MC 332 Fire Suppression Leadership, Organization and Management

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Fatal Chain of Errors:

Understanding Why Humans in High Stress Environments

Keep Making the Same Mistakes

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Why is it that in the last 25 years, technology in the fire service has come faster and farther than in any other time in history, but the number of firefighter injuries and fatalities have not declined any appreciable amount? We have the latest state-of-the-art personal protective equipment, apparatus, tools, and techniques available to us. Until recently, however, these losses have been accepted as part of the risk that goes along with the job. Why was this so? In times past, faults have always been attributed to the facts that we have had lacking equipment, erroneous strategies and tactics, outdated standard operating procedures, imperfect incident command systems, plain old accidents, and finally the human error factor which was, and still is, very difficult to pinpoint. Besides this last fact, what can we blame today?

The “chain of errors”, what it is, why it happens, and how to prevent it from occurring will be discussed in greater depth in this paper.

Even with all the technological advancements over the last twenty-five years, firefighter injuries and deaths have not dropped since the late 1970’s; they have actually been steady. If the technological advancements were not enough to stop, or at the very least, slow this yearly trend, the mere fact that the number of fires reported has dropped significantly should raise a red flag. One would have to wonder, or better yet question, why the injury and death numbers are still too high. This is unacceptable. Out of the over one million (266,300 career; 815,500 volunteer) firefighters in this country, we continue to suffer job-related injuries more than four times as much as the average private worker (includes mining, construction and logging industries which rank among the most hazardous occupations). That is 1 in every 3 firefighters! Fire suppression accounted for a mere 8.6% of all reported alarms, but line of duty injuries (by **type of incident**) came to a whopping 75.4% of emergency scene injuries (IAFF, 1998).

Figure 1

Distribution of Line of Duty Injuries by Activity 1998[1]

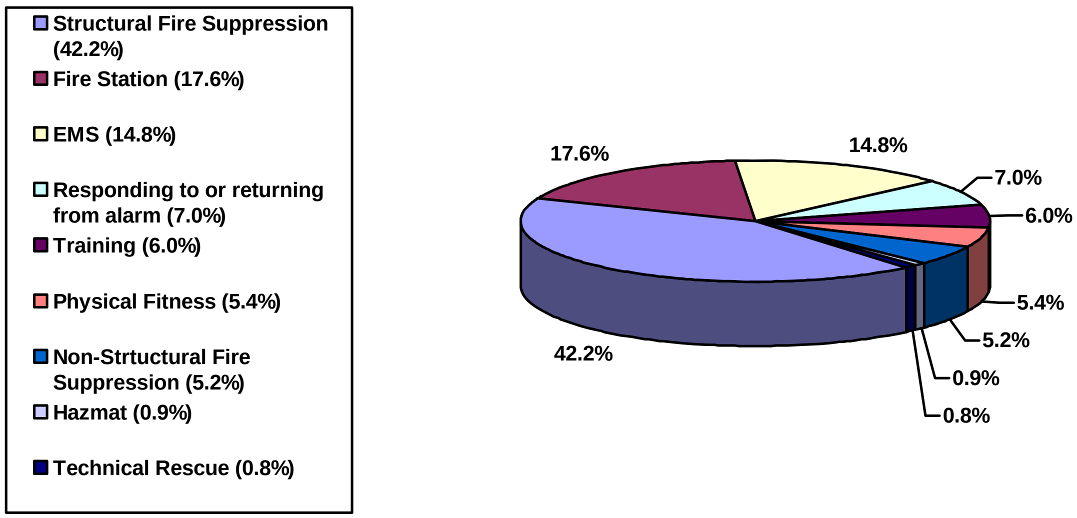
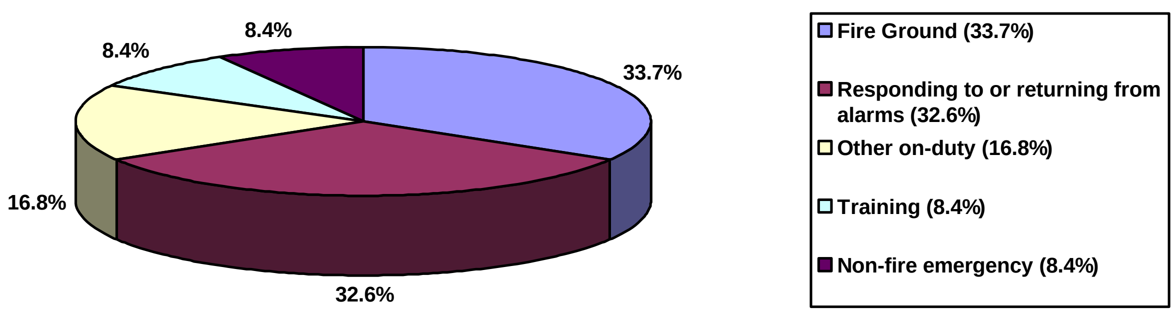


Figure 2

Firefighter Deaths by Type of Duty 1996

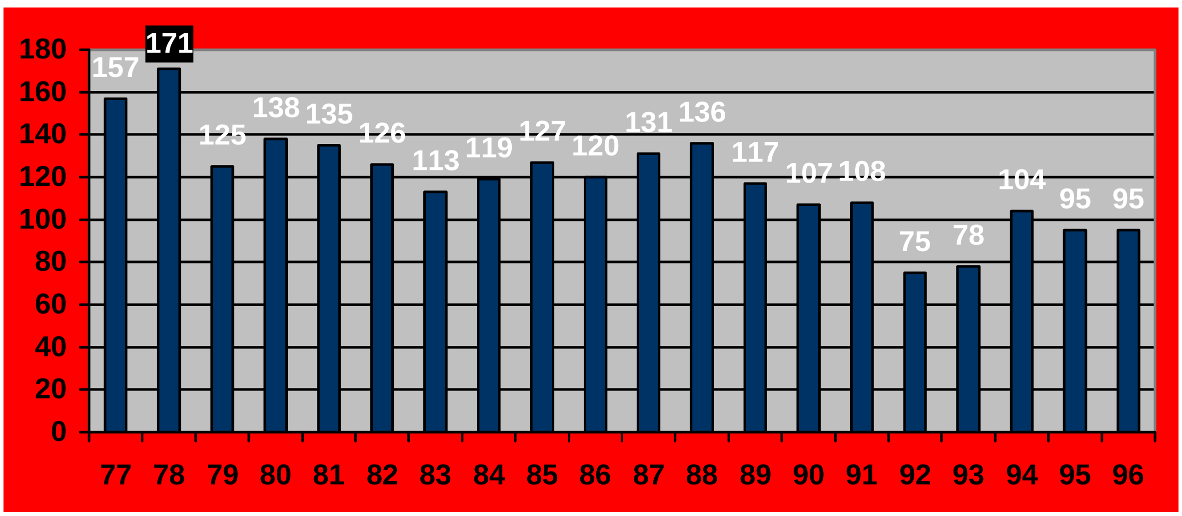


[1] These numbers should not be confused with Line of Duty Injuries by **Type of Incident** referenced in the preceding paragraph.

