

Final Report

Risk Perception, Sensemaking and Resilient Performance: The Sounds of Wildland Firefighting in Action (JFSP 14-2-01-11)

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I. Abstract

Managing wildland fire is an exercise in risk perception, sensemaking and resilient performance. Risk perception begins with individual size up of a wildfire to determine a course of action, and then becomes collective as the fire management team builds and continuously updates their common perception of risk. Karl Weick has called this “sensemaking.” This act of communication, of collecting and selecting information, naming it, and passing it on, in various forms and stages of completeness, from one individual or team to another – determines how resilient and effective the team’s performance is. Because all subsequent actions rely on this, the sensemaking involved with risk perception is a critical activity. It is hard work and prone to error, as numerous accident reviews, in the U. S. and abroad, have found. Although advances are being made in the structure of current reviews – such as by including human factors analyses, which helpfully focus on psychological factors (attention, fatigue, etc.) - resilient performance also requires developing a *collective* perception of risk, and for this analysis of communication and interaction is needed. It is time to take a close, structured look at wildland fire incident communication and interaction processes.

We sought to identify areas of communication competencies and constraints that affect the perception and communication of risk in wildland fire management. In doing so, we develop- for the first time - a comprehensive and coordinated perspective on communication, resulting in a set of insights into training, practice, and assessment to support continuous improvement in risk perception, sensemaking, and resilient performance.

II. Background and Purpose

The term *communication(s)*, used to describe technology and a process, is ubiquitous throughout wildland fire operations. (**Table 1**). Communication as a process is mentioned as standard operating procedures on two well-known and often used wildfire fighting checklists, such as Orders 6 and 7 of the Standard Firefighting Orders, Situations 6 and 7 of the 18 Watchout Situations, and the “C” in LCES. Communication is listed as a “responsibility” in the Incident Response Pocket Guide (IRPG). It is invariably mentioned as a contributing cause of accidents in wildfire injury and fatality investigation

Table 1: A selection of quotations where communication has been mentioned in wildland firefighter checklists, guidebooks, investigation reports, and training courses.

Reference Document	Communication Statement
<p>Ten Standard Firefighting Orders</p>	<p><i>Order 7: “Maintain prompt communications with your forces, your supervisor, and adjoining forces.”</i></p> <p><i>Order 8: “Give clear instructions and ensure they are understood.”</i></p>
<p>18 Watchout Situations</p>	<p><i>Watchout Situation 6: “Instructions and assignments not clear.”</i></p> <p><i>Watchout Situation 7: “No communications link with crewmembers/supervisors.”</i></p>
<p>LCES</p>	<p><u>Lookouts, Communications, Escape Routes, Safety Zones</u></p>
<p>PM 461, Incident Response Pocket Guide</p>	<p>Communication(s) (from IRPG)</p> <ul style="list-style-type: none"> • Radio frequencies confirmed • Backup procedures and check-in times established • Provide updates on any situation change • Sound alarm early, not late
<p>Fire Leadership Training Course—Leadership 180</p>	<p>Communication Responsibilities (P25 L-180 Facilitator’s Guide)</p> <p><i>All firefighters have five communication responsibilities:</i></p> <ul style="list-style-type: none"> • Brief others as needed • Debrief your actions • Communicate hazards to others • Acknowledge messages • Ask if you don’t know
<p>Pagami Creek Entrapments: Facilitated Learning Analysis, Superior National Forest, 2011</p>	<p>Communications-Social Aspects</p> <p><i>1-Avoiding language that might come off as too direct or extreme. For example, Forest leaders reflect they sometimes avoided saying “evacuation,” when that’s what they had in mind. And field personnel avoided calling their situation an “emergency,” when that’s what they had. (Item 1 of an 8 item list of how to improve communications, Pagami FLA report)</i></p>
<p>Cramer Fire Investigation Report, Salmon-Challis National Forest, July 2003</p>	<p><i>The fatality investigation report found Standard Firefighting Orders 7 and 8 had been violated in that “critical observations...were not communicated,” the two rappellers who died had not received an “update” and “instructions”...were “not well understood.”</i></p>
<p>Yarnell Hill Fire Investigation Report, Yarnell, Arizona, June 2013</p>	<p><i>“Collective sensemaking is about communication: it is about how crews, IMTs, and host agencies determine potential strategies and tactics, and how they convey and update these during planning meetings, briefings, operations, debriefings, and in after action reviews. Effective risk management communication involves more than simply reporting and transmitting messages. It requires developing effective shared meaning together through dialogue and inquiry.”)</i></p>

reports and in recommendations for improvement sections of Facilitated Learning Analyses. Communication is viewed as a necessary skill for all firefighters up and down the chain of command, and is now regularly taught in leadership courses.

It is not difficult to understand why communication is such an important part of a firefighter's work-life. Good communication is a basic practice in safe and efficient fire management operations, permeating every firefighting activity. A wildland firefighter who is alert to good communication practices and who works hard to be a good communicator has a better chance of not making mistakes that might result in an accident that could injure or kill a firefighter.

But what is effective wildland fire communication and how would we know it was effective if we saw it or heard it? To our knowledge in wildland firefighting environments this question had not been rigorously examined. Thus, we sought to describe the landscape of wildland fire communication focusing on remote communication (primarily via radio), including how members of the fire community think of it, how it is taught, how it functions and sounds in action. We were interested in looking at all angles, the social, cultural, symbolic, spatial and temporal aspects of communication, used on wildfires and from as many methods of observation and analysis as possible. From this mixture of viewpoints, methods of data collection and analysis, including field observations, we seek to offer recommendations regarding how communication processes might be improved in fire management operations. This eclectic approach to wildland fire communication's studies meets the JFSP's New Science Initiative in Social Science for research that would advance "innovative ideas," "push the frontiers of knowledge and understanding," and "generate new ideas and concepts" (**Fig 1**).

We are keenly interested in how firefighters communicate risk as they size up wildfires and communicate perceptions over the radio. We were also interested to learn how crews, individually and collectively, talked through situations in order to anticipate and contain small problems that might become larger problems if not caught and controlled when small. We focused on Type 3 complexity fires because they are often, at least in their early stages, unpredictable, fast changing and dangerous, thus requiring focused and accurate perceptions coupled with timely sensemaking.

Figure 1: To push the frontiers of knowledge, experts in communication from three universities—Valparaiso, Texas State and Bradley--were selected to be on the JFSP communication research team. Dr. Elena Gabor (Bradley University) and Dr. Rebekah Fox (Texas State University) are shown here with members of the Salmon-Challis rapell crew, Salmon, ID, August 2014.



We focused our inquiries in two areas:

Risk Perception and Resilient Performance – the sounds of wildland fire management

- What does high-quality sensemaking sound like when practiced? (Figure 2)
- What is the difference between individual and collective sensemaking?
- Are there specific words that firefighters use to indicate risk, processes in decision making, and resiliency that would provide evidence of HRO-mindfulness?
- What are the opportunities and constraints within current expected radio practices for communicating risk?
- How are various technologies (radios, smartphone apps, cell phones) used to make individual and collective sense of a fire?

Radio Training, Culture and Practice

- What is meant by the term “communication”?
- What are the standards and expectations of good radio performance; how are firefighters taught and socialized to learn and practice them?

- What implicit and explicit models for communication guide practice, and are there theoretical approaches that might assist with future improvements?

III. Study Description and Location

We sought to assess remote communication practices during wildland fire incidents to determine their productivity and efficacy in helping firefighters manage risks individually and collectively. We were interested in exploring and articulating the operative model of communication for firefighters (the model “in use”), and how firefighters are socialized to communicate (“best practices”). We hope the result will help the fire management community diagnose and repair communication problems in the moment, as well as identify improvements for training and practice.

We sought to understand remote communication from a gamut of wildland fire operational positions, as well as emerging fires (Type 3), which are often high-tempo and likely to contain all facets of communication (dispatch to ground, ground to ground, air to ground). Geographic areas of interest were selected based on interested partners (*e.g.*, Salmon-Challis National Forest, Tucson Interagency Dispatch Center, and Incident Management Academy, Lufkin, Texas), accessibility and fire potential. For example, we observed the S-520 IMT simulation at the National Advanced Fire and Resource Institute because we were aware that they used radios in simulation exercises.

Methods

Qualitative and rhetorical methods are generally used to study discourse in organizational contexts. Audio recordings of naturally occurring interactions are ideal and often supplemented with interviews of those involved to better understand the context and culture in which the communication occurred.

Our proposal was based on the assumption that one of our primary sources of fire communication data would be transcripts of audio recordings taped and stored at wildland fire dispatch offices throughout the country. We assumed these recordings existed and could be easily obtained, and that we would use standard qualitative techniques to analyze transcripts of a grab-sample of Type 3 events. This was based on the commonly held assumption by nearly all fire managers at all levels of firefighting agencies that dispatch offices around the country routinely record radio traffic and store these recorded tapes in maintained archives at the local level. We found this not to be the case. This finding made a huge difference in our approach.

What we discovered was that while some dispatch offices say they keep audio recordings of their fire communication, and some of them actually do, the archiving practices are non-systematic, making recordings haphazard and not amenable to sampling. For instance, we sought recordings from two dispatch centers (an R4 Forest, and an R3 Interagency Dispatch) whose leaders had offered to share recordings with our team. Despite this interest, we were unable to obtain any recordings because either recordings could not be located, tapes had been re-used, the recording was not easily retrievable and sharable, or interestingly, the local fire unit didn’t want to share the recordings with us.

Dispatch offices that have law enforcement responsibilities such as the Moose Interagency Dispatch in Grand Teton National Park and the Interagency Medford Communications Center dispatch office in Medford, Oregon, do capture audio recordings. However, since there is often sensitive law enforcement or search and rescue information on these tapes the dispatch offices rightfully are reluctant to release them without a FOIA request. We did not pursue this option.

Although we were unable to use existing radio dispatch recordings for this project, we still believe that this is a worthy line of inquiry to pursue. We address this in our recommendations for management and in our calls for future research.

Data Collection

We used three different methods of data collection: qualitative interviews, participant observations (participation in classroom training, observation of classroom and simulation training, and incident observation), and analysis of organizational texts. To enhance the credibility of the study results, we engaged in both researcher triangulation (five researchers were involved in data collection and analysis) and methodological triangulation. These three methods are recommended for the study of organizational cultures not only to detect the visible practices, norms, and rituals of organization, but also to distill the taken-for-granted assumptions that accompany those practices (Alvesson, 2002; Driskill & Brenton, 2011; Keyton, 2005). For example, we feel confident in our finding that radio communication training needs to be re-evaluated (see Findings section), because efficacy of training emerged across all research modalities; it was salient to our participants' experiences, it was evident in our observations of S-130/190, *and* emerged as a theme in our analysis of training materials.

Recordings: As noted above, we visited and interviewed forest level and interagency dispatch centers in a number of geographic regions, including Rocky Mountain, Northwest, Great Basin, and Southwest regions, including those with and without law enforcement responsibilities. At each we asked for recordings of radio communication of a Type 3 fire of their choice, but we were unable to obtain them for legal, organizational, or technical reasons. It was at this point that we realized we would need to rely on our planned series of interviews. As a result, we chose to expand the number and selection of interviewees to ensure as representative sample.

Interviews: In 2014, each research professor obtained approval from their respective institution's Institutional Review Board in order to ensure that our research protocol sufficiently protected participant confidentiality. We developed and used a sampling procedure to maximize demographic, experiential and functional variety: we sought air, ground, and dispatch communicators; and we spoke with novice to experienced to very experienced firefighters. We sought such participants through opportunistic sampling.

Organizational members are able to talk knowledgeably and authoritatively about their own organizational experiences and meanings. However, as Pearce (2007) observed, organizational members vary in their ability to reflect upon and articulate their own

communication practices and the cultural norms surrounding those practices. We found that many of our participants had clearly spent time reflecting on the issues we inquired about and were able to provide us with rich and nuanced answers.

We conducted in-depth interviews with 29 firefighters of varying levels of experience (novice, mid-career, highly experienced), operational realm (air, ground, dispatch), and operational role (dispatchers, AFMOs, ZFMO, fixed wing pilots, trainers, radio operators, communications specialists, engine crew members, dozer operators). Interviews were conducted in different geographic areas (Southwest, Great Basin, Rocky Mountain), both face-to-face and over the telephone. Interviews ranged between thirty minutes to two hours in length, with an average duration of just over one hour. Interviews were transcribed and verified against the audio recording, resulting in over 900 pages of written transcripts.

The interview protocol included questions about individual and team practices, such as, “What are the most important practices you personally try to follow when it comes to talking on the radio during an incident?” “What are the most common misconstructions or misinterpretations that happen over the radio?” “How does remote communication change as a wildfire transitions in complexity?” Questions also addressed the training participants received in radio communication and prompted participants to recall and articulate critical incidents when radio communication was particularly important. This interview protocol gave us insight into the participants’ values, norms and rituals surrounding radio communication, and produced a rich collection of narratives about various memorable incidents where use of the radio figured heavily in the incident.

Classroom data collection: In addition to the interviews noted above, we engaged in over 60 hours of field observations at two different firefighter training courses.

- All five members of the research team observed a live two-day S-520 evaluation at NAFRI, in Tucson, AZ (2/2014). S-520 is a week-long training for individuals seeking Type 1 qualification in their functional area. It culminates in a two-day simulation (16 hours) during which students are assigned to a Command and General Staff who are tasked with managing a Type 1 fire scenario. Observing the students in the S-520 exam room, as well as the SIM Teams in the SIM room, allowed us to better understand the firefighting organization, command structure, operational periods and reports, as well as the role of radio communication in fire operations. One purpose was to assess whether we could use transcripts of simulation exchanges for analysis. Another objective was to assess how we might record firefighter communication in the future.
- Two researchers completed a Forest Service sponsored “Guard School” (i.e. the weeklong S-130 Firefighter Training, S-190 Introduction to Wildland Fire Behavior, including the supplementary course, Leadership-180 (L-180) Human Factors on the Fireline) in Lufkin, TX (6/2015). Both researchers also passed the arduous physical fitness test to obtain firefighter’s red cards. Attending the courses allowed us to observe how radio use is taught to beginner (Type 5) firefighters, as well as how topics such as weather, fire behavior, and safety rules

are conveyed. The other three researchers previously completed the training in years past and contributed their recollections to the dataset.

Field observation: In August 2015, with the help of the Salmon-Challis National Forest in Salmon, Idaho, we obtained permission to “listen in” on a Type 3 fire and to record radio communication. While listening in on a portable King radio as well as on a Forest Service truck radio, we recorded over six hours of radio communication in the field. Ultimately, we found that those recordings produced limited usable data. First, they proved challenging to obtain (*e.g.*, we drove through difficult terrain and spent several hours in the field over two days). Second, they proved difficult to analyze due to discontinuities, occasional multiple simultaneous conversations, and poor radio reception (*i.e.*, we were able to hear one communicator but not the others due to their precise locations on the fire relative to ours). We concluded that while the experience was valuable for helping the researchers orient to the tempo and variations of verbal communication on a wildland fire, and that while participating in a ride-along was amenable to taking field notes, this approach was not ideal for collecting recorded data for formal analysis. In our view, this further supports the need to obtain recordings of naturally occurring interaction for purposes of research analysis. Additionally, although we believe it would be advantageous to ‘mic up’ participants prior to their dispatch, and then to record them during their time on a fireline assignment, we recognize the barriers and risks associated with this approach. We note, however, that with proper precautions this is achievable, as evidenced by Vidal and Roberts’ (2014) study of an Incident Management Team as well as Vidal’s (2010) successful study of an international simulation at the European Union’s training facility in southern France.

Archival communication: We analyzed organizational texts such as training manuals, handbooks, safety posters, and guides currently used for wildland firefighting, including the Incident Response Pocket Guide, and the S-130 and S-190 course books.

Selecting what texts to read is as important as understanding how to read them. We chose to focus our textual analysis on two documents to which every firefighter is exposed: the Incident Response Pocket Guide (IRPG), which is read and carried by most firefighters in the field, as well as the training manual for Guard school course, which is read by all FFT2 firefighters during their initial certification. We paid attention to instances where communication was mentioned, including recommendations for “effective” communication (*e.g.*, “Be clear”). We examined these for the communication model in use in order to tease out underlying assumptions about communication, risk perception, and collective sensemaking.

Academic subject matter experts – In addition to the data collection methods described above, we also engaged in structured conversations with two researchers who have studied communication in high reliability organizations, namely Tim Vogus (2015) and Frances Cooren (2015).

Data Analysis

We experimented with a combination of approaches, grounded theory, critical discourse analysis, rhetorical analysis, and metadiscourse analysis, to identify and assess communication. Using these complementary and overlapping analytical methods provides rich, nuanced and comprehensive insights on radio communication in wildland firefighting with implications for high reliability (performance), and organizational learning.

We examined current communication practices using multiple disciplinary and theoretical angles to map the communication “sandbox.” Theories from the fields of rhetorical theory, sociology, anthropology, and management provide further analytic tools for analyzing and theorizing communication in organizational contexts; example concepts include language and symbols, identity, emotion, performance, culture, and power and influence.

We used an *iterative analysis* process (Tracy, 2013) that alternates between emergent (emic) readings of the data and a deductive (etic) use of existing models and theories. As Tracy explains, “rather than grounding the meaning solely in the emergent data, an iterative approach also encourages reflection upon the active interests, current literature, granted priorities, and various theories the researcher brings to the data” (p. 184). In this study, the three communication researchers brought their expertise and pedagogical insights to the analysis.

Three researchers examined the transcript data and individually assigned words (codes) that captured their essence. These were collected and synthesized and will provide a sound analytic frame for future analysis (See Appendix A: Proposed Analytic Frame for Further Narrative Analysis of the Landscape of Radio Communication on Wildland Fire Incidents – a Preliminary Codebook).

