Use of Human Factors Analysis for Wildland Fire Accident Investigations

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Abstract
Accident investigators at any level are challenged with identifying causal factors and making preventative recommendations. This task can be particularly complicated considering that 70-80% of accidents are associated with human error. Due to complexities of the wildland fire environment, this is especially challenging when investigating a wildland fire-related accident. Upon reviewing past accident investigations within the United States Federal wildland fire program, many investigations stop short of identifying root causes of human factors that contributed to the accidents. This element of investigation is critical in accident prevention and can have a direct impact on wildland fire policies and standards.

We would like to present to the international wildland fire community a means of human factors analysis used in the United States—Human Factors Analysis and Classification System (HFACS). This model has been used primarily in aviation related accidents, and we are currently working towards implementing it for ground wildland fire accidents (and incidents) within the United States Federal wildland fire program. This model provides a tangible means of analyzing human factors, which often have many dimensions. After all, it is typically the actions or inactions of people that are directly linked to an accident, but we have failed to adequately account for this in past investigations.

The goal of our presentation will be to provoke thought and discussion, as well as sharing an extremely useful investigation tool with the international fire community, for the sake of improved wildland firefighter safety. We believe that when applied to wildland fire investigations, this model can significantly contribute to firefighter safety through preventative measures that may lead to improved firefighter training, wildland fire policy and/or standard changes.

Introduction
It is well known in the world of accident investigations that approximately 80 percent of accident causes are directly linked to human factors. After reviewing past accidents within the United States Federal wildland fire program, it is surmised that most of these investigations have stopped short in identifying accident causal factors related to the

human element. Past investigations have primarily focused on policy, training, environmental, and equipment failures. Although these focal areas are critical to identifying fire-related accident causal factors, they provide us with minimal to no information on human interaction in the causal factors of the accident. Several reasons for this investigation oversight can be attributed to:

- Human factors are often not directly observable or measurable
- Fear of impression of blaming victims or organizations
- Firefighting culture is operationally focused; therefore so are its accident investigations
- Investigators lack tools or training in identifying human factors

Discussion

For the purpose of this paper, the goal is to provide the reader with the knowledge and tools to allow wildland fire managers and accident investigators to better identify human factor accident (or incident) causal factors to ensure that appropriate accident prevention actions take place.   After all, the goal of accident investigation is accident prevention.

The realm of human factors is complex and incorporates many disciplines such as psychology, physiology, sociology, biomechanics, systems science, and management science. To help simplify human factors for accident investigation purposes, the model of Human Factors Analysis and Classification System (HFACS) has been adopted by the United States Forest Service (USFS) and Bureau of Land Management (BLM), which make up the largest federal firefighting forces in the United States, as the basis for human factors analysis for on-the-ground wildland fire investigations. HFACS has been utilized by the aviation industry in the United States for some time as has also been adopted by the Departments of Interior and Agricultures aviation investigators. The HFACS model may appear complicated at first glance, but to understand and utilize the analysis, it is important to understand its genesis. The HFACS model is based on James Reason's "Swiss Cheese" model of human error. This genesis of human error is described by Reason as four levels of human failure, each influencing the next (Exhibit 1).

Human Factors Analysis and Classification System (HFACS)

