Justice in/and the Design of AI Risk Detection Technologies

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Abstract

This article examines the role of communication design within platforms that combine the affordances of remote sensing and artificial intelligence (AI) technologies, focusing specifically on decision support systems used for managing climate risks and disasters such as wildfire. Building upon Carroll et al.'s [65] principles for Indigenous data governance, the authors advance an original heuristic for considering the design justice [17] of smart and connected community technologies in risk management. The authors perform a heuristic evaluation [58] of one AI wildfire detection platform (AIWDP), illustrating how platforms designs might promote openness, trust, and justice.

CCS Concepts

• **Human-centered computing**; • **Heuristic evaluations**; • **Information systems**; • **Decision support systems**;

Keywords

Artificial intelligence, Design justice, Climate crisis, Risk communication, Smart cities

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1 Introduction

Wildfire is significant hazard, posing a myriad of economic, environmental, and ecological risks to the Earth. According to the US Senate's Joint Economic Committee, each year wildfire causes $394 billion to $893 billion of economic loss within the US [40]. In addition to economic impacts, a recent United Nations report argued for more international cooperation towards managing wildfire disaster due to its adverse effects upon "human health and livelihoods, biodiversity, and the global climate" [70]. For instance, in a statistical analysis of mortality across 43 countries, Chen et al. found that mortality risk increased in relation to exposure to wildfire smoke (PM2.5) and that wildfire smoke is responsible for over 33,000 deaths annually [12]. Moreover, in a longitudinal analysis of forests in Latin America, Armenteras et al. warned that the occurrence of fire frequently resulted in forest degradation and/or long-term deforestation, reducing the habitat for wildlife and biodiversity affected landscapes [4].

Among the states located within the American West and Southwest directly experiencing these risks first hand, Colorado and Texas (where our academic institutions are located) have recently experienced the impacts of the devastating wildfires. Earlier this year, the Smokehouse Creek Fire became the largest fire in the history of Texas, consuming over 1-million acres, burning down over one-hundred homes, and killing over 7,000 cattle and two people. Similarly, in successive years, Colorado encountered both its largest fire in history, the Cameron Peak Fire in 2020, which burned over 200-thousand acres, damaged over two-hundred and fifty homes, as well as its most destructive fire, the Marshall Fire in 2021, which caused over $2-billion dollars in damage, destroyed over one-thousand homes, and killed two people. As Radeloff et al. observed, the number of U.S. communities located in the wildland-urban interface (WUI) continues to grow and these communities face an increased wildfire risk [63]. Further, a growing body of research suggests that wildfire frequency and severity will continue to increase as the climate changes [18, 75]. As a result, federal, state, and municipal government, as well as industry, nonprofits, and local communities are investing in technologies that promote climate resilience, including decision support systems necessary for managing the more frequent, higher-intensity, and extended duration of wildfire risk.

For example, the National Science Foundation (NSF) (2023) awarded $16-million to the Colorado-Wyoming Climate Resilience Engine to promote "innovative solutions that support communities to monitor, mitigate and adapt to climate impacts" [55]. Similarly, Xcel Energy, the Colorado Division of Fire Protection, and the US Forest Service (USFS) have deployed Artificial Intelligence Wildfire Detection Platforms (AIWDPs) in Colorado to advance early detection of the presence and location of wildfires, improving community-level awareness of wildfire events and/or providing emergency managers with tools for facilitating community evacuation, engaging in wildfire suppression, and/or evaluating and communicating risk during disasters.

Our aim within this research paper, then, is to consider how the use of AIWDPs in the Western and/or Southwestern US might broadly inform the design of remote sensing technologies and AI platforms utilized for promoting climate resilience. Specifically, we argue that (1) there are notable distinctions in the design paradigms that encircle the AIWDPs being utilized across this region, (2) these distinctions have important implications for the equity of risk, crisis, and disaster communication (RCDC) associated with AIWDPs, and (3) the divergence in approaches to the design of AIWDPs can

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be helpful in improving the equity in design of climate resilience technologies. Thus, we begin by situating our arguments within existing work on RCDC in technical and professional communication/communication design (TPC/CD), especially as it relates to newly emerging technologies such as augmentation technology, artificial intelligence, and/or remote sensing used for the purpose of promoting climate resilience within Smart Cities [27, 72] or what the Department of Homeland Security (DHS) referred to as Connected Communities [19]. Next, we introduce two design frameworks–FAIR and CARE–to evaluate one platform currently used in the region [65, 76]. Adapting these frameworks, we forward an original heuristic and perform a heuristic evaluation of the platforms' openness, trust, and justice using this frame. Thereafter, we discuss the broader implications of the design matrix and how it might be leveraged and/or utilized by communication design specialists seeking to consider the equity and design justice of climate resilience platforms that use augmentation, AI, and/or remote sensing technologies.