IV. Key Findings/Results

As might be expected with a broad, even sprawling topic, our findings cover a number of different areas. To assist the reader, we present our Key Findings in six sub-sections:

- **The landscape of radio communication.** We present a high-altitude overview of remote communication to more comprehensively describe the complexity we found. Our hope is that this may enable more nuanced and specific discussions among practitioners, managers, trainers and researchers in the future.
- **Communication models.** We assess the dominant communication model in use and provide some alternatives. The current model is popular but is an overly constraining one in that it limits the ability to capture and manage the complexity of communication.
- **Radio training, culture and practice.** We present key insights from analysis of interview data. This reveals not only *(over)simplifications* about communication in training and official discourse, but also the *complexity* of communication as experienced by participants in actual practice.
- **Risk perception and collective sensemaking.** We summarize key findings with respect to risk perception and collective sensemaking.
- **Best practices and creative “work-arounds.”** We share an array of techniques and practices that individuals use to manage the complexity of fire communication. Many of these could prove useful to the rest of the wildland fire management community.
- **Methodological lessons learned.** Various research methods attempted in acquiring communication field data raised important questions about data acquisition and added depth to our research about how risk and sensemaking are actively worked out on a wildfire incident.

These preliminary results produce important and serious implications (from the standpoint of safety) for both wildland fire management operations and future wildland fire communication research efforts. Note: these key findings are also grouped together in a different format in Appendix D, “Summary of Key Findings.”

The Landscape of Radio Communication

In this age of cell phones, satellites phones, and even drones, one would expect the federal wildland fire organization to have a sophisticated, rich, and widely shared “map” or mental model of tools, techniques and practices for successful communication during wildland fire operations. Such a map would help wildland fire personnel establish appropriate training, conduct and monitor how communication - in all its manifestations - affects firefighter performance, especially those communication practices relating to risk management, including perception and sensemaking. Our research suggests that such a shared map does not yet exist. Here, we share the perspective we developed over the course of our study.

One of our early discoveries was that members of the wildland fire community make virtually no distinction between *communications* – the technology used to communicate – and the creation, sending and processing of messages: *communication*. When we asked participants about communication, the conversation often turned to discussions about equipment issues associated with handheld radios (cloning, use of repeaters, changing channels and frequencies, monitoring battery life, and soon) rather than about how to skillfully talk, listen or make sense of a wildfire using radios. This perspective was mirrored in the classroom training in which two of us participated. Yet, when we asked the interviewees about their own communication practices, they discussed rich and sophisticated practices that seemed to overcompensate for the overly simplified version of communication presented in various training scenarios and in the broader discourse. It is this richness we seek to “map” and to reflect back to the wildland fire community.

Key Finding: Understanding Communication

Communication is poorly scoped in part because it is often conflated with the technology (equipment use) involved with communications, and in part because it covers so many different contexts, practices and behaviors.

Developing a richer map and language can assist.

The word “communication” has been stretched to mean everything from *communications* (referring to modes of communication such as radio, telephone, maps-on-the-hood-of-the-truck, etc.) to *communication*, referring to the process of interaction as well as the verbal and non-verbal messages themselves. This creates ambiguity which facilitates mis-understanding and impairs analysis.

When we asked wildland fire personnel about their experiences communicating risk and collectively making sense of an incident using a radio, they told us relatively little about these specific subjects, but, interestingly, they told us a lot about many other things. For example, we heard about the appropriate use of radios – such as to order resources or convey specific information, schedule meetings, and to provide updates. Much of this is transactional and uses a declarative style. We also heard about what is inappropriate use of the radio such as evaluating performance, relaying or discussing complex information, and anytime privacy is an issue. Much of this requires inquiry, sharing partial knowledge, discussing things that are not yet fully known or understood, and taking the time to collectively develop interpretations (i.e., core pillars of sensemaking). This suggests that rather than thinking of the radio as “the” tool for collective sensemaking, it might be fruitful to think of it as only one tool, and a limited tool at that, for conducting critical risk assessment and engaging in collective sensemaking. This also suggests a need for a broader discussion within the wildland fire community about the communication network and technologies necessary for successful sensemaking and risk management.

Our interviewees also shared what constitutes good and bad speaking practices, including instrument use, channel selection, mental preparation, what to say and how to say it (precise, objective); tempo, cadence, tone (convey confidence) awareness of the specific audience, ordering the message, and engaging others to seek explicit feedback.

Our interviewees spoke about how they listen and what they listen for when they are on the receiving end of the transmission (i.e., when they are primarily in listening mode). This includes: how to filter, how to listen for nonverbal content, how to size up the competence and experience of the speaker, and how to listen for a “code switch” (a marked change in talk) that indicates something might be wrong on the other end.

Do’s and don’ts are understood relationally. Speakers are generally aware of their own role and the role of the person(s) on the other end of the line, especially if they’ve spent time working together, and will adapt their communication objectives and behaviors accordingly. The roles also influence what they expect from the other person.

They shared how radio use conveys significant relational information – about one’s own role, communicating status/power, ways they genuinely try to put themselves in the others’ shoes; the need for tact, discretion, for the sake of the future relationship. They spoke about influence and impression management and how knowing someone beforehand significantly increases ability to ‘read’ into a transmission, as well as how physical demands of the job may affect how one sounds (tired, hungry, stressed). We heard about the high cost in terms of repercussions from going blank, sounding disorganized, or inexperienced, and the resulting performance anxiety this can create among new and inexperienced radio users.

From the critical incident stories, we heard evidence of how the interactional order changes when things are not going right, and how intervention and revision happens. We learned an enormous amount about formal and informal training and how fire personnel learn to talk on the radio. We heard about the problems and challenges they experience and how they cope with constraints posed by reliability and availability of technology (radio and cellphone) as well as organizational and regional differences in language.

This “landscape”, or “map” of radio communication is more vast than originally imagined. We observed that expertise is developed outside of training, its acquisition is self-directed and not guaranteed by current organizational systems. We have a sense that many of these self-developed skills facilitate risk perception, risk sharing and sensemaking. As we discuss each of these in greater detail, below, we will attempt to re-connect these to our primary research topic.

Key Finding: Communication Models

There is a critical need to understand the limitations of the current Sender-Receiver model (**Fig. 2**) and to intentionally build and use complementary systems when and where needed.

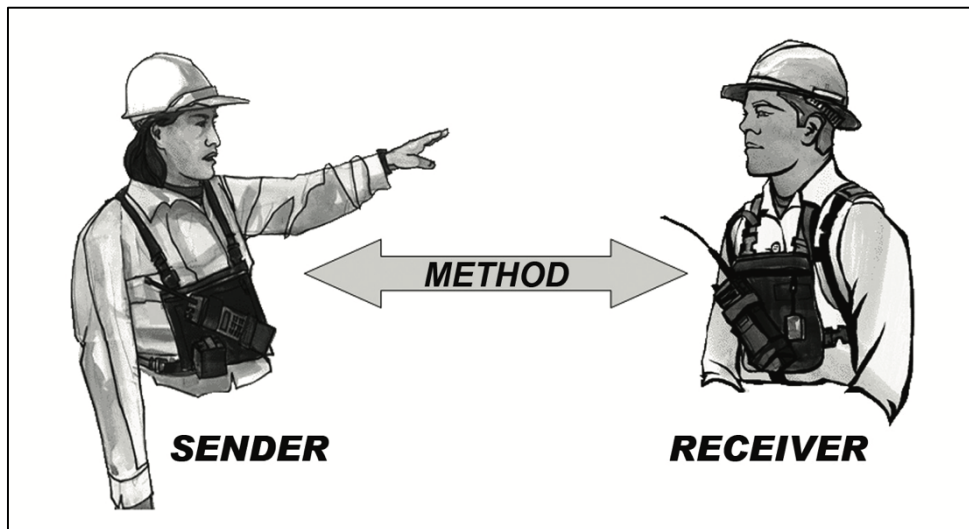
The current operative model for communication in discourse and training is the 1949 Sender-Receiver model, which vastly oversimplifies human interaction. It's conceptualization of communication as a one-dimensional frame has been criticized for not taking into consideration concepts such as culture and power, or the socially constructed nature of communication.

Communication Models

The dominant communication model used and taught in firefighting is the Sender-Receiver communication model proposed in (Shannon and Weaver), also known as the information transfer model. This model regards communication as occurring between two people - a speaker and a receiver- who transmit messages to one another via a particular medium (*e.g.*, telephone, radio, face-to-face, etc.).

Because the sender-receiver model is transactional rather than *interactional*, it focuses our attention on the sender's role while the receiver is simply a person waiting to become a sender. This model equates communication with *transmission* and assumes that the meaning of the message resides primarily with the sender, with the receiver as a passive role (**Fig. 2**).

Figure 2. 1949 Sender-Receiver model of communication as illustrated and described in Unit 2: Communication (NWCG Course, Leadership-180): Human Factors in the Wildland Fire Service.



According to the Sender-Receiver model communication is sequential. In this model, communication is said to be successful when the sent message is the same as the message received. Noise of any kind (semantic, physical, psychological) and ambiguity (multiple interpretations of a message) are seen as threats to communication fidelity rather than as natural and normal occurrences.

A number of alternative models have been proposed over the past several decades to address these limitations. The major shift is in positing meaning as co-created, that is with all parties actively engaged in creating an emergent meaning. For example, the ecology of meanings (Campos, 2007) regards communication as a “transversal discipline” that crosses all others. Campos’ model accounts for both physical/biological and social phenomena, thus connecting nature (cognition and emotions) and culture (ethics and politics), two areas that were previously considered separate and divergent.

In the ecology of meanings model, communication is both interactive and genetic-historic, “dependent on the historical evolution of social constraints derived from the concrete economic conditions of life and from the way public and private administration molds the insertion of individuals in society” (Campos, 2007:395). Campos suggests that communicators have both an inner response (*e.g.*, emotions) and outer response (*e.g.*, will to act) to an interaction, as they form configurations of meanings (constructed and co-constructed images of the world). These configurations of meanings may or may not be assimilated or accommodated by the participants in the conversation. The dynamic interplay of meanings is what forms a social environment (Campos, 2007). We find this model’s explanatory power quite helpful given the complex realities of the firefighting organizations, where speakers and listeners negotiate and intersect different meanings based on implicit and explicit, dynamic physical, social, cultural and political constraints.

It is not so much that the information transfer model (sender-receiver) is “wrong” so much there is a critical need to understand its limitations, and to intentionally build and use complementary systems when and where needed. In addition to ignoring the critical role of the listener in interpreting and creating meaning from the spoken message, the transmission model highlights the value of experts (Craig, 1999:125) Insofar as those on the initiating side of a radio transmission on a wildland fire incident are functioning as the local “expert” and have sufficient information available locally to build adequate situational awareness, this model may work just fine. Transmissions are intended to send or receive specific packets of information – such as a supply order or weather report, which may be independently interpreted correctly on the receiving end with a high degree of consistency. As such, the information transfer model is useful for coordinating among largely self-sufficient units.

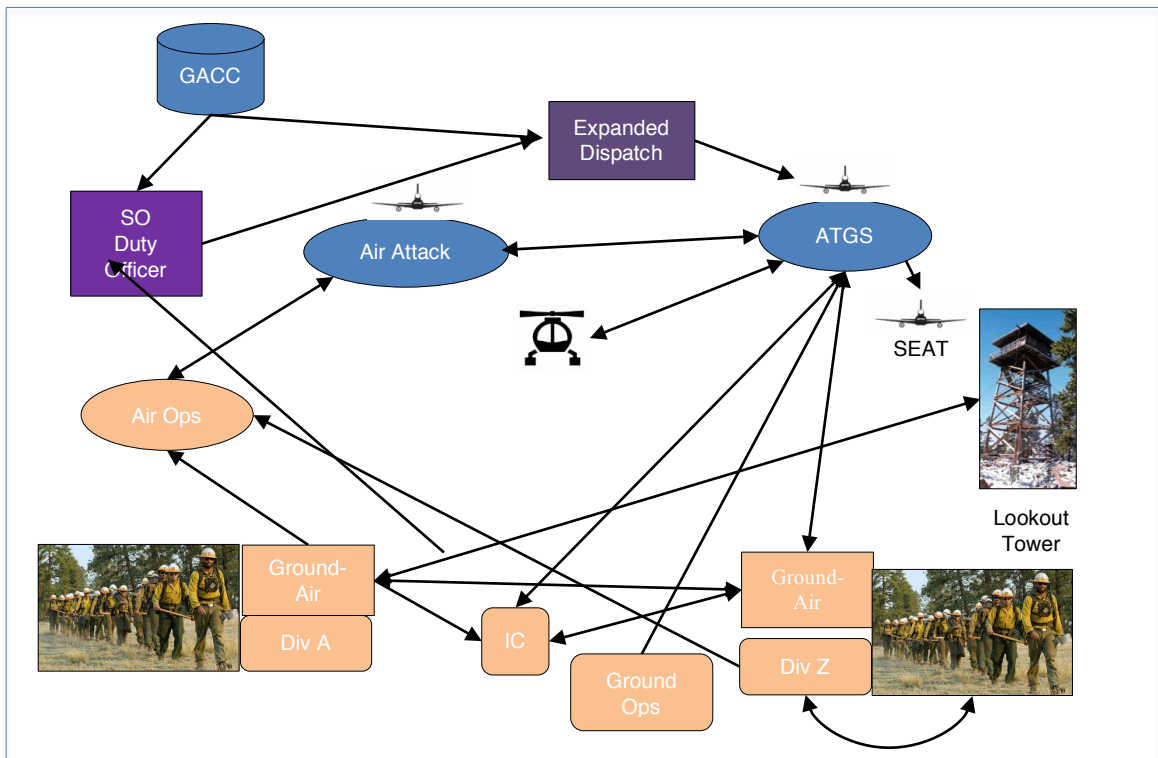
However, this model of thinking and functioning becomes problematic when there is a need is for making collective sense among remotely linked participants. It is likely most problematic during high tempo times such as an emerging incident in which broader scale dynamics (*e.g.*, developing air mass) force fundamental state changes at a local scale (*e.g.*, dramatic change in fire behavior) that are difficult to detect or make sense of given only local information. When situations are ambiguous in this way and multiple

perspectives are needed to appropriately assess risk. It also seems possible, given the limitations of radio bandwidths and lack of ability to ensure a closed container (i.e., the inability to keep out curious non-producers or prevent public scanning), that the radio *should not* be considered as a high-quality tool for sensemaking. We heard many instances of practice (possibly contrary to policy) that made deliberate and explicit use of face-to-face and/or cell-phone and/or smart tablet technology in such circumstances to facilitate the rich back-and-forth sharing of observations, meanings, and tentative interpretations that are foundational to collective sensemaking ... and antithetical to the culture and limitations of radio use.

Based on our research, we believe that deliberate examination and discussion about the appropriate role of other forms of remote communication in risk assessment and collective sensemaking would facilitate safety as would revising and updating current communication training communication practices.

In addition to recognizing that meaning is an emergent property of communication which requires acknowledgment of the tacit and active roles of both sender and receiver(s), our field observations reveal radio communications as a complex network, in which there are multiple actors and many in the audience (**Fig. 3**).

Figure 3. Simplified network representing types of radio communicators on a wildland fire incident.



Radio Training, Culture and Practice

There is always a natural gap between how people wish to perform and what we actually end up doing. Thus, we were not surprised to discover that there were noticeable gaps between how wildland firefighting communication is framed in official discourse and training and how wildland firefighters experience communication (as well as our own observations).

We found this gap between training and lived experience to be an extremely rich area of inquiry and sought to use it as a way to organize our findings. Training, as observed in the basic classes and reported by interviewees, tends to present communication as simple, while the lived experience, our data showed us over and over, is quite complex. In the section that follows, we use a conceptual framework that contrasts communication “Simplifications,” on the one hand, and communication “Complexities” (in practice), on the other. We use “Simplifications” to highlight potential problems associated with overlooking, making assumptions about, or otherwise reducing the complexity of a lived experience. “Complexities,” here, show how the simplifications could obscure the intricacy required to communicate effectively and to honor the many variables at work in any communicative situation.

To describe these simplifications and complexities, we organize them into four categories:

- Communication Training
- The Nature of Communication
- Message Framing
- Communication Technology

Communication Training

In addition to using qualitative analyses of 26 new interviews conducted for this project, data for this section come from participant observation (including participation in fire guard school by two of our research team), and a textual analysis of the S-130/L-190 course materials.

Current training in radio communication seems to be guided by the perception that communication is easy and all one needs is a basic working knowledge of the English language to be a good communicator. Classroom training aims at teaching beginner firefighters about the complexity of fire behavior and fire operations, but also indirectly at socializing newcomers to the organizational culture. While specific training in radio communication may vary according to how the introductory firefighting course (National Wildfire Coordinating Group S-130-Firefighter Training) is delivered in different parts of the country, in general these modules are short (*e.g.*, covered in 30-60 minutes) and focus on the mechanics of radio operation.

Key Finding: Formal and informal training often presents the practice of communication as being simple

Simplification: Radio communication training is considered to be adequately executed in formal training that is short (less than 60 minutes), lecture-based, technologically focused, with little to no practical exercises. Everyone attending such courses is trained to use the radio though in actual practice on a wildfire they may not have a radio.

Complexity: Communication is complex, involving much more than the mere operation of the radio. While classroom training plays an important role, current classroom training and materials are simplistic and do not reflect the complexity of the communication environment, or the challenges of publicly speaking and listening well. Also, it isn't well established what radio practices, if any, should be taught as firefighters move into higher level fire training courses.

The classroom lesson mostly consisted of a presentation of technical principles and key technological terminology (see S-130 course materials: <http://onlinetraining.nwcg.gov/node/177>). In terms of human interactions, the lesson briefly covered the mechanics of how to transmit and receive a message, followed by a few troubleshooting principles and advice from personal experience. The few tips offered for how to send/receive a message deemphasized the complexity of the actual operational environment. When asked about ways to communicate risk instructors indicated that “Mayday!” or “It’s getting hot here,” were common ways to report risk, but strategies to do so effectively or the complexity of communicating risk were not discussed in much detail. At the end of the lesson, students were left with the impression that radio communication would be simple, and mostly depend on their ability to use the equipment properly. Assessment of what students learned relied on memorization and used a multiple-choice test.

