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Data in Crisis: anticipating risk, vulnerability, and resilience through communication infrastructures

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This paper explores the implications of having interactions around crises progressively based in information and communication technology (ICT), data, and their infrastructures. Drawing on applied research from multidisciplinary projects to design crisis ICT, we describe the how these tools become fundamental to how crisis communication and governance can and does work. Crisis ICT facilitate collaboration and interoperability in ways that make it possible for crisis managers to share each other's strategies, processes, goals, and perspectives. They also bring together different histories of risk assessment practices and socio-political situations. Combining them meaningfully requires anyone working with the ICT to actively negotiate and deliberate what that combined view includes. We examine a series of tensions raised by infrastructuringdiverse crisis data and discuss what they mean for conceptions of crisis risk, vulnerability, and resilience. First, are tensions that emerge when trying to provide an underpinning logic that makes data shareable and comparable. Second, are the dynamics that come from misunderstandings as crisis practitioners from different disciplines and cultures engage with each other through these infrastructures. Third are the tensions raised through the anticipatory conflicts between concrete data needs of a technology and the uncertainties of how crises unfold. Finally, we consider how these infrastructures stabilise crises to make them visible, actionable, and contestable. We argue that crisis communication requires reflexive perspectives, building into all communication practices mechanisms by which actors can be mutually responsive to each other. Our aim is to provoke those engaging with such tools to consider how risk, vulnerability, resilience, and the lived experience of crises are intertwined with the infrastructures that make communication possible.

Keywords: crisis, data, infrastructures, risk, communication

Introduction

Crises are increasingly recognized as complex problem with boundaries and scales of activity that are impossible to fully discern from each other. Pandemics spread through both person-to-person contact and international flight patterns. Wildfires burn at wildland-urban interfaces and through electricity delivery routes. Flood risks are exacerbated by climate change and upstream land use patterns. Layered in social, economic, technical, and environmental challenges, crisis management requires collaboration and coordination of actors from diverse governance systems, disciplines, even nations. Through these interactions, frameworks are built to anticipate and address crisis risk and vulnerabilities.[1]

But these collaborations necessitate a level of information sharing that goes beyond what one person or disaster response agency can share with another. To support them, crisis managers are seeking new information and communication technologies (ICT) that facilitate collective, intersectional, and interoperable data in ways that make it possible to share each other's strategies, processes, goals, and perspectives.[2] By working with such ICT, crisis practitioners aim to better understand the crisis being faced, who has resources to address it, and how current perspectives leave gaps that create vulnerabilities. Engaged in this way, the ICT are kinds of infrastructures, with underlying abilities to sort, order, and connect as they bring disparate data into conversation.[3]

This paper explores the implications of having interactions around crises progressively based in ICT, data, and their infrastructures. To do so, we examine a series of tensions raised by *infrastructuring* diverse data and discuss what they mean for conceptions of crisis risk, vulnerability, and resilience. First, are tensions that emerge when trying to provide an underpinning logic that makes data shareable and comparable. Second, are the dynamics that come from misunderstandings as crisis practitioners from different disciplines and cultures engage with each other through these infrastructures. Third are the tensions raised through the anticipatory conflicts between concrete data needs of a technology and the uncertainties of how crises

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[1] Kathleen Tierney, 'Disaster Governance: Social, Political, and Economic Dimensions', *Annual Review of Environment and Resources* 37 (2012), https://doi.org/10.1146/annurev-environ-020911-095618.

[2] David Allen, Stan Karanasios, and Alistair Norman, 'Information Sharing and Interoperability: The Case of Major Incident Management', *European Journal of Information Systems* 23 (June 2013), https://doi.org/10.1057/ejis.2013.8.

[3] Susan Leigh Star and Geoffrey C. Bowker, 'How to Infrastructure', in *Handbook of New Media: Social Shaping and Social Consequences of ICTs* (Sage Publications, 2010), https://doi.org/10.4135/9781446211304.n13; Geoffrey C. Bowker et al., 'Toward Information Infrastructure Studies: Ways of Knowing in a Networked Environment', in *International Handbook of Internet Research* (Dordrecht: Springer, 2009) https://doi.org/10.1007/978-1-4020-9789-8_5.

unfold. Finally, we consider how these infrastructures stabilise crises to make them visible, actionable, and contestable. We argue that crisis communication requires reflexive perspectives, building into all communication practices mechanisms by which actors can be mutually responsive to each other. Our aim is to provoke those engaging with such tools to consider how risk, vulnerability, resilience, and the lived experience of crises are intertwined with the infrastructures that make communication possible.

Research approach and methods

This research builds on a mixed-methods approach that included observing and intervening in three multi-national research and innovation projects.[4] These projects all aimed at developing ICT to improve cooperation and communication across national, jurisdiction, and institutional borders. Our methods focused on the creative activities that make the informational infrastructures—technological, social, organizational, political—work.[5] Specifically, while the tools were being developed and tested, we examined the underlying infrastructures and assumptions about crises that were shaping why specific data was gathered and shared in specific forms.[6] Overall, our approach to this involved 'staying with the trouble' and working in the 'belly of the beast' to look from the inside to understand (and influence) the what, how and why of design choices and actions.[7]

These activities directly engaged with the technology designers and stakeholders. We intervened in their work, mediated between them and the crisis responders through the development of crisis scenarios. We encouraged hands-on play

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[4] This work took place within three multi-year European Commission research and innovation projects aiming to design information technology platforms for transboundary data sharing and coordination in crises: SecInCoRe (Secure Dynamic Cloud for Information, Communication and Resource Interoperability based on Pan-European Disaster Inventory) which ran from 2014-2017, IN-PREP (An INtegrated next generation PREParedness programme for improving effective inter-organisational response capacity in complex environments of disasters and causes of crises) which ran from in 2017 to early 2021; and STAMINA (Smart support platform for pandemic prediction and management) which runs from 2020-2022.

