Coal Canyon Fire

August 11, 2011

Serious Accident Investigation Report--Discussion and Analysis for Organizational Learning

Hell Canyon Ranger District
Black Hills National Forest
South Dakota

Introduction

Purpose and Philosophy

The purpose of this document is to promote dialog and learning from the Coal Canyon Fire. It is built on the philosophy that genuine learning is more than a transfer of information; it is an active process in which you develop your own understanding by personally engaging with events and ideas. This kind of learning also involves dialog among people with different perspectives, at different levels in your organization.

We approach the accident from multiple perspectives. Two reasons for this: First, firefighters on scene experienced these events from multiple points of view; so, part of understanding the accident is seeing it from their various perspectives. Second, you, the readers have diverse perspectives. You are diverse with respect to the agencies you work for, your levels of experience and responsibility, your learning styles, and your specific learning objectives.

There is also diversity in how you perceive and approach risk, and this offers opportunity and challenge. Bringing together multiple viewpoints provides tremendous opportunity to generate meaningful improvements to our complex organization. Yet it creates challenges as gaps emerge between beliefs about operations and the realities of operations.

This document paints a picture of real world decision-making and risk management as they occurred on the Coal Canyon Fire. We aim to get close to these events, *as firefighters experienced them, when it was time to act*. The purpose is to feed inquiry and robust discussion about risk. The approach relies on you to bring in your professional background and experience, and to engage in dialog with others in your organization. Over time, this will help bridge the gap between operations in theory and operations on the line, and it will support meaningful collaboration and improvement.

The Discussion and Analysis will also explore a number of Human Performance concepts. Some of these ideas will be new, some may seem wrong or inapplicable, and some will only describe what you already know and do. The concepts are here for you to use as you develop your own understanding of these events.

Using This Document

To serve these purposes, we shall be using a more conversational style than what you'll find in other parts of the Serious Accident Investigation (SAI) Report.

A quick note on tenses: In some places, we ask you to put yourself in the middle of the action, to try to see the world as decision-makers themselves saw it at the time, complete with the contradictions, surprises and uncertainty surrounding them. When we are trying to present the actors' in-the-moment perspective, we use **present tense**. On the other hand, we generally use **past tense** when we step back to analyze events as completed history. Past tense indicates a perspective from which the dust has settled and the smoke has cleared; outcomes are known,

and we have access to concepts and information outside the decision-makers' perspective. The Discussion and Analysis switches between these perspectives, in order to generate a multi-faceted understanding of events.

To get a more linear and complete overview of the story you have additional resources: you can refer to the **Expanded Narrative**, the concise narrative and the chronology in the main **SAI Report**, and the **Google Earth Depiction** (see below). Because these learning tools serve different functions, there are some differences in the narrative details included in each. Some quotes have been adapted to fit the narrative, while still preserving original meaning. The **Legend of Resources** toward the end of this document may be useful for keeping track of the fictitious, gender-neutral names used here.

Further Learning

The link below accesses a Google Earth presentation, which gives a brief overview of the Coal Canyon Fire. It is suitable for self-study and discussion. Download and open the zip file, which contains the Google Earth file and a facilitator's how-to guide. Once Google Earth is installed, double-click on the CoalCanyonFire.kmz file to begin.

Coal Canyon Fire Depiction Using Google Earth
http://wildfirelessons.net/documents/CoalCanyon.zip

> *To view the file: download it, load it into Google Earth, and follow the prompts. The user must have Google Earth installed; this software may be downloaded free of charge from http://www.google.com/earth/download/ge/*

In addition to learning from the tragedy at Coal Canyon, wildland fire-management organizations must strive to learn from how they study and present such accidents to the fire community. Help us continuously improve by providing feedback about the Coal Canyon Serious Accident Investigation and associated learning tools. Please follow the link below to fill out a brief questionnaire. Responses are anonymous, and they will help us improve this process and better serve the fire community.

Coal Canyon SAI Feedback Questionnaire (for use by federal employees only)

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I. Entrapment and Escape on Road 318

Intended Primary Audience
All firefighters

Why Did E2 Drive Forward?

Why did E2 drive forward? Look at this action through a real-time risk management lens, based on the information available to the driver and crew leader at the time. Consider these details:

> *We experience life moving forward, but only make sense of it looking backward.*
> -Adapted from Søren Kierkegaard

- The firefighters in E2 had at least two options for escape: drive up the road and out the way they came in, or drive down the road. Think of these as their primary and alternate escape routes.
- A tree was torching behind the vehicle. As with any engine, visibility inside the vehicle was limited. The driver saw smoke and fire behind him. The road curved, and the vehicle was oriented so the torching tree filled the driver's line of sight in his mirror. They saw far less smoke and flame in the road ahead.
- The engine was facing toward the top of the road. Driving forward is safer and more natural than driving in reverse, especially when you can't see what's behind you. Firefighters are trained to back their vehicles when parking, so they're ready to pull forward when it's time to go.
- Humans tend to go out the same way they came in. This is common in auditorium fires—audience members tend to crowd around the door they used to enter the theater, while other exits go unused.

Figure 1-Reconstruction of the driver's perspective when he had to take action

Set aside everything you know as a reader with hindsight and put yourself in the driver's seat at that time…

You have to GO, now. This fire is changing fast. You see smoke and fire behind you, and there are spots and torching back there. You don't know exactly what else is back there. You came in from the top and that way looks clearer from where you're sitting. You can drive forward safer and faster than if you try to do it in reverse. You've lost visual contact with the people behind you. But, they're on foot, so they've gone somewhere, and they didn't run forward past you, and they haven't jumped in the engine. They must have gone back to where it was calm and cool behind the spots. Or they might be in the road—so if you pull back you might hit them. From where you're sitting, every move you make is a gamble. Right now, will you:

- *Drive backward?*
- *Wait and figure out where the firefighters went who were behind you earlier, but now seem to have left?*
- *Drive forward?*

The driver and crew leader quickly talk, "Were gonna get out of this together. What do we do? We're gonna run up and out to the top."

So they drive forward.

In order to respond to risk and get to safety, they took the best option they saw.

Human Performance Under Stress

So far, we've been discussing this progression of events in terms of knowledge, options, and information—almost as a series of *decisions*. Now let's look at human physiology and how adrenaline affects our bodies and brains when we sense threat.

> *The decisions, judgments and perceptions that may seem so puzzling are just that: decisions, judgments and perceptions — if they are that at all.*
>
> -Adapted from Dekker, 2006, p. 41

From this angle, it would be a mistake to think firefighters had the cool and comfort and space and time that we now have to evaluate the situation and make a well-deliberated decision. They were reacting to survive, in the middle of it.

The human stress reaction is a physical, chemical change in the body and brain. Your heart rate and breathing speed up as you get ready to respond immediately and intensely to threats and challenges. A building cascade of hormones like adrenaline changes how your neurons, blood vessels, internal organs, skin, muscles, heart, lungs, and nerves function.

This escalation overpowers the deliberative thinking part of your brain, and the instinctive reacting part takes over. Your attention increasingly focuses on narrow immediate goals, like just getting to safety or winning.

Information and events become less and less likely to make it into your awareness. Communicating becomes more difficult, so does understanding what other people mean when they're talking to you—if you even hear them at all.

The hyper-focus, increased pain tolerance and onrush of physical energy are powerful and help you react quickly, fight hard, and move fast. This helped our species survive through hostile pre-historic environments.

This escalation prepares you to take intense extreme immediate action, yet it makes deliberative thinking more difficult. Things become harder and harder to figure out, unless they're automatic. Options disappear. You tune out inputs if it's not clear what to do with them right now. You can't waste time with second-guessing, speculation or uncertainty.

So, just when the complexity and risk of the situation is multiplying, your ability to think about all that is constricting. Now is the time to go for it, whatever *it* is.

In some ways, your performance sharpens. At the same time, some of the simplest tasks become difficult. Things aren't working how they're supposed to, like your fingers and your hands.

The world can become narrower and narrower, an increasingly frustrating and baffling place with very little room to maneuver. As you react to what is right here right now, you are neurologically less able to think about what is over the horizon or around the corner—or what might be. Ingrained habit, training, and instinct drive your reactions to specific, close-by, immediate stimuli.

Human Variability Under Stress

How you're reacting, and *what* exactly you're reacting to may have nothing to do with anyone else's big picture, so your actions may not make sense to anyone else. But this isn't the time for sensemaking; this is the time to act. Moreover, how you act is not entirely predictable. Sometimes people hunker down and hang on; sometimes they become hostile; sometimes they run. Sometimes they run the other way. Also, the stress reaction is not an all-or-nothing game, so what gets a shrug today may evoke an animal reaction tomorrow.

Without trying to guess at the minds of the firefighters in the cab, we can know they were in a stressful situation. We don't need to determine their exact stress level, or how far along this escalation they went. That wouldn't be the point here, anyway.

There is great variability in how humans react to situations they perceive as threatening. So, regardless of what you and I and anyone else may know about the situation, we can't be surprised if human beings, while sensing great threat, take action we didn’t expected.

Normal Human Variability

There's great variability in human performance anyway, even without stress. There's a range of meanings and reactions we could have for any event. We notice different things and interpret them in different ways, depending upon our mindset at the time and the mix of experiences we've had.

Usually, these variations don't have big consequences. We don't notice or plan for variability, because there's enough margin to recover, re-sync, and regain equilibrium as we're going along together. That's how things usually go. Yet, at some points, margins are narrow and stakes are high, and slightly different actions can lead to very different outcomes.

In hindsight, it's easy to ask, "Why didn't everyone just do the exact same thing that we now know worked out best?" The question could lead us astray, and trap us into thinking firefighters made poor decisions that should have been obvious at the time. The accusatory path is alluring: it allows us to distance ourselves from reality and provides some comfort. Yet, if we try to take a path of inquiry, we find:

They didn't all do the same thing, because different people react differently to the same situation—human variability is always in the mix.

They didn't all take the path that worked out best, because when they had to take action, they didn't yet know the future.

Human Variability on Razorback Ridges

Think about the difference between hiking in a canyon bottom vs. hiking on a razorback ridge. Watch a group hiking through a canyon and you will see variability: everyone has a slightly different stride and pace, speeding up and slowing down, and some will move a few steps to the right or left for whatever reason (or for no reason). Some might veer more widely and walk sidehill for a while. But they all end up the same place. In the end, all the little zigs and zags don't affect the outcome.

Now think about a group walking across a razorback ridge. Imagine there is some trouble on the ridge ahead, and you have to maneuver somehow. Some might take a few steps to the right, some to the left; some keep walking straight until they get closer to the problem and then figure out where to dive off.

