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Findings From the Wildland Firefighters Human Factors Workshop

Improving Wildland Firefighter Performance Under Stressful, Risky Conditions: Toward Better Decisions on the Fireline and More Resilient Organizations

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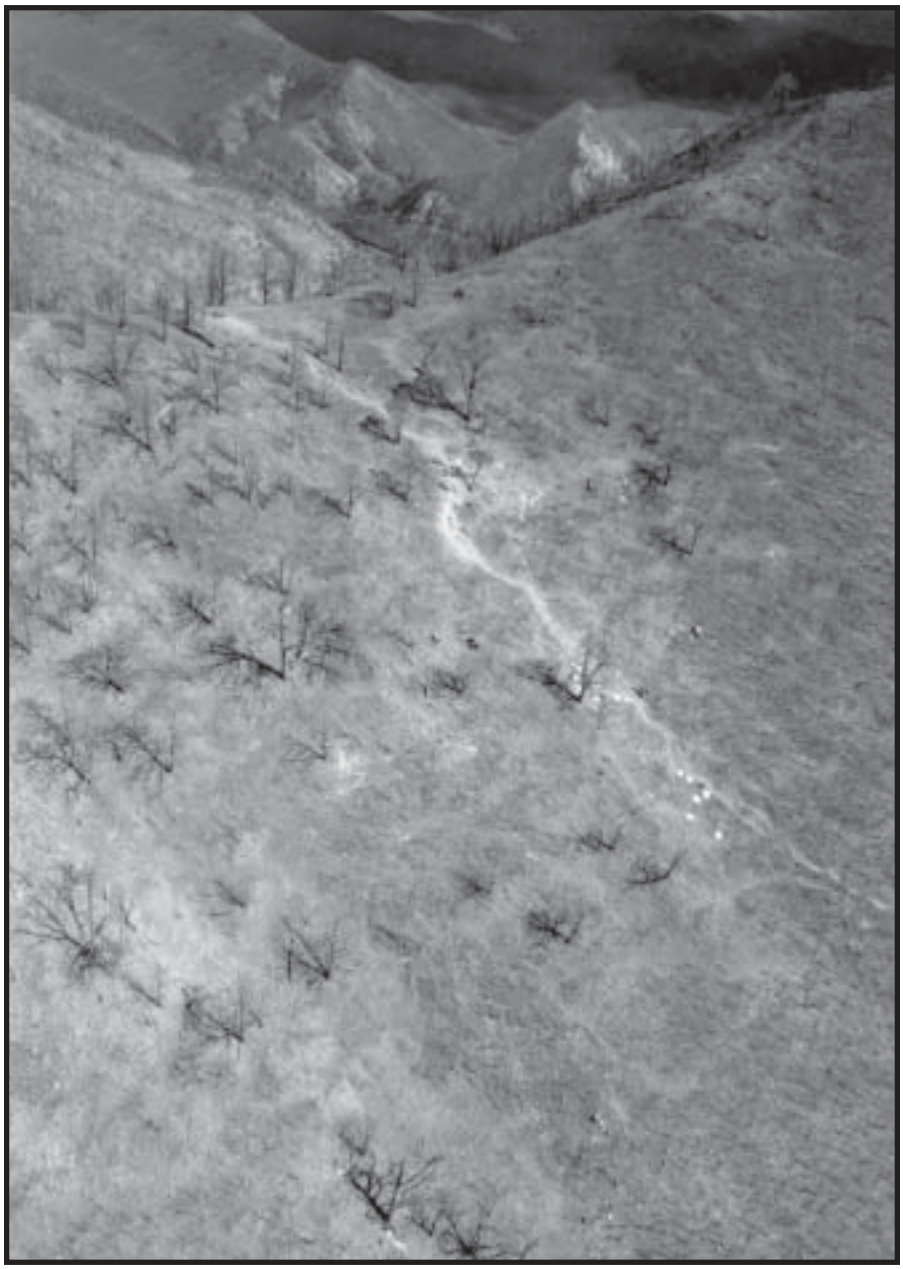
Background

It has become increasingly clear that wildland firefighters are experiencing collapses in decisionmaking and organizational structure when conditions on the fireline become life-threatening. Since 1990 wildland fire agencies have lost 23 people who might have survived had they simply dropped their tools and equipment for greater speed escaping fires. We are averaging more than 30 entrapments each year now. And during the 1994 fire season, 34 people died, 14 on the South Canyon Fire alone.



The main entrapment site at the South Canyon Fire where 12 firefighters lost their lives on July 6, 1994.

These facts tell us that firefighting organizations, crews, and individuals need to be much more proficient at decisionmaking under stressful, risky conditions. Improving proficiency will require new training and attitude changes. And this in turn requires a thorough examination of the human dimensions of wildland firefighting. This examination is not limited to firefighting crews and teams (i.e., smokechasers, engines, helitack, incident management, type I, and type II) but extends to fire management officers, dispatchers, fire support, managers with fire and resource responsibilities, up to Agency heads. These people encompass a fire community. Fire community implies an awareness that we are interconnected and interdependent and should approach firefighting from the point of view that we are all in this together.

To begin to address some of the human factors questions, experts in psychology, sociology, organizations, fire safety, and wildland firefighting attended a 5-day workshop in June 1995 to discuss ways of improving firefighter safety.

Workshop participants explored firefighter psychology, interactions among firefighters and among fire crews, and better ways to organize. After several days of discussions, they developed a series of recommendations for beginning to implement changes that would improve the fire organization and firefighter safety.

This paper outlines the workshop's findings and recommendations. The workshop represents a first step in what will be a long journey toward a better understanding of the human side of wildland firefighting.

Ted Putnam
Workshop Organizer

Workshop Overview

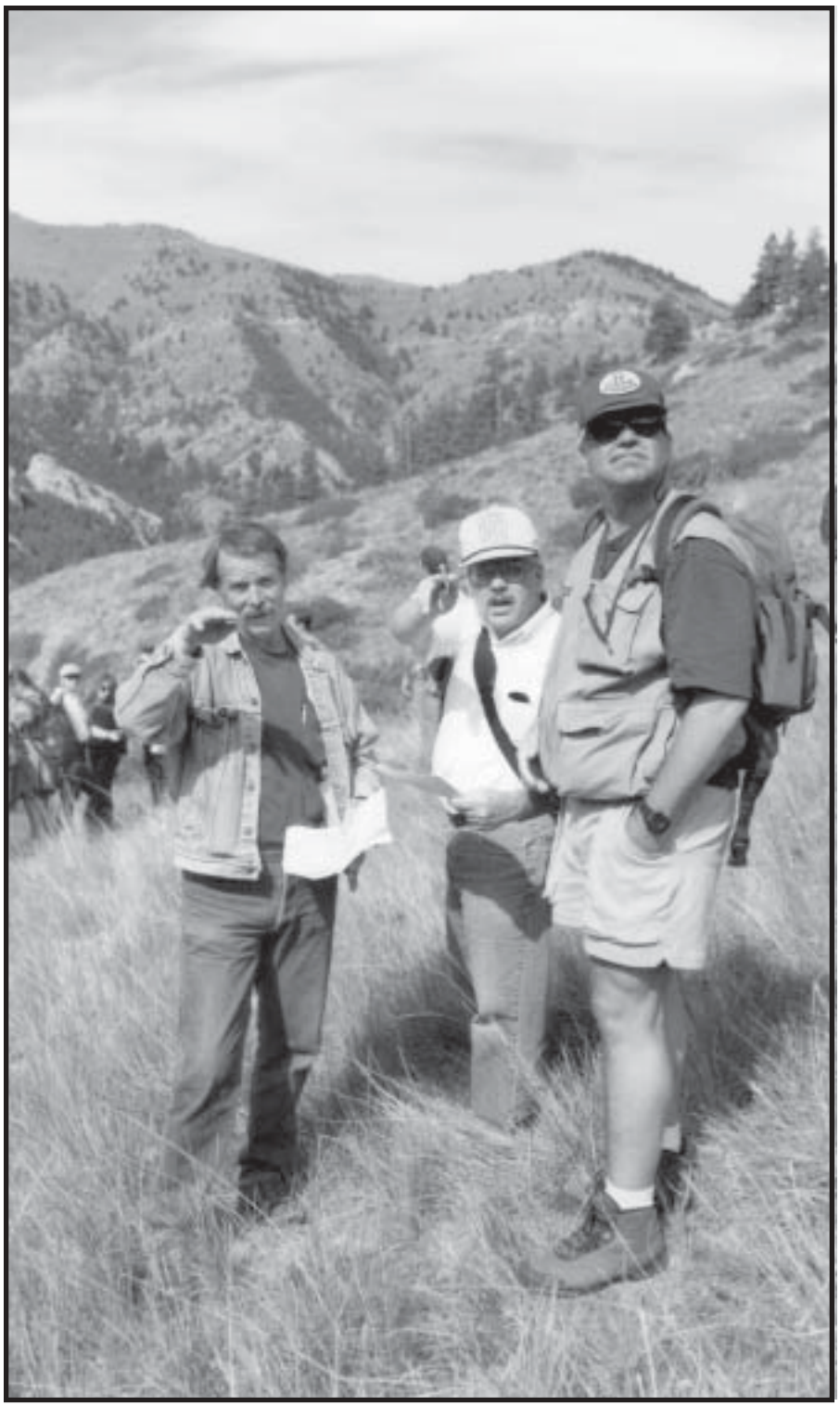
The Start

From the beginning, workshop emphasis was on people, not fire. It was about peopling fires, not fire suppression. With the former, we organize trained people to perform a task safely and efficiently, and the relevant task is fire suppression. In the latter, we suppress fires using people. Historically, this has led to overemphasizing the fire and de-emphasizing and devaluing the firefighter. We have spent millions on fire research but little on firefighter research. We have many fire researchers. We have no firefighter researchers.

On July 6, 1994, we lost 14 firefighters on Storm King Mountain. The investigation of these fatalities clearly showed both psychological and organizational failures. How did these failures come about? What can be done to bring the primary focus back to valuing people? Trees regrow, houses can be rebuilt, but the loss of a life is forever. What has unfolded in the aftermath is a reaffirmation that people are first. All else is secondary in wildland firefighting.

The 1994 fire season in which 34 people died was the catalyst that brought together firefighters, safety managers, psychologists, and sociologists for the workshop. Together we discussed the human side of fighting fires. We examined firefighters, firefighter crews, fire management, fire culture, and fire communities with the goal of enhancing the firefighter amid a more highly resilient organization.

The workshop began with four keynote speakers who discussed new concepts to give firefighters a look into ways to improve themselves, their interactions, and the entire wildland fire community. Kurt Braun discussed the role human behavior plays in safety and injury, with emphasis on risky behaviors common



Mark Linane (left), Bill Bradshaw, and Buck Latapie discuss the Mann Gulch strategies from a “human factors” standpoint.

in the wildland fire environment and how to change to reduce those risks. Gary Klein showed how experienced firefighters used recognition-primed decision (RPD) strategies and how experience is crucial for quick, effective decisions in a fast-changing, risky environment. David Hart discussed cultural attitudes that can enhance or hinder firefighter safety and effectiveness and how training can make individuals and crews more resilient to failures. Finally, Karl Weick introduced insights from high reliability organizations that help improve communication, leadership, group structure, and sensemaking, which in turn decrease stress and the chance of catastrophic errors.

That afternoon and the following day, the workshop experts discussed firefighters, firefighting, and the fireground, and explored the interconnections, emphasizing what was working or what was not. Possible solutions were discussed. The third day participants took the discussion into the field with a trip to Mann Gulch. The fire scenario was reviewed where it happened, including how people interacted with each other, the decisions that were made, and how events unfolded in an increasingly risky, changing environment. Insights not found in original reports were put forth to explain how and why 13 firefighters died on the Mann Gulch Fire. These new insights from a psychological perspective show that analysis and conclusions depend upon the experiential bias of the investigator. The Mann Gulch experience invigorated the participants. The final two days were spent exploring solutions and developing both long-term and short-term recommendations.

The goal of the workshop was not to come up with quick solutions. Rather it was to explore the human issues of wildland firefighting and recommend to fire management corrective actions that would have lasting effects. As with all explorations of human behaviors, the complexity and variety of issues was apparent. But it became clear that a great deal of relevant knowledge already exists that other organizations have institutionalized to reduce risk and improve safety. Before we can use this knowledge in the wildfire context, we must establish baselines for relevant behaviors. Without such benchmarks, we would have no precise way to measure change once corrective changes are implemented.

It was quickly apparent in our discussions that fire agencies are not routinely collecting and analyzing data that would give us a good idea about the current behaviors of wildland firefighters. We don't even collect crucial near-miss information on the wide variety of risks inherent in firefighting. We only do a good job of recording fatalities, Ensely (1995), but this strongly biases our view of normal, routine behaviors. Such a narrow focus precludes warning trends that would become apparent in an analysis of near-miss situations. Therefore, workshop output depended on the experience level and ability to recall relevant information gathered in workshop discussions, but for purposes of future discussion and corrective actions, the information is grouped into the following three main areas.

- A broad vision of how to reorganize wildland firefighting based on insights from High Reliability Organizations (HRO's).
- A specific reorganization of Incident Management Teams and fire crews along crew resource management (CRM) lines.
- Better assessment and feedback for all wildland firefighting activities.

High Reliability Organizations: A Vision for Fire Reorganization

The wildland fire community should reorganize using High Reliability Organizations (HRO's) as a model. Examples of HRO's are nuclear power plants and aircraft carriers.

Characteristics of HRO's include (Rochlin 1993):

- The activity or service is inherently complex in that tasks are numerous, differentiated and interdependent.
- The activity or service meets certain social demands that require performance at the highest level of service obtainable within present safety requirements, with both a desire for an even higher level of activity and a penalty (explicit or implicit) if service slackens.
- The activity or service contains inherent technological hazards in case of error or failure that are manifold, varied, highly consequential, and relatively time-urgent, requiring constant, flexible, technology-intrusive management to provide an acceptable level of safety to operators, other personnel, and/or the public.

  "As stipulated at the outset, the organization must not only meet service and safety goals simultaneously, but also must be perceived to have done so."

Although fighting wildfires is not as technologically complex as classic HRO activities, the management issues are similar, particularly in the urban interface and prescribed fire arenas.

The yardsticks to determine a wildland fire HRO's reliability and effectiveness could include the following (Creed and others 1993):

❖ From whose perspective is effectiveness or ineffectiveness judged?
- Management
- Firefighter
- Politicians
- OSHA
- Public
- Media

❖ On what domain of activity is the analysis focused?
- Safety
- Acres burned
- Houses saved
- Accidents
- Near misses
- Training
- Cause and effect
- Decisionmaking
- Sensemaking
- Attitudes

❖ What level of analysis is being used?
- Individual behavior
- Crew behavior
- Longitudinal
- Baseline
- Culture

❖ What is the purpose for assessing effectiveness?
- Error reduction
- Promoting safety
- Determining causal relationships

❖ What time frame is being employed?
- Short term
- Long term

❖ What types of data are being used for evaluating effectiveness?
- Error rates
- Incidents
- Accidents
- Compliance
- Safety checks

❖ What is the referent against which effectiveness is being judged?
- Agency standards
- OSHA standards
- Similar organizations

In analyzing the safety culture in HRO's, the factors and their contributory weights were (Koch 1993):

Factor	Percent explained by factor
Accountability/Responsibility	23.2
Adaptiveness/Responsiveness	16.3
Openness/Cooperation	15.4
Hazard awareness	14.2
Inquisitiveness/Search for detail	13.2
Role clarity	9.7
Maturity	8.0
	100.0

While HRO's depend more on technological controls than wildland fire agencies, the process of looking at their organizational structure is relevant.

Using the Crew Resource Management Model in Fire

Crew resource management (CRM) focuses on behaviors of crews. Adoption of CRM training and cultural changes has dramatically reduced near misses and accidents in the airline industry. Most of the organizational and interactive behaviors that are part of CRM are relevant to the entire wildland fire community.

CRM focuses on honing seven skills: situational awareness, mission analysis, decisionmaking, communication, leadership, adaptability, and assertiveness (Prince and others 1993; Frantz and others 1990).

These seven skills can be divided into taskwork skills and teamwork skills. Taskwork skills include: situational awareness, mission analysis, and decisionmaking.

❖ Situational awareness is the perception of what the fire is doing and what you are doing in relation to the fire and your goals. It involves an awareness of fire behavior and terrain and the ability to predict where the fire and you will be in the future. This skill depends both on individual perception and sharing it with the rest of the team.

❖ Mission analysis involves organizing and planning. It involves breaking the mission down into subtasks, assigning priorities to these subtasks, and monitoring completion until the mission is over. It begins with an organized briefing and clarifies important issues related to the mission.

❖ Decisionmaking involves deciding which decision model is most appropriate for firefighters, such as Recognition-Primed Decisionmaking. It also involves training firefighters in decisionmaking and using it under simulated stressful conditions. Decisionmaking includes collecting, integrating, and implementing information for the most effective task performance.

Teamwork skills include: communication, leadership, adaptability, and assertiveness. Communication and leadership involve at least two people,

❖ Effective communication primarily depends upon the clarity, quality, and timeliness of the message. Miscommunication has been a causal factor in many accidents.

❖ Leadership skills include delegating tasks, providing feedback, promoting crew motivation and cohesion—all in an atmosphere that fosters openness by allowing crew members to present alternative views without fear of criticism. The most effective leaders take an active role in involving the entire crew in a team effort, discussing interactions required for the tasks, and clarifying norms and roles.

❖ Adaptability refers to the ability to change behaviors during a fire to react to changing conditions and to other crew members. It refers to trying new behaviors when old behaviors are no longer effective.

❖ Assertiveness is necessary to help individuals who may feel intimidated by a person's position or fire experience. It assures that everyone's special knowledge will become group knowledge.

Communication and leadership involve at least two people, whereas adaptability and assertiveness are more individual characteristics.

Components of the CRM Taskwork Skills as They Relate to Fire (Prince and Salas 1993)

Situational Awareness—
- Identify problems/potential problems
- Recognize the need for action
- Attempt to determine why discrepancies exist with information before proceeding
- Provide information in advance
- Demonstrate ongoing awareness of fire assignment status
- Demonstrate awareness of your own task performance
- Note deviations

Mission Analysis—
- Define tasks based on fire assignment
- Structure strategies, tactics, and objectives
- Identify potential impact of unplanned events on a fire
- Critique existing plans
- Devise contingency plans
- Question/seek information, data, and ideas related to fire plan

Decisionmaking—
- Cross-check information sources
- Anticipate consequences of decisions
- Use data to generate alternatives
- Gather pertinent data before making a decision
- Evaluate information and assess resources
- Identify alternatives and contingencies
- Provide rationale for decision

Components of the CRM Teamwork Skills as They Relate to Fire

Communication—
- Use standard terminology
- Provide information as required
- Provide information when asked
- Ask for clarification of a communication
- Make no response (negative)
- Acknowledge communication (okay)
- Repeat information
- Reply with a question or comment
- Use nonverbal communication appropriately

Leadership—
- Determine tasks to be assigned
- Establish procedures to monitor and assess the crew
- Inform the crew members of fire assignment progress
- Verbalize plans
- Discuss ways to improve performance
- Ask for input; discuss problems
- Tell crew members what to do
- Reallocate work in a dynamic situation
- Focus crew attention to task
- Provide a legitimate avenue for dissent
- Provide feedback to crew on performance

Adaptability/flexibility—
- Alter fire plans to meet situation demands
- Alter behavior to meet situation demands
- Accept constructive criticism and help
- Step in and help other crew members
- Be receptive to others' ideas

Assertiveness—
- Advocate a specific course of action
- State opinions on decisions and procedures even to higher-ranking crew member
- Ask questions when uncertain
- Make suggestions
- Raise questions about procedures

This enumeration of examples under each of the seven CRM skills clearly shows the similarity in requirements for success between the cockpit and the fireline. Both place a premium on individuals operating as close-knit teams. Because of this similarity, CRM research data and training courses can be readily tailored to wildland firefighting.

Assessment and Feedback

Assessment and feedback are essential for effective individual, team, and agency success. That is why assessment and feedback are such an important part of both HRO's and CRM. But within the Federal wildland fire establishment, assessment and feedback are used so seldom that the workshop singled them out as the third area of major concern.

Throughout the workshop it was evident firefighters are being sent conflicting messages from a variety of sources: political oversight, the agency, the public, and the fire organization. Most firefighters feel the task of putting out the fire is primary and concern for their safety is secondary. Despite claims to the contrary, safety is not yet the number one priority.

Firefighters want to be safe and avoid injury, but there are times when the demands of the job obscure safe practices. To deal with these instances, firefighters need to be equipped with better situational awareness and decisionmaking skills. And they need feedback about how they are performing these tasks. Individuals and crews seldom receive feedback. But without it, there is no way to measure performance improvements. Assessment is needed at all levels of the fire organization to establish a baseline for policy, attitudes, and behavior. As changes are implemented, measurements can determine results. Feedback at all levels is crucial for achieving positive changes.

Workshop Findings

Dave Thomas points toward Wag Dodge's escape fire while Ted Putnam and Dave Turner consider his analysis.

The first three days focused primarily on determining where the fire community is organizationally, where it should be going, and how the needs of both the firefighters and the fire organization could be brought into closer alignment, with safety the first priority. Workshop participant inputs were organized into three areas: (1) reorganization strategies for fire agencies based on HRO's; (2) fire management Incident Management Team (IMT) and fire crew reorganization using CRM as a model; and (3) better assessment and feedback. The fourth day focused on future organizational studies, changes, and training that would move safety to the forefront and improve firefighter attitudes and effectiveness.

Fire Organization and Culture

❖ The wildland fire agencies should compare themselves with HRO's and use research results to improve the agencies.

❖ Fire crews should be organized using relevant CRM concepts for improved safety and effectiveness.

❖ There is a need to clarify management and public expectations of firefighters. Management and the public need to be more realistic in their expectations of the fire community. We should not feel pressured to do more while resources continue to dwindle. We cannot always do a good job with what we have now, and the situation is getting worse. There are too many conflicting messages about safety first versus getting the job done.

- Maximizing forest growth means more severe fires in the future.
- Often politicians and the public exert pressure to go all out to save homes in the interface.
- Unqualified personnel are making firefighting unsafe. This includes inexperienced EEO, downsizing laterals, and others who have not worked their way up in the fire organization with a combination of training and experience.
- Lack of financial and position incentives to keep experienced firefighters in the organization.
- We taught the public we should and can control all fires. Now they expect us to fight all fires with people, planes, helicopters, and retardant. This has led to higher cost fires and more risk taking in the sky and on the ground. There is a real need to re-educate the public about all the issues of fire management. We need to return to a more natural view that all fires are not stoppable in the same sense that we cannot stop hurricanes, earthquakes, floods, and other natural events.
- Management needs to redefine "success" and "failure" in firefighting, together with priorities and consequences. Evaluate all messages against agency goals especially the goal of safety first. Eliminate miscues.

❖ It is easier to modify behavior than attitudes. Changing attitudes occurs after a 3- to 5-year effort. Attitudes need to be exemplified in behaviors.

- Agencies are not well organized to handle extended initial attack and transition fires, where most fatalities occur.

- The current fire culture does not foster respectful interaction. If a fire is going to blow up, is it culturally acceptable for anyone to voice an opinion? Do all firefighters have the courage to raise this point? All firefighters should be allowed to verbalize their fears. Firefighters should be given situational assessments in a respectful context. When the situation is unsafe, they should also be allowed to pull back without loss of respect or threats. There is a need for organizational clarity on factors involved in not engaging or disengaging, and when these factors align to result in action to pull back. Some crews and crew supervisors have a good, experience-based comfort level for when to pull out, whereas others do not.

- Firefighters need to be responsible for their own destinies and help work through the "more with less" period. It will be worth it in the long run.

- We need to identify constants between firefighters' attitudes and management, and identify firefighter rituals, norms, values, etc.

- What is controlling fires about? What are we trying to do? Who is making sense out of all this—fire management? Firefighters? Are we on the same mission? Whose vision?

- Are rational models of fire organizations synchronized with the informal work culture?

- Worsening organizational strains include mixing personnel, declining experience levels, uncertainty of experience, under-funded training, downsizing, then placing laterals and EEO personnel with little or no experience in high responsibility fire positions.

- There is a critical organizational need to rebuild a sense of community from the top down and the bottom up, because it seems to be disintegrating now. If it takes up to six weeks for crew cohesion and trust to develop, are people and crews really interchangeable as managers presume? Are there better ways to accelerate cohesion and trust? Continually emphasize the fact that the humanity of the fire community is far more precious than any other resource. Remove barriers and inconsistencies between cultural expectations and actual practices. Promote better cohesion.

- Cultural differences between groups of firefighters:
  - The public and firefighters promote group images that pressure "elite" groups to "aim to please" and "live up to expectations."
  - The group culture affects risk taking and decisionmaking.
  - More respectful interactions are needed to bring expectations into line with capabilities, for a better sense of community.
  - Management and IMT's need to take group differences into account.
  - Elite crews need to feel that they are allowed to back down from risky, unsafe actions without any loss of respect.
  - Crews of different racial mixes have unique cultural concerns.

- Too many red-carded personnel do not have the expertise indicated by their cards and positions on fires. As a result a mistrust of all individuals is growing, and this in turn is a mistrust of the organization. There is an "us" versus "them" attitude between firefighters on crews versus IMT's or FMO's and dispatchers. Most of the training opportunities, hence higher red card ratings, go to PFT's as opposed to seasonals who have considerably more fire experience. Filling fire vacancies with engineers, foresters, and EEO candidates rather than seasonals further undermines the experience base, and it is getting worse. Creating unsafe managers through hiring practices flies in the face of upper level management pronouncements about safety first. These "new" fire managers who do not see the big fire picture often are overzealous micromanagers. The agency needs to take a hard look at qualifications of FMO's and dispatchers. They need CRM type training to better size up situations, make good decisions, and communicate the outcomes in an open, two-way atmosphere. There are too many incompetent people on the fireline. The red card system is failing, which puts more firefighters at risk. New evaluation processes such as "hot-seat" simulations, panel reviews, etc., are needed for key decisionmaking fire positions, to eliminate the possibility of one person being able to sign off another in a "buddy system" because of perceived pressure or because the organization needs them. The rating system must be consistent throughout the nation and between agencies.

- Management needs to stop talking and promote actions that foster real changes in the organization. Policymakers could use decisionmaking and situational awareness training.

- Working safely is a natural outgrowth of clear, effective management and leadership. It is the result of actions, not words.

- Most of the fireline firefighters are seasonal employees. What is the best way to organize, train, and acculturate them for the future benefit of both them and the fire community? There may be real benefits to bringing them on two weeks before the start of the fire season to foster safety training and cohesion. Currently, most

recognition goes to permanent employees. More recognition of seasonal employees and their value to the program is needed. Better incentives for seasonal workers would promote safety and learning.

- Organizational defensive behaviors are leading to unsafe practices. When investigation teams or managers cover up the causes of accidents and near misses, no learning takes place for the individuals or the organization. There is a need for forthright information and open discussion at all levels of the fire community.

- Psychologically, there is more pressure on firefighters to put the fire out than to do it safely.

- There appears to be too many fire orders and watchouts. A formal content analysis study may be able to reduce these guidelines to a few key ones such as LCES (Lookouts, Communications, Escape safety zones) that then should be prioritized. If some should never be violated, no matter what the circumstances, then they should be identified. Some fire orders and many watchouts are routinely disregarded. This is necessary at times to accomplish some fireline tasks and can lead to violating orders that are not just guidelines. When an order is violated and it works out okay, this can lead to more future violations. There is a general feeling that you must violate some, but that can get you in trouble when you string them together. Need to look at all the orders, watchouts, LCES and reorganize them for maximal clarity, minimum rules with clear direction from management, then enforce them routinely. Since attitudes and rules do not always predict behaviors, who is responsible for oversight and ensuring compliance?

- The agency should reorganize to support the firefighters and maximize their potential. The firefighters want to perform at a high level and need the organizational support to achieve that level. The agency has made fire suppression number one, and this needs to be changed so people are number one.

- There is an agency failure to follow up to see if objectives, training, etc., actually accomplish their goals. Often management sets things in motion without any idea what effect it produces in the field. Without feedback the organization does not learn.

- Fire managers, IMT's, and fire crews should periodically shut down their entire operation for a day, especially after near misses or accidents. Stop doing normal routines and reassess larger goals. Groups need to focus on what is going right and what is going wrong. What is the worst that can happen, and what can be done about it. Organizational shut downs can be valuable learning experiences.

- Agencies should encourage more job swapping for one year or one fire season. Examples would be hotshot/smokejumper or FMO/hotshot swaps. We could also have a safety officer, FMO, or dispatcher shadow a hotshot crew or be shadowed by a hotshot. This would help bring down barriers and create a true community feeling.

- The long-range forecast is for a period of cooler fire seasons. This is coming at a time of accelerated skill erosion of fire personnel, fewer FTE's and declining training dollars. As prescribed burning increases tenfold, the "classroom" should be moved to the burn site. OJT needs to be incorporated into the prescribed burn process.

- There is a need for more FTE's and career tracks for key firefighter supervisory personnel in order to promote better experience levels and provide a more professional nucleus for supervising seasonal hires. A shift should be made to more tenured firefighters as opposed to more FMO's and managers. Overdependence on firefighting as a collateral duty has diluted the professional firefighter base.

- Type I crews should have common physical fitness requirements. Current standards are too low, and the poorer fitness levels of a few are compromising the safety of the rest of the crew. This problem is especially disturbing when supervisors are less fit than their crews.

Fire Management, Incident Management Teams, and Fire Crews in a Crew Resource Management Context

Situational Awareness (Size-up)

- Basic situational awareness is highly dependent upon good information, skill, and experience. It is one of the most difficult skills to master and is a weakness in the fire community.

- Although basic subskills are taught in various classroom courses, little is done to see if the overall skill has transferred to the fireground.

- Most firefighters possessing situational awareness demonstrate declining performance as the fire accelerates. This indicates a need for simulation training in faster paced decisionmaking, to facilitate quick size-ups that keep pace with the fires.

- With lower tempo fire situations, we have better recall and use rational processes for assessing our situation. With high tempos, rational processes are too slow. We need recognition-primed decision (RPD) skills that come primarily through years of experience.

- The focus here is more on sensemaking than decisionmaking. Sensemaking (Weick 1995) is observing or creating patterns as we experience reality. These conceptual expectations form the basis to comprehend, explain, attribute, and predict events. It is experience driven rather than a logical decision process. When expectations are disconfirmed an ongoing activity is disrupted and then sensemaking is the process of coping with interruptions and surprises. It is the process of making things sensible.

- During OJT, situational awareness needs to be an expected, formal action and made public to others or written down. Then feedback should be used to compare predicted versus actual results to improve predictive skills. Otherwise, we tend to revise our past predictions to fit what actually happened. This latter process actually makes us worse at predicting future events. Later, under high-tempo conditions, this skill will be fluid and rapid.

- Part of the process of understanding situational awareness is to ask what are the adverse effects of incorrect size-ups.

- Does the local FMO or dispatcher accept your size-up? Do they give you all the resources you order? Are the resources timely? How does your situational awareness compare to theirs? Do they advise you of resource status, recommend alternatives, and assess consequences?

- Situational awareness is critical for making decisions on whether or not to fight the fire and later on whether to stay engaged or disengage from the fire.

- The higher the tempo the more often you need to perform another situational check.

- When any significant event changes, then another situational check must be made. When situational checks become too frequent, this is a cue to consider disengaging.

- Whenever you become unsure of your situational assessment and vacillate over various inputs then "safety first" directs you to assume the worst because people tend to underestimate the severity of situations. For example, if you are vacillating between whether the situation is severe enough to order retardant, then order the retardant.