Organizational Factors

Unsafe Supervision

Pre-Conditions for Unsafe Acts

Unsafe Acts
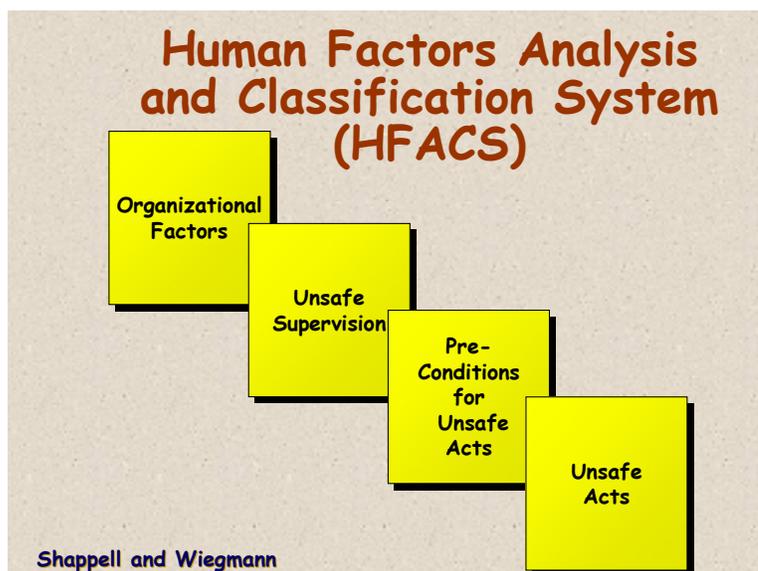
Shappell and Wiegmann

Exhibit 1

In this model, the taxonomy of errors begins with the first level, *Unsafe Acts*. This level depicts the actions or inactions by an individual that is directly linked to the accident. This is the level where most accident investigations focus and consequently where most causal factors are identified. This level, Reason describes as "active" failures that are easily detectable.

The last three levels are considered "latent" failures, which may lie dormant or undetected for any given amount of time (e.g., hours, days, week, months, years) until one day when they indiscriminately appear and are often overlooked by investigators. The first of the latent failures is the *Preconditions for Unsafe Acts*. These failures are best described by examples such as firefighter fatigue, poor interpersonal communications and coordination. We have often seen in accident investigations where fatigue has contributed to failure of communication and coordination resulting in poor decisions where errors result.

The third level of human failure, *Unsafe Supervision*, is more appropriately defined as inadequate supervision. As a latent error, poor or minimal supervisor performance or attention can have a direct impact on employee's actions or inactions, but go unnoticed until an accident occurs.

Reason goes onto to identify organizations as having an impact at all levels, thus the last level of *Organizational Factors*. Many of our past investigations have failed to identify systemic organizational factors as influencing accident causation. This model identifies the need to identify accident causal factors at all levels within the organization before appropriate prevention measure can be addressed.