Analysis of the primary texts used in the S-130 and the Introduction to Wildland Fire Behavior course S-190 shows that communication is framed as transmission of information instead of a process of meaning creation, negotiation, and sharing (see <http://onlinetraining.nwcg.gov/node/169>). The lecture emphasized when and where to report information and said nothing about how to frame messages (i.e., no discussion of how *sensemaking* occurs on an incident or what role radio communications plays in this). Students are not presented with scripts that could be used routinely to assist with framing messages so that radio users will be more likely to be understood, nor were common pitfalls in communicating certain types of information (e.g., size-ups, locations, directions, requests for resources, updates during fast and slow times) addressed. When problems with radio communication are discussed, the focus is exclusively about equipment and channel use, although our interviewees reported having problems with misunderstandings/miscommunications as a primary issue related to “trouble” on the radio. Additionally, in the section of course material titled “Proper Radio Use Procedures,” the information intended for the beginning firefighter was often *abstract*, *redundant*, and presented *without strategies how to actually carry off the instruction*.

Key Finding: Current formal and informal training does not suggest that communication skills will need to be practiced and updated

Simplification: Formal discourse and training convey that communication is easy and that good communicators do not need to prepare or engage in continuous practice.

Complexity: Today firefighters carry radios and may start, just because there are more radios available today than in the past, using them much earlier in their careers than in the past, but classroom training has not kept pace with this organizational reality. Experienced individuals report making time to practice speaking on the radio on their own.

Good communication takes continuous practice and learning. In the words of one interviewee: *It's not something you can do once in your career and call it good.*

Interviewees gave many concrete examples of how they developed skills to become good communicators (see also Best Practices and Creative Work-arounds section). These techniques mirror those used by highly experienced fire managers and personnel in other industries to become very good at the work they do (see Thomas, Leonard and Miller, 2012; Leonard and Swap, 2005; and Leonard 2014).

For instance, interviewees described integrating communication practices into the basic and refresher firefighter trainings they ran. For one firefighter working as Air Attack, the annual refresher sessions are ideal opportunities to rehearse fire communication out loud and in groups.

I did this [rehearsal] last year at an air attack refresher and it was really cool to see the response. I asked folks to [...] close their eyes. Turn the lights off in the room and said, "Okay, I want you to visualize a cockpit of an airplane. I want you to think about the sounds, the smells, the sensations and I want you to put yourself in the cockpit of the airplane. And now I want you to picture, you look out the right wing of the airplane and your engine is on fire. Think about what you would say to dispatch. Think about what you would say to the ground. Think about what you would say to the copter and what you would say to the pilot." Walk them through the process. Okay, cool. Two volunteers. They raise their hand and I say, "Say it out loud." And it was amazing. Two really experienced air attacks sounded completely, completely flustered trying to get the words out. I said, "Okay, let's do this again. Let's rehearse it. Would you change anything you said or any way that you did this?" They said, "Oh, yeah, absolutely." I told them, "Rehearse it in your head and say the words out loud." They went through it and they gave their description and their size up and what the issue was. It was one of those things that opened their eyes that not only do we need to practice these things in our head, but we also need to say the words aloud.

If you mentally rehearse these things and actually speak the words aloud repeatedly, when you get into that high stress, high tempo environment where your life may be in jeopardy or someone else's life may be in jeopardy, the last thing you would want to do is to fail them because of your inability to communicate, whether verbally, non-verbally, a radio, a cell phone. So it's something that has to be practiced, and it's something that could easily be taught. But it has to be maintained, if that makes sense. It's not something you can do once in your career and call it good.

Practices can also be incorporated into individual routines. In one example, a Fire Management Officer shared a strategy he uses:

If you ever come out and burn with us, you may see me show up to the briefing area, and I may park my truck, but I don't get out. I'm just sitting in there. [...] I'm looking at who's there. I'm looking at the weather. I'm running a lot of what-ifs through my mind. And basically, from start to finish, that burn is laid out in my briefing, and I've got that briefing format, that paper.

In another, an Air Attack shared that his solutions included watching others, recording and timing himself, playing out fire scenarios and communications in his mind while biking to work.

I've read, I've self-studied, I've recorded myself, I've taken tidbits from people that I respected and people that had good reputations. I've asked questions to those operators and said, "Hey, how did you get to sound so awesome on the radio? How did you get to be such an awesome aerial supervisor? What do you do? How do you practice?" [...]

I used to record all of my dispatch assignments, all of my air attack assignments I would record them. I would make a note on my board of times. I would just look at the recorder or look at my watch and write the time down if there was something I wanted to revisit or I thought I could do better. I'd go to my hotel at night and I would play back.

[...] How do I maintain my mental fitness? I do a lot of mental modeling. I do a lot of practice. I fight a lot of fire in my head. I get a really good opportunity where I get to ride my mountain bike to work, nine miles of single track to my office. It's awesome. So a lot of times what I'll do is I'll get on my bike and I'll start pedaling. I'll get my heart rate up. And then I'll start fighting fire in my head. One of the big things I do in communications with practicing that is the script. A lot of what we do in the air attack world, aerial supervision world, is scripted. We've standardized our phraseology. We've standardized our sequence. We've standardized all these different components, and it's a very perishable skill set. So part of how I maintain that mental fitness is I'll fight fire in my head. I'll start briefing six or eight or ten aircraft while I'm riding my mountain bike enjoying the day, riding to work or if I'm out hiking through the woods, if I'm out hunting doing things like that and I'm kind of bored, I'll fight fire in my head.

We found little evidence in our participatory research and qualitative interviews to suggest that current training is sufficient. When asked to recall their classroom training in radio communication, the majority of interviewees reported the following issues:

- Not enough experiential learning in the classroom.
- Lack of practice opportunities while on the job but not on the fire or during crisis.
- Not enough recognition by fire overhead and trainers about the anxiety that rookies, and sometimes even experienced firefighters, experience when communicating on the radio.

The Nature of Communication

Interviewees raised a number concerns with the simplifying assumptions stemming from current training models, including: there is one best way to communicate in all situations; it is possible and easy to intuit the needs of the listener, including emotional needs; communication sent is the same as communication received; radio interactions concern only the topic at hand – such as resources, or size-ups; and experienced communicators do not need to practice or take time to prepare.

Our initial research design and deliverables sought to identify a standard set of radio communication principles we could articulate and share. However, our interviewees indicated an absence of a shared and collective understanding of the landscape of radio communication (*i.e.*, training and formal culture). Instead, individuals develop – and sometimes mentor others in - their own rules of practice specific to their roles and lived experience. Moreover, we found that different roles (such as radio dispatchers, firefighters on the line, aviation resources, and incident commanders) function in different physical, psychological, and relational environments with differing constraints that require different communication skills.

Key Finding: Current formal and informal training suggests there is one “best way” to communicate

Simplification: Good communication is the same for all situations – it sounds the same and people listen and speak similarly. There is “one essential way” to communicate as a firefighter, and experience translates into competency.

Complexity: There are significant variations in what good communication sounds like depending upon Incident Command System (ICS) position; each faces different constraints and requires a different communications skillset.

Complexity: Many firefighters don’t know the communication constraints of other positions because they are unfamiliar with the tasks other ICS positions need to conduct, and how communications are worked out within the constraints inherent to each ICS position.

Complexity: Effective communicators adopt different radio communication behaviors depending on their circumstances, challenges, and needs.

As one Assistant Fire Management Officer (AFMO) said: *There is no right or wrong way of communicating out there. It's an individual thing.*

A dispatcher told us, *I wish more ground operations folks would come into dispatch to see what we do. They'd understand what we are up against and why we say what we say.*

The same dispatcher goes on to note how illuminating it is when other roles spend time in their work environment, significant and useful understanding and empathy emerge.

I've had enough field – engine captains and duty officers who have come into the dispatch to hang out and see how we do our job and then turning around as we do something and look at us and go, “Oh, my gosh, that's why you're so rude to me on the radio. Oh, I didn't realize that. [...] Oh, I now see why you kept bothering me for that size-up, because the duty officer keeps walking in the door and keeps demanding it.

Key Finding: Current formal and informal training does not teach firefighters how to organize or listen to messages

Simplification: Speakers will gain knowledge, through observation and intuition, of the needs of listeners and organize their messages accordingly.

Complexity: Spending time in another's work environment builds critical understanding and empathy.

Complexity: It is difficult to understand a message when you are not prepared to listen.

Complexity: People need to be taught how to organize messages to ensure understanding.

Complexity: Listeners need to be prepared for potential emotional effects of messages.

Although it may be easy to say that a message seems “unorganized” or “hectic,” speakers often overlook the strategies required to effectively organize and deliver messages. A primary step in planning an “audience centered” or “listener centered” message is recognizing the listener’s communication context. What type of pressure is the person on the “listening end” of a message having to accommodate? What are the demands of that situation? Effective message construction accounts for these types of needs. Related to this type of adaptation is the need to prepare the listener to receive certain types of information, especially complex information contained in long lists or has emotionally difficult content. Previewing messages by saying things like “I will be sending you this message in three parts,” and using transition language like “I’m moving into the second part of this list” provide the opportunity for the listener to keep up with the message being sent.

Key Finding: Current training suggests that communication is only focused on information content

Perception: Radio interactions only concern the topics being discussed, such as resupplying the fire with food or ordering another retardant drop.

Complexity: The ecology of meanings framework recognizes that verbal interactions also carry significant information about roles, identity, status and relationships. Interactions are about the process of delivering the topic via language (What is my particular method of talking?), identity (Who am I in the interaction?) and relational goals (What do we represent to each other in this interaction? What do the others who hear me think of me and what I am saying?).

Confirming what is found in conflict management literature, our interviews indicate that individuals are concerned not just about topic goals (the subject at hand) but also procedural (the process), identity (who am I in the interaction?) and relational goals (who are we to each other in this interaction?). We use one of the most frequent types of radio transmissions - ordering resources through dispatch – to illustrate.

The amount and type of firefighting resources a fire crew will receive depends on the complexity and priority of the wildfire a fire crew is working on. Ground firefighters often presume that their resource orders alone should indicate to the dispatcher the current and anticipated complexity of their fire. To take a simplistic example, an IC who asks for an additional 20 firefighters instead of 5 firefighters believes he is displaying the complexity of his fire by the mere size of his crew request. However, this communication is indirect and not easily understood, forcing dispatchers into an uncomfortable game of “20 questions” to determine all the other parameters—proximity to water, number of aircraft and so forth—that go into determining a fire’s complexity. Dispatchers feel, when they are forced to ask such follow-up questions that they risk being perceived as meddling in the operational management the fire. One dispatcher told us:

I think one of the hardest things to convey, and I’ve had this happen to me a bunch of times, is when you have an IC that’s out on a fire and they’re trying to request stuff, be it a hot-shot crew, a heavy air tanker, a helicopter, more engines and there’s really nothing that you can send them, because they are one of multiple fires going on, or there’s nothing really available local. You’re trying to get the IC to tell you, “Okay, why do you need that hot-shot crew?” over the radio without trying to sound like you’re quizzing them, like you’re trying to play “20 questions.”

A Fire Management Officer (FMO) described the type of back-and forth negotiation that occurs with dispatch, as well as infers the social unacceptability of extensive back-and-forth talk.

I’ve actually been asked, “You’re on a five-acre fire, and you’re ordering six crews. That’s enough resources to hold hands around a five-acre fire.” And then – yeah, and it’s just – “Yeah, sorry. This is what’s going on,” or you forgot to give an update or a critical piece of information. And that’s back and forth, over the radio.

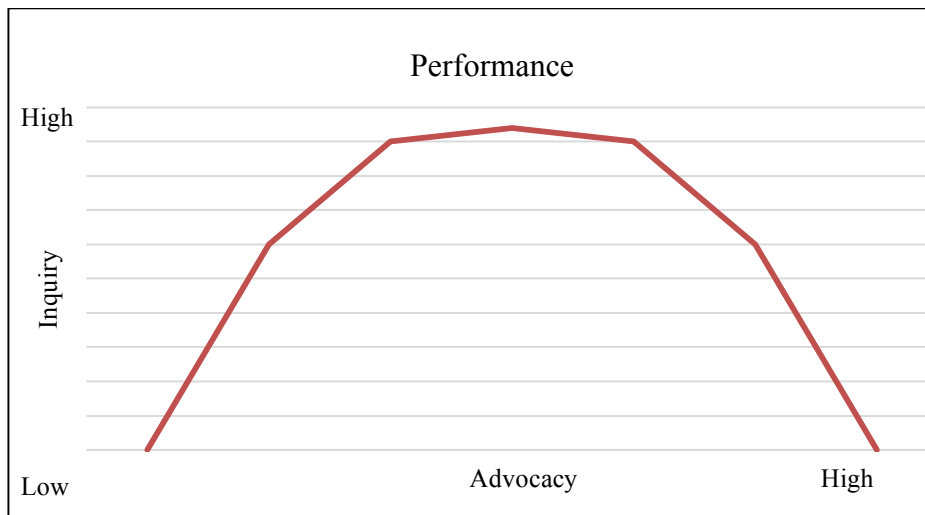
Message Framing

There is widespread perception, supported by training and culture, that a “good” message is brief, direct, and declarative. This results in conversations that focus on transmitting black and white conclusions. Such an atmosphere promotes efficient transmission of key information. However, this preference for declarative language (strong advocacy) eschews a style that invites inquiry and forwarding of tentative conclusions – the sorts of dialogic moves that characterize highly reliable organizations (Weick and Sutcliffe, 2001 & 2007). In other words, when we train people to be strong advocates for their positions, we are not necessarily recognizing tentativeness as a potentially fruitful communicative resource. Because this productive tentativeness of high reliability language is indistinguishable from unproductive instances, there is a tendency towards categorical

interpretation of *all* tentativeness as a lack of “command presence,” evidence of lack of confidence and/or competence. In some cases, it may well be; however, open, tentative and inquiry-based language is also necessary for collective sensemaking. It is not that such conversations do *not* exist in wildland fire, just that these are not apparent or encouraged over the radio.

The conundrum for the wildland fire community, thus, is when, where and how does a far flung group of people successfully conduct the necessary sensemaking? Consider forms of discursive closure (from caving-in and not saying anything to steamrolling where one is dominating the conversation) on a vertical axis and tentativeness (from uncertainty to question what is going on to robust inquiry where vibrant give and take talk is the norm) on a horizontal axis, and then plot performance, one quickly recognizes that performance is actually curvilinear (**Fig. 3**). At present, because a work performance model that equates high performance to conversational techniques balancing advocacy with inquiry is not “on the radar screen” of the wildland fire community, nor evident in culture or training, it has not been fully studied.

Figure 3. High performance requires use and balance of both advocacy and inquiry.



Accurate risk assessment and situational awareness require collective sensemaking and sufficient information in which to make sense of a situation. Yet, firefighters are taught and culturally socialized to be brief when speaking on the radio and to speak in short succinct words and phrases. When radio traffic is congested even brief statements may cause irritation among others also needing to use the radio. How should a firefighter operationalize both brevity *and* thoroughness? What should happen when brevity will not allow for the complete explanation of a complex action or scene on a wildfire?

<p>Key Finding: Brevity, as it is taught and practiced, may not accommodate all situations</p>
<p>Simplification: Good communication is brief and free of repetition.</p>
<p>Complexity: Brief communication is often based on familiarity with each other and needs of various positions.</p>

The brevity requirements vary across incident positions, based on work environment. Requirements for Air Attack, for instance, are more stringent than for dispatcher or ground firefighters. As one Air Attack told us, “being brief” in the air is different from “being brief” on the ground:

The guys on the ground obviously don't have the time compression dimension that the folks in the air have in that you're in a piece of metal that's moving and converging quickly. So sometimes that becomes in and of itself an issue. When Dispatch, who is sitting at zero knots and one force of gravity, they're not in an airplane, is not physically threatened with a collision or something that translates into maybe lengthy conversations or just a lack of awareness of the critical time component of a transmission or exchange of information.

A lot of it has to depend on who you're with, [...] most of the burn bosses we have kinda know what the fire activity is, know what's going on so you can tell 'em a little bit less. If you're out there on a wildfire with a new crew boss, you probably tell 'em a little bit more just 'cause you haven't worked with them and just make sure they understand exactly what you're doing or where you're at.

I also get to where, if it's a critical timing thing, I will repeat that timing a couple of times. You know, "I need this in the next five minutes. Did you copy? I need to have it in five minutes."

The experiences of our participants show that the history of their relationships with each other and their fire management operational roles influence the levels of brevity and repetition in radio interactions.

We also found several examples of how *individuals* ameliorate the weaknesses in the perception of “good message framing.” However, we did not find that these practices have been adopted at a larger collective scale.

Key Finding: To help firefighters “paint the picture” of a wildfire, current formal and informal training should emphasize all communication resources available

Perception: Highly descriptive language is unnecessary.

Complexity: Experienced communicators report using a wide range of persuasive language such as powerful adjectives, metaphors, repetition, hyperbole and understatement, and vivid imagery to “paint a picture” of the fire.

Interviewees also described how they use vivid descriptive terms, often loaded with emotional overtones to convey information on how the individual is interpreting the fire’s intensity and rate of spread:

*Then we got on the radio, and it was like, “Base camp, Hotshots. Fire’s up, making a **significant** run. It’s **slamming** our control line. Escape routes to the safety zone’s possibly compromised. We’re making a run for it,” adding some of those adjectives – And they painted them a pretty good picture that we were pushing it. Matter of fact, it painted a good enough picture to them, without ordering it, they sent aircraft over.*

In another case, an AFMO recalls how he purposely chose to use understatement to convey his understanding of both his local situation while acknowledging there was a separate broader one.

Hey, again, I know we're not the regional priority, but if I can get two loads of retardant for each – one load for each flank, that would help us out; that would be really nice to have.