2 Background

2.1 Risk, Crisis, and Disaster in TPC/CD

Over the past three decades, scholars in technical and professional communication and communication design (TPC/CD) have produced an extensive body of work dealing with disaster [9, 13, 20, 32, 38, 62], risk [34, 66, 67], and crisis communication [3, 7, 24, 69]. Recent studies often consider the role of emerging technologies within crisis, risk, and disaster communication. For example, researchers have examined the role of social and participatory media in communicating risk and responding to the impacts of crises and disasters [5–7, 21, 23, 31, 61, 62, 80]. Studies have also considered risk, crisis, and disaster communication in relation to wearables [2, 10, 41, 42], the internet of things [27], energy technologies [13, 28, 29, 47, 48], and artificial intelligence and machine learning [8, 9, 26, 27]. Certainly, Ding's argument that "we face new challenges today due to the rapid new developments in various areas" [22] resonates for work in risk, crisis, and disaster, especially as it relates to climate change. As concerns regarding climate collapse increase, the role of technology in mitigating its impacts is more critical than ever. TPC/CD scholars specializing in risk communication must shift their attention toward the design of effective, ethical, and just smart and connected community (S&CC) technologies, which could provide invaluable decision support tools for mitigating climate risk and disasters. These communities, which are equipped with networked communication infrastructures, can become better prepared to recover from climate-related disaster should TPC/CD scholars contribute to their development.

2.2 S&CC Technologies

2.2.1 How have smart technologies been used to gather real-time data for assessing environmental risk? The concept of smart cities first emerged in the 1990s as a novel corrective to urban planning through the use of information and communication technology (ICT). The aim was to improve quality of life by providing better access to essential services like health care and transportation, enhancing sustainability through promoting eco-friendly practices, optimizing urban infrastructure, fostering economic growth, and building disaster resilience and safety. To achieve these aims, community planners will need to overcome wicked problems such as infrastructure maintenance, congested transportation networks, digital inclusion, affordable housing, and climate change adaptation that often accompany structural inequities and differences between urban and rural spaces [1, 11, 57, 79]. Consequently, the concept of smart cities has evolved into the more expansive and inclusive concept of smart and connected communities (S&CC) to account for the reality that although people live in urban spaces, a majority of the world resides in suburban, exurban, and rural communities [71]. A S&CC is a larger community in which intelligent technologies, natural and built environments are seamlessly integrated. Aside from their relative population, urban and rural communities have different, but interconnected, histories and terrains. These interdependencies and disconnections matter as they create opportunities that will benefit more people than what was conceived under a smart cities framework.

2.2.2 How does the concept of interconnectedness in S&CC influence the identification of risk and management of disasters? Communication designers, community planners, and risk managers involved in S&CC project development must engage with the disparate impacts of climate change that span urban and rural communities, as disaster mitigation means differently across these environments. The diverging territorial realities surrounding these risks exacerbates the need for communication design to enhance connectivities between locations. Considering this connectedness is crucial for effective management of disaster risks for several reasons. First, urban and rural areas are often joined through shared resources such as water, energy, transportation, and food systems. Urban cities such as Denver may not directly face the same wildfire threat as rural communities in the Rocky Mountains such as Evergreen, Larkspur, or Craig, Colorado; yet wildfire can threaten urban cities' access to water stored in mountain reservoirs. Disruption in these systems in either a rural or urban location can create cascading impacts across regions: understanding and strengthening these supply chains ensures the continuity of critical services in the aftermath of a disaster. Second, urban and rural areas are also connected by population movements. Most of these movements can be classified as people transiting between cities and rural areas for work, education, and recreation. However, disasters between these areas can intensify-short and long-term migration in either direction. Thus, managing population movements becomes a necessity among emergency managers, city planners, and county leaders responsible for ensuring that support services and transportation remain adequate for citizens and evacuees. Third, urban and rural locations have different capacities that indicate varying levels of strength and vulnerability in disaster resilience. Making sense of resources across regions encourages collaboration in disaster preparedness and response efforts. Finally, and perhaps most importantly, urban and rural environments are connected through environmental interactions that when disrupted can have secondary impacts. For example, nonporous surfaces within a city that disallow water entering the ground can alter the hydrology of a region leading to increased flooding, non-point source pollution, erosion, or an urban heat island effect.

Wildfire disasters are particularly useful examples for considering how risks can span rural and urban environments, as the US Forest Service began using the concept of the Wildland-Urban Interface (WUI) in 1987 to manage risks "[w]here large urban areas are adjacent to State, Federal, and private forest lands, the intermixing of city and Wildland has. . . brought about major problems in fire protection, land use planning, and recreation impacts" [68]. Indeed, when urban environments are constructed near or within wilderness, it alters the risk profile within those environments, as human activities introduce fire ignitions sources that do not exist within nature. Recognizing the complexity of managing wildfire risk across lands that have characteristics of both urban-and wilderness-environments, fire scientist Jack Cohen advanced the WUI fire disaster sequence, which posits that when severe weather conditions (such as increased drought associated with climate change) exist, a wildfire ignition can lead to extreme fire behavior, which can advance to a high number of ignitions of residential structures, in turn, overwhelming the capacities of fire protection resources responding to mitigate the emergency and culminating in a WUI disaster [14]. The Marshall, CO (2021) and Lahnina (2023), HI Fires, which both spread rapidly from lands adjacent to highly populated urban areas are well known examples of recent WUI disasters. Both of these events underscore the increased risk of WUI disasters, as the expanding footprint of urbanity coupled with more frequent severe weather due to climate change means that variables necessary for a WUI disaster to occur are more common today.

