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Instabilities: an Ethnography of Mexican Earth and Expertise

DISSERTATION

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DOCTOR OF PHILOSOPHY

in Anthropology

by

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ABSTRACT OF THE DISSERTATION

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The deadly Mexican earthquake disaster of 1985 still looms in personal and institutional memory and makes credible seismic threats still to come. Earthquake early warning technologies, developed in its wake, have implications for not only publics at risk and the distribution of power and authority among experts in the seismic community, but, finally, for what Foucault has called the security apparatus of the Mexican state.

In this dissertation, I explore the relations between earthquakes and technoscientific knowledge when public welfare is at stake. I argue that as the disparate experts of the seismic community of Mexico and around the world develop and debate earthquake early warning technologies, they make geophysical energies moving through the material world meaningful. With careful attention to the everyday meaningful imbrications of geological and social worlds and the forces, practices, tools, ideas, and institutions which constitute them garnered through research methods including participant observation, surveys, interviews, and archival research, I investigate how expert work and seismicity, both importantly unstable, produce the conditions of possibility for political encounters with the moving earth.

INTRODUCTION

Mexico is waiting for the next big earthquake. There's no way to know when it will come, but all available scientific evidence indicates that it will, and that Mexico City, one of the world's largest megalopolises, will suffer in it. A terrible earthquake and its aftershocks, unprecedented in the documented human history of the area, devastated Mexico City in 1985. In living memory of this upheaval, experts and ordinary people in Mexico have some basis for anticipating just how destructive and how surprising the next big one might be.

After the 1985 earthquake,[1] the nation's orientation toward what is now called disaster prevention—that is, the prevention of severe damage to human life and wellbeing—was transformed. Mexican territory has always been physically unstable, but this massive and unanticipated event had wide-ranging effects, revealing failures in regulation and policy and motivating the development of new institutions and strategies for dealing with seismic hazard. Among these was a technoscientific tool, an environmental monitoring system which can effectively transform encounters with earthquakes for publics at risk. The development and use of this system, while troubled, has had implications for Mexican public disaster prevention efforts and similar ones around the world.

Mexico's Sistema Alerta Sísmica, an expansive public earthquake early warning system, promised to give people in Mexico City over a minute of warning before the next big quake

[1] Officially named the "Michoacán" for its origin site and more popularly referred to with reference to the year it happened, this quake and its aftershocks can be understood as a single earthquake event.

hit when it went online in 1991. It was the first of its kind in the world, and made earthquakes available to experience and emergency response in a new way. For the first time, it was possible for people to take cover or evacuate a building in the seconds before an earthquake even began to shake them. It was developed by an NGO with state support, and by now they have expanded its reach with user communities and sensory stations across the nation. Since then, this technology has been supported and debated diverse experts, a "seismic community" of policymakers, engineers, scientists, entrepreneurs, sociologists and anthropologists. It has not been developed within the logics and by way of the practices, priorities, or ideas that inform the various distinct pursuits of these experts, which may be somewhat coherent in their treatment of seismic phenomena and its implications. Instead, the principles of public earthquake early warning remain unsettled.

For public earthquake early warning, sensors are arrayed across Mexico. They register earthquakes, algorithms automatically process data to quickly ascertain how powerful they are likely to be, and based on this, alerts are broadcast to user communities. In every step of this process, including the placement of sensors, the bases on which large earthquakes are distinguished from smaller ones, and how users are alerted, system authors are implicated in complex decisions. The principles upon which they make these decisions and even how their successes can be distinguished from failures are subject to intense and ongoing debate within the community of experts concerned with disaster prevention. As I discovered in the course of my research, not all Mexicans receive alerts, not all alerts are timely, and not all timely alerts warn Mexicans about earthquakes that will shake them violently. Some alerts warn Mexicans about earthquakes they cannot feel at all.

Immediately after the 1985 earthquake, there were massive investments in new institutions and projects, among them the Sistema Alerta Sísmica Mexicana. This system was developed to help prevent another disaster like 1985. Members of the seismic community decided to array the first sensors of the system along stretch of coastline likely to produce seismic upheaval of similar magnitude to the terrible 1985 quake, and they maintain it in a state of readiness because that quake could happen at any time. The system was originally funded by and built around vulnerable Mexico City, still recovering from the destruction and loss of life. Its designers developed partnerships with radio and television stations so that anyone in that seismically sensitive areas might have some warning when the next big one was on the way.

1985 still looms in personal and institutional memory and makes credible seismic threats still to come. However, earthquake early warning makes other kinds of earth motions important for its designers and its users. Technical decisions about how to deal with ordinary, everyday instabilities of seismic Mexico—that is, the unpredictable earthquakes small and large that constitute Mexico's seismicity— have been essential to the development and critique of earthquake early warning technology. This technology has implications for not only publics at risk and the distribution of power and authority among experts in the seismic community, but, finally, for what Foucault has called the security apparatus of the Mexican state.

In this dissertation, I explore the relations between earthquakes and technoscientific knowledge when public welfare is at stake. I argue that that as the disparate experts of the seismic community develop and debate earthquake early warning technology, they make geophysical energies moving through the material world politically meaningful. With careful attention to the everyday meaningful imbrications of geological and social worlds and the forces, practices, tools, ideas, and institutions which constitute them, I trouble narratives about risk which focus only on major events in the past and future. Instead, I investigate how *ordinary* expert work and *ordinary* seismicity produce the conditions of possibility for political encounters with the moving earth.

Putting the Sistema Alerta Sísmica Mexicana at the center of my research allows me to explore expert practice and the constitution of meaningful seismic instabilities. In the context of the development and maintenance of this earthquake early warning system, my ethnographic research reveals Mexican techno-optimisms, powerful but distinct from those which may emerge in richer nations. These differences, and their mutual constitution, have become especially evident as Californian scientists struggle to develop an earthquake early warning system similar to the Mexican one.

This dissertation was researched between 2011 and 2015, and written, largely, between the spring of 2015 and spring of 2016. It began as a project on technoscientific expertise and public earthquake risk, but the complexity of seismic instability, and the difficulties negotiating its demands and affordances outside of the more-or-less intelligible rules of engagement which make the realms of geophysical or engineering disciplinary expertise coherent, upended these plans. I found myself researching, not the likelihood of a major earthquake and translation of that risk from a matter of scientific concern to one for publics, but rather negotiations over how seismicity matters. This dissertation, necessarily documents a politics of expert knowledge about the earth (of which there is both a long history and a vibrant contemporary literature) and engages with work in anthropology and other fields on material and energetic agency. In the next pages, I introduce these issues before describing more fully what I mean when I refer to instabilities not just underground but in the seismic community's approaches to disaster prevention. I then describe the dissertation's methodology, and, finally, an overview of the chapters to follow.

Seismic knowledge and its politics

Perceiving, analyzing and representing the geologic are concerns that have been subsumed, in the academic world, within the earth sciences— a much-divided group with different academic training. Today, earth science means primarily geophysics and geology, but also incorporates engineering at times, particularly those engineers with civil or structural specialties or those who, like many of the Mexican experts who took time to share their work with me, have come to undertake projects around seismicity. These experts, for all their differences, understand earthquakes to be caused when pressure builds up at some site in the earth's crust and then is released in one way or another— a volcanic explosion, a grating of land against itself, a collapse of something into something else which comes to be a problem for public safety when the energy in question shakes areas people live in and move through.

I was not trained in earth science or engineering. However, I trace negotiations around authority and knowledge, and was able, through participant observation, archival research, and interviews, to learn something of how my informants in the Mexican seismic community worked to contribute to and contest state-sponsored disaster prevention efforts. My informants' efforts are a matter of a politics of knowledge in three senses. First, my informants perform ongoing contests over authority in multidisciplinary policy spheres. Second, their efforts entail actual impact on state policy that must be negotiated in and through formal political means. Finally, they can now participate in determining the relevance and subsequent distribution of seismic risk and safety through out Mexican territory. While the terms of their politics may be unique, they are part of a long tradition of engagement with both social power and earth.

What I call the "seismic community" here not a closed group, but rather a name meant to designate a shifting collection of experts trained in a variety of fields but advocating for public safety, using their diverse technoscientific expertise in or in alignment with government projects, sometimes as functionaries, members of official committees, or otherwise instrumentally involved in state projects— positions which their expertise and their connections insure that they can achieve and rotate through. Most are based in Mexico City, where the issues of seismicity that I focus on here are of particular concern. Core membership is primarily male, and many are middle-aged, with substantial ties to each other through friendship, family relation, status as *compadres* or godfathers to each other's children, or experience with shared mentors. Perhaps several dozen Mexico City community leaders meet regularly at events and on committees, occasionally joined by leaders from across Mexico and the world with similar areas of expertise and matters of concern. Their students, coworkers, and people of related interest and expertise are present at these spaces too; members in the seismic community by way of interest and knowledge, though not necessarily as influential as core members**.** All are, without a doubt, an educated elite, but unlike the Mexican technocrats described by Camp (2012) and others, they are not working to use theoretical training to profoundly pivot state practice. Their influence indicates the power of technoscientific knowledge to persuade, but their perspectives are more diverse and the agendas that they advocate for and debate over are less radical than those technocrats have pushed.

The work my informants spoke to me about and allowed me to watch them perform— and even, occasionally, assist with— as part of a history of disciplinary engagements with earthly phenomena and its meanings. Ideas about what the land is like and how it came to be so have been called "geontological" in recent anthropological accounts of meaning-making which attempt to consider how ideas about the world entangle assumptions about what can count as life and non-life, provincializing, as Chakrabartay (2000) might put it, various humanist or bio-ontological philosophical articulations of subject, object, and agency to frame geological encounters. These issues, however persuasively articulated by contemporary thinkers, are not new; geological processes have challenged and undermined thinkers before.