Finally, an FMO stated very simply that the idea of “information sharing” was incomplete when it comes to message framing. He challenged the idea that if you “say it plainly, that will be enough” when he said:

Being an IC or Burn Boss is like being an artist. You have to be able to paint a picture. But, unlike an artist, then you gotta sell it.

Key Finding: Current formal and informal training does not recognize the potential for miscommunication due to “common” language use

Perception: Now that the 10-code communication structure (10-4 meant acknowledgement, okay; 10-33 signaled an emergency) has been replaced by a “clear text” concept (“copy” for okay and “good copy” for a strong okay), it means everyone is using the same language in the same way to talk to one another on the radio.

Complexity: Not everyone uses the same words to describe similar topics. Different organizations, sub-cultures and people from various parts of the country, will use a different vocabulary and colloquialisms to refer to the same thing.

The wildland fire communication system acts as if everyone knows and uses the words of the English language in the same way. We observed a variety of sub-cultures that contribute to confusion related to language: the use of common words with multiple meanings, particularly across different fire organizations (e.g., structure and wildland) and regional differences (the Southwest from the West, for example) produced different meanings and contexts when the same words were used. The use of localized jargon always presents problems, but common language choices may also present opportunities for miscommunication. We heard of several instances in which specific words are used to mean different things in different agencies:

*A prime example, you're getting flooded with radio traffic, and then somebody says, “Hey, I need you to **deploy** your truck along this road,” instead of saying, “I need you to go **stage** along this road.” Just that one word “deploy”, that's one of those key words that fire managers pick up on, and all you hear, with all this traffic, then all of a sudden you just hear the word “deploy”, the first thing that jumps in your mind is, “Somebody's deploying their fire shelter.”*

*Another word you hear is, “Yeah, we're down here. We're working this **spot** along our division.” Just the word spot means you've got a fire over your control line. You've got a spot fire, when they're just working a **location**.*

*a [...] **water tender**, [is] a water-supply truck. But then you get structural firefighters that are coming in, into the wildland realm, they call a water supply truck – a **tanker**. But in the wildland, a tanker's got wings; it's an airplane, and they say, "Hey, we need a tanker down here," and when they actually want a truck with wheels, not a plane with wings, bringing them water instead of retardant.*

There are also a number of differences based on the geographical and regional differences. As one interviewee pointed out:

[...] someone from Arizona is going to have a hard time – not hard time, but it's different. When you go to Northern Idaho, they use different terms for creeks, and cricks, and hollers, and valleys, and all this stuff. We were up there and we were using Spanglish 'cause we work on the border with the border guys and we learned a few words here and there and we were yelling, "Mira! Mira! (Look out!)" And the Idaho guys are like, "Why do you keep saying mirror?" "Oh, yeah, you guys don't know that word, do you?"

Given the size of the US and its territories, regional linguistic differences are rather common. A firefighter from Hawaii told us about expressions they use locally that are unknown to firefighters from the mainland:

We were talking to the helicopter pilot and we were using terminology, we were using "mauka" and "makai" and so you'd be calling in the helicopter and you'd say something like, "I'm mauka of you, keep coming," or "We're just makai of the pool," or whatever it may [...]. "mauka" means uphill, "makai" means downhill, literally towards the ocean. [...] We also use windward and leeward, so windward is your northeast side and the leeward is the southwest side, the hotter and drier part of the island versus the colder and wetter part. [...] if you grew up here you know what it is, but when their guys come in it's a new word and you hear twice and you still can't say it because it's just new.

Confusion can also emerge when locals give certain places nicknames that are different from the formal names on the USGS topographic maps.

A lot of places have formal names and if you've been there long enough, you give it your own name. The party places when we were a kid, it was really Irene Watch on the map but it was Michelob Flats to us. So if you say Michelob Flats, everyone that grew up in Globe knows that that is right there where the creek crosses.

These linguistic differences are often negotiated and aligned during wildfire events and people solve them by asking for clarifications or using universal compass points (north, south, west, east). They continue to occur during complex fire events when multiple fire organizations have to work together. One Forest Service organization in the mid-west created a list of local terms that they give to any incoming fire organization.

Key Finding: Current formal and informal training suggests that “good” radio use is free from emotion

Simplification: “Good” radio communication is absent of emotions or there is no place for emotions on the radio

Complexity: Emotion is always present. Experienced radio users, particularly when they know each other, glean important information from emotional cues. Significant information is transmitted non-verbally.

Complexity: Inability to communicate an appropriate sense of urgency (in which emotion plays a key role) might lead to failures such as those that occurred on the Dutch Creek (<https://www.nps.gov/fire/wildland-fire/learning-center/fatality-investigation/andy-palmer.cfm> and Cramer wildfires (<https://www.youtube.com/watch?v=ksMXpJXjj44>) fire incidents (<https://www.youtube.com/watch?v=ksMXpJXjj44>)

Complexity: Training and culture currently are silent on the issue of emotion so that learning to speak with emotional nuance occurs on a public stage, thus in the face of possible ridicule and censorship.

Complexity: Certain types of emotional expression *are* acceptable, even cultivated.

In the wildland fire community certain emotions are communicated via cadence, tone, pitch and descriptive words.

One of the most frequently reported communication characteristics associated with message creation is that radio communication should be free from emotion. The organizational socialization practices for new firefighters learning to communicate on a wildfire emphasize the importance of using a calm, neutral tone on the radio. Newcomers learn that it is important to monitor their tone of voice on the radio, to “not go off the deep end,” and reduce the emotional range and vocal variety of their radio interactions.

Fear, anxiety, panic are the most highly censored emotions, because they are associated with loss of command presence, and might show to those firefighters listening in that the incident commander’s decision-making abilities are flawed resulting in a higher likelihood of a negative outcome. A fuels AFMO told us:

When somebody goes off the deep end, it's rambling. There's no real organization to what they're trying to order. They start ordering stuff that's just way, way out there in left field. Their voice is everywhere. It's not only fluctuating in tone, but in pitch, speed. Speed and cadence. I would like to say I've never had that problem, but we can't always say we've never had that problem.

Ironically, our interviews reflect that firefighters are trained to *speak without* emotion, but when they listen, they *listen for* emotion. One AFMO told us: “We rely upon tone and inflection to give us ‘the rest of the story’ when there is an emergency.” When firefighters know each other well, they know what stress sounds like in someone’s voice even when that person’s emotional expressivity remains narrow and limited. Alternatively, such interpretation is difficult when participants don’t know each other, as is frequently the case on large incidents.

Our data shows that speaking competently on the radio involves a great deal of emotional labor or control of one’s emotions, as required by the organization.

For example, for dispatchers, a major source of stress is maintaining relationships and managing (mis)perceptions. For example, a dispatcher with ten years of experience reported that denying an IC’s resource request is a difficult thing to do:

...so many field-going people have a very negative view of dispatch and view us as meddling in their business [...]. Only reason I’m playing 20 questions with you is because as soon as I stop talking to you on the radio I’m gonna pick up the phone to call a geographic coordination center and they’re going to ask me these same 20 questions. I’m trying to get the information out of you, that way I don’t have to call you every five minutes, so that way you can at least do your job of dealing with the fire. There’s this tension between the two that you have to know about, except no one really wants to talk about it.

Learning the organizationally sanctioned emotional boundaries occurs through exposure and corrective feedback from co-workers, superiors, or dispatch. Here is an example of such an educational moment in one of our interviews with a crew boss:

Another crew had gone to a fire. We were listening to them call in. I can't really remember exactly what was going on, but I remember dispatch coming back and telling 'em, "Okay, stop for two minutes, catch your breath, and call us back. Organize what you're trying to tell us." And dispatch just flat told 'em that over the repeater.

Such a quote provides useful insight into how emotional distress occurs and also how unacceptable this is culturally. To almost any firefighter to be publically told over the radio to take a minute to “catch your breath” would be humiliating. Yet, this places the learner in an unenviable position: without a formal and safe practice field, learning occurs in an atmosphere of public ridicule and censorship.

Several participants told us that in stressful situations they slow their cadence down even more. These communicators insert a change in their tone that signals an out-of-ordinary situation, but in the opposite direction that untrained civilians would be expected to communicate stress.

Over the radio I’ve been told that the more pressure I seem to be under, the slower my cadence gets, and the more clear [sic] my talk becomes.

We also interviewed a few firefighters who could not accurately assess the seriousness of a situation because the other person sounded calm on the radio.

Another important communication consideration that seems to be left out of training is how to prepare for a potential emotional effect on the listener. A dispatcher shared how she became aware that her voice can have an emotional effect on others after a stressful and long fire event that ended with a medical evacuation of a firefighter:

that evening, as everyone was coming in off the fire lines, the paramedics kept walking in [...] over to the radio room to want to see me. I was like, "What happened?" and they were like, "We just wanted to thank you for the great job you did, because you've been on the radio for the last three days, they said, everyone knew your voice and you were the calming factor out there. Everyone knew your voice and we trusted everything that you said." [...] That experience made me, since then, to be very cautious about what I say over the radio and to be very sure and not try to sound authoritative, but sound very sure of myself on the radio and try not to sound questioning. I, inside, was a complete wreck. I was shaking.

Besides being mindful about the emotional effect on the listener, another aspect absent in training is what happens to the message when communicators play the role of human repeaters while engaged in intense emotional labor (controlling one's emotions in the interest of the organization). An experienced Air Attack talked about what it takes to "play the telephone game" effectively:

With communicating or serving as a human repeater which, as an air attack or an ASM happens frequently, you'll get a call from Division Zulu, "Hey, can you call operations and let them know that we're pulling off the line." Now I'm the middle man. Now I'm the kid playing the telephone game in the classroom, right? And Division Alpha sounds really pissed off. "Air Attack, why don't you call Ops and let them know we're leaving, this isn't going to work." And he sounds kind of cynical, I'm just over it, clearly Ops isn't listening. There's a lot of behind-the-message message. There's a lot of that question-behind-the-question kind of concept. So then I get to call in Operations and I've got to filter that. Operations, talked to Division Zulu. Doesn't sound like he's comfortable continuing; they're going to pull off the division. Operations calls back and he's obviously pissed off. "Okay, well, tell Division Zulu to get his butt into camp right now and we need to figure out what he wants to do out there." Okay. "Division Zulu, Air Attack. Talked with Ops. He said sounds good and he'd appreciate it if you could get in to ICP with a couple alternative plans that you guys could discuss." "Tell him I'll be there in an hour."

But serving as that mediator and not letting them affect my tone or tempo or anything like that is another way that, when it comes to radio calls, we've got to be careful of. [...] If I communicated the other way and told him, "Yeah, Ops sounds pissed and he wants you in ICP right now." If I relay the exact message, now I'm imparting stress and everybody else on the fire goes, "Ooh, Division Zulu's in trouble." [...] So you've got to be very calculated on how you do it. A lot of mitigations, a lot of rest, a lot of staying healthy, staying fit, staying active.

Especially from an Air Attack side, sitting in an airplane for four to five hours straight with no physical activity and a lot of mental activity is exhausting. [...] Physical fitness is paramount. Mental fitness is paramount. Being oxygenated. Having that red blood cell count to keep you frosty when you get stressed. All those things contribute to this communication environment.

These and other participants described this kind of emotional labor, where they controlled their own emotions and anticipated the emotional effect of their messages on others. As the quotes above show, communicators can alter messages as they participate in the “telephone game,” either by shortening messages, softening them, or allowing communicators to save face.

Communication Technology

Other gaps identified relate to the technology itself – issues related to equipment, such as finite number of channels and challenges of ensuring coverage, as well as those related to use, such as using correct channel, or on-going ambiguity surrounding appropriateness of cell phones and other tools for remote communication.

Key Finding: Communication Technology

Simplification: Radio communicators and trainers often assume that all radio equipment, not only the radios themselves but all the supporting electronics needed to make a forest or park-wide radio system functional, are reliable and will work when needed.

Complexity: Radio coverage over any existing geography may never be complete. There will always be “holes” in the radio or cell phone coverage, often induced by the mountainous terrain itself, where communicators cannot send or receive messages. The repeaters infrastructure is not up-to-date everywhere in the country.

A Communications Coordinator gave the repeaters infrastructure an average grade of B-:

Certain areas do a better job at the radio coverage than others. And that just depends on where you're at in the country, how much money has been spent to improve the local radio infrastructure and things like that. [...] When we look at this, one of the tenets of wildland fire is LCES, which stands for lookouts, communications, escape route and safety zones. From my point of view, we don't spend as near as much money as we should on the C portion of LCES.

[...] on my local unit, we've got a 30-year-old repeater system. It's not keeping up with modern technology. It's old. I mean it's antiquated. It's unreliable at best at times. The coverage isn't the best, and people – you know, it's not getting to the areas we're working and covering that. And they're aware of that, but it's gotten us by. So, we keep getting by with it.

Key Finding: Current formal and informal training does not allow opportunities to practice with the radio

Simplification: The proper use of channels, frequencies, and repeaters are understood similarly by all firefighters.

We heard stories of communicators whose anxiety went up as they needed to move their communication from Crew to the Command channel, as well as stories of firefighters who do not realize they they're on the wrong channel until they're told of their interference by others. Interviewees also reported that firefighters use different standards to judge what constitutes "emergency" radio traffic. One bulldozer operator recalled:

I can give you a prime example on a fire that I was on. The fire was blowing up. We were in a pretty bad situation. You know? Fire's coming right at us, full-on ground fire. We were trying to – we were scooting off to our safety zones; we were getting into it. [...] we were wanting to request basically close air support, heavy air tankers. And it wasn't another fire; it was another group involved with our fire got on the radio and thought they were on Tac channel, and they were on the Command repeater, and they were talking about moving their llamas from the corrals.

Key Finding: Fire managers are often unaware of how much anxiety use of the radio produces in firefighters

Simplification: It is unusual to become anxious completing what are considered "common" or "regular" radio operations.

Complexity: Many higher level fire managers do not realize how anxiety provoking it can be for rookies and other firefighters to try out something seemingly as simple like switching a radio's channel, frequency or going through a lookout tower's repeater can be for many firefighters, and not only rookies.

Key Finding: Current formal and informal training does not provide strategies for instances when radio channels are tied up.

Simplification: There are plenty of frequencies and channels for all radio traffic.

Complexity: Radio frequencies and channels are finite;” just because you have a radio in your hand does not mean there will be an open channel to use.

Although it may be an infrequent occurrence, an FMO recalled a specific situation when competition for radio channels added to the difficulty associated with managing multiple fires. He said:

Division Alpha happened to get on the radio first, “We got spot fires. I need additional resources; I need aircraft.” And then Division Bravo is waiting for him to quit, get done, and all of a sudden Division Charlie’s quicker on the button than Bravo is, and he’s doing the same thing. So, yeah, there’s some competition for – there’s – you know, I hate to say there’s just not enough frequencies out there. Radio operators, those poor guys sitting back at base camp are just getting bombarded in those hectic times. There’s just so much – so many people on the radio, trying to talk. TAC channels are blown up – not blown – just overwhelmed with communications and . . .

He also offered his solution to this problem when he said:

Sometimes the radio will get cluttered, and I find that the easiest way to go about it is indirectly, and that’s calling the IC, saying, “Hey, there’s a lot of traffic on this channel. Can we get a new channel for the squad or for the dozer,” or whatever. A lot of times when you go about that and you say, “Hey, it’s real cluttered,” they take a hint.

A final but important conundrum surrounds the role of the radio versus other tools in supporting effective remote communications. We heard several seemingly valid reasons for selecting a cell phone over a radio. One of these is the consequence of not having a secure, private radio channel that can only be heard by official fire personnel. Such a situation raises competing interests that must be negotiated by each radio user: the desire for clarity versus the need for privacy. It is easy to see why Type 3 Incident Commanders might want to talk to only a few people about their strategies and tactics before choosing a plan of action and, then, only after private deliberation, publically announcing their plan of action for the whole crew to hear over the radio.

Key Finding: Current formal and informal training focuses on radio use as the only form of communication technology

Perception: On wildfires the radio is not only the standard but the best form of communication.

Complexity: The radio appears to be successful as a means to convey transactional information. Other modes – face-to-face, cell phones, computers, walkie-talkies—can create the contexts for richer conversations for sensemaking to occur.

Complexity: Cellphones are used when radio is available – for having collective sensemaking conversations, to use the phone’s mapping abilities (Google Maps) and for obtaining fire weather forecasts. Some incident management teams require that cell phones be used for these purposes.

Complexity: When it comes to supposedly non-traditional communication devices—cell phone, handheld computers connected to the internet, walkie-talkies—official policy and procedures do not adequately reflect the unofficial, realistic, on-the-ground use of such electronic gadgetry, often leaving the users of such technology feeling guilty. Of course, this “unofficial use” of common everyday electronics produces an inconsistent, maybe inefficient, and sometimes unsafe system of operation.

Privacy issues – both formally recognized ones such as injury or need for brevity as well as informally recognized ones, such as vulnerability to peer criticism, seem to be ones in which the primary tool sought when face-to-face interaction is not possible is the cell phone. It is our understanding that while this might possibly be the most appropriate choice, it is currently a grey area in policy and formal culture. Such situations tend to produce an “underground” economy, in which community members operate “beyond the official radar.” This prohibits a deliberate, public conversation about the potential value, sideboards and agreements necessary to successful practice and operations.

Cell phones, they're so much better – cell phone communication groups or companies, they pretty much got a cell tower everywhere now. Do we need to be using cell phones for tactical situations? Most definitely not. But I think I already touched on it, making sure we got the appropriate, most modern technology for actual radio systems, keeping up with that. But knowing that you have cell phones, that that communication is going to occur, it's real easy to not make a tactical decision over a cell phone. But if you're looking for an update on the weather, you can get that via text message from either dispatch or the weather service. And then if it's any major change, then you can repeat that over the common frequency of the folks on the ground, instead of tying the repeater up for a five-minute reading of the updated weather, you can receive that through a text message if you had cell service. If you don't have cell service, you can't receive a text message or whatever; yes,

you're gonna have to read that over the radio. But getting that through other media also is good. It doesn't tie your radios up.