2.2.3 Have S&CC technologies effectively integrated risk assessment into planning and decision support tools? The concept of S&CC technologies can be valuable for identifying risk and mitigating disasters within and between rural and urban environments because they emphasize the importance of communication and coordination across these environments. These efforts include, but are not limited to integrated risk assessment, real-time data sharing, early warning systems, coordinated response systems, resilience building, and predictive analytics. For example, Kumar et al. [46] proposed an integrated risk assessment system to predict flood disaster events and offer real-time data-driven recommendations to emergency management personnel. Their system leverages regional demographic data as well as physical and social sensors to understand the extent of damage on people and property. Dong et al. [25] attended to the increased demand in energy consumption due to climate change-related weather events (e.g., extreme heat days) and potential blackouts and brownouts in power grid infrastructure. Since buildings consume a considerable amount of electricity produced by power grids, considering how buildings and their occupancy work with energy grids has become necessary in optimizing energy consumption. This approach to risk allows grid operators to balance the load on grids and building managers to adjust their own energy usage, especially during peak demand periods. Loftis et al. [50] focused on the StormSense initiative in Hampton Road, VA, which aims to forecast flood risks as the result of storm surges, heavy rain, or tides. This S&CC approach implements water sensors powered by the Internet of Things (IoT) to create a regional resilience monitoring network.

2.2.4 What influences whether various communities may be inclined to adopt and/or resist S&CC technologies? Given the potential usefulness of S&CC technologies as decision support systems for risk and disaster management, one might anticipate widespread support for adopting such tools. Yet, researchers have cautioned that "the concepts of smart rural communities and smart village are still rather underdeveloped" [39], and "First Nations remain an under-studied and under-appreciated stakeholder in regional and rural development… " [64]. Consequently, researchers studying smart rural communities have emphasized the critical importance of participatory-and community-centered approaches to implementing S&CC technologies in rural areas [16, 39, 44, 56, 64, 78].

In a study of rural perspectives in Australia that included First Nations and Local Aboriginal Land Councils, Randell-Moon and Hynes [64] observed that rural perceptions of S&CC technology is influenced by lived experiences with inequitable access to key infrastructures such unreliable access to internet. Moreover, these researchers also noted that S&CC technology policy often reflects the values, experiences, and aspirations of urban elite, suggesting that much stands to be gained in terms of sustainable S&CC development from deeper engagement with members of rural and Indigenous communities. Indeed, the researchers found that rural community members recognized that infrastructural investment can influence the success of local businesses and economies, the livability of rural communities, and in some cases, "population drift." This sentiment aligns with Jakobsen et al., who argued that "a community-centered and context sensitive approach" could promote a "deeper understanding of the factors that contribute to the success and failure of smart technology implementations in rural communities" [39].

Within the context of Colorado, then, it's important to recognize that rural and Indigenous communities' perspectives toward the implementation of S&CC technology will be influenced by localized experiences, values, and aspirations. Mountain communities located in Pitkin and Summit county, where urban elites vacation, have been early to adopt AIWDPs. However, these communities may not reflect the dispositions neighboring rural mountain communities hold toward S&CC technology. CSU, for example, is located in the urban center of Ft. Collins, which resides in Larimer County. However, there are also numerous rural farm-and mountain-communities located in Larimer, which may prioritize privacy and/or hold adverse perceptions of technology and surveillance [15, 36, 77]. Similarly, long-standing tensions associated with exercising sovereignty upon traditional and ancestral homelands, including decades of conflict surrounding water rights, have limited Native American and Indigenous communities' ability to develop water access in the western US [59]. Still, it is important to emphasize that rural and Indigenous communities are not monolithic, as many examples of innovative leadership with S&CC technologies exist [45, 51, 53].

2.3 AI Emergency Detection Platforms

2.3.1 S&CC Approaches to Wildfire Management. An S&CC approach is now being used for managing wildfire risk across the Western and Southwestern US. One particular technology currently being implemented for this purpose are Artificial Intelligence Wildfire Detection Platforms (AIWDPs) [52]. While there are notable

distinctions between AIWDPs, generally AIWDPs share the following characteristics. AIWDPs use high-definition, pan-zoom-tilt (PZT) cameras mounted on radio towers to provide a viewshed of a wild/rural, urban, or WUI environment. The cameras are connected to the internet via a local network and/or satellite connection and the streams are fed to a server that runs proprietary artificial intelligence (AI) software. AI uses variances in the images to detect fire/light/smoke, and, then, based on the geolocation of the detection, can send automated alerts to users signed up to receive them about the possibility of a fire in a defined geographic area. Users with access to the platforms can access and in some cases control the PZT features of a camera to garner more detail within a viewshed.

AIWDPs offer significant value to affected parties who, whether formally and/or informally, assess, communicate, and/or manage wildfire risk. For example, forest managers can use video to monitor the relative health of various areas of a forest (e.g., identifying the proportion of Beetle Killed Pine in a forest stand); first responders might receive alert notifications from AIWDPs in their response jurisdiction, alerting them to potential fire ignitions and/or access live video streams in order to gain situational awareness about a fire that has started in a hard-to-access area; government officials might use a live-stream to determine whether to evacuate a residential neighborhood that could be potentially affected by a nearby fire; citizens, commuters, or tourists might access a livestream feed to determine if they feel safe traveling on a transportation corridor that passes through a forest affected by a current wildfire; and, utility providers might use the location of an alert to temporarily suspend the transmission of electricity across lines that pass through lands that could be affected by wildfire.