In the nineteenth century, the Western Europeans at work developing the basis of the technoscientific disciplines that my informants in Mexico practice today wanted to map the particulars of those processes across history to construct a real biography of the earth, study its pasts and its potential futures. For this, seismic events, particularly massive ones, were key. One primary problem around which investigation was oriented involved the relationship between the world rendered in stratigraphic record and the present. Had the laws of physics and earth systems always been the same, as Uniformitarian thinkers suggested, or had there been periods of great upheaval in which the mountains and seas had been formed, as Catastrophists did? Previously, history had been painted with a "very broad brush," wrote historian Martin Rudwick (2008, 3) co**v**ering time and space both in quite general terms, or had been undertaken in very detailed local vignettes (focusing, again, on the reality of events in the deep past rather than their explanations, as, for example, geophysicists would one day do). The nineteenth century saw an integration of the two (Rudwick 2008), and that integration meant new tools to get at what historians have called "geontology": local and particular examples that could reflect larger trends, suggesting universal conditions.[2]

By the late 18th and early 19th century, when geological texts were more en vogue in England than any other kind of popular science (Shortland 1994, Bowker 2005), experts went around the world to look at particularly evocative or obvious sites to become faced with the overriding evidence of their own sight (for example, Lyell 1860 and von Humboldt 1850). These investigations, then, required field scientists (mostly independently wealthy but some just happenstance or funded by royalty, see Rudwick 2008, Walls 2009) to perform them, to experience sometimes-sublime encounters with deep time in geological

[2] A term that has since been taken up by Elizabeth Povinelli in efforts to unthink some of humanism's heritage.

formations, and to report to their peers. Thinking through abstract philosophical principles simply no longer did the trick.[3]

While Wolf demonstrates frames his wide-ranging overview of Mesoamerican anthropology and history, *Sons of the Shaking Earth*, in seismic instability, the development of contemporary scientific institutions was motivated strongly by resource extraction: first in silver and then in petroleum. In what historians call an emphasis on “useful arts,” (Saldaña 2006, 62) schools in what would one day be Mexico during the 18th century were created to “provide scientific and technical instruction,” (Saldaña 2006, 53) often with financial support of mine owners and merchants. Among these schools, the Real Seminario de Minería, founded in Mexico City in 1792, was particularly luminous. An important institution for the professionalization of engineering as an area of expertise, the Real Seminario was also a site of experimental and theoretical science. It the stuff of cutting-edge geontological theory and debates alongside “useful arts” (Azuela 2007), though always couched in certain practical applications: the best scientific training to be had in New Spain was about the earth— mines, particularly. The Real Seminario was the cradle of the institutions of Mexican science that followed it, particularly the Universidad Nacional

[3] in this, nascent earth sciences had a great deal in common with anthropology’s disciplinary heritage; Lyell, the nineteenth century Uniformitarianist scholar who took Britain, in particular, by storm, was a pivotal figure for both geoscientists and anthropologists: with his popular first work, rather hubristically titled Principia Geologica (1830, named after Newton’s foundational work) and his subsequent Geological Evidences of the Antiquity of Man (1863), his work was caught up in arguments not only about the age of the world and of humankind (1855) but also about the historical biological unity of the human species, eventually arguing for a 20,000 year timeline for the species and of single origin dispersing into “distinct races” and “different communities… each exposed for ages to a peculiar set of conditions” (Lyell 1863, 386). For scholars in the Victorian era, then, working with large amounts of data from multiple places was attractive means for constructing overviews of social life (see Stocking 1996, Raffles 2002, Daston and Park 2001, James Clifford 1990).

Autónoma de México, or UNAM, in Mexico City. In the course of my research, informants have reminded me with pride that it was granting doctorates while wild animals were still roaming the grounds that Harvard would be built upon. Much of the seismic community involved in developing and contesting the Sistema Alerta Sísmica Mexicana were trained there, and some still teach in its classrooms or advise its students.

There is a great deal of earth, moving in slow, inexorable, complex ways and even with contemporary instrumentation, only so much is measurable. In their proper disciplinary areas of engagement, contemporary geophysicists, geologists, and engineers have ways of negotiating with the kinds of knowledge it is possible to have about the earth; particularly about how and why earthquakes are produced and how they resonate through and out of soils. Pursuit of knowledge of the underground has not only been important for their ongoing disciplinary work, but has become key to the territorialization of sovereignty (Braun 2000) and technologies for rendering volume are becoming more sophisticated (Elden 2013, Bridge 2013, Steinberg and Peters 2015), and encounters more motivated by extractive projects (such as those documented by Bebbington 2012, Wylie and Willow 2014).

The underground offers not just an important field of knowledge for state projects and commercial interests, but a setting for thinking about tensions between what is hidden and what is revealed (as explored in very different ways by Yusoff 2013, Williams 1990, Lesser 1987). Like much that happens in underground, earthquakes have come to be symbolically potent, too, and deployed beautifully in arts and even in ordinary expressive language.

However, for all that writers deploy the "seismic shift," the community I document here is motivated to treat seismicity in its material, energetic particularities by their everyday work. 1985 changed things, but the ways that real irregular and ongoing earth motion comes to inform their work leads me away from attention to "seismic shifts," "ruptures," and "revolutions" of the sort that Latour (1993a) notes that we Moderns are so problematically fond of declaring and pushes me to investigate other ways that earthquakes come to be meaningful in and for contemporary technoscience.

Seismic energies

The 18th and 19th century fluorescence of interest in geontological debates about the history of the planet was supported by the development of new technologies and modes for rendering quakes. An interest in the particular qualities earth in motion only developed in the European scientific community in the second half of the nineteenth century. The earth science became less and less a matter of what Daston and Galison call "truth to nature"—that is, the strategic deployment of an ideal type either found or strategically exaggerated to render clear features deemed relevant (Daston and Galison 2010, 60) —and more a mechanical objectivity that relies on impartial machines (ibid: 139). When they take these shifts on, contemporary English and Spanish -language geophysical textbooks and histories begin to indicate broader international dialogues (Good 2000, Oreskes and Fleming 2000, Lomnitz 1974, Bolt 2005) It was only in the late nineteenth century that Italian, German and Swiss scientists worked in concert with British and Japanese researchers to begin develop the kinds of instruments that are still used today to detect earth motion and systematically document their long-range sensory capabilities.

When earthquake historian Deborah Coen argues that “the world became shakier in the nineteenth century,” (2013, 2) she conjures a confluence of trends: new technoscientific strategies for measuring earthquakes, the popularity of geologic inquiry, new abilities to travel and correspond across distance for scientists and , of course, political and industrial upheavals in the way that people lived. Public attention to ordinary trembling in the 18th and 19th subsided, as Coen writes, around World War I, as the newspapers filled with new horrors. Meanwhile, new technologies made seismic instabilities the subject of and available for mechanical objectivity and analyses among a smaller community of experts.

When I read about earthquakes today in the idiom of earth science, I encounter a quantifiable physical phenomenon. Seismicity is a matter of energy released within the land and moving, at different speeds, through the various substances of the earth’s lithosphere. The model of the earth that we use today is about heat, pressure, layers and motion. There is a core, an inner and outer mantle, an upper mantle, and on top of it all, a cracking floating folding melting growing crust. It is perforated with volcanoes and seamed with mountains. Deep trenches split it, and out of those molten rock wells up to form more of it. The crust moves away from itself, but also folds up, is driven under and grates against itself. For all that my informants' disciplinary forbearers might seek out and work to evoke the geological sublime in their writing (see White 2012, Shortland 1994), earthquakes are now commonly characterized by means of quantification: in terms of their size, that is, their magnitude at source or the acceleration that they subject a site to, how long they last, and their appreciable effect in the built environment, as in the Mercalli and Shindo scales. There are a variety of ways that this energy can be surfaced for conceptual work.

Earthquakes are energy moving through material. In some senses, this makes them like the wave forms that Stefan Helmreich described in his recent Morgan lecture, “entities at once material and measured, concrete and conceptual” (2014, 267). That is, they can be encountered in their particulars but have so much to them that abstractions are necessary for the kinds of treatment that I study. However, seismic energy is not material in the same way that Helmreich's wave prototypes in ocean water are. They are sound waves; vibration. While vibration exists in the material world, as Shelley Trower writes in her book on the topic, "Vibration is not itself a material object at all, but is bound up in materiality: vibration moves material, and moves through material" (2012, 6). Seismicity is available for encounter through materials of soil, water, and built spaces, but in a manner with particular and very specific concerns regarding registration and measurement, entangled with histories specific to thermodynamic systems and their analyses (as in Barry 2015, Stengers 2010).

As Daniel Miller (2005) points out, anthropologists have been investigating how materials come to be meaningfully animated since the very genesis of our discipline, and encountering there some of the same kinds of tensions between subject and object (and between philosophy and ethnography) that energetic phenomena seem to demand. The origins, sites, and properties of agency (or perhaps 'ability to do work,' as physicists define energy) is not, however, a new project.

Energy has been a recurrent concern for anthropologists. Anthropologists focus on energy as commodity and resource they consider, in Dominic Boyer's words, **“**how energic forces and infrastructures interrelate with institutions and ideations of political power” (Boyer 2014). This focus has been developed in a rich tradition of attention to imbrications of different kinds of energy, and its powers to do both material and symbolic work.

However, this is not the first appearance of energy in anthropological scholarship. In the mid 20th century, it was a matter efforts to address biological and cultural concerns simultaneously— concerned with how, in Leslie White’s words, “the life process” is sustained (1959, 34). There, the laws of thermodynamics were extended from the caloric to the social, and harnessing energy came to be a means by which advancement could be determined. Roundly criticized for its universalism and opposition to Boasian relativism, these efforts to theorize energy nonetheless frame ongoing work on resource extraction and cultural ecology. Inasmuch as it attends to how disaster prevention has been figured by scholars and policymakers, this dissertation is a study of some of the effects that these mid 20th century models of cybernetic environmental systems have had in the world.