[5] Helena Karasti and Karen S. Baker, 'Infrastructuring for the Long-Term: Ecological Information Management', *Proceedings of the 37th Annual Hawaii International Conference on System Sciences* (2004), https://doi.org/10.1109/hicss.2004.1265077; Karen S Baker and Helena Karasti, 'Data Care and Its Politics: Designing for Local Collective Data Management as a Neglected Thing', *PDC '18: Proceedings of the 15th Participatory Design Conference 1* (2018). https://doi.org/10.1145/3210586.3210587

[6] Geoffrey Bowker and Susan Leigh Star, *Sorting Things Out: Classification and Its Consequences* (Cambridge, MA: MIT Press, 2000).

[7] Ellen Balka, 'Inside the Belly of the Beast: The Challenges and Successes of a Reformist Participatory Agenda' (2006), https://doi.org/10.1145/1147261.1147281.

with technological prototypes, experimented with sandboxing around previous experience, and directed concept mapping in workshops. We engaged together in "collective inquiry into matters of concern" to envision crisis management support structures.[8] This included exploring how data travelled and was transformed, why design decisions were made, and what new links were forged along the way.[9]

This work was complimented by semi-structured interviews with crisis responders asking questions about their experiences with collaborative and transboundary interactions. Interviews were also conducted with technology designers, asking questions about their design impetus, their assumptions of user responsibility, and what kinds of public goods they see resulting from a tool's use. It was further enriched with observations at collaborative disaster response exercises, where responders were being trained on current or new systems intended to improve data sharing across boundaries. The work overall involved eliciting societal values and ethical assumptions that could arise through the design and use of the technology, as well as exploring different innovation potentials in response.[10]

The logics of shared pictures: crisis data infrastructures

Crisis management gets complicated when working across borders and organisations. For example, during wildfires, fire and police are often stationed at different command posts in order to maintain internal command structures and focus on unique priorities. They make separate decisions and inform the public about different aspects of hazards and risks. However, they are aware that the fragmented response and messaging that comes from these separate positions often leads to miscommunications between responders. It also leaves the public unsure of who to trust or how to act. To mitigate these critiques, crisis managers are increasingly investing in information and communication technology (ICT).

Crisis ICT provide an infrastructure for different technology, data, and practices to interact. They make it technically possible to collect data and draw shared

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[8] Carl DiSalvo, Melissa Gregg, and Thomas Lodato, 'Building Belonging', *Interactions* 21, no. 4 (2014): 2403, https://doi.org/10.1145/2628685.

[9] Catelijne Coopmans, 'Making Mammograms Mobile: Suggestions for a Sociology of Data Mobility', *Information Communication and Society* 9, no. 1 (2006), https://doi.org/10.1080/13691180500519274.

[10] Peter-Paul Verbeek, Moralizing Technology: Understanding and Designing the Morality of Things (Chicago: University of Chicago Press, 2011); Mariarosaria Taddeo and Luciano Floridi, 'What is Data Ethics?', *Philosophical Transactions of the Royal Society*, (2016), https://doi.org/10.1098/rsta.2016.0360. Lucas D. Introna, 'Maintaining the Reversibility of Foldings: Making the Ethics (Politics) of Information Technology Visible', E*thics and Information Technology* 9, no. 1 (2007), https://doi.org/10.1007/s10676-006-9133-z; Philip Brey, 'Disclosive Computer Ethics', *ACM SIGCAS Computers and Society* 30, no. 4 (2000), https://doi.org/10.1145/572260.572264.

pictures of the multi-sectoral and multi-national nature of a crisis' cascading effects.[11] They support data interoperability, which creates pathways for crisis practitioners to engage with each other's data without having to be immersed in each other's cultures of risk. The hope is that by adopting these ICT, multiple agencies will be able to share more efficiently and effectively what they know about a crisis to build a common picture from which to work. By using everyone's data to better understand what is going on in general and what everyone is doing in specific, those working through these tools can better foster collaborative relationships and address the unexpected. And, from that information sharing, they endeavour to make better policy, improve planning, and reduce risks to society.

These ICT can assemble different types and sources of data to enrich pictures of crisis risk. Data sources range from satellites, drones, alarm sensors in buildings, fire tracking cameras, flood sensors, GPS worn by responders at the scenes or found within response vehicles. They can include demographic data, critical infrastructure layouts, and historical environmental data. This can be paired with planning data such as evacuation perimeters, safety zones, estimated smoke plumes rates, and hospital bed capacities. Put together, these data can help make what the responders call *situational awareness* of risk that can inform a common approach to a problem and way of working together. Through this, crisis practitioners can see risk, vulnerability, and resilience beyond what any individual can know, supporting simultaneously more holistic and diverse perceptions of what communities face during crises.

Frequently taking the form of 'common operating pictures' and 'common information spaces', these tools layer, analyse, and merge information from different agencies to build pictures of a scene. For example, the Red Cross can see the fire perimeters from the fire authorities to plan evacuation centres, while police can see the evacuation centre locations as they become activated to know where to direct people. Crisis managers can use them collaboratively to make decisions, to understand each other's strengths or resource gaps, and to improve joint sense-making.[12] These ICT also support engagements with global networks of knowledge, by, for example, being able to get a researcher using a satellite in South Korea to point it at wildfires in California to enrich the view of responders on the ground.[13] They create information infrastructures for communicating risk.

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[11] Maximilian Mayer and Michele Acuto, 'The Global Governance of Large Technical Systems', *Millennium: Journal of International Studies* 43, no. 2 (2015), https://doi.org/10.1177/0305829814561540.

[12] Sarah Backman and Mark Rhinard, 'The European Union's Capacities for Managing Crises', *Journal of Contingencies and Crisis Management* 26, no. 2 (2018), https://doi.org/10.1111/1468-5973.12190.

[13] Ann Majchrzak and Philip H.B. More, 'Emergency! Web 2.0 to the Rescue!', *Communications of the ACM* 54, no. 4 (2011), https://doi.org/10.1145/1924421.1924449.

