The Communicative Construction of Safety in Wildland Firefighting

Jody Jahn[A]

[A]University of California Santa Barbara, 4108 SS&MS, Santa Barbara, CA 93106, jodyjahn@umail.ucsb.edu

Abstract:
This dissertation project used a two-study mixed methods approach, examining the communicative accomplishment of safety from two perspectives: high reliability organizing (Weick, Sutcliffe, & Obstfeld 1999), and safety climate (Zohar 1980). In Study One, 27 firefighters from two functionally similar wildland firefighting crews were interviewed about their crew-level interactions for implementing safety rules and tasks. Findings revealed that the two crews differed in their communicative interactions related to three specific routines: *planning*, *use of safety rules,* and *authority.* The crews also differed in their general interactions with one another related to *safety, groupness,* and *efficiency.* For Study Two, 379 firefighters participated in a safety climate survey. Safety climate refers to an organization's emphasis of production pressure over safety (Zohar & Luria 2005). Safety climate constructs assessed included: safety communication, failure learning behaviors, work safety tension, psychological safety, crew staffing patterns (dispersed, co-located), work styles (independent, task interdependent), crew prestige, and the value of after action reviews (AARs). Hypotheses tested and modeled how crew configurations and work styles combined to influence learning behaviors, member comfort with communicating safety concerns, and the value of communication and learning practices. Based on both studies, recommendations are presented for enhancing the crew-level safety communication environment.

Additional Keywords: Safety climate, high reliability organization, HRO, safety, communication

Introduction

The core of this dissertation project is examining how safety is a social accomplishment that occurs within the workgroup—or crew—environment. This two-study mixed-methods dissertation uses a communication-centered approach to examine two perspectives on safety in wildland firefighting crews. The crew level of analysis is central to both studies because the crew is the social unit where the organization is translated for members and where the forces of socialization and membership are the strongest (Moreland & Levine 2001). Thus, members hold themselves and each other accountable to "how things are done here" on their crew. The overarching questions guiding both studies include: how do crew-level interaction routines for implementing organization-wide safety rules (e.g., LCES, 10 &18) differ between functionally similar crews (Study One)? And, what factors in the crew environment are most influential in shaping how members interact with one another regarding task implementation and learning (Study Two)?

Study One investigated safety from a high reliability organizing (HRO) perspective in which the primary mechanism for safety is rooted in *consistent* actions and interactions among members as they implement firefighting tasks and organization-wide safety rules. A qualitative study compared how two functionally-similar heli-rappel crews implemented firefighting tasks, highlighting key differences in the two crews' routines. Implications for high reliability organizing are discussed.

Study Two examined safety from a safety climate perspective whose central mechanisms for safe outcomes include ways that the workgroup environment accepts or encourages safety-related activities and members' voicing of safety concerns. A wide scale survey assessed safety climate variables across 220 wildland firefighting crews.

Study one: High reliability and wildland firefighting

Study One explored safety from the perspective of high reliability organizing. An HRO perspective assumes that organizing occurs under conditions of situational ambiguity, such as fluctuating environments or complex organizational structures (Rochlin 1993). Based on these ambiguous conditions, threats to safety arise when hazards go unnoticed or errors accumulate. Therefore, this perspective considers that the central *mechanisms* for safety are those that contribute to consistently error-free organizing processes (Weick 1987). Research examines how member actions and interactions yield *consistent patterns* for anticipating, noticing, managing and learning about difficult-to-detect hazards (Weick, Sutcliffe, & Obstfeld 2005; Weick & Roberts 1993). Theory-building related to HROs identifies how local learning (e.g., from accidents) becomes available to the broader organization (e.g., through new rules or policies); and likewise, how the organization's body of knowledge (particularly from accidents) can become relevant and accessible to members in their everyday actions. In wildland firefighting the Ten Standard Firefighting Orders and 18 Situations that Shout Watchout are examples of organization-level knowledge derived from fatalities and accidents (Zeigler 2007). Study One examined this recursive interplay between organizational knowledge—specifically, the 10 & 18 and LCES—and local action routines occurring at the workgroup level--specifically what the two crews *did* to implement the safety rules.

Existing HRO research advances cognitive-based models explaining how *organizations* function as systems of interconnected parts (Weick & Roberts 1993), and how members notice and exchange information about safety cues (Weick 1995). A cognitive approach asks how *individual* members make sense through action, generating a cognitive representation of their surrounding environment which allows them to notice and bracket cues and gain understandings of cause/effect relationships (Weick 1995). However, this literature excludes an important element in the wildland firefighting environment, namely interactions that socially construct crew organizing, especially interaction that shapes norms and practices regarding hazards and use of safety rules. A communication perspective can significantly contribute to the cognitive-based HRO research because it examines *workgroup* interaction--where the organization is translated for members and where the forces of socialization and membership are the strongest (Moreland & Levine 2001).

A communication constitutes organization (CCO) theoretical approach examines how the organization and the individual are linked as members share actions and in doing so constitute the organization (Bencherki & Cooren 2001). The core mechanism of CCO is a dialectical relationship between *text* and *conversation* (Robichaud, Giroux, & Taylor 2004). Texts are past instantiations of the organization that occur through interaction and are referenced in subsequent interactions. C*onversations* generate, reify or change texts. Ongoing interactions referencing the organization develop sustained practices where knowledge becomes *textualized*. As *text*, knowledge is grounded in practices such as ongoing interactions involved in problem solving, rather than individual instantiations of sensemaking. *Co-orientation* is the foundation of *conversation.* Co-orientation involves members interacting about an object, such as implementing a rule. Each member brings into the interaction his or her own organizational perspective toward the object (e.g., supervisors see rules differently than do subordinates). Members *orient* toward the object differently, and they also orient toward one another (e.g., as supervisor to subordinate and vice versa). Their organizational perspectives inform how each party negotiates what to do about the object.

Constitutive communication is located in *processes* such as how rules and routines are used differently across HRO workgroups. From this view, rules and routines enter into members' conversations--sometimes as the object of interaction, other times alluded to or implied. Rules are general directives meant for flexible application across numerous situations, and as such, require interpretation based on local norms and practices (Zhou 1993). Routines are patterns of action that persist over time (Pentland & Feldman 2005) and are considered "effortful accomplishments" because unpredictable circumstances mean that routines can never be fully standardized. Communicative interactions bring rules

and routines into conversation where they are interpreted and enacted, meaning that routines often comprise the local actions that enact an organization's wider-reaching rules (Becker 2004). Therefore, if *reliability* is conceptualized as *consistent* patterns of action across the organization for enacting rules or routines, then it is important to know whether and how workgroups within the same HRO differ in their practices and interaction patterns. If there is variation across the HRO in workgroup-level enactments of rules and routines, then what are the implications for high reliability, and ultimately, safety?

Study One research questions asked: 1) how critical incidents from two crews compared in the ways firefighters co-oriented to enact firefighting rules and routines, 2) how critical incidents from the two crews compared in ways firefighters oriented toward the object of material space, 3) how norms compared between the two crews and informed their texts; how the texts of each crew pointed to similar or different sets of sustained practices for implementing rules and routines, and 4) how the two crews' texts point to interactions that facilitate learning.