The holes in the "swiss cheese" appear when defenses at each level are not established or not adequate enough to prevent an accident from occurring. The holes/defenses are not stagnant and will appear and disappear depending upon when they are applied (Exhibit 2).
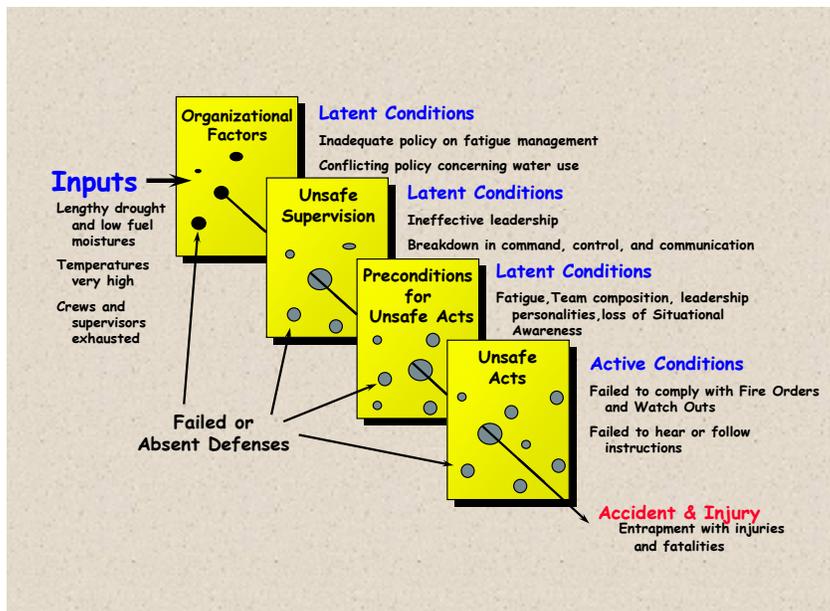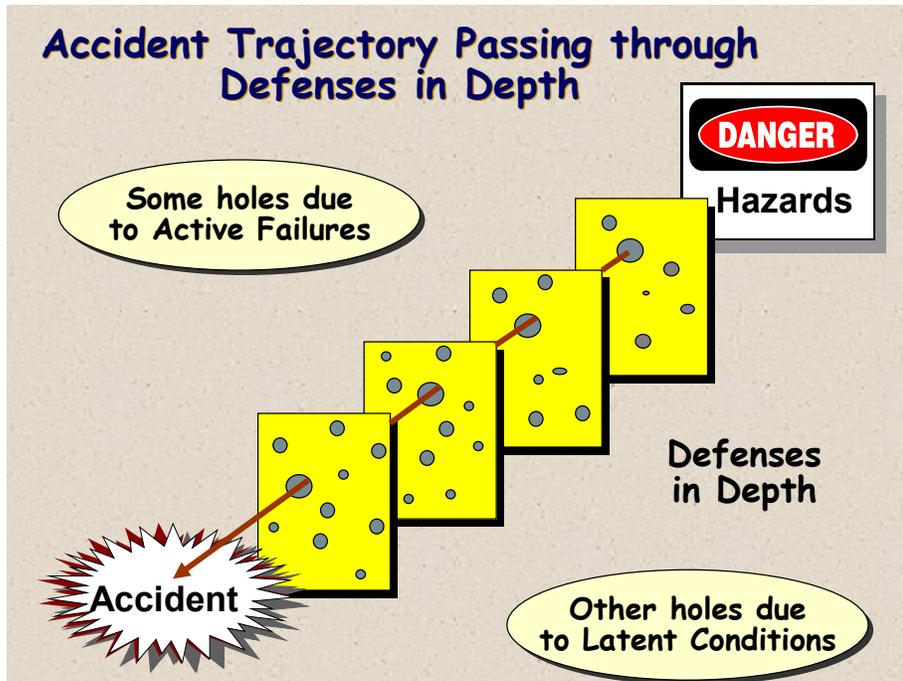

Exhibit 2

Exhibit 3

When active and latent failures line-up while the holes in defenses are aligned, an accident results. Reason terms this the accident trajectory (Exhibit 3). In wildland fire terms, mitigation measures are not identified or practiced which results in a negative outcome (injury, fatality, escaped fire).
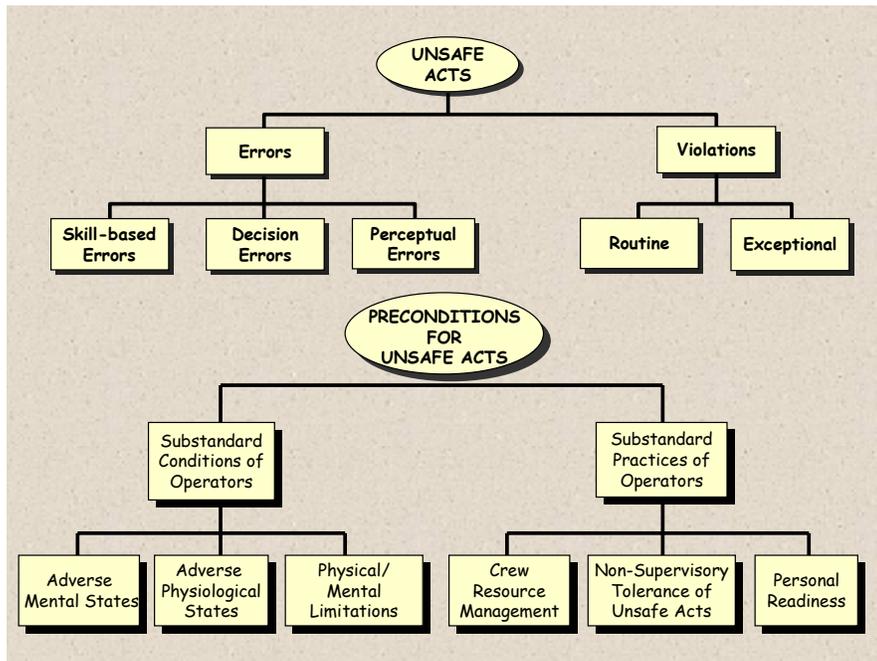