If the terrain is complex, these little variations in maneuvering may take you downhill along very different paths. If it is smoky enough or if you are above a cloud layer, you may not know exactly where you are heading. If it is steep enough, you may not have a chance to change your mind, backtrack, and try a different route. If things happen fast enough, you may not know where everyone else is or what they are thinking.

On a razorback ridge, small differences in maneuvering—just inches and seconds—might lead you in very different directions. Whether you zig or zag or hunker down, and *when* you do it, may lead to very different results. And, you may not be able to see far enough into the future to know which zig or zag to go for, or how it's going to work out.

Most of the time, our job is like hiking in a canyon. Slight differences in human action don't affect the big picture: the group ends up in pretty much the same place. Sometimes though, fighting fire is like walking across a razorback ridge: it is suddenly time to go one way or the other; you can't yet see the end result clearly; and once you commit, you're committed.

In terms of real-time risk, canyons sometimes turn into ridges, and the change may not be anticipated or obvious. And, even if you do realize you're now running a ridge, you may see no guaranteed route or right time to take it. A moment ago, it seemed you had plenty of time and space to maneuver. Suddenly, your margin is gone; inches and seconds make a difference, but you're not sure exactly what to go with or when.

Historical Accounts of Variability in Fire Entrapments

Historical fire accounts show how slightly different actions can lead to very different results. In moments of complex and immediate threat, there may not be a right move with a guaranteed result. The same actions that led to survival in some moments of crisis, led to loss in others.

During the Great Idaho Fires (1910), Ed Pulaski corralled his 45-person crew into a mineshaft and held them there at gunpoint. They all survived, except for five. Compare this to South Canyon (1994): on the west flank, staying with the group did not lead to survival—the firefighter who survived broke ranks.

On the Mann Gulch Fire (1949), Wag Dodge lit the grass where he was standing, in order to burn a safety zone ahead of the approaching fire front. He stayed there and survived. His firefighters ran, but did not survive, except for two who happened to make it through a crevice at the ridge top.

Finally, consider the Thirtymile (2001) entrapments. Some firefighters in shelters took unbearable heat, but others did not, even though some deployed near one another.

The First Rescue and Escape (Entrapment Site 1)

Let's back up in time, to a few minutes before the engine drove forward and was entrapped...

It's a normal day. There's some isolated torching down inside the black, but not much wind. E2 was doing a hose lay along the cool western edge. The edge turned and ran about a chain below and parallel to the road. They stayed direct along the edge, and the line was holding—even the scratch line ahead of their hose lay. Then, they got some spots over the road, so they moved the engine forward a bit.

Now they are working the spots. Kyle is standing behind the engine, by the pump, nozzle in hand. There's torching behind him. Reese is walking back down the road from the top, telling the engine to back up, again and again. They don't hear any of this. Reese passes the engine and now he's standing behind Kyle, expecting they'll start backing—now.

Then, all at about the same time: E2 drives up the road and disappears from view. Kyle drops the hose. Another firefighter, Kendall bursts up onto the road, crashing through the brush from below, with a sense of urgency he can't pinpoint.

Now Kyle, Reese, and Kendall are there, stunned.

The torching tree is still torching, and it's torching more. Kyle is in the middle of wind and heat and roar. He turns in a circle, a full 360°, looking for what to do and afraid to breathe. He lies down in the road, pack beside him.

Kendall and Reese notice him there, not far from them. They're baffled and frustrated.

Kyle hangs on for his life, keeping his head low, and protecting his airway. Smoke and flame bend over the road and now he's hidden from view. They're yelling at him. A window opens in the

torching and Reese steps in, hurls Kyle up by a handful of belt and yellow, and sets him on his feet.

Kyle races down the road toward E1, where they sit him down and begin first aid. Kyle is very thirsty. Soon he wants more and more water and keeps pouring it on himself, trying to soothe his arms and shoulders and skin. He's cold, and Reese gives him his space blanket.

Let's back up. Why did Kyle stay there next to the torching tree? Then, why lie down? Safety was just behind him, just a few steps away.

From the clarity of the training room, his actions seem puzzling. But he didn't have the knowledge and perspective we have now; right then, he only had his own. His narrowing world is rushing smoke and fire and pelting embers stinging and getting louder smokier and chokier and hotter and hotter.

Recall human variability under stress—we can't be surprised that he's stunned by what's going on, between the truck leaving and the torching. And we can't be surprised that whatever people are yelling, none of it makes sense enough to act on, if he's hearing it at all.

Immobilized, he did as he had drilled who knows how many times: he dropped to the ground and protected his airway, nuzzling his face into a groove in the road, arms pressed against the sides of his head. As it turns out, this saved his airway and allowed him to survive while sustaining severe burns.

All of this is such a shocking violation of onlookers' expectations; none of it makes sense to them. They're stumped, and it's enraging. They spoke and warned and yelled and pointed as clearly as anyone can, right? What didn't those guys understand, and what are they doing?

Right now, the worlds of the entrapped firefighters are very different from the worlds of their on-looking friends nearby. Nobody understands what the others are doing or what they're saying—if there's anyone else in their world right now at all.

The Driver's Escape (Entrapment Site 2)

Now let's move forward to the driver's escape…

The vehicle has driven forward, and was cut off by a wall of flame. So they pull back, and get stuck in the draw. The engine quits and now the fan is blowing hot air at them. Drew reaches out and turns it off, "We have to." He has his fire shelter out. As Rory's trying to get to his, Drew throws his shelter over them both. They're going to have to ride it out. They grab a radio, call Mayday, and make contact with Reese. The truck itself is catching fire and now there's smoke and flame inside the cab; over the radio they hear guys talking about trying to help them.

Then Reese radios, "You got a way out. Now's the time. Go down the road. Go. Do it now." Inside the cab, they talk, "Now's the time we gotta' go okay. Okay." The driver, huddled under the

shelter and breathing under his shirt, takes a deep breath, opens the door and runs. Next thing he knows, he's with Kyle and the group behind the other engine.

Look at the conditions and circumstances that allowed for Rory's escape:

- They had two shelters in cab of the truck. When Rory was struggling to get his shelter out of his pack, Drew pulled his own shelter over Rory, and they shared. They were breathing under their shirts. This allowed them to survive long enough for a window in fire intensity.
- They maintained radio communications while inside the shelter.
- Other firefighters intervened. When Reese and Kendall saw a brief window in fire intensity, they told the firefighters in the cab to get out.
- The firefighters in the cab knew and trusted Reese enough to try to leave the cab when he called them.

Together, these conditions allowed the firefighters to survive long enough to attempt escape when the fire gave them an opportunity.

With hot gas funneling into the cab, Rory made it out, but Drew did not. One difference stands out between Drew's situation and Rory's:

- Rory was able to get past the most intense heat without inhaling hot gas, but Drew was unable to complete his escape before taking another breath.

We do not know all the factors affecting fire behavior and the firefighters' escape attempts. Yet, one detail is clear: Rory, while under the shelter, took a deep breath before breaking the seal, and this enabled him to maneuver past the most intense heat before needing another breath.

This offers potential implications for training and operations.

While taking refuge in a vehicle or deploying a fire shelter, you are insulated from outside conditions. If you judge it's time to leave, you may encounter extreme conditions or unpredictable pulses of hot gas. Being able to maneuver through these conditions without having to inhale may be critical to survival. How can you increase the odds you'll be able to do this? If you can take a deep breath before leaving your shelter or refuge—so your lungs are already full of breathable air, before you break the seal and face conditions outside—this may give you a few extra seconds to maneuver and increase your chances of getting to safety.

The potential training application: In shelter drills, make a habit of taking a breath so your lungs are full of air, before breaking the seal and exposing yourself to the environment outside. The key would be to forge this habit through repetition, so you do it even in training, when you know the outside air is fine.

This discussion is not meant to suggest that Drew didn't take a breath before leaving the shelter, or that he would have survived if he had. Those details are not knowable. We do know what helped Rory escape, and may someday help other firefighters out of a bad situation.

Further Reading

On the Stress Reaction

Deep survival. L. Gonzales, 2003.

Judgment and decision making under stress: An overview for emergency managers. K. M Kowalski-Trakofler, C. Vaught and T. Scharf, 2003.

On Understanding Decisions and Actions in Context

Mistaking Error. D. Woods, and R. Cook, 2004.

Reconstructing human contributions to accidents: The new view on error and performance. S. Dekker, 2002.

Quote for Discussion

"Research that focuses on judgment must include scrutiny not only of decisions that are made, but also of real-world variables that influence them. The quality of any decision may have little or no direct relationship to the eventual outcome of its execution in a given situation. This is because a decision-maker is constrained not only by the stress of the situation or personal knowledge and attitudes, but also because he or she can only weigh information that is available. Acknowledging the complex context of concrete decision-making environments is a first step to understanding the skill of decision-making."

-Vaught et al., 2000, pp. 98, 99.

II. Risk and Resilience in Coal Canyon

1. Resilience on the Coal Canyon Fire

1a. Resilience and Rescue

Intended Primary Audience
ICT5s, ICT4s, ICT3s, module leaders

"To understand how [an accident] sometimes happens one must first understand how success is obtained—how people learn and adapt to create safety in a world fraught with gaps, hazards, [and] tradeoffs."

—Woods and Hollnagel, 2006, p. 3

Let's go to the moment when E2 drove away. In Section I, we sought the perspective of the entrapped firefighters. Now let's approach these events from the perspective of firefighters nearby…

He had spoken as clearly as he could, had given direct orders, told them which way to go. Said it over the radio, shouted it as he approached the vehicle, said it again to the driver as he walked past the open window, and again to the firefighter at the rear of the truck. "Back up now." Clear enough. They'll back up.

Before this, Reese was walking up the road toward the top, and his path was cut off by a flare up. Doesn't look like the road's going to hold the fire. He heads back down toward the engines, walking through that corner, above the draw. His engine and four others were log-jammed at this nasty spot less than a half-hour ago—they decided to park in the meadow above the fire and hike in rather than stay near that draw.

He sees a spot fire above the engines; then there's more. Is the whole canyon gonna go? Everyone needs to get back behind the spots and torching. He radios for everyone to back up, and now he's nearing E2 and yelling at them to back up. He passes them, shielding his face from a torching tree behind their engine. As E1 backs, he continues down to recheck the cool western edge—it's still holding fine. He stops to watch and make sure everyone gets moving. They just need to pull back 20 feet.

Why isn't E2 moving, yet?

The reverse lights flick on a moment—here they come. All right, they're finally backing.

They pull straight forward, directly toward the nasty draw and the flare up.

Take a step back from the action: This was a moment of fundamental surprise for Reese. It was clear to him what needed to be done. The engine had to back up, and he told them several times. Why would he doubt that was about to happen? Everything seemed on track—everyone was about to get to safety and then they'd reassess and make the next move.

