Excerpt from Incident Causation Module
Certificate Course in Occupational
Health, Safety, and Environmental Processes
University of Fredericton

Incident Causation Models

The traditional Mr. Safety approach involves jumping out of the bushes to catch people taking shortcuts.
--Peter Strahlendorf, "Ain't Misbehavin'"

Module Description

As you know, an incident is never a single event. An incident is a chain of events, sometimes quite complex, that leads to a loss or near-loss. Many models have been created to explain and describe incidents. One source estimates that in the last 80 years or so alone (the modern era of incident causation), theorists have published over 50 causation models, most of those since 1960 or so. In this module we are not really concerned with pre-modern incident causation models, as they are unscientific, unverifiable, and not well defined, but we will mention two in passing.

Objectives

In this module we will:

- Learn why causation models are important
- Investigate how causation belief affects causation models
- Evaluate models based on their types, strengths, and weaknesses
- Survey the the two basic pre-modern causation models and the six major modern models
- Probe the weaknesses and strengths of the modern models

Incident Causation Models Overview

Theorists writing about safety theory have proposed many models (over 50) to help explain incident causation, and give the investigator useful conceptual models to use in incident analysis. However, because so many of these models are so closely related (various versions of each other), we will be looking at six of the major causation models and their histories.

Many models stem from the personal interests of the author(s), or a particular type of incident or incident remedy. Again, this fragmentation of safety research probably means that everyone involved has deep-rooted beliefs about incident causation, and these theorists seek to build their models based on their beliefs.

We will also be using noted safety theorist Ludwig Benner, Jr.'s five broad categories to classify and evaluate models according to type, and looking at **process** and **content** models.

Historical Models (Pre-Modern)

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There are two major historical causation models, the Scapegoat, and Accident Proneness. These models have been thoroughly discredited in incident theory circles, but still hang on to some kind of popular acceptance at a sort of subconscious level. (These underlying cultural assumptions might cause **bias** – see "Bias.")

The Scapegoat

The Scapegoat is the most primitive (and longest-lived) of all incident causation models. This model states that incidents are the responsibility of some negative force (a bad influence, evil magic, "bad luck"), and only by finding the source of that negative force (the scapegoat) and getting rid of it can incidents be stopped. The name of this theory comes from an ancient practice of the Hebrews send a goat into the wilderness after having the sins of the people confessed over its head, so that it would supposedly take the sins of the people with it.

Accident-Proneness

In 1919, two theorists named Greenwood and Woods wrote a paper called "The incidence of industrial accidents upon individuals with special reference to multiple accidents." In the paper, they supposed that certain individuals were more likely than others to experience multiple incidents due to some fixed, inborn aspect of their character or makeup they called "accident proneness." As Tore J. Larsson says of Accident-Proneness in Volume 1, Issue 2 of "Safety Science Monitor," (http://www.ipso.asn.au/vol1/ISSUE2/editv1i2.htm) "To scientifically prove the existence of a certain stable individual trait which attracts misfortune would transcend science. It would be the ultimate proof that it is all our own fault."

Despite a lot of **junk science** attempting to "prove" the existence of such a "stable individual trait," it's never been found. Nevertheless, accident-proneness has an amazing popular currency. A lot of people believe that it really exists, and it gets a lot of popular coverage.

What is "junk science"?

Junk science is scientific work offered to the public as **valid** science, but which hasn't been properly tested by the scientific method and peer reviewing. (Peer reviewing is the evaluation of scientific work by a panel of experts in the field.) Junk science can be presenting selective results from research, politically-motivated misrepresentation of scientifically valid papers, or publishing non-reviewed work as believable science.

Junk science is **not** well-done, scientifically methodical research from honest researchers who are challenging the majority's opinion.

Junk Science definition from the **Union of Concerned Scientists**:

http://www.ucsusa.org/junkscience/whatisjunk.html

Flaws in the Accident-Proneness Theory

Some of the other flaws to the theory are:

- Giving others an excuse to blame the worker (and disguising a "dumb worker" mentality)
- Disguising design flaws or other systemic failures, and attributing statistical distribution to an inherent human condition.

Modern Models

As mentioned before, theorists have published approximately 50 causation models (and there are likely ten times as many unpublished). Naturally, we're not going to look at them all – especially since some of them are just refinements and later versions of other models. However, here are the six major models we will examine:

1) Heinrich's Domino Theory
2) Human Factors Model
3) Epidemiological Model
4) Fault Tree Models
5) Multilinear Events Sequencing (MES) Model
6) Failure Mode and Effects Analysis (FMEA)

These models, starting with Heinrich in 1929, show the development, increasing detail (and difficulty), and rigour of progressively later ideas about incident causation.

Why Causation Models Are Important

You may be wondering why causation models are important, since many incident investigators don't use them, at least not openly. However, a lot of the research that created these causation models has greatly affected the way people (and organizations) think about incident causation. (The next time you are reading safety literature, see if you can spot the causation model the author is using, whether they intend to use it or not.) In this course, we refer to this effect as **causation belief**. (For more information on causation belief, see Module 3 – "Relationship Between Causation Belief and Organizational Culture.")