Study one methods

Study One used interpretive methods to examine crew-level interactions and norms that influence task implementation and enactment of safety rules. Interviews were conducted with 27 firefighters from two wildland fighting crews (Table 1), Manzanita (Region Five; 12 interviewees) and West Fork (Region Four; 15 interviewees). Individual, semi-structured interviews addressed: 1) Workgroup norms—new member socialization, personal struggles to adjust, and how their current crew experiences differed from previous ones. 2) Critical incidents—descriptions of a memorable fire experience that was important for developing their firefighter expertise, such as instances when fire activity surprised them, when something went wrong/well, or situations in which they took responsibility or assumed leadership. Interviews lasted 30-60 minutes and yielded more than 400 pages of transcript.

Table 1
Study one participants and crews

West Fork (Region 4)	Manzanita (Region 5)
Interview Participants	
15 members: 12 males, 3 females	12 members: 11 males, 1 female
Crew Structures	
25 people, 2 helicopters	20 people, 1 helicopter
Low turnover; Long crew tenure	High turnover; Short crew tenure
Highly qualified; Few "apprentices"	Lower level quals; Many "apprentices"
Crew splits into modules, members rotate	Crew travels together almost always
Few formal or informal AARs	Numerous formal and informal AARs

I analyzed the data in two parts: First, I extracted all of the *co-orientations* from the critical incidents and sorted them based on the object of interaction (e.g., a rule, routine and use of space). I used a grounded theory approach (Charmaz 2006) to map the co-orientations, noting accounts of conflict, dialogue, power struggle, etc. Second, I sorted the data related to workgroup text. I used an open coding procedure (Strauss & Corbin 1998) to label crew-specific norms and expectations such as *efficiency, learning* and so on. I then mapped each crew's *text* noting how workgroup expectations influenced the pressures members felt and informed their practices.

Study one results

RQ1. The first research question examined workgroup level routines for implementing safety and firefighting tasks. This question explored the ways the two crews' members engaged in organizing, or *co-oriented,* through communicative interactions for implementing safety and firefighting tasks. From an HRO perspective, the primary mechanisms for safety are the consistent patterns of action for managing

and anticipating hazards. These consistent patterns of action were the crews' local routines. Findings revealed that the crews differed substantially on three routines: *planning*, *use of safety rules* and *authority*. The two crews were each aware of their collective experience levels, and as a result, how they needed to interact within the crew in order to facilitate consistent actions and stay abreast of emerging hazards. For example, the high number of inexperienced Manzanita members created a practical need for members to learn as quickly as possible. Therefore, a *mentorship* interaction pattern was embedded in the crew's planning, rule-use and authority routines. West Fork members, on the other hand, were highly experienced and often tasked with handling challenging situations that other crews were not qualified to handle. The mechanism for reliable actions took a different form for West Fork than it did for Manzanita. Whereas the goal for most of Manzanita's activities involved helping inexperienced firefighters gain experience, the main goal for West Fork members was to gain experience acting *autonomously* because most members were highly experienced they collectively considered themselves to be experts. Thus, mechanisms for reliably safe action were rooted in developing skills at individually evaluating situations, devising and defending plans, and voicing dissent. Interactions involving autonomy, discernment and asserting one's position characterized the planning, rule-use and authority routines.

RQ2. Because the situational ambiguity of the complex and ever-changing physical environment plays such a prominent role in the HRO perspective, the second research question examined how the two crews managed material space when implementing firefighting tasks and safety. For Manzanita, configuring the fire's spatial environment involved talking through options for locating escape routes and safety zones in relation to various terrain features and the fire. This process of managing space was embedded in the mentorship-based interactions between members that comprised the planning and rule-use routines. In contrast, several West Fork members described close-call incidents in which their safety zone was inadequate and they had to run from the fire. These experiences created a visceral understanding of space that caused them to *change* their subsequent implementations of safety zones. Thus, through close-call incidents, members deepened their understandings about difficult-to-detect hazards that trigger sudden changes in fire size, and adapted new methods for configuring their firefighting work environments. They gained understanding about where to place safety zones and escape routes and began to anticipate how the time of day and weather changes would influence certain spatial configurations (e.g., the proximity of safety zones relative to the fire), described a more deliberate process for anticipating and responding to changing or problematic circumstances.

RQ3. The third research question explored how past conversations (coorientations) that referenced the workgroup and safety routines served as a basis for members' ongoing instantiations of the organization. *Texts* refer to accumulations of past coorientations, or interactions (Taylor & Van Every 2000). Relative to high reliability organizing, this research question addressed how past interactions set a precedent for future interactions. Manzanita's interactions reflected that members prioritized the importance of *training* for its relatively inexperienced members. As such, their way of addressing this need was to embed a mentorship-based interaction in their routines. To contrast, West Fork's needs involved pushing members to act expertly and independently; to address the need, members (somewhat unintentionally) challenged themselves to engage in *conflict-based interactions* in which they practiced asserting themselves. From these different sets of needs, the two crews differed on three *texts,* including notions of *groupness*, *efficiency* and *safety*. For Manzanita, groupness was achieved through task-related communicative activities that built trust and cohesion. Efficiency was defined by members' abilities to notice and communicate about problems and safety concerns quickly and accurately. Safety was rooted in learning practices that pushed less experienced members to see and talk about fireline situations. All three of these texts interrelated to contribute to an environment that facilitated free exchange of questions and encouraged members to raise concerns and insights to facilitate learning. For West Fork, groupness was achieved through non-task related "fun" activities in which members played sports together or "joked around." However, the defining aspect of the West Fork's groupness was related to its expectations for professionalism; thus, it was equally important for members to demonstrate that they knew the difference between "work time" and "play time." Efficiency meant moving quickly and acting without supervision.

Safety resulted from members' abilities to think and act appropriately as individuals. These three texts contributed to creating expectations for members not only to act as experts, but also to see themselves as such.

RQ4. The final research question synthesized how the findings about coorientation, management of material space and crew texts inform what we know about how "high reliability" organizing occurs in wildland firefighting. Findings from Study One suggested that both Manzanita and West Fork crews operated as models of high reliability organizations, but that they did so by creating different types of expectations and interaction patterns. Further, both environments were better suited for some firefighters more than others. Specifically, less experienced firefighters would benefit from Manzanita's encouragement of open dialogue and learning as mechanisms for generating consistently safe actions. In contrast, firefighters with a baseline of experience should seek employment on crews like West Fork where they would be pushed to use their expertise and gain deeper experience through facing tough challenges.

Study two: Safety climate and wildland firefighting

Like the HRO perspective, the safety climate perspective also takes safety as its central problem. This perspective assumes that organizing processes occur under conditions in which high rates of production or output are prioritized (Zohar 1980; Zohar & Luria 2005). In this context, the primary obstacles to safety are attitudes and patterns of communication that de-value safety or discourage the implementation of it (Morrow, et al. 2010). Therefore, this perspective considers that the central *mechanisms* for safety are attitudes and behaviors that demonstrate value and commitment to safety by both vertical and lateral organization members. Safety climates depend on supervisors and subordinates sharing the same value for safe actions, while co-workers must also demonstrate their mutual commitment to prioritizing safe behaviors (Hofmann & Mark 2006).

Research on safety climate takes a post-positivist view, typically using quantitative methods to identify dimensions of the construct and to model relationships among predictor and criterion variables in various production-based organizational contexts, such as manufacturing and construction (Guldenmund 2000; Zohar 1980; Zohar & Luria 2005). Safety can be problematic in industrial contexts because workers struggle against time pressures to meet demanding production goals. Implementing safety involves extra steps and takes extra time, which hinders workers' abilities to meet these goals. As such, the social environment—hierarchically and/or laterally—might be hostile to members who display safe behaviors (and thus are slow). Therefore, safety climate studies are particularly concerned with factors in the work environment that discourage safe action.