From 1977 to 1996 there were 2,377 firefighter deaths.[2] These figures reached a high in 1978 of 171, to a low in 1992 of 75. That comes to an average of 119 firefighter deaths per year. In close relation to these numbers are the numbers for the average age of disability retirements for injury at age 50 and age 52 for occupational disease (IAFF, 1998).

Figure 3

U.S. Firefighter Deaths 1977-1996



According to the Webster's Dictionary (1986) the word *error* is defined as "an act or condition of ignorant or imprudent deviation from a code of behavior; an act that through ignorance, deficiency, or accident departs from or fails to achieve what should be done." What has become known as a "chain of errors", or what I call the "fatal chain of errors", can be described as human-factor related errors that in and of themselves do not add up to much. The "chain" part, however, means that an error is just one link of many possible factors that build upon one another and leads to an incident or accident, possibly involving a serious injury or death. The "chain of errors" has been studied by researchers

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[2] The numbers given reflect all causes of on-duty deaths.

since at least the late 1970's when the airline industry and other researchers were putting a growing emphasis on the "human factors" side of why different accidents were occurring. They were finding that instead of possible mechanical problems or one to two human errors, there were multiple errors committed leading up to an incident or accident which occurred in a sequence or chain of errors/events. A particular sequence or chain of errors could have started seconds, minutes, hours, or even days ahead of the potentially severe consequence of the last combined link; figuratively speaking, "the straw that broke the camel's back." Each link in this chain brings the responsible person(s) and those involved closer to an incident or accident. Poor judgment or decisions begets poor judgment or decisions thereby increasing the availability of false information which continues to give false indicators to each benchmark or decision. As the chain grows, the view of situational awareness may become more warped the further on one gets, hence, leading to more of a negative effect on decision making (Error Prevention Institute, 2000).

From a study of 50 fireground incidents it was found that the fewest errors that lead to an incident were four, with the average being seven (Rubin, Peterson & Phillips, 2001). In some fatal wildland fire investigations, like the Thirty Mile Fire in Washington State that killed four firefighters in July 2001, however, it was found that all 10 of the *Standard Fire Orders*[3] were broken (Solomon & Welch, 2001).[4] Some of the reasons for

[3] The *10 Standard Fire Orders* are direct statements of positive actions a wildland firefighter must take to operate safely. They have evolved over the years as a direct result of wildfire fatalities that occurred when those actions were not taken. These orders are supposed to work in unison with the *18 Situations That Shout "Watch Out"* (USFS in WFF in US).

[4] In 1990-1998, wildland firefighting suffered 133 fatalities in 94 separate incidents. Firefighters in burnovers died more than any other causes (USFS in WFF in US).

this happening were given as “inexperience” and “training”. These reasons for errors will be explored later.

Human error has accounted for 70% to 80% of all kinds of industrial accidents. For example, aviation accidents have been found to be caused more and more by human error, and decreasingly blamed on mechanical failure. The same pattern can be seen in the fire service (Weigmann & Shappell, 2001). In defense of investigators, locating the human error is like finding the needle in a haystack. This is probably because it seems like investigators have become so good at their jobs that the sciences of investigating have presented new challenges once they had found all they could mechanically wise, with exceptions of course. Manufacturers are getting more efficient improving hardware on a continuous basis. As stated earlier, an error could have started seconds, minutes, hours or even days ahead. Unless errors lead to an incident with or without injuries, it is seldom critiqued (Soloman, 2001).

According to Rubin (June, 2001), the links of these error chains are identifiable by means of 10 “clues”:

1. *Failure to meet benchmarks, tactical objectives of targets.* This factor comes into play when the measurable goals that the Incident Commander establishes are not met. Consequently, especially if they are not met, they need to be monitored because hints could indicate a catastrophic change on the operation ground. For instance, an attack on a building fire has taken place for around 10 minutes without change in status for the better. If the status has not changed, then the strategy may need to be changed.

2. *Use of an undocumented/unauthorized procedure.* This factor can vary from department to department for many reasons, one of which is training. Rarely is it acceptable to deviate from procedure. This is because usually there will be some type of acceptable method for almost all tasks. If an individual deviates from that, then something may go wrong. An example would be if someone trained a master stream appliance into a building with personnel inside.

3. *Departure from standard operating procedures.* Whether it is an intentional violation or just an error, this is the most likely jump off point for the first link in the "error chain". S.O.P.s that are well thought out and built from a multi-phase process do not have the overbearing issue of time constraints beating down on the authors. They are there for a reason and normally are tried and true for a particular situation. Even so, S.O.P.s cannot cover every single situation.

4. *Violating limitations.* This factor deals with some type of parameter that manufacturer has placed on their product for one reason or another. If the manufacturer says something should not be done, then DON'T.

5. *No one in command and/or free-lancing.* If no one has established a command presence, then who is driving the boat? Furthermore, if no one is paying attention to an established plan, how well is the boat being rowed? As Brunacini said, "the only thing worse than having no plan is to have two plans" and "if a firefighter has not heard the plan, he'll make up

his own." Note, this factor is very popular in the leading causes of firefighter death and injury.

6. *Personnel are unaware of their surroundings or are being distracted.* This factor can be from what is known as "tunnel vision". Unfortunately, this can lead to a deficit of "situational awareness", a very important safety factor.
7. *Incomplete or poor communications.* Poor communications can often be blamed on the sender, receiver or even the medium used to relay the message. However, on the fireground, there are also distractions, time pressures, high work/stress loads and others. For both the sender and receiver, make sure the message is understood. If you are not sure, ASK.
8. *Ambiguity/unresolved discrepancies.* This factor brings into play the everyday occurrence of seeing things differently than others. It can come in the form of such simplicity as two people looking at the same exact thing and getting two different answers. It can be the same person looking at something from another side or angle, or information that does not jibe with what they are seeing. Unfortunately this factor is many times put by the wayside for different reasons, only to show up again after an incident/accident. These potential problems need to be resolved before they snowball into an undesired situation. If you don't know, ASK.
9. *Confusion or empty feeling.* There are certain indicators in every individual that says things just might not be right. Each individual usually knows his or her own indicators, or hint that their body is trying to relay.

Theories suggest that if it does not "feel" right, DON'T do it. Rely instead on your knowledge and experience to help you out. Again, if you don't know, ASK.

10. *Belief of invulnerability.* This factor can be dangerous to not only the individual whose mind it is in, but to others surrounding that person. The "it can't happen to me" attitude needs to be quenched. This particular factor can also lead to additional errors, and maybe more importantly to violations in the present and future, the consequences of which may someday catch up in the form of an incident/accident. Statistically you can play Russian roulette and 83% of the time nothing will happen (Rubin, et al., 2001). Is it okay to circumvent standard operating procedures and accepted safe practices if one is put under stress to perform in dire circumstances? If you answered NO, then you are right. In a given situation, you may think you are performing an operation correctly, maybe slightly side-stepping safety, and maybe only once for a split second, the danger level does NOT change because of this. There is just as much, or more of a chance during this time that an error may occur. Pay heed, and listen to your senses. If you do not, this could immediately come back to haunt you. As Will Rogers said, "the problem's not so much what you don't know, but what you do know that just ain't so."