Look at how he was handling risk (see the Expanded Narrative for more detail). Much of his action has been anticipatory: he and others were mitigating hazards they might face later. They couldn't know exactly how things would unfold: they knew the potential for surprise was

everywhere, and they couldn't imagine or prepare for every possibility, much less every *combination* of possibilities. Yet, they were sensing multiple ways trouble could form, and they were acting to head off an array of potential problems.

That's the anticipatory aspect of their risk management.

They were also handling risk reactively: as specific risks and problems began to materialize, they recognized them early, took decisive action, and changed course to avoid trouble. All while they still had sufficient margin of time and space to maneuver.

Up to the point when E2 still wasn't pulling back, the situation seemed manageable enough. The fire was changing, and they were adjusting. Nothing unimaginable had happened. They weren't being stretched beyond their ability to adapt. The situation didn't seem unmanageable—not even close. Why would it?

But, starting at this point, what's happening is the opposite of what Reese was expecting. Of all the ways he thought things could go wrong, the engine pulling forward wasn't one of them.

Back into the action:

For a moment, Reese stands there, stunned. Not believing what he's seeing.

Kendall crashes up onto the road through the brush. Minutes earlier, he was over on the left flank; he had a gut feeling he should go to the road for some reason, so he started hiking, then sprinting. He can't explain his urgency. He meets Reese on the road and realizes what just happened with E2. For a moment he and Reese are stunned and angry together.

What they are about to do is critical: they will regain themselves, reorient themselves to the new events, see opportunities, and act to handle what's now emerging.

Look at this pattern: Elements of the situation that seemed under control a moment ago are suddenly out of their hands; the situation is deteriorating in stunning ways. They accept this new reality, see where they have real leverage, and act. Here's how it goes:

Reese sees Kyle lying on the ground. During a lull in the torching, he pulls him out of harm's way. Reese and Kendall radio the engine and yell after them. A moment later, the engine radios and says they're stuck, so Reese and Kendall try to rescue them. They keep trying to run in, again and again, but they're driven back by the heat from the drainage, then from the engulfed truck itself. Kendall wraps himself in a shelter so he can get closer to the engine. He makes it to within 50 feet—but it's just too hot.

Then, for a moment, the fire in the draw subsides. Reese sees a chance for the entrapped firefighters to get out. He radios, "If you can get out, now's the time. You just need to get back 50 feet." He's pressing closer to the engine, and his foot catches a nozzle lying in the road. For a moment, he looks down at this thing tripping him up. Then Rory catches his eye: he's out of the

truck, jumping through hot air. His hard hat falls off and almost lands in a pool of aluminum. He sprints past Reese, then Kendall. They shout him on and clap his shoulder as he runs by. They're trying to press closer, looking for the second firefighter, but no one's coming. Maybe...Did he get out and run the other way somehow?

Notice the transitions Reese and Kendall have made: Minutes earlier, they were fighting the fire, gathering more intel, making plans and thinking about contingencies. Then they shifted to pulling back, then rescuing entrapped firefighters. This agility is an aspect of resilient performance, and it played a critical role in helping two firefighters out of this emerging crisis.

Let's define resilience as the ability to anticipate and adapt to the potential for surprise and trouble (adapted from Woods and Hollnagel, 2006, pp. 3,4).

1b. Resilience and the Incident Within an Incident (IWI)

Resilience also characterized how others on the fire handled the entrapments. As the Incident Within an Incident (IWI) unfolded, firefighters across the fire fluidly shifted their attention and effort from suppression to rescue, first aid, extraction, transport and egress. Yet, fire operations did not collapse. Firefighters maintained overall safety and organization, even with these demanding and complex surprises. This was possible, because as leaders shifted their energy to the unfolding IWI, other firefighters stepped in to fill gaps.

On the left flank, IC(b) Blake hears the Mayday and leaves his lookout spot to head for the accident site; he activates life flight along the way. Near the quiet heel, Helo1 Crewmember Alex hears radio traffic on the Tactical frequency about water drops; he contacts the pilot on Air-to-Ground and calls in a drop on the vehicle. Then, Alex and Morgan start moving up the left flank. They cross paths with Blake on his way down, and he asks them to stay there as lookouts.

In the meadow above the fire, Sandy is just arriving to the incident with E8; he directs personnel to clear radio traffic for the IWI, and gathers EMT's from the engines. He tries to drive them down into the entrapment site from the top. That doesn't work, so he drives around trying to find safe access.

Above the entrapment sites, Helo1 is trying to drop water on the burning vehicle, but can't pinpoint it through the smoke. Personnel from E1 are treating the burned firefighters; and E1 is about to pull forward and use their water to try to cool the now fully engulfed E2.

Within all this activity, firefighters developed numerous options for getting the injured off the line and to the hospital. For more detail on this, see the textbox below.

Detailed Description of Actions and Options for Extracting and Transporting the Injured During the IWI

After hearing the Maydays, firefighters took the following actions:

- IC (b) Blake ordered life flight response;
- GPC Dispatch ordered ground ambulances from a nearby town;
- Helo1 crewmember Alex suggested to Blake—and was then tasked with—scouting, constructing and managing an emergency landing zone near the entrapment sites;
- E8 Captain Sandy gathered EMT's from the engines staged in the meadow, loaded them into his truck and tried to drive down to the injured firefighters;
- (b) Reese ordered a National Guard helicopter with hoist capabilities (he remembered an interagency medivac training session with the National Guard and life flight helicopters earlier that season. During the training session, firefighters met the pilots and discussed the ships' capabilities);
- IC (b) Blake asked Helo1 to reconfigure for medivac; and
- Reese started walking the road to see if E1 could drive out.

In taking these actions, the firefighters were preparing several options for extracting the injured firefighters from the fireline:

1. Load into Helo1 at the emergency landing zone,
2. Load into life flight helicopters at the emergency landing zone,
3. Hoist by National Guard helicopter,
4. Drive out to the meadow in E1, and
5. Drive out to the meadow in E8.

Once extracted from the fireline, the injured firefighters would need to be transported to the hospital. Here are their options:

1. Ground ambulances,
2. Helo1,
3. National Guard helicopter,
4. Life flight helicopters, and
5. Engines already on the fire.

In total, firefighters gave themselves dozens of combinations of options for extracting then transporting the two injured firefighters.

They couldn't be sure which options would work best or what unforeseen circumstances might materialize (Which helicopters would arrive first? Would there be problems communicating with the pilots by radio? Which pilots would be willing to use the landing zone just then under construction? How long would the landing zone take to prepare? Would the fire subside and allow them to drive out? Would the EMT's make it down to them from the meadow? Would one of the aircraft be unable to complete the mission due to mechanical trouble or some other factor? Was anyone else injured they weren't aware of yet? What level of medical attention did the injured firefighters need?)

For each of option, there's a level of uncertainty. Yet, because they set up multiple options—and did it early—they were prepared to mix and match and handle an array of unforeseeable circumstances.

As the situation progressed, firefighters made judgments about what to do with available options: they used some as intended, abandoned some, and re-purposed others.

As it turned out, the fire subsided and the road was drivable. So, they abandoned construction of the landing zone, and used E1 to transport the injured firefighters to the meadow. There, they used life flight helicopters to transport them to hospitals. They used ground ambulances to transport the rescuers for medical evaluation. Sandy brought the National Guard Physician's Assistant down to the draw to confirm the location of the third entrapped firefighter. Helo1 reconfigured and flew recon missions over the fire.

Firefighters couldn't know which options (or combinations) for extraction and transport would work best, or when. They also couldn't know what new circumstances might arise along the way. So they acted early to develop a robust set of options, and prepared themselves for an array of potential complications.

1c. Resilience on the Fire

This flexible readjusting, repurposing, and reconfiguring didn't start with the IWI; it characterized decision-making and risk management on the fire. For example, Incident Command was transferred several times, each time relatively smoothly without creating operational turbulence. Another example: When the group of five engines was first driving into the fire, crew leaders foresaw potential problems at the bottleneck, so they turned the trucks around, parked in a meadow above the fire, and reconfigured their engine personnel into a hand crew. A final example of smooth transition: early in the fire, firefighters changed command tones and tactical frequencies, and everyone got on the same page relatively quickly.

These little details may not appear flashy; maybe they just seem normal, but they turned out to be important to the flow of events. With the transfers of command, leadership moved to decision-makers with more experience. Staging five engines in the meadow and away from the fireline (rather than spreading them out along the road) reduced complexity along the road. Smooth frequency changes allowed firefighters to reduce the radio debacles that are common, especially early during initial attack.

2. Aspects of Resilience

This account shows resilience was fundamental to the group's handling of dynamic risk. Woods and Hollnagel (2006, p. 3) write:

> Success belongs to organizations, groups and individuals who are resilient in the sense that they recognise, adapt to, and absorb variations, changes, disturbances, disruptions and surprises… In a world of finite resources, of irreducible uncertainty, and of multiple conflicting goals, safety is created through proactive resilient processes.

Since resilience is critical to managing risk and creating safety, we will now describe and analyze aspects of resilience in detail.

2a. Initiative, Interaction, and Diversity

Notice that adapting and adjusting were not something individuals did by themselves. They maneuvered cooperatively, as a group. As firefighters took action to address emerging problems, others reinforced their efforts, filled in gaps and communicated changes. So, as firefighters adjusted to changes in the fire environment, they also adjusted to one another. There was initiative, but not independent action; we may call this "unity of effort."

In this geographically spread out, complex, high risk, rapidly changing environment, leaders were able to lead, because firefighters took initiative to own and solve problems. Beyond simply counting on firefighters to exercise initiative, leaders recruited their input and actively used it. And this was only beneficial because of the group's diversity.

Diversity and human variability go together: Different people see the same situation differently, depending upon their location, mindset, and experiences. They recognize different opportunities and risks, and see different ways of handling them. Leaders made their operation more robust by assimilating input from multiple viewpoints. In doing this, they leveraged human variability to manage complex risk.

We earlier discussed the Incident Commander's versatile set of options for extracting and transporting the injured firefighters, and how those options gave him flexibility to adapt. Notice, however, he did not create these options by himself; they were available because of:

- The diversity of operational backgrounds and perspectives in the group,
- The initiative and ingenuity of individuals on the fire,
- Firefighters' willingness to communicate and act,
- The leader's willingness to hear and assimilate input, and
- Modules' prior preparation and initiative. For example, Helo1 and other local units hired EMT's, purchased equipment and drilled for various medical emergencies. Federal policy does not compel them to do any of this, so their preparation and initiative are an example of how local adaptation can enhance system safety.