The study of safety climates also applies to high hazard organizations such as wildland firefighting in which the pressures to respond quickly to changing circumstances or emergent hazards might encourage members to cut corners in implementing safety. In wildland firefighting, as with other time-driven organizations, safety not only depends on safe *attitudes*, but on members *communicating* their safety concerns (Barton & Sutcliffe 2009). On this basis, Study Two assessed the safety climate of wildland firefighters across three federal agencies. The design of Study Two's safety climate survey incorporated key findings from Study One that informed the wildland firefighting communicative interaction context. Measures were adapted to assess the following group-level constructs: *safety communication* (ability to discuss safety issues with supervisors in-the-moment) (Hofman & Stetzer 1988); *task interdependence/independence* (Pearce & Gregerson 1991)*; failure learning behaviors* (processes to learn retrospectively from failures) (Carmeli 2007)*; psychological safety* (ability to discuss/take interpersonal risks in the crew) (Edmondson, 1999)*; crew prestige* (Mael & Ashforth 1992); and *work-safety tension* (belief that the organization values productivity over safety) (Morrow, et al. 2009). Items also asked crews to assess their use of After Action Reviews (AARs), retrospective group discussions used for firefighter learning. Cronbach's alpha reliabilities for each scale, based on responses from $N = 220$ crews, are reported in Table 2. I assessed frequency of and common reasons prompting AARs and the degree to which crew members value AARs. In the findings that follow, please note that

the Likert scales ranged from 1 (Strongly Agree) to 7 (Strongly Disagree) such that lower scores indicate higher levels of agreement.

Table 2
Descriptive statistics of crew-level scales

	N	α	*M*	*SD*
Task Interdependence	220	.69	1.98	.69
Independence	220	.73	2.93	1.02
Crew Prestige	220	.84	1.96	.69
Safety Communication	220	.73	2.09	.74
Psychological Safety	220	.68	2.16	.77
Failure Learning	220	.88	2.20	.73
Social WST	220	.57	5.24	.97
Environmental WST	220	.62	4.25	1.19
Value of AARs	220	.87	2.38	.88
AAR Frequency	220	n/a	2.68	1.36

Three research questions addressed the following: 1) how crew staffing patterns (co-located, dispersed) were related to work style (independent, task interdependent), crew communication activities and the crew's interaction environment; 2) how independence and task interdependence related to each another in the context of wildland firefighting work; and 3) how crew communication activities shaped (and were shaped by) aspects of the crew interaction environment. Each research question includes specific hypotheses.

Study two methods

A survey assessing workgroup safety culture was completed online by $N = 379$ federal wildland firefighters. Participants ranged in age from 19 to 60 years old, with a median age of 33 ($M = 35$, $SD = 8$ years). There were 330 males (87%), 45 females (12%); four participants did not report their sex. Ethnicity included 277 Whites, 23 Hispanics, 11 Native Americans, four African Americans, two Asian Americans, and 62 participants did not report ethnicity. Of the participants, 108 worked on engines, 54 on Type 2 crews (handcrews, initial attack or fuels crews), 113 were from interagency hotshot crews, and 104 from helitack or heli-rappel crews. There was participation from members at all levels in the crew-level chain of command including 75 superintendents, 58 foremen, 35 assistant foremen, 66 captains, 53 squad leaders, 40 senior firefighters, 49 non-supervisory members, and 3 did not report their crew position. Overall, the demographics generally represent wildland firefighting within the prominent federal wildland firefighting agencies (US Forest Service, Bureau of Land Management, and National Park Service).[i]

Because the survey was administered in early fall, the sample did not capture the seasonal workforce of college students who often have jobs as non-supervisory members and senior firefighters. For this reason, responses were heavily weighted toward the higher-level crew supervisors. Also due to missing the seasonal student workforce, fire experience and crew tenure were relatively high overall. Participants had a median of 12 wildland firefighting seasons ($M = 13.15$, $SD = 6.82$), and a median of five seasons on their current crew ($M = 6.14$, $SD = 4.75$).

After data were screened, they were aggregated by crew, which resulted in representation from 220 crews (Table 3). All analyses assessed the crew level. There was nearly equal representation across the four primary interagency crew types: hotshot (60 crews), helitack/rappel (57 crews), engine (74 crews) and Type 2 handcrews (29 crews). The majority of participating crews were from the western states (Figure 1).

Table 3
Number of crews that responded to the survey by state

State	*N*	Percent	State	*N*	Percent
California	35	15.9	South Dakota	4	1.8
Idaho	34	15.5	Florida	3	1.4
Oregon	26	11.8	Missouri	2	.9
Montana	22	10.0	Tennessee	2	.9
Colorado	18	8.2	Arkansas	2	.9
Wyoming	17	7.7	Nebraska	1	.5
Utah	12	5.5	Illinois	1	.5
Arizona	10	4.5	Mississippi	1	.5
Washington	8	3.6	Georgia	1	.5
New Mexico	8	3.6	Kansas	1	.5
Minnesota	6	2.7	North Carolina	1	.5
Nevada	5	2.3			
			TOTAL	220	100

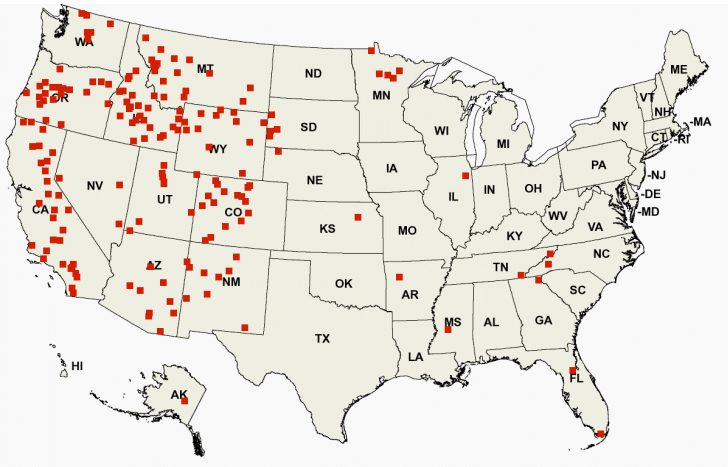

Figure 1. Geographic distribution of participating crews

Study two results

RQ1. The first research question examined how staffing patterns influenced safety climate (Table 4). The difference between co-located and dispersed staffing patterns was important in Study One because it seemed to shape each crews' ability to institute regular communication-based routines, and secondly, groups who work together all the time might be more comfortable together than groups whose members are always coming and going. The Study Two findings revealed that co-located crews and dispersed crews differed (as would be expected) with co-located crews revealing significantly higher task interdependency and significantly lower independence than dispersed crews. However, it was notable that co-located and dispersed crews did not differ significantly on any of the interaction environment or communication activity variables (see Table 4).