And see, that's – exactly, because what happens is, radio communications, in my opinion, is the most – the least effective form of communication out there. Because it's not like me and you. I'm not sitting here, looking you in the eye, when I'm telling you this, to make – I can see that you're understanding.

As we heard from a number of experienced communicators, one solution is to make difficult conversations private having them on cell phones. Here's what a dispatcher said:

A lot of times I will just tell the IC, "If you have cellphone service can you just give me a landline?" That way then I can talk to them a little bit more candidly without it going over the radio where I could offend a lot more people.

The absence of an explicit policy contributes to such situations as follows, in which a critical injury might have been attended to earlier had the communicator used a radio instead of a cell phone.

If they had just got on the radio and said, "We're on such-and-such a road, need a medical emergency, I need an EMT here, I need ambulances out here," that law enforcement EMT, with a full trauma kit, would have heard that, was only 2 minutes away from the accident site instead of waiting 30 minutes for the ambulance to respond.

And I'll just flat tell you, in that same medical emergency, if they had said it over the radio, the one kid that was there that was not injured, his phone would have instantly blown up with phone calls and text messages wanting to know what was going on instead of giving him the opportunity to do patient care. Which he did a great job on patient care with what he had, the equipment, taking care of his partner.

Risk Perception and Collective Mindfulness

As noted in our introduction, managing wildland fire is an exercise in risk perception, sense-making and resilient performance. Risk perception begins with individual size-up to determine a course of action, and becomes collective as the fire management team builds and continuously updates their common perception of risk. Karl Weick, in an oft-quoted and paraphrased one sentence summary of his model of sensemaking, asked: "How can we know what we think until we see what we say?" (1995:61-61), implying that sense is talked into being, and is exposed in words.

Information interviewees find most difficult to convey and most commonly miscommunicated over the radio:

- Location
- Direction
- Distance
- Time estimates
- Acronyms
- Tactics – when view from air is different from view on the ground
- Names of individuals – when multiple individuals with same name exist
 - Names of places – when multiple nicknames exist;
 - Size-ups; “painting a picture of the fire”
- Requests for resources – when resources are tight and needed on multiple fires; when the list is long; [Dispatch] asking an IC why s/he needs certain resources
 - Updates during busy times
 - Asking for help as a newcomer
- Correcting someone, especially one higher up in the hierarchy
 - Level of risk perceived

Here’s a scenario: A Type 3 incident commander is working a wildfire. He stands on a ridge overlooking the fire, observing the wildfire’s behavior, using experience-based techniques to predict how big the fire might get in the future, what an uncontrolled fire might damage or benefit, and how dangerous it could be for his fire crews. As he thinks and ponders over this new fire he begins to create a possible plan of work. He knows that after he formulates his plan in his own mind, he must share at least some of what he is thinking with the fire crews who will work to manage the incident. He knows that others will overhear what he is saying when he speaks on the radio, including members of his fire organization, the helicopter pilot flying above him with water buckets, the Air Attack in her fixed wing aircraft guiding retardant drops to his fire, as well as potentially unknown members of the public and/or media. As he communicates, he begins the process of making his individual sensemaking collective.

What language might this IC use as he transitions from individual sensemaking (inside his own head) to collective sensemaking? What language might others use to clarify, signal understanding, provide alternative or competing perspectives, and complete collective sensemaking? What does it look and sound like when “collective mind” emerges?

As we listened to fire practitioners reflect on their experiences in our interviews, observed them during training simulations, and listened in during wildfire incidents, we considered: Were there specific words? Was there a pattern or rhythm to radio traffic indicating high performance, or failure? Did that silence indicate the flow of high reliability or the formation of disaster? What could we detect in interview transcriptions?

To more fully understand the *sound of collective mindfulness*, it may well be valuable to watch for conversational patterns and facilitative skillsets like those taught as part of dialogue workshops (see, for example William Isaacs's work, "Dialogue: The Art of Thinking Together", 1999). In an Isaacs' workshops such conversation deepening techniques as David Kantor's "four player system" and Chris Argyris's "ladder of inference" (Senge, 1994) and "left-hand column" exercises are regularly taught. We believe these techniques are necessary precursors to the emergence of collective behaviors and parallel those HRO-mindfulness characteristics identified in the "organizational audits" in Weick and Sutcliffe (2007). Black and colleagues have also shown how such tools can help to better understand high reliability and organizational learning among wildland fire crews (Black and McBride 2013, Jahn and Black in press). Each of these conversational techniques could be easily taught to incident commanders, dispatchers, ground firefighters, and so forth, with the overall goal of enhancing communication practices to enhance collective sensemaking.

Best Practices and Creative "Work-Arounds"

Participants not only told us of their communication challenges but they also told us how they created solutions to deal with these challenges. We labeled these solutions "work-arounds" to suggest that they are not formally embraced or institutionalized through policy and training in the development of new members, but they, nonetheless, work in wildland firefighting environments and present a great potential for others to use in the future.

Practice talking before going on a wildland fire.

Before sand tables were popular [...] we did, in-the-field simulations, where we actually would go out on a tactical channel, and we would run a simulation in the field. [...] We'd [...] talk on the radio amongst ourselves and the crew. And we would – we would just learn how, and then we would debrief it and, "Oh, that wasn't the best appropriate way to talk on a radio," or, "Don't use those words; use these words," and critiquing it afterwards.

Practice speaking up and asking "what-if" questions.

Yeah, the number one thing that they need to do is to be comfortable in the ability to speak up and ask questions. There are no dumb questions out there. The second thing they need to do, and advice I give every one of 'em is, as they're listening to a briefing, or radio traffic, or anything that's going on, is play the what-if game in their mind, "What if I was in charge of this; what would I do," and see what plays out. You're gonna be right a lot of times, and sometimes you're gonna be wrong. And when you're wrong, follow up at the appropriate time and ask questions of why that operation or that decision went that direction. And then to add clarity was like, "Oh, yeah, okay. Now I see why you didn't do that." And just keep playing those what-if games, because [...] the more they can mentally prepare their selves for that eventuality, the better off they are, because you can learn way more from somebody's

mistakes than you can from their successes. Lessons that hurt stay with you a lot longer.

Use AARs but also perform an “annual AAR.”

“ we do AARs, and once a year, we get together and do a year AAR, whether it's about wildfires or prescribed burn or whatever, and everyone brings up stuff like that, that makes it run a little bit smoother or better so really just about everyone out there is more or less on the same page.”

Train firefighters to frame their messages; teach them how to “paint the picture.”

This work-around focuses on how to create vivid images with words to “paint a picture” for others. As one Type 2 Burn Boss with 19 years of experience said, “painting a picture” for others with different visual reference points is one of the most challenging things to do over the radio:

If you need to paint a picture to somebody who can't really see what you're seeing, or you're trying to describe something on a map or trying to tell 'em where the fire is or figure out where they are or where they're talking about, I mean, that kind of thing's really hard when you can't – you don't have that visual reference, and you're trying to describe something, and you know they're gonna see it differently because there's just no way around that.

“Painting a picture” is also important in the communication with dispatch so they understand what resources are needed. In addition, the community might decide to acknowledge and explicitly discuss how, when and where use of photographs taken/sent/received from hand-held devices might assist. The same interviewee:

Being a IC or burn boss is like being a artist. You have to be able to paint a picture. But, unlike an artist, then you gotta sell it.

The same participant talked about message framing in regard to adapting one’s message to different audiences.

[...] when you're talking about rookies, a lot of times the why is not really that important; it's the how-s. But when you get to more experienced people, whenever you have to change something in an operation, and you're communicating that over the radio [...] A lot of times I will go ahead and briefly leading into it say, "This is what we're gonna do and why we're doing it." And the why frames that leader's intent. They know the reason we're having to change. They buy it; now they own it, and then you can go with it.

Teach firefighters how to talk about potentially embarrassing situations while “saving face.”

To negotiate multiple goals participants underscored the need to continually ask questions, find ways to enhance privacy to increase the chances for candidness and, if a

humiliating or shameful experience or thought is being discussed, to save face while remaining professional.

The following example reveals how one FMO used an indirect way of addressing the shortcomings of a new firefighter. He cast himself and other experienced firefighters as responsible for making the kind of error he was trying to get the new firefighter to recognize in his/her own behavior. Although direct communication has certain advantages (less room for interpretation, often faster, etc.) indirect communication is an important resource that can be used in delicate situations wherein the direct communication may actually decrease the chance for the important lesson to be learned.

[...] you don't want to take and call that rookie or that individual out. You want to address it in the way – it's like, "Hey, I heard something today from somebody who said something about working on a spot on the line, and we've talked about this before, where you guys make real sure when we say stuff like that, we've got our standards." And you're not even looking at them, you know, 'cause you don't want to put them on the spot so to say. And you address that in AAR. Your senior guys, your veterans, they know exactly what you're doing, because you've done it before. And then they will tag in like, "Yeah, I noticed I'm getting pretty slack on that, and we need to start working," and they will address it from their – they'll take that like, "Yeah, I'm getting kinda lax on that; "That happens to me," or, "I do that," and then that individual doesn't feel quite as – alone because, "Hey, this guy here's been doing it for ten years, and he has the same problem." And that goes back into that cohesiveness, and that also goes back into that communications, which some of the most important communications we have on a burn is with our feet up on that table in there, at the end of the shift, when everybody's going home. And that's when you can really talk about what happened.

And at that point, you're senior guys is – we identify some of these things, and then as opportunity presents itself as a group, we'll bring in and you'll – I may lead into it and let one of them take it. And we're sitting there having this discussion, but we're actually focusing that on – we're talking about something that all of us knows inside and out, but you always need to remember what I know is not what you know.

Discuss the mixed messages created between official policy and regular operations. For example, is it “legal” to use cell phones on a wildfire instead of a radio?

The use of cell phones to communicate audio and visual information provides a valuable way for firefighters to communicate efficiently. However, policy messages tend to suggest that cell phone use is discouraged. See, for example, https://www.nifc.gov/PIO_bb/.../SMLetter.doc Instead of holding in place the difference between the policy and practice, the wildland fire agencies should strategically decide how to train firefighters concerning safe and unsafe practices using all available communication tools.

When everybody on the crew had a cell phone, I was on a shot crew, and our – I was the Assistant Superintendent on the crew, and our policy was, "When we're on the clock, your cell phone is turned off, and it is put away."

Note and discuss what firefighters believe are their best practices in high reliability.

Many of our interviewees have shown us creative ways they try to increase the likelihood that HRO-mindful behavior will occur. Interviewees talked about cognitive and communicative practices they use to fight fire safely. Examples included:

- The ability to anticipate future actions and steps both in regards to fire behavior and corresponding organizational response;
- Build rapport with other communicators;
- Keep an open mind;
- Create mental structures and maps to keep all the data in mind – develop “global mindfulness”;
- Understand that one is “always in a communication deficit”;
- Speak up even when you are the only one who thinks you saw something going on;
- How does one constantly think and doubt at the same time and yet continuously get work done?

Situational awareness [...] is an individual's understanding of where they are in time, space, and their relationship to events. But global SA is expanding that bubble,, it's to distill a one-hour cover point down, it's basically an educated guess of what's happening in somebody else's world. [...] Personally for me, the most important practice is maintaining global SA in my cock pit, in my airplane, so I try to keep a heightened level of understanding of what's going on on the ground, what's going on with the air attack, what's going on with dispatch, what's going out my tankers, because I can save a lot of radio calls if I already know what's comin'.

Another situation - I was the IC on a small fire, it was just above a town in California where I worked. I was talking with the SEAT plane. I gave them good directions. “I want you to start at” and I don't remember exactly what it was but start at this point and “I want you to go east along the fire line, run your line that way.” Him and I actually started arguing over what was east and what wasn't. The funny thing was you know I'm standing on the ground looking at a compass, I know I'm right, and I'm telling him, “You need to go down the east flank of this fire” and he kept, “I am going down the east flank of this fire.” He thought he had it and I thought you know I had given him good directions. Finally, we were able to work it out. You know we talked about it and then I told him from my mirror flash to another person's mirror flash that's where you want to go. He actually came back and well because I knew him because of working with him all the time he came back on the radio and “You're right.” You know he admitted that he had[made] the mistake.

And even if they [newbies] bring something up that is just totally just elementary, that it's like, "Where the hell did that question come from," you have to treat it seriously, and you have to respect that question and answer it respectfully in a positive way, because the next time, they may see something that I totally spaced and overlooked, but they're afraid to speak up.

So there's say five or six people talking trying to deal with that and you see something on your side, it's like, okay, I know the burn boss is busy right now, but I need to say something that there's this other thing going on. Well, I've done this in the past. Sometimes our burn boss will have somebody riding with him and he does that a lot I think to help with radio traffic because there is so much radio communication during certain times of the prescribed burn. [...] So sometimes I've just called, say the assistant, and it might be a dozer operator. It might be an AFMO. Somebody's riding around with him. If I know that they're with him, I'll try to call them.

As these quotes show, sophisticated, experienced communicators in wildland fire operations are aware of the context and timing of their messages, of the previous relationships upon which they can build, and about the impact of their interaction on other listeners.

Methodological Lessons Learned

In response to the JFSP request for proposals in 2014, we sought to identify potential new research directions. Methodology is a key component of any research project, and thus it should come as no surprise that we spent substantial time considering the feasibility of various data collection methodologies. Some of them worked out for us, and some of them did not. Here, we summarize our findings so that researchers coming after us have a roadmap as to what each data acquisition technique we attempted could and could not do when it came to studying firefighter communication (**Table 3**).

For purposes of understanding conversation, our data collection goal was to capture the actual language firefighters used, their particular word and phrase choice, including such subtle indicators of communication as nuance, tone, pauses, silences, and gaps in conversational patterns. More so, we desired conversational data that could give us a sense of how firefighters might have moved from individual sensemaking about a fire's activities ("This is what I think is going on...") to a collective sense of what is going on ("Do you see the fire in roughly the same way as I do?").

Key Finding: The sounds of sensemaking

Simplification (ours): HRO-mindfulness as defined by Weick and Sutcliffe (2007) could be identified by the word choices firefighters made, and these can be easily coded to reveal sensemaking, risk perception and resilience.

Complexity: Collective mindfulness seems to be a constellation of attributes that allows for rich open-ended conversations about what is happening on a wildfire. It depends on whether this picture is up-to-date or over-simplified, and whether the IC could take contradictory feedback about it. HRO-mindfulness, when it is properly being performed, is not as simple as going down the checklist of the five principles of mindfulness as spelled out by Weick and Sutcliffe.

Complexity: High reliability is likely evidenced by “flow” as well as “interruption.” Therefore, all aspects of a conversation (all sides of a conversation, individual cadence, tone, conversational pace and context) are needed to see HRO-mindfulness in action.

Complexity: Operationalizing HRO-mindfulness requires articulation of and attendance to various forms of non-verbal communication —silence, tone of voice, perceived command presence; to tempo - individual cadence and collective flow; as well as to the actual words exchanged.

Complexity: Further study is dependent upon developing operational definitions of these facets of HRO-mindfulness and obtaining complete radio sequences that might display the facets as they are being used.

We investigated a variety of ways to collect field data of firefighter’s remote communication with each other as they individually and collectively make sense of a wildfire. Our primary focus was on radio use, although we also listened for when, how and why firefighters sought other means to communicate when not using radios.

When we first designed the framework for this project, we thought the answer to the radio question was easy—analyze existing recordings that we’d been assured were recorded as standard operating procedure in most wildland fire dispatch offices throughout the U. S. As a back-up and to test potential field-data collection protocols, we planned to observe radio use during a simulation in one of the National Advanced Fire and Resource Institute’s (NAFRI) training courses (S-520). We also figured we could go to the field ourselves and with handheld digital recorders collect recordings in “real-time”. All of these data and other collection methods proved to be problematic.

What we learned was that this primary source of firefighter communication data – recordings from dispatch offices – was not as easily obtainable or as ubiquitous as is commonly believed, as tapes are often re-used, destroying the original recording. In fact,

we were able to obtain no digital recordings (see initial section on Methods for additional detail). Moreover, this investigation also disabused us of the mental model of radio communication as being “simple.” Specifically, ephemeral recordings of dispatch capture only one of at least three different types of radio exchanges on a wildland incident (Dispatch-Fire, Ground-Ground, Ground-Air, see Figure 3).

Key Finding: Methodological Lessons Learned

Because of the difficulties associated getting on or near a wildfire (logistics, researcher’s firefighter qualifications, scheduling and costs) studying radio communication in real time proved to be difficult. Also, our research methods changed when we discovered recordings of past wildfires are not readily available

Recording radio traffic on wildland fires is not, contrary to popular belief, commonly done in fire dispatch offices across the country. In fact, recording of radio conversations is a hit and miss proposition. Even in dispatch offices that do record radio transmissions (because it has law enforcement responsibilities, the National Park Service, for example, is required to record radio conversations and archive it), it is difficult if not impossible to retrieve radio recordings because of legal possible liabilities. In many cases researches would have to obtain FOIA request to obtain radio recordings.

Our interviews proved useful for understanding some important aspects of this research project – radio culture, training, appropriate uses of radio vs. other modalities. However, for purposes of understanding collective sensemaking practices, these data primarily provided ideas, intuitions, and approximations of what individual sensemaking might retrospectively sound like. Finally, interview data provided important insight into how firefighters manage the complexity of communication, however it does not expose the pressures of “live fire” firefighting. Even if interview protocols probe for examples of collective sensemaking, the results cannot replicate real life conversation on a wildfire with its assortment of environmental stressors, weather, and a fire that is constantly changing its behavior, heat and smoke. The environmental conditions prevalent in all wildfire environments has a major impact in the construction of collectively mindful firefighting scenarios.

Key Finding: Methodological Lessons Learned

Interviews, while a useful first step in ascertaining how firefighters talk to one another, do not capture all of the communication complexity being managed by firefighters.