2b. Shared Values and Interagency Relationships

This group's cohesion and shared flexibility are especially noteworthy, because it comprised personnel from local and state agencies and from two national forests. Additionally, the time span from smoke check to Mayday was less than 2 hours.

Their collective resilience relied on a foundation of interpersonal trust, and a shared sense of duty, respect, and integrity. These didn't first materialize with the IWI or the dispatch. They were in place before the fire, even before fire season. Their organizations trained together and worked together, and many of the firefighters were friends. They'd already been doing the work that builds trust, cohesion, shared values, and familiarity. So, when suddenly a crisis emerged, trust and shared values were already in place, enabling firefighters to adapt and move resiliently together as a group.

For a discussion of how local organizational leaders reinforced these values and supported the conditions for resilience, see Part IV of this Discussion and Analysis.

2c. Shifting Roles and Responsibilities

Another aspect of the group's resilience is firefighters' agility in switching roles and reassigning responsibilities as the needs of the situation evolved.

For example, after assuming command, IC(b) Blake asked Reese to handle (b) (6) on the right flank of the fire, calling the role (b) (6)(b) (6) (Note: Assigning an (b) (6) on a Type 4 incident is an option that is uncommon, but not unheard of in this area. Note also that Reese functioned more as a (b) on the right flank than an (b) for the fire). This delegation allowed the IC(b) to take on a (b) (6) and focus on scouting the fire and planning contingencies.

As these command roles were established, firefighters maintained the flexibility to shift roles according to changes in the situation. As the fire grew more complex, the IC(b) ended his (b) (6) assignment and stepped back into the role of primary decision-maker. At the same time, he recognized the fire's potential to outstrip his own capacity and asked GPC dispatch to start moving an IC(b) and the pre-established local IC(b) organization.

Minutes later, the IC(b) heard a Mayday and re-tasked his (b) as commander of the IWI. Then, recognizing that his IWI IC was already absorbed in immediate rescue efforts, the IC(b) took the function on himself and led the extraction and transport of the injured, while still attending to fire behavior and overall safety of personnel on the fire.

Around the same time, E8 Captain Sandy arrived in the meadow above the fire, and essentially stepped into the role of (b) (6)(b) (6)(b) (6), bringing order there as crisis developed just down the road. Prior to the IWI, resources in the meadow were part of Reese's responsibility. As Reese shifted his focus to rescuing entrapped firefighters, Sandy assumed this role. As with the smooth transition among radio frequencies mentioned earlier, managing firefighters in the parking area may not seem flashy, yet it mattered for maintaining smooth operations and eventually transporting the injured firefighters.

Alex's Shifting Roles

Within approximately two hours, Alex stepped into and out of leadership roles numerous times.

When Helo1 first landed, the plan was for Helo1 crewmember Morgan ICT5 (t) to function in the primary decision making role, under the mentorship of fellow Helo1 crewmember and IC(b) Alex. On landing, Helo1 (b) (6) (b) (6) Lynn redefined their roles: Morgan would not be in a trainee role.

When the two Helo1 crewmembers reached the fire and met with E1 and E2, Alex assumed command. He did preliminary scouting and size-up, making a basic plan of attack and safety plan.

When Kendall arrived, Alex briefed him and passed command to him. The handoff was made based on Kendall's skill and experience, not his qualifications rating (he and Alex are both IC(b).

With Kendall (IC(b)) in charge, Alex moved back into firefighter role; he fired up his saw and began widening hand line in support of the hoselay on the right flank, while fellow Helo1 crewmember Morgan directed helicopter water drops on the left flank. When Alex first heard some distress-type radio transmissions, he turned off the saw and reassumed a leadership role: unsure of the nature of the problem on the road, he called Morgan and they met near the heel of the fire so they'd be ready to respond together to whatever might be unfolding.

As Blake (IC(b) was leaving the left flank to head to the IWI on the road, he sent Alex and Morgan to serve as lookouts on the left flank. A short time later, Alex changed roles again. He suggested to Blake, and was tasked with, finding and managing an emergency helicopter landing zone (LZ). Alex then picked up his saw, headed down the road toward a small clearing he'd noticed earlier, and worked as a crewmember again—cutting trees to prepare the LZ. Once the (b) made the decision to drive out the injured in E1, he canceled construction of the LZ. Alex and Morgan rejoined the group, put the saw on the back of the E1, and walked out.

Helo1 crewmember Alex also moved into and out of various leadership and followership responsibilities several times. To trace Alex's roles, see the text box above.

2d. Fluid, Diffuse Command Structure

In these examples, responsibility and authority shifted continually as (1) firefighters exercised initiative to take on (and hand over) responsibilities as dictated by the situation, and (2) leaders explicitly delegated responsibilities.

How leaders delegated is important. Leaders didn't delegate and drop, and they also didn't micro-manage. They put another firefighter in charge of a problem or situation, which allowed them the mental space to focus on other aspects of the mission. At the same time, leaders stayed involved enough with the delegated situation to recognize when it was getting too complex or demanding relative to the individual assigned. When this started, the leader would intervene in some way, sometimes reassuming the delegated responsibility. There was ongoing balancing and re-balancing among delegating, monitoring, intervening, and reassuming responsibility.

Consider what all this means for the chain of command: in order to handle complex, dynamic events, decision-making authority and command responsibilities moved around fluidly. Authority was continually shifted, shared, and consolidated, and these shifts were sometimes more (and sometimes less) explicit. Moreover, decisions sometimes flowed directly from the incident commander to be carried out by subordinates (we can call this centralized authority). Yet at other times multiple people were making big decisions with big implications, simultaneously, at separate locations across the fire (we may call this diffuse, decentralized, or polycentric authority).

Mission Command Vs. Detailed Command

Decentralized decision-making is fundamental to the Army's "mission command" concept (in contrast to "detailed command"). Following is a comparison of these two Command and Control concepts:

> Historically, commanders have employed variations of two basic C2 [Command and Control] concepts: **mission command** and **detailed command**.
>
> **Detailed command** centralizes information and decisionmaking authority. It emphasizes vertical, linear information flow, where information flows up the chain of command and orders flow down. It inhibits the judgment, creativity, and initiative required for success in fluid military operations. Because of these disadvantages, mission command is a better C2 concept in almost all cases.
>
> **Mission command** is the conduct of military operations through decentralized execution. Successful mission command results from subordinate leaders at all echelons exercising disciplined initiative within the commander's intent. The basis of mission command is creating trust and mutual understanding between superiors and subordinates: commanders must establish a command climate that encourages subordinates to exercise initiative. Mission command tends to be decentralized, informal, and flexible. By decentralizing decisionmaking authority, mission command improves the subordinates' ability to act in fluid and disorderly situations.
>
> -*Mission Command,* pp. 1-14—1-19 (ie. paragraphs 1-61—1-80), abridged.

The fluidity and decentralization of authority resist description on a tidy organizational chart—it seems almost disorderly in writing. Yet, this may be a critical point about resilience: the fluid and diffuse nature of their command structure is precisely what enabled this diverse and spread out group to adapt rapidly to complex and dynamic risk. Note too, firefighters communicated transitions clearly enough for operations to continue near-seamlessly, so this shifting generally didn't create operational turbulence, disruption, or confusion. This style of command allowed the group to simultaneously:

- Respond to a rapidly emerging crisis and help two firefighters get to safety;
- Plan, prepare, and manage multiple contingencies for the timely extraction and hospitalization of the injured;
- Maintain command and control;
- Manage incoming resources; and
- Maintain basic operations and safety on the fire overall.

2e. Building Capacity for Tomorrow's Risk

There's another sense in which fluidity of command helps address risk. The group's approach to trainee roles and delegation can be seen through the lens of long-term organizational risk management. While moving into and out of roles, firefighters were building experience. So the group was not only organizing to handle *this* fire's risk, they were building capacity for managing future risk.

Rochlin, La Porte, and Roberts (1987, p. 82) describe a similar approach among sailors on an aircraft carrier:

> At any given moment, all but the most junior of the officers and crew are acting as teacher as well as trainee. A typical lieutenant commander, for instance, simultaneously tries to master his present job, train his juniors, and learn about the next job he is likely to hold… As a result, the ship appears to us as one gigantic school, not in the sense of rote learning, but in the positive sense of a genuine search for acquisition and improvement of skills.

Building an organization's capacity to manage tomorrow's risk involves mentoring and delegating to firefighters with less experience. There are inherent costs to mentorship, and inherent risks to delegation.

How and when to use trainees? How and what to delegate to them? These questions involve risk-management tradeoffs. The text box below presents a dilemma leaders can face in making these decisions. Notice how leaders on this fire maneuvered through these tradeoffs, by an ongoing rebalancing among delegating, monitoring, intervening, and un-delegating.

The Trainee Dilemma

Following are two extremes that organizations and leaders may resort to when working with trainees and subordinates:

1-Don't Delegate: Leaders handle problems themselves, or assign only experts, because they're most capable of handling the situation efficiently. This is an attempt to manage short-term risk. Yet it does little to prepare for future risk. What's left when the experts retire, or when they're over-tasked? It's not much different to **Delegate but Micromanage**. Either way, trainees miss opportunities to develop technical and decision-making skill.

2-Delegate and Drop: Leaders delegate and disengage, expecting the trainee to learn by doing, to sink or swim. This *looks* like a training opportunity. Yet it is hazardous: In the short term, trainees are inexpert at the risk they're tasked with. Without the benefit of a mentor's guidance and years of trial and error experience, trainees are left to invent the wheel for themselves. This creates long-term risk: they may discover all kinds of habits that seem to work in the short term, yet create hidden problems. So, with the sink or swim approach, a short-term risk is the trainee might sink. But the long-term risk is the trainee might learn to swim badly, without sinking obviously.

Either extreme can create problems, and the nasty irony is this: in the pursuit of expert and efficient short-term risk management, you may over-rely on experts and avoid delegation, then eventually find yourself stuck relying on inexperienced operators to sink or swim.

Discussion Questions: Overall, where does your organization fall along this spectrum? What results is this producing? Since your resources are limited, where are opportunities for building long-term capacity within current constraints?

Suggestion: Your best bet for finding and creating these opportunities is to engage in dialog with a diverse group from your organization and neighboring organizations.

3. Risk-based Decision-making

Why Go Direct Rather than Burn Off the Road?

In hindsight, the decision to go direct profoundly shaped the flow of events. Were they being too aggressive by trying to contain it down in the canyon? Would it have been safer to burn off the road? Look at the context surrounding this risk-management decision.

Considering terrain, fuels, time of day, and observed fire behavior, firefighters expected the fire might run up the South-facing slope and expand out into the canyons beyond. On the North-facing slope, fire behavior was moderate to mild, moving parallel to the road. Building hand line and a hose lay there, along the top edge of the black—this was a natural decision.