Table 4
Study two: Research question one hypothesis and results

RQ1: How does crew *staffing pattern* relate to *work style*, crew

communication activities and aspects of the *crew interaction* environment?	Findings
H1: Co-located crews will significantly differ from dispersed crews, reporting lower independence,* and higher task interdependence,* safety communication, psychological safety, failure-based learning behaviors and AAR frequency.	$F(6, 213) = .895$, $p < .001$ Independence: $F(1, 218) = 8.01$, $p < .01$ Co-located ($M = 3.03$, $SD = .99$) Dispersed ($M = 2.54$, $SD = 1.04$); Task Interdependence: $F(1, 218) = 11.92$, $p < .01$ Co-located ($M = 1.91$, $SD = .66$) Dispersed ($M = 2.30$, $SD = .75$)

* = Significant in predicted direction.
Staffing patterns = Co-located, dispersed.
Work style = Independent, task interdependent.
Communication activities = Safety communication, failure learning, AAR frequency, AAR value.
Interaction environment = Psychological safety, crew prestige, social work safety tension.

Findings from H1 suggested that staffing patterns might play a less important role in the safety climate than indicated in Study One. The implication for high reliability organizing is that consistency in action can emerge even if there is inconsistency in staffing. Considered in relation to Study One, this finding points to the importance of crew *text*. Manzanita and West Fork enacted their crew texts for efficiency, groupness and safety in different ways, and likewise, the texts informed their actions. Their collectively-held understanding of what made their crews distinctive served as a guide for their actions. Thus, even though West Fork members did not work together often, they still collectively understood that their crew text for efficiency, for example, meant that they were to accomplish tasks quickly without supervision. Thus, in relation to these Study Two findings, the crew's co-located or dispersed staffing pattern might play a less crucial role in guiding member action as compared to the influence of the crew's text. Therefore, the crew text provided specific guidelines for action (e.g., as a mentor or expert) that were consistent, regardless of whether the crew worked in a co-located manner or not.

Table 5
Study two: Research question two hypotheses and results

RQ2: How are independence and task interdependence related to each other in wildland firefighting? How do independence and task interdependence compare to each other in their influence on workgroup safety climate?	Findings
H2a: Specialty areas will differ in their levels of independence.*	$F(3, 216) = 9.75$, $p < .001$
H2b: Specialty areas will differ in their levels of task interdependence.*	$F(3, 216) = 4.36$, $p < .01$
H3a: Crew task interdependence predicts safety communication, psychological safety, failure-based learning behaviors and frequency and value of AARs.	$\chi^2(10) = 387.8$, $p = .000$; *CFI* = .23; *RMSEA* = .42; *SRMR* = .27.
H3b: Crew independence predicts safety communication, psychological safety, failure-based learning behaviors and frequency and value of AARs.	$\chi^2(10) = 454.4$, $p < .001$; *CFI* = .03; *RMSEA* = .45; *SRMR* = .33
H4: High independence** and low task interdependence predict high social work-safety tension.	$F(2, 217) = 7.57$, $p < .01$, $r = .26$, $R^2 = .07$ Independence ($\beta = -.24$, $p < .001$) Task Interdependence ($\beta = -.02$, $p = .87$)

* = Significant in predicted direction.
** = Significant in opposite direction than predicted.

RQ2. The second research question investigated how independence and task interdependence related to each other in influencing safety climate (Table 5). This finding indicated that task interdependence and independence are not opposite measures, as Study One findings seemed to indicate: Manzanita appeared to operate in a task-interdependent manner while West Fork was notably independent. Instead, these concepts appeared to capture different types of activities in the wildland firefighting context, rather than crew-specific organizing styles.

Hypothesis 2a revealed that specialty areas varied widely on independence, while they did not vary much on task interdependence (H2b). Further, high independence was a moderately strong predictor for low social work safety tension (social pressure from crew members to take risks) (H4). These findings suggest that crews in which members were accustomed to making their own decisions might have trusted themselves more and, as a result, might have been more resistant to the influences of the group regarding taking risks.

Task interdependence seemed to be a description of what was required for firefighting work tasks in general because most tasks are relatively large scale and require more than one person to accomplish.

However, there were some relationships in which task interdependence seemed to distinguish among crews. Specifically, task interdependence was a significant and strong predictor (along with failure learning activities) of crew prestige (H8; see Table 6 below). From the importance of task interdependence in that regression equation, it can be reasonably inferred that the degree to which members felt it was necessary to work together on tasks might have boosted their feelings that their collaborations were necessary to produce high-quality work. This, in turn, might have enhanced their evaluation of the quality of the crew (its crew prestige). In contrast, working independently might not have cued members to feel that collective effort was useful, and as a result, might not be an important contributor to members valuing the quality and reputation of the workgroup's efforts. A strong sense of task interdependence might cue an awareness of the collective crew, which may cause firefighters to consider more conservative actions regarding hazards because they are more aware of the safety implications for their entire crew.

Taken together, independence seemed to describe how a crew went about conducting work, while task interdependence tended to describe the kinds of responses required for the large-scale coordination-intensive tasks involved in wildland firefighting. Also, crew specialties tend to vary from one another on several of their duties, which might have contributed to their varying levels of independence. For example, helitack/rappel crews manage aircraft missions that require members to staff various helicopter landing and cargo sites dispersed across the geographic area of a fire. Hotshot and Type 2 hand crews each tended to work together as single units. Engine crews typically had small modules of three to seven members, and with so few people to manage (in comparison to a hotshot or Type 2 hand crew which typically staff 20 members), the unit might operate with a great deal of autonomy. However, task interdependence was a significant predictor of crew prestige (H8) which suggested that, in the wildland fire context, it played a strong and pointed role in contributing to crew prestige (above and beyond simply being descriptive of the type of coordination required for wildland firefighting tasks).

RQ3. Research question three focused specifically on the interplay among communication-based activities and the feel of the crew interaction environment. This research question reflected the basic premise found throughout the safety climate literature that climate and action are recursively related (Table 6). Therefore, the feel of the social environment influences whether members engage in safety-related action, and safety actions shape the feel of the crew's social climate. The hypotheses pertaining to this research question test which variables have more and less influence on each other, and how.

Table 6
Study two: Research question three hypotheses and results

RQ3: How do crew *communication activities*[A] and aspects of the crew *interaction environment*[B] inform a crew's safety climate?	Findings
H5: High frequency and value of AARs, safety communication*, failure learning and psychological safety predict low social work safety tension.	$F(5, 214) = 8.49$, $p < .001$, $r = .41$, $R^2 = .17$ Safety communication ($\beta = -.54$, $p < .001$)
H6: High crew prestige,* task interdependence* and independence* predict high safety communication.	$F(3, 216) = 21.09$, $p < .001$, $r = .48$, $R^2 = .23$ Crew prestige ($\beta = .36$, $p < .001$) Task interdependence ($\beta = .19$, $p < .01$) Independence ($\beta = .09$, $p < .05$)
H7: High crew prestige,* safety communication,* failure-based learning,* AAR value and AAR frequency predict high psychological safety.	$F(5, 214) = 54.02$, $p <. 001$, $r = .75$, $R^2 = .56$ Crew prestige ($\beta = .17$, $p < .01$) Safety communication ($\beta = .39$, $p < .001$) Failure learning ($\beta = .32$, $p < .001$)
H8: High failure learning,* safety communication, AAR value and AAR frequency, task interdependence* and independence	$F(6, 213) = 18.77$, $p < .001$, $r = .59$, $R^2 = .35$ Task interdependence ($\beta = .27$, $p < .001$)

predict high crew prestige.	Failure learning ($\beta = .30$, $p < .001$)
H9b: A crew's task interdependence moderates the relationship between crew prestige and social work safety tension.	$\chi^2(1) = 7.27$, $p = .007$; *CFI* = .70; *RMSEA* = .17, *SRMR* = .07
H9c: A crew's independence moderates the relationship between crew prestige and social work safety tension.	$\chi^2(1) = 8.82$, $p = .003$; *CFI* = .86; *RMSEA* = .19 *SRMR* = .07

* = Significant in predicted direction.
[A]*Communication activities* = safety communication, failure learning, AAR frequency, AAR value.
[B]*Interaction environment* = psychological safety, crew prestige, social work safety tension.