However, what's being infrastructured is not just data. Active decisions are taken to combine the complex awareness necessary for collaborative action with the capabilities of data analytics, modelling, and machine learning that underpin these ICT.[14] Moreover, each series of data is based in a unique set of risk assessment practices, socio-political situations, informational gathering techniques, goals, and purposes. These practices inform what kind of data is looked for in the first place to situate crises.[15] Combining them meaningfully requires anyone working with the ICT to actively negotiate and deliberate what that combined view includes. Through these activities, ICT become fundamental to how communication and governance of crises can and do work.

Puzzling Together the Ontologies of Risk

One way these infrastructures organise data together is through ontologies. In information and data science, ontologies are structures that represent the relationships between many distributed and different semantic resources in one domain, such as crisis response. Like complex network maps, they name and classify categories, as well as build relationships between concepts, properties, instances, languages, and norms.

An important side effect of this organising is that ontologies make conceptions of crisis temporarily stable. Ontologies act like formal representations, becoming standards, thresholds, and visual maps that get institutionalised and naturalized as they become incorporated into practices.[16] They provide "a background against which things become seeable, sayable, and doable with data across borders."[17] Working with these formalities helps spread norms, standards, and other mechanisms that support collective action.[18] In the process, crises—grounded in uncertainty—become describable, manageable, and governable.

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[14] Geoffrey C. Bowker and Susan Leigh Star, 'Work and Infrastructure', *Communications of the ACM* 38, no. 9 (1995), https://doi.org/10.1145/223248.278461; Kim Fortun and Mike Fortun, 'An Infrastructural Moment in the Human Sciences', *Cultural Anthropology* 30, no. 3 (2015), https://doi.org/10.14506/ca30.3.01.

[15] David Ribes, 'Notes on the Concept of Data Interoperability: Cases from an Ecology of AIDS Research Infrastructures', in *Proceedings of the 2017 ACM Conference on Computer Supported Cooperative Work and Social Computing*, CSCW '17 (New York, NY, USA: Association for Computing Machinery, 2017), 1514–26, https://doi.org/10.1145/2998181.2998344.

[16] Susan Leigh Star, 'Revisiting Ecologies of Knowledge: Work and Politics in Science and Technology', in Geoffrey C. Bowker; Stefan Timmermans; Adele E. Clarke; Ellen Balka, *Boundary Objects and Beyond: Working with Leigh Star* (MIT Press, 2016): 13-46.

[17] Jonathan Gray, 'Three Aspects of Data Worlds', *Krisis*, (2018), 1–3, 11.

[18] Tierney, 'Disaster Governance: Social, Political, and Economic Dimensions'.

At the same time, this work to represent crises as interconnected data points is value-laden, political, and performative.[19] Ontologies filter, select, and reflect information that make sense within an ICT's computational logic and the human cultures that created that logic.[20] As reverberated in the infrastructures and acts with the data, these formalities (at least partially) predetermine what information is considered useful and relevant to describe the properties of risk, vulnerability, and resilience.[21] Communicating through them can prioritise certain ways of knowing crisis over others, grounded in specific value systems, guiding implicit biases around what is at stake and who matters.[22]

Communicating risk and resilience

It is well acknowledged among crisis practitioners that what risk means is not the same on two sides of a border, let alone two agencies in the same region. What questions practitioners ask and data they use to answer the questions differs. Even how they use the same data differs.[23] Practitioners regularly noted that other agencies 'think in different dimensions than we do', both in terms of the scale and the timing of a crisis. What is run by a fire brigade in one country can be carried out by civil defence in another location, by police in another, by Red Cross somewhere else.

Differences even appear in root concepts of crisis management. Take 'resilience' as an example. It is a broad umbrella term that covers how systems respond to stressors and survive disruptions. In hazard research, resilience includes survival and coping by reducing impacts, avoiding losses, containing effects, and minimising social disruptions.[24] In humanitarian efforts, resilience is defined by building

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[19] Sheila Jasanoff, 'Virtual, Visible, and Actionable: Data Assemblages and the Sightlines of Justice', *Big Data & Society* 4, no. 2 (2017). https://doi.org/10.1177/2053951717724477.

[20] Tarleton Gillespie, 'Algorithmically Recognizable: Santorum's Google Problem, and Google's Santorum Problem', *Information Communication and Society* 20, no. 1 (2017), https://doi.org/10.1080/1369118X.2016.1199721.

[21] Olga Kuchinskaya, 'Twice Invisible: Formal Representations of Radiation Danger', *Social Studies of Science* 43, no. 1 (2013), https://doi.org/10.1177/0306312712465356; Evelyn Ruppert, Engin Isin, and Didier Bigo, 'Data Politics', *Big Data & Society* 4, no. 2 (2017), https://doi.org/10.1177/2053951717717749.

[22] Noortje Marres and Carolin Gerlitz, 'Interface Methods: Renegotiating Relations between Digital Social Research, STS and Sociology', *The Sociological Review* 64, no. 1 (2016): 21–46, https://doi.org/10.1111/1467-954X.12314.

[23] Jaime Abad et al., 'Comparison of National Strategies in France, Germany and Switzerland for DRR and Cross-Border Crisis Management', vol. 212 (2018), https://doi.org/10.1016/j.proeng.2018.01.113.

[24] Anne Tiernan et al., 'A Review of Themes in Disaster Resilience Literature and International Practice since 2012', *Policy Design and Practice* 2, no. 1 (2019), https://doi.org/10.1080/25741292.2018.1507240.

communities that are knowledgeable and healthy, organised, connected, with infrastructures and services.[25] While not incommensurable, they shift the foci of action and governance, placing vulnerability in different social and political processes.