As the fire changed, leaders recognized it early and revised their approach: Once they started getting spots across the road, they adjusted tactics. As fire activity continued to build, they revised tactics again and started pulling everyone back.

Personnel working the spots from the road were not far from the cool western edge. What would make any of them doubt they had more than enough time to get everyone to safety, if the fire were to change?

Local fire culture doesn't demand direct attack; in this area, firefighters sometimes go direct, sometimes burn off a road, and sometimes monitor the fire and wait for a good opportunity to engage. Firefighters said they did not feel constrained to catch the fire below the road, that they'd have no problem burning off, if it seemed like the right move. Leaders considered burning off the road, at least twice, and decided against it. One leader summed up the decision, "We

thought about just burning off the road, but why make a bigger mess than what we had? Why not just fight the fire?"

There are no guarantees with backing off and burning. Burning off would create its own risks: This tactic may not have been successful given fuel conditions. It would likely lead to a longer exposure period, more perimeter to secure, and more snag exposure. What scenarios could firefighters expect if they chose to burn off? It could have happened that firefighters started the burning operation, and then got spots. The RH could shoot up partway through the burn, leaving a dirty, incomplete burn, which would create all sorts of new hazards (as it turns out, the RH did shoot up: it went from 16% to 44% in one hour that evening—so this scenario was a possibility).

Moreover, setting up a burning operation can take time, which allows the fire to grow and could seem relatively less safe when firefighters see a reasonable opportunity to contain the fire safely while it's small. Another consideration: burning off involves positioning personnel with unburned fuel between them and the fire, so staying direct is commonly considered a safer tactic.

All kinds of new risks, uncertainties, and complexities ensue with the decision to burn off instead of going direct. Both options involve tradeoffs and risks, and require the professional judgment of firefighters. Burning off (or not engaging at all), would have mitigated some risks, but it would have created, transferred and postponed other risks.

It has been said that decision-making and risk management are about tradeoffs. If so, it is important to look very precisely at the tradeoffs firefighters made on this fire. It may not be most useful to think of their decision as a tradeoff between safety vs. production, or between efficiency vs. thoroughness. Rather, firefighters perceived it as a tradeoff of risk vs. risk. It was about the risks and uncertainties of going direct, balanced against the different risks and uncertainties of burning from the road or delaying engagement. Without a zero-risk option, they used their judgment to manage total risk. Their actions were meant to optimize risk over the duration of the fire, not only immediate risk during initial attack.

All of this may be a moot point, however, as firefighters commonly consider direct attack safer than indirect attack. In light of this, we can even understand their actions as an attempt to minimize immediate risk. Yet their lowest-risk option was still not a no-risk option: even with aggressive risk-management, human and environmental complexity combined to create an accident.

Topics for Discussion

Read the section, "Fire Operations Doctrine" in *Interagency Standards for Fire and Fire Aviation Operations (2011, pp. 01-07 – 01-09)*. Discuss how the firefighters on the ground used their judgment in carrying out:

- Fire Operations Command Philosophy
- Principles of Fire Suppression Action

Following is an excerpt from the *BKF Forest Supervisor's Letter of Intent (May 2011)*. Discuss how firefighters used their judgment in carrying out leader's stated intent with respect to mitigation of risk:

> Federal wildland fire policy says, "Firefighter and public safety is the first priority in every fire management activity." Toward that end, we should accept no unnecessary risk or unnecessarily expose incident responders to the potential for harm. Mitigation of risk should not result in transfer of risk to non-federal fire cooperators or the public.

Further Reading

On Resilience

Resilience Engineering. D. Woods and E. Hollnagel, 2006. See especially "Prologue: Resilience Engineering Concepts" (pp. 1-6).

Drift into Failure. S. Dekker, 2011. See especially Ch. 7 "Managing the Complexity of Drift" (pp. 169-203).

The Self-Designing High-Reliability Organization. G. I. Rochlin, T. R. La Porte, and K. H. Roberts, 1987.

Scott Page on Leveraging Diversity [Video Lecture]. S. Page, 2010.

On Risk

Risk management and the limitations of measurement. J. Adams, 2007.

Taking account of societal concerns about risk; Framing the problem. J. Adams, 2002.

Risk. J. Adams, 1995.

The Risks! and Benefits? of Risk-Benefit Analysis. S. Dreyfus, 1984.

On Diffuse Decision-making

Mission Command: Command and Control of Army Forces. (*Army Field Manual 6-0*, 2003).

> See especially pp. 1-14 —1-19 (ie. paragraphs 1-61 — 1-80) for the discussion of Detailed Command vs. Mission Command.
> See also pp. 1-8—1-12 (ie. paragraphs 1-37 — 1-54) for discussions of the Human Dimension, Uncertainty, and Time.

Coping with Tragedies of the Commons. E. Ostrom, 1999.

Beyond Markets and States: Polycentric Governance of Complex Economic Systems [Video Lecture]. E. Ostrom, 2010.

III: Cause and Complexity

What caused the accident? Where's the flaw?

Intended Primary Audience
Firefighters and leaders

Paradox

There seems to be a paradox here: In the midst of all this risk management, resilience, and reasonable decision-making, a tragic accident still happened.

In this section, we'll take up the questions,

- How is it that an accident could occur on this fire, when there was so much resilience and risk management going on?
- Shouldn't the fact of an accident indicate there was a bigger problem with the operation, or some unacceptable individual action?

So far, this analysis has focused on understanding specific actions and decisions, and we've considered how they could make sense in context. We have also looked broadly at decision-making, risk management, and interpersonal dynamics on the fire. Things seem...normal.

Individual decisions don't seem egregious or negligent. Some individual actions may look like bad decisions—at first. Yet once you dig into the context, it becomes clearer how a normal firefighter could take that action at that time, and why it may have seemed like the best or only move for addressing risk.

Moreover, in looking at overall decision-making, no obvious problems jump out as something firefighters or operational leaders should have seen and fixed, but failed to. Instead, we see firefighters aggressively managing risk, proactively and reactively creating safety in a complex, dynamic environment filled with the potential for all kinds of trouble and surprise.

Operational flaws and individual failures don't present themselves in this account, and this may seem perplexing, in light of the severity of the accident.

To address this, we begin with fire activity on the day of the incident.

The Fire Was Unremarkable Overall, but Intense in One Tight Drainage

It would be natural to expect (as many on the investigation team at first did) to find a large-scale blowup. Historically, this has been true of many fatality fires.

Yet it turns out fire behavior during the entire incident was relatively mundane. On the whole, it was unremarkable, even as the fire was burning very intensely in one narrow drainage.

During the entrapments, firefighters just above and below the entrapment sites were surprised *only* that they were hearing radio traffic about a problem somewhere on the fire. This was simultaneous to the entrapments and rescues. One firefighter, who was near the anchor on the western edge (less than 500 feet from the vehicle entrapment site, and about 150 feet from entrapment site 1), described his perceptions this way:

It's a normal Black Hills fire. We're doing what's normal: anchor, flank, and pinch. I'm cutting along the right flank and I'm feeling safe the whole time. Things are progressing.

Over the radio, I hear something about, "We can't catch these spots."

I stop the saw, head to the heel of the fire, and look around. From my vantage point there was nothing of concern, no obvious smoke color, not much of anything, nothing out of the ordinary or significant with the wind. I look around and there's no immediate danger. Light winds, swirly, but nothing of concern.

Then I hear the Mayday. And still, I don't see anything of concern, nothing extremely threatening—or even of curiosity. There's nothing out of the ordinary with fire behavior. I hear the call, and I'm like, "What?" I look around and I'm like, "How?"

Meanwhile, on the opposite ridge, the IC is looking out over his couple-acre fire. He sees the potential for escalating fire behavior and complexity, and asks dispatch to start an IC (b headed in his direction. Standing on this ridge, facing the entrapment sites, he's seeing gradual escalation, but not drastic transformation. Under the smoke and vegetation, the fire's focused and narrow run through the draw is not visible to him, even as he stands looking out over it. He would later say, "The whole time I was up there, there was nothing crazy as far as the winds went. There wasn't a blast or anything." (b) (6) down the ridge from him said the same.

So, this is not a story of area ignition or the explosion of a box canyon. It didn't involve a dramatic wind event or a canyon wide blow up. For many individuals inside and above and all around the canyon, fire behavior was uneventful and unremarkable. If the fire was changing, the change was gradual and manageable.

Yet, fire behavior was becoming extreme in a single, narrow drainage. In this specific north-facing drainage, on this afternoon, the fire was suddenly explosive, chaotic, baffling, and life changing. Look closely at the photo below (Fig. 2): The fire was intense enough to consume the drainage. Yet only in this draw, at this time, did the fire burn so powerfully. Note the vegetation on either side of the draw.

Figure 2-Fire intensity was greatest in the draw. E2 is at the sharp turn in the road. Notice the vegetation on both sides of the draw (photo rotated 90°).

The Underlying Factors Shaping Fire Behavior Were Unremarkable

Not only overall fire behavior, but the underlying conditions shaping fire behavior were individually unremarkable. Fire behavior is affected by terrain features, fuel conditions, and weather factors. Commonly, our accidents seem to involve something extreme, unusual, or rapidly changing with one or more of these conditions.

On the Coal Canyon Fire, however, none of the known fire behavior factors was alarming. Indeed, taken one by one, many of these conditions even appear favorable for success. ERC's for the day, were at 54. Winds, as discussed above, were notably calm. The entrapment sites were on a north-facing slope, just after 1500hrs. For more context around these conditions, see the text box below. For a more detailed discussion of fuels, weather, topography and fire behavior, see Fire Behavior Analysis (SAI Report, Appendix B).

Fire Behavior Conditions in Context

Relatively Calm Winds

Firefighters on the ground reported generally calm winds over the fire. (b) (6) Helo1 flew back and forth over the road while the entrapments were occurring; he made four passes at approximately 100 ft AGL and reported no significant wind. This is also consistent with a photograph of the smoke column taken later that day.

In contrast, entrapments on the South Canyon, Thirtymile, Loop, Cedar, Inaja, and Decker fires (and many others) involved drastic wind shifts. The wind *did* affect fire behavior in Coal Canyon, but there was not a dramatic wind event.

Northern Exposure

Slopes with a north aspect tend to be cooler and have higher fuel moistures. Vegetation tends to be thicker but it usually burns with a lower intensity. In the afternoon, these slopes receive less direct sunlight (which affects fuel temperatures, fuel moistures and relative humidity), so fire is typically most active on south- or west-facing slopes.