The variety and frequency of these 10 "clues" can vary by department or even crew. Some examples of why these occur, which will be reviewed later, are training, organizational influences, and unsafe supervision.

The Human Factors Analysis and Classification System (Weigmann & Shappell, 2001) is a general human error framework originally developed and tested for the U.S. Navy and Marine Corps as a tool for investigating and analyzing the human causes of aviation accident investigations. The HFACS framework has been used in over 1,000 military aviation accidents. This data has given deeper insight as to how accidents happen that involve human error, at the same time enhancing the quality and quantity of information that comes from these studies. This data also can lead to preventive strategies that researchers can implement in future training programs (Weigmann & Shappell, 2001).

There are four levels of human failure described by the Human Factors Analysis Classification System (Weigmann & Shappell, 2001).

1. Organizational influences. Organizational influences can directly affect management, supervisory, and line personnel practices at times in an undesirable way. Notably, organizational influences normally go unnoticed. This category is broken down into three sub-categories:

(a) Resource management. Resource management is the management, allocation, and maintenance of a wide range of resources in the agency including human, financial, and equipment. These areas are driven by the objectives of safety and fiscal responsibility. When there are adequate budgets, both of these areas may thrive; however, when budgets are lacking, unfortunately safety and training are among the first priorities to be cut (Weigmann & Shappell, 2001). This can potentially be a big mistake. Even though an agency can see the immediate positive effects on the budget, they can not see the short, medium, and long range effects on the entire system, albeit some effects may be intangible. As a matter of fact, taking chances in the safety and training areas may seem worthwhile in the short term, but the agency has to beware of one or more instances in the future that could be potentially prevented by these cut funds. This would threaten to wipe out the entire savings plus some on any number of cutbacks and short range feel good goals.

(b) Organizational climate. The organizational climate deals with variables that are affected by differing organizational issues and situations. These in one form or another affect the employee(s). This can also be seen in the "situationally based consistencies in the organization's treatment of individuals" (Weigmann & Shappell, 2001). An organization's climate can be evidenced by its chain-of-command structure, delegation of authority, how communication is handled through the ranks, formal accountability of actions, policy, and culture. As a result, when policies are ambiguous or vague, adversarial or conflicting, or maybe when injected with unofficial rules and values, confusion among the ranks takes over and many areas including the organizational climate and safety suffer (Weigmann & Shappell, 2001). Unfortunately, this is one of the wide ranging problems observed within the United States Forest Service today, some of which have led to serious injury and/or fatal incidents/accident.

According to (Johnson, 2001) the organizational climate can also be seen as “organizational factors or organizational failure.” Organizational failure can take two forms: managerial failure as previously stated, are the ways in which company may organize and manage their people and working practices; and regulatory failures are the ways in which government and other statutory bodies govern and monitor working practices with laws, rules, and regulations. These often are areas that can be improved upon. These two reasons, however, are often obscured by more prominent and easily discovered issues of “human factors” like errors, stress, fatigue, drugs, etc., not prompting a deeper investigation of causal factors. This is an area that deserves a call for a deeper, more comprehensive investigation and ways of learning.

(c) Operational process. This involves formal processes like the pace of operations, scheduling and time pressures, and production quotas; procedures that involve performance standards, work objectives and documentation; and oversight within the organization that include risk management and the use of safety programs. It may be direct or indirect, but if there is poor management of these factors that affect workers, performance, and the obvious and most important being safety will suffer.

2. Unsafe supervision. The category of Unsafe supervision says that the person responsible (supervisor) for operations will be accountable for his or her own actions in the process of directing others. Even though an individual is responsible for his or her own actions, the supervisor in many cases is ultimately

held accountable for his or her actions. Accidents can happen suddenly, however, and a supervisor is left with no control at times. This transfer of responsibility is actually quite common, and organizations have written policies that mandate supervisors be responsible for any and all actions of personnel under their command. This category is divided into the four sub-categories:

(a) Inadequate supervision. Inadequate supervision is considered as the short-fall of one or more supervisors by way of something they did or failed to due within their duties. This deals with giving individuals the chance to succeed through adequate training, guidance, oversight, and operational leadership. If these issues are not undertaken appropriately during an individual's career, he or she may be given bad direction or habits in a wide range of areas, therefore producing a disservice to the individual and maybe the crew. Speaking from experience, I can say that many times I have been wronged in direction or leadership, sometimes with consequences and sometimes not. For the most part, however, I feel I have learned from the right and even wrong directions.

(b) Planned inappropriate operations. Planned inappropriate operations deals with situations where the crew is put at a disadvantage because they are forced to operate in an untimely manner, whether it be scheduling or the pace of operations. Therefore, in order to avoid being adversely affected, crews must have proper rest, be teamed correctly, and risk factors taken into account during planning and operations.

(c) Failure to correct known problems. This is when a supervisor has knowledge of individual, equipment, training, or other safety-minded area that has a short fall, but does not rectify the situation.

(d) Supervisory violations. Supervisory violations are when supervisors knowingly violate rules, regulations, policy or procedures during the course of their duties.

3. Preconditions for unsafe acts. Comparing the preconditions for unsafe acts to unsafe acts is, as the Weigmann & Shappell (2001, p. 5) state "simply focusing on unsafe acts, however, is like focusing on a patient's symptoms without understanding the underlying disease state that caused it." These preconditions are broken into two sub-categories: (a) substandard conditions of operators and (b) substandard practices they commit (Weigmann & Shappell, 2001).

(a) Substandard conditions of the operator are further broken down into three sub-categories. The first deals with an item that is very important no matter what type of atmosphere an employee is working.

(1) Adverse mental states. These would refer to any mental conditions that have the potential to affect performance in an undesirable way. These can include, but are not limited to: loss of situational awareness, which is quite prevalent in high stress/high workload atmospheres; mental fatigue, a concern for anyone working long hours, odd hours or even under high concentration; circadian dysrhythmia, which refers to not

maintaining what is considered a normal clock awake/sleep schedule; and attitudes like overconfidence, which might put one in more dangerous situations, complacency, and even if someone has some misaligned motivation (Weigmann & Shappell, 2001). Adverse mental states would also include hazardous attitudes such as: anti-authority, where the individual doesn't normally follow rules or listen to their supervisor; impulsivity, where the individual is always in a "hurry up" attitude; invulnerability, where the "can't happen to me" mindset comes into play; macho attitude, where taking chances to show off or prove he or she is the best is this individuals method of operation; resignation is the hesitation for someone, usually a subordinate, to speak up if they see something wrong; and mission-itis where one has to complete the task no matter what (Error Prevention Institute, 2001).