- Part of situational awareness is to have a clear understanding when you are getting in over your head, when the situation no longer makes sense. Then it is time to call for more resources or to pull out.

- There should be a requirement to communicate revised size-ups among crews, FMO's, and dispatch every "x" hours, depending on fire danger and time of day.

- Identify situations requiring heightened awareness such as extended initial attack, transitions, interims until resources arrive, urban interface, the actual arrival of the resource, and interims after accidents or near misses.

- May need a checklist of factors to consider when sizing up a situation so no factor is missed. As a minimum, LCES should be included. Discuss emergencies, what are the early warning signs and what to do if they occur.

- Part of situational awareness should include giving good briefings and debriefings that communicate all the essential facts. This becomes the basis for the situational awareness of other firefighters. There should be standard briefing practices that are given and expected. Briefings should be face-to-face whenever possible. Ask questions to see if the essential content of the briefing has been understood.

- A pre-accident situational awareness would be to run through all known and suspected risks associated with a fire. This initial information becomes a checklist to consider once you get to the fire.

- Need a good sense of time. How long do certain actions take, how long until resources arrive, and how long to shadow during transitions?

- Situational awareness cannot be mandated. We need people to be thinking, discussing, and observing constantly for most effective use of this skill.

- Consider using the Campbell danger rating system or one like it for formalizing situational awareness and the language to communicate it to others. Need a system that teaches inexperienced firefighters to size up fires the way experts do. The same system should be used by the Incident Commander (IC), FMO, and dispatch for maximal information transfer.

- Part of situational awareness is knowledge of safety and deployment zones, escape routes, and escape time. This must be planned and communicated to all firefighters. Emergency actions must be well practiced and understood for them to be available and effective when needed.

- Situational awareness should include the fire, other people and resources, and a periodic internal check, and how all these interrelate over time.

- What are situational awareness red flags?
  - Change—large, unexpected, faster rate
  - Expectations not met—resource changes, times
  - People not communicating
  - Stress—various stresses are additive

- ❖ FMO's at the district, forest, or area level must develop clear criteria for determining when they are in severe or extreme fire danger. Then they must warn against business as usual and function in a high-tempo mode. They must communicate the situation to local and nonlocal fire personnel.

- ❖ Dispatchers, FMO's, coordination, and resource allocation centers must develop clear criteria for determining when they are in over their heads and then call for help. The process and criteria must be in place before the need, then reviewed weekly or daily as the fire season progresses.

- ❖ It is useful to project a likely situation and a worst plausible situation, then build a plan that can survive the worst plausible situation and can also work effectively for the likely situation.

- ❖ Judgment of safety margins, patterns of cues that signal that risk is too high, must be carefully trained before the assignment is accepted or crews deployed. It is easier to avoid than get out of a bad situation. The judgment can be refined to reflect changing conditions to determine when the safety margin has been gradually reduced to a point where it is unacceptable. Gradual reductions are particularly difficult to observe.

- ❖ Training should ensure breakpoints are overlearned for improved safety. Breakpoints involve the rapid recognition that the situation has become untenable and, rather than cope and adjust, it is time to radically change the game plan; survival has become the number one priority. This includes learning to abandon firelines that were built at considerable cost of effort.

Mission Analysis

- ❖ Mission analysis begins with overall fire strategies and tactics, situational awareness with size-ups and briefings. Then the larger tactics are broken down into specific tasks, task assignments are made, tasks are monitored, then tactics reassessed.

- ❖ Mission analysis tends to work well except for extended initial attack and transitions, and during interims before resources arrive, etc. In these situations environmental changes are occurring faster than strategies, tactics, and tasks can be changed to try to keep the mission on track.

- ❖ Mission analysis also includes awareness and knowledge of when the mission can no longer be accomplished safely. Do not start, or disengage as appropriate.

- ❖ It is crucial for overall mission success to explain the mission to the crew, explain their individual parts, then allow them a chance to ask questions and clarify the mission. It involves both briefings and debriefings. End of mission debriefings are important learning processes for transferring knowledge and learning.

- ❖ Mission analysis must take into account LCES and be ready to implement alternate plans when current plans fail. Complications occur with mixed resources, indefinite resource arrival times, and unexpected fire behavior.

- ❖ Each team member must have appropriate training and knowledge to accomplish a specific task. Mission analysis must clarify roles and ensure each person performs a role, yet interacts well with people or crews they border. When the mission changes, the people may need to make role changes quickly. The more risk or faster the tempo, the more supervisors must pay less attention to specific work tasks and more attention to the big picture and oversight supervision. At some point everyone must switch to emergency roles where escape becomes paramount and all individuals stop ordinary actions and focus on supervisory orders.

Decisionmaking

- ❖ Different decisions necessitate different models. A rational model looks at strategic decisions and therefore prescribes best tactics. Naturalistic models look at decisions under stress with minimal response times and focus on making sense of the situation and taking rapid action to alleviate problems. RPD is a naturalistic model. Firefighters need training with both models and guidelines that help determine when each model is better.

- ❖ Current firefighters receive little or no training on decisionmaking skills. Firefighters need to recognize a need for balance between individual decisionmaking and group decisionmaking. They need training on how situations, stress, other people, and groups affect their decisions, and on aids for clear decisions. They need to discriminate between sensemaking and decisionmaking.

- ❖ Training needs to be specific to the job. Firefighters need to make tactical decisions, and managers need to make organizational decisions.

- ❖ Factors in decisionmaking:
  - Decision point or branch
  - Errors
  - Does person have prerequisite skills?
  - Biases
  - Cultural differences
  - Intelligence differences
  - Reliability of the information

- ❖ Need to study decisionmaking in crews, operations, and IMT's. Training should be group specific. Some positions, such as division and crew superintendents, may need more than one type of training due to variable roles.

- ❖ Currently there is no clear sense of what is expected of firefighters. Institutional messages are conflicting, so decisions are not always consistent with management

expectations. Firefighters are asked to take risks, fight fire aggressively but safely. Where is the boundary between risk and safety. Who decides on where the boundary is: management, IMT, crew supervisor, or individual firefighters?

❖ There is a need to do a factor analysis on all the decision aids currently in vogue:
- 10 Standard Fire Orders
- 18 Watch-out Situations
- 5 Common Denominators
- 4 LCES
- 10 Downhill/Indirect Line Construction Guidelines
- 9 Urban/Wildland Watch-outs

56 total

A factor analysis would reduce these to a bare minimum. They should be grouped into never violate, transgress with extreme caution, and watch outs to avoid. If all these aids are only guidelines, then we should not criticize firefighters who do not follow them perfectly and accept that they made the best decision given their experience, training, and awareness level. Putting them in order of priority would help.

If we adopt a rule "safety first," then it must be reflected in all decision aids or at least be the top priority.

❖ Internal Watch-outs
- Physical fatigue
- Mental stress
- Fear/Anxiety
- Tight stomach muscles
- Action tunneling
- Want to speak out but don't
- Overconfidence, confidence increases
- Decisions made without feedback
- Situation ambiguous or doesn't make sense
- Microsleeping
- Changing belief to match action
- Accepting increased risk
- Recent family problem
- Organization or individual distrust

❖ Intrapersonal/Crew Watch-outs
- Two inexperienced persons in direct line of command
- Other person/crew is tired or stressed out and is making crucial decisions
- Person won't talk or is hostile
- Cocky, overconfident individuals
- Group polarization
- Declining communication and feedback; supervisors are reluctant to ask for help
- It is unclear who is in charge of the "big picture"
- Group consensus without sufficient information

❖ Management Watch-outs
- You don't receive resources or the dispatchers argue about what resources you need
- Resources will be late arriving
- Politicians are in the area
- Multiple agencies are involved
- Dispatchers/FMO's keep track of things in their heads rather than on paper
- Norms for radio discipline are loose
- Agency is reluctant to ask for help
- Administrators are getting on-the-job training
- Administrators say keep it simple
- When overheads are unknown or tough to find
- Dispatchers are more concerned with homes than firefighters
- News media are in the area
- Tensions and conflicts exist before the fire season

❖ Stresses that interfere with good decisionmaking include:
- Anxiety
- Frustration
- Noise
- Alcohol
- Heat
- Fluid loss
- Drugs
- Fear
- Anger
- Sleep loss
- Vibration
- Hunger
- Cold
- Time pressure
- Time of day
- Incentives
- Punishments
- Personal problems

Stresses are additive!

❖ Stress affects decisionmaking by:
- Lowering awareness
- Lowering concentration or ability to focus
- Making it harder to access long-term memory
- Locking us into repetitive, habituated behaviors
- Focusing more on task, working harder, and ignoring environment

❖ There is a crucial need to study factors involved in deciding whether to engage or disengage a fire. This includes initial attack and standard fireline duty. This whole area is vague to firefighters.
- What objective factors are involved?
- What subjective factors are involved?
- What is official agency policy? Rules take pressure off individuals.
- What rewards and punishments affect the decision?
- Where is the boundary between safety and normal, risky, aggressive firefighting? How narrow is the margin of safety?
- After difficult engagement decisions are acted upon, we need to follow up with good feedback and debriefing, then use the incident to improve decision factors.
- Must use a common language so it can be discussed more accurately.

❖ Should agencies enforce the use of LCES at all levels? Needs to be top to bottom, bottom to top. If institutionalized, LCES would be part of every briefing on the fireline, as well as for the IMT, FMO's, and dispatchers.

❖ Can LCES be an absolute, never violated? What are safety zones if a spot fire is in the middle of a 5-square-mile brush field? Do you need a lookout? Or does the procedure that says to discuss fire in relation to LCES become the basis for situational awareness on which to make the decision to engage?

❖ Making decisions without feedback shouts watch out. The tendency is to be overconfident when feedback is weak. No learning without feedback. Should give feedback to others and expect it from them.

❖ Explore types of decisions and when they are made. When are most crucial decisions made? Do we make them in an active or reactive state? If much information is being processed, is the information reliable, timely, and necessary? Are inputs assumed or is a checklist used?

❖ Consider adoption of the Campbell danger rating system or one like it to foster better decisions.

❖ Currently, there is no training to teach you when you're in over your head. Usually, by the time it sinks in, your safety has been compromised. Tendency is to hang on too long because it is admitting defeat if you do not. There needs to be more agency direction here to take pressure off the individual. Need training to recognize cues and early warnings to pull out or to ask for more resources before the situation becomes desperate. FMO's, dispatchers, and others need to monitor fire activity and assume a more active role in these decisions from a position of mutual respect with the IC.

❖ When there is a difference between expectations/beliefs versus action, we change our expectations and beliefs to fit our actions. If we are trying to foster new expectations such as "safety first," then we need to use incentives to reinforce the expectation and use feedback to correct inappropriate actions.

❖ When a group of risk takers is put together, the group will take more risks than any individual would take alone. This and other factors associated with risk taking need to be incorporated into the decision process. Even the way you think about risk affects risk taking. When we talk about saving something we are more conservative in taking risks. When we talk about losing something we will take greater risks.

❖ Information occurring close in time tends to be automatically linked together even when it is unrelated. Be aware of this when making decisions. When unsure of information, request clarification. Also be careful about how you put information together to brief others.

❖ Factors affecting whether to engage or disengage:
- Fire resources committed
- Fire resource timing
- Risk assessment
- Fire behavior—actual and expected
- Urban interface
- Public pressure
- Political pressure
- Value of resource you are protecting
- Recognized options
- Clear management guidelines

Communication

❖ Functions and Problems (Kanki and Palmer 1993)
- Functions
  - -Provides information
  - -Establishes interpersonal relationships
  - -Establishes predictable behavior
  - -Maintains attention to task and monitoring
  - -Is a management tool
- Problems
  - -Lack or misinformation
  - -Interpersonal strain
  - -Non-standard, unpredictable behavior patterns
  - -Loss of vigilance, situational awareness
  - -Lack of or misdirected leadership

❖ Communication on the fireline
- Good within a crew but not between crews
- Better between similar crews (i.e., hotshots)
- Better between people who know and trust each other
- Hard during transitions; need guidelines
- Need more skill training on maximizing information with fewest words
- Need to foster a cultural attitude of respectful interaction to promote trust
- Temporary employees have a hard time communicating upward
- Need nonthreatening method to communicate personal experience level. Try to communicate face-to-face as soon as possible.
- Need for more dialogue when people first meet, even if on radio, as this reduces the number of words needed for effective communication later as the people better understand each other's point of view.

❖ Story telling is an effective method for communicating agency values and lessons learned.

❖ Essential to have a common language (English), common terms, and common expectations (size-up and LCES) to convey more information in less time.

❖ Need for training, especially supervisors, IMT, FMO's, and dispatchers on interacting more effectively and removing mistrust and communication barriers. Need language and training to resolve differences of opinion as opposed to avoidance or going around someone we have difficulty with.

❖ Everyone in the fire community needs to talk and interact more with their counterparts both during the fire season and off season. This will re-establish a feeling of fire community and trust and improve communications when the tempo increases in severe fire seasons.

- ❖ Greater information flow up, down, and across improves everyone's experience and competency. This process takes years to develop. We should start now, stay enthused, and expect change over a longer period of time.

- ❖ Need for open dialogue when problems occur. Discuss and manage problems while they are small and less emotional. If you're thinking it, express it out loud.

- ❖ Firstline supervisors set the tone for communications. Agency must send clear signals to supervisors concerning their responsibility to promote open, two-way, respectful interaction. Supervisors should lead crews to avoid emotional-laden topics until mutual respect and crew cohesion have formed. Supervisors should clearly communicate expected norms of behavior, then use incentives and feedback to ensure compliance. Crews and individuals want cohesion and trust if it's allowed to develop naturally.

- ❖ Need a common tactical language such as the Campbell danger rating system to foster clearer communication of fire behavior, expectations, briefings, and feedback.

Leadership and Cohesion

- ❖ Leadership is a crucial skill for improving firefighter safety. An open, democratic leader promotes crew spirit, cohesion, and maximum crew growth. This occurs through an active teacher/mentor role to foster crew knowledge. A cohesive, knowledgeable, open crew is a safe crew.

- ❖ After a size-up, a good leader shares the information with the crew. Individual crew members are encouraged to do their own size-up, determine the outcome, and ask questions about why their size-up or the leader's size-up was on or off target. The leader should quiz crew members, who in turn should quiz the leader.

- ❖ A good leader provides maximal feedback to the crew to foster crew learning. The leader shares experience, training, and knowledge with the crew.

- ❖ In times of declining budgets and training dollars, a crew leader must take the classroom to the field on the job.

- ❖ On initial attack and transition fires, it is not always clear who is in charge. When authority is delegated, the chain of command should be clear to all firefighters. Official transfers should be face to face and signed in diaries. If a leadership change occurs on the fireline, the change should be relayed to dispatch and recorded.

- ❖ All leaders must have leadership and supervisory training, even if their official jobs do not require that skill. To be a leader on the fireline, you must be trained. Too often untrained leaders regress to being regular firefighters when conditions become stressful.

- ❖ Leadership training for firefighters is poor. Being an office supervisor does not equate to being a leader on the fireline. We need to determine what skills a fireline leader needs, then train people in those skills. Many problems occur on the fireline due to assuming office rank equates to fire rank.

- ❖ There is no good system in place to promote individuals who excel in fireground leadership. More FTE's should be set aside to create a career track for people who exhibit fireline leadership. They are the nucleus of the fire crews, and their experience is essential for safety on the fireline.

- ❖ It is essential for crew leaders to debrief their crews after each incident. Leaders should insist on a debriefing from the IMT or IC and give their own debriefing to the crew. This feedback is essential for learning to occur. Leaders should give orders, then explain them as much as possible.

- ❖ Crew supervisory job descriptions should be revised to reflect the need for people who are open and honest, and who can act as teachers and mentors as well as being skilled in leadership and knowledgeable about fire behavior.

- ❖ All incident leaders need to foster more intermixing between people and crews to create an open atmosphere for sharing experiences and knowledge. This should be expected behavior among all firefighters.

- ❖ Identify skills needed for effective fireground leadership, including:
  - Command and control practice
  - Time and space relationships
  - Quick, bullet-type communication
  - Stress awareness
  - Experience
  - Situational awareness and assessment
  - Criteria on when to engage or disengage
  - "Hot-seat" decisionmaking under stress for quicker decisions—RPD type decisions
  - Task assignment
  - Mission awareness

- ❖ Leadership training courses should be mandatory for all IC's and division superintendents. Courses should be Marana style (upper level) with simulations under stress.

- There is definite skill erosion during light fire years. Leaders should be heavily involved in prescribed fire to hone skills.

- When leadership changes on the fireground it should be formal:
  - Face to face
  - Declared to dispatch and entered in the dispatch log
  - Both IC's should sign diary with time and date of exchange
  - Consider other positions for sign off (in addition to IC's)

- Leadership, crew cohesion, and safety are strongly correlated. Open leadership style fosters better cohesion and safety.

- Good crew supervisors do not focus on safety but rather on good supervision, crew cohesion, and work ethics. Safety is the result. Supervisors who constantly talk about safety have more accidents than those who focus on working relationships.

- A lot is known about crew leadership, cohesion, and trust, which takes 6 to 8 weeks to develop. It may develop quicker for fire crews. Is there a way to study this and accelerate the effect?

- When people off districts, forests, etc., are brought together to form a crew, they are much more effective and safer if they spend a day together getting to know each other before going on the fireline. This technique should be further investigated as a method to speed up group cohesion.

- There used to be a better sense of fire community among firefighters and managers. Has this sense been lost or has the fire family become dysfunctional?

- Leaders need to work with crew members and promote respectful interactions; encourage their input so they feel part of the crew. Once leaders get input, crew members should expect leaders to make decisions and lead them to accomplish goals.

Adaptability/Flexibility

- Adaptability skills need to be addressed. How flexible are wildland firefighters to quickly change tactics as environmental conditions change? Do our crews stay too long at the task at hand when a new approach is called for?

- Need flexibility to keep reassessing the situation on a routine basis.

Assertiveness

- Assertiveness is natural for some firefighters. But for others, it is a skill that must be learned, then practiced.

- Leaders of teams and crews are pivotal in creating a climate that encourages all firefighters to speak up.

- Firefighters have a tendency to internalize what's bothering them rather than speak up about it. We need to emphasize more external dialogue.

- We also need more assertiveness between leaders to communicate their size-ups to others and to discuss their experience level with others. We need this exchange so both leaders perceive the same external environment as a basis for future decisions and know what to expect from the other person based on their past experience.

- Assertiveness is also necessary to request fire and weather information, briefings, debriefings, etc., when they are not given. This includes asking questions or requesting that someone repeat information you did not understand.

Assessment and Feedback

- The current system for reporting entrapments is working, but not very effectively. Some entrapments are reported only after long delays, and some aren't reported formally until someone follows up on rumors and pressures a person or crew to fill out the forms. This system should be re-examined and made more effective. Firefighters should not have the option to fail to report entrapments without penalty. They should not be penalized when they do report entrapments in a timely manner.

- A new system must be implemented to record and track near-miss situations for all wildland fire operations. It should include all accidents and incidents, even minor ones. This baseline information is necessary to determine where we currently have problems and if management or training changes decrease near-misses, accidents, and incidents. This system should be modeled after the airline industry where there is no penalty for calling in an accident or near miss when reported at the earliest opportunity. An open, nonthreatening system will promote more frequent and more accurate reporting, therefore greater safety.

- It would be useful to have trained individuals or teams go out on the fireline each fire season to observe crews and individuals in action. The information gathered would show whether training or management objectives have transferred to the fireline. IMT and crew members could be quizzed or interviewed to determine skills and knowledge.

- The agencies should require that leaders reassess their situation every 15 to 60 minutes, depending upon fire danger. Taking time out to reassess allows you to determine if new actions are required. There should be a formal checklist like LCES.

- Every person in the fire community and on the fireground needs to increase communication and feedback up and down the chain of command to maximize learning. Everyone needs to become more expert at both giving and receiving feedback.

- Attitudes don't always predict behavior. So it is important to determine what behavior is encouraged or discouraged in the actual work environment. What are the real consequences for following various orders. Stories, games, and videos are three methods of communicating expectations and consequences.

- Once entrapments and close-call data are analyzed, the facts must get to individual firefighters for learning to take place. This feedback heightens situational awareness and the ability to recall the information if needed. The individual and crew names can be removed as long as the key facts are well communicated.

- Firefighters need quality briefings when they first arrive on a fire. If they start out behind, they will remember and process less information in critical situations.

- Individuals must practice behavior before it happens automatically.

- Consider a 1-800 hotline to collect safety data. It should be a nongovernmental agency to ensure higher reporting rate and anonymity.

- Try to teach in the field as much as possible. It promotes better learning and recall because that's where it will be needed in a critical situation. Prescribed burns are a great classroom setting.

- An agency protocol is needed for briefing each other on our current firefighting qualifications. The red card ratings are deceptive and there needs to be more face-to-face discussion of qualifications to size up individuals or crews you will be working with. That is part of the overall situational awareness. What is agency protocol if you feel the other person isn't qualified?

- There is a need to explore alternative training and feedback methods:
  - Interactive investigative books
  - CD games
  - Hot-seat simulations

- MTDC should publish a quarterly human factors newsletter similar to ***Health Hazards of Smoke*****.** Target all fire safety personnel and firefighting crews in addition to normal region/ forest/district distribution.

- Are extended initial attack, transitions, urban interface, helicopter downwash, etc., really our most risky, hazardous situations or is this rumor? What are the trends and how significant are they? What are the situations that cause the most firefighter injuries?

- Start using computers to move people to and from fires and while on fires to eliminate all the waiting time. Figure out ways to use down time for training.

- Small individual AM receiving radios are a dollar or two. If each firefighter wore one, it would be a means for broadcasting weather, fire behavior, news, and other general information.

- Situation checks should be required within a crew and among crews as a double check that everyone agrees with the situational analysis. The check could follow LCES. Respectfully discuss differences. When a situation gets critical, ask the recipient to repeat the analysis back to you.

- Fire safety officers should do spot checks on safety equipment and practices. They can determine what training has been given and if firefighters know the basics. They can ask firefighters to give them a situation size-up based on LCES and hazards in the immediate area.

- Need better, consistent post-fire debriefings for individuals, crews, and IMT's. The process should encourage feedback both up and down the chain of command.

- Need a long-range look at what we are about and what we do. Need longitudinal field studies to accomplish this task. This would make it clear whether management objectives get incorporated into behaviors in the field.

- Greatest safety factor on the fireline is clear thinking. Look for clues, analyze the input, and predict. If you can't predict, then stand back and watch what's happening until you can predict. Then take action based on clear thinking.

Discussion

High Reliability Organizations and Crew Resource Management models were used to organize workshop discussion topics. This appeared to be a successful strategy because most workshop topics fit the characteristics cited for HRO's and CRM. This in turn suggests these areas are worthy models to pursue as we look at ways to better organize wildland fire agencies and fire crews.

Joseph B. Sylvia's marker cross on a steep Mann Gulch slope where 13 firefighters lost their lives on August 5, 1949.

Recommendations

❖ Contract to have organizational experts evaluate Fire and Aviation Management (F&AM) and propose ways to reorganize it into a high reliability organization able to function at a high tempo during fire season. Evaluate F&AM using the seven factors presented earlier for effective HRO's. Consider workshop input for organizational change when evaluating F&AM.

❖ Contract to have CRM course materials adapted to wildland fire crews and teams. Determine if other skills are necessary that are unique to the fireground environment. Consider workshop input when modifying CRM for firefighters. Change name to Fire Crew Dynamics and Fire Team Dynamics if course material would be different for firefighting crews and IMT's.

❖ Study current loss of experienced firefighters, crew supervisors, FMO's etc., to determine how to reverse these trends. Consider more FTE's, higher pay, and other incentives. What is the effect of combining positions and collateral duties on the organization?

❖ Offer more incentives for seasonal firefighters to return and be better trained. Consider:
- Bring them on earlier for extra training
- Increasing bonus system for those returning for a third, fourth year, etc.
- Pay for training costs incurred by firefighters in the off season when it is relevant, and they are returning another year, or give bonus in lieu of all costs.

❖ Contract to examine all the fire orders, situations, etc., to determine if they can be simplified and prioritized. Are any of them absolutes? Can what's left be followed and still put out fires? Add management, crew, and internal watch-outs as needed.

Workshop participants eat lunch on top of the ridge where Bob Sallee and Walt Rumsey escaped the Mann Gulch Fire.

❖ Red Card Qualification System does not work effectively. Contract to determine what the system is supposed to do and how to make it work.

❖ Study and formalize guidelines for engaging and disengaging from fire assignments. Study real crews and use content analysis and interview techniques such as Cognitive Task Analysis.

❖ Initially develop decisionmaking examples suitable for wildland firefighters. Use firefighting examples to demonstrate how stress and other environmental and psychological factors affect decisions. To be effective, decisionmaking must be incorporated in all other training programs rather than, offered as a stand-alone course.

❖ Develop a situational awareness class and determine critical cues and how to accelerate training of inexperienced firefighters. Study the RPD model of rapid awareness and decisionmaking by studying firefighters in their natural environment.

❖ Adopt common protocol and language for all firefighting communications. Consider Campbell danger rating system for communicating vital fire information quickly and accurately.

❖ Develop leadership course(s) for all IC's and crew supervisors. Determine type of leadership needed on fireline and train people accordingly.

❖ Develop a family of "hot-seat" style fire simulators to train and evaluate CRM skills while in a high-tempo situation. A good developmental project could use the same inputs that allow computer modeling of an actual fire when relevant data is input. It can be used for training when inputs are chosen and firefighters must make a response.

- ❖ Conduct longitudinal study on fire crews to identify relevant behaviors that increase cohesion, safety, and productivity. Study whether management attitudes become crew attitudes. What factors and activities speed up the learning process? Are there sexual, racial, or age factors involved?

- ❖ Require all prescribed burn plans to adopt a "classroom" element so the burn is fully utilized as a training exercise.

- ❖ Publish a human factors in wildland firefighting newsletter similar to ***Health Hazards of Smoke*.**

- ❖ Hire professional instruction system designer to determine best format for implementing training, i.e., video, printed materials, computer simulation, etc., to maximize training transfer. Need to consider more hands-on, interactive training. Need more field-based training, which improves memory transfer and learning, and is less boring than classroom-based training.

- ❖ Organize more national, regional, and local rendezvous where there is more mixing of type I, type II, engine, and helitack crews, FMO's, IMT's, and dispatchers so they can share knowledge and discuss problems.

- ❖ Implement all assessment and feedback proposals from the workshop. Without strong institutionalized baseline measurements and incident reporting, there is little chance to learn.

- ❖ Develop methods to speed up crew cohesion and work practices before fireline assignments.

- ❖ The bulk of training occurs through OJT, but little preparation and care are given to make OJT work efficiently. Contract to study the best way to boost skills in a relatively short time with little cost through improved OJT.

- ❖ Contract to have professionals provide guidance in setting up procedures for collecting and disseminating lessons learned from fireline duties and entrapment that will be interesting and used by firefighters and managers.

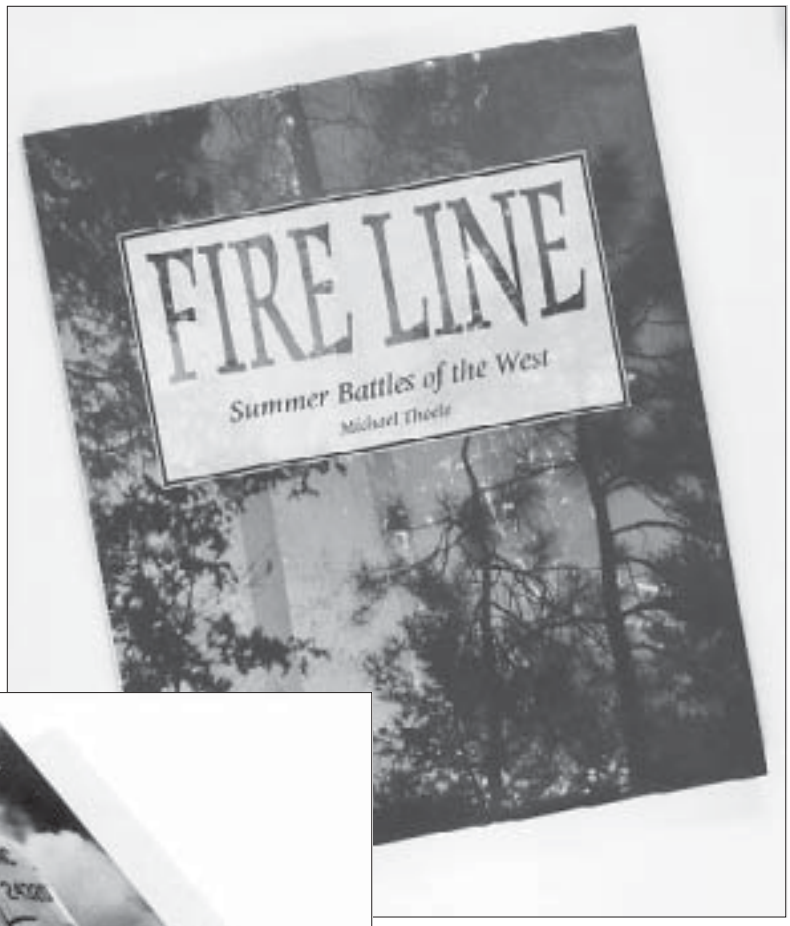
The above recommendations are not in any order of priority. The participants did not discuss priorities. In addition, even more recommendations could be pulled from the workshop notes. We felt that priority setting should have greater consensus than our group. In the mid-1980's, a number of conflicting equipment needs surfaced. To set priorities, more than 2,300 questionnaires were sent out to Forest Service and Interior Department offices and State agencies. Something similar is recommended here. We would like to encourage readers of these notes to suggest other recommendations, and we in turn will ask that NWCG consider surveying and prioritizing projects through input from the entire wildland fire community.

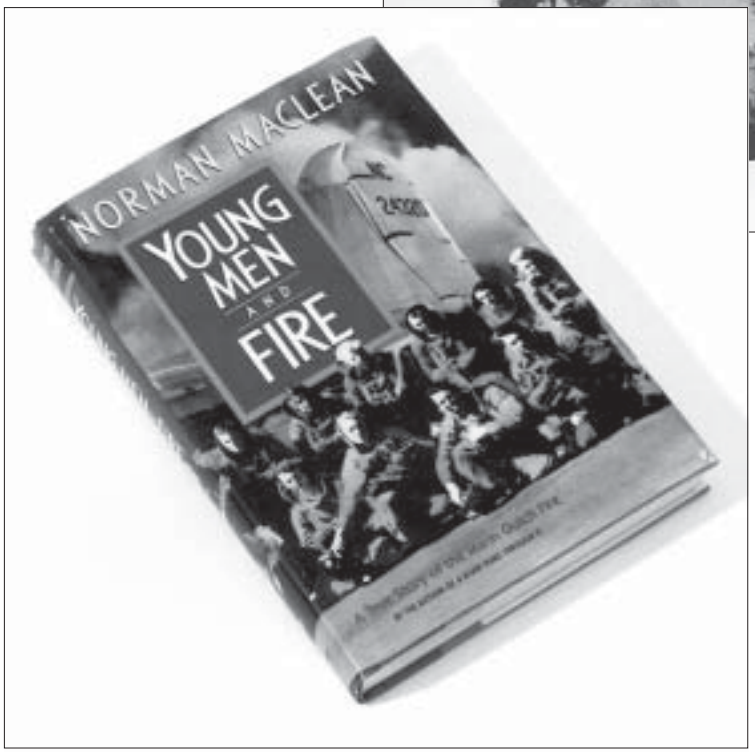
A Final Note

The workshop findings and recommendations are not meant to be an end product but rather the beginning of a continuing assessment. It would be a mistake to think that a one-time effort to develop new training or a new organizational structure is enough.

