impact the **Plan** step include 'avoiding losses' and 'optimism bias' whereas at the **Understand** step they include 'availability bias' and 'confirmation bias'. At each of the SUPPA™ model steps there are between 10 – 21 Cognitive Origins™ (average of 17) to choose from and the investigator can choose up to

4. This gives the investigator the option to consider all the key underlying reasons without being forced to select just one.

Planned Deviations

The Plan step is split into two groups of high-level causes. One that involves no known deviation from a rule/procedure and the other where the individual made a planned deviation. The literature (see HSG 48) splits human failures into two categories: errors and violations. The HSE describe violations as 'deliberate deviations from rules, procedures, instructions and regulations'. As these deviations are planned the research suggests that they can be explained in terms of social and motivational factors and require a different approach (Reason et al., 1990).

Our Cognitive Origins™ relating to planned deviations are based on the Theory of Planned Behaviour (TPB). The TPB (Ajzen, 1985) is an established model in Psychology that helps users understand the precursors and influences on a planned behaviour and has been shown to highly predict intentions to act (Armitage and Conner, 2001). Essentially, the model highlights that an individuals' intention to perform a behaviour is influenced by their attitudes and beliefs towards the behaviour, the opinions and behaviour of others (subjective norms) and the real or perceived control they have over achieving the behaviour. The model is widely used and the success of its application is based on accurately conceptualising and capturing the attitudes, norms and perceived control.



Attitudes

In order to categorise the beliefs that an individual might have had about the behaviour at the time of the planned deviation we have adapted the work of Reason (1990) and Mason (1997) on the different 'kinds' of deviations (violations) to create 3 categories: **ROUTINE GAINS**; **SITUATIONAL RESILIENCE**; **EXCEPTIONAL EVENTS**. Within these categories we developed specific Cognitive Origins™ that may have influenced the behaviour. The specific Cognitive Origins™ were developed by completing a thematic analysis of major incidents and the relevant research.

The 3 categories are:

- **ROUTINE GAINS**
  - Routine Gains can influence individuals' so that they slowly drift from the prescribed way of doing things and new accepted methods are established (work-as-done). There might be a variety of gains for the individual in the new method of work such as improved efficiency, quality or prioritisation.
- **SITUATIONAL RESILIENCE**
  - Situational deviations occur when individuals find themselves in a position where they feel it is necessary to deviate from the rules to get the job done successfully. These situations can include when circumstances change, the procedures are deficient or resources are lacking.
- **EXCEPTIONAL EVENTS**
  - Exceptional events are when an unexpected and urgent event occurs that requires an individual to respond in the moment. In this case an individual may act on impulse or intuition.

Subjective Norms (Social Influence)

Subjective norms refer to the individuals' beliefs about whether other (important) people approve and support a behaviour. These norms are formed based on what other people do (descriptive norms) and say (social norms) in relation to the behaviour and the resulting social pressure. An absence of any opinion can also be seen as condoning or accepting a deviation. Although the research on the impact of subjective norms on intentions is not always consistent, there are many studies that have found a strong relationship (E.g. Ham et al., 2015) between the two.

Perceived Behavioural Control (PBC)

This relates to an individual's perceived (or actual) control over the behaviour. This may relate to the individuals' beliefs about their own personal abilities or it could relate to not having the correct physical resources, making it physically difficult or impossible to perform the behaviour. With regards to our model these PBC aspects (E.g. procedures, available time etc.) are captured in our set of contextual factors.

Contextual Factors

These are additional factors that give a wider contextual understanding of the behaviour. They help explain the situation at the time for an individual and the all things that may have negatively impacted the performance of the behaviour. They are often referred to using other terms such as Performance Influencing Conditions or Error Producing Conditions. The HSE splits these factors into 3 categories: Job; Person; and Organisation (https://www.hse.gov.uk/humanfactors/topics/pifs.pdf). There are many different lists of these factors and each tend to include similar items including items such as procedures, training, environmental issues, communication, workplace design etc. The lists often overlap to a large extent (see this review: http://www.think.aero/HRA/Ref6.pdf). In creating our contextual factors, we reviewed and themed existing frameworks and researched the factors that affect performance the most.

We created a list of 30 contextual factors that strike a good balance between covering the main contextual items but not being over-cumbersome. The items are divided into 7 themes: Task Preparation; Equipment & Interfaces; Work Pressures; Individual factors; Work Culture; Working Conditions; Workforce Management. It is possible that even if a situation was present it may not really have impacted the performance of the individual. For instance, even if an individual did not have had access to written instructions it might not have impacted their performance that much if they knew the job well. In order to ascertain whether the contextual factor made a significant difference to the incident, investigators are asked to select whether it had a high/medium/low impact on the behaviour. In essence it is a mixture of the factual and observable situation with how the individual interprets the situation based on their beliefs and understanding that creates the impact (see note below).

NOTE: The recent (2020) white paper by the Chartered Institute of Ergonomics and Human Factors (CIEHF -https://www.ergonomics.org.uk/CIEHFLearningfromAdverseEvents) describes two concepts: the situational factors (the factual circumstances of the behaviour) and the contextual factors (the meaning people assign to the situation based on past experiences, beliefs and perceptions). They highlight that it is this interaction between the situational and the contextual factors that creates the impact on performance.

5M-Causes

The 5M causes are based on the descriptions developed by Kaoru Ishikawa as part of the development of the fishbone (cause and effect) analysis. The fishbone analysis is widely used as a simple tool to resolve quality issues and to understand root causes. The 5M's stand for Machine, Material, Method, Measurement and Mother Nature. In the HF-AIR™ tool anything that is not a behaviour is categorised as one of the 5M's. In order to analyse a 5-M cause issue we use the popular technique '5-why analysis'. The theory of '5-why' is simple. Through repeatedly asking 'why' until it does not make sense to do so anymore (could be less than 5 times) the investigator is able to systematically identify the underlying root cause. We link our 5-why method to behaviours so that any root causes that are behaviours are analysed further using the SUPPA™ model.

Research and Bibliography

HF-AIR™ is built on a wealth of Ergonomics, Human Factors and Psychological research. We have listed here many of the articles and books that informed the tool.

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