These traditions indicate is the utility of attention to empirical meaning-laden social engagements with the production, motion, and effects of energy — some of which inform more than just my anthropological perspective on ongoing, every day seismicity but have been taken up themselves to inform the goals and methods of disaster prevention.

Instabilities

The ground beneath Mexico is essentially unstable, and this has been a concern for a number of technoscientific experts. Ongoing earth motion can shake people physically in different ways, depending on where and how they encounter it. Seismic motion offers a variety affordances for knowledge projects, too. New technologies of earthquake early warning entail new practices and meaningful encounters with these physical instabilities. In this dissertation I explore how significant seismicity and the seismic community are co-produced. Ethnographic attention to the seismic community and their technoscientific knowledge politics, however, reveals not only a social, technical, and material constitution of significant seismicity, but one which is far from uniform or uncontested in its details. The instabilities of seismicity offer affordances for instability in technoscientific ideas; spaces for political contestation and for conflict, some of which is reconcilable but some of which is built on such radically different conceptions of seismicity and disaster prevention that it may not be.

The production and reproduction of coherent and integrated assemblages of ideas, practices, and social roles have animated many anthropological investigations. Much social science has been concerned with internal stability of society (as in Durkheim1893); functionalist research famously considers social practices with respect to the physical and material needs of human beings (such as Malinowski 1932). Efforts to evaluate how cultural practices incorporate environmental conditions (as in Steward 1955 and 2006) or considering societies in ecological relation with these conditions (as in Harris 1979, Vayda and Rappaport 1968) are not just influential in anthropology's history, but have informed

Mexican disaster prevention work themselves. These are designed around the promise that intervention into complex systems of relation can reduce the impact of a hazard like an earthquake; that, in the language of Norbert Weiner's far-ranging and widely-influential 1948 cybernetic systems theory, certain kinds of governance can regulate a system and keep it stable. Ideas about the how disasters can be prevented hinge on the notion these systems might be modified or intervened upon to make hazards like earthquakes less disastrous.

The relation between social practice, technological intervention, and material environment is of concern for my informants, motivated by the threat of seismic disaster to consider how people might be put in danger and how they as experts can use their technoscientific knowledge to intervene and defang seismic threats for a public at large. I have suggested already, though, that the efforts and goals by which some members of the seismic community conceptualize and undertake these projects can be inconsistent with those of other members, drawing on ideas and incorporating practices that run counter to each other in their engagements with seismicity and with publics at risk and which can even undermine mutually-agreed-upon goals.

Seismic instabilities come to be meaningful for the seismic community's efforts in the context of practices, models, ideas, and stakes around projects like the Sistema Alerta Sísmica Mexicana, opening spaces for flourishing contests over authority. These contests suggest instabilities of the seismic community's approaches to disaster prevention.

Here, unpredictable ongoing seismicity offers certain affordances for such instabilities, especially in the context of the wildly varying qualities of soil and built environments across Mexico and, the dramatically limited resources that the Mexican state has available to do disaster prevention work. These do not tear the community of experts apart nor facilitate a dysfunction which might destroy the kinds of systemic relations that functionalists and neo-functionalists render. Instead, scholarship on expert communities and knowledge practices suggests that such disjunctures in ideas and practices may be considered commonplace within technoscientific communities. Stabilization should be considered the result of continual, coordinated effort, and not expected to be a basic social condition, especially not at the scale of a single project.

The language of stability and instability has a substantial history in research on expert knowledge and practice. Even setting aside totalizing Kuhnian work on paradigms, research on the basic terms of engagement with the world that has entailed working through such ideas. Stabilization is key to Bruno Latour's description of Modern science (1993a) and the "hardening" of facts (1993b). Pickering (1992) explains that stabilization happens when "all of the different elements of scientific culture that one might care to distinguish— social, institutional, conceptual, material—evolve in a dialectical relation with one another" (1992, 14).

This, indeed, is often a matter of the kind of practice through which expertise and its objects are called into being. In her "History of the Modern Fact," Mary Poovey documents this kind of coordination carefully (though she does not use the term stabilization) as she addresses the complex production of what she calls “epistemological units like facts,” as well as institutions which “ inform *what* can be know at any given time, as well as *how* this knowledge can be used,” (1998, 5, italics hers)— that is, for her, the means by which an epistemological unit might be constituted, recognized, deployed, tested, contested, or discarded.

The well-documented unpredictability of seismic motion and the new public importance of minor tremors as well as major ones that emerged with the use of earthquake early warning provides certain challenges for those who would know it and intervene upon in public space. As I will document in this dissertation, the nature of a seismic emergency, pertinent measurement of seismic phenomena, and how phenomena in the more-than-seismic to and made visible has become troublesome here and matters for political (in all senses indicated earlier) contestation in ways that these issues simply are not when they are pursued for other purposes, or in other contexts.

The stabilization of institutions, epistemological units, or "elements of a scientific culture" is an ongoing, performative process (in the sense that Callon has used the term, 2007 and 2010), and the promise of a form of dynamic and resilient environmental and social stability, conceptualized along different lines but with similar principles of complex systemic relation, motivates interventions into disaster prevention. In this context, it can be no surprise when stability in concepts, practices, and goals sometimes escape members of the seismic community when they work on projects for public disaster prevention.

What Joan Fujimura might call the "package" of agents, processes, ideas about earthquakes are not entirely shared. between disciplines or institutions to facilitate what she calls “collective work by members of different social worlds and fact stabilization” (Fujimura 1992, 176). For all that the Mexican earthquake early warning system was built in response to the threat of major earthquakes, the kinds of decisions that this kind of technoscientific intervention into public safety makes necessary have made ongoing shaking a key focus of attention and dissent. Still-unsettled challenges about how earthquakes might be dangerous, what kinds of earthquakes people might benefit from early warnings about, who should be alerted to them, and how this alerting should be done— and even the ways such issues might be assessed or the terms by which they might be debated— allow ordinary earthly instability to make instabilities in the concepts and practices of disaster prevention possible.

Studying a technoscientific system

Mexico’s seismic histories, and the ideas about the energetic and material environment’s relation to people at risk, are evident and continue to be rendered in the context of the design, maintenance, contests, and neglect of earthquake early warning technologies and related disaster prevention institutions. Long a site for complex and often extractive geological and geontological projects, Mexico today is a privileged site of geophysical knowledge production, among the most important national spaces in this field, although its status as a middle income nation make national participation in that technoscientific work very different than it is in richer nations like Japan and the US. Researchers in seismology and volcanology are international leaders in their fields and guide policy not only in Mexico but throughout the world. As US scientists develop their own earthquake early warning system in California, the seismic community that this dissertation focuses on has been drawn into international work through which uneven geographies of power are both challenged and rearticulated.

The earthquake early warning system that I document in much of this dissertation was planned around Mexico City and the likely origin site of major earthquakes, for all that dealing with ordinary seismic instabilities became essential to its design and development. However, in the intervening decades, it was extended through Mexican geography. Where once it had 12 sensory stations, now it incorporates 98. While Mexico City was once the community it was designed to alert, now there are six cities that can receive its alerts when earthquakes are imminent. Just as users have proliferated, so have modes of accessing alerts. In recent years, cognate and semi-integrated systems have been built. Earthquake early warning remains a project in which the seismic community works out, though does not settle, priorities, ideas, techniques, and relations to public safety and energetic threats of an seismic environment.

In this dissertation, I investigate how earthquake early warning makes possible meaningful relations between a moving earth and human safety. Studying the earthquake early warning system allows me to put analytic focus on how and what it makes meaningful in different contexts, terms, and debates. I can consider not just its presence but how it comes to be taken up or operate as a political object, an object of political knowledge, in different arenas— particularly as it has been deployed to operate within complex environmental and social systems. By these means, I can get consider the practice of disaster prevention; rendering how seismic energy offers affordances for and is taken up in high-stakes technoscience.

This dissertation research took place over a period between 2011 and 2016, entailing over 17 months of fieldwork in Mexico and the US. My fieldwork, while largely ethnographic in nature, relied heavily on archival work. Generous access to the archives at Mexico's disaster prevention institute, CENEPRED, and libraries of CIESAS and Universidad Iberoamericana, facilitated investigation into the instability of the seismic community's approaches to disaster prevention and risk management in the wake of 1985, as well as the design and development of the Sistema Alerta Sísmica Mexicana.

At this writing, I have met with members of the seismic community in offices and boardrooms across Mexico and California. I have visited conferences, talks, and gatherings of geophysicists, earthquake engineers, and even earthquake early warning specialists. I went to cafes, offices, and homes, and performed life history interviews with a variety of people professionally involved in disaster prevention.

I spent eight months visiting the offices of CIRES, the Centro de Instrumentación y Registro Sísmico, the NGO organization that has developed and maintained the Sistema Alerta Sísmica Mexicana with funding from various Mexican governmental entities since its inception. Many of the 70-some men and women employed by CIRES were generous with their time and their reflections, working to help me understand the everyday labor that allows this system to run. At their headquarters in Mexico City, I conducted surveys, interviews, sat in on and sometimes took an active role in meetings and events, and followed engineers, technicians, communications professionals, and administrators in their ordinary work. I met with entrepreneurs building semi-integrated or cognate earthquake early warning systems, toured their offices and investigated their equipment too, as part of the work of investigating the Sistema Alerta Sísmica Mexicana was investigating other means of pursuing the same kinds of ends, and considering how one or another might come to be taken up by different users.