These differences often lead to siloed approaches to crises. One responder described a time when a bridge failed on an isolated but busy road on the hottest day of the year. Response plans for a broken bridge centred the risk around the cars. Thus, only stakeholders related to traffic, road maintenance, and police were involved. While the bridge was under repair, cars piled up, and people were stuck in hot cars on a hot day, unable to divert. But because risk for these actors was defined by the movement of cars over a bridge; none of these actors thought to check on the people in the cars. Health services and local municipalities were not called in to help with providing water for dehydration and medical treatment for heat stroke, turning a broken bridge into a small-scale crisis. Indeed, many regional resilience forums (e.g., in the UK and Sweden) were established because of lessons learned from situations like these, where crisis management included ontologies of risks that were too narrowly defined.[26]

Priorities for managing crisis risk similarly reflect ontological challenges.[27] In Germany, responders will first attend to those in need of aid, then they will attend to the safety of the scene. The greater risk is to the immediate lives lost. In France, it is the other way around. First the scene is secured, then those in need of aid. The greater risk is to the ability to provide services. If the first responders are injured, then no one will be helped. In the United Kingdom, the aim is to remove all victims from the scene so both scene and person can be treated separately. Each practice of risk management has different data that is immediately relevant: data about who is where and in what condition; data about who has the capacity to provide aid to victims; data about movement and travel of victims and responders. Focusing on data about the scene, context, or broader picture each suggest different ontological orders.

In one workshop, these differences became particularly salient. Practitioners from different disaster response agencies and countries across Europe had been asked to provide details about the data they collect during an active disaster response. One

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[25] International Federation of Red Cross and Red Crescent Societies, 'IFRC Framework for Community Resilience', (2014). https://www.ifrc.org/sites/default/files/IFRC-Framework-for-Community-Resilience-EN-LR.pdf

[26] Civil Contingencies Secretariat, 'The Role of Local Resilience Forums: A Reference Document', (2013), https://www.gov.uk/government/publications/the-role-of-local-resilience-forums-a-reference-document.

[27] Allen, Karanasios, and Norman, 'Information Sharing and Interoperability: The Case of Major Incident Management'.

question was on what data they gather relating to 'people affected'. The final list produced included:

Vulnerable people requiring specialist assistance
People whose presence is not compatible with rest-centres
People at risk
People needing evacuation
Number of victims
Survivor information
Fatality information
People with disabilities
Anyone needing to be rescued?
Anyone still missing?
Location of people at risk
Trapped people?

Not even the grammar (statement or question) was consistent across the practitioners. Each of these approaches to collecting information about who is affected engages different understandings of vulnerability. Each suggest different foci and priorities for action: the body, the scene, the jurisdiction. Focusing on trapped people shifts, in a nuanced way, the informational needs to the environment, to what needs to be done to access the individual live bodies. Focusing on people needing evacuating implies the need for health data and information about resources to secure the bodies to maintain that level of health. Focusing on fatalities suggests information about cause of death, person identification, and family contacts. What aspects should be most visible shift as the categories do, including who should be involved and what decisions need to be made. For example, revisiting the distinction between survivors, fatalities, and victims:

If people affected are *survivors*, priorities include information on who can house them and how to feed them

If people affected are *fatalities*, priorities include information about hazards, impacts, and body storage

If people affected are *victims*, priorities include information about hospital networks and injuries

While all the terms form a broad categorical comparison of people affected by crisis, choosing between terms is a bit like deciding if the glass is half full or half empty. Each communicate different valences of risk and resilience, suggesting different relational needs and positions with other concepts. The differences are culturally grounded, situated in specific events and places, and unstable over time and scale. The

opportunities ICT afford in communicating crises highlight the need for new forms of reflexive skills for those who work with such tools, to be able to acknowledge and critically consider the situatedness, positionality, and politics of this work. They need to reanimate the stability offered by the ICT.[28]

Misaligned understandings

Misunderstandings happen regularly as these data valences meet in concrete ontologies. While most European countries primarily work with a command-and-control model that has three levels (strategic, operational, and tactical), the risk management decision responsibilities at each level are not consistent. For example, decisions taken by a tactical team in the Netherlands can be taken by an operational team in Italy. When responders from different places interact with each other, the same basic question keeps emerging: "why are you doing it that way?" Crisis managers regularly note how misunderstandings will happen, especially with the softer terms, like vulnerability, or language idioms, like 'perfectly acceptable'. One described how the definition of 'critical infrastructure' is viewed quite differently by public agencies, political entities, and businesses. Even semantically, who is considered a 'first responder' or what role an 'ambulance' plays is not the same between countries, even within European civil protection structures.

This is not limited to disaster terminology. As culture and language move across borders, descriptive names for geographical features can lead to misaligned understandings of how that name implies risks. This, in turn, can filter down into long standing crisis management practices. For example, Mike Davis describes such a situation as the Spanish travelled to the Americas and carried with them the name 'arroyo'.[29] While arroyos are waterless most of the time, when it rains they not only transform into rivers but also are regularly flood, bringing necessary water to the surrounding plants and animals. Risk to life, here, is when flooding *does not* happen. When the Spanish came to the Americas, they applied this term to the features of the semi-arid west. However, when the English conquered the land, they wanted to translate everything to demarcate their claim. But in English there is no direct translation. The closest is 'dry creek'. Creeks are defined by having water, emphasized by the need to put 'dry' in front. Yet, with this image, wet is normal and flooding is not. Risk to life, here, is when flooding *does* happen. Each term anticipates specific

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[28] Rob Kitchin, 'Big Data, New Epistemologies and Paradigm Shifts', *Big Data & Society* 1, no. 1 (2014): 2053951714528481, https://doi.org/10.1177/2053951714528481.

[29] Mike Davis, 'Los Angeles After the Storm: The Dialectic of Ordinary Disaster', *Antipode* 27, no. 3 (1995), https://doi.org/10.1111/j.1467-8330.1995.tb00276.x.

notions of crisis, one based in dry and one in wet. They suggest what is considered normal and abnormal, producing specific imaginaries for vulnerability and risk.