(2) Adverse physiological states. These are things like spatial disorientation, hypoxia, visual illusions, illness, intoxication and pharmacological problems. These are not only very important for flight, which is the reason this study was done, but they also apply to emergency services and the medical field (Weigmann & Shappell, 2001).

(3) Physical and/or mental limitations. Limitations can include instances where the individual does not have the knowledge, skill, ability, or time to safely control the situation.

This also includes times when needed sensory information is not being collected as fully as it should, thereby not giving the individual the needed information to fully process an action/reaction to a given situation. This may include when an individual is in a situation that requires a rapid action/reaction both mentally and physically, but the human body can't process it fast enough (Weigmann & Shappell, 2001).

(b) Substandard practices can, and often do, lead to unsafe acts. This is because it always has the potential to evolve into an undesired situation if the crew is not working in a safe, efficient, and effective manner. Substandard practices of the operator are divided into two sub-categories:

(1) Crew resource management. Crew resource mismanagement, as the author refers to it, includes breakdown in communications, absence of a team atmosphere among the crew, and supervisors not operating properly on their own tasks to help accomplish the overall goal. If not all members of the crew are at par with practices, it can lead to confusion and poor decision-making, (Weigmann & Shappell, 2001).

(2) Personal readiness. It is imperative individuals also make certain that they are holding up their part of the team through personal readiness. Personal readiness deals with issues like not getting enough rest, not following drug and alcohol rules, or not

taking care of themselves in general, and if not for their own good, at least maybe for their crew (Weigmann & Shappell, 2001).

4. Unsafe acts of operators. Unsafe acts of operators can be divided in two categories; (a) errors and (b) violations. It is important to note these terms and differences because they denote whether the action or inaction was intentional.

(a) An error is something that can be seen as a proper or improper action/inaction performed erroneously, also known as a "legal" activity. Errors can be broken down to three types;

(1) Decision-based. A decision error is one where the plan for the set objective is taking shape, but proves deficient or unsuitable for a situation (i.e.: if a smaller hoseline than is needed is taken into a building, but more fire than originally thought demands backing out for lack of water). Errors like this can also be called "honest mistakes", but they can really be procedures that are inefficiently carried out, unsuitable choices, misinterpreted information, or the use of incomplete information, which is not something out of the ordinary.

(2) Skill-based. A skill-based error takes place with little or no conscious thought about the task (i.e.: using the proper procedures for getting water to the nozzleman, but without actually thinking about how to properly perform the task). The problem with skills like this and others is that they can fall victim to attention or memory failure brought on by a number of different

distractions, despite having been trained on and performed many times.

(3) Perceptual. Even though the perceptual error has been cited less often, it is still an important factor. Perceptual errors occur when the incoming information, in any form, is somehow obscured and maybe incomplete, sometimes forcing the operator to still to take action (i.e.: operating in a smoke-filled environment).

(b) Violation is something that is an intentional discount of standard operating procedures, policies, laws, etc. Violations are items that must be monitored, especially if an employee(s) is continually committing them.

Violations are found in two types;

(1) The routine violation is one which is repeatedly performed without consequences most of the time, (i.e.: when a fire crew violates one or more of the Ten Standard Fire Orders and the outcome is good) (Weigmann & Shappell, 2001). However, this sometimes develops into negative reinforcement, which can result in the person getting away with violations and not suffering any consequences, especially if a supervisor allows it (see Unsafe Supervision-Failure to correct problem). This can also be referred to as "bending the rules". According to an article in the ICHIEFS (2001), firefighters are driven, sometimes more often than not, to accomplish to the goal of extinguishment while putting the so-

called stated priority of safety aside. This article, which gained information from a study of one thousand firefighters, prompted by the Storm King Mountain tragedy[5], says that 40% said "getting the job done was just as important as safety." What is frightening is that 15% said it was "policy" (unwritten of course) to break rules to complete the job. An astonishing 40% polled said they did not receive mandatory briefings about escape routes and safety zones. In addition, more than 25% working on line said they routinely ignore the "18 Situations That Shout Watch Out", (Solomon, 2001). One of the many troubling signs which this information brings forward is that it is a pattern and the same errors have been made over and over on the fireground for decades. It is usually because someone did not heed, or more accurately, violated rules or warning signs. As we all know, unfortunately it is sometimes easier to do, than following all of the rules all of the time. However big or small the chance may be, if this is done with success, then it is still a negative reinforcement of an individual's action. Once an individual gets this reinforcement however, the chance that they may okay another infraction rises.

(2) The second type of violation is called exceptional. Exceptional violations are ones that are isolated cases and are not indicative of the individual's normal demeanor. These violations

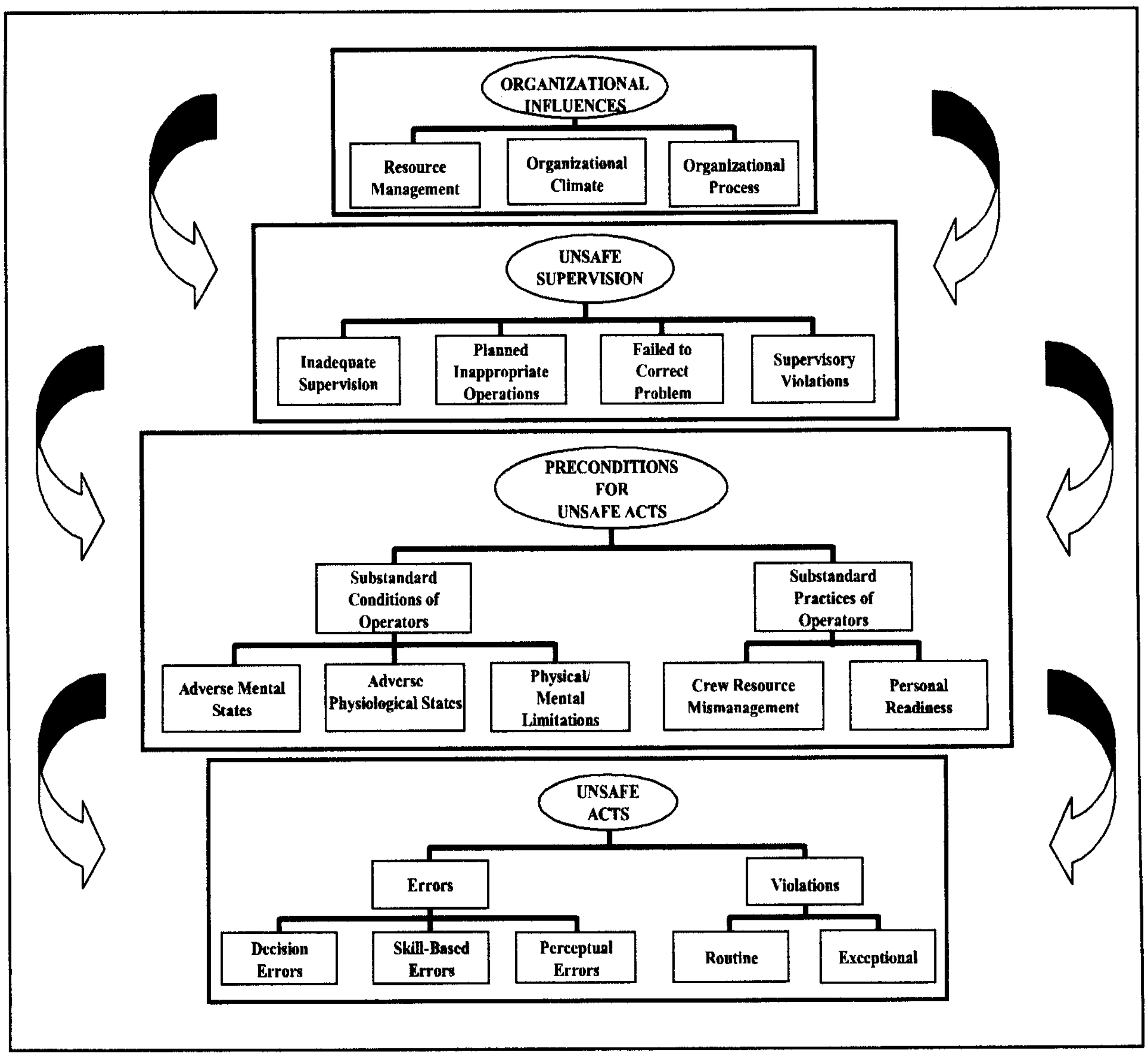
[5]Refers to the South Canyon Fire outside Glenwood Springs, CO in which fourteen firefighters perished in a single incident in 1996.