In Mexico City's Centro Historico as well as Chilpancingo, Guerrero and Oaxaca City, Oaxaca I spoke about earthquake safety with communities using the Sistema Alerta Sísmica and other means for earthquake safety. There, I met with officials, engineers, teachers, sociologists, policymakers and department heads whose responsibility it was to make disaster prevention work for the people they worked with and for whose safety they were, in some way, responsible. I shared lunches, coffees, and long walks with these people, and joined them for long meetings and even conferences. Our more and less formal interviews helped me get a sense of the urgency and confusion which can inform disaster prevention efforts on physical and organizational scales that vary from city-wide to that of a single building or even room.

I am a member of the user community, myself: I have been sent out to a Mexico City street at night with my shoes still untied by an earthquake alert. This dissertation draws on all those experiences, conversations, and materials in order to consider how the earth's motions are taken up in and made meaningful through technoscientific knowledge and practice, and how, in this way, the shaking earth comes to be a matter for Mexican state sovereignty.

Risk and ongoing seismicity

This research began as an attempt to engage with risk; with, particularly, the imbrications of probabilistic earthquake forecasting. I learned in my earlier work on high-risk organ transplantation that risk can be quantified in fascinating ways, but can nonetheless be very difficult for non-experts to make sense of, especially when they are frightened of the implications of risky events. I was interested in how earthquake forecasting was being taken up by experts, and how their forecasts might come to be translated for public use.

One defining characteristic of earthquakes, as far as the earth sciences are concerned, is their unpredictability. Predicting the location, magnitude or timing of earthquakes with any accuracy (as defined by the National Academy of Science Panel on Earthquake Prediction in 1976, see Geller 1997) is simply not possible with current technologies and knowledge. Some may, however, be heralded by signs such as pre-shocks, gas release, which scientists are still researching. What most researchers are left with is forecasting by way of statistical analysis of historical quakes.

I had understood notions of risk to depend on historical, disciplinary, and social context. While, as Mary Douglas writes, once the word "risk" might have referred to gain or loss, it has now "been preempted to mean bad risks" (1990, 3). These "bad risks" or "harms" are generally understood to be measurable and can be attended to through probabilistic projection (Daston 1988, Hacking 1990), themselves tools used to reduce fear (see Daston, 2008).Even as they become quantifiable, they are understood often to cascade, incorporating unexpected and unexpectable admixtures and entailments (Fortun 2001, Petryna 2006), and people often respond to and mobilize the qualitative experience of engaging with them, too (as in Massumi 2005, Lakoff 2008, Woodward 1999).

But in my readings around risk, I did not think about the basic presence of seismic activity and what it would (and could be made to) mean. For all that this ethnography takes technoscientific work as its focus, in many ways it resonates with the way that Eric Wolf made a state of constant seismicity both a defining feature of life and a world-ending threat in his sweeping 1959 overview of Mesoamerican histories, geographies and cultures *Sons of the Shaking Earth.* In the researching and writing of this dissertation, "risk" began to seem too easy to discuss, its components, whether qualitative or quantitatively rendered were simply too epistemologically settled to provide terms for the kinds of technoscientific efforts and contests about that earth and its effects which I saw unfolding around the Sistema Alerta Sísmica Mexicana.

The first chapter of this dissertation, *Grounded Histories,* is a matter of histories and soils, inflected with political meaning. Neither the availability of sensitive subterranean materials as a site for a massive megalopolis and the importance of that megalopolis should be taken for granted. In the next pages I will describe the political history of these soils and the meaningfulness of their effects long before 1985.

In the second chapter, *The Production of Emergencies*, I am interested in pursuing the implications of this multiplicity by attending ethnographically to practices around earthquake emergencies. Here, I surface the ways in which experts connect earthquake early warning system function to threats to users in order to investigate the nature of the earthquake emergencies that these systems make possible in Mexico and elsewhere, in relation to earthquakes and events *about* earthquakes, like the one that pulled me off my air mattress in September 2015, tripping over my own feet and frightened, but never shook me at all. I seek to highlight how emergencies are materially, socially, and technologically produced, and, as such, how they are contingent, plural, and contested. When the meaningfulness of emergencies is investigated rather than naturalized, the production of relation between cause and effect, for all its fractured relations, demands, and tensions, can be addressed, too.

In the third chapter, *Measurement and the Moving Earth*, I follow some of the practices and uses of quantification that engineers at CIRES undertake themselves and advocate for, both to other experts and to users, in order to make the Sistema Alerta Sísmica function as effectively as possible (for a given set of goals). By this quantification and the work that it enables, the people I'll describe articulate a place for themselves as *engineers* and their work *as* engineering. I argue here that reflecting on, performing, and communicating about quantification and its uses is a key way in which engineers attempt to intervene on how others relate to earthquakes. I address the work of quantification context of, first, the ways that engineers frame their efforts to measure earthquake effects, and second, the ways that engineers work to make these measurements useful to users. Tracking how earthquakes come to "count," so to speak— or, perhaps more to the point, the ways in which my informants work to make them countable and then to make that form of counting really significant for users— provides an important opportunity to reveal how earthquakes come to be treated by and have effects in expert practice and the sociality of the authority that they try to conjure—the sociality and authority of engineering.

In the fourth chapter, *Managing Sense in a More-Than-Seismic Environment*, I explore the ongoing work of managing the Sistema Alerta Sísmica Mexicana as it extends through and develops in the material, social, and technological environments. First, I focus on considerations of the system from the center of its technical network, describing it as a whole and how social pressures and techno-politics along with the action of tectonic plates and faults underground have been made to inform the development of the Sistema Alerta Sísmica and continue to frame its futures. Then I discuss its component sensory stations in situ, considering the "field" in which they sit as a type of place before highlighting how the physical and social environments encountered there come to be understood as problems to be intervened upon. Finally, I address work on the network in the context of the onslaught of frightening violence that has recently haunted some of the most seismically active territory in Mexico. Attempts to manage how the network, its stations— and the field teams who work on them— respond to and engage with these forces have been particularly demanding.

In the fifth and final chapter, *Disaster Prevention and the Mexican Security Apparatus*, I give an account of an unstable and only partially integrated Mexican security apparatus. I describe how state approaches to earthquakes and other hazards were transformed by an earthquake in 1985. As I do so I consider not just the coordination of a security apparatus, but the contingency and trouble that define this coordination. First, I discuss the National System of Protección Civil, an institution which has been developed since 1985 to conduct disaster prevention and more modest risk management efforts. Then, I consider the interventions into everyday life that this institution makes possible—because, as I will show, a value of possible that looks, from some perspectives and in some cases, very like impossibility. Within earthquake early warning, values and priorities around emergency, measurement, and complex environments are unstable.

I felt three sizable earthquakes while I was in Mexico. They were of sufficient intensity and length to frighten me, to send me out of a building or under a desk for shelter. I was unhurt, and, in fact, no one was reported hurt at all in any of them. There were others that I did not feel, or did not notice feeling. This dissertation is not, by and large, about those experiences, though the confusion of the unsettled unexpected motion have been important for me to think about as I write about seismic motion and disaster prevention. Drawing on research that spans five years, two nations, and makes use of diverse ethnographic and archival methods, I develop an integrated account of how material instabilities come to inform and be taken up in technoscientific disaster prevention efforts. Focusing on expert practice allows me to query how those efforts take the forms that they do. Meanwhile, the thermodynamic movement of tectonic plates and the subsequent release of seismic energy through soils, water, built environments, bodies and air continues.

Chapter 1

GROUNDED HISTORIES

Contemporary seismic instability in Mexico is always happening in wake of one shocking disaster, still recent and lively in memory. The earthquake that exploded from six miles off the coast of Michoacán state and nearly 12 miles beneath the Pacific Ocean floor in 1985 was bigger than anything else on record for that area: measured at magnitude 8.1 by the Mexican National Seismological Service, its strength could be compared to TNT by the megaton or the meteoric impacts. In all of Earth's massive underground thermodynamic system, there is rarely more than one earthquake of this size per year. While the energy of the 1985 earthquake off Mexico's coast dissipated through soils, oceans, and air, leaving in many places no perceptible traces at all, it is very appropriate indeed to compare it to the kinds of events which leave craters many miles wide. Somewhere between five and twenty thousand people lost their lives in Mexico City alone (official reports vary drastically and disturbingly), and many more were seriously injured. Perhaps two hundred and fifty thousand were left homeless.

The 1985 quake was terrible, and a massive turning point; today it is considered a pivot point and moment of great change. After this earthquake, Mexican institutional practices around seismic hazard, and disaster prevention more generally, were transformed. New agencies, regulations, policies, and organizations were funded, and even today their political, social, and technical configurations and priorities can be easily traced to that 1985 subterranean rupture and the damage it caused in Mexico City. While I will address these various configurations in subsequent chapters, here I consider the conditions of possibility for the contemporary Mexican technoscientific efforts to reckon with seismicity, which include the 1985 quake but not, perhaps, in as straightforward a way as one might expect. I put the 1985 earthquake in the context of a material, technoscientific, and social history of Mexican seismicity. The 1985 earthquake did not come to be disastrous, or politically important, simply because of its size, but not just any quake could have had its impact. This chapter is not only an engagement with an important event in Mexican history but also constitutes an investigation into the means by which a single material event can come to matter so much, motivating action in communities with such different ideas about seismic disaster prevention and how it should be undertaken.

Earthquakes themselves never been uncommon in this territory, although they are rarely so devastating as the Michoacano quake of 1985. The Ring of Fire that circles the Pacific Ocean in violent earth motion and volcanic activity is especially active along the Pacific Coast. Seismic activity, then, is a basic condition for geography and geology, and as nations along the Ring of Fire have urbanized, it has been an important to the design of the built environment. It is in this context that Chilean civil engineers wrote for the UN's Centre for Housing, Building and Planning of the Department of Economic and Social Affairs:

> "Earthquakes are implacable judges that expose mistakes and carelessness in the design, construction and use of buildings, the exposure of flaws being the punishment imposed by seismic disasters on those who have shown bad judgment..."
> (Ayarza, Rojas, and Crisosto 1977)

Earthquakes have marked seismically active areas not only, as the above suggests, in revealing "mistakes and careless design." They certainly do inform ongoing development understanding of the material and built environment, what it might do, and in the process they reveal conditions and propensities that might otherwise remain hidden. How seismicity's effects are understood, and what earthquakes come to reveal, how, and to whom— these can have political implications when the social distribution of power and safety is at stake.