We hope to set in motion a process that will lead to a fire organization that reinvents itself as a high reliability organization where:

- ❖ The capacity to learn and adapt are valued and encouraged for the organization and the individual.
- ❖ The people are committed to the principles of CRM on the fireground.
- ❖ Safety and firefighters are number one.





Suggested reading, see page 23.

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Appendix A—Overview

Decision Workshop

Improving Wildland Firefighter Performance Under Stressful, Risky Conditions: Toward Better Decisions on the Fireline and More Resilient Organizations

June 12–16, 1995
Village Red Lion Inn
100 Madison Street
Missoula, Montana

Overview—

It has become increasingly clear since 1990 that wildland firefighters are experiencing collapses in decisionmaking and organizational structure. Wildland fire agencies have lost 23 people since 1990 who might have survived had they simply dropped their tools and equipment for greater speed escaping fires. More than 30 people are entrapped each year. Our crews are not as proficient at escape, fire shelter deployment, and decisionmaking under stressful, risky conditions as they could or should be. Partly, this reflects attitudes, and partly it is a lack of knowledge.

This workshop will explore firefighter psychology, interactions among firefighters and among fire crews, and better ways to organize. To do this, we have brought together experts in psychology, sociology, organizations, fire safety, and wildland firefighting. We will be looking at the current situation on the fireline and ways to make the often-dangerous job of wildland firefighting safer. Finally, we will develop a series of recommendations for implementing the changes needed to improve firefighter safety.

The session begins with four presentations that outline the psychological and organizational aspects of wildland firefighting. These talks will set the tone for the session as we focus on the individual firefighter, fire crews, and organizational structures on the fireline. We hope the unique mix of professionals will create a synergism that leads to meaningful change and a safer firefighting environment.

Ted Putnam
Workshop Organizer

Dave Thomas
Workshop Moderator

Jerry Meyer
Workshop Facilitator

Appendix B—Agenda

MONDAY, JUNE 12
0800–1200

Keynote Presentations
(open to the public)

0800–0900
Behavioral Bases of Accidents and Incidents: Identifying the Common Element in Accidents and Incidents
Curt Braun, Ph.D., University of Idaho

Human behavior plays the largest role in firefighter safety. Faced with the known and essentially constant risks of a wildland fire, human behavior is the only factor that can greatly increase or decrease the risk of injury. Despite its large role in safety, however, behavior is frequently overlooked during accident investigations. Endeavoring to discover the cause of a workplace injury or fatality, investigators often focus on the special environmental circumstances and not on the behaviors that preceded that accident. This overemphasis on circumstances fails to consider the fact that the vast majority of accidents result not from the environment but from known risky behavior that is part of common work practices.

To address safety challenges, specific consideration must be given to the element common to all accidents: human behavior. A behaviorally based safety program can reduce the risks associated with wildland fire suppression by: (1) identifying antecedent behaviors that lead to accidents; (2) determining the frequency of these behaviors; (3) evaluating the training programs and management systems that either directly or indirectly support the behaviors; and (4) developing a training and management remediation program aimed at changing behavior.

0900–1000
Recognition Primed Decision Strategies
Gary Klein, Ph.D., Klein Associates

Studies of firefighters show that they rely primarily on Recognition-Primed Decision (RPD) strategies as opposed to sifting through alternatives and comparing how they rate on different evaluation dimensions. The RPD model explains how people can make decisions under conditions of time pressure and ambiguity and shifting conditions. Specifically, the model explains how experienced decisionmakers can generate a reasonable course of action without having to contrast alternatives, and how they can evaluate a course of action without comparing it to alternatives.

We can also use the RPD model to understand some of the errors that can arise in naturalistic settings. These primarily stem from inadequate experience bases. In turn, these error types suggest some strategies for decision-centered training.

1000–1100
The "Cultural Inertia" Impacts of Team Decisionmaking
David Hart, TIG, Inc.

Cultural attitudes permeate the decisionmaking of teams working within the organization. "Anytime, Anywhere," "Can Do," and "Make It Happen" are examples of adopted cultural attitudes that have both assisted and (in some cases) inhibited crew effectiveness. This discussion investigates the impacts of cultural-based attitudes as barriers to individual and crew decisionmaking processes. It includes discussion of lessons learned from other high-risk/high-threat environments in establishing a non-attribution/non-retribution environment, and overturning cultural attitude barriers within the individual and the organization as a whole.

1100–1200
South Canyon Revisited: Lessons from High Reliability Organizations
Karl Weick, Ph.D., University of Michigan

There is an emerging body of work that has begun to describe how organizations that face the possibility of catastrophic error every day, cope with this prospect. These organizations, referred to as high reliability organizations, include nuclear power plants, air traffic control systems, aircraft carriers, flight crews, and chemical plants. Several issues that are discussed in studies of these organizations are similar to issues that have surfaced in discussions of the South Canyon Fire incident on July 6, 1994. The purpose of this presentation will be to discuss some of these similarities with special attention being focused on issues of communication, group structure, stress, mindsets, leadership, and sense making.

1200–1300: Lunch
Closed Workshop Session Begins
(limited to invited participants)

1300–1700: Focus will be on the dynamics of individual decisionmaking and individual firefighter experience

1830–: No-host bar and dinner (if there is sufficient interest)

TUESDAY, JUNE 13
0800–1200: Focus on interaction between crew members

1200–1300: Lunch

1300–1700: Focus will be on interactions between crews and organizational structure

WEDNESDAY, JUNE 14
Trip To Mann Gulch

0545: Assemble at Village Red Lion Inn and board bus

0600: Depart Missoula

0600–0800: Workshop discussions enroute

0830–1800: Mann Gulch guided tour

On August 5, 1949, a wildfire overran 16 firefighters at Mann Gulch. There were only three survivors. Significant controversy has surrounded this fire, including firefighter decisions and actions as well as the ensuing entrapment investigation. On July 6, 1994, a wildfire overran 49 firefighters at South Canyon. There were 35 survivors and 14 fatalities. Many investigators believe the two events are connected and ask how much have we learned in the intervening 45 years. A trip to Mann Gulch has been planned to explore that connection and foster further workshop dialogue in a "real life" setting.

Mann Gulch is about 150 miles east of Missoula and 25 miles north of Helena, Montana. A bus will leave the Village Red Lion Inn parking lot promptly at 0600. It is about a 2-1/2 hour drive to the Gates of the Mountain Marina and about a 30-minute boat ride down the Missouri River to Mann Gulch. We are paying for the bus, but each participant will need to pay about $10 for the boat ride (round-trip). We will return to the marina around 1730-1800 and will be back in Missoula by about 2000. Each participant should bring a sack lunch and a canteen of water as well as snacks for the return trip. In addition, bring clothing appropriate for the weather, as well as other items desired such as cameras, daypacks, and so forth.

We plan to have two guides knowledgeable about Mann Gulch available to retrace the events. An EMT with a first aid kit and radio will also accompany us.

The walk up Mann Gulch is about 1-1/2 miles over grassy, rocky ground. Sturdy work or hiking boots (well broken in) are strongly recommended. The slope is steep, but people of varied fitness levels have tackled it successfully walking at their own pace. Snakes and footing are the only other hazards, though snakes are rare. The trip will be canceled if rain or strong winds are forecast. More information will be provided at the workshop.

1800–2000: Return trip to Missoula

THURSDAY, JUNE 15
0800–1200: Focus on future research, investigations, and training

1200–1300: Lunch

1300–1700: Workshop recommendations

FRIDAY, JUNE 16
0800–1700: Workshop volunteers finish write-ups on findings and recommendations

Suggested Reading:

Young Men and Fire. Norman Maclean. 1992. University of Chicago Press. Chicago, IL.

Fireline: Summer Battles of the West. Michael Thoele. 1995. Fulcrum Publishing, Golden, CO.

Mann Gulch Fire: A Race That Couldn't be Won. Richard Rothermel. 1993. INT-GTR -299. U.S. Department of Agriculture, Forest Service, Intermountain Research Station, Ogden, UT.

*****Mann Gulch Fire: A Race That Couldn't Be Won. Richard C. Rothermel.

*****Available on the worldwide web at: http://www.xmission.com/~int/pubs.html

For a printed copy, contact:

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Appendix C—Participants

Participants

***Dave Aldrich*—**branch chief for ground operations safety, Forest Service Washington Office, Fire and Aviation Management. Dave began his Forest Service career as a seasonal employee in 1958 on the Powell District in R-1. He has worked in R-1 and R-3 in fire management jobs as well as the National Office and at the Intermountain Fire Sciences Laboratory in Missoula. He has been a fire behavior analyst on national fire teams and has been involved with several national fire training courses. Dave chairs the NWCG Safety and Health Working Team. He has a BS in forestry from the University of Montana.

***Bill Bradshaw*—**works for the Forest Service Washington Office in fiscal and accounting, specializing in incident administration and claims. Bill has been active with decision analysis projects in the past and is currently involved with efforts to enhance wildland firefighter safety through improved attitudes, leadership, and responsibility.

Curt Braun, Ph.D.*—**is an assistant professor of psychology at the University of Idaho. As an ex-firefighter for the Sawtooth National Forest, he evaluates fire suppression from the firefighter's perspective. He recently coauthored ***Human Decisionmaking in the Fire Environment, which will appear in an upcoming special issue of Fire Management Notes. He holds a Ph.D. in human factors psychology with an emphasis on human performance from the University of Central Florida.

***Jim Douglas*—**is Director of the Office of Hazard and Fire Programs Coordination for the U.S. Department of the Interior. Before coming to that post, he served as the Interior Department's fire program coordinator. His career with Interior began in 1979 in the Office of Policy Analysis. He was also in the Department's Office of Budget for 7 years. He was on the Interagency Management Review Team following the South Canyon Fire and serves on the Federal Wildland Fire Policy and Program Review. He has an undergraduate degree in political science from Grinnell College and a master's degree in public policy from the University of Michigan.

Jon Driessen, Ph.D.*—**is a professor of sociology at the University of Montana. He also holds a faculty affiliate appointment at the Missoula Technology and Development Center. He specializes in the sociology of work and for the past 12 years has studied the culture of work in Forest Service field crews. His latest project for the Forest Service is a 48-minute video, ***Making a Crew. Jon has a doctorate in sociology from the University of Colorado.

***Kelly Esterbrook*—**is currently a smokejumper squadleader with the Forest Service, in Redmond, OR. Kelly started her Forest Service career on the Rogue River National Forest in 1978. She spent 2 years on Rogue River engine crews and 2 years as a Rogue River Hotshot crewmember. She then spent four seasons on the Deschutes National Forest as an engine foreman and one season with the Redmond Hotshots. She began jumping in 1986. She was detailed to the Union Hotshots in 1992 as superintendent. In 1994 she completed Technical Fire Management Training.

***Paul Gleason*—**is currently fire ecologist for the Roosevelt and Arapaho National Forests in Northern Colorado. His emphasis is the restoration and use of fire as a natural process to achieve land management goals in the central Rocky Mountain ecosystems. From 1991 to 1994, he was fire management officer for the Estes-Poudre and Redfeather Ranger Districts in Northern Colorado. Prior to that time Paul spent 23 fire seasons with the Interagency Hotshot Crew programs on the Angeles, Mt. Hood, Okanogan, Pike and San Isabel National Forests. Because of his extensive wildland fire suppression experience throughout the U.S., Paul has been active in fire suppression/fire behavior course development and presentation. He has an undergraduate degree in mathematics from Colorado State University and is pursuing graduate studies in fire ecology and effects at Colorado State University.

***Dave O. Hart*—**has extensive experience as in instructor and facilitator in the delivery of crew resource management training. He is a former Air Force B-52 instructor navigator, and instructor at the Air Force's Undergraduate Navigator Training. He served as lead facilitator for Hernandez Engineering, the crew resource management contractor for the Air Force Air Mobility and Air Combat Commands. He is an Air Force Reserve C-130 navigator for the 731st Airlift Squadron, which provides wildland firefighting support through the MAFFS (Modular Airborne Fire Fighting System) program. Dave cofounded TIG Inc., where he works as a training consultant and facilitator. He is currently responsible for assessment, design, development, and delivery tasks associated with the new Army National Guard Special Forces Decision Training Program. He received his bachelor's degree in aircraft maintenance engineering from Parks College and is pursuing a master's degree in aerospace studies from Embry-Riddle Aeronautical University.

***Jerry Jeffries*—**has spent his entire Forest Service career in fire and safety. He recently was named safety project leader at the Missoula Technology and Development Center. From 1990 to 1995 he served as safety and health manager for aviation and fire management in R-1. Before that time, he was for many years safety manager on the Bitterroot National Forest. He has held a variety of fire positions during his career, including interregional hotshot crew supervisor, division supervisor, line boss, air attack boss, and air support group supervisor. In 1992 he received the

Government Employees Insurance Co. (GEICO) public service award for fire prevention and safety from a group of over 200 nominees worldwide.

Jim Kautz—is a videographer/photographer at the Missoula Technology and Development Center. He began his firefighting career at Darby Ranger District and was a smokejumper for 3 years in R-1. For the past few years one of Jim's primary responsibilities has been to provide photo documentation as part of wildland fire entrapment investigations. Jim holds a degree in film and television from Montana State University.

Gary A. Klein, Ph.D.—is chairman and chief scientist of Klein Associates. He has performed research on naturalistic decisionmaking in a wide variety of task domains and settings, and has developed significant new models of proficient decisionmaking. His research interests include the study of individual and team decisionmaking under conditions of stress, time pressure, and uncertainty. He has furthered the development and application of a decision-centered approach to system design and training programs. He has also studied applications of case-based reasoning for domains such as the cost/benefit evaluation of training devices and developing marketing projections for new products. He holds a doctorate in experimental psychology from the University of Pittsburgh.

Buck Latapie—is currently the fire training and safety officer for R-6. He has served continuously on incident management teams since 1983 in plans, operations, and as an incident commander. Early in his Forest Service career he served as a hotshot foreman and engine foreman. In 1978 he was hotshot superintendent on the Bitterroot National Forest. He later worked as a silviculturist on the Fremont National Forest, district fire management officer on the Deschutes National Forest, and as a forest aviation and fire management officer on the Ochoco National Forest. He holds a bachelor's degree in forestry/fire management from the University of Montana.

Mark Linane—is the Los Padres Hotshot superintendent on the Los Padres National Forest in Region 5. The crew is located at the Santa Barbara Ranger District office compound 10 miles north of Santa Barbara, CA. Mark has 30 years of wildland fire experience, the last 23 as superintendent of the Los Padres Hotshots. He is considered a leading spokesperson for the hotshot community. He has been involved with safety and training issues for years, most recently working on the revision of the Strike Team/Task Force Leader training course.

Lark S. McDonald—has performed assessment, development, and design work in human factors training programs for a wide variety of aviation-based applications, including aeronautical decisionmaking and cockpit management for civilian pilots. He has served as designer and developer for crew resource management programs for the Navy T-45, Air Force T-1, and commercial MD-80 for McDonnell Douglas Corp. He has worked as a development program manager for United Airlines and Martin Marietta, and as the lead instructional designer for Hernandez Engineering, the crew resource management contractor for the Air Force Air Mobility and Air Combat Commands. His recent work has included assessment and adaptation of CRM training for use with Air Force test pilots and their ground-based engineer and logistic counterparts. In a further extension of moving CRM-type training into high-risk, high-stress environments, he recently cofounded TIG Inc. with David Hart, which currently provides decisional training and leadership programs for teams with the National Guard Special Forces. He received his education in aviation management and psychology from Metropolitan State College, Denver, CO.

Robert J. Martin—is the Forest Service national aviation safety and training manager at the National Interagency Fire Center, Boise, ID. Bob's aviation experience covers the fields of maintenance, accident investigation, piloting, and program management. For the past 30 years he has been employed in the military, commercial, and public sectors of aviation. His Forest Service career began in 1977 in R-3. Since that time, he has served at national fire center and R-6, Portland, OR. During 1987-1988, he worked with U.S. Customs air interdiction program and returned to the Forest Service in 1989. Bob received his BA in aviation management from Boise State University and his MA in aviation management from Embry-Riddle Aeronautical University.

Jerry Meyer—has worked for the Forest Service since 1971 in a number of capacities, primarily in timber management. He has also worked as a firefighter, wilderness guard, writer/editor, and historian. His most advanced red-card qualification is division/group supervisor, but he most often takes field observer assignments. Jerry will facilitate the workshop discussions. He holds a BA in history/political science from the University of Montana.

Dave Pierce—is currently the smokejumper project leader at the Missoula Technology and Development Center, a position he has held since 1980. His Forest Service career began in 1964 as a "smokechaser" on Red River Ranger District in Idaho. From 1965 through 1968, he was a smokejumper in R-6 and R-1. Between 1969 and 1971, he worked in private industry as a commercial pilot. In 1971 he returned to firefighting as a smokejumper with the BLM. With 30 years of experience working with both the Forest Service and BLM smokejumping programs, Dave has accumulated some "street smarts" about initial attack firefighters. During his years with the BLM Alaska smokejumping program, he was responsible for organizing smokejumper crews for safety and effective-

ness. At MTDC, he has finished several projects related to safety in smokejumping/aviation operations where the objective was to develop materials designed to change institutional attitudes.

Ted Putnam—is a fire and safety equipment specialist at the Missoula Technology and Development Center. He started working for the Forest Service in 1963 and spent 3 years on district fire crews, 8 years as an R-1 smokejumper, and 3 years as a supervisory smokejumper. In 1976 he came to MTDC. He is responsible for developing firefighter's protective clothing and fire shelters, including training materials. He is a member of two National Fire Protection Association standards-setting committees for protective clothing and equipment. Ted holds a Ph.D. in experimental psychology from the University of Montana.

Jim Saveland—is a fire ecologist for the Forest Fire and Atmospheric Sciences Research Staff, Washington, D.C. He began his Forest Service career in 1978 on a district fire crew in Elk City, ID. Jim spent 4 years as a smokejumper in R-6 and R-1. In 1984 he became fire management officer on the Moose Creek Ranger District. In the incident command system, Jim was a division/group supervisor and a fire behavior analyst. In 1988 he transferred to the Southern Fire Lab in Macon, GA. Jim became project leader in 1991. In 1994, he moved to his present position in the Washington Office. He has taught several classes on various aspects of fire and risk management at the University of Idaho and at the district, forest, regional, and national levels of the Forest Service. He is the unit leader for the Risk Management and Decision Analysis unit of the National Interagency Prescribed Fire Behavior Analyst course taught at the National Advanced Resource Technology Center in Marana, AZ. The Interagency Management Review Team for the South Canyon Fire asked Jim to lead a team to develop a report on the collection, distribution, and utility of live fuel moisture information. Jim has a BS in mathematics from Auburn University, and an MS in forest resources and a Ph.D. in forestry, wildlife, and range sciences from the University of Idaho. His Ph.D. work concentrated on the application of artificial intelligence, decision science, and cognitive psychology to fire management.

Lyle Shook—is currently safety and health manager for R-5. He has 21 years of experience in Forest Service wildland fire operations in Regions 3, 5, and 6. His experience ranges from hotshot and helitack crews to acting Regional fire coordinator. In the incident management system he is a type I operations chief, plans chief, and safety officer. He has been a type II incident commander for 3 years. He has been in his current position since 1988.

David A. Thomas—is fire management officer on the Superior Ranger District, Lolo National Forest. He started his Forest Service career as an emergency firefighter in 1967. He has been a member of fire crews on the Kootenai and Clearwater National Forests. Later, he was helicopter foreman of an 18-person crew. Dave has been a member of numerous type I and type II incident management teams. He was a fire behavior analyst on the 1988 fires in Yellowstone National Park. As a prescribed fire manager, Dave has developed and implemented many prescribed burns ignited for various silvicultural and fuels management objectives. Dave holds a BA in geography from the University of Montana.

Karl E. Weick, Ph.D.—is the Rensis Likert Collegiate Professor of Organizational Behavior and Psychology at the University of Michigan. He is also the former editor of Administrative Science Quarterly, the leading research journal in the field of organizational studies. He studies such topics as how people make sense of confusing events, the social psychology of improvisation, high reliability systems, the effects of stress on thinking and imagination, indeterminacy in social systems, social commitment, small wins as the embodiment of wisdom, and linkages between theory and practice. His writing about these topics is collected in four books, one of which—***The Social Psychology of Organizing***—is cited as furnishing

significant background for Peter's and Waterman's In Search of Excellence. Karl has consulted with a variety of organizations, including Corning Glass, Narco, Cole Products, Dalton Foundries, Southland Corp., Motorola, Texas Instruments, Lockheed, the National Science Foundation, the National Institute of Education, and the National Institute of Mental Health. He has a Ph.D. in psychology from Ohio State University.

Pat Wilson—is manager of the Grangeville smokejumper base, a position he has held since 1987. He started his firefighting career in 1974 on an engine crew with the Idaho Department of Lands. He became engine crew foreman in 1976. In 1978 he was an assistant foreman of the now-defunct Coeur d'Alene Hotshots. The next season he joined the St. Joe Hotshots as a lead sawyer. He began smokejumping in 1980 in Missoula, transferring to Grangeville in 1981. He became a squad leader in 1983. He served for 2 years on the forest safety committee and currently is a member of the National Aerial Delivered Firefighter Study, and a group that is rewriting the ***Smokejumper and Paracargo Handbook.***

Patrick Withen—a smokejumper based in McCall, ID, he is assistant professor of sociology at Centenary College, Shreveport, LA. His fire experience includes 14 seasons as a smokejumper, 1 season on a hotshot crew, and 2 seasons on a helitack crew. As a forest sociologist he spent 1 year conducting baseline social data collection and social impact analysis for landscape analyses and environmental impact statements. He has been a college instructor for 5 years. Patrick has a Ph.D. in sociology and an MBA from Boston College. He also holds a BS in psychology from the University of Oregon.

Steve Wolf—is a research associate at Klein Associates. He has played a key technical role on projects concerned with expert knowledge and decision support. He was the project leader on a recently completed effort sponsored by the Navy to develop a decision support system for crew members in a combat information center. He heads a related effort to examine potential training applications. His current projects include a review of National Fire Academy curriculum designed to enhance rapid decisionmaking on the fireground. He has been a member of a technical team studying helicopter pilot safety, allocation methods used by fire direction officers, and review of human-computer interface designs for a surveillance platform developed jointly by the Army and Air Force. He holds a BS in psychology from Wright State University, Dayton, OH.

Special thanks to these people for their assistance during the workshop:

Laurel Chambers, workshop notetaker, Superior Ranger District, Lolo National Forest, Superior, MT

Tim Crawford, Gates of the Mountains Marina, by Helena, MT

Mary Jo Lommen, Mann Gulch EMT, Superior Ranger District, Lolo National Forest, Superior, MT

Dave Turner, Mann Gulch interpreter, Helena Ranger District, Helena National Forest, Helena, MT

The following people were invited to the workshop but were unable to attend:

Paul Broyles, training and safety specialist, National Park Service, NIFC, Boise, ID
Jim Cook, superintendent, Arrowhead Hotshots and training specialist, National Park Service, NIFC, Boise, ID
Mary Jo Lavin, director, Fire and Aviation Management, USDA Forest Service, Washington, D.C.
Holly Maloney, squadleader, Lolo Hotshots, Lolo National Forest, Missoula, MT
Stan Palmer, safety and health group leader, Bureau of Land Management, NIFC, Boise, ID
Gina Papke, superintendent, Zig Zag Hotshots, Mount Hood National Forest, Zig Zag, OR
Bill Russell, acting director, Aviation and Fire Management, Region 3, Albuquerque, NM
Jerry Williams, director, fire operations, Fire and Aviation Management, USDA Forest Service, Washington, D.C.

Appendix D—Keynote Presentations

Addressing the Common Behavioral Element in Accidents and Incidents

Curt C. Braun, Department of Psychology, University of Idaho

Virtually every college student has faced the philosophical question, "If a tree falls in the woods and no one is there to hear it, does it make a sound?" The answer of course is no; the falling tree does not make a sound. While many people struggle with this answer, it is important to remember that the answer relies, not on the physics associated with a falling tree, but rather on the definition of sound. Sound is a subjective sensation created when the ear is stimulated by changes in the surrounding air pressure. Given this definition, a tree falling in the woods makes no sound when an ear is not present. A comparable safety question might be, "If there is a snag in the woods and there is no one there, does it pose a risk?" Again, the answer would be no. As with the sound example, the answer centers not on the physics of a falling tree, but rather on the definition of risk, a chance of loss or injury to a human. In the absence of a human, a falling snag creates no threat of injury or loss. Although this relationship appears obvious, it is important to realize that there are two components to this question: the snag, and the presence or absence of the human. Both play a role in creating a risky situation.

If an individual is injured by a falling snag, clearly both had to be present. This situation can easily be represented by the following model:

Environmental Hazard (Snag) + Human = Accident

The role of the snag and the individual in this situation are significantly different. The fact that the snag will eventually fall is well known and in contrast to the actions of the human, represents a relative constant. We know that the snag will eventually fall, but not when. If the environmental hazard remains essentially constant, only one component is left to vary: the actions of the human.

The level of risk created by the snag can be mitigated or exacerbated by the behavior of the individual. Injury and loss are more likely when the individual fails to attend to the known risks. When the individual is struck by the falling snag, the proximate cause is apparent, inattentiveness. It is not apparent, however, that this was an isolated case of inattentiveness. This inattentiveness might represent a general pattern of behavior that places the individual at risk in a variety of situations. To adequately respond to the accident, consideration must be given to both the proximate cause and the behavioral pattern. Unfortunately, traditional safety programs have placed far more emphasis on the former than on the latter.

Human Behavior and Accidents

Few will argue that most accidents and mishaps are directly related to unsafe behaviors. A review of the national air traffic control system revealed that 90% of the committed errors could be directly linked to human inattentiveness, poor judgment, or poor communications (Danaher, 1980). Mansdorf (1993) lists nine different causes of accidents and attributes all of them to human error in the form of inadequate training, supervision, and management. Given this consensus, the solution is simple; change the behavior where the accidents occur. Despite the intuitive appeal of this approach, efforts to increase safety in this manner often fail to produce the anticipated reductions in accidents. These failures occur because traditional safety programs generally focus on the unique circumstances and risks that, like the snag, remain relatively constant. Moreover, these programs often do not consider the broad spectrum of situations where the same behavior can also result in an accident.

Krause and Russell (1994) suggest that accidents result, not from unique circumstances or behaviors, but from the intentional display of risky behaviors that occur with such regularity that they have become common practice. These authors contend that an accident represents an unexpected result of an unsafe act that has become part of the working culture. Despite the best efforts to mandate safety, risky behaviors increasingly become acceptable practice each time they are performed without negative consequences. The process is similar to that seen in individuals who interact with hazardous products. Safety researchers have found an inverse relationship between safety behavior and familiarity (Goldhaber & deTurck, 1988). The probability that an individual will comply with safety guidelines decreases as familiarity with the product increases.

Wildland firefighters are not immune to this process. In response to the South Canyon fire of 1994, Rhoades (1994) writes, "And sometimes, even often, the risks we take in doing our jobs include violating the ***10 Standard Fire Fighting Orders*** or ignoring the ***18 Situations that Shout Watch Out***." He further writes, "Nonetheless, very seldom does our inability to comply with the orders cause us to abandon our tasks..." Rhoades' statements reflect the fact that it is possible to violate standard safety practices without the worry of negative consequences. More importantly, however, Rhoades' comments suggest that the violations have occurred with such great regularity that they have become accepted practice in wildfire suppression.

Accident Prevention From a Behavioral Perspective

An effective prevention program begins by understanding that accidents often reflect the unfortunate outcome of

hazardous acts that have become common practices and that these practices frequently span a multitude of different job tasks. To be effective, a safety program must: 1) identify the antecedent behaviors that result in accidents and near-miss incidents; 2) determine how frequently these behaviors occur; 3) evaluate training and management programs; 4) provide consistent and active feedback and reinforcement, and 5) develop remediation plans.

Identifying Antecedent Behaviors. Traditional accident investigations tend to be very myopic, focusing only on the circumstances immediately involved in the accident. The purpose of an investigation is to identify the accident's cause with the aim of creating new procedures, equipment, and standards to eliminate or at least minimize the risk (Mansdorf, 1993). This investigative approach, however, must go beyond the traditional microscopic analysis to identify behaviors that are common in a variety of accidents. To facilitate the identification of these behaviors an investigation team should be composed of individuals from all levels of the work force (Krause & Russell, 1994; Mansdorf, 1993). Moreover, efforts should be taken to reconstruct the accident with the aim of identifying the underlying behavioral patterns that might have precipitated it. Once identified the investigation needs to assess the extent to which these behaviors have been present in other incidents or accidents. Finally, the investigation must assess the degree to which the actions reflect the acceptance of hazardous and risky behavior as common practice.

Assessing the Frequency. To assess the frequency of unsafe acts, a system for reporting accidents, and near-miss accidents must be created. Near-misses play an important role in assessing the frequency of risky acts. From the behavioral perspective, near-misses represent accidents without the consequences (Krause & Russell, 1994). Moreover, given that unsafe behaviors infrequently result in accidents, near-misses can provide better insight into employee safety. Mansdorf (1993) reports that for every serious industrial accident there are approximately 10 minor accidents, 30 property damage accidents, and 600 near-miss accidents.

The overarching motivation driving a reporting system should be the acquisition of reliable and valid data. To facilitate this process, the reporting system must encourage reporting from all levels of the work force. Moreover, individuals should be instructed as to their reporting responsibilities. With regard to the logistics of the system, every reasonable effort should be taken to reduce the cost of complying with reporting requirements. These efforts might include simplifying reporting forms, the use on-site or telephone based interviewers to whom unsafe acts can be reported, the use of anonymous data collection systems, the creation of safety surveys, the use of trained field observers, or the use of automated data collection systems. Such reporting programs might also guarantee immunity from disciplinary actions for individuals who report.

Evaluating Training and Management. There are a variety of questions that must be asked when evaluating training and management. Are instances of the desired behavior demonstrated during training? For example, fire shelter training has traditionally placed more emphasis on getting into the shelter than on other factors such as situational awareness, site evaluation, ground preparation, and contingencies all of which are essential to a successful shelter deployment. Are employees trained in the selection of the appropriate behavior? Invariably more than one option is available for each situation. In a situation where a burnover is inevitable, a firefighter can deploy a fire shelter or attempt to escape. Factors that influence this decisionmaking process must be considered in advance. Training should include techniques and procedures used to evaluate the various options. Is there a system to continue training apart from the classroom? On-the-job-training (OJT) is a widely used technique but it suffers from many shortcomings. Trainers are frequently unaware of instructional techniques, training occurs only when time is made available, the situation typically dictates what skills are learned, and trainees often take a passive role merely watching and not demonstrating behavior (Gordon, 1994). Managers and supervisors must assess the extent to which training relies on OJT and develop specific programs to maximize its usefulness.

After training, are the behaviors practiced? Just as firefighters exercise to maintain a level of physical fitness, skills learned in training must be practiced to ensure competency. In a recent article on decisionmaking in the fire environment Braun and Latapie (1995) noted that training should include the rehearsal of behaviors that are needed in stressful conditions. Safety critical behaviors must be practiced until they become automatic. Finally, what is the perceived priority of safety? Do supervisors and managers expect safe behaviors? Are firefighters asked to work in high-risk conditions that are outside of safe parameters? Is there an established code of conduct that specifies the safe behaviors an individual is expected to display? Finally, is there an accountability system to which all firefighters are held? The answers to these and other questions provide an indication of the priority safety is given.