We posit that it is vital that communication design specialists with expertise in the ethics and justice of risk communication and user-interface design to participate with the design and implementation of S&CC technologies such as AIWDPs, as the application to AI and other types of IoT technologies are emerging and rapidly proliferating, including for applications associated with risk, emergency, and disaster management. These technologies do not exist outside sociopolitical contexts. Social justice concerns emerge when AIWDPs are not equitably distributed among communities. Vulnerable and marginalized communities, such as those in low-income and under-resourced rural areas, may have limited access to advanced detection technologies or could be ignored in planning processes when deciding where to position these technologies. Designing inclusive systems that consider the needs and challenges of a variety of communities can help address disparities. We see a role for technical communication scholars in this communication design effort. As Natasha Jones [43] has argued, TPC/CD researchers cannot sit idly in light of sociopolitical exigencies that call for justice. Global climate change is a wicked problem and there are varied roles that TPC/CD researchers can do to support climate resilience which includes but is not limited to advocating for communities and fair policies [34], complicating understandings of risk [13, 60], and participating in the creation of technologies [37, 41]).

Moreover, as noted above, the NSF recently awarded $16M (with the potential of up to $160M over ten years) to the Colorado-Wyoming Climate Resilience Engine for the purpose of commercializing climate resilience technologies and promoting workforce development for new careers in this sector of the economy. This example illustrates that the US government anticipates that this sector of the economy has the potential to grow–as humans become more accustomed to leveraging data-driven decision making in their private, civic, and economic lives, especially as those lives are affected by changes to climate. Thus, it's sensible to anticipate that a broader array of S&CC technologies will be mobilized for the express purpose of assessing, communicating, and managing climate risk, emergencies, and disasters. In sum, it's vital for numerous scholars in TPC/CD to contribute to and participate in the design and critique of these platforms, as risk communication scholars [34, 66] have repeatedly demonstrated that social and communicative interactions surrounding risk often reflect inequitable differentials in expertise and power. It's also easier to adapt and redesign systems while they are in a developmental phase than when they have become established, as users and designers become familiar with and expect consistency in terms of the economies, interactions, and flows of information instantiated with incumbent designs.

3 Evaluating S&CC Technologies

3.1 Social Justice, AI, and TPC/CD

As Haas and Eble [35] argued, scholarship in TPC/CD increasingly demonstrates "a turn toward a collective disciplinary redressing of social injustice sponsored by rhetorics and practices that infringe upon, neglect, withhold, and/or abolish human, non-human animal, and environmental rights" (p. 5). Certainly, the editors asserted that "technologies and sciences are unequally prescribed, controlled, and delegated" and that "[t]hey have been used to empower and oppress" (p. 5). Moreover, as Walton, Moore, and Jones [74] reminded us, despite the foundational steps TPC/CD has taken toward centering social justice, "[o]ur sites of work, often mundane and driven by minutiae, remain sites of injustice," calling for "coalitional action, collective thinking, and a commitment to understanding difference that is not necessarily demanded by other technical communication problems" (p. 1). This is precisely the case, we posit, regarding the development of S&CC technologies such as AIWDP, especially because these tools will be applied for managing, mitigating, surviving and/or recovering from climate change and climate disaster. Indeed, Duin and Pedersen [27] observed that, despite the attention on justice and ethics within the field, it is critical for more work focused specifically on augmentation technology and AI [AT/AI]:

> [W]hile [TPC] has begun to come to terms with socioethical problems and inequities, augmentation technology and AI design, adoption, and adaptation have not followed suit, nor have they properly dealt with grand challenges including algorithmic bias, lack of diversity in development teams, and misuse of augmentation technologies and AI in the field." (2023, p. 22).

To address gaps in the ethical orientation of AI/AT designs, Duin and Pedersen [27] articulated the "Ethical Futures Framework," which consists of three conceptual domains: (1) understand the rhetoric of augmentation technologies, (2) build literacies, and (3) design ethical futures. Whereas the first domain deals with how

factors such as agency, commercialization, and economies influence the design and practice of AT/AI, the second domain deals with cultivating the array of digital literacies necessary for identifying and responding to the types of harm that can be caused by AT/AI, and the third domain outlines how designers might work to improve the ethical quality of AT/AI. While distinct from Duin & Pedersens's "Ethical Futures Framework," we have found two frameworks, respectively advanced by scholars affiliated with the open and responsible science community and the Indigenous Data Sovereignty Interest Group, helpful for advancing our own thoughts regarding how we might evaluate the ethical quality and justice of AIWDPs. Allow us to briefly discuss the genesis of these frameworks and how they have informed the design of a heuristic matrix we offer for communication designers interested in evaluating the justice of S&CC technologies.

3.2 Data Governance Principles

The open and responsible science movement has increasingly sought to advance the usefulness of scientific research and data for users across industry, government, civic, and scientific sectors. One byproduct of this movement are the FAIR Data Principles [76] that seek to increase the usefulness of scientific data and/or metadata, including a specific emphasis on improving the ability of computational uses of data, digital objects, and "algorithms, tools, and workflows that led to that data" (p. 1). The framework outlines how researchers might work to increase the findability, accessibility, interoperability, and reusability (FAIR) of "digital assets" for downstream, derivative uses such as reproducing studies and/or leveraging the capacity of machine learning to parse large sets of data. While there is considerable value in FAIR, it expressly privileges "transparency, reproducibility, and reusability" (p. 1). Yet, centering such goals also created "tensions" with other laudable aims. Most notably, respecting the sovereignty of Indigenous communities to self-determine how data and digital assets that they have created are taken up by individuals and groups external to those communities [65].