Coming to be materially possible in place like Mexico City, much less a means by which designers and builders (and their regulators) can be assessed, is by no means simply something earthquakes do. The easy reference to the agency of earthquakes in civil engineering above, excerpted from an article published in the late 1970s, demonstrates how an earthquake might act as an "implacable judge" in the built environment. It does not, however, highlight the material, social, and technological conditions under which such judgment is possible.

Encounters with earthquakes have revealed "bad judgment" of just the sort cited above as early as the Enlightenment. In the wake of the disastrous 1755 Lisbon earthquake, Rousseau wrote a letter to Voltaire stating that "nature did not construct twenty thousand houses of six to seven stories there, and that if the inhabitants of this great city had been more equally spread out and more lightly loved, the damage would have been much less and perhaps of no account" (see Masters and Kelly 1992, 110).

Bringing the earthquake's material effects, and the production of its social significance, into accounts of "bad judgment" is necessary to account for what happened in 1985 and what has happened since then. As post-humanist thinkers including Povinelli (2015) and Wolfe (2009) note, our models for thinking agency are heavily influenced by Enlightenment concerns. The notion that the dangers of seismic disasters might be avoided if only the designers of built environments made different choices is still powerful today. In a paper published in 2000, Russell Dynes, an influential disaster studies scholar and founder of the Disaster Research Center, identifies in the correspondence between Rousseau and Voltaire the germ of his school's "modern" perspective on human agency in the production disasters. While it is very much the case that modifications to the design and use of built environment could have saved thousands of lives in 1985, focusing solely on operationalizing refinements to code and practice in advance of such massive events can foreclose attention to how, where, and for whom seismicity comes to be understood as dangerous and politically significant in the first place; issues that, as I will demonstrate throughout this dissertation, are both important to the welfare of Mexicans at risk and importantly unsettled among experts.

Mexican is a matter of complex and ongoing thermodynamic system made meaningful in conjunction with other systems of events and their ideologies (see Masco 2010 and Barry 2015). Hannah Knox and Tone Huse have recently celebrated research on "the specific ways in which matter – conceived not just as 'stuff', but as complex systems of relationships that cross both physical and conceptual boundaries – impinge on, frame, and rearrange the subjects and objects of politics" (2015, 3). By demonstrating how seismic energy and the conditions and propensities of the substances it moves through articulate with political histories, I highlight not the complexity of these relationships, but how it is that those relationships we recognize as earthquakes and soil conditions of Mexico City have come to be meaningful in the ways that they are today.

In this chapter, I will describe some of the material, social, and technical l conditions that are entangled in the issue of ordinary Mexican seismicity as well as massive quakes. First I address Mexico City's seismic history, attending to the production of its particular geological conditions and knowledge about them over the course of the city's history. Next, I deal with the 1985 earthquake itself, describing the physical traces of the event in Mexico City today, the disaster itself, and, finally, the conditions of possibility for both its devastating power and ongoing significance. While much of this chapter is oriented around this upheaval and its tragic effects, it is nonetheless an effort to critically consider that single earthquake event in historical and material context—an event which is necessary, but not sufficient, to make sense of the how the everyday work of dealing with ordinary as well as extra-ordinary seismicity has become key site at which complex orientations toward emergency, measurement, and more-than-seismic environments are articulated with the Mexican security apparatus today.

Seismological Histories

Earthquakes reveal not just "bad judgment," things about material world through which it resonated and in which it had effects which could be measured, discussed, circulated. Unlike many accounts of the 1985 earthquake, which draw direct connections between disaster, the state's negligence and corruption, and the strength of social organizing in Mexico City, here the notion of evidence emerges differently. The ways that seismicity effects, and has effected, the built environment have come to demonstrate stuff of the material world and the social world; in Mexico City, the two are importantly entangled and mutually constitutive.

Site effects are not just a matter of the size of the seismic waves. The frequency of those waves and length of the 1985 earthquake, which moved the ground 18 inches over 3.5 seconds for three minutes, was utterly different from the effect that the same earthquake had in other places. At the epicenter, it only lasted 45 seconds, a quarter of the time over which the city shook. This, rather than simply the magnitude of the quake, contributed to the destruction it caused, moving at a frequency that tall buildings responded to like tuned guitar strings, and for long enough that they could shake themselves to pieces.

While the underground is not ordinarily available to perception, its effects are. The soil under Mexico City is sometimes mysterious, but its different capabilities and capacities are made not just evident but important for reflection in the context of seismic phenomena.

In 1936, at the first international meeting on soil mechanics José A Cuervas offered Mexico City's soil up as a rare case. It was "hyper reactive" and he wrote that it offered "a field exceptionally rare to study Soil Mechanics and Foundation Engineering at large" (1936, 301). It held, for him and his new science, a great deal of promise, so much so that in a discipline that was pushing to systematize and make scientific the evaluation of soils, he resorted not only to descriptions of material structure and water in the subsoil, but also evocative language about the "marvelous twilights" that the fine volcanic particulate would have created before it had settled to earth. This exceptionally rare soil took a great deal of time to accrete.

Mexico City is on a high plateau, over 7,000 feet above sea level. It is circled by volcanic materials— that is, flows of lava, volcanic rocks, and ash— laid down over the last 66 million years, during the Cenozoic age over lime stones of the Cretaceous, dating to perhaps another hundred million years before that. Around the plateau sit a chain of volcanoes, among them, Popocatéptl and Ixtaccíhuatl,[4] easily identifiable when they are visible through the city's smog. These delineate a barrier between Mexico Valley and Puebla Valley. They are roughly one million years old.

It was only fifty to one hundred thousand years ago that the Sierra Chichinautzin volcanic field closed the Valley off to the south and created the basin that could become marshy ground that was strung with lakes, until Spanish colonial cosmographer Enrico Martinez began to drain the lakes in the early 17th century.

The conditions produced in lava flow, fine floating ash, and the Spanish colonial work map danger for present-day Mexico City. In the center of the city, where the lakes were, there was a hard surface, a sequence of clay layers and sand, volcanic glass, fossils to a depth of 14 meters and finally deep deposits , while around it the rock is compact. To the west, sand

[4] The Nahuatl names of these translate to Smoking Mountain and White Woman, characters in a tragic love story.

is mixed with silt and clay into a loam with high gravel content and volcanic tuff; to the south and east basalt, to the north breccia and more tuff.

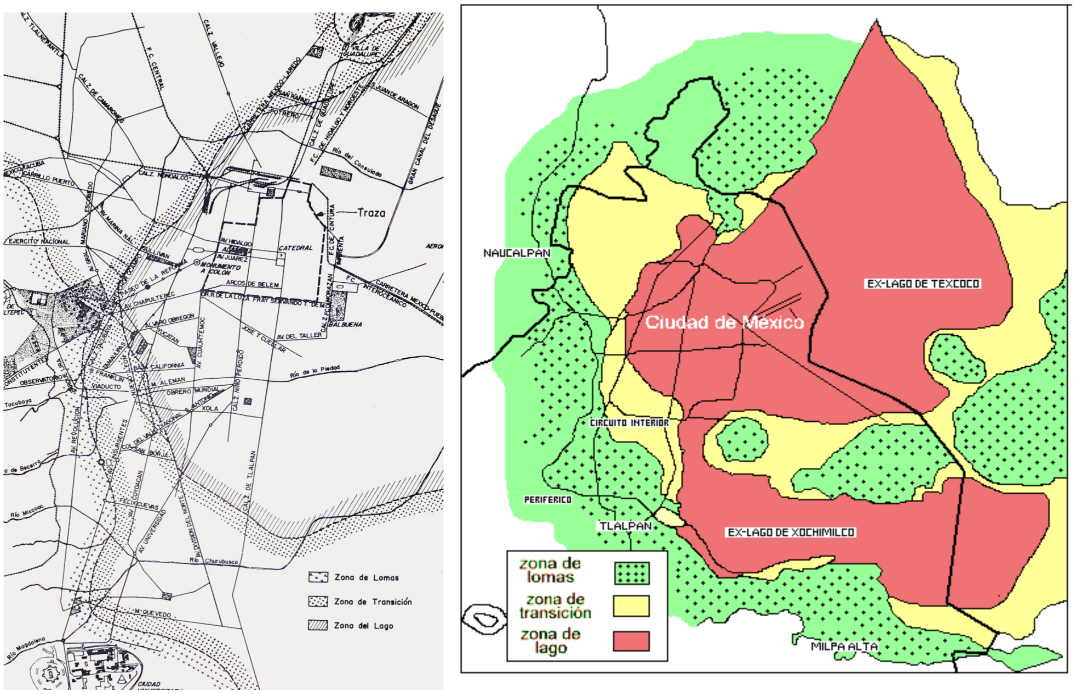

Figure 1.1. *left,* Mexico City soils and zones of seismic sensitivity as seismic zones as represented midcentury (Marcel and Marzari 1959); *right,* those same soils as rendered today courtesy of the Servicio Sismologico Nacional.

Understandings of the differences between the zona de lago, the lake zone, and the hard-rock zona de lomas have been developed over some time. They effect buildings, of course, demanding different kinds of foundation work especially for large or monumental structures that tend to sink into the earth in the lake zone.

Civil engineers began to document the seismic amplifications that the soil lake zone soil caused in the 1950s (Ordaz et al. 1993), though, as the maps above reveal, their sense of the extension of that zone was less fine-tuned than it has come to be. In the contemporary color coded map from the Mexican National Seismographic Service, lake and hard-rock zones have been set off in red and green. Between them is transition soil, a mix of fine particulate and volcanic rock, silt, sand, and clay that can be subdivided into further types, its variety attributed to the growth and shrinkage of the valley's waters. This transition zone tends to be less sensitive to seismicity than the lake zone, and more than the hard-rock areas.