Feedback and Reinforcement. The concepts of training and reinforcement are closely related. At its most basic level, training serves to educate an individual about the various reinforcement contingencies (Anderson, 1995). That is, during training an individual learns the actions and behaviors that will be reinforced when training is complete. After training is complete, are the trained behaviors expected and reinforced? Moreover, have the trained behaviors been directly or indirectly extinguished by example or directive? For example, are firefighters more often reinforced for

taking risks than for demonstrating good judgment?

While it is important to assess if trained behaviors have been reinforced, it is just as important to determine if unsafe behaviors have been inappropriately reinforced by environmental events. Although the ultimate goal of firefighting is fire suppression, a suppressed fire is not an appropriate reinforcer for firefighting behavior. This unsuitability stems from the fact that all fires eventually go out independent of the actions taken by firefighters. This inevitability makes fire suppression an indiscriminate reinforcer. That is, fire suppression could reinforce both safe and unsafe behaviors. Some would agree that factors such as weather often play a larger role in suppression than firefighters, but still argue that firefighters should be reinforced by the fact that the size of the fire has been limited. There might be some truth in this statement, however, it is not completely verifiable because firefighters often take advantage of areas where the fire would stop on its own (e.g., natural fuel breaks).

Care should be taken in determining the types of reinforcement and feedback individuals obtain from the environment. The containment and suppression of fires, the saving of structures and resources, and other similar events make poor reinforcers because they are indiscriminate and because they target the outcome of behavior and not the behavior itself. Efforts must be made to reinforce the safe behaviors independent of the outcomes.

Remediation Plans. Shortcomings in training, supervision, or management should not be viewed in isolation but as representative of a company-wide pattern of behaviors. Efforts to remediate these shortcomings must endeavor to address both the specific behaviors and the broader culture. Each plan should identify short-term and long-term objectives and the criteria against which the plan will be evaluated.

Conclusions

Programs aimed at enhancing safety by addressing the proximate cause of an accident only consider a small portion of the safety picture. Merely addressing the proximate cause fails to consider that the system either directly or indirectly trains, reinforces, and even expects employees to demonstrate hazardous behavior. An effective safety program must consider both the proximate cause and the working environment that promotes hazardous behavior. The program must identify unsafe behaviors and assess their prevalence. It must evaluate training to ensure that individuals not only gain the necessary skills but are provided with opportunities to exercise and practice those skills. The safety program must survey supervisors and managers to determine if skills learned in training are actively reinforced, and finally, it must make recommendations that affect behaviors and the system that supports them.

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Naturalistic Decision Making and Wildland Firefighting*

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The Recognition-Primed Decision Model describes what people actually do when they make difficult decisions. This has many implications for training and helping people make decisions under stressful situations. It can also help explain the factors behind bad decisions.

The standard method of decision making is the rational choice model. Under this model, the decision maker generates a range of options and a set of criteria for evaluating each option, assigns weights to the criteria, rates each option, and calculates which option is best. This is a general, comprehensive, and quantitative model which can be applied reliably to many situations. Unfortunately, this model is impractical. People making decisions under time pressure, such as fire fighters, don't have the time or information to generate options and the criteria to rate each option.

The rational choice model is also too general. It fits each situation vaguely, but no situation exactly. The worst news is that in studies in which people have been asked to follow the rational choice model exactly, the decisions they come up with have been worse than decisions they make when they simply use their own experience base. This model is of little value to training because it does not apply to most naturalistic settings or to how people actually make decisions when faced with complex situations under time pressure. Decision aids which have been produced to assist with the application of the rational choice model have been largely ineffective. Because of these drawbacks, a field emerged called Naturalistic Decision Making (see Table 1). This field emerged because governmental sponsors such as NASA, FAA, the military, and others, realized that they had spent a lot of money and built decision models that did not work in the field. They wanted to get away from building analytical models which didn't work when they were brought into action. Naturalistic Decision Making uses expert decision makers, and tries to find out what they actually go through in their decision making process.

Instead of restricting decision making to the "moment of choice," experts are asked about planning, situational awareness, and problem solving to find out how these all fit together. This model is used to understand how people face decisions in shifting and unclear situations and under high stakes. Team interactions and organizational constraints with high stakes are also used as factors. For years, researchers had been simply asking college sophomores what they would do given a set of options, and a clear goal. For Naturalistic Decisionmaking research, experts are asked to size up actual situations, using all cues and constraints to set goals and make decisions.

The first study I performed to generate models and training recommendations for decision making under pressure and certainty was a study for the Army. The Army Research Institute wanted some data on decision making in real, stressful situations, and I thought that urban firefighters would be a good example of people who had become experts at making such decisions. We studied commanders who had about 20 years of experience, and studied the most difficult cases they had. Of the cases we studied, there was an average of five changes in the fire and in the way it had to be handled. About 80 percent of the decisions were made in less than a minute. As we started the study, we found that each expert firefighter told us that they had never made any decisions. They explained that they simply followed procedures. But as we listened, we realized that in each case, there was one option which they thought of quickly. They evaluated that one option, and if it seemed viable, they went ahead with it.

We began to wonder how they came up with that first option and how they were able to evaluate one option without others for comparison. The strategy used by the firefighters is the basis for the Recognition-Primed Decision (RPD) Model (see Figure 1). The first level

Table 1—Features of Naturalistic Decision Making research.

Positive Features	Contrasts
• Studies people with expertise	• Studies novices
• Tries to describe	• Tries to evaluate
• Takes a broad focus	• Takes a narrow focus
• Task context: field settings	• Task context: laboratory settings
Time pressure	Ample time
Shifting conditions	Stable conditions
Unclear goals	Stated goals
Degraded information	Precise information
Subtle cues and patterns	Clear inputs
Team interactions	Individual tasks
Organizational constraints	Individual tasks
High stakes	Low stakes
• Focus on cognitive processes	• Focus on analytical strategies
• Relies on Cognitive Task Analysis	• Relies on performance measures

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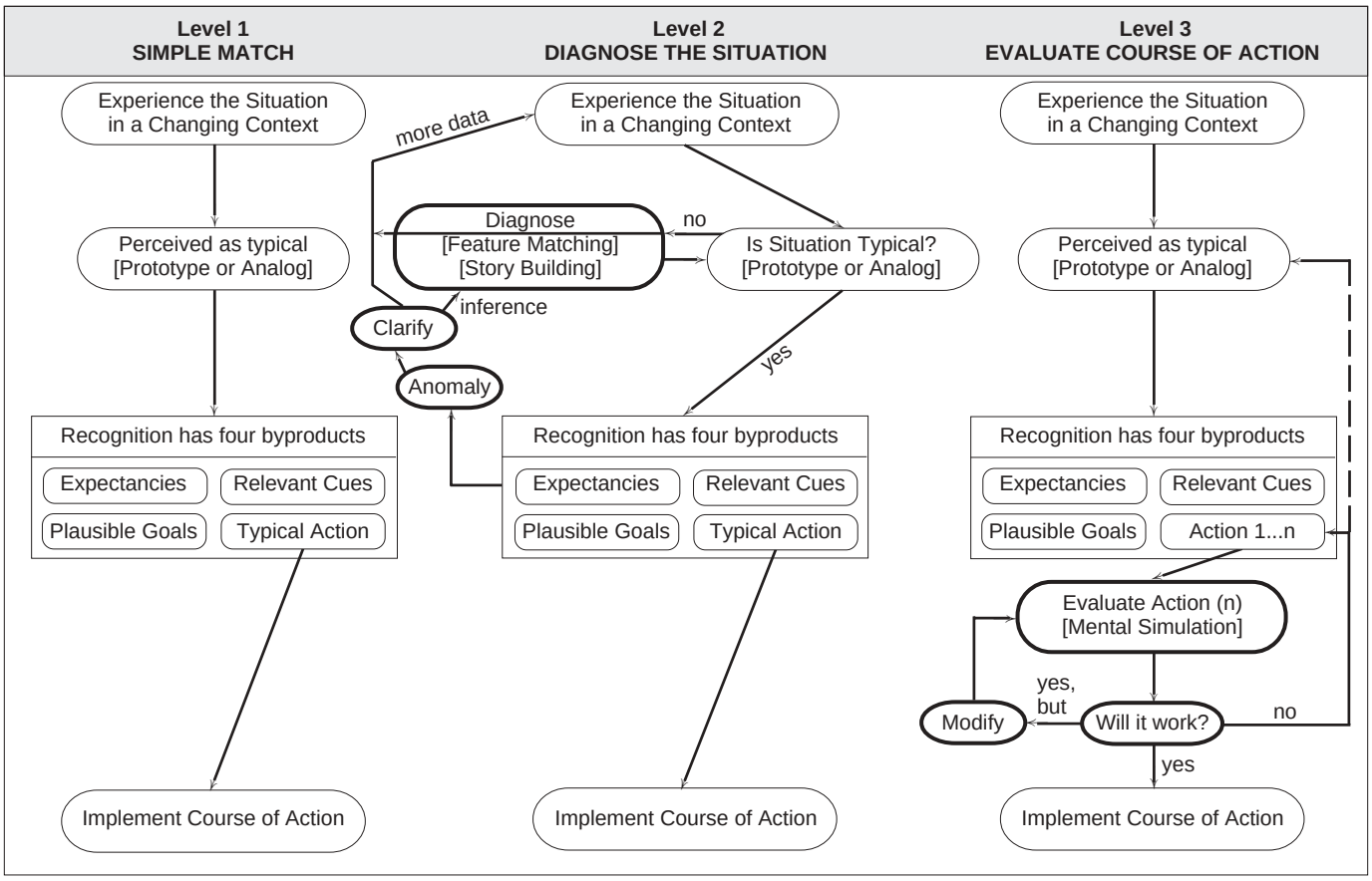

Figure 1—Recognition-Primed Decision model.

consists of a simple match, where decision makers experience a situation and match it to a typical situation with which they already have experience. Because of this, they know what to expect. They know what's going to happen, they know what the relevant cues are, what the plausible goals are, and a typical action. They are able to do all of this because of their experience base. Experience buys them the ability to size up a situation and know what is going on and how to react. That's what decision researchers weren't learning when they studied college sophomores who didn't have an experience base.

An example of the first level of the RPD model is a firefighter I interviewed early in the process. He explained to me that he never made decisions. After trying to press him on the issue, I asked him to describe the last fire he was in. He told a story of a fairly conventional fire. He described parking the truck, getting out his hoses, and going into the house. I asked him why he went into the house instead of simply working from outside, as I would have been tempted to do. He explained that he obviously had to go in because if he attached it from the outside, he would just spread it deeper inside the house. He took into account the nature of the fire, the distance of the house from other buildings, and the structure of the house. But, even while he was attending to these conditions, he never saw himself as making a decision. He never experienced that there was another option. He immediately saw what needed to be done and did it.

The second level of the model includes diagnosing the situation. On this level, expectancies are violated. The firefighter is trying to build a story to diagnose the event, and when evidence doesn't fit the story, the firefighter has to come up with a new scenario which fits the new evidence. There is still no comparing of options.

On the third level, decision makers evaluate the course of action they have chosen. Originally, we weren't sure how people could evaluate single options if they had no other options to compare it to. As we looked through the materials we were getting, we found that a decision maker would evaluate an option by playing it out in his/her head. If it worked, they would do it, if it didn't, they would modify it, and if modifications failed, they would throw it out. In the incidents we studied, commanders simply generated each option and then evaluated it for viability. Usually the first option an experienced firefighter generated was a viable option, but they

also understand that they should simply be satisfying, not optimizing. They will not necessarily pick the best option. They will pick the first one which is possible and involves minimal risk. The first viable option is chosen and improved upon, if necessary. It is not compared with all other options to see which one will be best. As soon as it is deemed viable, it is chosen and applied.

Naturalistic Decision Making has implications for training. Decision training needs to teach people to deal with ambiguous, confusing situations, with time stress and conflicting information. Situation awareness, pattern matching, cue learning, and typical cases and anomalies can be taught by giving people a bigger experience base. Training could teach decision makers how to construct effective mental models and time horizons and how to manage under conditions of uncertainty and time pressure.

Methods for providing better training include changes in such things as ways of designing training scenarios. Another strategy is to provide cognitive feedback within After-Action Reviews. This would do more than point out the mistakes which were made in an exercise. It would be an attempt to show decision makers what went wrong with their size up, and why. Another method would include cognitive modeling and showing expert/novice contrasts. This would be done by allowing novice decision makers to watch experts. Novice decision makers would also benefit by learning about common decision failures. On-the-Job Training should be emphasized rather than simply assuming that once the traditional training is finished, decision makers are ready to begin to function proficiently. Test and evaluation techniques and training device specification could also be improved. All of these might have an effect on the ability of firefighters to deal with stressful situations.

Why is it that people do make bad decisions? I looked through a database of decisions to identify reasons behind bad decisions. We came up with 25 decisions which were labeled as poor. Of those, three main reasons for bad decisions emerged. By far, the most prominent reason was lack of experience. A smaller number of poor decisions were due to a lack of timely information. The third factor was a de minimus explanation. In this situation, the decision maker misinterprets the situation, all the information is available, but the decision maker finds ways to explain each clue away, and persists in the mistaken belief.

The problem of lack of experience has many effects (see Figure 2). Inexperienced decision makers lack the understanding of situations to be able to see problems and judge the urgency of a situation, and properly judge the feasibility of a course of action. These are skills which could be developed to improve decision making.

The field of Naturalistic Decision Making research is more appropriate than traditional decisionmaking models for understanding how crisis managers, such as firefighters, handle difficult conditions such as time pressure and uncertainty. We have broadened our focus from the moment of choice, to take into account situation awareness, planning, and problem solving. By so doing, we have gained a stronger vantage point for understanding errors and for designing training interventions.

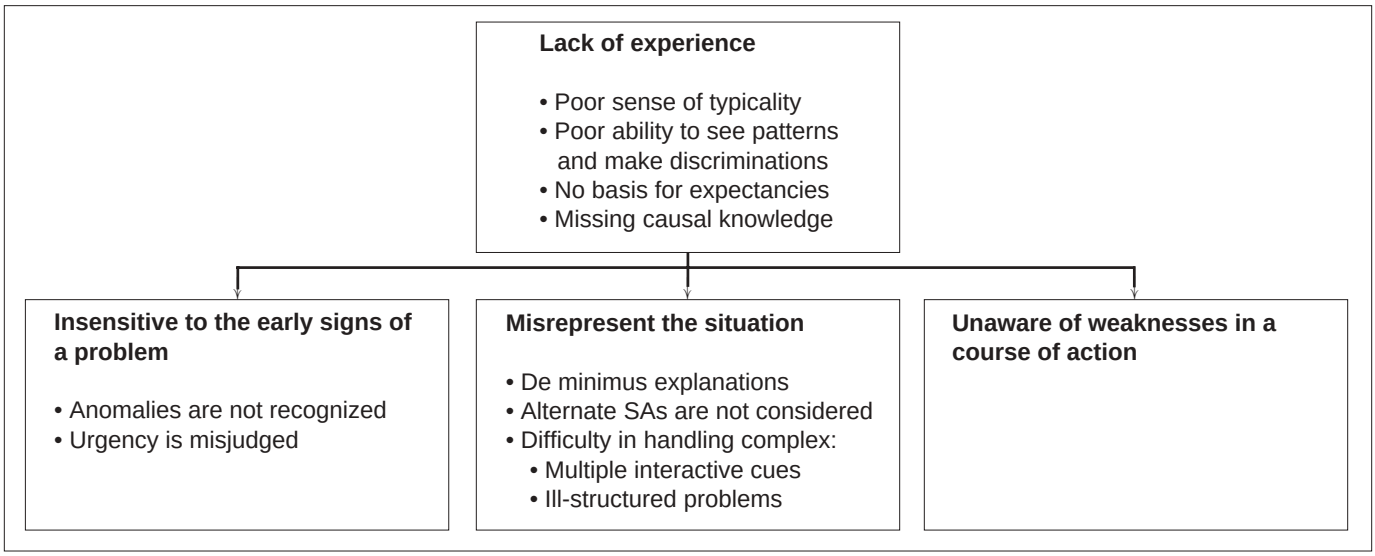

Figure 2—NDM factors that———→ poor decision outcomes.

Cultural Attitudes and Change in High-Stress, High-Speed Teams

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What is Decision Making?

As we saw in the other presentations, there are a variety of ways to model decision making. The importance here is that it can be modeled, described, and examined. By examining decision making as a system, we can learn how attitudes, individual and cultural, affect the quality of our decisions.

There are as many decision making definitions as there are models. For this discussion we'll need to have a common reference to work from when talking about decision making. Also, because we are talking about organization and team decision making, we'll focus the following definitions in that direction. A definition of decision making to keep in mind during this discussion is:

The process "of reaching a decision undertaken by interdependent individuals to achieve a common goal. What distinguishes team decision making is the existence of more than one information source and task perspective that must be combined to reach a decision."

Decision Making Factors

Close examination of this definition reveals many important aspects of the decision making process in high-stress environments. These include, but are not limited to:

- Ill-structured problems
- Uncertain, dynamic environments
- Shifting, ill-defined, or competing goals
- Action-feedback loops
- Time stress
- High stakes
- Multiple players
- Organizational goals and norms

All these factors affect how well the decision making machine works. If you think back, you've probably encountered most (if not all) of these factors during fire fighting operations.

DM and Attitudes

In this discussion, the factors we'll be concerned with are those that relate to and affect cultural attitudes. In general, attitudes that enhance the DM process are seen as positive, and those that act as barriers to effective DM as negative. Many attitudes have both positive and negative effects. All this may seem intuitively obvious to even the most casual observer, but it is important to establish a common ground before we delve too deeply into this subject. In the spirit of "crawl, walk, run" we'll need to first understand how attitudes affect the individual before we can understand the impacts of cultural attitudes on an organization.

Attitudes and the Individual

Before we go too much further, we'll need another definition. This time we'll be defining attitudes.

The ***American Heritage Dictionary of the English Language*** defines attitudes as: "a state of mind or a feeling; disposition." A longer definition is: "An enduring organizational, motivational, emotional cognitive process with respect to some aspect of the individual's world. Attitudes and beliefs imbued with emotional and motivational properties." Another shorter definition, is: "Affect for or against a psychological object."

They all say the same thing—an attitude is how you ***feel*** about ***something***. Now that we know what attitudes are, let's see where they come from.

Generally, your experience forms, has an effect on, or shapes your attitudes. Some attitudes may last only minutes, others a lifetime. Another way of looking at it is to say that your attitudes come from your values and goals (remember those DM factors). So the attitudes you use as firefighters come from your training and experience as firefighters.

What Do We Do with Attitudes

Attitudes help us make sense out of our surroundings and allow us to build and maintain our Situation Awareness (SA). How? By providing each of us a set of rules and guidelines we use to gather and process information. Therefore, attitudes aid in our decision making by framing and shaping the information we use to make our decisions. You could almost say that attitudes are imbedded in every aspect of decision making. Good, bad, or indifferent, attitudes affect the quality of our decisions.

On a team, the synergy that develops can compensate for attitudinal failures or barriers in one of its members. Effective teams recognize attitude problems and find ways to work around the "attitudinal outages". A good example of this is the issue of women as crewmembers in combat aircraft. Many male aircrew have a real "attitude" about women in the cockpit. Probable fallout from this barrier is reduced communication, increased stress, conflict, with a resulting loss of efficiency and effectiveness. A good team will recognize the barrier and react by:

- Increasing communication to and around the affected people,
- Closely evaluating the information sent by the affected parties to weed out any attitude biases,
- Finding ways to reduce stress (knowing military crewmembers, humor would be a likely choice),
- Defusing any conflict before it engages the entire crew.

We've looked at the what, how, and why questions regarding attitudes and the individual, and even looked briefly at a possible individual attitude outage scenario and the team's possible response. Now let's turn our focus to teams.

Attitudes and the Team

Cultural attitudes—what are they, and why are they different? As to what they are, our definition is still valid, but with this added: the attitude is shared by every member of the organization. Organizations and teams use attitudes for the same purpose as individuals, to build and maintain their knowledge of the environment. The big difference is that the synergistic effect of teams magnifies and multiplies the effect of attitudes.

The multiplication and magnification cuts both ways. Positive attitudes provide a uniform strength and negative attitudes, uniform weaknesses. An example of a positive effect is providing baseline goals, values, and priorities (once again, remember the DM factors), to establish a cohesive team more easily and quickly. Failures are much more insidious.

When an attitude fails (e.g., is no longer valid) or is working against a team, it becomes an attitudinal "blind spot." Because everyone in the team and/or organization possesses the attitude, no one can perceive that there is a problem—there is nothing to compare it against. For example, the team has an attitude barrier that inhibits communication. By reducing the amount of information flow, and possibly, information quality, there can be a substantial loss of synergy, cohesiveness, leadership, recognition, awareness, and communication. All these elements, working at full capacity, are crucial to effective decision making.

It is important to note that despite these undesirable results, critiquing and correcting the failure is difficult because you can't "see" the cause.

Where Attitudes Come From

We've already determined that an individual's attitudes come from his or her values and goals. The same holds true for any organization. The cultural attitudes grow out of the organization's values and goals. The source for these attitudes can be either internal or external to the organization.

Internal sources are the easiest to identify. Policy statements, directives, and even official memos are examples of how organizational goals and values manifest themselves.

Looking to the South Canyon Fire (SCF) incident, the Grand Junction District Management Team directive that all fires be "initial attacked and suppressed as soon as possible" is an example of policy working as a cultural attitude. What you gain from this attitude is a concrete direction for the firefighting teams. The goals of their decisions are unambiguous. On the flip-side, this attitude can become a decisional one-way road. It doesn't provide a way out of a fire that cannot be suppressed. Also the added emphasis on mission accomplishment can come into direct conflict with existing safety attitudes.

The "can do" attitude identified in the SCF investigation report is common to many high stress, high speed teams. It helps build team cohesion, which is important to the team for synthesizing information and integrating the individual perceptions of the situation into a common perception. But taken too far, this attitude can have lethal consequences. By going above and beyond to complete the job, mission success is prioritized ahead of safety.

We see this in the report where the "can-do" attitude is attributed with the compromise of the 10 Standard Firefighting Orders (SFOs) and 18 Watch Out Situations (WOSs).

When there is a disconnect between training and experience, a barrier to effective decision making exists. This disconnect causes a gap between the individual and resulting team perception of reality and actual reality. This example is more ambiguous than the previous two, but when seen in an actual example, it leaps right out at you. The SCF report found that "some firefighters failed to recognize the capability and limitations of the fire shelters and deployment sites." And "some questioned the value of the fire shelters under any conditions and may not have been carrying shelters." It is apparent that the training received was not supported or validated by the experience of the cited firefighters. This kind of gap between perception and reality can, and has produced, deadly results.

The final internal example is the attitude or sense of being part of a larger "family." This is most often seen as an elitist attitude. In this case we use elitist to mean special, different, or set apart. It is often expressed with the statements "we watch out for our own," or "we take care of our own." This increased awareness of your teammembers translates into an increased safety awareness. Carried to an extreme, it can result in a lack of leadership. The B-52 bomber crash at Fairchild AFB in Spokane was allowed to happen because the commanders at the base failed to ground the pilot for flying the aircraft outside its operational limits because, he was "one of our own," and for fear of "ruining his career."

For external sources of organizational attitudes, we'll look at two particular to firefighting, and one common to the entire federal government.

Pressure from the public and media generates the attitude that fires with the most public attention should be attacked first. Normally, being responsive to the needs of your customer is seen as a positive goal and attitude. But by allowing people outside the organization to control priorities, you end up with shifting, ill-defined, or competing goals (sound familiar?).

The harsh spotlight of the news media can have a similar effect. An organization is usually highlighted because of some failure or near-failure. The organization usually responds by reacting with abrupt changes in goals and values, then attitudes, then decisions. In the case of the SCF, the reaction was increased emphasis on safety, but unless the spotlight is on something that needs to be changed, the resulting changes may not be for the good of the organization.

The last external example is one that everyone connected with the federal government, most state governments, and some corporations have felt: "do more with less". In a perfect world this would allow organizations to get the most from their resources. Unfortunately, we don't live in a perfect world. In reality, this attitude is a time bomb just waiting to go off.

"Do more with less" pushes people and equipment to perform beyond their capabilities, usually by sacrificing the normally accepted margins of safety. It usually takes a catastrophe many times worse than the SCF for the federal leadership, from Congress on down through each agency involved in the concerned operation, (in this case wildfire fighting) to realize that you do less with less. Adopting a "do less with less" attitude would mean letting some fires burn themselves out when they don't directly threaten the local populace. Unfortunately decisions like these usually come at an immeasurable cost.

Attitudes, Training, and Experience

Attitudes, training, and experience have a deeply interrelated relationship. Cultural attitudes affect the emphasis of training, and experience shapes and modifies our attitudes. When experience and training validate each other, there is usually a positive attitude effect. When they don't support each other, there's usually a negative attitude effect.

Start with the training attitude that by emphasizing fire behavior, fuels, weather, and tactics, entrapments will be avoided. Add to that the historically low frequency of losses, an experience based invulnerability attitude (i.e. "it won't happen to me") can develop. The overall experience, expertise, and success of firefighters fosters the attitude that they can handle any fire (i.e. elitist, can do, or 10:00 fire), which in turn feeds the training and experience attitude "why should we over-learn emergency procedures (fire shelter use and bailing out of a situation). From this vantage point, it would appear that these attitudes are leading firefighters to lean on luck and circumstance to keep them safe.

The combination of low frequency of losses (experience), and highly experienced teams (experience) conspire to subvert important safety procedures and attitudes (training).

Attitude Impacts on SCF

Cultural attitudes played a significant roll at South Canyon. Some of the cultural attitudes that were carried into the fire were:

- "All fires will be initial attacked and suppressed as soon as possible."
- "Highest priority fires are ones that threaten life, residences, structures, and utilities."
- "We can handle the fire."
- "Can do"
- "It won't happen to me."

This last attitude is a training/experience trap stemming from the fire training attitude and the fire shelter attitude.

What impact did these attitudes have on the incident? First, we need to recognize that safety and operational effectiveness are opposite sides of the same coin. The first Standard Fire Order supports this. At South Canyon, the additional emphasis suppression received was both caused by and resulted in the erosion of safety margins. Each time the firefighters "got away with" pushing into their safety margins to suppress a fire, it reinforced the attitude that they could do the job with a smaller margin for error. The fact that some of the firefighters were uncomfortable with the situation at South Canyon demonstrates that Grand Junction's suppression directive was causing some shifting and competing goals. This erosion of the safety attitude coupled with SA and communication breakdowns critically compromised the team and individual decision making ability. Among the elements that led to this breakdown are physical and mental fatigue, recognition gaps, weather information not communicated or used, safety concerns not communicated, concerns about who was in charge (leadership) and the numerous compromises of the SFOs and WOSs. When the blow-up occurred, these came together with deadly results. The attitudes also blocked the last escape path—dropping tools and packs, bugging out, and using shelters.

After situations like these many questions are raised. Some that need to be answered in order to affect any kind of change are:

- Do tactical teams know to increase meaningful communication during a crisis? Also, do they know how to communicate effectively?
- What about pre-planning for crisis situations?
- Do tactical teams get the best information before and during a fire crisis?

Changing Cultural Attitudes

Before we look at examples of how these changes are affected, let's look at why that change is made.

Why do cultural attitudes change? Because it is recognized that the long term goals of the organization are not being met.

How do you recognize that an attitude is no longer valid? Since you have no "attitude out" light, you usually know by unwanted results produced by practicing the behavior associated with the attitude. The feedback from the environment may be obvious or subtle. Because of the blind spot effect talked about earlier, it is harder for teams to find the offending attitude than for individuals. Organizations, being larger and more complex than their component teams, find it more difficult digging out an invalid attitude.

Why is it harder for an organization to change an attitude? You have many more people needing to change and change is naturally difficult for people. Because they're doing something new and different, it take times and effort to make it stick. Let's look at a typical process by which organizations can change attitudes. Then we'll look to commercial and military aviation as examples of organizations that have undertaken this kind of change.

Preliminary Requirements. Before the change process can be started, the organization, in particular the senior leadership and managers, needs to recognize that their greatest contribution to this sort of change is providing a supportive environment that will foster the growth of the change effort.

Patience, perseverance, and commitment from the leadership and managers is absolutely necessary. Recognizing that this sort of change happens one person at a time and that it will be slow and sometimes difficult, they will be supporting the change and their own role in the effort.

For the individual, making the change can be as simple as changing the behavior associated with the attitude. This can happen very quickly, but may not have a lasting effect. As soon as the need for the change has passed, the individual is likely to revert to old behavior patterns and start the cycle all over again. Actually changing the attitude is more difficult than changing the behavior. It takes more time, but has a more permanent effect. For an organization, the time and effort is greatly magnified.

Commitment, or lack thereof, will either make or break this type of program.

What needs to be changed? Initially a survey of the organization should be conducted to determine the attitudes and values regarding team effectiveness. Areas that are typically covered in this type of survey are leadership, communication, recognition and management of stress, needs for achievement, and job satisfaction. For accurate data to be gathered the need for anonymity is essential. In addition a cross-section of the entire organization, top to bottom, left to right, needs to be sampled to prevent inaccurate, misleading, and skewed data. This information is then used as a benchmark to measure the change against, and to help determine the types of tools to necessary to make the change.

How does it happen? Using the data from the survey, a program of change is developed. Usually this takes the form of training or organizational interventions. The program is usually developed by or in conjunction with professionals involved in this arena. Credibility of the developers, program, and delivery personnel is critical to the program's success. This is the first step in assuring the buy-in of the front-line teams.

Finally, programs should be designed to fit seamlessly into the culture. It can't be seen as one time fix or just another training requirement. To change the culture, it must be part of the culture.

Where does it start? Programs which work to improve team attitudes and effectiveness usually consist of a number of inter-connected training modules.

Initial "awareness" training is designed to introduce the program and set the stage for the training to follow. It is usually directed at all organizational members who are targeted for change.

A *leadership/management "staff" course* for the senior management is also conducted in the initial phases. These programs provide management personnel the essentials to fulfill their role in the change process. They need to "walk the talk" if they expect the rest of the organization to do the same.

Baseline training is the longest and most in-depth phase. It provides the background, vocabulary, skills, and feedback the teams need to affect this change.

Instructors and Evaluators play a special role and therefore need special training. This type of training is focused on observing, instructing, and evaluating the new attitude.

Finally, *continuation training* provides ongoing reinforcement of the concepts learned in the baseline training. For the best results, it should be practiced in an environment as close to actual as possible.

As with support, training must also run from the top down. No one is exempt from training, no matter what their standing in the organization. Each phase builds on the previous. This continuity is necessary so that previous training isn't invalidated by the next phase. The training that is the most important is usually the most neglected.

Instructor/evaluator and continuation training are probably the two most critical modules for assuring long-term success. The instructors and evaluators must embrace the change and its concepts and procedures, or the training will be

useless. Lack of buy-in from the instructors and evaluators can result in training invalidating training, and evaluation invalidating or ignoring training.

Continuation training, on the other hand, keeps the ball rolling. Remember this is a long term program, not a quick fix Band-Aid. These concepts and skills need to be revisited not just annually, but at every training opportunity if it is going to be a permanent part of the culture. As with anything new, practice, practice, practice makes perfect. One final, important point regarding continuation training—***Keep it Fresh!!*** Nothing will kill a program faster than tired, overused training material. As new information becomes available it should be integrated into the program.

Looking back...we see that this is just a sample of what a program for cultural change could look like. A real program is much more complex, but then again, real change is much more challenging.

Other organizations have undertaken to change attitudes within their culture. Most notable is the aviation community. We'll look now at commercial and military aviation to see what brought them there and what they've done and gained.

In the Beginning...