What is not available in retrospective interviews are all the things that make fighting a wildfire complex and dangerous—how hot and fast the fire is burning, what the fire weather is forecasted to be and how this incoming weather will affect tactics and what the living conditions (food, shower facilities, sleeping areas) are like for the firefighters. These factors affect the physical and emotional status of firefighters and have a corresponding effect on how they communicate with each other.

Richer data about collective sensemaking was obtained from the NAFRI coordinated S-520 advanced fire management simulation. However, a simulation, though producing as close to real life wildfire conversations as one can get, is still a simulation. Since the participants in the S-520 course could either pass or fail it, we were not allowed to record their conversations. Importantly, conversations during the simulation are designed to challenge the students, and thus do not reflect real-time wildfire conversations.

We then considered how we might obtain real-time conversations. Options included partnering with a wildland fire unit or team to mic up various parties, direct observation, and trying to record through a ground-based radio. Of these, the latter two appeared most practical. We were able to partner with two wildland fire units and gained permission to observe a prescribed fire and a wildfire. The prescribed burn was postponed for this year, however we were able to observe a Type 3 incident. Getting on or as close to a Type 3 wildfire is often logically challenging and expensive to pull off. Moreover, even when we were near the fire we knew we were still not hearing “all sides” of the conversation due to topographical interference and multiple channels active at once.

We suggest capturing real-time conversations during a prescribed fire for transcription and later analysis combined with observing the burn to comprehend the complexities involved with sensemaking in action, especially the timeframes, the tempo of moving between “flux” to “sifting,” and the signals missed along with those picked up on, and then finally to acting on what has been sifted and named. This would also allow researchers to interview participants at a later date to clarify thinking, meaning, and actual conversation.

Key Finding: Methodological Lessons Learned

Prescribed fires offer an important research opportunity

As a next logical step to further explore collective sensemaking, we suggest recording communication during a prescribed fire. A prescribed burn is a self-contained operation. It would be relatively easy logistically and inexpensive for a research team to get to a burn. A prescribed fire would provide not only the opportunity to record live radio conversations, but if the research was properly set up in advance, follow-up interviews with the prescribed burners could be conducted.

We tried at least seven different methods (**Table 3**) to collect conversational data to assess collective sensemaking-in-action among wildland firefighters as they sized up and fought wildfires. Each method, though oftentimes producing interesting data, had both limitations and advantages. It became clear as our research project evolved that some methods of capturing sensemaking data were better than others—being as close to a wildfire or prescribed fire, for example—and that what is now needed is the development of specific research procedures that would allow us to effectively, efficiently, collect this data in field situations.

Table 3: Various research methods, field tested as part of this JFSP communication project.

Method	Pros	Cons
Face-to-face interviews	<ul style="list-style-type: none"> • Simple • See body language, facial nuance, hesitations, and so forth 	<ul style="list-style-type: none"> • Convenience sampling of interviewees (we included who we could get) • Closer to studying interaction but still an approximation: reflective discourse from participants who are engaged in impression management (they told us what they wanted us to hear)
One-on-one telephone interviews	<ul style="list-style-type: none"> • Easy to set up • Cheap • Logistically easy 	<ul style="list-style-type: none"> • Could not observe body language • Interviewees conveniently selected
Simulations (NAFRI S-520)	<ul style="list-style-type: none"> • An actual interaction as close as one can get without being on a wildfire 	<ul style="list-style-type: none"> • A simulation is a contrived interaction
Fire lookout (LO) recording radio traffic from a lookout tower	<ul style="list-style-type: none"> • Inexpensive • Seemingly easy to do • Supposedly get all sides of radio transmissions 	<ul style="list-style-type: none"> • Voice-activated recorders hard to manage • LO has to be trained • LO has other duties • Radio traffic congested on LO
Firefighter conversations made using digital recorders positioned as close to a wildfire as possible	<ul style="list-style-type: none"> • Real-time data • True to life • All the complexities of the fire environment (weather, dust, noise, helicopters, blunders, mistakes, good things) present 	<ul style="list-style-type: none"> • Higher cost • Hard to schedule a wildfire • Logistics (Research time on the wildfire itself?) • Convening the researchers to be in the same place at the same time as the wildfire burns • Transcribing recordings of a whole wildfire is a big, costly job • This question persists: What communication did we miss?
Using audio tape recordings from dispatch offices	<ul style="list-style-type: none"> • If available for interesting fires • Cheap 	<ul style="list-style-type: none"> • Difficult to locate and tape a wildfire germane to our research • Unexplained reluctance of dispatch offices to give us available tapes.
Observing radio conversations inside a fire dispatch office	<ul style="list-style-type: none"> • Do not hear all the talk that occurs on a wildfire 	<ul style="list-style-type: none"> • Only hear one side of conversation; potentially altering practice if dispatchers feel self-conscious

V. Management Implications

Even though there is much still to be learned from a theoretical standpoint about the nature of communication practices in wildland firefighting we felt there were dozens of practical commonsense actions that could be taken right now that would dramatically improve overall communications with the corresponding possibility that firefighter safety would be also be improved. In the bullet list below we have highlighted a dozen of these practical actions.

- At training sessions discuss implications of the word communications as it used in common field guides such as the IRPG and Fireline Handbook.
- Take more time to discuss the various aspects of communicating in standard firefighting courses such as L-110 and S-130.
- Practice actually talking on the radio.
- Practice talking on the radio where a serious problem is occurring when emotions might be high.
- In classroom situations have lower level employees practice talking to higher level employees such as squad, crew bosses and incident commanders. This would be practicing what is often called “speaking truth to power.”
- Spend time in another’s work environment to develop empathy for the communication challenges they face. For example, a firefighter would spend a day in the dispatch office and, if possible, the dispatcher would spend a day on the fireline with a engine crew or firefighter.
- “Painting the picture:” practice framing clear and concise messages for common wildland fire actions that are likely to occur—fire is heating up; fire is spotting; a firefighter has been injured and so on.
- Discuss terminology that might be only local in nature and might not be understood by incoming out of region firefighters.
- Discuss with crew members the ways they either show or don’t show emotion when talking on the radio. Discuss how they can often feel nervous about being misperceived and embarrassed while using the radio.
- Ensure that all rookie firefighters have been taught the complexities of radio operation and the common technological pitfalls of radio operations.
- Discuss the issues that might come up communicating on a single incident with radios, cell phones, field operated computers, and walkie-talkies (“squirrel channels”) all of which are now regularly used on wildfires.
- Discuss how one’s individual perception of what is going on with a wildfire becomes “collective,” something the whole crew can use.

In our view, the most important managerial implication concerns the training of beginner firefighters. The leadership of fire organizations need to decide 1) how important radio communication is for their organization, and 2) what pedagogical objectives should be met in the basic courses, S-130/S-190.

If these teaching objectives involve application of skills and not just knowledge, then a realignment of teaching assignments and classroom tools using Bloom's (1956) taxonomy of learning is necessary. For example, if management and expert trainers decide that mere *knowledge*/memorization of how a radio works is a sufficient and optimal teaching objective, then a quick lecture and a multiple choice test are appropriate (these were the learning objectives and tools used at the S-130 course we observed and we found them profoundly misaligned with needs of firefighters in the field). Alternatively, if management decides that the needed teaching objectives are the development of radio listening and speaking *skills*, along with a deep *understanding* of radio communication challenges and constraints in the broader firefighting organization, and ability to *create* and *evaluate* effective radio messages, then lecture/story-telling, as well as practice, exercises, opportunities to fail and get feedback in the classroom are more appropriate teaching tools. For too many, the guard school is less a place of true learning but a place of quick vetting and certification on one's way to acquiring a red card. While we acknowledge the time and cost challenges involved in redesigning the teaching tools for radio communication, we believe it will provide long-term organizational benefits (see Appendix B for additional training recommendations).

VI. Relationship to other recent findings

Our study resonates with previous calls for more in-depth training and reflexivity about radio communication practices issued by communication coordinators and trainers in a variety of forums such as FLAs, *International Journal of Wildland Fire*, *Fire Management Today*, and *Two More Chains* (e.g., Ferranti, 2008; Frederick & Tuominen, 2009; Shouldis, 2013; Varone, 2003; Whiting, 2006). This study also adds to the recent work of one of our team members (Gabor, 2012, 2013, 2015), where she drew attention to the need for more training for message design, as well as to the role of emotions in radio interactions to convey truthfulness. Further, this work builds on previous research aimed at capturing the language of HRO and the communication practices associated with mindfulness and situational awareness (Jahn & Black, in press; Thomas, Fox, & Miller, 2014)

VII. Future work needed

In this section we highlight future research opportunities that would further expand the "frontiers of knowledge" framework the initial JFSP proposal asked for. Each of the eleven future research efforts described below will provide an even more nuanced view of firefighter communications, and, once developed, come closer to drawing a more complete map of wildfire communication practices.

1. Our interview data suggests that "pockets of wisdom" have been developed to meet the demands of a complex communication environment. Employees have developed and reflected upon their own creative ways of dealing with the barriers to effective communication. Because some of these employees are also responsible for teaching the S130/190 courses, future research should mine the best practices among those who teach these courses for successful ways to teach communication content in the classroom. We suggest a modified version of "appreciative inquiry" aimed at gathering these pedagogical tools to share among the forest service more broadly.

2. Our research focused on the S 130/190 courses because they represent the common experience of wildland firefighters as the basic required courses. We also believe that these courses are responsible for the primary framing of the task of communication. In other words, the “seeds that get planted” in these courses concerning the complexity of communication (or lack thereof) is important because of its primacy in the learning process and its potential to impact how students think of communication in the future. However, many interviewees reported that they encountered messages about communication in courses beyond these introductory courses. As such, the communication content in higher-level courses and the pedagogical techniques used to teach these competencies should also be explored.
3. When communication is isolated and taught as a separate competency within a larger curriculum, we have a chance to examine communication as its own phenomena but verbal and nonverbal communication play a key role in other areas of emphasis as well. For example, wildland fire leadership courses (<http://www.fireleadership.gov>) focus on developing leadership skills. Effective leadership depends on effective communication. In other words, discussions of effective leadership styles for different situations are incomplete without a discussion of the communication strategies used to carry out those leadership styles. A more in-depth review of the “embedded communication” within these courses should shed light on opportunities to strategize intentionally about effective ways to teach this content.
4. Our research contributes a better understanding of the complex communication context and identifies opportunities to shape classroom pedagogy to answer that complexity. Packaging these ideas into classroom supplemental materials that can be used by instructors with varying level of pedagogical experience is an important next step. Here, we envision a “menu” of experiential learning opportunities that would complement the existing curriculum. These experiential opportunities could include developing individual, dyadic, and team level communication skills and should include assessment measures so that students and teachers can gain confidence in the learning process.
5. How do firefighters manage public- private boundaries in their talk on the radio, including strategic use and non-use of the radio itself? We have noted that firefighters told us they hold back, keeping some things private (*i.e.*, not communicating certain information at all), or hiding in plain sight when certain publics are listening (*e.g.*, the press), such as by talking in code or relaying just enough important information for those who know what to listen for to be able to pick it up. While it may seem obvious, just because something is not relayed over the radio does not mean the interaction is not happening elsewhere on the fire, whether face-to-face or on a cell phone or text. Indeed, conversations involving conflict may specifically be held away from the medium. What may be carried over the radio may be the mundane, quotidian business of running the fire, whereas especially difficult and impactful interactions may be held elsewhere. Learning

more about these topics could have important implications for the political context and its implications for safety.

6. A more comprehensive understanding is needed of what we might call the “ecology of radio communication” on a particular fire. Firefighter and fire managers seem aware of what might be termed an ecology of communication that emerges on a particular fire and within particular frequencies. There is a pecking order of who gets to inhabit which airwaves and an implicit set of rules that emerge regarding the allowable interaction that take place there. Different dos and don’ts apply, then, within a particular communication ecology on a fire, depending on what kind of channel you are talking on, its purpose, and who has access to it. We heard from interviewees of the need to adapt one’s communication to different contexts and levels. Indeed, adaptability itself is regarded as an important skill to cultivate. Learning more about this could have important implications for command and control, operations, as well as leadership development in fire.
7. Firefighters report developing a vocabulary and practice that heightens the visual qualities of communication (*e.g.*, “painting a picture” for the person on the receiving end of the radio). Learning more about how they “paint this picture” could have important payoffs for both training and firefighting safety.
8. The emotional landscape firefighters navigate, including how they engage in personal impression management and recover from missteps in what sounds like a relatively unforgiving landscape of judgment for perceived (or actual) poor performance, needs additional study. What are the emotional taboos, methods to self-regulate emotion, how does sanctioning of emotion happen and do women and men perceive communications differently are key questions?
9. The status and power inherent to various ICS positions needs to be studied from a communications standpoint. Oversimplifications regarding communication tend to overlook issues of status and power that come with people interacting from within different roles, but firefighters we talked to report the need to navigate role differences and to establish and maintain good relationships on fires in order to perform well in their jobs. With further study, we could learn more about how asymmetric roles influence interactions, how roles are performed on the radio, as well as about the similarities and differences between existing face-to-face relationships and mediated communication, including the benefits and complications of personal friendships. We could learn more about existing communication strategies to engage in better perspective taking as well as ways of overcoming roles stereotypes. Learning more about these topics, including, could have important implications for general communication practice, but also training, leadership development, and safety.
10. Despite the emphasis in training on what to say and how to say it, the highly refined listening and speaking skills firefighters already employ is an important element in organizing for high reliability. Our initial conversations point out that

communication is not just for information transmission, but rather that good listening aides in the continual process of collective sensemaking. Firefighters continually compare information and update their understanding with both nonverbal and verbal communication, despite the “communication deficit” they are working with in terms of blinded cues and time pressure.

11. It may not be possible to simply detect the sounds of high reliability in action (objectively) but rather the sounds of high reliability in action may be in the *ear* of the beholder. That is, in future studies, we may need to identify and work with people who we presume are already skilled in HRO-mindfulness, and know what to listen for and how to respond. We see potential sensitivity to operations evidence and preoccupation with failure in good listening skills and willingness to adapt. Resilience is evident in how, when something doesn't add up, people attempt to repair in order to ensure continued collective sensemaking and so that the organization does not unravel. If that doesn't work, they intervene and “grab the controls” by acting unilaterally.

VIII. Deliverables

Deliverable	Progress
Report on summary of findings with direction for further study	Final Report
Recommendations of updates to the communication section of Incident Pocket Guide & various training courses	See Appendix A: Re-designing radio training.
Compendium of examples linking how communication practices connect from one fire to another	We were only able to observe one actual incident. The Key Findings section captures communication practices we found common to many of our interviewees, and represent both wildland and prescribed fire incidents. We have also summarized Key Findings in Appendix D.
A pamphlet showing what high reliability organizing (HRO) sounds like	This is partially addressed in the HRO section of the final report, and will be discussed in a peer-reviewed paper. Our research under this project has convinced us this is not the most effective or feasible way to think about, train or evaluate high reliability.

<p>4 conference presentations</p> <p>2014 Poster Abstract</p> <p>2015 Ziegler Abstract</p> <p>2015 NCA</p> <p>2016 Poster .pptx of Dramaturgy present</p> <p>pdf of 2016 poster</p>	<p>Thomas, D., Gabor, E., Fox, R. Ziegler, J., Black, A. (2014). <i>JFPS Project: Risk Perception, Sensemaking, and Resilient Performance: The Sounds of Firefighting in Action.</i>” Oral presentation at the International Association of Wildland fire, IAWF Large Wildland Fires: Social, political and ecological effects” conference, Missoula, MT. May 19-24, 2014.</p> <p>Ziegler, J., Fox, R., Gabor, E., Thomas, D., & Black, A. (2015). <i>Radio Technology Opportunities and Constraints: Using Dramaturgy as an Analytic Tool.</i> Paper presented at the International Association of Wildland Fire “Managing Fire, Understanding Ourselves: Human Dimensions in Safety and Wildland Fire, 13th International Wildland Fire Safety Summit & 4th Human Dimensions of Wildland Fire Conference, Boise, ID, April 20-24, 2015.</p> <p>Gabor, E. Fox, R. L. Ziegler, J., Thomas, D., & Black, A. (2015). <i>The Sounds of Wildland Firefighting in Action</i>, Poster presented at the International Association of Wildland Fire “Managing Fire, Understanding Ourselves: Human Dimensions in Safety and Wildland Fire, 13th International Wildland Fire Safety Summit & 4th Human Dimensions of Wildland Fire Conference, Boise, ID, April 20-24, 2015.</p> <p>Gabor, E., Fox, R., Thomas, D. (2015). <i>Securing Extramural Research Funding: Challenges and Opportunities for Communication Scholars.</i> Panel presentation presented at the National Communication Association Annual Conference, Las Vegas, NV, November, 19th-22nd, 2015.</p> <p>Fox, R. L. Gabor, E., Thomas, D. Ziegler, J. & Black, A. (2016). <i>Reluctant to Simplify: Examining Assumptions About Wildland Firefighting Communication.</i> Poster presented at the International Association of Wildland Fire 5th International Fire Behavior and Fuels Conference. Portland, OR. April 11-15, 2016.</p>
<p>1 peer reviewed manuscript submitted to “International Journal of Wildfire,” August 29, 2016. See Appendix E.</p>	<p>Cultivating a reluctance to simplify: Exploring the HRO communication context in Wildland firefighting. This article builds on the work of Thomas, Fox, and Miller (2015). This paper’s basic point is that an understanding of the language firefighters use without an understanding of the context from which it emerges is incomplete. We need to better understand what is constraining their language and to more deeply comprehend what shapes their language choices. We weave together two lines of literature – training and communication— while keeping a sharp focus on the assumptions and simplifications firefighters use making these choices.</p>

IX. Conclusion

The JFSP proposal our research group responded to —New Science Initiative for Social Science—asked scientists to complete broad research efforts that would push “the frontiers of knowledge.” In particular, JFSP wanted researchers to consider the questions surrounding the concept of “risk perception,” and for this specific area of study to articulate “new concepts or frameworks,” to develop “an experimental design to test” hypotheses and, in all cases, demonstrate how proposed actions would “advance innovative thinking.”