The implications of these physical properties are fascinating and fantastically dangerous. Mexico City is not close to very seismically active areas, but the soil under the lake zone of the city reacts violently to ground motion, sometimes registering motion at 75 times greater than hard-rock sites at an equal distance the motion's epicenter and 8 to 50 times greater than places on volcanic rock within the city's borders (see Singh, Mena, and Castro 1988).

Seismicity in Mexico is not only the subject of ongoing inquiry, but takes on different kinds of meaning with respect to political context. Neither the availability of sensitive subterranean materials as a site for a massive megalopolis and the importance of that megalopolis should be taken for granted. In the next pages I will describe the political history of these soils, arguing that their instabilities had taken on political meaning long before 1985.

Mexico City becomes sensitive

The import of what happens in Mexico City needs unpacking, in part because it seems so obvious to so many. When journalist Jacobo Zabludovsky wrote that the earthquake of 1985 was the largest tragedy in the history of the capital "preceded only by the destruction of the Aztec city at the hands of the conquistadores in 1521" (Zabludovsky 2010),[5] he was writing not only about tragedies for cities that occupied the same geographic site, bu**t** also about cities that were each uniquely important in their nations.

In other words, the earthquake was a dramatic moment for the city, and, because it was not just any city, the city's drama was the nation's**.** Mexico City, as a center of intellectual, political, and economic power in the nation, was not the only place the earthquake damaged, but it was the place that the earthquake damaged most significantly. It was, furthermore, a place that could be very significantly damaged. Damage there could be considered in terms of total population, national business and political administrative power, economic circulation, and symbolic efficacy with respect to the nation as a whole.

In 1521, Tenochtitlan was the heart of the Aztec Empire. Only two hundred years old when it was conquered by a coalition between Spanish forces and those of the violent Empire's rival states, including mainly Tlaxcalan forces with support from Totonacs and Texcocans. The city sat on the same site as Mexico City, roughly, but on land interspersed with lakes: Lake Zumpango, Lake Xaltocan, Lake Xochimilco, Lake Chalco, and Lake Texcoco, and though they are nearly invisible today to most people in the city, their water levels once

[5] El próximo domingo se cumplen 25 años del terremoto. El tiempo ha ubicado la tragedia del 19 de septiembre de 1985 como la mayor en la historia de nuestra capital, antecedida sólo por la destrucción de la ciudad azteca a manos de los conquistadores en 1521.

varied drastically throughout the year so that even the dry areas of the Valley of Mexico could be waterlogged at times. The soil was very fertile, though, and the lakes themselves could provide water for city dwellers, for agriculture nearby, and for transportation between the two. The Aztec forebears, the Mixica, started building the city in the early 14^{th} century and were a powerful political presence in the Americas within a century, ruling ten million subjects in central Mexico (Helms 1982).

The site of their capital was technically challenging, and what the Aztec built there was by all accounts a marvel of architecture and engineering. A system of canals kept the farms irrigated and were used for transport into and out of the city, and were crisscrossed by causeways. The Spaniards who visited in the 16^{th} century called it the “Venice of the New World” (Tylor 1861, 41), and from this site Tenochtitlan's builders, now the Aztec, ruled empire which stretched from the Atlantic to the Pacific Ocean. After the Spanish conquest, it remained an administrative and trade center for New Spain — that is, the region that was to become Mexico and much of the Western United States of America. From a site now called "Mexico City," then, viceroys administered all of New Spain— and became troubled by periodic flooding.

Figure 1.2. Mexico and the Lakes (Candiani 2014).

One way in which they enacted this power was a massive and ambitious reworking of the site of the city itself. Tenochtitlan's canals and lakes were drained. Though flood control was the central rational of the project, one of the first attempts flooded the city for a period of five years. This hydro-engineering system has been under construction or repair more or less consistently since 1607 and, in the labor relations it made possible, framed colonial relations in diverse and powerful ways, mediating envirotechnical values and practices of different groups (for more on the expensive and troublesome hydrology project, see Candiani 2014, as well as Trabulse 1983, Ezcurra 1990)

The city's present seismic sensitivity has been physically produced by the conditions that have made it attractive to the wandering Mixica and the people who had long since settled the basin when they arrived, by whose combined hydrological labors the area became truly agriculturally fecund. It was fertile because of volcanic soil and irrigation, and supported settlers whose violent empire flourished between the 11th and 14th centuries. When the Spanish chose to seat their capital there it was no easy choice, as Vera Candiani points out in her history of the great drainage and environmental transformation (2014, 26). It was the center of an empire already and well-appointed, though, and perhaps its waters even offered the conquistadores some strategic barrier before their periodic flooding became too clearly troublesome.

Today, the people of Mexico City live on top of soils that can be so violently shaky precisely because lakes that would otherwise prevent the occupation of this tremendously dangerous territory were drained in a massive attempt to demonstrate dominion over a newly colonized people, and much of the present day city is built on what once was lakebed. The soils under a great deal of the city are silt and volcanic particulate, and so fine that they are hypersensitive to seismic energy.

Since the late 19th century, the Mexican state had demonstrated ongoing efforts to conjure a centralized patrimony in what Elizabeth Ferry has argued stood in ideological opposition to liberal models of property relations emerging at the same moment (Ferry 2002 and Azuela 2011). One strategy for doing so has involved collecting and displaying archeological objects from around the nation in Mexico City, sometimes at high cost

(Rozental 2014). But Mexico City's national importance entangles that symbolic register with other kinds of systems and concerns. In 1985, at the time of the quake, Mexico City produced 44% of the Mexican GDP, and was home to one fifth of the country's total population as well as one-third of all the public employees. (See Robinson, Franco, Castrejon and Bernard, 1986, 87). It housed the nation's premiere universities, museums, and important physical nodes in national infrastructure as well, such that Mexico City's trouble disrupted the economic, emotional, administrative lives of people across the nation as well as their telephonic communication.

The capitol city with central roles in Mexican state governance structure and in Mexican national imagination. Its soils, histories, and massive resources have produced conditions for meaningful earth motion, and although recording practices and technologies make only recent earthquakes (and their politics) available for the kinds of systematic evaluation that technoscientific experts in geophysics or earthquake engineering rely upon to forecast the likely frequency—and magnitude —of quakes.

Rendering Historic Earthquakes

The earthquakes in Mexico's past are available, to some limited extent, to contemporary encounters with the seismicity of the territory, though the kinds of information available are sometimes of marginal use to contemporary analysts. Precolombian writings address earthquakes, not only in terms of ushering in a new era, as earthquakes indicated a new kind of time in most of the more than 20 varieties of prehispanic myths that deal with successive epochs and the violent transitions that precipitate change between them (see

Elzey 1976 and Korvach 2004). In indigenous records, large quakes are recorded with respect to the year in which they occurred. The day or hour of earth motion is left unrendered in these writings, but the glyph ollin, for movement, can be written with colors and signs to show whether it happened in the day or at night. Intensity may be registered there, with subtle variations. As Mexican anthropologist and earthquake specialist Virginia Garcia Acosta pointed out, “it is not unreasonable to think that variants of the signs represent intensity" (1988, 413).

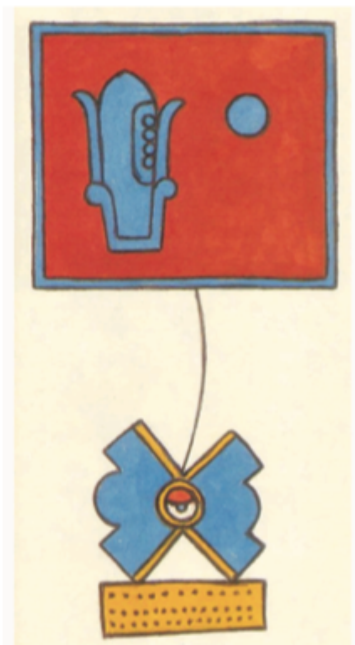

Figure 1.3. Nahuatl glyph ollin indicating a night-time earthquake, dated to year “one flint” (Espinosa Aranda et al. 2009).

Colonial settlers wrote of earthquakes and their effects at length, though, according to Garcia Acosta, they did not systematically include time until public clocks and came into common use in the 17th century. Earthquakes were recorded, then, at the closest time to the nearest 10 minute interval, renderings becoming more precise as the 18th century approached. People recounted, additionally, the orientation of seismic waves as indicated in waves on water or the swing of pendulums and their experience of the motion.

There were some efforts to standardize intensity, but often surviving written material has only casual reference and everyday adjectives for contemporary scholars to extrapolate from: horrible, light, not too strong, and so on. The Catholic church was more systematic, though. As earthquakes were understood to be expressions of holy anger, parishioners performed (and recorded) coordinated religious events like prayers, processions, from which indications of the intensity of a given earthquake can sometimes be gleaned (Garcia Acosta 1988).

All this information can rolled into some kinds of statistical analysis, facilitating better understanding of frequency in earthquakes and even some good estimations of epicenters. The very existence of Garcia Acosta's massive collaborative effort with geophysicist Gerardo Súarez to compile a database of historical quakes indicate the utility of such data for historians and seismologists both. However, the new kinds of tools for rendering earthquakes which came to available in the 20th century made it possible to describe and compare patterns in the energy itself in more precise terms.

Not only did this century see the development of the still-used Mercalli scale[6] to allow the effects of earthquakes on the visible environment to be quantified, but also the growth of a fleet of machines which could record the waveforms of seismic energy around the world.

[6] developed by Giuseppe Mercalli in 1883 out of the Rossi Fore scale, itself dated to 1873 at least, but Wood and Newman revised it in 1931, and it is still in use.