The 1970s saw a number of air carrier crashes. The fact that aircraft crash wasn't new, but the reasons for crashing were. More and more accidents were being attributed to "human" or "pilot error." Highly experienced, trained, and motivated (sound familiar?) crews were ***allowing*** aircraft to crash. Most notable is the Portland DC-8 crash where the crew flew the aircraft out of gas while troubleshooting a gear problem on a clear night within sight of their destination. Another is the L-1011 that slowly descended into Florida everglades as the crew tried to decide what was wrong with a 68¢ lightbulb. The crew was focused on the lightbulb and no one was minding the store: why?

The "why?" questions were asked by the airlines also. Human error was the answer—but how do you keep it from happening? This answer took the form of Cockpit Resource Management (CRM).

A program for change was initiated at a number of airlines. It probably looked like the program we just outlined. What they found was that certain elements in the human equation needed change. They were, and are, ***communication, stress management, leadership, decision making, and attitudes.*** These programs are designed to make the pilots and flight engineers more effective and efficient flight crews.

As the programs became more and more a part of the airline culture, the benefits of this type of training was seen in other areas within the community. They also started seeing some return on their investment.

A notable (but not isolated) case is the Sioux City DC-10 crash. Enroute to their destination, the #2 engine, the one in the vertical stabilizer, disintegrated. Pieces of the engine cut through the hydraulic lines for the primary, secondary, and standby systems. Without hydraulic

power, the pilots were unable to control any of the flight control surfaces. By all rights, the aircraft should have crashed, killing everyone aboard. That's what the engineers at the airline and aircraft manufacturer said. But Capt. Al Haynes attributes his and the passengers' survival directly to CRM. The open, continuous communication, creative synergy, and their recognizing and using all available resources are principles at the heart of CRM, and were the ones used successfully by the flight crew.

Increased focus on and awareness of effective and efficient flight operations helped to broaden the scope of the program. The first to be brought into the fold were the cabin crew, hence the name change to Crew Resource Management. Then it spread to the maintenance organizations.

In the early to mid-1980's military aviation became aware of the benefits of CRM. The USAF Military Airlift Command (MAC) was the first to come on board. Their operations were the closest to the airlines, so it was natural for them to see the benefits first. MAC "spun" the airline programs to better fit their environment. The military was interested in the effectiveness and efficiency issues, but were more interested in CRM's major by-product: SAFETY. In an environment where your enemy is actively trying to reduce you to an aluminum rain shower, a program that keeps you from doing your enemies' job is always attractive!

Today, CRM is an inseparable part of the airline culture. Human factors related accident rates are down, incidents are down, safety is up and so is efficiency. The program is working.

As for the military, the change is still taking root. Military CRM hasn't reached the stage the airlines have, but then as we have said, these things take time. It has also moved out of the aircraft arena. Other military units are seeing the benefits of CRM. Maintenance, test engineers and pilots, and special forces units are just a few that have embraced the concepts of CRM.

Last Words

Changing a cultural attitude can be a daunting process. But in this environment, as in some of the others we've talked about, ignoring an attitude that is in conflict with the organization's goals and values is not just inconvenient, it's downright lethal.

By believing that what you're doing is important, you will be able to make the changes in your culture. These changes will have far reaching benefits for the individual and the organization in safety, decision making, and operational effectiveness.

—TIG, Inc. is a consulting company in Aurora, Colorado. We specialize in the delivery and development of Crew Resource Management (CRM) and human factors training. TIG, Inc. is currently providing services to the Army Guard Special Forces and The USAF Reserves flying and maintenance organizations.

South Canyon Revisited: Lessons from High Reliability Organizations[1]

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In this paper I want to explore the idea that organizing to prevent wildland fire disasters such as the South Canyon Fire on July 6, 1994 in which 14 people lost their lives, is an ongoing struggle for alertness. My intention is to look more closely at that struggle. I want to do 4 things. First, I want to discuss 4 pieces of my earlier analysis of the Mann Gulch fire that seem relevant to South Canyon. In particular, I want to discuss briefings, leadership, tools, and wisdom.

Second, I want to discuss organizational issues at South Canyon that are less visible in Mann Gulch. These include discrepancies, levels of experience, the will to communicate, and Watch Outs involving management. Third, I want to touch on solutions. And I want to conclude by discussing some questions about South Canyon that continue to haunt me.

Similarities Between Mann Gulch and South Canyon

Briefings. The struggle for alertness at Mann Gulch was undermined by many of the same things that undermined it at South Canyon, one of which is briefings. Briefings are an attempt to give people in a crew a common framework in advance including assumptions about what they may face, how it will develop, and how the crew will function and update its understanding of what is going on.

At Mann Gulch, the crew of 14 essentially proceeded without much of a briefing. They basically knew only that they were jumping on a fire that would likely be out by 10:00 the next morning. After landing, all some of them knew was that Dodge had scouted the fire on the South slope with Harrison, had used the phrase "death trap" to describe what he found, and had ordered the second-in-command William Hellman to march the crew down the North slope toward the Missouri River. Dodge didn't say whether this tactic was to escape the death trap or to position the crew to fight the fire, or simply to get closer to the river. When the fire spotted to the North side of the gulch, Dodge turned the crew around and angled them up toward the ridge, and soon ordered them to drop their tools, and then to enter an escape fire, all without verbalizing his reasons (Dodge, 1949, p. 121). Since the crew did not know each other well, since Dodge knew only 3 of them, since several were on their first jump, and since Dodge himself was rusty on leading a crew (Maclean, 1992, p. 41), it was imperative to build some common understanding and common action into this assortment of strangers. That didn't happen.

But neither did it happen 45 years later at South Canyon. The South Canyon accident investigation team allocated almost a full page (Report of the South Canyon Fire Investigation Team, 1994, p. 26: hereafter referred to simply as Report, 1994) of their report to "Safety briefings" as a "significant contribution" to the 14 deaths. The hand-off of the fire the evening of July 5 from the BLM crew to the smokejumpers and Jumper-in-charge Mackey is a good example of how not to brief people. The hand-off is by radio rather than face to face, is made after the BLM crew who know the terrain and foliage has left the scene, and the jumpers inherit a handline which is partially constructed but already lost by the time they collect their gear and are ready to extend it. Without checking whether the assumption is correct or not, the departing Incident Commander says in his statement, "I ***knew*** (ia.) that Mackey would look (sic) at fire from the air before they jumped and that he would make a decision on what to do with it after we left. I did not feel that smokejumpers needed additional guidance" (Report, 1994, p. A 5-9). Mackey got off to a bad start, and the quality of the briefings didn't improve much from then on. For example, the Prineville Hot Shots were not told how Gambel Oak burns when it is dry, nor were they told that in previous days, fires had made spectacular runs through this material in Colorado.

Why so much casualness? One possibility is that everyone seriously underestimated how much continuing effort and shared information it takes to build coordination and hold it together, especially during transitions from an initial attack to an extended initial attack, from one level of complexity to another level, and from one organization to another. The investigation team, on p. 6, states the following: "as is typical in extended attack situations, firefighting groups arrived on the fire at intervals from dispersed locations and blended into the existing organization." The key word there is "blended." Blending sounds like something that occurs automatically not something that people work at. Many would say it's especially hard to blend into an "existing organization" if that organization itself is invisible, as was the case for some people at South Canyon. Some people trying to blend did not know who the Incident Commander was, or which radio traffic had the force of authority, or what the suppression strategy was since it seemed counter-intuitive.

The questions that need to be pursued are, why does briefing continue to be treated casually and what does better briefing sound like? Back in 1949, during the investigation of Mann Gulch, Henry Thol's father understood the

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essentials of a briefing even if much of his emotional testimony ("I owe this to my boy", p. 201) was tough to follow. "Usually the foreman he always looked out for all, to take care of anything that happened. We always looked out for that before he put the men on the fire line. He had something to fall back on . . . let's go in there boys, the wind isn't blowing now. We'll go in there. But watch out, the wind can change any moment" (Thol, 1949, p. 200). More recently, researchers have studied effective cockpit crews in aircraft and have found that better briefing leads to better performance. This is relevant because in cockpits, as well as on fire lines, people often work with strangers. In particular, effective leaders establish and reaffirm norms of conduct for behavior in the group, and insist that people keep each other informed on what they were doing and the reasons for their actions and the situational model that gave rise to those reasons and actions. Almost no one at Mann Gulch or South Canyon heard someone say,

1) Here's what I think we face:
2) Here's what I think we should do;
3) Here's why;
4) Here's what we should keep our eye on;
5) Now, talk to me.

Leadership. But Mann Gulch and South Canyon are similar not only in their casual briefings. There was uncertainty about leadership in both cases. At Mann Gulch, leadership moved uneasily among Navon, Hellman & Dodge. At South Canyon, it moved uneasily among Blanco, Mackey, Longanecker, Shephard, among others. At Mann Gulch, as at South Canyon, crew members were not closely acquainted with their foremen due to continual rotation of people among crews and assignments. (Fite, 1949, p. 28). Dodge knew only 3 people in his crew, Hellman, McVey, and Thol (Dodge, 1949, p. 125). Hellman, who was better acquainted with the men (Dodge, 1949, p. 125) was near the ***front*** of the line as they raced uphill (Sallee, 1949, p. 76) and reportedly said "to hell with that, I'm getting out of here," when Dodge ordered people to jump into his escape fire.

At Mann Gulch people were torn between 2 conflicting influences. But, the same thing happened at South Canyon. Haugh and Erickson both yelled at the retreating Hotshots to drop their tools (Report, 1994, p. 16) and run for the ridge while Thrash, who was at the head of the line of jumpers and hotshots stopped and began to deploy his fire shelter as did smokejumper Roth. Hipke and Blecha said in essence, to hell with that, I'm getting out of here and continued to run.

This similarity may be merely a coincidence. It may be more significant. It seems worth exploring, however, because it adds uncertainty to a situation that already has lots of puzzles. Uncertainty about leaders puts increased demands on crews, dispatchers, and pilots at a time when they are close to overload. Uncertainty pulls groups apart which, makes them more susceptible to panic (Weick, 1993, pp. 637-638). And uncertainty in the face of unclear leadership often cuts off the flow of information because people don't know who to send it to and responsibility keeps shifting at will. As we will see later, uncertainties about leadership were not confined to South Canyon. They extended up through the organization and this sets the tone for actions reflected throughout the organization.

Tools. A small, but powerful similarity between Mann Gulch and South Canyon is that, in both cases, when people were fleeing the blowup and were told to drop their tools so they could move faster, some resisted. Several calculations suggest that this resistance may have cost them their lives (Report, 1994, p. A3-5). They would have been able to move 15-20% faster (Putnam, 1994) without their packs and tools. Firefighters are not the only people who are reluctant to drop their tools. Naval seamen on ships are trained to wear steel-toed shoes at all times and often refuse to take them off when they are ordered to abandon a sinking ship. Fighter pilots report being reluctant to eject from the "warm womb" and "cocoon" of oxygen in a cockpit that is out of control into a far more harsh environment. It is just as hard to drop shoes or an aircraft as it is to drop a pulaski and a pack.

At Mann Gulch, Dodge told his crew to "drop all heavy tools" 200 yards after they turned upslope. According to Sallee (1949, pp. 75-76) and Rumsey (1949, p. 103) people either threw away everything or nothing. Dodge in his testimony said he "didn't know until later that they had discarded shovels and pulaskis" (1949, p. 118). Sallee reported that with the fire racing at them, smokechaser Harrison was sitting resting "and he still had his pack on" (Sallee, 1949, p. 88).

This same pattern was repeated at South Canyon. Some of the smokejumpers who deployed their shelters above the lunch spot, did drop their tools. But in doing so, they were struck by the enormous symbolic significance of what they were doing. One observed that putting down a saw was like running up a white flag (Rhoades statement); another (Petrilli), that the "Pucker factor" went up a notch (Report, 1994, p. A5-69).

What about those who didn't drop their tools? If dropping your tools signifies you're in deep trouble, keeping them may help you feel you're safe. To hold onto your tools is to stay in control, to remain a firefighter rather than a victim, to appear calm. I'm still in it. This is not just an issue of symbolism since tools are needed to scrape an area clear before deploying a fire shelter. But the reluctance to drop tools may come from other sources such as economics, habits, avoidance of failure, predictions of fire behavior, and social dynamics. Equipment is expensive and jumpers, at least, are told repeatedly and early in their training to carry out everything that

is dropped to them. Habits built up during training are much more likely to involve moving with tools in hand, rather than moving and discarding tools. People have no idea what it feels like to run and discard tools or even how to do it. Rhoades in his statement mentions that as he was running to escape the South Canyon fire he kept looking for a place to put the saw down so it wouldn't get burned, a search which undoubtedly slowed his progress. In his words, "at some point, about 300 yds. up the hill....I then realized I still had my saw over my shoulder! I irrationally started looking for a place to put it down where it wouldn't get burned. I found a place I it (sic) didn't, though the others' saws did. I remember thinking I can't believe I'm putting down my saw." These words have even more impact when it is recalled that, among the fatalities, firefighter #10 (Putnam, 1994) was found with a saw handle still in his hand. To discard one's tools may signify more than giving up control, it may also be an admission of failure which, in a "can do" culture, is a devastating thing to admit.

There is a further complication with the seemingly simple act of dropping one's tools. If people drop their tools, they still face a tough choice, namely, do I now run faster or do I stop and deploy my shelter? It is tough to do both although some people at South Canyon tried. Running faster and stopping to deploy are incompatible and uncertainty about which one to do may compel people simply to keep doing more of what they are already doing, namely, running with tools. To keep running is to postpone having to make a tougher choice, especially if the person feels both exhausted and uncertain how safe the shelter really is. People may also hold onto tools because their predictions of fire behavior suggest that the fire won't reach them. This is a clear possibility at South Canyon. As the fire moved toward the hotshots and jumpers moving North along the fireline, it repeatedly was channeled toward the ridgeline along draws that ran at right angles to their movement. This fire behavior could have created the impression that the crew was at the flank rather than the head of the fire which meant there was no need to drop tools.

Finally, people may hold onto their tools as a simple result of social dynamics when people are lined up. If the first person in a line of people moving up an escape route keeps his or her tools, then the second person in line who sees this may conclude that the first person is not scared. Having concluded that there is no cause for worry or that I'm not going to be the only one who goes back without tools, the second person also retains his or her tools and is observed to do so by the third person in line who similarly infers less danger than may exist. Each person individually may be fearful, but mistakenly concludes that everyone else is calm. Thus, the situation appears to be safe except that no one actually believes that it is. The actions of the last person in line, the one whose back feels most intensely the heat of the blowup are observed by no one, which means it is tough to convey the gravity of the situation back up to the front of the line.

What hasn't changed in 45 years is the power of symbols. Packs and saws may be heavy and slow one's pace. But that may be one of their less important qualities. More significant may be their ability to reduce one's sense of danger. If throwing tools is a sign of surrender, keeping them may be a sign of a standoff or victory. It may be important for trainers to emphasize, "Look people, you're going to want to hang onto this stuff. Don't! It could cost you your life.

Wisdom. The fourth aspect of my Mann Gulch analysis that fits South Canyon centers on the idea of wisdom. To understand why the idea of wisdom fits here, you need to understand first that wisdom is a mixture of knowledge and ignorance. When one of them grows, so does the other. To know something better is also to discover that new questions about it are raised. Wisdom is an attitude that what you know is only part of what could be known, and therefore, you need to stay alert. You need to avoid excess confidence that you know everything and excess caution that you know nothing, if you want to stay flexible.

Wise organizations know what they don't know. They know two things: first, they know that they have not experienced all possible failure modes and second, they know that their technology is still capable of generating surprises (Schulman, 1993). Thus, when they act on the basis of their past experience, wise organizations act as if that experience is both credible and limited. They simultaneously believe and doubt they know what is up. Consider the case of a near miss or a close call. The fascinating thing about a near miss is that, "Every time a pilot avoids a collision, the event provides evidence both for the threat and for its irrelevance. It is not clear whether the learning should emphasize how close the organization came to disaster, thus the reality of danger in the guise of safety, or the fact that disaster was avoided, thus the reality of safety in the guise of danger" (March, Sproull, and Tamuz, 1991, p. 10). If the moment is interpreted as safety in the guise of danger, then learning should be diminished because "more thorough investigations, more accurate reporting, deeper imagination, and greater sharing of information" are all discouraged (Sagan, 1993, p. 247). The attitude of wisdom sees a near miss as evidence that the system is both safe and vulnerable, that people must remain alert, and that a safe environment is not measured by an absence of accidents (that outcome is largely dependent on luck), but is the result of active identification of hazards and their elimination (Allinson, 1993, p. 186).

At Mann Gulch, people believed they were fighting a fire that would be out by 10:00 the next morning and failed to raise questions about whether this expectation remained accurate. At South Canyon people believed they could "hook" the fire before the winds

would build and they presumed that lookouts and a commander had the big picture even though the firefighters had seen no evidence of this.

The attitude of wisdom is one way to remain alert, because it leads people to remain open to what is happening and to rely cautiously on their past experience. I've always been struck by evidence suggesting that there are certain periods during a person's career, when they are most in danger of getting injured or killed. Police, for example, are in most danger of being shot during their 5th year on the force. Firefighters are in most danger of fireline accidents either in their first 2 years or after 10-15 years of experience (Pyne, 1984, p. 391). Young firefighters are vulnerable because of their inability to recognize hazardous situations. The more experienced firefighters are vulnerable because they presume they've seen it all, they have less openness to new data, thus the validity of their models decreases. The unexpected gets them.

Crews and commanders need to keep learning and updating their models. This won't happen if they presume that nothing about fires can surprise them, if near misses are treated as testimonials to safe practices, and if they are certain that they've experienced all possible ways in which a system can fail. These attitudes won't change if they reflect similar attitudes in top management. You may recall that Maclean felt "the Forest Service wanted to downplay the explosive nature of the Mann Gulch fire to protect itself against public charges that its ignorance of fire behavior was responsible for the tragedy" (Maclean, 1992, p. 125). The key word there is "ignorance." The service doesn't want to appear ignorant. Nor do it's crews. The price of creating this impression may be a loss in vigilance, learning, and wisdom.

It is tempting in a world of boldness and aggressive attacks, to conclude that there is no place for doubt. But as Thoele (1994) has suggested the best firefighters do not confuse risk with recklessness, and they are able "to say 'no' without sustaining dents in their machismo" (p. 28). That's what wisdom is about, and why it's worth striving for.

Differences Between Mann Gulch and South Canyon

Discrepancies Between Beliefs and Actions. Having suggested at least 4 ways in which dynamics of organizing in South Canyon replay themes that unfolded earlier in Mann Gulch, I now want to explore some additional issues that were less visible in Mann Gulch but that stand out in South Canyon.

The first of these is the unusually large number of inconsistencies between beliefs and actions at South Canyon. I want to dwell on these because they suggest one reason why people persisted so long doing things that violated fire orders and watch outs.

A recurring belief among people fighting wildland fires is that some of the fires they fight are on worthless land. This was a prominent issue at Mann Gulch. As Earl Cooley (1984) put it, "One of the main questions was why we risked lives and spent many thousands of dollars to save scrubby timber and cheatgrass" (p. 91). A basic discrepancy that firefighters and overhead face over and over is between their belief that the land is worthless and the reality that they are risking their lives to defend it. The action of defending is inconsistent with the belief that the area is worthless. Contradictions such as this cause tension and continue to do so until the person either changes the belief—the land is more valuable than it looks—or changes the action, and uses low priority suppression tactics. Either change reduces the inconsistency.

Let's extend this scenario to South Canyon and a key decision, the decision made at 9:30 the morning of July 6 to cut a direct fireline, downhill (Report, 1994, p. A4-6). What is noteworthy about this decision is that it involves a troublesome discrepancy. Building direct line downhill is dangerous. Longanecker said, "going downhill direct is a bad deal" (Report, 1994, A5-52). Archuleta asks, why are we punching in line? Erickson asks, "Where are the safe areas?" and hears the answer, "there really aren't any." Rhoades, Doehring, and Shelton overhear this conversation. But the decision is made to build a direct line anyway, which leaves everyone tense. They believe that the action is dangerous, yet they are doing it. What makes this really troubling is that the decision is a public, irrevocable, choice. There is good research evidence (e.g., O'Reilly and Caldwell, 1981; Salancik, 1977) that when people make choices of this kind, they are more likely to change their beliefs so that they become consistent with the action they are now committed to. In this case people should begin to believe that building direct line downhill is safe after all in order to justify what they are actually doing.

And that's what seemed to happen. Listen to how Quentin Rhoades in his own words, handled things: "I resolved not to go down that hill digging line . . . Smokejumpers arrived and started digging line. I remember thinking that I must have missed something. I hadn't been on a fire since August 18, 1992 and I felt a little green." Rhoades convinces himself that the main reason the situation seems dangerous is that it's his fault, he's rusty, he's missed something, which means the situation is not as dangerous as it looks. Other people resolve the discrepancy in other ways. They convince themselves that the leaders know what they're doing, that it won't take long to cut the line, that the predicted weather front won't be that strong, that they can "hook the fire before the front passed" (Report, 1994, p. A5-53), that the crews are really on top of this job, and that more resources are coming (Report, 1994, p. A5-47). There is a grain of truth in all of those explanations. But people also have a stake in needing them to be true, since they reduce the tension associated with doing something they believe to be

dangerous. The trouble is, they now have a vested interest in ***not*** seeing warning signals. If they do notice these signals, then their whole sense of what is happening collapses. Listen again to what Rhoades says: "My ditty bag contained a copy of standard fire orders and watch situations. I considered looking at it, but didn't. I knew we were violating too many to contemplate."

When people take public, irrevocable actions for which they feel responsibility, their mind set is to justify those actions and to assemble evidence that shows the action makes sense (Ross & Staw, 1986). They are not indifferent toward evidence that raises doubt about the action. Instead they avoid, discredit, ignore, or minimize this contrary evidence and keep looking for positive reasons that justify continuing the action. People who justify their actions persist, or in the words of the investigating team, "strategy and tactics were not adjusted to compensate for observed and potential extreme fire behavior" (p. 35).

I have dwelt on this one decision at South Canyon to show how people justify their actions and in doing so, become more committed to continuing those actions. There are several other discrepancies that could be analyzed the same way, such as the belief that this was a low priority fire yet Type 1 crews were put on it; the policy that two or three trees burning is a standard smokejumper dispatch (French), yet jumpers were not dispatched immediately; the belief that this is a potentially serious fire, yet a crew walks off it the night of the 5th; the belief that retardant works only at certain stages of a fire, yet requests for it at that stage are refused; aerial reconnaissance that spots fingers of fire in west drainage on July 6, yet these are not drawn on the map (Report, 1994, pp. 26, A5-70). My point is not simply that there were discrepancies at South Canyon. Life is full of discrepancies and people manage to deal with them by sizing up pro and con evidence. My point is that, key discrepancies at South Canyon seemed to occur in a context where people got locked into public irrevocable, volitional actions, and had to justify those actions. These justifications made them more committed to those actions, which led them to persist longer in executing those actions despite growing dangers. Notice that the people who would be spared from this process of escalation would be those who were forced to cut line (there is low choice), people who saw escape routes, (the action is revocable) and people who did not express their views in public (the decision is not linked to them as individuals).

Levels of Experience. Earlier I mentioned that experience has both an upside and a downside. The upside is that it gives you more patterns that can be retrieved and matched with current puzzles to make sense of them. The downside is that more experience can sometimes lead to less openness to novel inputs and less updating of the models one uses. Failures to revise often produce ugly surprises.

I want to dig deeper into the issue of experience levels at South Canyon, partly because the accident investigation team seemed reluctant to do so. I say this because if you look at the ***Fire Entrapment Investigation and Review Guidelines*** (Report, 1994, pp. A12-3 to A12-11) which they followed religiously in structuring their report, the only category out of the 28 that they omitted was category 23, "V. Involved personnel profiles - Experience levels" (Report, 1994, p. A12-7). This omission may be due to the fact that, on paper everyone is qualified. But just because they're qualified on paper, doesn't mean that their experience is deployed well in this incident or sufficient to handle its changing character or easily adapted to it. Issues of experience levels at South Canyon are complicated, difficult to untangle, and touchy when untangled. But that's no reason to avoid them.

The overall level of relevant experience for leadership appears to be low. Several people appear to be in over their heads, which gives a whole new and somewhat chilling connotation to the personnel category, "Overhead." Experience is unevenly distributed across the several activities at South Canyon and does not always line up with authority. There are no clear mechanisms to mobilize and focus and implement the experience that is scattered around. And finally, everyone is accessing their experience under increasing amounts of stress, which means they are likely to fall back on those habits and understandings they have overlearned (Weick, 1990, pp. 576-577). Unfortunately, these may be the very habits and understandings that are ***least*** relevant to the unique conditions in South Canyon.

There are at least three reasons we need to tackle the issue of experience and how it is mobilized. First, an important finding from studies of high reliability organizations is that they have multiple structures. Aircraft carriers, for example, have a bureaucratic hierarchical structure for normal functioning during slack times, a different structure built around expertise for "high tempo" periods of extended flight operations, and a third structure explicitly designed for emergencies. High tempo structures are especially relevant for wildland firefighting where rank in the formal hierarchy does not always coincide with technical expertise. LaPorte and Consolini (1991) describe a high tempo structure on carriers this way: "Contingencies may arise that threaten potential failures and increase the risk of harm and loss of operational capacity. In the face of such ***surprises***, there is a need for rapid adjustment that can only rarely be directed from hierarchical levels that are removed from the arena of operational problems. As would be expected, superiors have difficulty in comprehending enough about the technical or operational situation to intervene in a timely, confident way. In such times, organizational norms dictate noninterference with operators, who are expected to use considerable discretion.

Authority patterns shift to a basis of functional skill. Collegial authority (and decision) patterns overlay bureaucratic ones as the tempo of operations increases. Formal rank and status declines as a reason for obedience. Hierarchical rank defers to the technical expertise often held by those of lower formal rank. Chiefs (senior noncommissioned officers) advise commanders, gently direct lieutenants, and cow ensigns. Criticality, hazards, and sophistication of operations prompt a kind of functional discipline, a professionalization of the work teams. Feedback and (sometimes conflictual) negotiations increase in importance; feedback about "how goes it" is sought and valued" (p.32).

People in South Canyon did not seem to have the capability to form a high tempo structure where influence flowed from expertise and experience, rather than from the formal chain of command. In part, the problem was that it was never clear where the relevant expertise was located so that the structure could form around it. Furthermore, there was no clear chain of command that could defer to more experienced people nor was there a clearly understood set of signals by which such a shift in structure could be conveyed immediately and unequivocally to everyone.

A second reason the issue of experience is important is because it has the potential to create a smarter system that senses more. A key idea in system design is the notion of requisite variety: it takes a complex system to comprehend a complex environment (Miller, 1993). Analyses of South Canyon that are consistent with this principle have already begun to appear. For example, Topic 3.5 in the IMRT review states that managers should "match qualified incident commanders with the complexity of incidents" (Wildfire, Vol. 3, No. 4, Dec. 1994, p. 46). That's requisite variety. Inadequate requisite variety occurs when a less complex incident commander, or a less complex jumper crew, or a less complex dispatcher, cannot adequately comprehend a more complex event.

Requisite variety that is more adequate can be illustrated by a crew of smokejumpers who have had prior experience as hotshots. Such a crew has the capability to function either in a more independent jumper mode or a more disciplined hotshot mode, which gives them a larger variety of ways to cope with a larger variety of fire behaviors.

The notion of requisite variety also alerts us to a hidden danger in ***successful*** firefighting. There is growing evidence that success leads to system simplification (Miller, 1993), which means successful systems steadily become ***less*** sensitive to complex changes around them. This insensitivity culminates in a sudden string of failures and the horrifying realization that one has become obsolete and faces a nasty, prolonged period of playing catch-up.

Again, the lesson from high reliability organizations such as the Diablo Canyon nuclear power plant is the need to cultivate diverse experiences, variety, multiple points of view, and conceptual slack (Schulman, 1993) so that people have a better sense of the complexity they face. And, there also need to be well-learned, trusted, procedures to handle the inevitable conflicts that arise when people make different interpretations, such as when a Fire Management Officer and a Hotshot superintendent differ on how the fire should be fought.

The third and final nuance of experience that I want to raise is the question of what happens when you are at the limits of your experience where demands exceed capabilities? And what can be done about it?

For the sake of illustration, let's look at jumper Mackey who was jumper-in-charge at South Canyon and who had just recently been given a permanent appointment. What's interesting and troubling about Mackey's position is that the system makes it hard for him to do a good job on this fire. If we put ourselves in Mackey's shoes we discover that he is in a bad spot almost from the start.

He starts with a sloppy hand-off the evening of July 5 and an unfinished project which he is unable to continue. He's dropped on unfamiliar terrain, at twilight, with rolling debris and steep slopes. The crew is unable to get much sleep. The resources (two Type 1 crews) that Mackey requests the night of the 5th arrive in small numbers at unpredictable intervals the next day (8 jumpers at 10:00 a.m., 10 hotshots at 12:30 p.m., another 10 hotshots at 3:00 p.m.) and Mackey is not even sure they'll come at all since he's been told his fire is low priority. When there is disagreement about building line direct and downhill, the incident commander does not resolve it and the hotshot superintendent does not seem to question the strategy when he arrives around noon (Report, 1994 pp. A4-6, A4-7).

At some level Mackey knows the downhill strategy is risky because, in response to a flare-up at 10:35 AM, he begins to pull the crew out (Report, 1994 p. A5-70) only to have that decision questioned by Longanecker who suggests doing bucket drops. The drops are made and the crew resumes cutting line. Not long after this Rhoades observed that "Don looked terrible." Still later, when the saw Rhoades is using breaks down, Mackey offered to sharpen it and help him cut line. This looks like a clear instance of a person falling back on overlearned behavior when that person is under pressure. Mackey discards the less familiar activity of keeping your head up and supervising for the more familiar activity of keeping your head down and cutting line.

I mention this example to make the point that when demands exceed capabilities, which is the basic condition under which people experience stress (McGrath, 1976), this is seldom simply the fault of an individual. The buck doesn't stop with that person. Instead, the buck stops everywhere (Allinson, 1993). The people around Mackey made his assignment harder and reduced his capabilities to handle it. The resulting pressure made it harder for Mackey to gain access to the experience he already had, which

increased pressure when his decisions were questioned, which gave him even less access to his experience until he was caught in a vicious circle where he did what he had always done on fires, namely cut line rather than supervise. The Hotshots had no idea something like this might be developing, and when they saw Mackey, he seemed to be moving around and checking, which is what overhead is supposed to do.

The system let Mackey down. It did little to remove or redistribute pressures, it did little to simplify his assignment, and it did little to monitor the fact that he and others had less and less energy to cope with growing complexities. The crew was losing variety and alertness, and no one spotted this or slowed the loss, or altered the work so that whatever alertness remained was sufficient.

Communication. In the preceding discussion of levels of experience, I steadily enlarged the size of the relevant organizational unit from jumpers and hotshots and South Canyon overhead, to the system in general including dispatcher, interagency coordinators, and top management. I did so in the hope that we would not fall into the trap of glibly saying that South Canyon is another instance of operator error, but would instead incorporate a larger, earlier, higher set of design decisions as significant contributors to the incident.

You may recall that the team investigating South Canyon felt that "Management support and dispatch coordination" were not "significant contributors" to the disaster, but merely "influenced" it (Report, 1994, p. 33). I mention this partly because not everyone agrees with this assessment (e.g., OHSA, IMRT), and partly because this is the same kind of questionable assessment that was made by the team investigating the Challenger disaster. In the Challenger report, the ***Main Cause*** of the disaster was listed as "failure in the joint between the 2 lower segments of the right solid rocket motor" (Allinson, 1993, p. 111) and the ***Contributing Cause*** was listed as flaws in the decision making process. The implication of such an analysis is that people should devote the brunt of their energy to correcting the main cause.