In response to concerns regarding data sovereignty growing from the open science movement, members of the Indigenous Data Sovereignty Interest Group advanced the CARE Principles for Indigenous Data Governance that build upon ownership, control, access, and possession (OCAP), a set of principles formulated by First Nations in Canada [65]. Indigenous researchers have critiqued FAIR as a heuristic because it ignores power differentials and historical context in favor of unrestricted data sharing between interested parties. Advances in open data and science have made it increasingly difficult for Indigenous People's not only to control their data but also access it. A correction has been to operationalize FAIR principles with CARE–collective benefit, authority to control, responsibility, and ethics–principles that offer a more ethical and equitable approach to scientific data management and stewardship. "Be FAIR and CARE" principles ensure that all data collected from Indigenous People's presents equitable and direct benefits to Indigenous communities.

Still, we believe that more can be done. First, this example usefully illuminates how a set of principles advanced to improve the ethical quality of science evolved in response to arguments articulated by members of the data sovereignty movement, who pointed out how FAIR reified injustices lived by Indigenous communities, people, and scholars. That is, this example directly illustrates how "coalitional action and collective thinking" can ensure that frameworks move toward justice in technical and scientific contexts. Second, we believe that the adapted "Be FAIR and CARE" framework of principles can be useful not just for thinking about data governance (specifically) but interface and platform design (more broadly). S&CC technologies, which–while not necessarily inherently part of the open science movement–impact how data and information circulate across use-contexts. We believe that these principles can and should be used to influence design decisions about how S&CC technologies handle openness, trust, and justice. We have found the concerns of Indigenous People especially persuasive in terms of illuminating how the current pursuit of open data and science does not adequately address their interests, and we believe that centering the needs of communities that have been historically and systematically disenfranchised can move designers to help ensure that the design and use of S&CC technologies such as AIWDPs account for the standpoints and needs of those who are often underserved by such systems. We have operationalized "Be FAIR and CARE" within a heuristic matrix (see Appendix) to consider how they intersect with openness, trust, and justice, as factors that govern the design of AIWDPs. We offer this heuristic as a tool that can be used not only for the critique of existing S&CC technologies but also as an aid for attention to openness, trust, and justice of such technologies in the design phases of technological development and implementation.

Openness as a factor encompasses issues governing participation, transparency, and accessibility in design processes and outcomes. Openness means actively involving those who are often excluded or marginalized in the design process. It is not enough to simply invite them to participate. Efforts should be made to identify and remove barriers that prevent full participation, whether they are physical, digital, social, or economic. Recruitment should be active and must ensure that everyone has the necessary tools to participate throughout the design process. Such attention ensures that all participants' needs, experiences, and perspectives shape design outcomes. For example, consider how openness and responsibility as factors intersect to guide an approach to design. A designer might ask themself, "How do I ensure the needs of diverse communities encircling the platform are accounted for? And how do I invest in developing benefits to the communities supporting the platform?" Trust necessitates ensuring that design processes and outcomes are just, inclusive, and effective. Trust involves building and maintaining confidence between designers and communities in ways that engender mutual respect, transparency, relationality, and long-term commitment. When designers center trust, all participants feel respected, valued, and confident that their input will lead to positive and meaningful outcomes. A design team might act by considering how trust augments notions of accessibility. Specifically, they could ask about what documentation they might need to provide to help participants understand the origins and context of data so that all participants feel equipped to meaningfully participate in conversations.

While equity is a corrective to equality, equity emphasizes fairness and justice in the way people are treated, often considering their specific circumstances and needs. It is about ensuring that individuals or groups get what they need to be successful or to participate fully in society, which might mean providing different levels of support to different people to achieve fairness. Justice is long-term equity. It requires fixing the system and often implies a more rigid and universal application of laws and principles to ensure fair treatment. Designers focused on justice rather than equity might seek to understand what theories of justice guide their data management practices or platform design.

4 Evaluating the AlertWest AIWDP

User experience (UX) designers commonly adapt heuristics such as Nielsen's ten principles of usability to perform heuristic evaluations (HE) [33, 54]. According to Pannafino and McNeil HE is a valuable method for "assessing a product's usability" when researchers do not have access to users [58]. This section offers a HE of three factors–openness, trust, and justice–that influence the usability of the AlertWest AIWDP, applying a heuristic we created by adapting FAIR-CARE principles (see Appendix). In evaluating these design factors, we have selectively applied the heuristic due to space limits. Broadly, our intent is to demonstrate the potential of this heuristic for considering equity and justice in the design of S&CC technologies, rather than generating a comprehensive analysis of this particular platform.