Mexico installed its first seismographs— massive Wiechert devices weighing between 12 and 17 tons each, in Tacubaya, just to the southwest of Mexico City's historic center, in 1910. Others were installed in major cities around the country and a total of nine were active by 1923.

With these machines, Mexico was on the seismic vanguard, since the first seismograph in North America was only installed near San Jose California in 1897. The installation was undertaken at the end of the end of Porfirio Diaz's rule. This regime is well known for placing heavy priority on scientific development and industrialization (as well as the effective concentration of land and power in the hands of a relative few).[7] the installation was completed and the National Seismological Service founded in time to record of the Madero quake of 1911.

The quake had serious effects: 45 died, the town of Guzman in Jalisco was demolished, and damage done to Mexico City's enduring Palacio Nacional and Instituto Geológico. With the seismograph, the movements quake of June 7 was measured at magnitude 7.6 and could compared to other quakes around the world, rendering the motion now on something other than memories and marks on bodies and the environment. It was named and rendered a symbol through other means: it was said to coincide with revolutionary Francisco Madero's entrance into the capital to take power in the wake of a bloody agrarian revolution against Porfirio Diaz's regime.

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[7] During the Porfiriato (1876-1911), science became, in the words of Priego in her book on the subject, "algo para daría lustre al país y le permitería superar el atraso, para formar parte de los países modernos," that is, "Something that may give luster to the country and enable it to overcome its backwardness, to gain a place among the modern countries of the world" (2009, 21).

In this quake, like the Angel Earthquake of 1957— in which seismic motion of magnitude 7.5 emerging from an epicenter on the Guerrero coast to shake Mexico City so severely that a good deal of the data from Tacubaya was useless (see Quaas Weppen 1991). The instrumentation of the day was not equipped for strong motion caused a guided statue crowning Mexico City's Column of Independence on Reforma to topple and which killed 52 and injured over 550, damaged 100 buildings. The damage was, like that of the Madero quake before it, distributed geographically in much the same way that it would be in the 1985 quake.

All these quakes damaged the built environment and cost lives. The distributions of their effects demonstrate not just the resonance of the built environment (for all that it has significantly as materials and building styles transformed throughout the 20th century), but the capacities of the various soils beneath the city to respond to earthquakes originating from many miles away. These earthquakes were, however, much smaller than the massive upheaval in 1985. Building regulations designed around them did not necessarily reveal "bad judgment" when they were insufficient for a magnitude 8.1 quake that continued for three minutes. As I have demonstrated, however, they did bear the mark of hundreds of years of social work which made material sensitivity of Mexico City possible.

1985 and its Traces

The 1985 earthquake was powerful enough to leave physical traces across Mexico City still visible today. It opened spaces in the dense city for subtle memorials, and framed regulations and practices that make the territory subtly and obviously seismic. Traces of this quake are deployed today as memorials and reminders to residents at risk that more quakes of this size, as well as that of the comparatively smaller Madero or Angel quakes, are possible here. Alongside direct representations, which during my fieldwork included a wrenching photographic exhibit mounted in Parque Chapultapec on the anniversary of the earthquake, there were more subtle and permanent indications of both the earthquake and the political tensions that I will argue here framed its significance for Mexican institutions and disaster prevention efforts going forward.

The built environment in the most affected areas of the city has not been utterly rewritten since the earthquake. The large thoroughfare of Calle Insurgentes still seams the west side, and the historic city center's cathedrals, palaces, and prehispanic temple are still intact. Some buildings were not knocked away or reconfigured into other kinds of spaces. Some, severely damaged in 1985, have simply remained so: boarded up, condemned, housing squatters if anyone, becoming more dangerous to those people as well as the buildings and beings around them with every new quake or drenching thunderstorm they weather. In other places, the traces of 1985 are evident in different ways.

Figure 1.4. *left,* Multifamiliar Juarez buildings A1, B2 and C3 destroyed. Taken from above on 25 September 1985, courtesy of the ICA archive; *right*, the wreckage of one of the buildings taken between the 21st and 24th of September, 1985, courtesy of photographer Guillermo Aldana.

Multifamiliar Juarez, or, more formally, Centro Urbano Presidente Juárez CUPJ, had been designed by well-known architect Mario Pani, a cluster of buildings in the center of the Roma neighborhood that provided dense housing. The space left behind when four of the complex's buildings were destroyed in the earthquake sat empty for twenty-seven years, overgrown, troubled by vandalism, and home to feral city cats before it was converted into a community garden, a Huerto Organico, where visitors and volunteers could wander, care for or buy vegetables, and learn about urban forestry.

Figure 1.5. Huerto Roma Verde, photo by author.

It is a lovely place to walk on a warm day. It smells of herbs and is shaded with elaborate and fanciful structures. Redevelopment of the space had been deferred so that, in the words of former director of the Institute for Social Security and Services for State Workers (ISSSTE), Dr. Alejandro Carrillo Castro, "we will have green spaces as an homage." The green space, before the Huerto, had been less an homage to those who died there than an overgrown space where potential hazards, human and nonhuman, flourished, and now that the Huerto was and active, the energy of its occupant lives and projects rarely drew on earthquake stories directly.

The homage, here, is subtle. The Huerto has no plaque, and the kinds of projects taking place there have little to do with seismicity or overtly celebrating the history of the place. Much of the crowd who came to celebrate Dia de la Candelaria and eat exotic tamales from around the nation in the Huerto certainly didn't. It was available, nonetheless, and made possible a site for the easy conversation, festival atmosphere, and small-batch artisanal mescal sampling; made possible by the earthquake and a reminder of it those who knew what had been there before.

The Huerto, like broken plaster, speaks to the general seismicity of the city, and to the variety of ways that what happened in 1985 particularly still marks the city physically and discursively. In the next pages, then, I will discuss the 1985 quake and the political context and projects in which its massive destruction and death toll were taken up, demonstrating how these projects were never just about the massive quake.

Mexico City, 1985

The first earthquake shook Mexico City on September 19 1985 between 7:19 and 7:22 in the morning. It started on the coast and shook 370 Km across Mexico to the city over the course of two minutes. It was measured at a magnitude 8.1 at source and a IX on the Modified Mercalli scale for its readily visible effects on the built environment. In one place the ground moved 18 inches backwards and forwards once every 2 seconds. at a place 5 km away, in the center of the city, it did the same thing in 3.5 seconds. It did this for three minutes.

Neither the built environment nor the people moving through it were prepared for earth motion at this frequency, intensity, or length. Building codes simply had not taken this possibility into account. The same seismic energy was felt widely, causing landslides and damage to buildings and highways across Mexico.[8] It was detected in Texas and Guatemala. The tsunami it caused was measurable in Ecuador, El Salvador, Hawaii, and even Tahiti. Water well fluctuations were recorded as far away as Florida and Maryland (United States Geological Survey, nd). None of these places, however, experienced the destruction that Mexico City did.

Destruction was not evenly spread around the city. Certain areas got the worst of it: Tree-lined Roma and La Condesa and parts of the historic city center were hit badly. The equally historic slum Tepito suffered. Tlatalolco, just to the north and famous for a 1969 student massacre, did too. Tlalpan and Xochimilco to the south— once towns in their own right and now incorporated into the megalopolis conglomerate— shook in ways that Coyoacán, built on volcanic rock rather than sensitive soils, did not.

In this quake and its aftershocks, as many as 3,000 buildings were damaged (Poniatowska 1988). Something like 770 came down (see Dynes, Quarantelli, and Wenger 1990). Many of these, troublingly, were government buildings, key nodes in organizational and technical infrastructure. One estimate suggests that 120 government agencies lost part of their facilities, which impeded coordinated emergency response capabilities severely. Most transportation infrastructure was not significantly damaged, but the same could not be said for water, communications, and electricity infrastructures. Space in the hospitals that remained open was insufficient.

[8] It was felt in the states of Jalisco, Colima, Michoacan, Guerrero, Oaxaca, Chiapas, Mexico, Puebla, Hidalgo, and Veracruz

Emergency response to this quake is often described by commenters as the very opposite of smooth, though research and analysis by noted disaster studies scholars Dynes, Quarantelli and Wenger suggest that this assessment may be product of a lack of integrated response efforts rather than actual chaos (1990). In 1985, there was no overarching city disaster plan, though a group at UNAM had put together the bases of such a document only a few years before. The federal government did have a plan in place: called the DN-3, it assigned responsibility for coordinating emergency response to the Mexican Army. However, complications with civil authorities and the sheer magnitude of the issues faced, colored by the delicate politics of an armed forces intervention only 15 years after Tlatelolco and in the middle of a severe nationwide debt crisis made it difficult for the armed forces to take over smoothly.[9] Where and when they went to work, military responders under DN-3 were authoritative and inflexible. Volunteer rescue workers resisted their authority and priorities. The role of the military was restricted to providing security and crowd control in Mexico City, though elsewhere they were able to do more.

The second quake happened the next evening at 7:38, an aftershock, a big one. It was measured at magnitude 7.9 by the National Seismological Service. It was significantly smaller, as magnitude is an exponential measurement, but after the damage of the first earthquake, its effects were still nasty. Preliminary information about damage was released then, and Mexicans learned that the 11-storey tall Hospital Juarez had collapsed with perhaps 700 people inside; that the OBGYN unit at the General Hospital had also come

[9] While sublimated to or at least deeply entangled in civilian structures of authority unlike militaries elsewhere in Latin American (as Camp 1999 argues) the threat of the military gaining power was worrisome in the moment of the emergency (see Dynes, Quarantelli, and Wenger

down, with 500 patients and an unknown number of newborn babies; as was the Nuevo Leon building in Tlatelolco, home to 185 families; several buildings in the Multifamiliar Juarez housing complex; six hotels with an unknown number of guests within, as well as private households and office buildings with fewer occupants. They learned that maybe one thousand people were likely to be trapped in the rubble, eight thousand had been injured.