To summarize research question three, findings showed that members' ability to speak openly and in-the-moment about safety (safety communication) was a powerful predictor of both low social work safety tension (H5) and the crew's high psychological safety (H7). Exploring the conditions that enabled safety communication, H6 found that crew prestige was the strongest among several predictors for safety communication, followed by task interdependence and independence. This finding revealed the unexpected importance of crew prestige in shaping the workgroup's safety climate and interaction dynamics. Further exploring crew prestige as a central predictor for engaging in communication-based learning activities, H8 investigated which factors contributed to it. Findings revealed that crew prestige was most closely tied to task interdependence and failure learning behaviors. These findings suggested that crew prestige is closely associated with a sense of crew collectiveness and an atmosphere that promoted member learning through deliberate discussion-based activities, as indicated by the survey items.

To synthesize H9a, H9b and H9c, the relationship between crew prestige and social work-safety tension was opposite than predicted such that high crew prestige predicted low social work safety tension. High independence levels also predicted low social work-safety tension while task interdependence had no influence on the dependent variable. This revealed that members felt less pressure to engage in unsafe work when they felt free to act independently, or if their crew was highly prestigious. Prestige seemed to relate to sense of concern for the collective such that prestigious crews were those whose members were aware that there was collective concern for acting safely. Independence appeared to relate to an individual's sense of control over avoiding being drawn into group activities he or she felt no control over.

Further, the findings drew a clear distinction between minimal conditions for members to act safely, and deliberate activities designed to enhance learning and comfort of the collective crew environment.

*Minimal conditions for safety***.** Minimal conditions for safe action were indicated in H5, which revealed that out of several constructs including safety communication, failure learning, psychological safety, and frequency and value of AARs, only safety communication had a significant and strong influence on reducing social work-safety tension. It was initially surprising that failure learning behaviors and psychological safety did not have significant effects on social work safety tension. Examining the items that comprise safety communication, AAR value, failure learning, and psychological safety, it appeared that safety communication captured the basic and necessary conditions for safety on the crew—specifically, the in-the-moment expression of safety concerns. As a result, safety communication partially diffused pressure to engage in hazardous activities.

Deliberate activities and intentional climate. In addition to basic conditions for safety, there also are deliberate actions that contribute to intentionally building a safety climate. Psychological safety measured the degree to which the workgroup environment felt safe for interpersonal risk-taking. This type of crew environment is likely important in wildland firefighting because firefighters face ambiguous fireline circumstances in which it is difficult to discern and prioritize hazards. It can be difficult for a firefighter to know if what he or she is seeing warrants the concern of others, and members may fear

social costs associated with bringing up seemingly insignificant concerns. Having strong safety communication and failure learning practices in place appeared to facilitate an environment in which there were fewer social costs associated with expressing concerns and participating in learning, particularly learning from mistakes (H7). In this case, safety communication can be considered a necessary condition that enables failure learning activities to occur, meaning that failure learning activities would not likely occur without there also being safety communication, but safety communication can be present even when failure learning activities are not.

Finally, I fit a structural equation (path) model (Kline, 2011) that was a good fit for the data $\chi^2(3) = 7.86$, $p = .05$; *CFI* = .99; *RMSEA* = .09; *SRMR* = .03, and all regression paths were significant (Figure 2). This model showed several important relationships and how these constructs worked together in crew interaction. First, safety communication ($\beta = .61$, $p < .001$) was a strong predictor for failure learning behaviors. Previous hypothesis tests suggested that safety communication referred to in-the-moment communication behaviors while failure learning referred to a more deliberate retrospective learning activity. Second, safety communication ($\beta = .44$, $p < .001$) was a stronger predictor for psychological safety than was failure learning ($\beta = .34$, $p < .001$), which suggested that the degree to which members feel comfortable for interpersonal risk taking on the crew was more strongly influenced by their ability to voice concerns in-the-moment (safety communication) than it was by whether their crew deliberately engaged in learning activities (failure learning). Third, psychological safety moderately and significantly predicted crew prestige ($\beta = .35$, $p < .001$) indicating that highly reputable crews were those whose members felt generally comfortable interacting with one another. Finally, crew prestige predicted whether the crew engaged in failure learning activities ($\beta = .21$, $p < .001$), as well as the degree to which a crew was rated as task interdependent (($\beta = .39$, $p < .001$). Task interdependence acted as a moderator between crew prestige and safety communication such that a greater degree of task interdependence predicted higher safety communication ($\beta = .27$, $p < .001$).

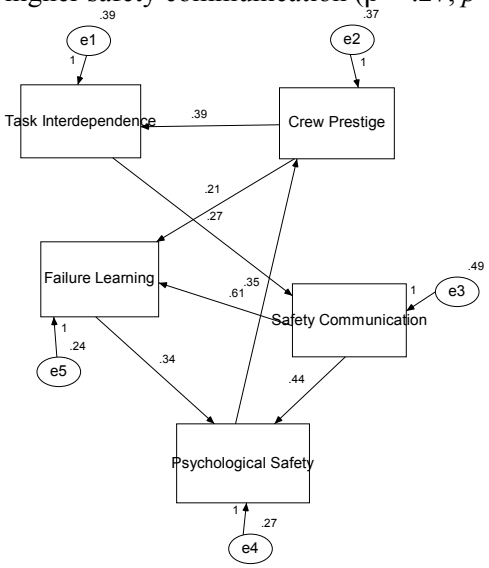

Figure 2. Structural equation model depicting relationships among variables measuring the crew interaction environment and communication activities. $\chi^2(3) = 7.86$, $p = .05$; *CFI* = .99; *RMSEA* = .09; *SRMR* = .03

In summary, safety communication appeared to capture the basic and necessary conditions for safety on the crew such that safety communication partially diffused pressure to engage in hazardous activities. To contrast, failure learning seemed to be a deliberate activity rather than a spontaneous one.

These findings point to safety communication as being a more important predictor for safety climate, in general, because members will feel safer when they are able to speak freely about questions and concerns.

Integration of study one and study two findings

The primary reason for conducting a mixed methods study using an *initiation* approach is to use insights derived from one research paradigm to inform findings from another while maintaining the integrity of both paradigms (Greene, et al. 1989; Leech & Onwuegbuzie 2009). Greene et al., argue that researchers who use this approach often are looking for areas in which the findings from one study diverge from the findings from another. These areas of disagreement can point to new research questions. This section integrates findings from Studies One and Two to illustrate how one perspective informs the other. Therefore, in the following discussion, I apply the central question from the HRO literature to the safety climate literature. The central HRO question is: How do patterns of actions and interactions contribute to members' efforts to anticipate, notice, manage and learn about difficult-to-detect hazards? I also apply the central question from the safety climate literature to the HRO literature, specifically: What are the social pressures that encourage or discourage safe action? I have organized this section around key concepts: communication and safety, groupness, task interdependence versus independence, and prestige.