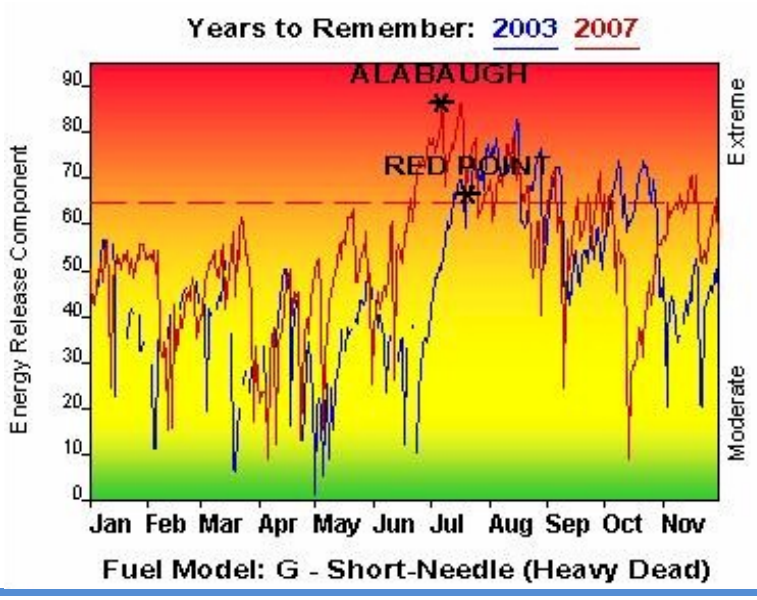
Entrapments during the South Canyon, Cramer, and Loop fires (and many others) all occurred on south- or west- facing slopes, during the afternoon.

ERC

Energy Release Component is a measure of the overall dryness/flammability of both live and dead fuels. The higher the ERC, the higher the potential fire intensity.

The day of the entrapments on the Coal Canyon Fire, the area had an ERC of 54. To provide context, here are some figures for local ERC's:

- High 80's—ERC's during the Alabaugh Fire (on which there was an entrapment).
- High 60's—ERC's during the Red Point fire.
- 64—the 90th percentile for ERC's in the area.
- 58—historical average ERC for the area on this date.
- 54—ERC for the area on the day of the entrapments on Coal Canyon.



So, which fire behavior factor caused the flare-up? It seems strange to ask the question this way. It's not quite right to label any one of these conditions *the* cause of fire behavior. Instead, all these factors interacted and combined to shape fire behavior.

Similar Underlying Conditions Produced Drastically Different Results

An array of unremarkable, normal (even favorable) conditions combined to give rise to very intense fire behavior within a single narrow drainage. At the same time, the *same* conditions were combining to generate unremarkable results elsewhere on the fire—at some locations firefighters were seeing gradual incremental change, in other places they were getting favorable results. The same conditions which brought about incrementally changing (or even uneventful), fire behavior overall in Coal Canyon, combined to create very rapid escalation in one tight drainage.

This pattern deserves our close attention:

At the micro level, the underlying conditions affecting fire behavior were normal and relatively un-alarming, in some places even favorable.

At the macro level, fire behavior overall was normal, unremarkable, in some places even favorable. The situation was changing, but it appeared manageable.

Yet in a specific narrow location, ordinary conditions were combining to create overwhelming chaos for the people there. And beneath all this chaos were the same conditions that were producing normalcy and success at other locations on the fire.

To summarize the pattern:

- Things can seem fine at the micro and macro levels based on everything you can see and know right now;
- At multiple locations, things can be working alright—local situations look manageable. The situation is evolving, but manageably; and
- Yet in one tight spot, seemingly manageable events can converge in a way that creates rapid change, driving the situation far beyond what people there can foresee and adapt to.
- These can all happen at the same time.

Predictability, Uncertainty and Real-time Risk Management

The exact calculus of how conditions will combine—and precisely what will happen where and when—is impossible to know with certainty or specificity in advance. Currently, even our most advanced fire behavior modeling software does not account for microclimate situations, such as a narrow draw. Models smooth outputs to represent average fire behavior for conditions. Moreover, outputs are probabilistic—the software produces plausible large-scale scenarios.

Firefighters have an intuitive sense of what the fire is doing and where trouble could arise. This guides decision-making. It isn't quite right to label this "prediction," because they can't know

exactly what will happen and when. This means real-time risk management must be a process of:

- Acting on what seems like the most likely path to success, while
- Keeping enough margin to maneuver if potential problems materialize, and
- Adjusting continually, as risk and opportunity evolve.

This way of thinking about real-time risk management is very different from the idea that fire behavior is always entirely knowable in advance, and that firefighters can deduce precisely what's going to happen and simply take the appropriate action. Things don't work that way.

Foreseeing potential events and preparing sufficiently for each of several potential problems is one thing. What is really tricky is preparing for a *combination* of surprises. When several events suddenly materialize at once, your margin may quickly disappear, even if your plan was robust enough to handle each potential by itself.

We don't need to think the events of this fire were either entirely predictable or entirely unimaginable, nor do we need to think the accident was the product of any single event or chain of events. Instead, this accident is about the unforeseeable *combination and timing* of surprises. The operation was robust enough to handle these surprises individually, yet they came together too quickly to adapt.

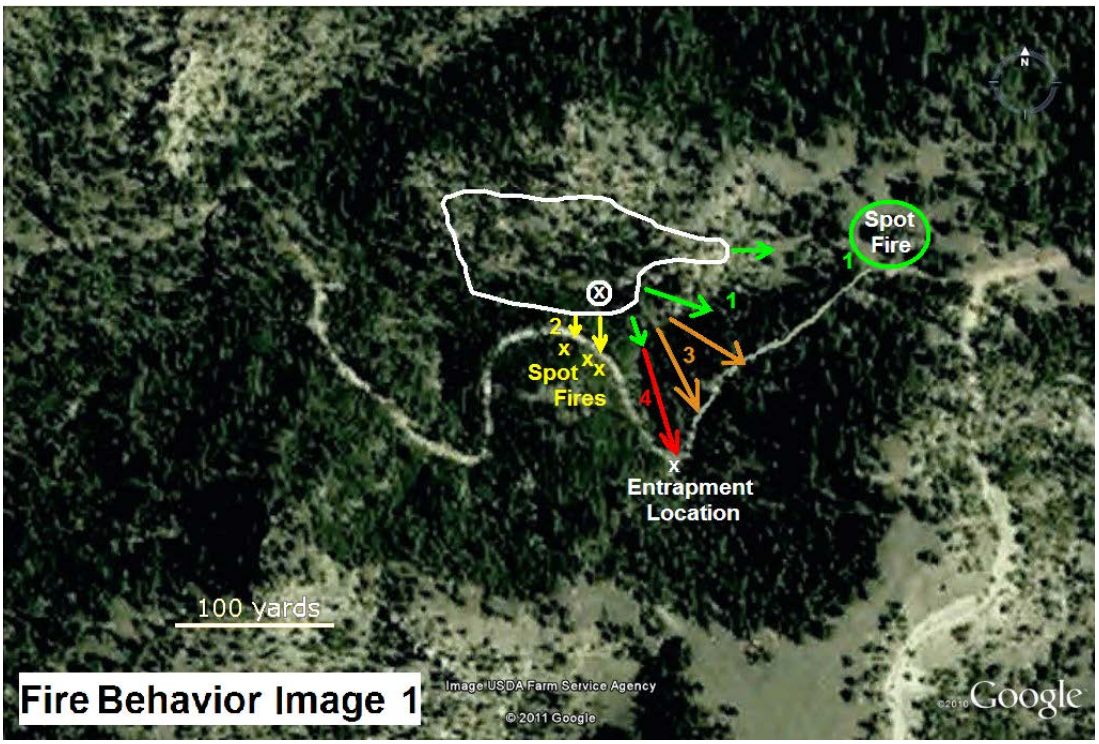
Decision-making and Risk Management

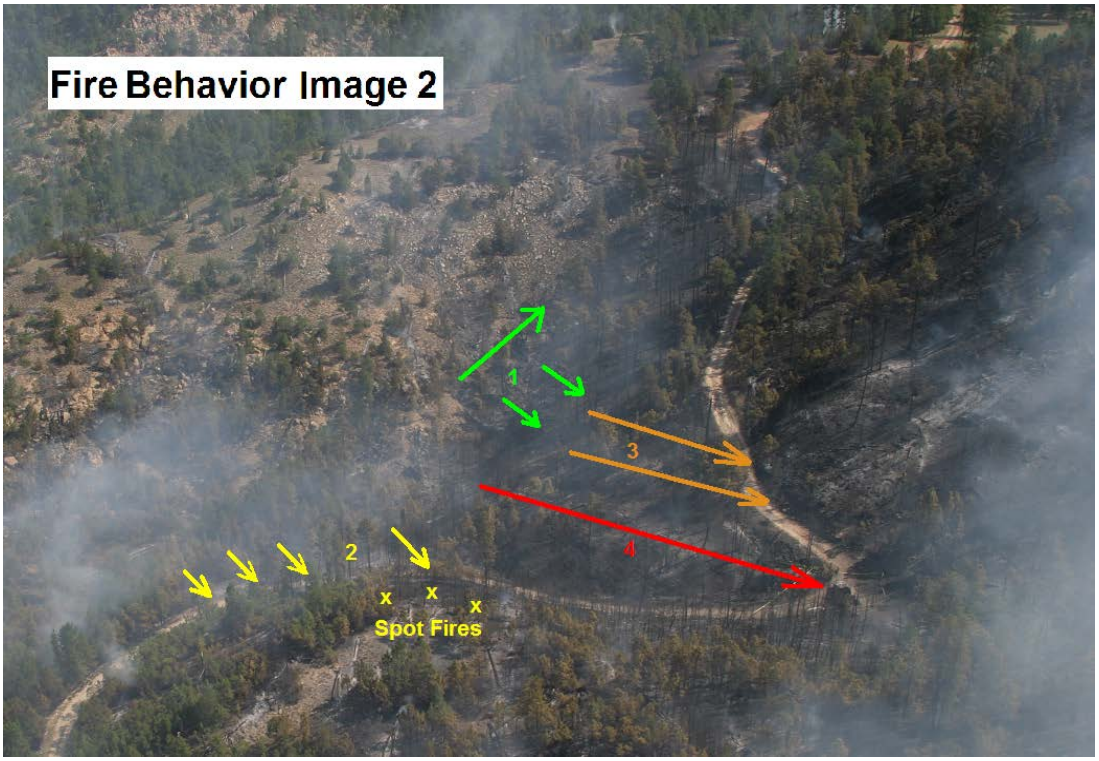
Now we return to our initial questions about whether the tragedy is evidence of a problem with the operation or some individual in it.