Such misaligned understandings affect who gets included in the crisis management process as well as who is benefited by those processes. In one disaster training exercise to practice for large-scale flooding, two actors were using flood maps as part of their analysis, one set of maps from an environmental agency and one set from a local utility company. Throughout the exercise, flood levels were hypothetically escalating. To explain the severity of the situation, an announcement about the flood levels made a comparison to historical data. It stated, 'the flood has reached 1910 levels.' Both actors quickly pulled up historical records of what was 'under water' at that time as a reference for what was going on at present.

The category 'under water' was intended to be a common-sense way of describing parts of the city affected by water being on top of things it should not be. But what was marked as 'under water' on each agency's map was quite different. The environmental agency's map outlined land that had been recorded in 1910 to physically have water on top of it, consistent with expected flood zones. The actor could assess flood damage to buildings or who would need rescue. The utility company's map took a different shape, extrapolating what current power infrastructure would be affected by the flooding in 1910. From that, the actor was able to assess who was more broadly affected by the floods due to, for example, electricity cuts. As a result, what the map delineated as 'under water' was a larger area than simply outlining whose homes were flooded, instead including homes affected by the flooding. Both "homes flooded" and "homes affected by flooding" are valid ways of engaging data to describe the impact of being under water. Each can be interpreted to disciplinarily appropriate ends.

Each actor expressed frustrations over how the other was neither aware of the differences nor understood how to communicate these differences. The nuances in how terminology was used overrode any work done in the broader exercise to assure everyone in the room that they each were working with good data and had accurate, shareable maps. Trust between actors was eroded. They did not really interact for the rest of the training exercise.

Without skills to engage the communication tensions between diversity and inclusivity, it was hard for the actors to determine if what looked like a bad piece of data resulted from poor categorisation, poor data gathering choices, or just differences in good data types. These interactions demonstrate that how data should be folded into insights and decisions must be anticipated well before a GPS collects and sends data, before a satellite translates thermal sensors into pixel colours, before specific demographics are surveyed in order to even begin to make such assessments possible.

Anticipation and reflection

Crises happen because of what is not anticipated, because of what is not foreseen or planned for, because of what is structurally invisible. Understandings of crises are grounded in extrapolations from historical experience, which are used to stand in for relevant qualities of potential futures.[30] But futures are filled with novel risks and unique vulnerabilities. Thinking about the future is key to crisis management, fundamental to preparing understandings of who needs to be supported, how, and with what at stake.[31] Without anticipation, crisis management can enact memories and assumed vulnerabilities rather than looking forward to what a crisis may bring.[32] In doing so, it can prolong injustices that perpetuate crises.[33]

To a great extent, infrastructuring crisis communication is also an act of anticipation, of reflecting in advance upon what is important to know about a crisis for all actors involved. Predefined relations and properties only go so far. Seeing resemblances between two different crises can make visible what is historically significant or who is most affected. But resemblances are arguments, arguments for what is really at stake in a disaster. They can unintentionally anticipate what can happen in the world framed as it is currently known, with the features of the present, instead of building an image with room for unknowns yet to come.[34]

To make the data meaningful for crisis management, those working with the data need to make judgements in advance about what is valued or prioritised about the context and situation. All parties need to agree upon how to determine accuracy of the data, how that data can be of benefit to whom, what ought to be done in response to specific data, and who is responsible for those acts. This requires considerable reflexivity, awareness of assumptions and historical experience, and

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[30] Spencer R. Weart, *The Rise of Nuclear Fear*, (Cambridge, MA: Harvard University Press, 2012), https://doi.org/10.4159/harvard.9780674065062; Andrew Lakoff, 'Preparing for the next Emergency', *Public Culture* 19, no. 2 (2007), https://doi.org/10.1215/08992363-2006-035.

[31] Jonathon P. Leider et al., 'Ethical Guidance for Disaster Response, Specifically around Crisis Standards of Care: A Systematic Review', *American Journal of Public Health* 107, no. 9 (2017), https://doi.org/10.2105/AJPH.2017.303882.

[32] Kim Fortun, 'Remebering Bhopal, Re-Figuring Liability', *Interventions* 2, no. 2 (2000), https://doi.org/10.1080/136980100427306.

[33] Benjamin K. Sovacool, 'Don't Let Disaster Recovery Perpetuate Injustice', *Nature* 549, no. 7673 (2017), https://doi.org/10.1038/549433a.

[34] Alfred Nordmann, 'Responsible Innovation, the Art and Craft of Anticipation', *Journal of Responsible Innovation* 1, no. 1 (2014): 87–98, https://doi.org/10.1080/23299460.2014.882064.

ongoing negotiations about what risks exist, what vulnerabilities could be relevant, and what resilience intends to achieve.[35]

But it is very hard to anticipate what information will be available or relevant during a crisis, let alone what is needed for other agencies beyond your own.[36] This became evident at a workshop with emergency responders to elaborate how transboundary ICT could work. Workshop participants were asked: imagine you had the perfect communication tool, what would it look like and what else would you need to make the tool work? As they worked this out, the discussions never arrived at details like categories, collaborations, or even what they'd use it for. Nor did they really formulate what their ideal tool looked like. Each time they tried to settle on the kinds of organisational knowledge and infrastructural connections necessary for such an imaginary tool to work, they would consistently have to move backwards in time, to earlier steps that had to be in place for their configurations to work.

For example, to get the data they wanted, policies had to be in place to support the data gathering for public use. These policies required there to be already existing political relations and contracts necessary to get access to the data, store it, and use it for various purposes. To gain political will, efforts to build public trust had to already be in place prior to the political relations and contracts. Well in advance of this trust building, communication processes had to be established for each party to know even what kinds of interactions could be of value and where stumbling blocks might emerge. The future imaginaries for crisis and resilience started with activities that had to take place years prior to new data or new ICT being valuable parts of communication.