4.1 AlertWest

The AlertWest AIWDP works within an overarching private-public partnership model wherein an university system manages a local network of the system, DigitalPath Incorporated provides AI hardware and/or AIWD software for a fee to the universities, and outside institutions such as utility companies and/or emergency management and response agencies sponsor the cost of operating the network. Cameras operating within the network are publicly accessible to users who visit the AlertWest platform and/or websites that the universities operate and individuals affiliated with sponsoring institutions can be assigned log-ins that allow them to operate the PZT functions of cameras. For example, the University of California, San Diego manages AlertCalifornia "a public safety program" that includes over 1,000 AIWD cameras within state, sponsored by entities such as Pacific Gas and Electric (PG&E), Southern California Edison, and California Department of Forestry and Fire Protection (CALFIRE). The stated mission of AlertCalifornia is to "understand natural disasters and determine short and long-term impacts on people and the environment to inform management decisions" [73]. The platform enriches emergency and disaster management in a number of ways. For instance, use of AI can reduce the time between the ignition and detection of a fire, which often relies on citizens passing by an area to report a fire to a dispatch center (i.e. 911) and has to route the report to the agency jurisdictionally responsible for managing emergencies within a particular geographic information. Similarly, the alerts the platform sends to incident commanders jurisdictionally responsible for managing fires include a link to the live camera feed, providing emergency managers insights into the location, terrain, fuel types, growth, intensity, spread, and/or size of fires within seconds, rather than having to wait for the first arriving unit that physically arrives at a location–response into remote wilderness locations can take extended periods of time–to perform an initial size up that gathers the types of information contained within the camera feeds. Yet, in addition to the utility AlertWest provides to emergency and disaster managers, it also enables public citizens to sign up for and receive the alerts and/or view camera live-feeds used by first responders and incident commanders. One differentiation in the interaction design available to various users is that individuals affiliated with an emergency or disaster management agency and/or the entity sponsoring cameras within the larger network can utilize a sign-on to access the PZT controls to move the focus of a camera. Beyond these features, the AlertWest platform also archives data for scientific, emergency, and/or public uses, integrates camera feeds and runs AI detection on cameras outside of the system (such as camera feeds operated by the Department of Transportation (DOT) and Federal Aviation Administration (FAA) [49].

4.2 Openness

Here we've selected three locations from the heuristic matrix to discuss openness within the AlertWest AIWDP: findable, reusable, and collective benefit.

Findability is largely a strength of openness of this design, as users from both lay and expert positionalities might access camera streams and data from the system. However, the architecture of the platform does draw distinctions between those users who have access to platform log-ins and those who do not. While this distinction in the design architecture does not adversely affect which users might create and receive alerts for potential detections and/or view the feeds, it does place limitations around who might control functions about where the camera is pointed. It appears that the platform seeks to limit access to these particular functions to ensure that individuals responsible for managing potential disasters and/or emergencies have the ability to move the camera view if/when detections occur. Still, an increased version of openness for the PTZ controls would be to enable all users to access the controls and create a weighted hierarchy that allows super-users to lock casual users out from the system when/if detections are active.

Reusability is also a notable design strength of this platform, as the platform supports users across civilian, scientific, and emergency management contexts. The data and information from the platform can provide users operating within such contexts a wide range of value, as a civilian could access a camera to assess the weather in an area where a camera is located just as easily as a scientist might access that camera to evaluate the health of a stand of trees in a forest. Moreover, the platform also archives data collected from the camera feeds. These, too, could have a variety of useful applications for a range of users. Whereas investigators might request access to archival data from a specific date and time to collect potential evidence regarding the cause of a fire, scientists could, perhaps, request access to archival data over years to develop machine learning techniques for analyzing the health of trees in a region or changes to snowpack from year-to-year. Still, a drawback in our analysis is that we're unable to speak meaningfully to the degree to which members of marginalized and/or underserved

communities have participated within the design of this feature of the platform. In particular, it's difficult to determine whether or not the processes utilized for collecting, displaying, and archiving images within this platform respect the cultural values, practices, and relations that Native American People and Nations Indigenous hold towards the lands depicted in camera feeds.

Collective benefit also appears to be a design strength in this category for the platform, as the data and/or usefulness of the platform has not been siloed in a pay-to-play structure. Instead, the public-private partnership model of platform management provides maximal benefits to a broad array of users, rather than focusing on the needs of a single user: such as profits for platform designers or reserving the monitoring capacity solely for emergency managers. Yet, the limits of our analysis here suggest that subsequent user experience design research might further enrich the collective benefit of this platform by investigating how benefits could be extended, especially to those within marginalized or underserved communities.

4.3 Trust

Here we've selected three locations from the heuristic matrix to discuss trust within the AlertWest AIWDP: authority to control, collective benefit, and interoperability.

Authority to control is an area of the platform design that may be considered a relative weakness for the platform. Camera feeds within close proximity of residences, for instance, often include digital filters that pixelate the view of homes within a camera view-shed in order to increase privacy for occupants. Clearly, the presence of such filters may serve to increase the trust users assign to the platform. Yet, the process associated with determining which cameras include such filters is not transparent. From one perspective, this could be a strength in this category; the presence of filters seems to reflect a responsiveness to user requests to exert control over how camera data is displayed. It could also be that the filters were implemented unilaterally by the platform via an internal policy or that users may have had to petition the company to implement filters. Additionally, the archive of data is not immediately publicly available, and requires users to file requests for access to archives. Again, the process for determining which requests are granted is not transparent, which illustrates another example of an opportunity for the platform to promote further trust with audiences.

Collective benefit appears to be a category where the platform design demonstrates both strengths and weaknesses. In this case, the openness of data increases the collective benefit of the platform and, in turn, lends trust to the system. As discussed above, various users have the ability to make use of video streams for a wide range of rhetorical aims. Moreover, the model of private-public partnership surrounding the platform reflects a coalitional approach to platform design, as utilities, telecommunication companies, universities, municipalities, communities, emergency managers, and scientists contribute to the operation and maintenance of the platform as partners. Moreover, because many of these institutions function as high-reliability organizations (Roberts, 1990) and/or serve the collective interest of publics, it could be argued that the presence of these organizations within the coalitional, private-public partnership, advances the interest of collective benefit. Subsequently, the formation of the coalitional partnership to advance the collective interest of improving decision making and increasing information related to management of disasters such as wildfires serves as considerable positive aspects of the AlertWest platform. Still, as with authority to control, it appears that there are opportunities for further growth and improvement, especially in terms of data governance and coalition formation. Most notably, the absence of Native American People and Nations from the list of partners could be potentially reflective of a blind-spot in the approach to including which groups are approached as partners.