The fire behavior itself offers an analogy. Dramatic fire behavior in one drainage happened at the same time that fire behavior overall was unremarkable. In the same way, work was generally running safely and without incident on the fire overall: in general, the system was running smoothly and unremarkably, even as chaos and crisis were barreling through the worlds of firefighters hidden under the smoke in one narrow drainage.

Not only did the fire overall appear ordinary and manageable, but the underlying conditions shaping fire behavior were ordinary and un-alarming, even favorable. In the same way, conditions shaping action on the fire seem normal, even favorable: we see resilience and aggressive proactive and reactive risk management, cooperation and teamwork, a shared sense of duty respect and integrity, planning and contingency planning and revising plans, briefing, communication, anticipation, and so on—all the stuff success is made of.

Yet, the unlikely combination of ordinary conditions, in a specific drainage all at the same time, led to events that were extraordinary for people there.





Figures 3 and 4-Fire progression on the right flank (from Fire Behavior Analysis, Appendix B): Fire moving up canyon (1) spots, blocking Reese's progress up the road. Then at (2) he finds spots above the road near the western edge of the fire. E2 works these spots and later drives forward from here. Their escape is cut off by fire laying over the road (3), so they pull back. The vehicle gets stuck in the turnaround spot in the draw, and fire runs through the draw (4).

Consider some of the events leading up to the entrapments:

- The firefighters in E2 did not hear Reese's warnings. Whether this had to do with the noise of the fire and the pump, or the firefighters' focus on their tasks, or curves in terrain sometimes blocking radio transmissions, or some other condition—they didn't get the message.
- The firefighters in E2 drove forward. We saw in Part I how this risk-management action makes sense, given their knowledge and perception at that moment.
- The fire made a series of narrow moves—first torching behind the engine (so they pulled forward and drove past the drainage), then lying across the road ahead of them (so they pulled back, then got stuck at the drainage), then running directly through the tight drainage (where they were stuck). Note that if the specific sequence, timing, or energy of the fire's narrow moves had been even slightly different, outcomes may have been very different. Moreover, such differences could have involved only slight variations in the conditions shaping fire behavior. (See Figs. 3 and 4, above)

No one of these events seems unimaginable in isolation: Firefighters sometimes miss radio transmissions and verbal messages, and sometimes drive in a direction onlookers don't expect. Fires make pushes at times and locations that were not specifically predicted, at least not very far in advance.

These events are not entirely unimaginable, yet they are not entirely predictable either. Reasonable people don't expect their communication to be unsuccessful, because it usually isn't. The firefighters outside the engine expected it would pull back, because from their perspective that's the only action that made sense. Firefighters knew the fire had the potential to create problems on the mid-slope road—at some time—but expected they'd have enough time to move everyone to near-by safety if things started heating up.

Even though firefighters could not predict these specific events, firefighters had a plan robust enough to handle any of them. Yet the combination of all these events, all at once—quickly stripped away their margin to maneuver and gave rise to the accident.

This tragedy does not mean there was something inherently flawed with the way this group was fighting fire and managing risk, or that any individual made an egregious decision. Nor can we call any single event or condition *the cause* of the tragedy—it wouldn't make sense to say that for this situation. Nor does any single thing in this situation present itself as the right place to pin blame.

What Can We Do Now?

We can avoid the other extreme of thinking, "If we don't pin blame anywhere, then there must be nothing to learn or improve. If there was nothing wrong, then there's nothing to do." That's bad logic.

We can still learn from these events, and try to understand them as they unfolded. We can learn about the dynamics of fire, human beings, teams, and organizations. We can better understand the conditions that support resilient performance and the conditions that undermine it. Given recent years' advances in leadership development, safety, and research, we can take a new look at where our vulnerabilities tend to emerge, where margins tend to erode suddenly, and why this is not always apparent in the moment. We can have robust discussions and reflection about values, risk, and what's worth risking what for. We can revisit the urgent question of what it takes to develop firefighter expertise. We can think about which risk tradeoffs we might make differently, and which aspects of this account can serve as a model for our own performance and for our local unit.

Genuine learning from these events requires you, as a professional, to actively engage the story and ideas surrounding it. Doing this can generate real value if you engage in dialog with others with different perspectives, at different levels of your organization.

Further Reading on Cause and Complexity

The complexity of failure: Implications of complexity theory for safety investigations. Dekker, Cilliers, and Hoffmeyr, 2011.

Drift into Failure. S. Dekker, 2011. Especially Ch. 6 "What is Complexity and Systems Thinking?" (pp. 127-168).

Friendly Fire. S. Snook, 2010. Especially Ch. 7 "Conclusions" (esp. pp. 202-219).

Harvard Business Review's September, 2011 "Spotlight on Managing Complex Organizations" includes:

- Learning to Live with Complexity. G. Sargut and R. G. McGrath.
- Embracing Complexity. M. G. Mauboussin.
- Smart Rules: Six Ways to Get People to Solve Problems Without You. Y. Morieux.

Quotes for Discussion

"Fire is a complex, dynamic and often unpredictable phenomenon… While the magnitude and complexity of the fire itself and of the human response to it will vary, the fact that fire operations are inherently dangerous will never change. A firefighter utilizing the best available science, equipment and training and working within the scope of agency doctrine and policy, can still suffer serious injury or death."

—*Interagency Standards for Fire and Fire Aviation Operations*, 2011, 01-7, lines 12, 15-19

"Rather than being the result of a few or a number of component failures, accidents involve the unanticipated interaction of a multitude of events in a complex system—events and interactions, often very normal, whose combinatorial explosion can quickly outwit people's best efforts at predicting and mitigating trouble. Interactive complexity refers to component interactions that are non-linear, unfamiliar, unexpected or unplanned, and either not visible or not immediately comprehensible for people running the system."

—Dekker, 2011, p. 128.

"[Systemic accident models] do not have to rely on anything 'going wrong', or anything being out of the ordinary… Even though an accident happened, nothing really went wrong—in the sense that nothing that happened was out of the ordinary. [Systemic accident models]… explain accidents by a confluence of a number of things, just on the border of the ordinary. Systemic models see accidents as a byproduct of the normal functioning of the system, not the result of something breaking down or failing inside of that system… They are models of a system's or organization's normal functioning."

—Dekker, 2006, p. 92.

"To understand how [an accident] sometimes happens one must first understand how success is obtained—how people learn and adapt to create safety in a world fraught with gaps, hazards, [and] tradeoffs."

—Woods and Hollnagel, 2006, p. 3.

IV. Fighting Fire in the Black Hills

Intended Primary Audience
Fire leaders
District and Forest Leaders

In Part II, we examined conditions that shaped performance on the Coal Canyon Fire and enabled firefighters to adapt to rapidly evolving problems and risks. Key conditions included:

- Fluidity of command
- Group cohesion
- Interpersonal trust and a shared sense of duty, respect and integrity
- Training and personal development

These conditions did not spring into existence when firefighters arrived on scene; they were already part of the organizational (and inter-organizational) culture. So now we turn to the actions and attitudes of local fire leaders and how they shaped operational culture.

Interagency Cooperation and Respect

Recall the sense of interpersonal trust and respect that allowed for cooperation and group cohesion on the fire line. This was a critical condition for the driver's escape and survival. During a window in fire activity, Reese called the entrapped firefighters and told them to get out and go. When the driver was asked why he trusted Reese enough to leave his fire shelter, get out of the vehicle, and run through fire, the driver said, "I have a close relationship with Reese. Because of who he is, and because it came from him; there was no hesitation that was what we had to do." Keep in mind, they work for different agencies. Moreover, the entire process of rescue, care, extraction, and transport of the injured was a multi-agency effort. Recall also the collegiality of firefighters from different organizations as they established and transferred command, then made and changed plans, delegated and reassumed authority.

It was not always like this. Local leaders remember mutual resentment and animosity 20 years earlier, and they recall how this distrust and disrespect was detrimental to operations:

> It doesn't seem like that long ago when things were not good. Very contentious—it was not a good place.
>
> Since that time, there's been a lot of organizational maturity—that includes all of us in the interagency community in the hills.
>
> We all just finally understood that the old ways and the animosity were getting us nowhere, and that it's not about ourselves. We were not serving the people on the ground. We weren't getting the firefighters what they needed. That's wrong.
>
> We—the dispatch center board of directors with representatives from the agencies—needed to set the example. We don't always agree, but we can respectfully disagree, and it's not personal. It used to be personal, but we've moved beyond that.

> I have a lot of respect for the people on that board. Anything I can do to make things better for the people on the ground, that's my responsibility, and I believe the vast majority on the board of directors feels the same way.

One local leader estimated it took 10 years of deliberate effort to transform relationships among cooperators. An SDS leader uses the saying, "One team, one fight" to express the camaraderie among cooperators. When asked his opinion about the saying, the BKF FMO responded, "We all subscribe to that." Then he gave an operational example, "The whole notion of closest forces is not just talk. First on scene establishes command. Once things are sorted out [i.e. jurisdiction], they may keep the fire or they may pass it on. We don't care, as long as the fire is staffed and there's good command presence."

Interagency Training

Interagency training has a critical function in shaping interpersonal and interagency relationships. Let's look at how they train together in the Black Hills.

First, the Great Plains Dispatch Center (GPC) training committee is made up of reps from all wildland fire agencies represented on the dispatch center board of directors, regardless of the size of the agency or acreage under their jurisdiction. This committee manages the training curriculum based on an interagency needs analysis. Instructors from multiple agencies lead the classes.

Second, prior to fire season, there is a scenario-based refresher training for ICT4s and ICT5s from local, state, and federal agencies. They do time-pressured simulations on sand tables. ICT4s and 5s fill the roles of district duty officers and dispatchers. The purpose is to help firefighters learn the system they all work in together, and to "help everyone understand they're not the only show in town."

Third, the State also holds a live fire exercise: a number of interagency resources are dispatched to a start, which they manage with helicopters, engines, etc. The participants, instructor cadre, and roving teams of evaluators are all multi-agency.

Fourth, the BKF recently started hosting annual fire simulations. The scenario in 2010 was an emerging fire in the wilderness, and participants were members of the standing local type 3 organization. The 2011 scenario expanded to include Agency Administrators, whose task was to establish a common set of objectives based on values at risk. The simulation also included the injury of a Parks Service employee on a Forest Service fire. The intent was to challenge Agency Administrators to navigate differences between the two agencies' protocols for injuries.

GPC also had group exercises in which participants had to prioritize scarce resources around multiple fires and make decisions about emergency evacuations. They created an in-depth exercise with multiple components. In describing the evolution of these scenarios, BKF FMO said, "We started small, and we try to make our exercises bigger and more complex every year."