The implications of forgoing anticipation like this directly played out in a series of pilots to test newly designed ICT to support cross-agency crisis management. In an early pilot, the crisis practitioners quite liked the tools but realised the local data they had on hand fell short of making them usable. In a second pilot, the tools were not used at all; the data categories within them were all wrong for the crises scenario and did not match the data they had. Anticipatory lessons learned, before the next round more foresight work took place, with emails going back and forth between the responders and ICT designers for months in order to figure out what data should be included in the system to support the desired collaboration and coordination. However, even with the right data structures, the pilot participants realised they did not have access to the data to use within that structure. Two years

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[35] Nordmann, 'Responsible Innovation, the Art and Craft of Anticipation'.

[36] Benedikt Ley et al., 'Information and Expertise Sharing in Inter-Organizational Crisis Management', *Computer Supported Cooperative Work: CSCW: An International Journal* 23, no. 4–6 (2014), https://doi.org/10.1007/s10606-014-9205-2.

later, political negotiations were still ongoing with another public authority to gain access and build the necessary data arrangements. Anticipation in the past was a prerequisite to configuring crisis infrastructures in the future. Each new situation and context required forecasting of new data arrangements in addition to new crisis risks.

The il(logics) of communicating crises

These collaborative infrastructures piece together different perceptions of risk, different data valences, as well as different expectations and approximations of the world. Each carry with them ever-changing cultures of practice and histories of experience.[37] Each configuration does different discursive work to make crises visible.[38] But it is not always possible to see such details in even the most well-structured big data, especially when it comes from across a border.[39] As ICT are geared up to communicate risks, they stand in friction with the fluid and relational nature of how crises unfold, of how risks are emergent, and of the work necessary to make data shareable.[40]

When working at the intersection of multiple risk management practices, then, the challenge becomes one of choosing what kind of knowledge gets included in a system, without erasing all diversity and ambiguities for the sake of making things common enough for all.

Is it a victim or a person at risk?
Is it under water or not?
Is it a threat or a new opportunity?
Is it a duck or a rabbit?

To substitute one for another for the sake of a common ontology raises questions, like who gets the power to define what is important about the particulars of a vulnerability and what is deemed meaningful to a describe a risk.[41] These types of issues are unavoidable to some degree because information and communication technology,

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[37] Brittany Fiore-Gartland and Gina Neff, 'Communication, Mediation, and the Expectations of Data: Data Valences across Health and Wellness Communities', *International Journal of Communication* 9 (2015). https://ijoc.org/index.php/ijoc/article/view/2830.

[38] Tarleton Gillespie, 'The Politics of "Platforms"', *New Media & Society* 12, no. 3 (2010): 347–64, https://doi.org/10.1177/1461444809342738.

[39] Tiernan et al., 'A Review of Themes in Disaster Resilience Literature and International Practice since 2012'.

[40] Anna Lowenhaupt Tsing, *Friction: An Ethnography of Global Connection*, (Princeton: Princeton University Press, 2011), https://doi.org/10.1525/pol.2006.29.2.291.

[41] Baker et al., 'Data Care and Its Politics: Designing for Local Collective Data Management as a Neglected Thing'.

particularly ones positioned as boundary objects, require alignments to work.[42] Coordinated acts need common reference points and structures within which people can find a way to relate new to familiar.

But, in providing this structure, ICT codify values, stating them as concrete, describable rules.[43] As formal representations, they become evidence for why a piece of information is valid to consider or invalid towards a specific risk. They become underlying arguments as to why decisions being made using that information are relevant, proportionate, and inclusive.[44] While focusing on alignment moves the negotiations more horizontal to include the needs and concerns of diverse actors, it still raises questions about what form such alignment should take.[45] Should alignments be between crisis actors? At what scale of activity? Or should alignments be with specific communities or society as a whole?

Using these tools focuses a crisis practitioner's attention in specific ways. Infrastructures act as technical representations of responsibility, defining what makes 'good' and 'bad' decisions.[46] If one set of practices is prioritized over another in the design of data structures, collaborators from across boundaries can be unintentionally disenfranchised when they do not see their crisis experiences in the 'good' definitions. Even more, how data are approached and decisions taken during disasters can "reinforce, intensify and produce new and uneven stratifications" while leaving root causes for risk and vulnerabilities hidden within the formalities of data sharing structures.[47] If a crisis responder or ICT assume specific identifiers for risk, vulnerability, and resilience then any inequalities that exist in less well represented features start to have greater weight and impact on how a crisis could unfold.

However, choosing all schema for the sake of inclusivity risks muddled information leading to discord or confusion, such as the multiple ways of describing

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[42] James R Griesemer and Susan Leigh Star, 'Institutional Ecology, "Translations" and Boundary Objects: Amateurs and Professionals in Berkeley's Museum of Vertebrale Zoology, 1907-39', *Social Studies Of Science* 19, no. 3 (1989).

[43] Martha Lampland and Susan Leigh Star, 'Reckoning with Standards', *Standards and Their Stories*, (Cornell University Press, 2008); Gray, 'Three Aspects of Data Worlds'.

[44] Kuchinskaya, 'Twice Invisible: Formal Representations of Radiation Danger'.

[45] Barbara Ribeiro et al., 'Introducing the Dilemma of Societal Alignment for Inclusive and Responsible Research and Innovation', *Journal of Responsible Innovation* 5, no. 3 (2018): 316–31, https://doi.org/10.1080/23299460.2018.1495033.

[46] Sebastiaan Princen et al., 'Establishing Cross-Border Co-Operation between Professional Organizations: Police, Fire Brigades and Emergency Health Services in Dutch Border Regions', *European Urban and Regional Studies* 23, no. 3 (2016), https://doi.org/10.1177/0969776414522082.

[47] Peter Adey, 'Emergency Mobilities', *Mobilities* 11, no. 1 (2016): 42, https://doi.org/10.1080/17450101.2015.1103533.