are also not condoned by authority (i.e.: driving over one hundred miles per hour in a fifty-five zone), (Weigmann & Shappell, 2001).

The following chart makes a graphic statement as to how errors may start at the top of an organization with organizational influences and proceed to the bottom, or potential end product of unsafe acts.

Figure 4

Overview of the Human Factors Analysis and Classification System (HFACS, 2001).



This next table shows the data gained from a Human Error Analysis of Commercial Aviation Accidents using the Human Factors Analysis and Classification System (HFACS). The highlighted areas represent the four highest categories which are: **Skill-based Errors**, 60.5 % (Unsafe Acts); **Crew Resource Management**, 29.4 % (Preconditions of Unsafe Acts); **Decision Errors**, 28.6 % (Unsafe Acts); and **Violations**, 26.9 % (Unsafe Acts) (HFACS). This study shows (not included in chart) that the proportion of accidents that included **Skill-based Errors**, **Decision Errors** and **Violations** is relatively constant over the six year period of 119 accidents investigated. *Why is this important to the fire service?* Its importance lies in the fact that the data in this and other studies shows how it is to work in areas that are very similar to the fire service, or emergency services in general, that suffer the same types of problems in the human error chain, not to mention the fact that these similar errors occur in emergency services but we are not being trained/educated on how to avoid them like the airline industry and armed forces are. All of the categories in this study would apply to emergency services. The similarities are numerous, some of them being the challenges of trying to work as a team in high stress atmospheres, which puts a strain on the possibility of unsafe acts as evidenced below by having three of the top four errors in this category. Crew Resource Management involves the direction, coordination, and teamwork of a crew which also directly or indirectly affects all of the categories. The opportunity to fall into any of these categories is enormous. Anyone on a team can be affected in any way at any time. There are more similarities than dissimilarities.

Additional factors that have been found to affect performance and possibly lead to errors are: inadequate communication, distractions of any kind, exceeding incident command span of control, expected fire behavior not acted upon, inexperience, fatigue, target fixation, not performing assigned tasks, hazardous attitude, interpersonal relations, not taking positive feedback, lack of preparedness, and political pressure. Another factor which may be in the same realm is the *Abilene Paradox*. The *Abilene Parado*x occurs when a situation arises where a group of people makes a decision. Even though this group collectively makes the decision, however, no one in the group actually supports the decision. It is interesting to note that if asked individually with each person speaking freely, he or she would confirm lack of support for the decision.

Table 1

Percentage of Accidents Associated with each HFACS category

HFACS Category	Total[6]
Organizational Influences	
Resource Management	2.5% (3)
Organizational Climate	0.0% (0)
Organizational Process	8.4% (10)
Unsafe Supervision	
Inadequate Supervision	5.0% (6)
Planned Inappropriate Operations	0.8% (1)
Failed to Correct Known Problem	1.7% (2)
Supervisory Violations	1.7% (2)
Preconditions of Unsafe Acts	
Adverse Mental States	13.4% (16)
Adverse Physiological States	1.7% (2)
Physical/mental Limitations	10.9% (13)
Crew-resource Mismanagement	29.4% (35)
Personal Readiness	0.0% (0)
Unsafe Acts	
Skill-based Errors	60.5% (72)
Decision Errors	28.6% (34)
Perceptual Errors	14.3% (17)
Violations	26.9% (32)

[6] Numbers reflect percentages of accidents that involved at least one instance of an HFACS category. Numbers in parentheses are actual numbers of accidents. Because more than one causal factor is generally associated with each accident, the percentages will not equal 100%.

Below is a study in 1989 on medical environment mistakes taken from 710 reports which reveals some of the most common contributing factors that take place. Additional factors to errors were fatigue, workload, and nighttime hours[7] (Busse & Wright 2000).

Table 2

Classification of Incidents in Complex Medical Environments

Commonest Contributing Factors	Percentage
Inattention/Thoughtlessness	28
Inexperience	25
Failure to Check Equipment	15
Poor Equipment Design	12
Poor Communication	12

Inexperience represents a personal factor which was one of the most common contributing factors found from 10 years of research (Busse & Wright 2000).

[7] Nighttime refers to late night or graveyard shifts, thereby not coordinating with normal circadian sleep cycles.