Fifth, there was a recent interagency medivac training session that included both life flight and National Guard helicopters. The intent was to bring local resources together so they could learn about the limitations and capabilities of local aircraft and get to know the pilots. Recall that at a critical point in the IWI, Reese remembered this training session from about a month earlier and ordered a hoist-capable National Guard helicopter.

Local fire leaders made deliberate choices, policies, structures and training which shaped interagency relationships and fire line performance during the incident. Firefighter interaction also demonstrated the shared values of trust, duty, respect, and integrity.

Instilling Values

Now we narrow our focus to the organization with jurisdiction over Coal Canyon—the Black Hills National Forest—to see how leaders' actions and attitudes shaped culture. We are particularly interested in how leaders shaped a culture of initiative, adaptability, and cooperation, which were critical to managing risk on the fire.

During interviews, leaders made it clear that building a climate of trust within their organization was paramount:

> It's about trust. If you invest in people and encourage them, they're going to do great things for you. I can't be everywhere, I can't make every decision for them, nor can the division chiefs. If you lead by example you empower, train, and invest in people, and you let them know their decisions will be supported, as long as they're not out of their scope of duty.

Leaders see trust and respect from the top as the critical condition for developing adaptability and initiative among firefighters:

> People here feel supported in their decision-making. We talk about doctrine and we take decision-making to its lowest level. They know that up to the Supervisor's Office level they'll be supported in their decision-making processes.
>
> I tell them all the time, "When you make decisions, I'm not going to second-guess you. Know that you'll be supported as long as you're not operating outside the scope of your duty or disregarding policy.

Leaders on the forest also focus on communicating clear expectations around risk. For example, when the Forest Supervisor receives the Regional letter of intent for the season, he attaches his own letter, framed in terms of task, purpose and end state, and distributes this to employees. Then, the Forest FMO travels around the forest each year and talks to personnel on all modules in order to reinforce leader's intent and expectations.

BKF Forest Supervisor's Letter of Intent

During interviews, BKF employees mentioned the Forest Supervisor's annual Letter of Intent. The text of the letter, 18 May 2011, is included here for your reference:

> I would like to thank you for your safe work in responding to an early fire season in the southern part of the Rocky Mountain Region and southern plains as well as your preparation and coordination with our partners, for what the remainder of the 2011 fire season may hold in store. There have been several fatalities and entrapments this spring, a trend we must do all we can to avoid in the future. On April 26, the Regional Forester issued his leader's intent and expectations regarding risk management. In this letter I am summarizing key information as leader's intent for Black Hills National Forest personnel engaged in fire management activities.
>
> Leader's Intent
>
> Our task is to provide fire management leadership for safe, effective and efficient fire, fuels and aviation management program delivery.
>
> The purpose for this work is to meet the direction contained in the Forest Land and Resource Management Plan, the Fire Management Plan and Forest Service policy. We must continue to honor our agreements with federal, state and local partners through cooperative agreements and annual operating plans. Per manual direction, every employee has a responsibility to support fire suppression activities as the situation demands. Each employee can provide support directly or indirectly, and you provide the leadership to help achieve these purposes.
>
> The end state is to recognize the inherent risk present in the fire environment and to use sound risk management principles to guide us in making sound strategic and tactical decisions. Our decisions and situational awareness must ensure that each and everyone involved in fire, fuels and aviation management return home safely. Our folks deserve nothing less.
>
> Federal wildland fire policy says, "Firefighter and public safety is the first priority in every fire management activity." Toward that end, we should accept no unnecessary risk or unnecessarily expose incident responders to the potential for harm. Mitigation of risk should not result in transfer of risk to non-federal fire cooperators or the public. We have a long history of safe, efficient and effective decision making in the fire environment. I have the utmost confidence that will continue in the 2011 season.

Communicating clear and consistent expectations is one way the FMO builds trust and respect among his personnel. He also builds relationships by making time to step out of a supervisory role and see first-hand how work is done. For example, he dedicates a day a year to work with his helitack crew, riding in the chase rig when they get dispatched. Another example: On one of his recent days off, he heard the hotshot crew dispatched to a local fire, so he drove to the fire and cut line with the crew for a few hours. He said his role at that time was not to micromanage or look over their shoulder, just to build trust and give them an opportunity to ask questions.

This is his way of providing a "leadership example of support." He adds, "I believe people will do great things if they have that support. They'll do great things for themselves and for their program."

Leaders also reinforce core values with challenge coins. Based on recommendations from field personnel, coins are awarded to employees for showing initiative and taking responsibility in support of the program. Each district has its own coin design, as does the forest. The coins carry a leadership message, such as "You can't lead from behind" or "Leadership by example." (See Fig. 5.)

Figure 5-Challenge Coin from the BKF FMO's office. The Back reads, "LEADERSHIP BY EXAMPLE; DUTY, RESPECT, INTEGRITY."

Developing Subordinates

Finally, we turn to developing subordinates' skill and experience. In Part II, we saw how leaders on the fire line aggressively sought opportunities for trainees, as long as the complexity and risk of the situation allowed. This approach has long-term implications for organizational risk management by developing subordinates and building capacity for the future. Field performance here resonates with organizational leaders' philosophy of personnel development:

> We look for every opportunity to build capacity. If you don't start building qualifications at the lowest level, nothing is going to get any better. So we're really aggressive about looking for trainee opportunities. We're supported by line—they're not telling us it's too expensive to place trainees.

The crux of this leader's succession planning is to rigorously build subordinates' experience and qualifications.

Leaders aggressively encourage firefighters to go out and build fire experience around the country when fire season is slow at home. "We have a drawdown plan and we follow it the best we can. Other than that, I kick them out the door. Go out and get that experience. My battalion chiefs and division chiefs share this view."

Summary

Communicating clear expectations around risk, reinforcing core leadership values with challenge coins, making time to see how work is done first-hand, prioritizing trust, expecting and rewarding initiative, and emphasizing workforce development—these leadership actions and attitudes all shape the culture in which firefighters work. This culture, in turn, provides the background for firefighter performance.

Recall the firefighters' adaptability, resilience, initiative, and cooperation from Section II. These qualities were key to how firefighters managed risk during the fire, handled a rapidly evolving emergency, and helped save two fellow firefighters. Their performance in the field is an outgrowth of the actions and attitudes of organizational leaders.

V. Topics for National Consideration / Recommendations

The primary intent of this report is to describe and understand events surrounding the accident, and to create opportunities for learning. The details of this account did not indicate simple flaws or simple fixes. Yet, several actionable considerations arose through the process of developing the reports and through collaboration and dialog with peer reviewers and the Accident Review Board. What follows is not a finished list, and none of these recommended considerations can offer a guarantee of preventing a future accident. These may, however, improve system conditions and outcomes overall.

Learning:
This is the most critical response: for members of the organization to bring their professional expertise to this accident, regard the report and accompanying materials as a contribution to an ongoing dialog, and generate insights for continuous improvement. This approach should recognize the risks involved with using any single accident as the sole data point for determining further recommendations.
For context, see:

- Introductions to the main SAI Report, Expanded Narrative, and Discussion and Analysis
- Discussion and Analysis, Part III, Subsection entitled "What Can We Do Now?"

Learning about Learning:
Following the report's release, consider methods and approaches used by the investigation team: How did these contribute to organizational learning and other organizational objectives? Where are opportunities for refinement or replication in future investigations?

- The Coal Canyon SAI Feedback Questionnaire provides one opportunity for feedback from the field.
- Consider convening a group of subject matter practitioners to evaluate the agency's approach toward learning during investigations and revise current policy.

More broadly, develop a deeper understanding of how learning happens within the organization. Members of the organization engage in kinds of learning, improvement, and adaptation which are meaningful, yet unobserved and unmeasured by research, and not entirely visible across levels. Learning how we are already learning will yield insights relevant to current leadership initiatives, collaboration across levels, and the continuous improvement of learning culture.

Evaluate the need for national policy around Emergency Medical Services, specifically in support of Emergency Medical Technicians (EMTs) for land management agencies:
Current conditions finds agency units hiring EMTs on field level crews to provide a higher level of care because of the remote work environment and delays in local medical response. The complexity and exposure includes medical providers working across multiple jurisdictions in the performance of providing care to fellow employees with different levels of medical direction.

Review current research and protocols for Critical Incident Stress Management (CISM), develop recommendations in light of the latest science and practice.

Research "dry lines," consider integrating new knowledge into fire behavior training curriculum:
Regardless of the ambiguous role of a dry line in this accident, the weather phenomenon is not well known in the field, and may be useful knowledge for the future.
See: SAI Report, Appendix B: Fire Behavior Analysis, Weather.

Fire Shelter and Survival Training:
Evaluate "Breath Before You Leave" concept for integration into training.
See:

- Discussion and Analysis, Part I, Subsection entitled "The Driver's Escape"
- SAI Report, Personal Protective Equipment Analysis, Recommendations.

Consider providing guidance on how to deploy fire shelter inside a vehicle, to include vehicle limitations:
Some field trials and study is occurring around this topic. Information will be released once researchers have had a chance to complete their work. Release date of October 2012 anticipated.

Develop training to prepare firefighters for driving in a smoky environment:
Current engine academies may be covering this in different ways. Evaluate what information is already available, review, than produce tech tip training document.

Research Resilience:
Conduct further research into the conditions that support resilient performance and the conditions that undermine it.

Evaluate and integrate current Department of Defense research insights and training methods with respect to acute stress:
At the module level, use portable heart rate monitors as a training tool during tactical decision exercises, including sand table scenarios.
Monitors can be inexpensive and non-intrusive. Using this tool would help participants build familiarity with their individual stress reactions and may contribute to handling of acute stress during operations.
See:

- Discussion and Analysis, Part I, sections entitled "Human Performance Under Stress" and "Human Variability Under Stress."

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Legend of Resources

Resource type or number	Agency/Forest	Role or work title during incident	Title and fictitious name used in this report
Helo1	Black Hills National Forest		(b) (6) Lynn
E1	Volunteer Fire Department	IC(b	Crewmember Alex Crewmember Morgan Chief Lee Crewmember Pat
E2	State Department of Forestry		Leader Drew Crewmember/Driver Rory Crewmember Kyle
E3	Black Hills National Forest	IC(b)	Captain Kendall
E4	State Department of Forestry		
E5	Nebraska National Forest	(b) (6) IWI	Captain Reese
E6	Volunteer Fire Department		
E7	Black Hills National Forest	IC(b	Captain Blake
E8	Black Hills National Forest	(b) (6)(b) (6)(b) (6)	Captain Sandy
(b)	Black Hills National Forest		BKF (b) Gail
District	Black Hills National Forest, Hell Canyon RD		(b) (6)(b) (6) Terry
(b)			
Duty Officer	Black Hills National Forest		Duty Officer Prescott