'under water'. The ability to assign value to the data is not determined by the data itself but by ever-shifting contexts and situations of use.[48] Yet, actors are not always aware of their own assumptions, interests, and values when they decide upon how they structure and categorise data.[49] Fear of losing control of a situation because of misunderstandings about how data from one framework should be used in another can easily transform inclusivity into a source of distrust rather than solidarity.[50] Specific skills are needed to not just interpret one's own data but to ensure it is accurate, credible, and not misleading for others with whom it is being shared.[51]

If those collaborating through these infrastructures are not able to relate one understanding to another or find synergies between different risk assessment frameworks, it becomes increasingly difficult to communicate why some data is included within a specific view of a crisis and others not. Responders need to know, for example, if relating their understanding of social vulnerability to another organisation's data on infrastructural instability is an accurate and relevant association to make. To ask questions like 'who could be the most vulnerable?', 'what could exacerbate a crisis?', 'how ought resources be distributed?' and 'who is responsible?', crisis practitioners need to be able to also ask how societal challenges are framed within the data, by whom, and what rationales informed the forms the ICT have taken.[52]

Each use of ICT needs to be paired with an actor's ability to ask questions and contest what about a crisis is communicated. Just as much, each actor needs to be

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[48] Sabina Leonelli, 'Locating Ethics in Data Science: Responsibility and Accountability in Global and Distributed Knowledge Production Systems', *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences* 374, no. 2083 (2016), https://doi.org/10.1098/rsta.2016.0122.

[49] Mark S. Ackerman et al., 'Sharing Knowledge and Expertise: The CSCW View of Knowledge Management', *Computer Supported Cooperative Work: CSCW: An International Journal* 22, no. 4–6 (2013), https://doi.org/10.1007/s10606-013-9192-8; Gina Neff et al., 'Critique and Contribute: A Practice-Based Framework for Improving Critical Data Studies and Data Science', *Big Data* 5, no. 2 (2017), https://doi.org/10.1089/big.2016.0050.

[50] Katrina Petersen, Rachel Oliphant, and Monika Büscher, 'Experimenting with the Ethical Impact Assessment as a Grounding Socio- Technical Practice'. *Proceedings of the ISCRAM 2016 Conference,* Rio de Janeiro, Brazil (2016), http://idl.iscram.org/files/katrinapetersen/2016/1364_KatrinaPetersen_etal2016.pdf.

[51] Stuart R Campo et al., 'Signal Code: Ethical Obligations for Humanitarian Information Activities', Harvard Humanitarian Institute, (2018). https://hhi.harvard.edu/files/humanitarianinitiative/files/signal_obligations_final_05.24.2018.pdf?m=1606847511.

[52] Elvira Uyarra, Barbara Ribeiro, and Lisa Dale-Clough, 'Exploring the Normative Turn in Regional Innovation Policy: Responsibility and the Quest for Public Value', *European Planning Studies* 27, no. 12 (2019): 2359–75, https://doi.org/10.1080/09654313.2019.1609425.

mutually responsive to the diversity of institutionalised and established approaches being folded together.[53] This does not come easy. After playing with one of these systems in a disaster training exercise, one responder insightfully noted: "they improve our awareness of each other, but we are not actually interacting." The mechanisms for noticing difference and building dialogue were proving genuinely challenging to design and teach.

Indeed, there can be great benefits to learning from different perspectives, helping to see what might be missed or biased in historical practices. Communication and data sharing practices have to take on new forms of reflexivity and adaptivity in order to make visible and engage with these logics. More specifically, the infrastructures need to support interpretive flexibility, so practitioners can best work with characteristics of crisis that are subject to situational, contextual, political, and social processes of interpretation.[54] For this to work, those engaging through these infrastructures need help not only seeing what can be learned from others or what they might have in common, but also help in communicating difference.

To do so, people need tools (in the broadest sense) to support noticing and critically thinking about how technology, data, and categories have politics and how that politics might affect others.[55] This requires articulation mechanisms, methods by which actors are able to be aware of others, express difference, and align activities in the moment.[56] These are practices that raise more than awareness; they raise engagement and reflexivity in relation to one's situation of interaction.[57] By

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[53] René Von Schomberg, 'A Vision of Responsible Research and Innovation', in Richard Owen, John Bessant, and Maggy Heintz (Eds) *Responsible Innovation: Managing the Responsible Emergence of Science and Innovation in Society*, (Wiley, 2013), https://doi.org/10.1002/9781118551424.ch3.

[54] Bernd Carsten Stahl, Job Timmermans, and Catherine Flick, 'Ethics of Emerging Information and Communication Technologies: On the Implementation of Responsible Research and Innovation', *Science and Public Policy* 44, no. 3 (2017): 369–81, https://doi.org/10.1093/scipol/scw069.

[55] Langdon Winner, 'Do Artifacts Have Politics?', in *The Whale and the Reactor a Search for Limits in an Age of High Technology*, vol. 109 (Chicago: University of Chicago Press, 1980); Lucy Suchman, 'Do Categories Have Politics?', *Computer Supported Cooperative Work (CSCW)* 2, no. 3 (1993), https://doi.org/10.1007/bf00749015.

[56] Gavin Doherty, Nikiforos Karamanis, and Saturnino Luz, 'Collaboration in Translation: The Impact of Increased Reach on Cross-Organisational Work', *Computer Supported Cooperative Work* 21, no. 6 (2012), https://doi.org/10.1007/s10606-012-9175-1.