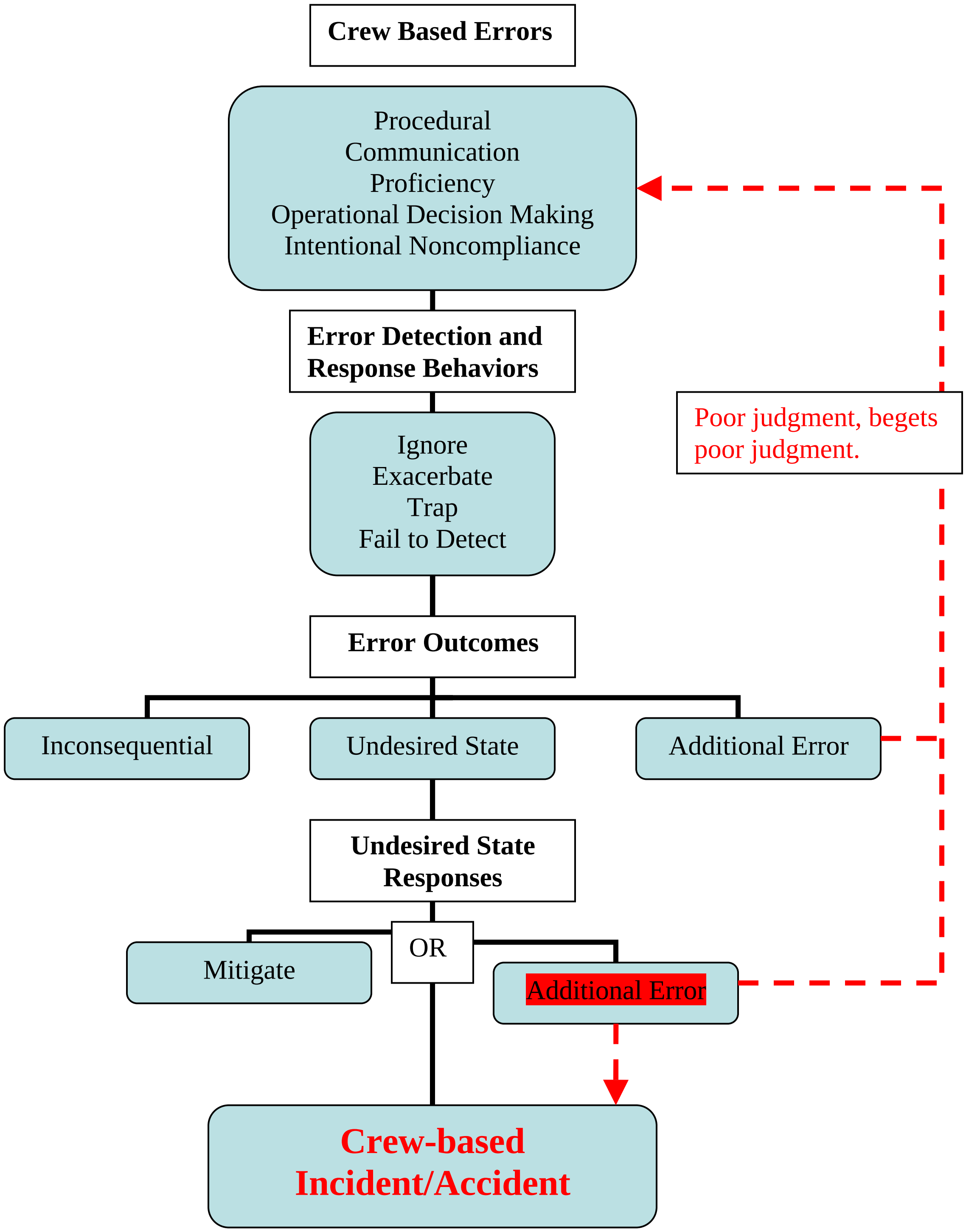
Table 3

Classification of Contributing Factors in Aviation

Type of Error	Percentage
Procedural	37.8
Knowledge/Skill	9.2
Communications	9.7
Non-compliance	40.3
Tactical decision making	4.1

Figure 5

A model of error in flight operations



What are the ways that we can break the chain of errors, or, better yet, prevent them from even being built? When dealing with many different error types, it has been found appropriate to utilize differing methods for management and remediation of errors (Busse & Wright 2000).

One answer may be the “Crew Resource Management Program”, which was started in 1981 by United Airlines after a 1978 investigation revealed why a United Airlines DC-8 crashed in Portland, Oregon. The mechanical cause of this crash was identified as fuel starvation while in a holding pattern around Portland’s airport trying to resolve a landing gear problem. Looking further into this the Federal Aviation Administration investigation found that the flight crew was preoccupied with the landing gear light while they were burning off fuel for a possible crash landing. This preoccupation led to the low fuel warnings not being heeded and consequently the aircraft crashing, killing 10 people and injuring 23 others. The captain of the plane was partially to blame for putting off these warnings from both the flight engineer and first officer (Rubin, et. al, 2001).

Crew Resource Management is the proper use of all available resources to achieve safe and efficient operations. United and other airlines joined researchers from the National Aeronautics and Space Administration to study their operations and recommend changes.

The roots of Crew Resource Management training can be traced back to a workshop sponsored by NASA in 1979. The research for this program was convened to figure out the causes of air transport accidents. The result of this study was that human error was a causal factor in the majority of air crashes.

The goals of Crew Resource Management are *improving communications, situational awareness, leadership, and decision making.* A comprehensive CRM program will take into account the type of tasks that are to be performed, surrounding environment in which they will or may take place, and the organizational factors that may contribute to the overall scope of processes. The information gained will then be analyzed to detect elements that may lead to human errors. Once this is accomplished, this information will then be used to hopefully eliminate, or at least severely restrict, these errors as soon as possible in any process (Veillette, 1998). Traditional CRM courses contain areas in communication, situational awareness, attitude management, and how to stop error chains from developing (USDA, 1999). During a study in 1991, Dr. Alan Diehl found that six airline companies who had incorporated comprehensive CRM programs had seen an accident rate drop of 28%-81%. In one case, a helicopter company had an amazing 54% drop. It has been unfortunately found, however, that there have been some CRM programs that have been enacted just to satisfy requirements which have failed terribly. A major airline company, who had an excellent record with no CRM related accidents before they did this, had three fatal accidents and two major incidents within one year after starting a non-comprehensive CRM training program (Veillette, 1998).

The Crew Resource Management program can actually be looked at as a countermovement to avoid errors. CRM actually has three different ways it can prevent errors: (a) avoid error by enacting the behaviors and concepts of CRM that were learned in training; (b) be able to detect and nullify errors before they become a problem; and (c) alleviate the potential consequences of those errors that do might slip by and occur

(Helmreich, 1996). An important and major part of this is that it requires the organization to properly and officially recognize human fallibility. Included in this is the adoption of non-punitive policies to everyday errors. Understandably, this last part in itself is very difficult for managers and organizations to swallow, possibly because these entities see this as a possible heyday on errors with no consequences. However, this is not true because just as important, this does NOT suggest more tolerance of violations[8] (conscious instance of failure to follow S.O.P.s) (Helmreich, 2001).

The military took the CRM process even further when in 1990 they started a research program called Tactical Decision Making Under Stress (TADMUS). The incident that was the precursor to this program happened on July 3, 1988 when the USS Vincennes mistakenly shot down an Iranian airbus over the Persian Gulf, killing all 290 people aboard. After this incident, based on the recommendations of an American Psychological Association workshop in 1988, the TADMUS program was started. Part of their focus was on the Combat Information Center on warships. They recognized that previous research on human decision making contains a great deal of useful information, but the designers of decision aiding systems, i.e. on-board computers, were lacking in the area of human interaction. It seems that technology in hardware and software was out-pacing the human side of the equation. This brought about not only potentially costly errors, but lack of confidence and possible rejection by users (Weigmann & Shappell, 2001). It is interesting to note that errors in relation to machines of all types have led to the creation of what is known as error-tolerant systems. These machines, from assembly-lines to airplanes and everything in between, are made to absorb human error and allow for recovery (Busse & Wright 2000). The researchers also recognized the need for

[8] See definition for *errors* and *violations* in section 4 (a) p. 17 & 4 (b) p. 18.

additional research in the areas of decision making in high-workload environments, pattern recognition, and option generation in unstructured situations, which is very prevalent in emergency services (Weigmann & Shappell, 2001).