Communication and safety

Two key concepts around safety emerged from Study One, which informed Study Two: safety communication and failure learning. Study One showed that Manzanita made safety visible through regular debriefings during which there was ongoing interaction between members. In these interactions, members defined the situations and discussed which action options were available. Manzanita also regularly conducted retrospective learning-based discussions, which members said were important for creating a comfortable communication atmosphere on their crew. In contrast, West Fork's safety text was around voicing their views, acting as individuals and developing discernment that was both tactical and social, enabling them to notice problematic situations and to overcome social constraints in order to take action. West Fork did not routinely engage in a retrospective learning-based discussion.

Sources for safety-related pressure were different for the two crews: Manzanita members engaged in dialogue between mentors and mentees as a way to understand situations and decide which actions to take. Thus, there was pressure to engage in learning through communication—to discuss situations and ask questions before engaging in firefighting action. West Fork members described a pressure to act as experts, which was opposite from Manzanita. There was pressure to act independently and decisively, and to take on more challenging situations than less-experienced crews. However, a large part of West Fork's expertise was communicatively developed (and demonstrated) as they resisted enacting bad decisions that other firefighters—from their crew or from other crews—recommended. They described their communication-based methods for voicing dissent and asserting themselves in order to fulfill their expert role.

Study Two indicated that safety communication—in-the-moment communication—was a foundational, necessary condition for a safety climate. Safety communication was the strongest predictor of low social work-safety tension. Thus, being able to communicate about hazards helped people to feel that they had control over how they would handle inherent job risks. This hints at the high reliability notion of *redundancy,* which is the idea that organizational systems containing duplication and back-up plans therefore contain more possible ways to successfully and safely complete a task (Weick, Sutcliffe, & Obstfeld 1999). Redundancy also takes the form of skepticism. This means that safety climates in which members feel free to voice concerns in-the-moment (have high safety communication) will be more redundant, and thus, more highly reliable. Manzanita members incorporated safety communication into their dialogue-based coorientations with one another while West Fork members engaged in conflict-based coorientations in which they asserted a position. Both the conflict- and dialogue-based models for redundancy reflect the notion of skepticism. Through dialogue, Manzanita members ask questions of each other in order to discover whether they have fully considered the situation and action options. Dialogue

coorientations place the mentor in the position of explaining and justifying their rationale to mentees. The dialogue process might involve mentor and mentee confirming the soundness of the safety of a plan, which would be a form of duplication. Alternatively, mentees might ask questions about hazards that the mentor overlooked, thus introducing a form of skepticism into the interaction that can be further discussed. Similarly, West Fork's conflict-based coorientations introduce skepticism, because they force the coorienting parties to justify the safety of their positions.

Failure learning routines were a defining element of the Manzanita crew, whose members highly valued the AAR learning activity. West Fork members did not talk about regularly engaging in such a practice, largely because their dispersed staffing patterns did not enable them to easily institute it. However, West Fork did not appear to be hindered by their lack of retrospective learning routines, while Manzanita did seem to greatly benefit from them. Study Two results indicated that failure-based learning was an equally strong predictor as safety communication in contributing to a crew's psychological safety. This finding indicates that the psychological safety of a crew's interaction environment benefits from open communication, in general. However, the deliberate nature of conducting retrospective (e.g., failure-based) learning discussions might hint at a particular type of crew environment. For example, in Study One, both Manzanita and West Fork appeared to be able to communicate freely with each other, however Manzanita's deliberate efforts to engage in learning-based discussions reflected a collectively-held view that the purpose of their crew was to help members learn. In summary, safety communication and failure learning were central predictors influencing the psychological safety of the workgroup's climate.

Groupness

Study One illustrated that Manzanita's sense of groupness involved concern for the collective of the group while West Fork embraced a broader sense of collective identity as experts. Further, the notion of workgroup *texts* illustrated how notions of groupness informed their actions. Manzanita's concern for collective learning prompted them to engage in activities that promoted crew cohesion and conversation. West Fork's expert identity prompted members to take on challenging assignments and act autonomously without supervision.

From a safety climate perspective, the groupness *texts* for both Manzanita and West Fork add insights to understanding how social pressures arise from a safety climate. Texts are past conversations that have set a precedent for how future interactions should unfold. Therefore, Manzanita's groupness text, based on building cohesion, sets expectations for members to value cohesion and do what they can to promote it within the crew. Conversely, members who act in ways that divide the crew or who refuse to participate in collective activities will face social costs. West Fork's groupness text, based on being independent experts, set expectations for members to be autonomous and resourceful on their own. This expectation might have pressured members to feel as though they should avoid asking questions for fear that they would appear to be less than an expert, or not worthy for their position on the crew. Therefore, different crew texts point to the types of behaviors crews expect of members, and simultaneously, the types of behaviors that they marginalize or belittle. Behaviors that are and are not accepted can inform the types of social pressures influencing safety-based activities in the workgroup. Thus, safety climate literature highlights the importance of supervisors and co-workers in creating environments in which members feel comfortable engaging in safety-based activities. Considering additional social factors (e.g., identities, expectations) in safety climate literature can add breadth to the research.

In Study Two the measurements for groupness were grounded in communication activities and task interdependence. It makes sense to measure a sense of groupness by focusing on activities that bring members together; however, Study One showed that a sense of groupness was also rooted in individualism. West Fork exhibited a strong sense of groupness, but it was based on their collective identity as *independent* experts. Further, their sense of collective identity was invoked during activities that brought members together, but that they likely took for granted, such as joking around or engaging in a sport-based activity. At an organization-wide scale, it might be informative to capture the variety of activities that cue groupness for other crews like West Fork who assemble around their individualist

identity rather than their mutual engagement in typical group-based forms of organizing. However, open-ended survey responses, observation of crew activities, and additional interviews could be used to gain a wider understanding of various forms of groupness.

Independence versus task interdependence

In Study One, independence and task interdependence emerged as the defining features of the two crews: West Fork was a highly independent crew, based largely on their dispersed staffing patterns; Manzanita was a highly task interdependent crew, based on their co-located staffing and regular occurrence of learning-based communication routines (e.g., AARs, retrospective discussions, proactive planning dialogues).

The intention for testing task interdependence and independence in Study Two was to identify crews that were similar to either West Fork or Manzanita. However, crews often scored highly on both measures, which pointed to richer conclusions. Thus, instead of using the measures to identify which crews were task interdependent versus independent, Study Two ultimately explored how independence and task interdependence each influenced safety climate. The concepts, task interdependence and independence, appeared to capture different types of activities in the wildland firefighting context.

On one hand, task interdependence was a significant and strong predictor (along with failure learning) of crew prestige. This finding suggested that the degree to which members felt it was necessary to work together on tasks might have boosted the feelings that their collaborations were necessary to produce high-quality work. A strong sense of task interdependence might cue an awareness of the collective crew, which could cause firefighters to consider more conservative actions regarding hazards.

On the other hand, task interdependency appeared to assess basic and ongoing aspects of firefighting, as the work tends to be large-scale, and it typically requires coordination among numerous resources. Thus, task interdependence may simply cue members to think about the nature of the work rather than distinctive aspects of how their crews operated (which was the intended measure). In contrast, firefighters did notably vary in their opportunities to work independently. Independent crews were found to be more resistant to pressures to take risks than were less independent crews. Thus opportunities to exercise independent action enable members to feel more control over their circumstances, and as a result, less pressure to go along with hazardous decisions made by groups.