Exhibit 4

The HFACS authors have taken Reason's model and further defined and expanded upon the four levels to provide better descriptors of how to apply it during accident investigations. They have essentially filled in the holes of the cheese. Thereby, allowing for better identification of human factor causal factors that will lead to appropriate corrective actions and ultimately prevent the same or similar accident from occurring (Exhibits 4-7).
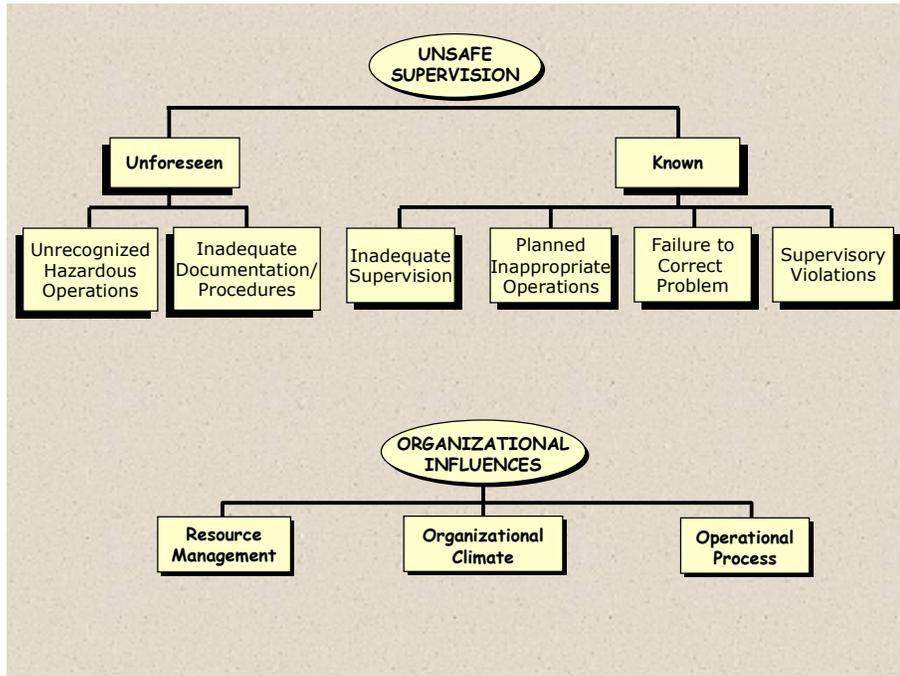

Exhibit 5

The basis for HFACS was based upon numerous naval and commercial aviation accidents within the United Stated. The United States Forest Service and Bureau of Land Management have taken the HFACS analysis and "de-aviationized" it to create a Human Factors Accident and Incident Analysis (Attachment 1) for on-the-ground wildland fire accident investigations. There are many other human factor models available, but HFACS was chosen due to the logical and corresponding analysis elements that were easily adaptable to wildland fire.

With the integration of human factors into our accident investigations, we are at the beginning of a new era in accident prevention for the wildland fire program. Thorough human factors analysis can result in effective intervention and prevention strategies and provide for appropriate recommendations that will ultimately lead to improved firefighter safety.

The entire HFACS document, plus the USFS Accident Investigation Guide, as well as the BLM's Chief Investigator Guide can be found on the National Interagency Fire Center website at www.nifc.gov, select the safety category. Recommended additional reading includes:

"Managing the Risks of Organizational Accidents", James Reason (1997)
"Managing the Unexpected", Karl Weick and Kathleen Sutcliffe (2001)

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