[57] Julia Powles and Helen Nissenbaum, 'The Seductive Diversion of "Solving" Bias in Artificial Intelligencesolving Bias in Artifical Intelligence', *Medium*, (2018), https://onezero.medium.com/the-seductive-diversion-of-solving-bias-in-artificial-intelligence-890df5e5ef53; Jack Stilgoe, Richard Owen, and Phil Macnaghten, 'Developing a Framework for Responsible Innovation', *Research Policy* 42, no. 9 (2013): 1568–80, https://doi.org/10.1016/j.respol.2013.05.008.

encouraging these kinds of communication practices, the infrastructures can shift the conversation from what we do to who we are.[58]

Making this work means approaching infrastructuring in ways that include activities that take on a "more interpretative, intuitive mind-set."[59] These need to extend beyond questions that focus on the design of technology or communication practice to activities that more broadly treat infrastructuring as a way of thinking and approaching a problem. The data need to demand interrogation, explanation, and resolution in ways that problematise unspoken orders and struggles.[60] They need to reabsorb human complexity.[61] Just as much, the infrastructures need to support a crisis manager's understanding of their unique responsibilities with the data and the ICT.[62] They also need to support different communicative acts with the data, from binding people together to defending a position. Building such situated yet reflexive infrastructures can help make visible why some values or orders matter more in some circumstances and to some people than others.[63] In doing so, crisis ICT can become a means to share meaning as well as to build respect, to seek solidarity, and acknowledge differential impacts and needs.

Conclusion

As crisis practitioners work through ICT, the acts they take with data, in part, make the crises they are responding to governable.[64] But in making data shareable, these tools are also sharing different stakeholder and societal interests that may overlap, conform, or conflict, relationships that shift depending on the scale of activity.

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[58] Jessica Nicholson and Elizabeth Kurucz, 'Relational Leadership for Sustainability: Building an Ethical Framework from the Moral Theory of "Ethics of Care"', *Journal of Business Ethics* 156, no. 1 (2019), https://doi.org/10.1007/s10551-017-3593-4; Layla J. Branicki, 'COVID-19, Ethics of Care and Feminist Crisis Management', *Gender, Work and Organization* 27, no. 5 (2020), https://doi.org/10.1111/gwao.12491.

[59] Christian Bason, *Leading Public Sector Innovation: Co-Creating for a Better Society*, Leading Public Sector Innovation: Co-Creating for a Better Society, (2010), https://doi.org/10.1332/policypress/9781847426345.001.0001.

[60] Jasanoff, 'Virtual, Visible, and Actionable: Data Assemblages and the Sightlines of Justice'.

[61] Catherine D'Ignazio and Lauren F. Klein, *Data Feminism*, (Cambridge, MA: MIT Press, 2020), https://doi.org/10.7551/mitpress/11805.001.0001.

[62] Stilgoe, Owen, and Macnaghten, 'Developing a Framework for Responsible Innovation'.

[63] Danielle J. Corple and Jasmine R. Linabary, 'From Data Points to People: Feminist Situated Ethics in Online Big Data Research', *International Journal of Social Research Methodology* 23, no. 2 (2020), https://doi.org/10.1080/13645579.2019.1649832; Deborah Lupton, 'How Do Data Come to Matter? Living and Becoming with Personal Data', *Big Data and Society* 5, no. 2 (2018), https://doi.org/10.1177/2053951718786314.

[64] Ruppert, Isin, and Bigo, 'Data Politics'.

Through the data structures, different value and reasoning systems are pitted against each other, each vying for power and influence over how risks and responsibilities are defined.[65] The differences between collecting data on trapped people instead of the number of people needing evacuation can be nuanced, but fundamental to how risks are defined, to how meaning is attributed to vulnerability and resilience, to who gets the privilege of resources, and to who remains unseen. The ICT become material manifestations of these tensions, offering insight into the broader and competing agendas at play.[66]

They are also reminders that there are consequences for how we come to know the world.[67] Data infrastructures and the categories upon which they function are just approximations of the world, helping those looking to pay attention in specific ways.[68] Seemingly mundane design decisions, such as to include one set of data relations over another, have the ability to both empower and disempower actors, embed a community's values in a way that imposes them upon others, misalign two approaches to crisis management, or focus anticipation in a specific direction.[69] Each time a new potential form of data interconnectedness is created through these information infrastructures, new contexts need to be narrated, new features of society need to be recognised, new qualities of risks imagined. Otherwise, data inconsistencies have the risk of being translated into societal vulnerabilities.[70]

Communication in crisis requires that the data politics and data worlds be acknowledged.[71] Doing so asks for a shift in focus from how data might be shared or infrastructured to produce a more complete picture, to how data and its use might be more responsive to diverse perspectives and potentially conflicting societal needs in a crisis. This offers an opportunity to use these tools, along with their collision of differences, misalignments, and unexpected configurations, as a way to better understand one's own hidden values, assumptions, and historical experiences. They

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[65] Sheila Jasanoff, 'Epistemic Subsidiarity – Coexistence, Cosmopolitanism, Constitutionalism', *European Journal of Risk Regulation* 4, no. 2 (2013), https://doi.org/10.1017/s1867299x00003305.

[66] Griesemer and Star, 'Institutional Ecology, "Translations" and Boundary Objects: Amateurs and Professionals in Berkeley's Museum of Vertebrale Zoology, 1907-39'.

[67] Ribes, 'Notes on the Concept of Data Interoperability: Cases from an Ecology of AIDS Research Infrastructures'.

[68] Bowker et al., 'Toward Information Infrastructure Studies: Ways of Knowing in a Networked Environment'.

[69] Leonelli, 'Locating Ethics in Data Science: Responsibility and Accountability in Global and Distributed Knowledge Production Systems'.

[70] Sharon S. Dawes and Mohammed A. Gharawi, 'Transnational Public Sector Knowledge Networks: A Comparative Study of Contextual Distances', *Government Information Quarterly* 35, no. 2 (2018), https://doi.org/10.1016/j.giq.2018.02.002.

[71] Ruppert, Isin, and Bigo, 'Data Politics'; Gray, 'Three Aspects of Data Worlds'.

are an opportunity to enrich the kinds of understandings that can make underlying causes of crises more visible. This also opens the potential to conceive of worlds different than one's own situation, building an awareness that allows greater anticipation of crises in all their complexity.

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