Prestige

Study One indicated that West Fork members thought highly of their crew and strived to uphold its highly professional reputation within the firefighting community. Thus, West Fork was a prestigious crew. Manzanita members did not talk directly about their crew being prestigious, but that did not mean that they lacked prestige. Rather, for them, they took pride in playing a pivotal role in facilitating less-experienced firefighters' efforts to gain experience. While highly valued, they did not talk about their prestige in terms of upholding a particular "reputation" (as West Fork members did). In Study One, West Fork members, whose interviews invoked the concept of crew prestige directly, informed which indicators I chose to explore in Study Two. West Fork members talked about how their crew had a good reputation, and that working there "looked good" on their firefighting resume, etc. In conducting Study Two, I anticipated that the notion of crew prestige would be linked to upholding a capable reputation and therefore, pressures to perform when safety was not fully implemented--a feeling that some West Fork members said they experienced.

However, Study Two revealed very different results than expected. First, results showed that crew prestige was a significant predictor of psychological safety when combined with failure learning and safety communication. The higher the collective esteem about the crew, the more members valued their contributions and wanted to share them, thus the higher their psychological safety. In contrast to Study One, this finding linked crew prestige with a desire to contribute to the collective group, rather than linking prestige to independent actions.

Second, I hypothesized that high crew prestige would predict high pressure from crew members to engage hazards (social work-safety tension). This hypothesis was significant, but in the opposite direction than expected. High crew prestige, in fact, predicted lower levels of social work-safety tension ($\beta = -.28$, $p < .01$; see Table 6). If prestige indicates that certain actions were rewarded with a good reputation, then this finding indicates that fire crews value conservative actions toward engaging hazards, rather than taking bold risks. This is a substantial finding because it illustrates a broadly-reaching value among wildland firefighters for conservative actions.

In a third hypothesized relationship (H6, Table 6), crew prestige was found to be the strongest predictor of safety communication (along with task interdependence and independence). Items in crew prestige measured the degree to which a crew was highly regarded both by members and within the firefighting community. This finding could be interpreted to mean that freedom to voice safety concerns upwardly and in general (i.e., safety communication) among the crew was a highly regarded activity in wildland firefighting. Further, for members to consider their group to be prestigious, they must think highly of the collective, including the ways the crew accomplished work, the degree to which it upheld high standards, and the belief that membership on the crew was sought-after within firefighting.

Therefore, Study Two diverged from Study One findings on the notion of prestige. In Study One, prestige was linked to West Fork's autonomy, high expertise and pressure to take on hazards that other crews were not experienced enough to handle. In contrast, Study Two revealed that prestige, within the broader wildland firefighting profession, was linked to safety communication behaviors, a lack of pressure to engage hazards, and the psychological safety of the crew's interaction environment. This diversion in results might indicate that West Fork's emphasis of living up to a certain reputation did not, in fact, reflect the notion of prestige as it is conceptualized within the broader firefighting community. Perhaps West Fork's emphasis on their good reputation was a way to justify how their particular style of crew organizing was valuable, and set them apart from other crews (rather than defining a widely accepted notion of prestige among wildland firefighting crews).

Management implications: Recommendations for crew leaders

Findings from both studies summarized in this report affirmed the importance of crew level activities for implementing safety and developing firefighter experience. Study One showed that Manzanita and West Fork each maintained different communication and learning models that involved fostering mentorship and gaining practice with asserting authority, respectively. These learning models each contributed to the distinctive feel of the crew environments, and served the crews in different ways. Related to the feel of the crew environments, Study Two findings showed that open communicative exchange on crews contributed to members feeling comfortable voicing their concerns, and avoiding pressure to engage situations when safety was not in place. From these findings, I next describe how organizational leaders and crew leaders can foster consistent communicative routines, and learning from in-the-moment action.

Consistent communicative routines

The two studies in this project illustrated the importance of consistent communication routines in contributing to a comfortable and safety-conscious crew environment. A communicative crew environment is particularly important for crews that have high turnover, and for crews which have inexperienced members. When communicative routines (such as AARs or informal debriefings) are conducted on a regular basis within the crew, members who are unfamiliar with each other (e.g., due to high turnover) can become more comfortable voicing concerns as they get to know their crew members. Also, when inexperienced members are encouraged to talk about their fire experiences and questions, they become accustomed to voicing their questions and concerns. Consistent communication routines help to create a communication environment that facilitates safety.

How leaders can facilitate the crew's communication environment. A communication forum

plays an important role in helping members deepen their experience through sensemaking processes. The after action review (AAR) is one example of a possible communication forum that crews can draw upon. My findings show several recommendations for managers that would enhance the efficacy of this type of routine.

First, members must share and accept the value of the routine. Crew leaders can facilitate their members' acceptance of the routine by demonstrating their own value of it. If managers take the routine seriously, then they will set the example for how other members interpret the routine's value.

Second, managers should foster a comfortable communication environment so that members feel welcome to contribute openly to the discussion. Crew leaders can accomplish this by encouraging (but not forcing) members to participate. For example, crew leaders can positively reinforce member participation by thanking members for sharing, by asking follow-up questions that encourage more discussion with the participating member, and by sharing their own questions and insights in ways that demonstrate the spirit of what the routine aims to accomplish (e.g., communicative openness on the crew). It is important that the crew environment be free of judgment so that members feel they can talk about anything, including their mistakes, which is crucial for HROs that are "preoccupied with failure."

Third, findings from Study One showed the importance of having the communicative routine be a consistent aspect of crew life. Manzanita members expected to debrief after every work shift, regardless of what occurred that day. For this reason, members said they actively thought about questions and topics to discuss as they engaged in their work. Therefore, by making sure that the routine is conducted on a consistent basis, crew leaders demonstrate the importance of the routine. Members know they will be expected to participate to the routine, and as a result, will hold themselves accountable to finding topics to discuss.

Learning from in-the-moment action

Findings from Study One showed the importance of in-the-moment-action in generating experience for West Fork members. West Fork members were highly experienced and were challenged to take on independent assignments and high levels of responsibility. Many of the members had moved beyond a mentorship model of communication and learning and were focused on honing their skills at thinking independently like experts. Thus, helping members to develop skills with their in-the-moment action was a crucial step toward deepening expertise. Crews with highly experienced members, and crews whose members have high collective tenure, can benefit from providing members with opportunities to manage in-the-moment action.

How crew leaders can facilitate learning from in-the-moment action. First, members should be allowed opportunities for tactical experimentation. This means that they should be given assignments challenging them to step out of their "comfort zone." Crew leaders can provide members with chances to be autonomous in deciding which tactics to implement. Opportunities for autonomy cultivate independent thinking because members carry the weight of their responsibility and decisions. Crew leaders can facilitate autonomous action on these types of crews by also leveling the hierarchy of the crew such that all members are given decision-making latitude and are granted authority and flexibility to act autonomously on a regular basis on the crew.