Interoperability is a considerable strength for the design of this platform. In particular, the platform outlines that it is capable of ingesting existing camera feeds and running AI software on them for the purposes of wildfire detection. As noted above, AlertWest has already done so with cameras respectively operated by the DOT and FAA. Moreover, the openness of the system promotes both technological and organizational interoperability, which is critical for communities, agencies, and industries responsible for working together to co-manage wildfires. For instance, an alert could provide firefighters with situational awareness of a fire as well as enable utility providers to perform a public safety power shutoff (PSPS) to an electrical line passing through the area where a fire has occurs. Indeed, this may be one of the most critical aspects of the platform, as it facilitates the coordination of cross-institutional, cross-jurisdictional fire management activities. If the platform had instead been built around a subscriber model–whereby individual fire agencies or companies pay for access to the camera feeds–this would severely limit the ability of organizations and/or communities who lack access to platform to gain insights necessary for coordinating fire management. Instead, by providing open access to the platform, designers facilitate operational interoperability between agencies, and consequently, trust in the platform is greatly increased.

4.4 Justice

Here we've selected three locations from the heuristic matrix to discuss justice with respect to the AlertWest AIWDP: findability, authority to control, and responsibility.

Findability, from the perspective of the overall justice of the design of AlertWest, is an area that could benefit from improvement. For instance, the user interface (UI) of the platform requires a familiarity with literacies such as navigating and interacting with digital maps. Yet, a larger issue is that the AlertWest network of camera is more and less established within the southwestern US. Whereas Utah has a handful of cameras, Colorado has dozens of cameras and California has over a thousand. There are, in other words, areas where the presence of cameras is highly saturated and others where the presence of cameras is lowly saturated. One reason for this is that UCSD helped to promulgate the camera network and platform within the State of California, so the system reflects this history. However, users in locations where there is low camera density may not be familiar with the platform and consequently wonder why it's difficult to identify a camera within their region. Conversely, users in locations where there is high camera density may find it difficult to navigate the UI, such as clicking successfully on a particular camera, because there are too many cameras to choose from. By

zooming in within the map, users might be able to make selections with better accuracy; but, this assumes a familiarity with and proficiency with this type of digital literacy. Ultimately, findability impacts the justice of the platform, as differential access to the core features of the platform and/or the digital literacies necessary for making use of the platform will adversely impact which users' are ability to leverage the platform for making decisions about wildfire disaster and risk. Most notably, users located in areas where there are few cameras might question if the platform's design accounts for equitable access to the benefits of the AIWDP. For instance, an underserved rural, mountain community might wonder why public lands adjacent to a metropolitan area have multiple cameras when their area has one or none.

Authority to control is another factor that, when considered from the perspective of justice, illustrates both strengths and opportunities for improvement. The public-private partnership model used by AlertWest reflects local interests, as the private and public entities who sponsor cameras within the platform make decisions about where cameras are located. Of course both AlertWest and UCSD make decisions about the technical design of the platform, the pricing for hardware and software, and policies governing the overall system, such as data governance processes. There is a distributed authority to control various components of the platform, as its composition is highly inflected by economic and market forces. Places where critical infrastructure exists tend to be prioritized by utility providers and emergency managers who currently pay to sponsor the operation of cameras. However, the distributed nature of the platform could also mean that the types of inequities that exist broadly in society may be reflected within the system because whomever has funding to sponsor a camera may decide where cameras are located. Of course, those entities may engage users within the communities in town hall meetings and/or public comment periods. Still, these processes may not counter the power dynamics associated with serving as a funding agency that can make or break whether a camera is installed in the first place.

Responsibility is a factor here where the platform designers have acted in a way that illustrates a strong care for justice. The designers have built an open and interoperable platform, albeit a system that reflects areas of more and less robust investment. The AlertWest system does extend access to the system on trail pilots, which also reflects a significant care for removing barriers to the platform by enabling communities to determine whether investing in the platform is a viable long-term strategy for mitigating wildfire risk. These dimensions of the design are undoubtedly positively correlated with justice.

5 Implications

One limitation of our evaluation is that it has not captured data about the communication needs of actual users, including how they might operationalize this tool for risk and disaster management. Despite this limitation, the heuristic offers prompts that emphasize questions that communication designers might seek to prioritize in participatory and community-centered approaches. While our heuristic emphasizes three factors that influence the usability of an AIWDP, more comprehensive analyses of existing designs require access to historical and first-hand knowledge of the processes used within existing or proposed designs. As frameworks for data governance, FAIR and CARE principles highlight how (in)justice surrounds the design of data provenance, ownership, and management. Yet, data governance is a component of multiple factors and design decisions, including openness, trust, and justice that influence the design and user experience of platforms. Carroll et al. [65] demonstrated that engaging FAIR and CARE principles together can help researchers to identify the types of structural injustices that surround design contexts. However, designers must move beyond simply creating for others and consider how they can facilitate opportunities for users to play larger roles in design processes. We see many parallels between our heuristic and Costanza-Chock's [17] design justice principles, which seeks to emphasize processes of design with rather than design for which "produces a spiral of exclusion, as design industries center the most socially and economically powerful users, while other users are systematically excluded on multiple levels" (p. 77). Moreover, we believe there are implications of these approaches that could enrich the ethical stance through which the US Department of Homeland Security is pursuing its Connected Communities Initiative [19] or that the Federal Emergency Management Agency (FEMA) seeks to achieve its core mission of "helping people, before, during, and after disasters" [30]. The heuristic we've sketched here could provide designers with useful guidelines for working toward two core goals: "instill equity as a foundation of emergency management" and "lead whole of community in climate resilience." It also could serve as a useful guideline for designers building S&CC technologies used within emergency and disaster management, as realizing effective and equitable climate resilience in communities depends to an astonishing degree upon the quality of justice within design processes and underscores the critical importance of community-engaged, participatory, and user-centered approaches to the development, design, and implementation of risk communication platforms such as AIWD.