This final report indicates that we made headway on each of these broad actions, sometimes at a sketchy, preliminary level. We dipped the toes of our research efforts into as many pools of communication theory and practice as we could, including surveying such disparate topics as collective mindfulness, high reliability organizing mindfulness, dramaturgy, pedagogical communication practices in the classroom, and models of communication.

JFSP underscored their interest in purely innovative thinking stating that there was “no requirement to demonstrate immediate relevance to land managers.” However, we discovered dozens of practical actions immediately useful to on-the-ground firefighters that can be used now, from modifications in how communications is taught in introductory wildland fire firefighting courses to the way firefighters might practice talking and, listening, to one another as they, in both low key and high tempo fire situations, determine the risks involved (personal safety and property damage) with wildfires.

Our literature reviews showed the lack of empirical peer reviewed studies in many crucial areas involving risk perception and firefighter communication, areas rich for the advancement of knowledge. Here we name only three of the most prominent knowledge gaps identified:

- 1) Even the most basic question of all—how does communications, in its various manifestations, affect firefighting safety?—has not been, at least to our satisfaction, thoroughly studied and written about.
- 2) We discovered an immense knowledge gap in how firefighters as members of firefighting teams make collective sense of a wildfire.
- 3) As our research efforts intensified over a three year period we found ourselves adapting and, improvising, specific field methods for obtaining communication data, especially in the communications that occurs on an actual wildfires. This dilemma opened up the whole area of “how best” to capture live wildfire communications that can be scientifically analyzed.

Academic papers are currently being drafted from data obtained in this research project that will begin to address these and many other questions.

The possibilities to decrease firefighting accidents, including the loss of lives, and to increase worker productivity, by making even small improvements in how firefighters communicate with one another as they make collective sense of the risks involved with wildfires and prescribed fires, are huge. This preliminary research effort has exposed a few of these possibilities, and in so doing, has expanded the frontiers of knowledge in the area of firefighter communications and risk perception.

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Appendix A: Proposed Analytic Frame for Further Narrative Analysis of the Landscape of Radio Communication on Wildland Fire Incidents – a Preliminary Codebook

This section discusses an element of methodology that we explored in this initial grant. Given that the landscape of radio communications tends to be oversimplified in official discourse and training, we sought to map the actual territory of radio communication practice as it is experienced and reflected upon by firefighters and fire managers in practice. Specifically, we sought to develop a code book that captures and organizes topics that are salient to practicing firefighters and fire manager in order to point to what can and should be studied about this phenomenon in a future study. In this element of the grant, we were able to determine initial set of answers to the following questions: **What do firefighters and fire managers talk about when they talk about radio communications in wildland fire? What initial observations are we able to make based on these discussions, and what do the data suggest about potentially fruitful areas for future study?**

We used a semistructured interview format that was intended to guide the conversation in a certain direction, including what constitutes effective radio practice and how they learned what they know. As such, in some respects our interviewees talked about topics that we initially chose. Looked at another way, however, one might say that while we narrowed the field of discussion, the interviewees gave us a robust tour of the space of action that they occupy in their roles as they understand it and reflect on it. In other words, within these broad categories that we set, firefighters and fire managers talked about topics and issues that they believe are salient for researchers and other practitioners to know about regarding radio communications in fire. It is important to point out that the interviews involve *reflective* discourse and not recordings of actual interaction. Therefore, the data contained in our interviews already reflect some level of sensemaking by our interviewees. Actual radio communication practice may be different; or, some

practices may be more/less salient or common/uncommon in the field than were discussed in the reflective interviews.

Each interview was transcribed and reviewed against the audio recording to accuracy. We then selected a subset of the transcripts to code inductively and emically (using the categories that made sense to the participants). We refined and arranged like items together into higher levels of abstraction. The result below is an illustrative category scheme for how current and future interviews might be coded. (The actual quotes and content of the discussion are included elsewhere in this report.) Because this was completed from a convenience sample, this map should not be regarded as the complete territory. Nevertheless, we believe it is a good illustration of how research can complicate the oversimplified narrative of radio communications in official discourse and training.

In the process of coding we also reflected on how communication research might inform or be informed by the participants' observations. As a result, the section concludes with what more could be learned if this project were to be expanded and continued in the future.

WHAT WE FOUND

What do people talk about when they talk about radio communications? When we engaged firefighters and fire managers in communication about radio communication, we learned that they want to talk about – and there is much to learn about – the following:

Reasons for using the radio and when not to use. Appropriate uses include:

- Ordering resources
- Relaying information
 - Weather
 - Fire behavior
 - Positions of personnel
 - Strategy
- Scheduling face to face meetings
- Providing updates on work

Inappropriate uses include:

- When evaluating performance
- When relaying extensive or overly complex information
- When privacy or discretion is otherwise needed
 - Indicates awareness of public nature of medium (see more about this topic below)
- Taboo topics: What can't or shouldn't be said on the radio and why

Good practices and bad practices when initiating or holding the floor, or tips and tricks that work, as well as practices that are ineffective for achieving your communication objective on the radio (including why they are effective or ineffective). These include:

- Channel selection

- Awareness of channel range
- Knowing the “sound” of a particular frequency
- Appropriateness/inappropriateness of what information should and should not be broadcast to a certain radius
- Mental preparation
 - There is an expectation that people will think about their performance before they key the mic
- Handling the radio properly
 - Click pause, distance from mic, waiting to speak, etc.
- Vocabulary set (particular code or language)
 - With a vocabulary set: Word choice: what to say, what not to say, and how to say it
- Tempo (overall speed of talk)
- Cadence (different from tempo; cadence refers to rhythm of talk regardless of speed)
- Awareness of audience
 - The need to adapt one’s communication to different contexts and levels.
- Ordering of communication
 - Arranging one’s talk in a pattern, whether visual or temporal
 - Developing a vocabulary and practice that heightens the visual qualities of communication (e.g., “painting a picture” for the person on the other end)
- Precision
 - Using objective (e.g., map markers, standard units) and not relative language (e.g., “200 yards from me” or “moving fast”)
- Tone including command presence and conveying confidence
- Ways of holding the floor and respecting the needs of the listener given the limitations of the medium (e.g. copy, we’ll get back to you; break)
- Engaging interlocutor including seeking explicit feedback

How they listen, and what they listen for, when they are on the receiving end of the transmission (primarily in listening mode). This includes:

- The skill of managing their attention by tuning out but listening with one ear and tuning in when activity increases.
- How they “listen for nonverbals” -- making the most of every cue available in a medium that is not very rich (tone, speed, relevance).
- How they listen for competence and experience of the person; sizing them up.
- How they piece together multiple pieces of information, including triangulation, but initiate check-backs and seek feedback when something does not add up.
- How they listen for a “code switch” (a marked change in talk) that indicates something might be wrong on the other end.
 - Listening for potential and emerging conflict
- How they listen for something that might be called a “code break,” where the person is actually exhibiting signs of distress to where the conversation cannot continue on the radio or other intervention is needed.

- Often mental illness labels are used to describe these moments: crazy, going off the deep end, etc. (more about this below in interactivity and repair)

Within these topics, we found that **Dos and Don'ts vary by role**. What can be a do for a person acting as dispatcher can be a don't for a person acting as a pilot. **Also, Do's and Don'ts are also understood relationally**. That is, Dos and Don'ts are not understood as objective rules that apply universally to anyone who ever talks on the radio. Rather, the speaker is aware of their own role and the role of the person(s) on the other end of the line and will adapt their communication objectives and behaviors accordingly. The roles also influence what they expect from the other person.

As such, firefighters and fire managers also took the conversations into these directions as well.

Observations about interaction on the radio within a relational context

- Establishing and managing work relationships on the fire
 - Interpretation of one's own role (e.g., seeing role as "customer service")
 - Navigating and overcoming role stereotypes
 - Communicating and respecting status and power
 - Ways they genuinely try to put themselves in the others' shoes
 - The need for tact, discretion, for the sake of future relationship
 - Strategic withholding of things that are difficult to communicate (like person on the other end not being a priority)
- Influence and impression management
 - The need to influence others, to be impactful quickly
 - But while moderating the effect they don't want to make (e.g., sounding angry, sounding stupid, sounding like you're not from around here)
 - How physical demands of the job may affect how one sounds (tired, hungry, stressed)
 - Repercussions from going blank, sounding disorganized (few chances to get it wrong)
- The relationship of face to face meeting and interaction, on the one hand, and communicating with those same people on radio, on the other
 - Effect of ordering of those two – know someone beforehand vs. making first contact over radio
 - Seeing the person in role in situ
 - Benefits and complications of working with friends over the radio.

Resilience and repair in radio talk. We asked participants to relay a critical incident. From these stories, we see evidence of how the interactional order changes when things are not going right, and how intervention and revision happens.

- From simple repair:
 - E.g., verbally correcting on the record ("Sorry..")
- To closing the feedback loop (e.g., asking for repeat backs)

- To intervention, or trying a different approach in the conversation
 - Metacommunicating
 - Actively directing the other party who may seem to be slipping into distress
- To abandoning the medium and acting unilaterally using other modes
 - Example: dispatch just sending resources. (maintains order and avoids unraveling)

Training and Skill Development. We also asked firefighters and fire managers how they learned to develop these skills and nuances. When asked how they learned how to talk on the radio, firefighters and fire managers talked about:

- Value of certain training courses and not others (e.g., S-190 less valuable; L381 and Div Sup more valuable)
- Role of on the job training, and where and when that happens
 - Sheer repetition on the job
 - Critical incidents that taught them something that influenced their future practice
 - High profile/ high stakes moments that linger in memory
 - Value of watching /admiring others / including learning what not to do
 - Sheer pleasure of hearing good practices worth emulating
 - Marking and remembering good and bad performances
- Off the job reflection and training
 - Rehearsing while off the job
 - Deliberate self skill development
 - E.g., recording self and going back to listen to recording later
 - Swapping war stories with others
 - Collecting tips and tricks for their repertoire
- Desire to coach (and strategies for coaching) others
- Training needs
 - Need for more training about communication process, generally
 - Need for refreshers (get “rusty”)

Problems and challenges they experience, and how they cope with them

- **Constraints posed by**
 - Reliability of technology
 - Radios (mainly, age)
 - Repeaters
 - Batteries
 - Availability of technology
 - Not enough channels (leading to “fights” for radio time)
 - Technology as a medium for communication (regardless of reliability)
 - Linear nature of comm/turn taking
 - Creates time pressure which can affect performance
 - *Note this equation:* Channel shortage + time pressure = Constraints on performance

- “Communication deficit” or radio as a poor proxy for richer face to face communication
- Ways of overcompensating
 - Adding in time to think
 - Using pauses
 - Writing things down
 - Using human repeater
 - Exploring new technology innovations
- **Standards**
 - Regional differences in talk that might impede understanding

Other topics of discussion (not otherwise categorized)

- Cellphone use
 - Advantages and disadvantages
 - When to use and when not to use
- Concept of a radio as a “lifeline”
- Risk of exercising voice and speaking up
- Humor on the radio, or entertaining self and others with radio talk
- Managing overload when multitasking (multiple fires, multiple things have attention)

WHAT MORE WE COULD STUDY

For a practice that is largely taught in terms of how to code one’s transmission so as to be informative but also unobtrusive, firefighters and fire managers step into a much more complex communication environment when working on a fire that involves remote communications. As we probed further in our conversations, and coded the more advanced elements of the discussions, our initial interviews pointed to the following potentially fruitful areas for future communication research. For the topics below, we could continue to learn more by engaging in further reflective interviews. But we could also study these topics by observing and recording actual interactions on fires.

How firefighters and fire managers manage public- private boundaries in their talk on the radio, including strategic use and non-use of the radio itself. Above we noted that firefighters told us they hold back, keeping some things private (i.e., not communicating certain information at all), or hiding in plain sight when certain publics are listening (e.g., the press), such as by talking in code or relaying just enough important information for those who know what to listen for to be able to pick it up. While it may seem obvious, just because something is not relayed over the radio does not mean the interaction is not happening elsewhere on the fire, whether face to face or on a cell phone or text. Indeed, conversations that are potentially conflictual may specifically be held away from the medium. What may be carried over the radio may be the mundane, quotidian business of running the fire, whereas especially difficult and impactful interactions may be held elsewhere. Learning more about these topics could have important implications for the political context and its implications for safety.

A fuller understanding of what we might call the “ecology” of radio communication on a particular fire. Firefighter and fire managers seem aware of what might be termed an ecology of communication that emerges on a particular fire and within particular frequencies. There is a pecking order of who gets to inhabit which airwaves and an implicit set of rules that emerge regarding the allowable interaction that take place there. Different dos and don’ts apply, then, within a particular communication ecology on a fire, depending on what kind of channel you are talking on, its purpose, and who has access to it. We heard from interviewees of the need to adapt one’s communication to different contexts and levels. Indeed, adaptability itself is regarded as an important skill to cultivate. Learning more about this could have important implications for command and control, operations, as well as leadership development in fire.

How compensating for the non-richness of the medium, actually shows up in their talk. Above we noted that firefighter and fire managers report developing a vocabulary and practice that heightens the visual qualities of communication (e.g., “painting a picture” for the person on the other end). They also using objective and not relative language (map markers, standard units, not “200 yards from me” or “moving fast”). Learning more about this could have important implications for training.

The emotional landscape they are navigating, including how they engage in personal impression management and recover from missteps in what sounds like a relatively unforgiving landscape of judgment for perceived (or actual) poor performance. We could learn more about emotional taboos, self-regulation of emotion, how sanctioning of emotion happens, and the emotional impact of working in such and environment. There may also be evidence of gendered communication practices here. Learning more about this could have important implications for role identity, training, leadership development, and safety.

The relational landscape they are navigating (related to role). Oversimplifications regarding communication tend to overlook issues of status and power that come with people interacting from within different roles, but firefighters and fire managers we talked to report the need to navigate role differences and to establishing and maintaining good relationships on fires in order to perform well in their jobs. With further study, we could learn more about how the asymmetric roles of people influence the interactions, how roles are performed on the radio, as well as the interplay between existing face to face relationships and mediated communication, including the benefits and complications of personal friendships. We could learn more about existing communication strategies to engage in better perspective taking as well as ways of overcoming roles stereotypes. Learning more about these topics, including, could have important implications for general communication practice, but also training, leadership development, and safety.

Despite the emphasis in training on what to say and how to say it, **the highly refined listening and repair skills firefighters and fire managers employ can be a very important element in organizing for high reliability.** Our initial conversations point out that communication is not just for information transmission, but rather that good listening aides in the continual process of sensemaking and collective sensemaking.

Firefighters and fire managers continually compare information and update their understanding with both nonverbal and verbal communication, despite the “communication deficit” they are working with in terms of blinded cues and time pressure. We see potential sensitivity to operations evidence and preoccupation with failure in how they use good listening skills and are ready to adapt. Resilience is evident in how, when something doesn't add up, they attempt repair in order to ensure continued collective sensemaking and so that the organization does not unravel. If that doesn't work, they intervene and “grab the controls” by acting unilaterally. This nuances and potentially reframes our initial question about “the sounds of high reliability organizing in action” in this sense: It may not be possible to simply detect the sounds of high reliability in action (objectively) but rather **The sounds of high reliability in action may be in the ear of the beholder**. That is, in future studies, we may need to identify and work with people who are skilled in knowing what to listen for and how to respond. Learning more about this could have important implications for incident management, leadership development, and safety.

Appendix B: Recommendations for training beginner firefighters in radio communication

In our interviews we've asked participants to evaluate the current training in radio communication. The majority agreed that radio communication does not receive much attention when training new firefighters, despite its recognized importance in the field and despite the fact that radios are assigned to firefighters much earlier in one's career than in the past. Below are our recommendations for redesigning radio communication training for beginner firefighters along three sets of skills: speaking, listening, and trouble shooting. Through a communication-centered radio communication module, students would learn not just practical skills, but also about the fire organization's culture, the role of radio, and their own role in the organization. These recommendations are based on Bloom's taxonomy that recommends a match between the pedagogical goals (e.g., to remember something, to know how to do something, to understand complex information, to create something new, etc.) and pedagogical tools (lecture for remembering, practical activities and role-playing for developing skills, story-telling for understanding complex info).

Overall recommendations:

- Lengthen the time dedicated to radio training to include not just brief lectures, but also practical exercises, role-playing activities, and story-telling.
- Assess students' confidence in their radio skills at the beginning and end of the course.
- Use real radios and dispatch recordings to facilitate hearing the sounds of firefighting in action. Students could visit a dispatch office.

1. Developing Radio Speaking skills:

- Use *experiential* activities, such as practical exercises for identifying oneself, calling, feedback, confirmations;
- Practice communicating a size-up; ordering resources; preparing messages before keying the radio; providing feedback.

- Practice “creating a picture”; giving directions, describing location/position; reporting weather; providing space & time information;
- Practice communicating with different people up and down the chain of command and know what may be important to them (the “how” for a rookie; the “why” for dispatch or supervisor)
- Practice communicating an emergency and maintaining a calm vocal tone.
- Practice mechanics of diction, distance from microphone, vocal tone, and cadence; use diction exercises, breathing exercises, and tongue twisters to improve radio communication performance.
- Practice with conditions that occur on fires – e.g., wearing gloves and dealing with background noise.
- Learn to document one’s communication;
- Role-play a human repeater.
- Reflect on effective language use – which words are best to use, which ones to avoid; students could create their local booklet of slang terms used locally, and learn how certain words can be misused (e.g. “tanker”; “deploy”; “spot”).
- Learn about message framing and adapting to one’s audience from experienced firefighters with high adaptability..
- Learn about effective use of cell phones and how it can complement radio communication.
- Learn about workarounds to technological constraints and their possible repercussions for safety.