Allinson (1993, p. 111) among others has argued that the Challenger investigating team had their priorities reversed. The failure was set in motion by actions and choices that said it was safe to launch and by the decision to launch itself. The defect in the O-ring can't harm anyone as long as that defect stays on the ground. The fact that a defective design even "existed at all was the result of previous decisions to select this design. That it was allowed to continue to exist was the result of previous decisions not to alter it, despite repeated warnings. That it was allowed to be in use in unsuitable weather conditions was also the result of decisions made to allow it to operate despite the danger that the weather conditions represented. [Allinson concludes by saying] It seems more appropriate, then to describe the technical defect of the ***Challenger*** with the term "proximate cause" and management's decision to launch the Challenger without an adequate regard for safety, the 'primary cause' " (p. 113).

Since the South Canyon report focuses on the crews cutting line, it is difficult to spot earlier administrative decisions that are potentially significant. But there is certainly no shortage of possibilities. Crews at South Canyon are told to be aggressive but are given little support to do so and later are faulted for being too aggressive. Prineville Hotshots are requested and then treated poorly when they arrive at the Glenwood Springs office at 8:00 a.m. on the 6th (Report, 1994, p. A5-80) where they are forced to look around to find tools and then go to the 7-11 to get food. Their understandable agitation at being handled this way probably does not disappear the moment they get to South Canyon. Instead, much like the married pilot who takes command of an airplane shortly after an intense domestic quarrel, the crew starts their work at a level of stress which is already quite high. It doesn't take much additional stress before the quality of their judgment and thinking may begin to suffer. Radio discipline is practically non-existent (Report, 1994, p. A5-37). Dispatch keeps reminding people that South Canyon is a low priority fire, that there is nothing out of the ordinary (LaDou statement), and they keep saying "Roger" to all requests for resources without any feedback as to how and when the request will be handled, if at all. Requests for retardant are denied, weather briefings are unevenly distributed, and no one takes responsibility for better distribution. The IC is invisible (Report, 1994, p. A5-67) and there is no guidance for helicopter use which means that people compete continuously (Byers statement) for its services (Report, 1994, p. A5-22). These poorly integrated managerial decisions are spread over the period from July 2nd through the 6th and may reflect even earlier decisions about safety and how people are to be treated.

The questionable decisions continue after the blowup, suggesting that the incident within the incident is mishandled. Aircraft are kept circling above the blowup for 45 minutes in 50 knot winds (Ferneau statement). The governor is allowed to tie up a key phone connection for 15 minutes which delays rescue efforts for the people deployed in shelters. Helicopter pilot Good, who seems to have a stunning amount of endurance and resilience, is still being ordered around at 9:00 at night, this time to fly body bags in. He speaks for a larger group when he refuses, saying, "I've had enough" (Report, 1994, p. A5-50).

These are all symptoms of problems far removed from the crew boss on the ground, and our job is to diagnose symptoms of what. Many would say these are symptoms of problems in communication. This is what the Hotshots said: "The crew wants to know where the communications broke down with the red flag warning" (Report, 1994, p. A5-81). The answer to their question

about a breakdown is that the communications broke down everywhere, which is an inevitable diagnosis when you argue that the buck stops everywhere.

Here's what good communication looks like. The example comes from Winston Churchill. When he discovered to his horror that Singapore was vulnerable to a Japanese land invasion during WWII, Churchill said, "I ought to have known. My advisers ought to have known and I ought to have been told and I ought to have asked" (Allinson, 1993, p. 11). Notice how much complexity Churchill has described. There is no one cause for this disaster. Churchill could have known. Others should have known. Those who should have known, should have informed Churchill without his asking. If others did not know, they should have found out and informed Churchill on their own without waiting for him to ask. If they didn't know, Churchill, by inquiring of them, might have prodded them to find out. If they had known but failed to speak up, Churchill, by inquiring, may have been given the necessary information. Any of these eventualities might have changed the course of events (adapted from Allinson 1993, pp. 11-12).

It is everyone's responsibility to challenge and to respond to the challenges in a trustworthy manner, and to listen carefully and respectfully to the response. When people fail to engage in respectful interactions (Weick, 1993, pp. 642-644), things can get dangerous. Let me suggest why that happens.

One possibility in wildland firefighting is that a norm has developed which says essentially, no news is good news. Partly because people on crews are independent, adventuresome, take-charge people; partly because radio traffic is so hard to control; partly because there are no detailed and systematic communication protocols for dispatchers and crew leaders to exchange information about changes in fire status; and partly because people presume the basic task itself is straightforward, a failure to report is treated as a positive message that things are OK. Notice, that if things are not OK and people are preoccupied and unable to send a message, this too will result in a failure to report.

Thus, no reporting can mean either things are OK or things are not OK. The Zebrugge Ferry disaster on March 6, 1987 involved this very misunderstanding. The person responsible for closing the bow doors of the ferry did not report any deficiency to the Captain, not because there was none, but because he had fallen asleep before closing the doors. The Captain steamed into the channel unaware that the doors were open and water was flowing into the vessel. Five minutes after leaving the coast of Zebrugge, the ferry ***Herold of Free Enterprise*** capsized, sank, and 193 lives were lost. The buck stops everywhere on this incident. Virtually the same scenario happened 5 years earlier on October 29, 1983 aboard the ferry ***Pride***, but was caught before the ship capsized. At that time, the Master urgently communicated with management requesting that there be some indication on the bridge whether the watertight doors were closed or not (Allinson, 1993, p. 203). Management did not listen. Their responses to this request are preserved in the accident investigation and included remarks such as, "Nice, but don't we already pay someone?"; "Assume the guy who shuts the doors tells the bridge if there is a problem"; "My goodness." People at the top didn't feel it was part of their job to inquire, or to listen attentively, or to pass along information. So there is no reason for the Masters' of the vessels to act differently if this is the preferred communication style at the Peninsula and Oriental Steam Navigation Company (Allinson, 1993, p. 195).

People associated with South Canyon didn't know a lot of things they should have known. This raises at least 3 questions: why weren't they told, why didn't they ask, and why didn't they tell what they knew? They may not have been told because others thought the information would have no effect, was not desired, or would not be passed on. They may not have asked because they thought they had all the answers or wouldn't get them anyway. And they may not have passed on information because they assumed it would not receive a hearing. If any of these possibilities are true, and if people also believe that no news is good news, then wildland firefighting is a thousand administrative accidents waiting to happen and is even more dangerous than people realize. Fire is not the problem. The problems are alertness, trust, trustworthiness, respect, candor, and "the will to communicate" (Allinson, 1993, p. 41), a list that fits Mann Gulch as much as it fits South Canyon. The difference is that in South Canyon, the list applies to a more dispersed set of people with a more diverse set of interdependent tasks.

Safety attitudes are inherent in good management practice rather than something that are tacked on. Free flow of information is good management practice, gets things done, and saves lives. If people fail to pass along information, fail to listen attentively, and fail to elicit information actively, that is bad management and unsafe management. I suspect Stephen Pyne (1984, p. 394) has it about right when he said that "All too often 'safety' is a cosmetic, a mandated and barely tolerated veneer of declarations, memorandums, task force reports, safety officers, and exhortations that has little relevance to the conduct of practical affairs. Something is taught as a 'safe' procedure rather than the only procedure. Safety is something added to a program, not something integral to it . . . Most safety programs fail at the bottom because they are not truly practiced at the top."

Watch Outs for Administrators. In the context of a closer look at administrators, it makes sense to look at the 10 fire orders and 18 Watch Outs that are potential guidelines for firefighters, guidelines that remained on a card inside Rhoades' ditty bag, untouched and unread. I want to make two points

about these two lists. First, I think firefighters should begin to compile a list of Watch Outs for administrators. In the same way that the current 18 Watch Outs alert crews to increased hazards at the site of the fire itself, administrator Watch Outs would alert crews to conditions back at headquarters that are just as hazardous as the fire itself. Recall that Longanecker (Report, 1994, p. A5-54) proposed just such a watch out in his statement after South Canyon: Watch out "when you don't receive the resources that you need or you are debating with the dispatcher about the resources you need." A handful of other Watch Outs might include, Watch out,

1. When the governor is in town (Report, 1994, p. AF-64);
2. When interagency ties are strained (Report, 1994, p. A5-63);
3. When dispatchers keep track of things in their head rather than on paper;
4. When the norms for radio discipline are loose (Report, 1994, p. A5-37);
5. When people are reluctant to ask for help;
6 When administrators are getting on-the-job training;
7. When administrators say "keep it simple;"
8. When the overhead is tough to find (Caballero statement); and
9. When you don't know which office to report to, you think about it, and having thought about it you then go to the wrong one (Taft statement).

The second point I want to make is that a good place to start in developing a list of administrative Watch Outs is with existing efforts to boil the ten fire orders down to the acronym LCES (Gleason, 1991). If **l**ookouts, **c**ommunication, **e**scape routes, and **s**afe areas, are good enough for firefighters, they are good enough for administrators. The principles are essentially the same in either case. For example, the administrative counterpart of ***lookouts*** is a person with the big picture. In nuclear power plant control rooms, there is a person called the shift foreman (Weick, 1987, p. 116) whose sole responsibility is to maintain the big picture. The most effective aircraft cockpit crews are those in which, during an emergency, the aircraft is flown by the first officer (co-pilot) not the captain and the captain plans how to deal with the emergency and tracks progress.

Although, I have already discussed ***communication***, a good way to illustrate it is by a surprising finding in studies of captains who lead the best aircraft crews. Investigators found that these captains readily acknowledge that their decision making ability is ***not*** as good in times of emergency as it is at other times (Helmreich, Foushee, Benson, & Russini, 1986). Captains who are the ***worst*** leaders, say that their decision making ability is just as good in time of emergency as it is at other times. Poor leaders don't listen because they don't think they need to. Good leaders don't fall into that trap. Recall an earlier point I made that a potential trap when people gain experience is that they lose openness to new information. Here we see clear evidence that good pilots—and by extension, good leaders in general—don't let that happen.

Escape routes for administrators consist of things like options, revocable actions, pulling the plug, seeing the temptation to escalate a commitment to salvage a losing cause and then avoiding it. The scary thing about administrative escape routes, is that sometimes they are used to deny individual responsibility and to pass the buck. That's the mind set that we want to undercut with a culture where the buck stops everywhere. Managers responsible for treating people with respect need to have the welfare of those people in mind and not just their own reputation, when they vow never to get into anything without having a way out for everyone. Safe flight operations on aircraft carriers are made possible because that's precisely what managers believe and put into practice (Weick & Roberts, 1993).

Safe areas for administrators are created by such things as clear norms about the relationship between failure and learning, secret ballots, anonymous reporting of near misses, access to brainstorming where evaluation of ideas is intentionally suspended, the equivalent of a penalty box where people who commit glaring errors are put for a finite period of time after which they rejoin the action, and availability of 3rd parties to mediate conflicts that are difficult to resolve. It is the very availability of these safe areas that allows administrators to act in a candid manner that can then be mirrored on the fireline.

If a firecrew sees that management is violating its own version of LCES, they should be just as wary and alert as if they saw themselves violating LCES at the fire itself. The dangers, in either case, are real, immediate, and serious.

Moving Toward Solutions

My analysis so far has been largely speculative and has consisted of extrapolations from what is known about high reliability organizations to seemingly analogous circumstances in South Canyon. Given the tentative quality of this diagnosis, it is premature to talk about remedies. Nevertheless, remedies have already been implied in what I've said and I want to illustrate briefly some directions in which those implications point.

1. If leadership is an issue, then it seems important to look more closely at the possible pathways by which one can become a smokejumper foreman, whether the route is through expertise with parachutes, or with leadership, or with fires. Depending on which route is favored, people in the field could have very different habits they fall back on when put under pressure.

2. If people feel there are too many rules binding on firefighters (10 fire orders + 18 Watch Out situations + 4 LCES + 4 common denominators + 3 sources of judgment error [ignorance, casualness, distraction] + 9 guidelines for indirect/ downhill line construction = 48, in Gleason, 1994, pp. 24-25), and if firefighters say they need to violate orders to keep fires from growing (Rhoades, 1994, p. 22), then clearly some priority setting is in order. It is here where I think it makes sense to talk about simultaneous centralization and decentralization. What you want to do is centralize everyone in terms of 3 or 4 key values which are treated as non-discretionary and imperative (LCES?), and decentralize the others issues so that they serve as guidelines and a platform for improvisation to meet unanticipated local conditions. I have no idea what the final partitioning of Gleason's 48 guides would look like. I do know that discussions to hammer out such a partitioning would strengthen the will to communicate.

3. I would pay close attention to what people overlearn during their training, since this is what they are most likely to do when put under pressure. For example, the 23 people (Report, 1994, p.14), who fled from the ridgeline did not take the shorter, safer, more direct route used by Haugh, Hipke, and Erickson, but instead ran out the same way they had hiked in, which exposed them to more danger for a longer period. If firefighters haven't practiced and overlearned shelter deployment, or dropping their tools, or using a checklist, or watching out for the safety of a buddy, or running from fire as fast as possible (Maclean, 1992, p. 272) over and over, then it's a safe bet they won't do those things either when they are under intense pressure.

4. I think Dave Thomas (1994, pp. 45-48) is right in his insistence that fire stories and case studies are a crucial means to extend people's repertoire of experience, even if that experience is second-hand. There certainly are enough "old fire dogs" around to make it possible for live cases to be made a regular part of training. Our research on socialization of newcomers on aircraft carriers suggests that old hands who tell war stories are an invaluable source of training. Remember, we're talking about organizations in which it is hard to learn by trial and error. The next error may be the last trial. If trial and error learning is limited, then case studies become very important.

5. I think there is a key training lesson in the recent experience with airline training in cockpit crew management. This training didn't have much effect or credibility until the people being trained were put in flight simulators where they solved in-flight problems and were video-taped doing so (Helmreich and Foushee, 1993, p. 28). Pilots saw themselves actually committing the errors that up to then, had only been described in dry classroom lectures. And what may have been most crucial in this Line Oriented Flight Training is that each videotape was erased immediately after the performance had been critiqued. Videotapes of crew interaction during fires, of dispatchers allocating scarce resources, or of administrators briefing local property owners, all could prove to be a valuable window on just how well the struggle for alertness is being waged.

I know these are all small solutions to potentially big problems. But they are a start, they can be done in parallel, they can be done simultaneously in different places, and they may stimulate a better set of starting points.

Lingering Questions

Even though I have some hunches about what might have been going on in South Canyon, there are some questions that continue to baffle me. For example, how is it possible that so many fire orders and Watch Outs were being violated (20/28 were violated according to the South Canyon investigation team, p. 3), enough violations that Rhoades was scared to count them, yet Ryerson is quoted in the Wall Street Journal (8-22-94) as saying "it happened fast enough that none of us knew we were in danger . . . It happened in a matter of seconds" (Page A1, column 1) and Blanco called dispatch shortly before the blowup "and told them that things looked good" (Report, 1994, p. A5-11)? I realize that Ryerson probably means the blowup itself happened fast, yet conditions had been steadily worsening and the blowup was not the first moment people sensed danger. People either weren't keeping score of the number of violations, or didn't want to know the score, or because they arrived at different times with different information had a different sense of the number of violations.

A different set of questions concerns the role that groups play. Why didn't the Prineville Hotshots speed up, look back, drop their tools? Perhaps they didn't think they were in great danger. The fire could have burned straight uphill toward the lunchspot. But what we may also be seeing here is the flip side of what I think happened at Mann Gulch. At Mann Gulch the group disintegrated, which led to a loss of meaning and then to something approximating panic. At South Canyon the group remained together (Report, 1994, p. A4-10) and things stayed meaningful, but people held onto the wrong meaning. Imagine what a typical hotshot might be thinking. Erickson and Haugh are strangers and jumpers to boot; they are saying "run," but this has been a sloppy operation from the start. Furthermore, we didn't hear anything about a weather front nor did we hear the argument about cutting direct line downhill, so presumably we're safe and they're probably exaggerating.

It may be that group ties were too tight among the hotshots, the level of concern was too low, and the meaning persisted, like it did at Mann Gulch, that this is just one more 10:00 fire.

Perhaps there is such a thing as a group being too disciplined and too cohesive. High cohesion wards off panic, but it also encourages groupthink and wards off more disturbing and more varied meanings of what may be happening. Variety may have been crucial to surviving this incident. The 12 people climbing up the fireline toward the ridge all did the same thing and perished. The other 37 people on the mountain did different things, most of which worked. Three ran to the top of the fireline; 8 ran above the lunch spot and deployed shelters; 1 stayed at the lunchspot; 23 headed for Helitack 2 but then stopped and went down various portions of the east drainage; and all of these people lived. Two people tried to make it to Helitack 2, but failed. To put it in the most extreme form, the hotshots didn't panic and that may have been their problem. If they had come closer to doing so they might have lived. I know how bizarre that sounds. But it's important to realize that we are dealing with strong, competing, human tendencies toward independence and conformity. That lies behind respectful interaction. People need sufficient social support to stay calm and sufficient independence to be innovative. People who fight wildland fires aren't freed from this dilemma simply because they are bold. As long as crews and danger and different experiences mix together, we can expect puzzling outcomes.

Notice that we can take a totally different approach in analyzing the Hotshots' behavior. Earlier, I argued that because they were poorly treated in Glenwood Springs, they may have been under some stress when they got to South Canyon. If, in addition, they had doubts about the safety of what they were doing, then the level of stress might have been quite high when they were ordered to retreat to the ridge. If, during hotshot training, people overlearn paramilitary discipline, regimentation, and obedience, then we would expect this pattern of discipline to be especially visible under high stress. The general idea is that when stress increases, people fall back on overlearned habits. Thus, the brisk, well-spaced, steady march up the fireline toward the ridge with tools in hand, may represent the behavior of a group under enormous pressure rather than that of a group that is relatively calm and thinks this is just another fire, albeit one that has been has been managed a bit more poorly than usual.

A further puzzle at South Canyon concerns the possibility that this fire fell in a kind of "no man's land" at a crucial period. Jumpers who dropped on the fire the night of August 5th found a fire that seemed larger than an initial attack fire for which they are experts. When the shots began trickling in around noon on August 6th, they found a fire that seemed smaller than fires for which they are experts. The result is a fuzzy situation where the fire is too big for some, too small for others, and too foreign to the experience of the people in charge. The problem may not be that a transition was mishandled and resulted in fatalities. Rather, the problem at South Canyon may have been that the complexity of the fire fell outside the scope of everyone who tried to control it. If that's plausible then it suggests the need for rethinking the adequacy of existing fire categories and their matchup with training and expertise. Problems may occur not only when fires move from one category to another, but also when they defy categorization in the first place.

As a final lingering question, I wonder if 48 guidelines might be too few guidelines to be of much help to firefighters? There seems to be lots of overlap and similarity among the guidelines, so much so in fact that if we study them closely, we might discover that they have too little variety to match the large amount of variety in wildland fires. If that were possible, then it would explain why firefighters feel they have to violate orders. They do so to regain the variety of attack they feel is necessary to combat the variety in the fire they face. The possibility that 48 guidelines actually reduce requisite variety is also consistent with the idea that these guidelines may serve the function of deflecting blame from administrators onto crews, and are only incidentally relevant to safe practice. With this many guidelines in place, it's fairly easy after the fact for administrators to spot at least one violation that occurred and to spotlight it as THE cause of the accident.

My point here is not to be cynical. Instead, I want to raise the possibility that the system may know less about firefighting than it thinks it does. The multiple guidelines give the impression that much is known, but the guidelines may be redundant, they may say the same thing in several different ways. The result may be that when people take these guidelines seriously they ***reduce*** their ability to sense subtle variations in fire behavior and therefore undertake more dangerous actions. The guidelines may shield management, but they also may create blindspots for firefighters. I think that possibility needs to be explored carefully.

If it turns out that the 48 guidelines say just a handful of different things and anticipate a relatively limited set of variations in fire behavior, then efforts should be made to develop a more comprehensive, more varied set of guides. If it turns out that all 48 are different, varied, and necessary, then it would seem important either to prioritize them as mentioned earlier, or divide up responsibility for them among the crew. If there are 48 guidelines and 10 crew, then each crew member would be assigned 5 guidelines to monitor, champion, and communicate.

Conclusion

Something that both Mann Gulch and South Canyon share in common is a series of events in which something very small escalated into something monstrous. A good example of two events that can be caught in an escalating spiral that starts small and ends monstrous are the events of "fear" and "understanding." As fear increases, understanding

decreases, which causes fear to increase even more, which leads to even less understanding, and this escalation increases until something explodes. That could be what happens as people discuss how to prevent more South Canyons. But if the discussion leads to more understanding, then we create a world where more fear leads to more discussion which leads to more understanding which leads to ***less*** fear. My remarks should be understood as an invitation to discussions that improve our understanding and lessen our fears.

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Appendix E—Related Reports

The Collapse of Decisionmaking and Organizational Structure on Storm King Mountain

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Stress, fear, and panic predictably lead to the collapse of clear thinking and organizational structure. While these psychological and social processes have been well studied by the military and the aircraft industry (Cockpit Resource Management) (Weick 1990 and Wiener, Kanki, and Helmrich 1993), the wildland fire community has not supported similar research for the fireline. The fatal wildland fire entrapments of recent memory have a tragic common denominator—human error. The lesson is clear: studying the human side of fatal wildland fire accidents is overdue.

Historically, wildland fire fatality investigations focus on external factors like fire behavior, fuels, weather, and equipment. Human and organizational failures are seldom discussed. When individual firefighters and support personnel are singled out, it's often to fix blame in the same way we blame fire behavior or fuels. This is wrong-headed and dangerous, because it ignores what I think is an underlying cause of firefighter deaths—the difficulty individuals have to consistently make good decisions under stress.

There's no question individuals must be held accountable for their performance. But the fire community must begin determining at psychological and social levels why failures occur. The goal should not be to fix blame. Rather, it should be to give people a better understanding of how stress, fear, and panic combine to erode rational thinking and how to counter this process. Over the years, we've made substantial progress in modeling and understanding the external factors in wildland fire suppression, and too little in improving thinking, leadership, and crew interactions.

Decisionmaking—A Telling Model

Human thinking and decisionmaking have been studied and modeled. The decision process is essentially additive: A+B+C. For example, a decision to build fireline may be characterized by firefighters (FFa, FFb, FFc, FFd) basing their choice on these factors:

FB—fire behavior
W—weather
FL—fuels
E—equipment
P—personnel, experience, skill
S—safety
M—expectations of management

Numerous studies show no matter how many factors are important, the human mind normally can handle only about seven factors (e.g., seven-digit telephone numbers). People differ both as to how many factors they use and the value placed on these factors. In this modeling, the first factor is the one each firefighter pays the most attention to with the other factors added in decreasing level of importance.

So the decisionmaking processing leading to fireline building could be modeled:

FFa = M+W+FB+S+P+E+FL
FFb = S+P+M+FB
FFc = FB+P+E
FFd = P+E+S+FB+W

Although their decisions were the same, they arrived at them through quite different factor evaluations.

However, in situations that create stress, fear, and panic, minds regress toward simpler, more habitual thinking. This regression could be modeled:

FFa = M+W (Get the work done, weather permitting)
FFb = S (Safety first)
FFc = FB (Fire behavior most important)
FFd = P+E (People and equipment dominant)

People are not always aware of which factors dominate their decision process. Although we say "safety first," this does not mean it's necessarily first in actual decisions. Also, people are seldom aware of the few factors they actually are processing, so they tend to be overconfident in their decisionmaking ability. Although people are unable to use all the available information for decisionmaking, especially when under stress, computers have no such limitation. Computers process information interactively, AxBxC, and can use most of the available information for better decisions. People are very good at determining the state of each factor, the inputs, but not so good at integrating all the factors to make a decision. While computers are of help to incident management teams, normally they aren't available for extended initial attack.

So when fireline conditions are routine, most people would reach similar decisions because they are more aware and take more information into account. When fireline conditions worsen, decisions are more at the mercy of the one or two factors individuals are still processing and their level of experience. In the example above, under stressful conditions even though each firefighter's main factors differ, if they readily communicate as a crew, most of the factors are still present. Although individual decisions are additive, where good communications exist, the group decision can approach the better interactive process.

Studies also show that our linear thinking tends to underestimate hazards, particularly if the hazard is increasing at a logarithmic or exponential rate as can happen on the fireline. An example would be estimating rates of fire spread. A computer would give the better decision in a heartbeat. People would tend to underestimate the rate of spread and have difficulty deciding on an appropriate course of action. And so it is important to understand the limits of how we process information and the common types of errors that can occur.

Leadership and Group Behavior

Stress, fear, and panic take their toll at all levels of the wildland firefighting organization. Under stress, leadership becomes more dogmatic and self-centered. It regresses toward more habituated behavior. Groups tend to fragment under stress into smaller units or to stick together and follow their leader without joining the decisionmaking process. Either way, most of the information available for the best decisions is not utilized.

An extensive 12-year study of Forest Service field crews conducted by sociologist Jon Driessen (1990) showed there is an inverse correlation between crew cohesion and accident rates. The study also identified factors fostering cohesion. Driessen found it takes about 6 weeks for good crew cohesion to take effect. So firefighting crews are predisposed toward accidents until they become cohesive units. Unfortunately, this type of information is not normally considered even when sending crews to riskier fires.

An excellent case study of leadership under stress on a smaller scale is Dr. Karl E. Weick's ***The Collapse of Sensemaking in Organizations: The Mann Gulch Disaster*** (Weick 1993). Although the leadership and organizational structure discussed are based on Norman Maclean's ***Young Men and Fire***, Weick's analysis is thought-provoking. It is also haunting because the ***South Canyon Fire Investigation*** report shows the human and organizational failures on Storm King Mountain are similar to those he hypothesizes happened at Mann Gulch 45 years earlier.

Risk-Taking in Wildland Firefighting

First, wildland fires cannot be fought without risk. Making decisions while at risk assumes firefighters can evaluate the likelihoods of various states of nature. On larger fires, with structured incident management teams (IMT), specialists, and portable weather stations, etc., the likelihoods are more objective and outcomes are better predicted. An excellent study of leadership under stress on a larger (IMT) scale is Taynor, Klein, and Thordsen's 1987 article, ***Distributed Decisionmaking in Wildland Firefighting***. They describe the IMT as a very robust organization due to lengthy experience levels, the common experience of working together, excellent communication structure, and well-defined, well-practiced roles. In contrast, on smaller fires, the likelihoods are more subjective, based on skill and experience rather than instruments. When small fires grow larger and more complex, such subjective estimates become less accurate, and decisionmaking regresses to a reliance on fewer and fewer factors. The result is a failure to keep up with rapidly changing conditions, and people on the fireline are put at greater risk.

Second, risk-taking is subject to perceived and actual rewards and punishments. When we attach a stigma to deploying a fire shelter, we bias firefighters into taking more risks to escape. If there's a stigma associated with dropping packs and tools, firefighters will carry everything while trying to outrun a fire. If a stigma is attached to abandoning a fire or the fireline, firefighters will take more risks to control a fire. The various payoffs associated with risk-taking are not necessarily those managers claim are operating. We need professionals specializing in the study of decisionmaking under stress to interview managers and firefighters, so we can begin to better understand actual risk-taking on the fireline.

Collapse of Decisionmaking on Storm King Mountain

On the South Canyon Fire the first decision failures occurred at the BLM (Bureau of Land Management) district level. Although the fire started July 2 in a fire exclusion zone, resources did not reach the fire until July 5. It was the worst fire season in years and local resources were stressed. Holding costs down and making do with local resources dominated decisionmaking. From our earlier analysis, we can predict a tendency to fall back on habituated tactics, such as letting the fire go until a local crew is available. Although many crews were available nationally, the district did not request help until July 5. The longer initial attack was delayed, the greater the risk the firefighters faced.

An incident commander (IC) from the local BLM district arrived on the fire the morning of July 5. But because of mechanical problems with their chain saws, the IC and crew left the fire that evening as a load of smokejumpers were dropped onto a nearby ridge. The first person out the door of the jumper aircraft became the jumper-in-charge (JIC). Via radio the IC turned the fire over to the JIC. This situation raises two immediate leadership questions: Why did the IC leave the fire? Was first experienced person out the door the best way to choose the JIC?

The jumpers fought the fire most of the night as it continued to grow in size. In response, the JIC ordered two more Type I crews. The IC returned with his crew the morning of July 6. By 10:30 a.m., a second load of jumpers arrived, and the JIC of that plane load became the line scout (LS). The IC and his crew stayed on top of the ridge building fireline, while the jumpers began constructing fireline downhill on the west flank. At 12:30 p.m., 10 members of the Prineville Hotshots (PHS), including

their superintendent, arrived at the fire. The IC, JIC, and PHS superintendent agreed to send 9 PHS down to help build fireline on the west flank. At 3:00 p.m., the remaining 10 PHS arrived at the fire and stayed on top of the ridge with their superintendent to help the IC and his local crew.

So the organization structure before the blowup was:

Location	Local Resources	National Resources
Ridgetop	9 BLM District 2 USFS District 2 Helitack	11 PHS
West flank	None	9 PHS 8 Missoula SJ 4 McCall SJ 2 North Cascades SJ 1 West Yellowstone SJ 1 Grangeville SJ

All the ingredients were in place for a catastrophe. Three local crews (BLM, USFS, Helitack), the Prineville crew split into two groups, and jumpers from five different bases led by two somewhat randomly selected JIC's were thrown together and asked to perform as a team under increasingly unstable conditions. Neither leadership roles nor a cohesive organizational structure stabilized before the blowup.

On the west flank, a group of nine smokejumpers split off to construct fireline to the southwest, forming a third group. These three groups began to focus on their own immediate problems and communications among them continued to decline. As the wind picked up after 3:00 p.m., so did fire activity and firefighter stress levels. And, predictably, decisionmaking and organization collapsed inward, with fatal consequences.

From the ***South Canyon Fire Investigation*** report and witness testimony, we can find signs of collapse similar to those Weick identified in his analysis of Mann Gulch, including:

- Leadership questioned and challenged (for incident commander, jumper-in-charge, and line scout).
- Decisions questioned.
- Most experienced people not consulted and locked out of decision process.
- Poor communication concerning deteriorating conditions—especially among groups.
- Continued fragmentation into smaller groups.
- Decreased talking within groups.
- Failure to integrate vital, available information when changes occurred.
- Failure to act on the weight of the evidence.
- Underestimating the current and potential fire behavior.

Once the blowup occurred, in the ensuing stress, fear, and panic, people's actions followed classic lines of regressing to more habituated patterns of behavior:

- On the ridgetop all but two people ran out the east drainage, a potential death trap. This was not a matter of thought as much as regression—going back the way you had come in.
- The two helitack refused to go into the east drainage and ran back along the ridge they had been dropped off on, possibly looking for a copter pickup site.
- The west flank SJ and PHS went back up the fireline they had been digging.
- Virtually all the escaping firefighters carried their tools and packs even though it cost many of them their lives (Putnam, 1994).
- Even when the firefighters were yelled at to drop their tools and equipment, they did not. This deeply ingrained response pattern resulted in fatalities.
- Even though their lives were at stake, very few firefighters made any attempt to use their fire shelters, resulting in a higher number of fatalities (Putnam 1994).
- Although firefighters knew what fire shelters were and how to open them, they clearly did not know how to use them effectively or where they would work best.

Training to Make Decisions Under Stress

Courses such as *Cockpit Resource Management* train crews to counteract the natural tendencies for behavioral regression. Countermeasures mentioned by Weick and others include:

- Nonstop communication, both verbal and nonverbal is crucial, especially when people first come together.
- Survival goals (threat recognition, escape, shelter use) must be overlearned through repeated practice or they will not be dominant in dangerous situations.
- Cross-train in roles.
- Value wisdom and openness.
- Initiate respectful face-to-face encounters between crew members and between crews.
- Remain curious and observant.
- If things don't make sense, speak up.
- Avoid overconfidence and overcautiousness.
- When situations deteriorate, pay more attention to leadership, perceptions, and group interactions. Strengthen ties.
- Group dynamics before a crisis affect survival during a crisis.
- Expect everyone to work safely, communicate effectively, and cooperate.