The objective of TADMUS was to enhance the quality of tactical decision making in high-stress operational environments. The three main goals were to, (a) increase overall skill levels, with the idea that if individuals and teams were already able to perform their jobs with the highest of competence, then they will be more resistant to any negative effects stress can have on their performance, (b) expose trainees to some type of related stress during training, which was thought to further strengthen trainees towards any stress related downfalls in performance situations, and (c) concentrate on skills that are wide open to the affects of stress to evaluate the processes these have on the skills (Weigmann & Shappell, 2001). The TADMUS experiments showed a 40%-50% increase in quality and timeliness in tactical decision making. Tactical decision making was not the only area to improve when command teams used innovative training or decision support interventions. The other areas for improvement were in communications, anticipating team members' needs, planning response actions and maintaining situational awareness.

The HFACS research found additional stressors also, but they may be similar to the ones previously listed. They also found that the operational environment yields many different types, for instance, multiple information sources, rapidly changing and evolving scenarios, adverse physical conditions, time pressures, auditory overload/interference, incomplete and/or conflicting information, requirement for team coordination, performance pressure, high work/information loads, and possible threats. Some of these items can be found in an emergency incident and all may be found in some (Weigmann & Shappell, 2001).

The HFACS research found that for the best possible high-level capabilities during a high-stress atmosphere, the development needs to move from a benign, sterile atmosphere that only trains on one skill at a time, to a more challenging field-type, multi-level, all-inclusive training that develops multiple skills at the same time. In essence, this type of training needs to move to more of an actual work environment while developing adaptive individual and team skills. This needs to be accomplished on an as needed basis for both continuing and new skill levels. Researchers found that *normal training performed in a non-stress atmosphere did not improve the performance of the task when it came time to perform in a stress-type atmosphere where the task would have to be performed anyway*. This is where stress training applies. Stress training is meant to develop and augment acquaintance with the stress environment, and at the same time teach the skills needed to deal with a particular problem efficiently. The three goals of stress training are: (a) comprehension of and proficiency with the stress environment; (b) acquiring skills to be efficient and successful during stressful conditions; (c) develop assurance one can perform during these times (Weigmann & Shappell, 2001). A National Research Council study found that ways to reduce stress are accomplished by promulgating information and awareness about future events.

Research that is closely related has been done on overtraining/learning. Information has been gained that says overtraining/learning is a very effective method to reduce stress levels in a high-stress environment. Basically, the training has to be performed beyond the entry level skills and abilities. The student must grasp a deeper understanding of the task. This training must also be taken beyond even this step in-so-far-as performing under stressful conditions, the real-world environment, and with multi-task situations. This is because even if a task is over-trained, it will not improve performance like it would in a multi-task situation, therefore not showing the results needed at the time the task is performed normally. Another basis for these reasons is that some training scenarios, both single and even multi-tasked, may work under the somewhat less stressful environment in training, but may not work in real-world high-stress environments where the decision making process is less efficient. It is also possible that when someone is in one of these high-stress situations without training in it, he or she will become more apt to develop tunnel vision and not work well as part of the team. As the saying goes “we train like we fight and fight like we train” (Weigmann & Shappell, 2001).

Another related area is the individual training. Reliable training is understood to be the cornerstone of effective team training. With this being accomplished, the individual will be able to monitor him/herself and the team performance for functioning of duties. This will give the individual the ability to monitor performance of self and the team for inter-reliant roles so they can help with another task if needed. It must be noted that conventional training is not really designed to assist in the development of metacognitive[9] and self-regulatory skills (Weigmann & Shappell, 2001). Research has also found that someone with less experience has inferior metacognitive skills than someone with experience. This would make sense for a less experienced person, because he or she does not have the insight that an experienced person would have and cannot

[9] Metacognitive skills are the self-monitoring skills which is the ability to know how well one is performing, when one is likely to be accurate or in error of judgment.

evaluate his or her own performance as well (Kruger, 1999). If the less experienced person is doing sub-par, he or she may not be aware of it because for the most part, people decide on the most reasonable choice, thereby potentially overestimating their skills and abilities and not knowing it.

If someone starts out under stress and is expected to perform well while training early on, this might instead hinder his or her learning and comprehension of the tasks. Something that needs to be watched is even if trainees do well during training conditions, they still may have problems adapting to changing and real-world situations. This matter is proof that trainees who are able to get the experience and insight required to be expert are better able to tune into situational awareness, prioritizing, and strategic trade-offs. The trainees that were trained like this did better in the previous situations than did performance goal trainees, even though the performance trainees did better in some areas themselves. Make note, adaptive skills need to be developed in some type of performance environment. Also, behavior oriented training that is performance driven and attempts to eliminate all errors may prove well in some situations, but may downgrade the development and insight that is truly needed. In other words, training needs to be insightful in developing knowledge, skills, and abilities instead of merely going through the motions just to get it on paper. The learning gained also needs to be challenging while meeting the training goals (Weigmann & Shappell, 2001).

Keep in mind that technical skill is a must, but alone it does not take into account the stress environments mentioned earlier. Again, stress training needs to be interjected in the training (Weigmann & Shappell, 2001). “It is interesting to note that in general, most training focuses on technical skills rather than the human factors such as following or questioning orders or recognizing fatigue," (Solomon, 2001, p. 5) A 2001 report on the United States Forest Service said that, "leadership is poorly taught, when taught at all," (Solomon, 2001, p. 4). An interesting note on this report is that general fire-agency guidelines do not necessitate having supervisors of any type take personnel management courses. Actually, when it is available, it is voluntary and "delivered far too late in people's careers," (Solomon, 2001, p. 4).

A note of importance is that cross-training for all members of the team can lead to better operations through communications and effective decision making during high-workload/stress events. It was found that a team with high levels of overlapping knowledge of other's jobs/tasks, the more proficient the team actually performed compared to teams without this knowledge (Weigmann & Shappell, 2001).

"It is immensely important that no soldier . . . should wait for war to expose him to the aspects of active service that amaze and confuse him when he first comes across them. If he has met them even once before, they will begin to be familiar to him," (Cannon-Bowers & Salas, 1998, p. 43). Part of a study in relation to this asked World War II combat veterans what type of training they most lacked. The answer of most frequency was *training under realistic conditions.*

Critical thinking is another area that is vitally important in the realm of decision making. This helps by not only catching conflicting information in what is observed and what the brain interprets it as, but notices doubtful ideas/thoughts where the data may be skewed or contrary to what the brain actually is seeing. It also helps with the time factor during decision making, therefore helping experienced decision makers effectively contend with uncertainty. What this can actually mean is that critical thinking allows the decision maker the ability to seek out the correct information and get to the meat of the problem by setting aside ambiguous, unneeded information and coming to a timely decision so action can be undertaken (Cannon-Bowers & Salas, 1998).