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A Appendix

Table 1: Fair-Care Principles Adapted for Heuristic Evaluation

	FAIR Principles (Wilkinson et al., 2016)				CARE Principles (Carroll et al., 2020)			
	Findable	Accessible	Interoperable	Reusable	Collective Benefit	Authority to Control	Responsibility	Ethics
Openness	How do platform designers affect the ease with which users might locate data and/or information? What information architecture features and/or metadata standards do platforms designers incorporate to enhance discoverability of data and/or information? What feedback mechanisms do designers enact to ensure that the platform genuinely understands users' needs and challenges?	How do platform designers support the accessibility needs that distinct users have when accessing data and/information? Does the platform align with Web Content Accessibility Guidelines 2.2 (2023)?	How do platform designers support collaboration between downstream applications, platforms, and/or systems? How do platform designers support the ability of users affiliated with a variety of organizations and/or institutions to achieve their aims? How do platform designers use data structures to enable interoperability across different platforms and ensure openness for diverse users, while maintaining security and privacy standards?	How do platform designers support the reusability of information across different contexts (e.g., for the purposes of scientific and emergency management), while also adhering to principles of transparency across cultural contexts?	How can designers support frameworks that increase access to and data-sharing between users and platforms by that prioritizing openness and transparency, while ensuring that the collective benefits of data and platforms are beneficial to all stakeholders, especially marginalized or underserved communities?	How do designers handle decisions regarding the authority to decide how data and information generated by the platform is accessed and managed, including how ownership rights and/or control of data is managed? How do designers create mechanisms for balancing the principles of data openness, promoting transparency and collaboration, while safeguarding information consider sensitive, private, or privileged by various stakeholders?	How do designers handle the responsibility for ensuring that platforms respond to the needs of diverse communities and stakeholders? How do designers ensure that access to platform data and information in benefits to the communities most directly contributing to or supporting the platform?	How do platform designers seek feedback and/or consent from individual and groups in areas where platforms are being used? What ethical principles and values guide designers' decisions about data control and protection, and how does the platform navigate ethical dilemmas related to balancing openness with privacy, transparency with security?

Trust	In what ways can designers ensure that trust is integrated into data management practices? What features or tools are available for users to cross-check or validate data?	What documentation have the platform's designers provided to help users understand the origins and context of data?	How do platform designers design a data system that not only facilitates seamless exchange and integration of information across different platforms and users but also instill confidence in the accuracy, reliability, and ethical handling of that data?	How do platform designers build data systems that enable seamless reuse of information across different contexts while maintaining high standards of data integrity, accuracy, and ethical handling to ensure trust among users?	How can designers maximize the collective benefits of platforms, ensuring robust mechanisms for data governance, security, and privacy for building and maintain trust among distinct user groups?	How do designers ensure that the processes for accessing platforms and/or collecting, storing, and sharing data is transparent to affected parties? Do designers handle transparency in access granting and data handling practices in ways that contribute to building trust and respect a diversity of user preferences and/or privacy rights? Do users have control over their own data, including the ability to grant or revoke consent for its use?	Who is responsible for managing the processes for collecting, storing, and sharing data? Who is responsible for ensuring that users have control and that their rights and concerns are respected?	What ethical principles and values guide decisions about data collection, use, and sharing? How have the platform's designers addressed ethical dilemmas such as fairness, justice, and respect for individuals' rights in the context of data management?

Justice	What measures have platform designers taken to ensure data can be accessed by people with varying levels of digital literacy and different abilities? What steps do platform designers take to include diverse perspectives and datasets?	How do platform designers ensure that data is accessible to all users, including those from marginalized or underserved communities, while providing just access and representation in the data itself?	How do platform designers promote just access, representation, and participation to data and information, ensuring that data interoperability not only facilitates information exchange but also fosters inclusivity and addresses systemic biases?	How can platform designers design data systems and protocols that promote the reuse of information across different contexts while also ensuring that access to this data is inclusive?	How can designers promote diversity and inclusion in platforms, ensuring that the benefit aligns with experiences, perspectives, and values of individuals and communities affected by the platform? How can designers empower individuals and communities to actively participate in the co-creation, governance, and decision-making of associated with platform design?	How are communities involved in data governance processes, and who has the authority to facilitate community engagement? How does community involvement promote justice by ensuring that data initiatives are responsive to the needs and priorities of diverse communities?	What responsibility do platform designers have to remove barriers to access and promote inclusivity in data and information accessibility?	What ethical principles guide platform designers understanding of justice? What steps are platform designers taking to ensure data practices ensure the interests of a variety of affected users?