- Talk to other crew members and crews. Expect them to talk to you—then listen.

- Be especially wary of accepting increments of worsening conditions. It is deceptive to accept the increments rather than the entire change.

It is apparent from this list that to be adequately prepared requires training, overlearning, and using these skills routinely before a crisis strikes. It is also clear these skills are a necessary prerequisite for effective decisionmaking concerning integrating fire behavior, weather, fuels, equipment, and human factors.

A Start

Within the wildland fire agencies, awareness is growing about the value of cockpit resource management type training and the need to pay more attention to psychological and sociological aspects of fighting fires. Paul Gleason, a seasoned hotshot superintendent, believes that the ***10 Fire Orders***, ***18 Watchout Situations***, and ***9 Downhill/ Indirect Line Construction Guidelines*** can be information overload for the firefighter on the line. For this reason he believes four of the key factors should be constantly emphasized: ***Lookouts, Communications, Escape routes, and Safety zones*** (LCES) as central to safe firefighting (Gleason 1991,1994). We know from our previous model that 30+ warnings are an overload under normal conditions (seven is the practical limit) so LCES, while based on the others, is an excellent system because it is manageable in crisis situations. Since LCES is easy to use, firefighters can constantly reevaluate their situation. Gleason concludes that a change in training content is not needed and that we need to better practice what we already know.

However, I'm arguing that a different kind of training is needed to be able to use our existing knowledge (including LCES) in crisis situations. To link the human factors involved in firefighting to the classic ***Look Up, Look Down, Look Around***, we can add ***Look Inside***. And we could change LCES to I-LCES, where the "I" means Inside, Inner, and Interpersonal.

Patrick Withen, a smokejumper and sociologist, has discussed firefighter attitudes and has pointed out (Withen, 1994) that there is no way to "just say no" in firefighting that doesn't carry formal or informal sanctions. The onus is on the individual firefighter—not management—to justify the decision. Routinely, there is a stigma attached to leaving the fireline.

While looking at the firefighter from psychological and sociological perspectives is encouraging, this idea has not been well received by many in the wildland fire community. When suggested to the South Canyon Fire Investigation Team and the follow-up Review Board as a possible causal factor, the suggestion was dropped from further consideration. Their strongest recommendations should come as no surprise—improve fire behavior prediction, improve weather forecasting, develop better fuel inventories, and look at our firefighting institution from the external perspective. These tried-and-true solutions simply fail to deal with a major cause of the fatalities.

We lost firefighters on Storm King Mountain because decision processes naturally degraded. At this time we do not have training courses that give firefighters the knowledge to counter these processes. Both the Investigation Team and Review Board recommended creating a passion for safety but did not acknowledge that this passion is determined by psychological and sociological processes. The type and skill level of investigation team members and review boards (typically they include IMT personnel, a fire weather forecaster, fire behaviorist, fuels specialist, equipment specialist, but no psychologist or sociologist) predisposes them to focus on the traditional inputs, which effectively excludes other types of input, hence predetermining the outcome. This calls into question the very process and structure by which we investigate fatalities and communicate the results to the fire community. We can and ought to do better.

Discussion

There is no intent here to blame the individual firefighters and managers for what they did or didn't do related to the fire on Storm King Mountain. The real issue is that we are not preparing our firefighters and managers to operate with maximal effectiveness under known stressful, risky conditions. The processes and papers cited, when considered in the light of the South Canyon Fire Investigation report, clearly demonstrate that an almost automatic collapse of decisionmaking and organizational structure occurred. It should also be clear that we are not unique in operating under stressful, risky conditions. Other organizations have reduced fatalities through training using techniques with a proven track record. Paying more attention to the psychological and sociological processes of our people is long overdue.

It is clear that even our best crews are not adequately trained in escape procedures and fire shelter use. This is a reflection of the prevailing attitude among managers that if we give firefighters more training and better predictions for fire behavior, fuels, weather, and tactics, entrapments won't happen. So why plan for them? Individual firefighters agree with their managers and also have the attitude that *it won't happen to me*, so why practice for an entrapment. These attitudes caught up with our best and brightest firefighters on Storm King Mountain and were a causal factor in the fatalities.

Since 1990, extended droughts and more severe fire behavior have shortened the time firefighters have to decide whether to try to escape or to deploy shelters. Some 23 firefighters

have perished trying to escape uphill carrying packs and equipment. Estimates show most would have lived had they simply dropped their gear and run for safety carrying only fire shelters.

This is why mandatory training for shelter use, escape, decisionmaking under stress, and stress-resistant organizational characteristics should become national priorities.

Everyone agrees our top priority should be reducing the number of entrapments by practicing safety and LCES. But we also need to face the reality that on average 30 firefighters are trapped each season, and that we have not taught them how to escape, how to use fire shelters effectively, or the concepts discussed here. Clearly, firefighters need this type of training. Better personal and interpersonal skills will enable firefighters to use all their training and experience optimally under risky, stressful conditions.

Recommendations

❶ Implement recommendations in fire shelter training stemming from the analysis of protective clothing and equipment and its use on the South Canyon Fire (Putnam, 1994).

❷ Convene a task group of firefighters, fire training and safety officers, psychologists, sociologists, and others who will recommend specific actions for individuals and groups that will maximize their resistance to decision and organizational collapse under stressful conditions.

❸ Develop a training program to communicate these new skills to personnel such as Incident Management Teams, Type I and II crews, strike team leaders, and others at risk or who make decisions under stress.

❹ Analyze the organizational structure of initial attack and extended initial attack crews and how these crews interrelate to form an effective organization with optimal leadership and decisionmaking capabilities.

❺ Develop professional requirements, best skills mix, and organizational structure for fatality investigation teams and review boards. Form IMT-type teams before fatalities occur so investigation teams are trained and ready for dispatch.

❻ Consider adding a ***Look Inside*** component to ***Look Up, Look Down, Look Around*** and an "I" to LCES. Incorporate an inner check list into the Fireline Safety Reference Notebook.

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The Collapse of Sense-making in Organizations: The Mann Gulch Disaster

Karl E. Weick. Reprinted from *The Collapse of Sensemaking in Organizations: The Mann Gulch Disaster* by Karl E. Weick published in Administrative Science Quarterly Volume 38 (1993): 628-652 by permission of Administrative Science Quarterly. 0001-8392/93/3804-0628.

This is a revised version of the Katz-Newcomb lecture presented at the University of Michigan, April 23-24, 1993. The 1993 lecture celebrated the life of Rensis Likert, the founding director of the Institute for Social Relations. All three people honored at the lecture—Dan Katz, Ted Newcomb, and Ren Likert—were born in 1903, which meant this lecture also celebrated their 90th birthdays. I am grateful to Lance Sandelands, Debra Meyerson, Robert Sutton, Doug Cowherd, and Karen Weick for their help in revising early drafts of this material. I also want to thank John Van Maanen, J. Richard Hackman, Linda Pike, and the anonymous *ASQ* reviewers for their help with later drafts.

The death of 13 men in the Mann Gulch fire disaster, made famous in Norman Maclean's ***Young Men and Fire***, is analyzed as the interactive disintegration of role structure and sensemaking in a minimal organization. Four potential sources of resilience that make groups less vulnerable to disruptions of sense-making are proposed to forestall disintegration, including improvisation, virtual role systems, the attitude of wisdom, and norms of respectful interaction. The analysis is then embedded in the organizational literature to show that we need to reexamine our thinking about temporary systems, structuration, nondisclosive intimacy, intergroup dynamics, and team building.

The purpose of this article is to reanalyze the Mann Gulch fire disaster in Montana described in Norman Maclean's (1992) award-winning book ***Young Men and Fire*** to illustrate a gap in our current understanding of organizations. I want to focus on two questions: Why do organizations unravel? And how can organizations be made more resilient? Before doing so, however, I want to strip Maclean's elegant prose away from the events in Mann Gulch and simply review them to provide a context for the analysis.

The Incident

As Maclean puts it, at its heart, the Mann Gulch disaster is a story of a race (p. 224). The smokejumpers in the race (excluding foreman "Wag" Wagner Dodge and ranger Jim Harrison) were ages 17-28, unmarried, seven of them were forestry students (p. 27), and 12 of them had seen military service (p. 220). They were a highly select group (p. 27) and often described themselves as professional adventurers (p. 26). A lightning storm passed over the Mann Gulch area at 4 p.m. on August 4, 1949 and is believed to have set a small fire in a dead tree. The next day, August 5, 1949, the temperature was 97 degrees and the fire danger rating was 74 out of a possible 100 (p. 42), which means "explosive potential" (p. 79). When the fire was spotted by a forest ranger, the smokejumpers were dispatched to fight it. Sixteen of them flew out of Missoula, Montana at 2:30 p.m. in a C-47 transport. Wind conditions that day were turbulent, and one smokejumper got sick on the airplane, didn't jump, returned to the base with the plane, and resigned from the smokejumpers as soon as he landed ("his repressions had caught up with him," p. 51). The smokejumpers and their cargo were dropped on the south side of Mann Gulch at 4:10 p.m. from 2000 feet rather than the normal 1200 feet, due to the turbulence (p. 48). The parachute that was connected to their radio failed to open, and the radio was pulverized when it hit the ground. The crew met ranger Jim Harrison who had been fighting the fire alone for four hours (p. 62), collected their supplies, and ate supper. About 5:10 p.m. (p. 57) they started to move along the south side of the gulch to surround the fire (p. 62). Dodge and Harrison, however, having scouted ahead, were worried that the thick forest near which they had landed might be a "death trap" (p. 64). They told the second in command, William Hellman, to take the crew across to the north side of the gulch and march them toward the river along the side of the hill. While Hellman did this, Dodge and Harrison ate a quick meal. Dodge rejoined the crew at 5:40 p.m. and took his position at the head of the line moving toward the river. He could see flames flapping back and forth on the south slope as he looked to his left (p. 69).

At this point the reader hits the most chilling sentence in the entire book: "Then Dodge saw it!" (p. 70). What he saw was that the fire had crossed the gulch just 200 yards ahead and was moving toward them (p. 70). Dodge turned the crew around and had them angle up the 76-percent hill toward the ridge at the top (p. 175). They were soon moving through bunch grass that was two and a half feet tall and were quickly losing ground to the 30-foot-high flames that were soon moving toward them at 610 feet per minute (p. 274). Dodge yelled at the crew to drop their tools, and then, to everyone's astonishment, he lit a fire in front of them and ordered them to lie down in the area it had burned. No one did, and they all ran for the ridge. Two people, Sallee and Rumsey, made it through a crevice in the ridge unburned, Hellman made it over the ridge burned horribly and died at noon the next day, Dodge lived by lying down in the ashes of his escape fire, and one other person, Joseph Sylvia, lived for a short while and then died. The hands on Harrison's watch melted at 5:56 (p. 90), which has been treated officially as the time the 13 people died.

After the fire passed, Dodge found Sallee and Rumsey, and Rumsey stayed to care for Hellman while Sallee and Dodge hiked out for help. They walked into the Meriwether ranger station at 8:50 p.m. (p. 113), and rescue parties immediately set out to recover the dead and dying. All the dead were found in an area of 100 yards by 300 yards (p. 111). It took 450 men five more days to get the 4,500-acre Mann Gulch fire under control (pp. 24, 33). At the time the crew

jumped on the fire, it was classified as a Class C fire, meaning its scope was between 10 and 99 acres.

The Forest Service inquiry held after the fire, judged by many to be inadequate, concluded that "there is no evidence of disregard by those responsible for the jumper crew of the elements of risk which they are expected to take into account in placing jumper crews on fires." The board also felt that the men would have been saved had they "heeded Dodge's efforts to get them to go into the escape fire area with him" (quoted in Maclean, p. 151). Several parents brought suit against the Forest Service, claiming that people should not have been jumped in the first place (p. 149), but these claims were dismissed by the Ninth Circuit U.S. Court of Appeals, where Warren E. Burger argued the Forest Service's case (p. 151).

Since Mann Gulch, there have been no deaths by burning among Forest Service firefighters, and people are now equipped with backup radios (p. 219), better physical conditioning, the tactic of building an escape fire, knowledge that fires in timber west of the Continental Divide burn differently than do fires in grass east of the Divide, and the insistence that crew safety take precedence over fire suppression.

The Methodology

Among the sources of evidence Maclean used to construct this case study were interviews, trace records, archival records, direct observation, personal experience, and mathematical models.

Since Maclean did not begin to gather documents on Mann Gulch until 1976 (p. 156) and did not start to work in earnest on this project until his seventy-fourth birthday in 1977, the lapse of almost 28 years since the disaster made interviewing difficult, especially since Dodge had died of Hodgkin's disease five years after the fire (p. 106). Maclean located and interviewed both living witnesses of the blaze, Sallee and Rumsey, and persuaded both to accompany him and Laird Robinson, a guide at the smokejumper base, on a visit back to the site on July 1, 1978. Maclean also knew Dodge's wife and had talked to her informally (p. 40). He attempted to interview relatives of some who lost their lives but found them too distraught 27 years later to be of much help (p. 154). He also attempted to interview (p. 239) a member of the Forest Service inquiry team, A. J. Cramer who, in 1951, had persuaded Sallee, Rumsey, and ranger Robert Jansson to alter their testimony about the timing of key incidents. Cramer was the custodian of seven or eight watches that had been removed from victims (p. 233), only one of which (Harrison's) was released and used as the official time of the disaster (5:56 p.m.). To this day it remains unclear why the Forest Service made such a strong effort to locate the disaster closer to 6:00 p.m. than to 5:30, which was suggested by testimony from Jansson, who was near the river when the fire blew up, and from a recovered watch that read 5:42. Maclean had continuing access to two Forest Service insiders, Bud Moore and Laird Robinson (p. 162). He also interviewed experts on precedents for the escape fire (p. 104) and on the nature of death by fire (p. 213).

The use of trace records, or physical evidence of past behaviors, is illustrated by the location during a 1979 trip to the gulch, of the wooden cross that had been placed in 1949 to mark the spot where Dodge lit his escape fire (p. 206). The year before, 1978, during the trip into the gulch with Sallee and Rumsey, Maclean located the rusty can of potatoes that had been discarded after Hellman drank its salty water through two knife slits Rumsey had made in the can (p. 173). He also located the flat rocks on which Hellman and Sylvia had rested while awaiting rescue, the juniper tree that was just beyond the crevice Sallee and Rumsey squeezed through on the ridge (p. 207), and Henry Thol, Jr.'s flashlight (p. 183). Considering the lapse of time, the destructive forces of nature over 28 years, and the power of a blowup fire to melt and displace everything in its path, discovery of these traces is surprising as well as helpful in reconstructing events.

Archival records are crucial to the development of the case, although the Forest Service made a considerable effort after its inquiry to scatter the documents (p. 153) and to classify most of them "Confidential" (p. 158), perhaps fearing it would be charged with negligence. Records used by Maclean included statistical reports of fire suppression by smokejumpers in Forest Service Region 1 (e.g., p. 24); the report of the Forest Service Board of Review issued shortly after the incident (dated September 29, 1949, which many felt was too soon for the board to do an adequate job); statements made to the board by people such as the C-47 pilot, parents of the dead crew (p. 150), and the spotter on the aircraft (p. 42); court reports of litigation brought by parents of smokejumpers against the Forest Service; photographs, virtually all of which were retrieved for him by women in the Forest Service who were eager to help him tell the story (p. 160); early records of the smokejumpers organization, which was nine years old at the time of the disaster; reports of the 1957 task force on crew safety (p. 221); and contemporary reports of the disaster in the media, such as the report in the August 22, 1949 issue of ***Life*** magazine.

Direct observation occurred during Maclean's three visits to Mann Gulch in 1976, 1977, and 1978 (p. 189), trips made much more difficult because of the inaccessibility of the area (pp. 191-192). The most important of these three visits is the trip to the gulch with Sallee and Rumsey, during which the latter pair reenacted what they did and what they saw intermittently through the dense smoke. When their accounts were matched against subsequent hard data (e.g., their estimation of where Dodge lit his escape fire compared against discovery of the actual cross planted in 1949 to mark the spot), it was found that their reconstruction of events prior to

the time they made it to safety through the crevice is less accurate than their memory for events and locations after they made it to safety. This suggests to Maclean that "we don't remember as exactly the desperate moments when our lives are in the balance as we remember the moments after, when the balance has tipped in our favor" (p. 212). Direct observation also occurred when Maclean and Robinson themselves hiked the steep slopes of Mann Gulch under summer conditions of heat and slippery, tall grass that resembled the conditions present in the disaster of 1949. The two men repeatedly compared photos and maps from 1949 with physical outcroppings in front of them to see more clearly what they were looking at (e.g., photos misrepresent the steepness of the slope, p. 175). There were also informal experiments, as when Rod Norum, an athlete and specialist on fire behavior, retraced Dodge's route from the point at which he rejoined the crew, moved as fast as possible over the route Dodge covered, and was unable to reach the grave markers as fast as the crew did (p. 67). During these trips, Maclean took special note of prevailing winds by observing their effect on the direction in which rotted timber fell. These observations were used to build a theory of how wind currents in the gulch could have produced the blowup (p. 133).

Personal experience was part of the case because, in 1949, Maclean had visited the Mann Gulch fire while it was still burning (p. 1). Maclean also was a Forest Service firefighter (not a smokejumper) at age 15 and nearly lost his life in the Fish Creek fire, a fire much like the one in Mann Gulch (p. 4). Maclean also reports using his practical experience as a woodsman to suggest initial hypotheses regarding what happened at Mann Gulch (e.g., he infers wind patterns in the gulch from observations of unusual wave action in the adjacent Missouri River, p. 131).

Having collected data using the above sources, but still feeling gaps in his understanding of precisely how the race between fire and men unfolded, Maclean taught himself mathematics and turned to mathematical modeling. He worked with two mathematicians, Frank Albini and Richard Rothermel, who had built mathematical models of how fires spread. The group ran the predictive models in reverse to see what the fire in Mann Gulch must have been like to generate the reports on its progress that were found in interviews, reports, and actual measurements. It is the combination of output from the model and subjective reports that provide the revealing time line of the final 16 minutes (pp. 267-277).

If these several sources of evidence are combined and assessed for the adequacy with which they address "sources of invalidity," it will be found that they combat 12 of the 15 sources listed by Runkel and McGrath (1972: 191) and are only "moderately vulnerable" to the other three. Of course, an experienced woodsman and storyteller who has "always tried to be accurate with facts" (p. 259) would expect that. The rest of us in organizational studies may be pardoned, however, if we find those numbers a good reason to take these data seriously.

Cosmology Episodes in Mann Gulch

Early in the book (p. 65), Maclean asks the question on which I want to focus: "what the structure of a small outfit should be when its business is to meet sudden danger and prevent disaster." This question is timely because the work of organizations is increasingly done in small temporary outfits in which the stakes are high and where foul-ups can have serious consequences (Heydebrand, 1989; Ancona and Caldwell, 1992). Thus, if we understand what happened at Mann Gulch, we may be able to learn some valuable lessons in how to conceptualize and cope with contemporary organizations.

Let me first be clear about why I think the crew of smokejumpers at Mann Gulch was an organization. First, they have a series of interlocking routines, which is crucial in Westley's (1990: 339) definition of an organization as "a series of interlocking routines, habituated action patterns that bring the same people together around the same activities in the same time and places." The crew at Mann Gulch have routine, habituated action patterns, they come together from a common pool of people, and while this set of individual smokejumpers had not come together at the same places or times, they did come together around the same episodes of fire. Westley's definition suggests it doesn't take much to qualify as an organization. The other side is, it also may not take much to stop being one.

Second, the Mann Gulch crew fits the five criteria for a simple organizational structure proposed by Mintzberg (1983: 158). These five include coordination by direct supervision, strategy planned at the top, little formalized behavior, organic structure, and the person in charge tending to formulate plans intuitively, meaning that the plans are generally a direct "extension of his own personality." Structures like this are found most often in entrepreneurial firms.

And third, the Mann Gulch crew has "generic subjectivity" (Wiley, 1988), meaning that roles and rules exist that enable individuals to be interchanged with little disruption to the ongoing pattern of interaction. In the crew at Mann Gulch there were at least three roles: leader, second in command, and crewmember. The person in the lead sizes up the situation, makes decisions, yells orders, picks trails, sets the pace, and identifies escape routes (pp. 65-66). The second in command brings up the rear of the crew as it hikes, repeats orders, sees that the orders are understood, helps the individuals coordinate their actions, and tends to be closer to the crew and more of a buddy with them than does the leader. And finally, the crew clears a fire line around the fire, cleans up after the fire, and maintains

trails. Thus, the crew at Mann Gulch is an organization by virtue of a role structure of interlocking routines.

I want to argue that the tragedy at Mann Gulch alerts us to an unsuspected source of vulnerability in organizations. Minimal organizations, such as we find in the crew at Mann Gulch, are susceptible to sudden losses of meaning, which have been variously described as fundamental surprises (Reason, 1990) or events that are inconceivable (Lanir, 1989), hidden (Westrum, 1982), or incomprehensible (Perrow, 1984). Each of these labels points to the low probability that the event could occur, which is why it is meaningless. But these explanations say less about the astonishment of the perceiver and even less about the perceiver's inability to rebuild some sense of what is happening.

To shift the analytic focus in implausible events from probabilities to feelings and social construction, I have borrowed the term "cosmology" from philosophy and stretched it. Cosmology refers to a branch of philosophy often subsumed under metaphysics that combines rational speculation and scientific evidence to understand the universe as a totality of phenomena. Cosmology is the ultimate macro perspective, directed at issues of time, space, change, and contingency as they relate to the origin and structure of the universe. Integrations of these issues, however, are not just the handiwork of philosophers. Others also make their peace with these issues, as reflected in what they take for granted. People, including those who are smokejumpers, act as if events cohere in time and space and that change unfolds in an orderly manner. These everyday cosmologies are subject to disruption. And when they are severely disrupted, I call this a cosmology episode (Weick, 1985: 51-52). A cosmology episode occurs when people suddenly and deeply feel that the universe is no longer a rational, orderly system. What makes such an episode so shattering is that both the sense of what is occurring and the means to rebuild that sense collapse together.

Stated more informally, a cosmology episode feels like vu jàdé—the opposite of déjà vu: I've never been here before, I have no idea where I am, and I have no idea who can help me. This is what the smokejumpers may have felt increasingly as the afternoon wore on and they lost what little organization structure they had to start with. As they lost structure they became more anxious and found it harder to make sense of what was happening, until they finally were unable to make any sense whatsoever of the one thing that would have saved their lives, an escape fire. The disaster at Mann Gulch was produced by the interrelated collapse of sensemaking and structure. If we can understand this collapse, we may be able to forestall similar disasters in other organizations.

Sensemaking in Mann Gulch

Although most organizational analyses begin and end with decision making, there is growing dissatisfaction with this orthodoxy. Reed (1991) showed how far the concept of decision making has been stretched, singling out the patching that James G. March has done in recent discussions of decision making. March (1989: 14) wrote that "decision making is a highly contextual, sacred activity, surrounded by myth and ritual, and as much concerned with the interpretive order as with the specifics of particular choices." Reed (1991: 561) summarized March this way: "decision making preferences are often inconsistent, unstable, and externally driven; the linkages between decisions and actions are loosely-coupled and interactive rather than linear; the past is notoriously unreliable as a guide to the present or the future; and…political and symbolic considerations play a central, perhaps overriding, role in decision making." Reed wondered aloud whether, if March is right in these descriptions, decision making should continue to set the agenda for organizational studies. At some point a retreat from classic principles becomes a rout.

There have been at least three distinct responses to these problems. First, there has been a shift, reminiscent of Neisser and Winograd's (1988) work on memory, toward examining naturalistic decision making (Orasanu and Connolly, 1993), with more attention to situational assessment and sensemaking (Klein, 1993). Second, people have replaced an interest in decision making with an interest in power, noting, for example, that "power is most strategically deployed in the design and implementation of paradigmatic frameworks within which the very meaning of such actions as 'making decisions' is defined" (Brown, 1978: 376). And third, people are replacing the less appropriate normative models of rationality (e.g., Hirsch, Michaels, and Friedman, 1987) based on asocial "economic man" (Beach and Lipshitz, 1993) with more appropriate models of rationality that are more sophisticated about social relations, such as the model of contextual rationality (White, 1988).

Reed (1991) described contextual rationality as action motivated to create and maintain institutions and traditions that express some conception of right behavior and a good life with others. Contextual rationality is sensitive to the fact that social actors need to create and maintain intersubjectively binding normative structures that sustain and enrich their relationships. Thus, organizations become important because they can provide meaning and order in the face of environments that impose ill-defined, contradictory demands.

One way to shift the focus from decision making to meaning is to look more closely at sensemaking in organizations. The basic idea of sensemaking is that reality is an ongoing accomplishment that emerges from efforts to create order and make retrospective sense of what occurs. Recognition-primed decision making, a model based in part on command decisions made by firefighters, has features of sensemaking in its reliance on past experience, although it remains grounded in decision making (Klein, 1993). Sensemaking emphasizes that

people try to make things rationally accountable to themselves and others. Thus, in the words of Morgan, Frost, and Pondy (1983: 24), "individuals are not seen as living in, and acting out their lives in relation to, a wider reality, so much as creating and sustaining images of a wider reality, in part to rationalize what they are doing. They realize their reality, by reading into their situation patterns of significant meaning."

When the smokejumpers landed at Mann Gulch, they expected to find what they had come to call a 10:00 fire. A 10:00 fire is one that can be surrounded completely and isolated by 10:00 the next morning. The spotters on the aircraft that carried the smokejumpers "figured the crew would have it under control by 10:00 the next morning" (Maclean, p. 43). People rationalized this image until it was too late. And because they did, less and less of what they saw made sense:

1. The crew expects a 10:00 fire but grows uneasy when this fire does not act like one.

2. Crewmembers wonder how this fire can be all that serious if Dodge and Harrison eat supper while they hike toward the river.

3. People are often unclear who is in charge of the crew (p. 65).

4. The flames on the south side of the gulch look intense, yet one of the smokejumpers, David Navon is taking pictures, so people conclude the fire can't be that serious, even though their senses tell them otherwise.

5. Crewmembers know they are moving toward the river where they will be safe from the fire, only to see Dodge inexplicably turn them around, away from the river, and start angling upslope, but not running straight for the top. Why? (Dodge is the only one who sees the fire jump the gulch ahead of them.)

6. As the fire gains on them, Dodge says, "Drop your tools," but if the people in the crew do that, then who are they? Firefighters? With no tools?

7. The foreman lights a fire that seems to be right in the middle of the only escape route people can see.

8. The foreman points to the fire he has started and yells, "Join me," whatever that means. But his second in command sounds like he's saying, "To hell with that, I'm getting out of here" (p. 95).

9. Each individual faces the dilemma, I must be my own boss yet follow orders unhesitatingly, but I can't comprehend what the orders mean, and I'm losing my race with the advancing fire (pp. 219-220).

As Mann Gulch loses its resemblance to a 10:00 fire, it does so in ways that make it increasingly hard to socially construct reality. When the noise created by wind, flames, and exploding trees is deafening; when people are strung out in a line and relative strangers to begin with; when they are people who, in Maclean's words, "love the universe but are not intimidated by it" (p. 28); and when the temperature is approaching a lethal 140 degrees (p. 220), people can neither validate their impressions with a trusted neighbor nor pay close attention to a boss who is also unknown and whose commands make no sense whatsoever. As if these were not obstacles enough, it is hard to make common sense when each person sees something different or nothing at all because of the smoke.

The crew's stubborn belief that it faced a 10:00 fire is a powerful reminder that positive illusions (Taylor, 1989) can kill people. But the more general point is that organizations can be good at decision making and still falter. They falter because of deficient sensemaking. The world of decision making is about strategic rationality. It is built from clear questions and clear answers that attempt to remove ignorance (Daft and Macintosh, 1981). The world of sensemaking is different. Sensemaking is about contextual rationality. It is built out of vague questions, muddy answers, and negotiated agreements that attempt to reduce confusion. People in Mann Gulch did not face questions like where should we go, when do we take a stand, or what should our strategy be? Instead, they faced the more basic, the more frightening feeling that their old labels were no longer working. They were outstripping their past experience and were not sure either what was up or who they were. Until they develop some sense of issues like this, there is nothing to decide.

Role Structure in Mann Gulch

Sensemaking was not the only problem in Mann Gulch. There were also problems of structure. It seems plausible to argue that a major contributor to this disaster was the loss of the only structure that kept these people organized, their role system. There were two key events that destroyed the organization that tied these people together. First, when Dodge told Hellman to take the crew to the north side of the gulch and have it follow a contour down toward the river, the crew got confused, the spaces between members widened appreciably, and Navon—the person taking pictures (p. 71)— made a bid to take over the leadership of the group (p. 65). Notice what this does to the role system. There is now no one at the end of the line repeating orders as a check on the accuracy with which they are understood. Furthermore, the person who is leading them, Hellman, is more familiar with implementing orders than with constructing them or plotting possible escape routes. So the crew is left for a crucial period of time with ill-structured, unacknowledged orders shouted by someone who is unaccustomed to being firm or noticing escape routes. Both routines and interlocking are beginning to come apart. The second, and in some way more unsettling threat to the role

system occurred when Dodge told the retreating crew "throw away your tools!" (p. 226). A fire crew that retreats from a fire should find its identity and morale strained. If the retreating people are then also told to discard the very things that are their reason for being there in the first place, then the moment quickly turns existential. If I am no longer a firefighter, then who am I? With the fire bearing down, the only possible answer becomes, An endangered person in a world where it is every man for himself. Thus, people who, in Maclean's words, had perpetually been almost their own boss (p. 218) suddenly became completely their own boss at the worst possible moment. As the entity of a crew dissolved, it is not surprising that the final command from the "crew" leader to jump into an escape fire was heard not as a legitimate order but as the ravings of someone who had "gone nuts" (p. 75). Dodge's command lost its basis of legitimacy when the smokejumpers threw away their organization along with their tools.

Panic In Mann Gulch

With these observations as background, we can now look more closely at the process of a cosmology episode, an interlude in which the orderliness of the universe is called into question because both understanding and procedures for sensemaking collapse together. People stop thinking and panic. What is interesting about this collapse is that it was discussed by Freud (1959: 28) in the context of panic in military groups: "A panic arises if a group of that kind [military group] becomes disintegrated. Its characteristics are that none of the orders given by superiors are any longer listened to, and that each individual is only solicitous on his own account, and without any consideration for the rest. The mutual ties have ceased to exist, and a gigantic and senseless fear is set free." Unlike earlier formulations, such as McDougall's (1920), which had argued that panic leads to group disintegration, Freud, reversing this causality, argued that group disintegration precipitates panic. By group disintegration, Freud meant "the cessation of all the feelings of consideration which the members of the group otherwise show one another" (p. 29). He described the mechanism involved this way: "If an individual in panic fear begins to be solicitous only on his own account, he bears witness in so doing to the fact that the emotional ties, which have hitherto made the danger seem small to him, have ceased to exist. Now that he is by himself in facing the danger, he may surely think it greater."

It is certainly true in Mann Gulch that there is a real, palpable danger that can be seen, felt, heard, and smelled by the smokejumpers. But this is not the first time they have confronted danger. It may, however, be the first time they have confronted danger as a member of a disintegrating organization. As the crew moved toward the river and became more spread out, individuals were isolated and left without explanations or emotional support for their reactions. As the ties weakened, the sense of danger increased, and the means to cope became more primitive. The world rapidly shifted from a cosmos to chaos as it became emptied of order and rationality.