The proper critical thinking training can improve on not only the end decision, but the process of decision making itself. This is done through information-based instruction on concepts, a presentation of critical thinking, and training on realistic problems. It has been proven that more information during the decision making process does not mean more effective and better decisions. An example can be seen in the seemingly unlimited information technology that is now available can possibly lead to a roadblock of incoming information due to the large amounts of data that inundate the decision maker (Cannon-Bowers & Salas, 1998).

The TADMUS research investigated a number of decision models. Among them were the rational models, descriptive models, and naturalistic models of decision making. They found, for example, that rational models are focused on an outcome-oriented platform, or in other words teaching people to *make the right decision*. The naturalistic model, however, is geared more towards the process of decision making by teaching people to use their experience in making a decision in the field environment, as it more closely resembles actual situations than do other decision models due to numerous factors affecting these decisions in the field like time constraints, uncertainties, and unreliable information, just to name a few. Naturalistic also combines its use with other decision making models. In contrast to rational decision making, naturalistic decision making teaches people to make decisions *in the right way* (Weigmann & Shappell, 2001).

Whatever type of decision making is used for a particular situation, we still must train people to think "out of the box", and to give them the free will in case they encounter unusual circumstances or something that just does not work while training them under stressful conditions to follow protocol. This is because TADMUS research found that decision making that incorporated rational models was not turning out what would be normally expected decisions described by these models. As a matter of fact, decisions made were routinely missing the mark in both the prescribed course of action and result (Cannon-Bowers & Salas, 1998). The theory of "bounded rationality" was borne when it was found that when people that are in a situation do not normally calculate all of the possible options of actions they can take. The consideration of all possible options would be to potentially enhance the decision making by having all of the information. However, in bounded rationality this is not done, but instead the choice that will do is chosen when they reach enough options to find one that just satisfies them. This method would be referred to as "satisficing" (Cannon-Bowers & Salas, 1998).

One graphic example that has to do with "thinking out of the box" took place in California in the 1950's & 60's. The California Highway Patrol has always been known to be a top notch police agency, however, during this time they had experienced a number of officer involved shootings. Some of these incidents had very undesirable outcomes. After they analyzed more and more of these incidents, they came to see a pattern develop. This pattern was that after an officer had been shot and/or killed during a shoot-out, they were finding the spent shell-casings in the officer's pockets. Further investigation led to findings that this was a factor in the officer being wounded or killed. This sequence of events was found to actually be a training error, hence, errors beginning seconds, hours, days or weeks ahead of the actual incident/accident. The officers were doing just as they were taught in the academy which was to remove the shell casings from their revolver and put them in their pocket so as none were left on the firing range. This was borne out of the strictness of the academy and standard operating procedures. Fortunately the California Highway Patrol had the foresight to dig deeper and find out what was really happening. Standard operating procedures were changed immediately.

Another success story, one of the most prime ever sited, was the United Airlines flight 292 from Los Angeles to Chicago, also known as the Sioux City crash in 1987. The flight of this DC-10 jumbo jet was quite routine and uneventful up until the number two engine disintegrated after a turbine fan blade came apart. This in turn knocked out the main and redundant hydraulic system used to control the aircraft. With no plausible way to safely land this now multi-ton missile, Captain Al Haynes was trying to formulate a plan to thwart what he knows is a most likely non-survivable crash. Largely due to the proceeding events in the cockpit from actions of the crew, an amazing 180 people survived, even though unfortunately 112 perished. The main reason this flight was mostly saved was because the Crew Resource Management was employed. The areas of Crew Resource Management of communication skills under stress, teamwork and leadership, task allocation, and critical decision making all came together to make for the best outcome possible under the absolute worst circumstances (Rubin, et al., July 2001).

Safety officers are very important on every working incident of any kind. These are the extra set of eyes and ears that has one sole job: *to provide for safety*. According to Rubin's article (May, 2001) ". . . in the truest sense of the word *error*, the person making the miscue cannot detect his or her own mistake. If the decision makers recognized that they are going to make mistakes, they would have the ability to prevent the problem and never make a flub." Therefore, someone else is more likely to detect an error.

Of course, for any program to work the way it was intended, the organization needs to fully buy into it beyond just training. If this is not done, the programs will not likely achieve the desired outcome and may raise questions about circumstances surrounding the program. This list is a stepping stone to reaching the goal (Helmreich, 2001):

- **Build trust.** An agreement of a cooperative atmosphere needs to be forged between administrative management and the employees. This in turn needs to develop into a level of trust that will facilitate individuals to share safety information within the organization.
- **Adopting a non-punitive policy toward error.** A policy that deals with errors that were committed while the employee was performing their job within standard operating procedures needs to have a goal of furthering safety programs while learning at the same time being void of punishment. The approach without punishment will further the handling of safety issues within the organization.
- **Demonstrating a willingness to reduce error in the system.** An avenue for programs to pursue ways to deal with safety is paramount in delivering the education programs needed.
- **Providing special training in evaluating and reinforcing error avoidance, detection, and management for instructors and evaluators.**

Before the systems of the framework can be implemented, personnel have to be put in place and specially trained. This is so they can decipher the problems within error management, build programs, formulate plans and deliver needed training. An all-inclusive system will foster an environment that promotes safety for the all important employee.

- **Collecting data that show the nature and types of threat and error.** Different methods are needed to ascertain the large amount and complex data. This data gleaned from numerous sources can then be analyzed to assist with forming programs.
- **Providing training in error avoidance, detection, and management strategies for crews.** Once the framework of error policies, data analysis, and loss prevention programs have been evaluated, training programs need to be formulated and delivered to all personnel. When this is underway these programs will give the personnel the tools to effectively deal with safety problems within a large scope.

It is interesting to note that none of these possible remedies to errors involves punishment. It is widely accepted, with the exception of the medical field, that punishment as a means to prevent future adverse events is the wrong approach to error management. The medical field is still under the belief in what is known as punitive "perfectibility mode" where there will be NO mistakes if staff are properly trained and motivated. It must be noted however, that one theory says that the best policy to shrink violations is to hold crews and supervisors accountable for their actions. This method has apparently worked for the Navy and Marine Corps. Also, this is tied into another report that says Crew Resource Management errors in some instances have stayed somewhat stagnant and are not being reduced by the CRM training. Furthermore, this is also tied into accountability, type of training material, and the type of training that the crews have received (Weigmann & Shappell, 2001).

A safety culture includes a strong commitment to training as well as reinforcing safe practices and establishing open lines of communication between operational personnel and management regarding threats to safety.

Remember, we can always learn from other’s past mistakes, but nothing will take the place of true, insightful, meaningful, necessary training. So … the next time someone says “it’s only training”, or “training is a waste of time”, give them the facts from this paper and recite this quote.

“It is better to be careful a hundred times than to get killed once.”

Mark Twain

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