If you can spot the frameworks of ideas that form your, your organization's and others' causation beliefs, you can find out a lot about how you, your organization, and your colleagues view incident causation. When you know that, you can learn how to do the type of investigation which will best suit your and your organization's purposes and needs. Also, by investigating your colleagues' causation beliefs by

examining the causation models that underlie their work, you can watch out for any hidden assumptions, **bias**, or any other affecting factors that might prevent you from getting good information from their work.

Also, causation models can help you perform a systematic, orderly analysis of incidents by giving you a framework to plug your facts into. Sometimes, especially when you are faced with extremely complicated situations, having a **model** to look at can help you understand the circumstances.

Each theory has contributed investigation technique advancements. These advancements add to investigation's value and usefulness.

Evaluating Models

Classifying models into two types, "process" and "content" can help you evaluate them to find out their application to your needs, wants, and techniques.

"**Process**" models try to account for why incidents occur in terms of failure, errors, and management systems inadequacies, such as the Domino Theory, or Fault Tree Model.

"**Content**" models attempt to account for how incidents occur by looking at the hazards or mechanisms that caused them. Examples of content models are the Epidemiological and MES Models.

Some models are totally process or content oriented. For example, a content-only model will describe the factors involved, but will make no assumptions on how they interrelate. Other models describe both process and content.

Likewise, Benner's critique of various causation models breaks them down into five distinct types:

1) single event theories (root or one cause theories)
2) chain-of-events theories
3) determinant factor theories
4) logic tree theories
5) process theories (multilinear sequences)

To see Benner's outline of these types of theories, go to
http://home.mgfairfax.rr.com/lbjr/papers/AAAM.html

Single Event Theories

Single event theories work on the assumption that incidents are **single events** with one cause. Single event theories say, "Find the cause and eliminate it, and you will eliminate the incident." Although recent developments in safety state that incidents

have multiple causes and are not really single events, single event theories have a lot of popular power, largely reinforced by

- references in general-public literature to “accidents” as single events
- some arguments for so-called “no-fault” insurance
- literature used by police and highway safety officers

and other widely-circulated sources.

An example of a single event theory is The Scapegoat.

Chain-Of-Events Theories

Chain of events theories state that incidents are the **result** of **one** series of sequential events. Chain of events theories say, “Break one link in the chain (remove one factor), and you will prevent incidents.” Chain-of-events theories are useful for analyzing simple incidents that don’t involve multiple timelines and multiple causal factors. (For a good example of a multiple-timeline, multiple cause incident, look at the case study of the Edson, AB train derailment in the article, “A Matter of Culture” in OHS Canada Magazine, July/August, 2001.)

Chain-of-Events theories are still in wide use, and enjoy a lot of popularity, both among the general public and among safety professionals. An example of a chain-of-events theory is Heinrich’s Domino Theory. (See **“Heinrich’s Domino Theory”** later in this module.) Benner’s main criticism of chain-of-events theories are that they are based on investigators’ conclusions, not on actual observation, and lack scientific **rigour**.

Determinant Factor Theories

Determinant Factor theories state that incidents are the result of **one most influential cause** (the determinant factor), or “single independent variable” affecting a system of factors. Determinant factor theories started with Newbold and Greenwood’s “accident-proneness.” Newbold and Greenwood **inferred** the existence of a **determinant factor**, which they called “accident-proneness,” from their work with statistics.

Determinant factors set incident investigation’s purpose as the gathering of incident data so that statistical comparisons allow investigators and researchers to make unbiased judgements on the influence of **variables** in certain effects on incident probability, including pre-existing conditions of the things and people involved.

Determinant factor theories assume that some common elements exist in incidents, and that investigators can find them out from the right information. This assumption helped lead to the belief that it’s important for incident investigators to get all the facts. Another example of a determinant factor theory is the **Epidemiological Model**.

Logic Tree Theories

Logic Tree theories (also called “fault trees”) provide a model where events flow in a chain-like sequence from their various origins in the system toward the incident, which is represented as being the “top” of the logic tree. (Like filesystems on some computer operating systems, and unlike real trees, logic trees have their “branches” downward.) Depending on whether or not any of the conditions waving like “leaves” on the ends of logic tree branches occurred, the sequence of events could eventually lead to the incident.

A safety theorist named Watson first developed logic trees in the 1960s to provide the US military with a method of predicting ways in which accidental missile launches might happen. Logic tree theories allow investigators to organize events, conditions, and possible events into a visible, easy-to-read and analyze display, which shows where more information might be needed, and allows investigators to test the model against its own sequential logic (**if** this happens, **then** this happens **or** this happens).

Fault Tree Models or MOTS are examples of Logic Tree theories.

Process Theories

Process theories state that incidents are one piece of a range of activities, or one slice of a **process**. Process theorists view incidents as changes where activities in a **steady state** (**homeostasis**) are interrupted with harm or loss (an incident). Process theorists describe the **changing states** incident process in terms of interrelated **actors** performing actions in a sequential order during a specific time and place. As Benner states in “Benner’s First Law,” “Everyone and everything always have to be someplace doing something.”

Process theory analyses usually follow the pattern

event = actor + action

where

- the **event** is a change of state (which can either be an incident or produce one)
- the **actor** is the “everything or everyone” in question, and
- the **action** is the “something” the actor is doing

MES and FMEA are process theories.

<insert Overview self-test here>