2. Developing radio listening skills:

- Visit a dispatch office and listen to the radio communication
- Invite representative from Dispatch, Air Attack, Ground Ops (dozer operators, hotshots) to describe how radio communication is influenced by their work environment. (Or have their testimonies recorded).
- Keep a radio in the room to listen to communication on an active fire. During off-season use a dispatch recording to familiarize students with the sound of fire.
- Learn to interpret the presence and absence of emotion in radio transmissions;
- Learn different regional language differences, slangs and accents.

3. Developing technical skills:

- Demonstrate technical features of the radios with actual radios used by the fire organization.
- Learn how to troubleshoot – batteries, cloning radios, programming frequencies; learn about the different frequencies - squirrel channels, command channel, air-to-ground, etc.
- Learn the location of repeaters on the map and how reliable they are. Problem solve if repeaters don’t work.

Appendix C: Dramaturgy Framing

Given the tendency of the fire community to focus on radio communications in terms of technology, and the tendency to oversimplify the remote communication function; and given the unique features and constraints of the radio medium (broadcast one to many, constraints posed by limited channels and time pressure), as well as scrutiny on the moment of performance (by self and other), we decided to explore the productivity of the performance metaphor for communication to see if it could help expand thinking and discourse about radio communications.

Our goal was to assess usefulness of a “theater” metaphor for understanding the human side of radio communications on wildland fire incidents:

When someone keys the mic on a wildland fire incident, to what extent is this like stepping into the spotlight on a stage and performing to an audience who will interpret not only what is being said but how it is being performed? And, if talking on the radio on an incident is a series of performances, how does that affect how people who are distributed across space collectively make sense of and address the risks on a wildland fire?

We reasoned this would honor the tendency of the fire community to focus on radio talk largely in terms of the actions of the speaker (e.g., admonitions in training to “be brief” and “be clear”) while also pointing to other contextual factors that can be adapted from the theater context to be included in a comprehensive model that can inform training and practice, such as audience, repertoire, style, etc.

We reviewed different theoretical approaches to dramatic perspectives, including sociological, rhetorical, and performance studies perspectives. Although we believe the first two will be useful in analyses of interaction and text, respectively, we found the vocabulary and perspectives within the field of performance studies to be somewhat generative, although to a limited extent.

The sociological approach

- Focuses on:
 - The actual mechanics of interaction
- Helps us to see:
 - Challenges of coordination
 - Importance of transition points
 - Passing from backstage to front stage
 - Recovering from face threats, misfootings
- **Usefulness:**
 - Places where interaction “almost” breaks down reveals the script and the pressure points

The rhetorical approach

- Focuses on
 - Meaning (and contest over meaning)
 - Terms people privilege in their talk
- Helps us to see:
 - How human action

- is accomplished through talk
- is inherently dramatic in that it invites a particular view of reality (but not melodrama)
- **Usefulness:**
 - (Possibly) how language use shapes shared risk assessment on an incident

The performance studies perspective

- Focuses on:
 - Performance Studies, or... the study of performance
- Helps us to see:
 - Definitions
 - Processes
 - Levels
 - People

Realm	Activity
Existence	Being
Action	Doing
Performing	Showing “Doing”
Performance Studies	Explaining “Showing-Doing”

Images adapted from Schechner, R. (2013). *Performance Studies: An Introduction (3rd Ed.)*. New York: Routledge.

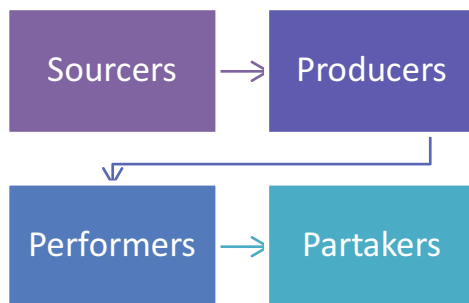
Levels of performance remind us that radio is used instrumentally to achieve further aims and is not an end in itself. Indeed, the medium is regarded by firefighters and fire managers as a necessary but poor proxy for full interaction on a fire. It is simultaneously a lifeline but also a medium that may be abandoned on occasion if its limitations outweigh its usefulness. Nevertheless, it is important to be good at performing on the radio and displaying this proficiency to others. As such, we see radio as grounded between doing and showing-doing but we do not go so far as to recommend a performance studies of radio communication (i.e., not explaining showing -doing). Process, or Phases of performance can inform a comprehensive training model, including by pointing out developing a repertoire, the importance of rehearsal, etc.

- **Process**
 - Performances have specific time-space sequences
 - Helps us to see: Necessary phases of performance
 - **Usefulness:** For understanding development and mastery



Images adapted from Schechner, R. (2013). *Performance Studies: An Introduction* (3rd Ed.). New York: Routledge.

- **People**
 - Performance Quadrilogue
 - **Usefulness:** Understanding of audience(s), expertise, authority, repertoire



Images adapted from Schechner, R. (2013). *Performance Studies: An Introduction* (3rd Ed.). New York: Routledge.

There are few ways that radio talk can be usefully viewed as performance. First, it is usefully viewed from the point of view of the individual actor. We saw evidence in our interviews that firefighters and fire managers attend to radio talk as performance on a personal level. Specifically, they recall and report specific high stakes moments, such as their initial transmission on a command frequency when a novice (a “hot flush” moment that sticks in memory). A major error they committed that others teased them about later reveals a scrutiny on particular performances where getting it wrong can be costly. As they learn, they mark and remember good and bad performances as a way of adding dos and don'ts to their own repertoires. As radio talk become part of their regular work practice, they take pleasure in hearing good practices worth emulating. Indeed, proficiency in radio talk can be a marker of status and a source of judgment from others about one's proficiency in their role.

Second, radio talk can be usefully viewed as performance of the fire itself. This perspective relates to our hunch that the radio may be the place where one may hear the sounds of high reliability in action. In a very real sense, to incident management teams, the radio can be the medium of action and interaction on the fire. It is the most comprehensive aural display of actions and interactions on the fire. We saw evidence of this in the simulation: Near the end of the simulation, the simulation was still going on, but everyone who could possibly be on the other end of the radio was now in the same room. Nevertheless, when asked to move to another activity, the IC examinee paused and asked, "should I turn the radio off?" It could be that he was still trying to honor his role in the simulation (i.e., if he is the IC and the IC is supposed to attend to the radio, then he should maintain that frame). At another level, we took this question to mean, "is the fire over?" That is, if the radio is off, the "active fire" part of the simulation is done. This illustrates how the radio is the medium of action and interaction for crews that are distributed in space but connected in time and task. They learn to monitor the chatter and background noise of the radio and move it to the front of their attention when there is a change in the rhythm and pace of the conversation. When actively listening, they try to overcompensate for missing cues by extracting every modicum of meaning they can, such as listening for and interpreting nonverbals. To the extent that it is where one may hear the sounds of high reliability, it is in tone, cadence, and other non-verbals to which experienced radio users are tuned even more so than to the actual words used. Based on initial interviews that were in progress, we developed a model that describes, from the speaker's point of view, the notion of radio broadcast as performance. We presented the following at a conference and received feedback:

- When you key the mic, you must already be skilled to speak, and under time pressure you must convey content, specifically paint a picture for those on the other end who cannot see. You must manage the impression you make on others as a professional, and you must achieve an intended emotional effect on those who are listening.
- What you say and how you say it is heard and evaluated by others, and it reflects on yourself, your crew, your forest/unit.
- Furthermore, the rhythm and sound of the radio is part of the foreground, background, and tempo of the fire, and it is a useful skill to manage your attention by tuning in and out to focus on what is important.
- Surveillance is ever present not just from peers, but from a variety of audiences, which places this standard for realist interpretation in an interesting tension with masking and concealment.
- Despite the emphasis on the moment of performance there is relatively little formal training at the proto-performance end of the spectrum, and there seems to be relatively little "rehearsal" in the actual performance phase of the spectrum.
- In the aftermath phase, members of the fire community remember and mark performances, reflect on them, and use them as a kind of informal training, adding and discarding scripts and methods from repertoires for future use.

The feedback that we received pointed to other contextual issues for us to study: Familiarity with others at remote distance, cultures of different frequencies, differences expectations for roles and among different subcultures, level of experience in moderating emotional effect. (All of these were borne out by our interviews.) In summary, exploring this perspective was useful for generating a broader landscape of issues we should explore to study practice and to inform training. But we stop short of recommending a performance studies of radio communication per se due to the instrumental use of radio in remote communications

Appendix D: Summary of Key Findings

<p>Understanding Communication</p>	<p>The word “communication” has been stretched to mean everything from <i>communications</i> (referring to modes of communication such as radio, telephone, maps-on-the-hood-of-the-truck, etc.) to <i>communication</i>, (referring to the process of interaction as well as the verbal and non-verbal messages themselves).</p> <p>Current usage conflates technical, physical communications with the social process. It is used indiscriminately to refer to many different and divergent contexts, practices and behaviors. This creates ambiguity which facilitates mis-understanding and impairs understanding, analysis, and improvement. Developing a richer understanding of the entire arena and enriching language can assist.</p>
<p>Communication Models</p>	<p>There is a critical need to understand the limitations of the current model used in training and practice and to intentionally build and use complementary systems when/where needed.</p> <p>The current operative model for communication in discourse and training is the 1949 Sender-Receiver model which vastly oversimplifies human interaction. It’s conceptualization of communication as one dimensional has been criticized for not taking into consideration concepts such as culture and power, or the socially constructed nature of communication.</p> <p>Updating the theoretical and practical model with richer, more complex and comprehensive model is likely to dramatically assist by enabling more specific and nuanced attention to the many facets of this important aspect of risk perception, sense-making and resilience.</p>
<p>Communication Training</p>	<p>Simplification: Radio communication training is considered to be adequately executed in formal training that is short (less than 60 minutes), lecture-based, technologically focused, with little to no</p>

	<p>practical exercises.</p> <p>Complexity: Communication is complex, involving much more than the mere operation of the radio. While classroom training plays an important role, current classroom training and materials are simplistic and do not reflect the complexity of the communication environment, or the challenges of publicly speaking and listening well.</p> <p>Simplification: Formal discourse and training convey that communication is easy and that good communicators do not need to prepare or engage in continuous practice.</p> <p>Complexity: Today firefighters carry radios and start using them much earlier in their careers than in the past, but classroom training has not kept pace with this organizational reality. Experienced individuals refer to radio communication as a perishable skill and report making time to practice speaking on the radio on their own.</p>
<p>The Nature of Communication</p>	<p>Simplification: Good communication is the same for all situations – it sounds the same and people listen and speak similarly. There is “one essential way” to communicate as a firefighter, and experience translates into competency.</p> <p>Complexity: There are significant variations in what good communication sounds like depending upon Incident Command System (ICS) position; each faces different constraints and requires a different communications skillset.</p> <p>Complexity: Many don’t know the communication constraints of other positions because they are unfamiliar with the tasks other ICS positions need to conduct, and how to work within the constraints inherent to each ICS position.</p> <p>Complexity: Effective communicators adopt different radio communication behaviors depending on their circumstances, challenges, and needs.</p> <p>Simplification: Speakers will gain knowledge, through observation and intuition, of the needs of listeners and organize their messages accordingly.</p> <p>Complexity: Spending time in another’s work environment builds critical understanding and empathy.</p>

	<p>Complexity: It is difficult to understand a message when you are not prepared to listen.</p> <p>Complexity: People need to be taught how to organize messages to ensure understanding.</p> <p>Complexity: Listeners need to be prepared for potential emotional effects of messages.</p> <hr/> <p>Perception: Radio interactions concern the topics being discussed, such as resupplying the fire with food or ordering another retardant drop.</p> <p>Complexity: The ecology of meanings framework recognizes that verbal interactions also carry significant information about roles, identity, status and relationship. Interactions are about the process of delivering the topic via language (My particular method of talking), identity (Who am I in the interaction?) and relational goals (What do we represent to each other in this interaction? What do the others who hear me think of me and what I am saying?).</p>
<p>Message Wording and Framing</p>	<p>Simplification: Good communication is brief and free of repetition.</p> <p>Complexity: Brief communication is often based on familiarity with each other and needs of various positions.</p> <hr/> <p>Perception: Highly descriptive language is unnecessary.</p> <p>Complexity: Experienced communicators report using a wide range of persuasive language such as powerful adjectives, metaphors, repetition, hyperbole and understatement, and vivid imagery to “paint a picture” of the fire.</p> <hr/> <p>Perception: Now that the 10-code communication structure (10-4 meant acknowledgement, okay; 10-33 signaled an emergency) has been replaced by a “clear text” concept (“copy” for okay and “good copy” for a strong okay), it means everyone is using the same language in the same way to talk to one another on the radio.</p> <p>Complexity: Not everyone uses the same words to describe similar topics. Different organizations, sub-cultures and people from various parts of the country will use colloquialisms and vocabulary.</p> <hr/> <p>Simplification: “Good” radio communication is absent of emotions or there is no place for emotions on the radio</p>

	<p>Complexity: Experienced radio users, particularly when they know each other, glean important information from emotional cues. Significant information is transmitted non-verbally.</p> <p>Complexity: Inability to communicate an appropriate sense of urgency (in which emotion plays a key role) can lead to failures (such as Dutch Creek and Cramer incidents).</p> <p>Complexity: Training and culture currently are silent on the issue of emotion, and learning to speak with emotional nuance occurs on a public stage, thus in the face of possible ridicule and censorship.</p> <p>Complexity: Certain types of emotional expression <i>are</i> acceptable, even cultivated.</p>
<p>Communication Technology</p>	<p>Perception: Radio communicators and trainers often assume that all radio equipment, not only the radios themselves but all the supporting electronics needed to make a forest or park-wide radio system functional, are reliable and will work when needed.</p> <p>Complexity: Radio coverage over any existing geography may never be complete. There will always be “holes” in the radio or cell phone coverage, often induced by the mountainous terrain itself, where communicators cannot send or receive messages. The repeaters infrastructure is not up-to-date everywhere in the country.</p>
	<p>Simplification: The proper use of channels, frequencies, and repeaters are understood similarly by all involved.</p> <p>Complexity: Many higher level fire managers do not realize how fraught with anxiety something seemingly as simple as changing a radio’s channel, frequency or going through a lookout tower’s repeater can be for many firefighters, and not only rookies.</p>
	<p>Simplification: There are plenty of frequencies and channels for all radio traffic.</p> <p>Complexity: Radio frequencies and channels are finite and just because you have a radio in your hand does not mean there will be an open channel to use.</p>
	<p>Perception: On wildfires the radio is not only the standard but the best form of communication.</p>
	<p>Complexity: The radio appears to be successful as a means to convey transactional information. Other modes – face-to-face, cell phones, computers, walkie talkies—can create the contexts for richer</p>

	<p>conversations for sensemaking to occur.</p> <p>Complexity: Cellphones are used when radio is available – for having collective sensemaking conversations, to use the phone’s mapping abilities (Google Maps) and for obtaining fire weather forecasts. Some incident management teams require that cell phones be used for these purposes.</p> <p>Complexity: When it comes to supposedly non-traditional communication devices—cell phone, handheld computers connected to the internet, walkie-talkies—official policy and procedures do not adequately reflect the unofficial, realistic, on-the-ground use of such electronic gadgetry, often leaving the users of such technology feeling guilty. Of course, this “unofficial use” of common everyday electronics produces an inconsistent, maybe inefficient, and sometimes unsafe system of operation.</p>
<p>The Sounds of Sense-making</p>	<p>Simplification (ours): HRO-mindfulness could be identified by the word choices firefighters made, and these can be easily coded to reveal sense-making, risk perception and resilience.</p> <p>Complexity: Collective mindfulness seems to be a constellation of attributes that manifest from moment to moment in response to an evolving context. These attributes allow for rich open-ended conversations about what is happening on a wildfire. Collective mindfulness depends on whether this picture is up-to-date or over-simplified, and whether the IC could take contradictory feedback about it. HRO-mindfulness, when it is properly being performed, is not as simple as going down the checklist of the five principles.</p> <p>Complexity: High reliability is likely evidenced by ‘flow’ as well as ‘interruption’. Therefore, all aspects of a conversation (all sides of a conversation, content, individual cadence, tone, conversational pace and context) are needed to see HRO-mindfulness in action.</p> <p>Complexity: Operationalizing HRO-mindfulness requires articulation of and attendance to various forms of non-verbal communication —silence, tone of voice, perceived command presence; to tempo - individual cadence and collective flow; as well as to the actual words exchanged.</p> <p>Complexity: Further study is dependent upon developing operational definitions of these facets and obtaining complete radio sequences.</p>
<p>Methodological Lessons Learned</p>	<p>Recording radio traffic on wildland fires is not, contrary to popular belief, commonly done in fire dispatch offices across the country. In</p>

	<p>fact, recording of radio conversations is a hit and miss proposition. Even in dispatch offices that do record radio transmissions (for instance, because it has law enforcement responsibilities, the National Park Service is required to record radio conversations and archive it), it is difficult if not impossible to retrieve radio recordings because of legal possible liabilities. In many cases researches would have to submit a FOIA request to obtain radio recordings.</p>
	<p>Not available in retrospective interviews are all the things that make fighting a wildfire complex and dangerous—how hot and fast the fire is burning, what the fire weather is forecasted to be and how this incoming weather will affect tactics and what the living conditions (food, shower facilities, sleeping areas) are like for the firefighters. These factors affect the physical and emotional status of firefighters and have a corresponding effect on how they communicate with each other.</p>
	<p>As a next logical step to further explore collective sense-making, we suggest recording communication during a prescribed fire. A prescribed burn is a self-contained operation. It would be relatively easy logistically for a research team to get to a burn. A prescribed fire would provide not only the opportunity to record live radio conversations, but the ability to conduct follow-up interviews.</p>

Appendix E: Record of Manuscript Submission

International Journal of Wildland Fire

Submission Confirmation Thank you

for your submission

Submitted to Manuscript ID Title

Authors

Date Submitted

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Cultivating a reluctance to simplify: Exploring the HRO communication context in wildland firefighting

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