Second, tactical experimentation provides members with the chance to see firsthand which actions work and which do not. Having opportunities to make mistakes is important here because the firsthand observation helps members to embody the knowledge. For example, West Fork members talked about experiences in which they had to change the ways they implemented escape routes and safety zones in spatial terrain due to having to narrowly escape flames. These experiences could be considered "mistakes," even though the tactics made sense in the moment. Thus, through autonomous action and tactical experimentation, members discovered new insights about which characteristics to prioritize when designating a safety zone. Crew leaders can foster tactical experimentation on crews by first knowing members' skills and experience levels, and then by assigning fire assignments to members that will push

them slightly beyond their skill levels. However, it is important to note that crew leaders must have thorough knowledge of their crew members' experience levels because pushing them too far beyond their capabilities could place members in situations that they are not equipped to handle.

Conclusion

The two studies summarized in this document have illustrated that communication processes critically shape how safety is accomplished in wildland firefighting workgroups. Both studies demonstrated that wildland firefighting is not an individual activity, but a group one. Therefore, safety is a collective accomplishment that is socially defined through the workgroup's appropriate and normative safety actions. Study One showed the importance of communication in shaping everyday enactments of tasks and safety; findings illustrated how members' patterns of interactions set a precedent for appropriate behavior. These expectations influence how members enact tasks. Study Two illustrated that communication-based activities helped members to feel less pressure to take risks and enhanced their perception that the workgroup was a safe interpersonal environment.

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[i] I did not directly sample within federal agencies whose wildland firefighting resources are relatively limited, primarily temporary/seasonal, or embedded in localities that lacked a central contact representative. These agencies include the US Fish and Wildlife Service and the Bureau of Indian Affairs (BIA). Sampling from the BIA might have somewhat increased representation by Native American firefighters.

References

Barton, MA, Sutcliffe, K (2009) Overcoming dysfunctional momentum: Organizational safety as a social achievement. *Human Relations* 62, 1327-1356.

Becker, MC (2004) Organizational routines: A review of the literature. *Industrial and Corporate Change* 13, 643-677.

Bencherki, N, Cooren, F (2011) Having to be: The possessive constitution of organization. *Human Relations* 64, 1579-1607.

Bullis, C, Tompkins, PK (1989) The forest ranger revisited: A study of control practices and identification. *Communication Monographs* 54, 287-306.

Carmeli, A (2007) Safety capital, psychological safety and learning behaviors from failure in organizations. *Long Range Planning* 40, 30-44.

Charmaz, K (2006) 'Constructing grounded theory: A practical guide through qualitative analysis.' (Thousand Oaks, CA: Sage)

Cooren, F, Taylor, JR (1997) Organization as an effect of mediation: Redefining the link between organization and communication. *Communication Theory* 7, 219-260.

Desmond, M (2006) Becoming a firefighter. *Ethnography* 7, 387-421.

Desmond, M (2007) 'On the fireline.' (Chicago, IL: University of Chicago Press)

Desmond, M (2010) Making firefighters deployable. *Qualitative Sociology* 34, 59-77.

Edmondson, A (1999) Psychological safety and learning behavior in work teams. *Administrative Science Quarterly* 44, 350-383.

Flanagan, JC (1954) The critical incident technique. *Psychological Bulletin* 51, 327-358.

Greene, JC, Caracelli, VJ, Graham, WF (1989) Toward a conceptual framework for mixed-method evaluation designs. *Educational Evaluation and Policy Analysis* 11, 255-274.

Gremler, DD (2004) The critical incident technique in service research. *Journal of Service Research* 2, 65-89.

Guldenmund, FW (2000) The nature of safety culture: A review of theory and research. *Safety Science* 34, 215-257.

Hofmann, DA, Mark, B (2006) An investigation of the relationship between safety climate and medication errors as well as other nurse and patient outcomes. *Personnel Psychology* 59, 847-869.

Hofmann, DA, Stetzer, A (1996) The role of safety climate and communication in accident interpretation: Implications for learning from negative events. *Academy of Management Journal* 41, 644-657.

Kline, RB (2011) 'Principles and practice of structural equation modeling' (3rd ed). (New York: The

Guilford Press)

Leech, NL, Onwuegbuzie, AJ (2009) A typology of mixed methods research designs. *Qual Quant* 43, 265-275.

Lewis, A (2008) Safety in wildland fire: Leadership and employee voice. (Unpublished master's thesis). (University of Idaho, Moscow, ID)

Mael, F, Ashforth, BE (1992) Alumni and their alma mater: A partial test of the reformulated model of organizational identification. *Journal of Organizational Behavior* 13, 103-123.

Moreland, RL, Levine, JM (2001) Socialization in organizations and work groups. In 'Groups at work: Theories and research' (Ed ME Turner) pp. 69-112 (Mahwah, NJ: Lawrence Erlbaum)

Morrow, SL, McGonagle, AK, Dove-Steinkamp, ML, Walker, CT, Jr, Marmet, M, Barnes-Farrell, JL (2009) Relationships between psychological safety climate facets and safety behavior in the rail industry: A dominance analysis. *Accident Analysis and Prevention* 42, 1460-1467.

Pearce, JL, Gregersen, HB (1991) Task interdependence and extrarole behavior: A test of the mediating effects of felt responsibility. *Journal of Applied Psychology* 79, 838-844.

Pentland, BT, Feldman, D (2005) Organizational routines as a unit of analysis. *Industrial and Corporate Change* 14, 793-815.

Robichaud, D, Giroux, H, Taylor, JR (2004) The meta-conversation: The recursive property of language as the key to organizing. *Academy of Management Review* 29, 617-634.

Rochlin, GI (1993) Defining high reliability organizations in practice: A taxonomic prologue. In 'New challenges to organization research: High reliability organizations.' (Ed K Roberts) pp. 11-32 (New York MacMillan)

Simpson, JL, Seibold, DR (2008) Practical engagements and co-created research. *Journal of Applied Communication Research* 36, 266-280.

Strauss, A, Corbin, J (1998) 'Basics of qualitative research: Techniques and procedures for developing grounded theory' (Thousand Oaks, CA: Sage)

Taylor, JR, Van Every, E (2000) 'The emergent organization: Communication as site and surface.' (Mahwah, NJ: Lawrence Erlbaum Associates)

Thackaberry, JA (2004) 'Discursive opening and closing in organizational self-study. *Management Communication Quarterly* 17, 319-359.

Weick, KE (1987) Organizational culture as a source of high reliability. *California Management Review* 29, 112-127.

Weick, KE (1995) 'Sensemaking in organizations.' (Thousand Oaks, CA: Sage)

Weick, KE, Roberts, K (1993) Collective mind in organizations: Heedful interrelating on flight decks. *Administrative Science Quarterly* 38, 357-381.

Weick, KE, Sutcliffe, K, Obstfeld, D (1999) Organizing for high reliability: Processes of collective mindfulness. In 'Research in organizational behavior' Vol. 1 (Eds RS Sutton, BM Staw) pp. 81-123 (Palo Alto, CA: Stanford: Jai Press)

Weick, KE, Sutcliffe, KM, Obstfeld, D (2005) Organizing and the process of sensemaking. *Organization Science* 16, 409-421.

Zeigler, JA (2007) The story behind an organizational list: A genealogy of wildland firefighters' 10 Standard Fire Orders. *Communication Monographs* 74, 415-442.

Zhou, X (1993) The dynamics of organizational rules. *American Journal of Sociology* 98, 1134-1166.

Zohar, D (1980) Safety climate in industrial organizations: Theoretical and applied implications. *Journal of Applied Psychology* 65, 96-102.

Zohar, D, Luria, G (2005) A multilevel model of safety climate: Cross-level relationships between organization and group-level climates. *Journal of Applied Psychology* 90, 616-628.