It is intriguing that the three people who survived the disaster did so in ways that seem to forestall group disintegration. Sallee and Rumsey stuck together, their small group of two people did not disintegrate, which helped them keep their fear under control. As a result, they escaped through a crack in the ridge that the others either didn't see or thought was too small to squeeze through. Wag Dodge, as the formal leader of a group he presumed still existed, ordered his followers to join him in the escape fire. Dodge continued to see a group and to think about its well-being, which helped keep his own fear under control. The rest of the people, however, took less notice of one another. Consequently, the group, as they knew it, disintegrated. As their group disintegrated, the smokejumpers became more frightened, stopped thinking sooner, pulled apart even more, and in doing so, lost a leader-follower relationship as well as access to the novel ideas of other people who are a lot like them. As these relationships disappeared, individuals reverted to primitive tendencies of flight. Unfortunately, this response was too simple to match the complexity of the Mann Gulch fire.

What holds organization in place may be more tenuous than we realize. The recipe for disorganization in Mann Gulch is not all that rare in everyday life. The recipe reads, Thrust people into unfamiliar roles, leave some key roles unfilled, make the task more ambiguous, discredit the role system, and make all of these changes in a context in which small events can combine into something monstrous. Faced with similar conditions, organizations that seem much sturdier may also come crashing down (Miller, 1990; Miles and Snow, 1992), much like Icarus who overreached his competence as he flew toward the sun and also perished because of fire.

From Vulnerability to Resilience

The steady erosion of sense and structure reached its climax in the refusal of the crew to escape one fire by walking into another one that was intentionally set. A closer look at that escape fire allows us to move from a discussion of what went wrong at Mann Gulch, to a discussion of what makes organizations more resilient. I want to discuss four sources of resilience: (1) improvisation and bricolage, (2) virtual role systems, (3) the attitude of wisdom, and (4) respectful interaction.

Improvisation and Bricolage

The escape fire is a good place to start in the search for sources of resilience simply because it is clear evidence that, minimal though the organization of the crew might have been, there still was a solution to the crisis inside the group. The problem was, no one but Dodge recognized this. The question then becomes, How could more people either see this escape fire as a solution or develop their own solution? This is not an easy question to answer because, from everything we know, Dodge's invention of burning a hole in a fire should not have happened. It should not have happened because there is good evidence that when people are put under pressure, they regress to their most habituated ways of responding (e.g., Barthol and Ku, 1959). This is what we see in the 15 people who reject Dodge's order to join him and who resort instead to flight, a more overlearned tendency. What we do not expect under life-threatening pressure is creativity.

The tactic of lighting a fire to create an area where people can escape a major prairie fire is mentioned in James Fenimore Cooper's 1827 novel ***The Prairie***, but there is no evidence Dodge knew this source (Maclean, p. 104). Furthermore, most of Dodge's experience had been in timbered country where such a tactic wouldn't work. In timber, an escape fire is too slow and consumes too much oxygen (p. 105). And the fire that Dodge built did not burn long enough to clear an area in which people could move around and dodge the fire as they did in the prairie fire. There was just room enough to lie down in the ashes where the heat was less intense (p. 104).

While no one can say how or why the escape fire was created, there is a line of argument that is consistent with what we know. Bruner (1983: 183) described creativity as "figuring out how to use what you already know in order to go beyond what you currently think." With this as background, it now becomes relevant that Dodge was an experienced woodsman, with lots of hands-on experience. He was what we now would call a bricoleur, someone able to create order out of whatever materials were at hand (e.g., Levi-Strauss, 1966; Harper, 1987). Dodge would have known at least two things about fires. He would have known the famous fire triangle—you must have oxygen, flammable material, and temperature above the point of ignition to create a fire (Maclean, p. 35). A shortage of any one of these would prevent a fire. In his case, the escape fire removed flammable material. And since Dodge had been with the Forest Service longer than anyone else on the crew, he would also have known more fully their four guidelines at that time for dealing with fire emergencies (p. 100). These included (1) start a backfire if you can, (2) get to the top of a ridge where the fuel is thinner, (3) turn into the fire and try to work through it, and (4) don't allow the fire to pick the spot where it hits you. Dodge's invention, if we stretch a bit, fits all four. It is a backfire, though not in the conventional sense of a fire built to stop a fire. The escape fire is lit near the top of a ridge, Dodge turns into the main fire and works through it by burning a hole in it, and he chooses where the fire hits him. The 15 who tried to outrun the fire moved toward the ridge but by not facing the fire, they allowed it to pick the spot where it hit them.

The collapse of role systems need not result in disaster if people develop skills in improvisation and bricolage (see Janowitz, 1959: 481). Bricoleurs remain creative under pressure, precisely because they routinely act in chaotic conditions and pull order out of them. Thus, when situations unravel, this is simply normal, natural trouble for bricoleurs, and they proceed with whatever materials are at hand. Knowing these materials intimately, they then are able, usually in the company of other similarly skilled people, to form the materials or insights into novel combinations.

While improvised fire fighting may sound improbable, in fact, Park Service firefighters like those stationed at the Grand Canyon approximate just such a style. Stephen Pyne (1989), a Park Service firefighter, observed that people like him typically have discretion to dispatch themselves, which is unfathomable to the Forest Service crews that rely on dispatchers, specialization, regimentation, rules, and a conscious preference for the strength of the whole rather than the versatility and resourcefulness of the parts. Forest Service people marvel at the freedom of movement among the Park people. Park Service people marvel at how much power the Forest Service is able to mobilize on a fire. Pyne (1989: 122) described the Park Service fire operations as a nonstandard "eclectic assembly of compromises" built of discretion and mobility. In contrast to the Forest Service, where people do everything by the book, "The Park Service has no books; it puts a premium on the individual. Its collective behavior is tribal, and it protects its permanent ranks." If improvisation were given more attention in the job description of a crew person, that person's receptiveness to and generation of role improvisations might be enhanced. As a result, when one organizational order collapses, a substitute might be invented immediately. Swift replacement of a traditional order with an improvised order would forestall the paralysis that can follow a command to "drop your tools."

Virtual Role Systems

Social construction of reality is next to impossible amidst the chaos of a fire, unless social construction takes place inside one person's head, where the role system is reconstituted and run. Even though the role system at Mann Gulch collapsed, this kind of collapse need not result in disaster if the system remains intact in the individual's mind. If each individual in the crew mentally takes all

roles and therefore can then register escape routes and acknowledge commands and facilitate coordination, then each person literally becomes a group (Schutz, 1961). And, in the manner of a holograph, each person can reconstitute the group and assume whatever role is vacated, pick up the activities, and run a credible version of the role. Furthermore, people can run the group in their head and use it for continued guidance of their own individual action.

It makes just as much sense to talk about a virtual role system as it does to talk about a virtual anything else (e.g., Bruner, 1986: 36-37). An organization can continue to function in the imagination long after it has ceased to function in tangible distributed activities. For the Mann Gulch fire, this issue has bearing on the question of escape routes. In our research on accidents in flight operations off nuclear carriers (Weick and Roberts, 1993), Karlene Roberts and I found that people who avoid accidents live by the credo, "never get into anything without making sure you have a way out." At the very last moment in the Mann Gulch tragedy, Dodge discovered a way out. The point is that if other people had been able to simulate Dodge and/or his role in their imagination, they too might have been less puzzled by his solution or better able to invent a different sensible solution for themselves.

The Attitude of Wisdom

To understand the role of wisdom (Bigelow, 1992) as a source of resilience, we need to return to the crew's belief that all fires are 10:00 fires. This belief was consistent with members' experience. As Maclean put it, if the major purpose of your group is to "put out fires so fast they don't have time to become big ones" (p. 31), then you won't learn much about fighting big fires. Nor will you learn what Maclean calls the first principle of reality: "little things suddenly and literally can become big as hell, the ordinary can suddenly become monstrous, and the upgulch breezes can suddenly turn to murder" (p. 217). To state the point more generally, what most organizations miss, and what explains why most organizations fail to learn (Scott, 1987: 282), is that "Reality backs up while it is approached by the subject who tries to understand it. Ignorance and knowledge grow together" (Meacham, 1983: 130). To put it a different way, "Each new domain of knowledge appears simple from the distance of ignorance. The more we learn about a particular domain, the greater the number of uncertainties, doubts, questions and complexities. Each bit of knowledge serves as the thesis from which additional questions or antithesis arise" (Meacham, 1983: 120).

The role system best able to accept the reality that ignorance and knowledge grow together may be one in which the organizational culture values wisdom. Meacham (1983: 187) argued that wisdom is an attitude rather than a skill or a body of information:

To be wise is not to know particular facts but to know without excessive confidence or excessive cautiousness. Wisdom is thus not a belief, a value, a set of facts, a corpus of knowledge or information in some specialized area, or a set of special abilities or skills. Wisdom is an attitude taken by persons toward the beliefs, values, knowledge, information, abilities, and skills that are held, a tendency to doubt that these are necessarily true or valid and to doubt that they are an exhaustive set of those things that could be known.

In a fluid world, wise people know that they don't fully understand what is happening right now, because they have never seen precisely this event before. Extreme confidence and extreme caution both can destroy what organizations most need in changing times, namely, curiosity, openness, and complex sensing. The overconfident shun curiosity because they feel they know most of what there is to know. The overcautious shun curiosity for fear it will only deepen their uncertainties. Both the cautious and the confident are closed-minded, which means neither makes good judgments. It is this sense in which wisdom, which avoids extremes, improves adaptability.

A good example of wisdom in groups is the Naskapi Indians' use of caribou shoulder bones to locate game (Weick, 1979). They hold bones over a fire until they crack and then hunt in the directions to which the cracks point. This ritual is effective because the decision is not influenced by the outcomes of past hunts, which means the stock of animals is not depleted. More important, the final decision is not influenced by the inevitable patterning in human choice, which enables hunted animals to become sensitized to humans and take evasive action. The wisdom inherent in this practice derives from its ambivalence toward the past. Any attempt to hunt for caribou is both a new experience and an old experience. It is new in the sense that time has elapsed, the composition of the hunter band has changed, the caribou have learned new things, and so forth. But the hunt is also old in the sense that if you've seen one hunt, you've seen them all: There are always hunters, weapons, stealth, decoys, tracks, odors, and winds. The practice of divination incorporates the attitude of wisdom because past experience is discounted when a new set of cracks forms a crude map for the hunt. But past experience is also given some weight, because a seasoned hunter "reads" the cracks and injects some of his own past experience into an interpretation of what the cracks mean. The reader is crucial. If the reader's hunches dominate, randomization is lost. If the cracks dominate, then the experience base is discarded. The cracks are a lot like the four guidelines for fire emergencies that Dodge may have relied on when he invented the escape fire. They embody experience, but they invite doubt, reassembly, and shaping to fit novelties in the present.

Respectful Interaction

The final suggestion about how to counteract vulnerability makes explicit the preceding focus on the individual and social interaction. Respectful interaction depends on intersubjectivity (Wiley, 1988: 258), which has two defining characteristics: (1) intersubjectivity emerges from the interchange and synthesis of meanings among two or more communicating selves, and (2) the self or subject gets transformed during interaction such that a joint or merged subjectivity develops. It is possible that many role systems do not change fast enough to keep up with a rapidly changing environment. The only form that can keep up is one based on face-to-face interaction. And it is here, rather than in routines, that we are best able to see the core of organizing. This may be why interaction in airline cockpit crews, such as discussed by Foushee (1984), strikes us so often as a plausible microcosm of what happens in much larger systems. In a cockpit under crisis, the only unit that makes sense (pun intended) is face-to-face synthesis of meaning.

Intersubjectivity was lost on everyone at Mann Gulch, everyone, that is, but Sallee and Rumsey. They stuck together and lived. Dodge went his own individual way with a burst of improvisation, and he too lived. Perhaps it's more important that you have a partner than an organization when you fight fires. A partner makes social construction easier. A partner is a second source of ideas. A partner strengthens independent judgment in the face of a majority. And a partner enlarges the pool of data that are considered. Partnerships that endure are likely to be those that adhere to Campbell's three imperatives for social life, based on a reanalysis of Asch's (1952) conformity experiment: (1) Respect the reports of others and be willing to base beliefs and actions on them (trust); (2) Report honestly so that others may use your observations in coming to valid beliefs (honesty); and, (3) Respect your own perceptions and beliefs and seek to integrate them with the reports of others without deprecating them or yourselves (self-respect) (adapted from Campbell, 1990: 45-46).

Earlier I noted a growing interest in contextual rationality, understood as actions that create and maintain institutions and traditions that express some conception of right behavior and a good life with others (Reed, 1991). Campbell's maxims operationalize this good life with others as trust, honesty, and self-respect in moment-to-moment interaction. This triangle of trust, honesty, and self-respect is conspicuously missing (e.g., King, 1989: 46-48) in several well-documented disasters in which faulty interaction processes led to increased fear, diminished communication, and death. For example, in the Tenerife air disaster (Weick, 1990), the copilot of the KLM aircraft had a strong hunch that another 747 airplane was on the takeoff runway directly in front of them when his own captain began takeoff without clearance. But the copilot said nothing about either the suspicions or the illegal departure. Transient cockpit crews, tied together by narrow definitions of formal responsibilities, and headed by captains who mistakenly assume that their decision-making ability is unaffected by increases in stress (Helmreich et al., 1985), have few protections against a sudden loss of meaning such as the preposterous possibility that a captain is taking off without clearance, directly into the path of another 747.

Even when people try to act with honesty, trust, and self respect, if they do so with little social support, their efforts are compromised. For example, linguists who analyzed the conversations at Tenerife and in the crash of Air Florida flight 90 in Washington concluded that the copilots in both cases used "devices of mitigation" to soften the effects of their requests and suggestions:

> A mitigated instruction might be phrased as a question or hedged with qualifications such as "would" or "could." …(I)t was found that the speech of subordinate crew members was much more likely to be mitigated than the speech of captains. It was also found that topics introduced in mitigated speech were less likely to be followed-up by other crew members and less likely to be ratified by the captain. Both of these effects relate directly to the situation in which a subordinate crew member makes a correct solution that is ignored… The value of training in unmitigated speech is strongly suggested by these results. (O'Hare and Roscoe, 1990: 219)

If a role system collapses among people for whom trust, honesty, and self-respect are underdeveloped, then they are on their own. And fear often swamps their resourcefulness. If, however, a role system collapses among people where trust, honesty, and self-respect are more fully developed, then new options, such as mutual adaptation, blind imitation of creative solutions, and trusting compliance, are created. When a formal structure collapses, there is no leader, no roles, no routines, no sense. That is what we may be seeing in Mann Gulch. Dodge can't lead because the role system in which he is a leader disappears. But what is worse, Dodge can't rely on his crew members to trust him, question him, or pay attention to him, because they don't know him and there is no time to change this. The key question is, When formal structure collapses, what, if anything, is left? The answer to that question may well be one of life or death.

Structures For Resilience

While the answer to that question is not a matter of life or death for organizational theorists, they do have an interest in how it comes out. A theorist who hears Maclean's question, "what the structure of a small outfit should be when its business is to meet sudden danger and prevent disaster," might come back with

a series of follow-up questions based on thinking in organizational studies. l look briefly at four such questions to link Mann Gulch with other concepts and to suggest how these linkages might guide further research.

First, there is the follow-up question, Is "small" necessarily a key dimension, since this group is also young and transient? Maclean calls the 16-person smokejumper crew "small," except that it is conventional in the group literature to treat any group of more than 10 people as large (Bass, 1990: 604). Because there is so little communication within the crew and because it operates largely through obtrusive controls like rules and supervision (Perrow, 1986), it acts more like a large formal group with mediated communication than a small informal group with direct communication.

It is striking how little communication occurred during the three and a half hours of this episode. There was little discussion during the noisy, bumpy plane ride, and even less as individuals retrieved equipment scattered on the north slope. After a quick meal together, people began hiking toward the river but quickly got separated from one another. Then they were suddenly turned around, told to run for the ridge, and quickly ran out of breath as they scaled the steep south slope. The minimal communication is potentially important because of the growing evidence (e.g., Eisenhardt, 1993: 132) that nonstop talk, both vocal and nonverbal, is a crucial source of coordination in complex systems that are susceptible to catastrophic disasters.

The lack of communication, coupled with the fact that this is a temporary group in the early stages of its history, should heighten the group's vulnerability to disruption. As Bass (1990: 637) put it, "Groups that are unable to interact easily or that do not have the formal or informal structure that enables quick reactions are likely to experience stress (Bass, 1960). Panic ensues when members of a group lack superordinate goals—goals that transcend the self-interests of each participant." While the smokejumpers have the obvious superordinate goal of containing fires, their group ties may not be sufficiently developed for this to be a group goal that overrides self-interest. Or Bass's proposition itself may be incomplete, failing to acknowledge that unless superordinate goals are overlearned, they will be discarded in situations of danger.

Second, there is the follow-up question, Is "structure" what we need to understand in Mann Gulch, or might structuring also be important? By structure, l mean "a complex medium of control which is continually produced and recreated in interaction and yet shapes that interaction: structures are constituted and constitutive…of interpersonal cognitive processes, power dependencies, and contextual constraints" (Ranson, Hinings, and Greenwood, 1980: 1, 3). Structuring, then, consists of two patterns and the relationships between them. The first pattern, which Ranson et al. variously described as informal structure, agency, or social construction, consists of interaction patterns that stabilize meaning by creating shared interpretive schemes. l refer to this pattern as shared provinces of meaning, or meaning. The second pattern, variously described as configuration, contextual constraints, or a vehicle that embodies dominant meanings, refers to a framework of roles, rules, procedures, configured activities, and authority relations that reflect and facilitate meanings. l refer to this second pattern as structural frameworks of constraint, or frameworks.

Meanings affect frameworks, which affect meaning. This is the basic point of the growing body of work on structuration (e.g., Riley, 1983; Poole, Seibold, and McPhee, 1985), understood as the mutual constitution of frameworks and meanings (Ranson, Hinings, and Greenwood, 1980) or relations and typifications (DiMaggio, 1991) or structures and structuring (Barley, 1986). Missing in this work is attention to reversals of structuration (Giddens, 1984). The use of descriptive words in structuration theory such as "continually produced," "recreated in interaction," "constituted," and "constitutive" directs attention away from losses of frameworks and losses of meaning. For example, Ranson, Hinings, and Greenwood (1980: 5) asserted that the "deep structure of schema which are taken for granted by members enables them to recognize, interpret, and negotiate even strange and unanticipated situations, and thus continuously to create and reenact the sense and meaning of structural forms during the course of interaction." The Mann Gulch disaster is a case in which people were unable to negotiate strangeness. Frameworks and meanings destroyed rather than constructed one another.

This fugitive quality of meaning and frameworks in Mann Gulch suggests that the process of structuring itself may be more unstable than we realized. Structuring, understood as constitutive relations between meaning and frameworks, may be a deviation-amplifying cause loop (Maruyama, 1963; Weick, 1979) capable of intensifying either an increase or decrease in either of the two connected elements. Typically, we see instances of increase in which more shared meanings lead to less elaborate frameworks of roles, which lead to further developments of shared meaning, etc. What we fail to realize is that, when elements are tied together in this direct manner, once one of them declines, this decline can also spread and become amplified as it does so. Fewer shared meanings lead to less elaborate frameworks, less meaning, less elaborate frameworks, and so on. Processes that mutually constitute also have the capability to mutually destroy one another.

If structuration is treated as a deviation-amplifying process, then this suggests the kind of structure that could have prevented the Mann Gulch disaster. What people needed was a structure in which there was both an inverse and a direct relationship between role systems and meaning. This is the only pattern that can maintain resilience in the face of crisis. The resilience can take one of two forms. Assume that we start with an amplifying system like the one in Mann

Gulch. The role system lost its structure, which led to a loss of meaning, which led to a further loss of structure, and so on. This is the pattern associated with a deviation-amplifying feedback loop in which an initial change unfolds unchecked in the same direction. One way to prevent this amplification is to retain the direct relation between structure and meaning (less role structure leads to less meaning, more structure leads to more meaning) but create an inverse relation between meaning and structure (less meaning, more structure, and vice versa). This inverse relationship can be understood as follows: When meaning becomes problematic and decreases, this is a signal for people to pay more attention to their formal and informal social ties and to reaffirm and/or reconstruct them. These actions produce more structure, which then increases meaning, which then decreases the attention directed at structure. Puzzlement intensifies attentiveness to the social, which reduces puzzlement.

The other form of control arises when a change in structure, rather than a change in meaning, is responsible for counteracting the fluctuations in sensibleness. In this variation, less structure leads to more meaning, and more meaning then produces more structure. The inverse relationship between structure and meaning can be understood this way: When social ties deteriorate, people try harder to make their own individual sense of what is happening, both socially and in the world. These operations increase meaning, and they increase the tendency to reshape structure consistent with heightened meaning. Alienation intensifies attentiveness to meaning, which reduces alienation.

What is common to both of these controlled forms is an alternation between attention to frameworks and attention to meanings. More attention to one leads to more ignorance of the other, followed by efforts to correct this imbalance, which then creates a new imbalance. In the first scenario, when meaning declines, people pay more attention to frameworks, they ignore meaning temporarily, and as social relations become clearer, their attention shifts back to meanings. In the second scenario, when social relations decline, people pay more attention to meaning, they ignore frameworks temporarily, and as meanings become clearer, attention shifts back to frameworks. Both scenarios illustrate operations of wisdom: In Meacham's words, ignorance and knowledge grow together. Either of these two controlled patterns should reduce the likelihood of disaster in Mann Gulch. As the smokejumpers begin to lose structure they either also lose meaning, which alerts them to be more attentive to the structure they are losing, or they gain individual meaning, which leads them to realign structure. The second alternative may be visible in the actions taken by Dodge and Rumsey and Sallee.

This may seem like a great deal of fretting about one single word in Maclean's question, "structure." What I have tried to show is that when we transform this word from a static image into a process, we spot what looks like a potential for collapse in any process of social sensemaking that is tied together by constitutive relations. And we find that social sensemaking may be most stable when it is simultaneously constitutive and destructive, when it is capable of increasing both ignorance and knowledge at the same time. That seems like a fair return for reflecting on a single word.

Third, there is the follow-up question, Is "outfit" the best way to describe the smokejumpers? An outfit is normally defined as "a group associated in an undertaking requiring close cooperation, as a military unit" (Random House, 1987: 1374). The smokejumpers are tied together largely by pooled interdependence, since the job of each one is to clear adjacent portions of a perimeter area around a blaze so that the fire stops for lack of fuel. Individual efforts to clear away debris are pooled and form a fire line. What is significant about pooled interdependence is that it can function without much cohesion (Bass, 1990: 622). And this is what may have trapped the crew. Given the constantly changing composition of the smokejumping crews, the task largely structured their relations. Simply acting in concert was enough, and there was no need to know each other well in addition. This social form resembles what Eisenberg (1990: 160) called nondisclosive intimacy, by which he meant relationships rooted in collective action that stress "coordination of action over the alignment of cognitions, mutual respect over agreement, trust over empathy, diversity over homogeneity, loose over tight coupling, and strategic communication over unrestricted candor." Nondisclosive intimacy is a sufficient ground for relating as long as the task stays constant and the environment remains stable.

What the Mann Gulch disaster suggests is that nondisclosive intimacy may limit the development of emotional ties that keep panic under control in the face of obstacles. Closer ties permit clearer thinking, which enables people to find paths around obstacles. For example, when Rumsey squeezed through a crevice in the ridge just ahead of the fire, he collapsed "half hysterically" into a juniper bush, where he would have soon burned to death. His partner Sallee stopped next to him, looked at him coldly, never said a word, and just stood there until Rumsey roused himself, and the two then ran together over the ridge and down to a rock slide where they were better able to move around and duck the worst flames (Maclean, p. 107). Sallee's surprisingly nuanced prodding of his partner suggests the power of close ties to moderate panic.

One might expect that the less threatening the environment, the less important are relational issues in transient groups, but as Perrow (1984) emphasized in his normal accident theory, there are few safe environments. If events are increasingly interdependent, then small unrelated flaws can interact to produce something monstrous. Maclean saw this clearly at Mann Gulch: The colossal fire blowup in Mann Gulch was "shaped by little screwups that fitted together tighter and tighter until all became one and the

same thing—the fateful blowup. Such is much of tragedy in modern times and probably always has been except that past tragedy refrained from speaking of its association with screwups and blow-ups" (Maclean, 1992: 92).

Nondisclosive intimacy is not the only alternative to "outfit" as a way to describe the smokejumpers. Smith (1983) argued that individual behaviors, perceptions of reality, identities, and acts of leadership are influenced by intergroup processes. Of special relevance to Mann Gulch is Smith's reanalysis of the many groups that formed among the 16 members of the Uruguayan soccer team who survived for 10 weeks in an inaccessible region of the Chilean Andes mountains after their aircraft, carrying 43 people, crashed (see Read, 1974 for the original account of this event). Aside from the eerie coincidence that both disasters involved 16 young males, Smith's analysis makes the important point that 16 people are not just an outfit, they are a social system within which multiple groups emerge and relate to one another. It is these intergroup relationships that determine what will be seen as acts of leadership and which people may be capable of supplying those acts. In the Andes crash, demands shifted from caring for the wounded, in which two medical students took the lead, to acquiring food and water, where the team captain became leader, to articulating that the group would not be rescued and could sustain life only if people consumed the flesh of the dead, to executing and resymbolizing this survival tactic, to selecting and equipping an expeditionary group to hike out and look for help, and finally to finding someone able to explain and rationalize their decisions to the world once they had been rescued.

What Smith shows is that this group of 16 forms and reforms in many different directions during its history, each time with a different coherent structure of people at the top, middle, and bottom, each with different roles. What also becomes clear is that any attempt to pinpoint the leader or to explain survival by looking at a single set of actions is doomed to failure because it does not reflect how needs change as a crisis unfolds, nor does it reflect how different coherent groupings form to meet the new needs.

The team in the Andes had 10 weeks and changing threats of bleeding, hygiene, starvation, avalanche, expedition, rescue, and accounting, whereas the team in Mann Gulch had more like 10 minutes and the increasingly singular threat of being engulfed in fire. Part of the problem in Mann Gulch is the very inability for intergroup structures to form. The inability to form subgroups within the system may be due to such things as time pressure, the relative unfamiliarity of the smokejumpers with one another compared with the interdependent members of a visible sports team, the inability to communicate, the articulation of a common threat very late in the smokejumpers' exposure to Mann Gulch, and ambiguity about means that would clearly remove the threat, compared with the relative clarity of the means needed by the soccer players to deal with each of their threats.

The point is, whatever chance the smokejumpers might have had to survive Mann Gulch is not seen as clearly if we view them as a single group rather than as a social system capable of differentiating into many different sets of subgroups. The earlier discussion of virtual role systems suggested that an intergroup perspective could be simulated in the head and that this should heighten resilience. Smith makes it clear that, virtual or not, intergroup dynamics affect survival, even if we overlook them in our efforts to understand the group or the "outfit."

As a fourth and final follow-up question, If there is a structure that enables people to meet sudden danger, who builds and maintains it? A partial answer is Ken Smith's intergroup analysis, suggesting that the needed structure consists of many structures, built and maintained by a shifting configuration of the same people. As I said, this perspective makes sense when time is extended, demands change, and there is no formal leader at the beginning of the episode. But there is a leader in Mann Gulch, the foreman. There is also a second in command and the remaining crew, which means there is a top (foreman), middle (second in command), and bottom (remaining crew). If we take this a priori structure seriously, then the Mann Gulch disaster can be understood as a dramatic failure of leadership, reminiscent of those lapses in leadership increasingly well documented by people who study cockpit/crew resource management in aircraft accidents (e.g., Wiener, Kanki, and Helmreich, 1993).

The captain of an aircrew, who is analogous to a player-coach on a basketball team (Hackman, 1993: 55) can often have his or her greatest impact on team functioning before people get into a tight, time-critical situation. Ginnett (1993) has shown that aircraft captains identified by check airmen as excellent team leaders spent more time team building when the team first formed than did leaders judged as less expert. Leaders of highly effective teams briefed their crewmembers on four issues: the task, crew boundaries, standards and expected behaviors (norms), and authority dynamics. Captains spent most time on those of the four that were not predefined by the organizational context within which the crew worked. Typically, this meant that excellent captains did not spend much time on routine tasks, but less-excellent captains did. Crew boundaries were enlarged and made more permeable by excellent captains when, for example, they regarded the flight attendants, gate personnel, and air traffic controllers as members of the total flight crew. This contrasts with less-excellent captains, who drew a boundary around the people in the cockpit and separated them from everyone else.

Excellent captains modeled norms that made it clear that safety, effective communication, and cooperation were expected from everyone. Of special interest, because so little communication occurred at Mann Gulch, is how the

norm, "communication is important," was expressed. Excellent crews expect one another to enact any of these four exchanges: "(1) I need to talk to you; (2) I listen to you; (3) I need you to talk to me; or even (4) I expect you to talk to me" (Ginnett, 1993: 88). These four complement and operationalize the spirit of Campbell's social imperatives of trust, honesty, and self-respect. But they also show the importance of inquiry, advocacy, and assertion when people do not understand the reasons why other people are doing something or ignoring something (Helmreich and Foushee, 1993: 21).

Issues of authority are handled differently by excellent captains. They shift their behaviors between complete democracy and complete autocracy during the briefing and thereafter, which makes it clear that they are capable of a range of styles. They establish competence and their capability to assume legitimate authority by doing the briefing in a rational manner, comfortably, with appropriate technical language, all of which suggests that they have given some thought to the upcoming flight and have constructed a framework within which the crew will work.

Less autocratic than this enactment of their legitimate authority is their willingness to disavow perfection. A good example of a statement that tells crewmembers they too must take responsibility for one another is this: "I just want you guys to understand that they assign the seats in this airplane based on seniority, not on the basis of competence. So anything you can see or do that will help out, I'd sure appreciate hearing about it" (Ginnett, 1993: 90). Notice that the captain is not saying, I am not competent to be the captain. Instead, the captain is saying, we're all fallible. We all make mistakes. Let's keep an eye on one another and speak up when we think a mistake is being made.

Most democratic and participative is the captain's behavior to engage the crew. Briefings held by excellent captains last no longer than do those of the less-excellent captains, but excellent captains talk less, listen more, and resort less to "canned presentations."

Taken together, all of these team-building activities increase the probability that constructive, informed interactions can still occur among relative strangers even when they get in a jam. If we compare the leadership of aircraft captains to leadership in Mann Gulch, it is clear that Wag Dodge did not build his team of smokejumpers in advance. Furthermore, members of the smokejumper crew did not keep each other informed of what they were doing or the reasons for their actions or the situational model they were using to generate these reasons. These multiple failures of leadership may be the result of inadequate training, inadequate understanding of leadership processes in the late '40s, or may be attributable to a culture emphasizing individual work rather than group work. Or these failures of leadership may reflect the fact that even the best leaders and the most team-conscious members can still suffer when structures begin to pull apart, leaving in their wake senselessness, panic, and cosmological questions. If people are lucky, and interpersonally adept, their exposure to questions of cosmology is confined to an episode. If they are not, that exposure stretches much further. Which is just about where Maclean would want us to end.

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This document includes an overview and the findings of a workshop held to address the human factors involved in firefighter safety. The deaths of 34 firefighters during the 1994 fire season, including the 14 firefighters who died on the South Canyon Fire in Colorado, helped point out the need for the workshop. Participants explored firefighter psychology, interactions among firefighters and among fire crews, and better ways to organize firefighters. Appendixes include the four keynote presentations and two related papers addressing human factors involved in firefighter safety.

Keywords: group behavior, organizational behavior, psychological factors, safety, sociological analysis.