Thirty-nine hours after the first quake, President de la Madrid finally addressed the Mexican people on television, a medium which many homes, especially those outside of the sensitive loamy zones at the center of the city, still had access to. He had rejected external help after the first earthquake, but changed tactics as the extent of the wreckage became clear. Applauding popular bravery and hard work, he finally acknowledged that emergency response would not be swift.

> "Unfortunately I must admit such a tragedy has overwhelmed us in many cases. We cannot do what we would wish to do as quickly as we would wish, especially to save lives… the truth is that we do not have the necessary resources in the face of such an earthquake to respond effectively and promptly,"

de La Madrid said (quoted in Dynes, Quarantelli, and Wenger 1990). Though he had begun working immediately, this was his first public comment on the topic. His reputation suffered for it, and for the response more generally.

Estimates of damages and deaths mounted. Recovery volunteers write they were overtaken by a psychosis, a madness. They labored desperately and without rest. There was never really a shortage of food or volunteers, but organizing them was a problem.

Two multi-departmental commissions were created by the president the day after the quake: the National Emergency Commission (CNE) to coordinate response out side Mexico City.[10] and the Metropolitan Emergency Commission (CME)[11] to deal with the issues within it. These did not start operating until September 22, three days after the first earthquake. CME headquarters were not staffed around the clock, even then.

Throughout the first three days, recovery efforts were fragmented and many did not happen under the authority of either commission. Search and rescue, shelter and care, and other emergency tasks were undertaken by public and private agencies, locally, and ad hoc. Rescue workers organized at the most local levels to extract survivors from the debris, distribute shelter and food, and dispose of bodies. Many participants were new to emergency response. With no electricity and limited phones, their means of integrating efforts was limited. Those radio and television stations which continued to function announced sites of damage and places where attention was needed. As the Televisa studios he usually worked from were destroyed, Jakobo Zabludowski, a journalist, reported for the radio from his car phone.

Moving bodies, coordinating efforts, putting ambulances on the same radio frequencies, making sure shelters were themselves free of health hazards, came to be small but

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[10] Containing secretaries of national defense, the navy, foreign relations, health, education, communication and transportation, planning, budged, urban development, ecology and others.
[11] Under the charge of the Distrito Federal's executive officer, this commission had tasks including: inspection of buildings, medical and health services public safety, heavy equipment, shelters, food, products, and law around the issues of the dead and damages.

important stumbling blocks. The army's actions were immediate but not well coordinated with local needs. Nonetheless, people flooded in from around the country. Locals and people from around the nation and the world came to volunteer, sometimes to the frustration of the ordinary people to whom resource organization fell (Dynes, Quarantelli, and Wenger 1990, Lefomex SA 1985).

Labor, itself, was intense. "Our volunteers, in the first days especially, did not rest and worked ceaselessly day and night," reported Emilio Díaz Cervantes, one member of a now-internationally active emergency team called the Topos, or Moles (1995, 20). Dynes, Wenger and Quarantelli research indicates that one out of every 8 adults living in the city volunteered in recovery work, which amounted to approximately two million people. Many who didn't perform rescue and recovery work themselves contributed financially to support the effort.

By October 1 there were twenty thousand people in homeless shelters. These received, per day, donations that had to be measured in tons: eighty tons fruit and vegetables, two hundred and six thousand liters of milk, four hundred thousand rolls of bread, fifteen thousand kilograms of tortillas, four hundred thousand liters of purified water (see Diaz Cervantes 1995 and Dynes, Quarantelli, and Wenger 1990). Electrical power supply and local telephone connectivity was almost reestablished at this point, although national long distance telephone lagged, as did international telephone services.

Tallying losses was never entirely possible. Some guess that economic loss generated by the earthquake alone approached forty million USD (Cruz Atienza 2013). Others estimate a reconstruction cost of about 6% of the nation's gross national product, maybe five or ten billion USD (Dynes, Quarantelli, and Wenger 1990, 3).[12] It is marked in different ways, though, and some who were there render the experience in terms of loss, evidence of systemic failure and, sometimes, as a revelation, an evidence of new possibilities.

"Since then," wrote one survivor, reporter Adolfo Montiel Talona "ever since the morning of Thursday on September 19, 1985, the new history of Mexico City is being written: one of the emergence of other protests, of the reaffirmation of one identity. One of unity and solidarity" (Colección Reportaje, nd: 9).

Telling the story

Many accounts of the earthquake are in print. Reflecting on her experience and those of others in a powerful testimonio, journalist Elena Poniatowska wrote:

> In Mexico everyone told me their earthquakes. What's more, no re-encountered friend would even let me tell them good morning. First they told me their earthquakes. It was *sine qua non* to restart the dialogue. I had to be initiated, aware, involved somehow.... And I wonder: if the quake marked Mexicans so much, if it so invaded their lives, their memories, their minds, if it shook them so much that in one way or another its effects continue to re-emerge, what will be the mark that it leaves? (Poniatowska 1989, 311)

The importance of involvement, of experience and what it might have done, resonates with what was said to me in meetings, presentations, and even in passing at dinner parties thirty

[12] As Diane Davis (2015) points out, a great deal of reconstruction money should be understood to have been diverted to other uses, especially given Mexico's troubled economy at the time.

years later. Stories are still published to commemorate the quake every year. Threaded through them, and through the books which compile testimonios of earthquake survivors and can be readily found in archives and bookstores today, are more than pain, fear, and struggle. They describe and grapple with the effects of the earthquake: what it made clear, and what it made possible. In one testimonio, a commenter named Cristina Pacheco simply wrote that the events of 1985 led to "Another stage of our lives as people and as Mexicans" (1995, 7).

The way that the quake of 1985 is memorialized in many testimonios demands careful attention. These testimonios, true to their genre, are always political. A testimonio is tricky genre in Latin America. As Anne McClintock defines the genre with heavy reference to Doris Summer (1988) it is a story “told to a journalist or anthropologist for political reasons" , with "an implied and often explicit plural subject,” (1990, 218) making it a story with a speaker rather than a story about the speaker, incorporating into a personal narrative things that might not have happened, precisely, to the author but which are nonetheless essential to their subject position and the story they write. A testimonio can render the social as experienced, and their duality (Nelson 2009) as at once both narrative of personal experience and representative of shared trauma have been the subject of interpretive glosses that Liisa Malkki generously calls “romanticization” (1997, 93) and consequent critiques of biographical accuracy when that plurality is made clear. Nobel Prize winner and indigenous activist Rigoberta Menchu's testimonio of Guatemala’s violent civil war is among the most famous, and certainly such glosses and critiques have been deployed with respect to her work (for example, Stoll 1999).

Of those testimonios published about of the 1985 earthquake, the most well-known is probably Elena Poniatowska' s, quoted above. Her collective chronicle began in the daily *La Jornada* and was eventually published as a single book and eventually translated to English, too. It offers up intimate stories of experiences of the earthquake that reveal larger themes: ordinary Mexicans' suffering and capacities to organize and support each other in light of the challenges that many attribute to the state's negligence.

The testimonio she compiled is only one of many circulating in Mexico. These tend to share its format: an introduction followed by a series of sections, each given over to one narrative or another. Stories of the earthquake and the days afterward are recounted in colloquial but literary Spanish, without the abundance of the Nahuatl words, slang phrases, or curses which stud everyday Mexico City linguistic practice.

In these testimonios, survivors offer up "their earthquakes" and the days afterwards in serious, grammatically correct and linguistically conservative prose as lived evidence. They tell stories about confronting the army and rescuing their neighbors, and supporting each other. They attend to both how the disaster happened and what it revealed. In many testimonios, that means discussing failures in regulation and leadership before and immediately after the quake, as well as hope inspired by the rescue and recovery efforts they witnessed and participated in. Cristina Pacheco’s overview (1995, 11) declared:

> As of September 19, 1985 and nothing was nor would be the same. The city has become another beneath wounds and scars, some still visible in many places. To see

> them has to remind us that the victims would have been fewer in in the absence of corruption, overcrowding, greed, homelessness, speculation ...

The neglect and solidarity that the earthquake exposed are paired, the former making the latter possible and necessary. The traumatic seismic disaster not only revealed "bad judgment" of corruption and greed, but gave evidence about the resourcefulness of neighbors, making change imaginable. Testimonios to this effect were written in the context of an ongoing economic crisis and decade of national restructuring which entangled the whole nation.

Following a period of stability and nationalization, Mexico's economic situation had degraded dramatically during the Echeverría presidency in the early 1970s. Major government spending and efforts to support troubled industries had been subsidized by foreign loans. While newly-discovered oil reserves were promising, an International Monetary Fund loan taking their anticipated revenues into account made it possible for the Mexican government to gain access to bigger loans and more debt. The oil price crashed. By 1982, only three years before the earthquake, Mexico could no longer pay debt service, and had to enter into a new agreement with the IMF and agree to significant structural and free market reforms.

At the time of the earthquake, then, the situation was bad. Mexico was carrying ninety seven billion USD in foreign debt and the international oil prices that had made these loans seem reasonable had fallen significantly and quickly. This was not just a matter for economists to be concerned with; ordinary people felt the effects of this crisis in their economic lives. In the immediate wake of the earthquake, one insurance company report declared a sad expectation that many homes would be found to be technically uninsured at the time of the quake as "Strong cash-flow constraints have forced many policy holders to become late premium payers." This lateness, a matter of uncertain financial flows, would turn out to be a crucial issue. The report went on to indicate that " insurance law establishes automatic cancellation of policies 30 days after premium payment due date" (Lefomex SA 1985, 3,14).

Although their economic resources were shaky, Mexico City residents had been gaining experience organizing. Throughout the late 1960s and 1970s, many had mobilized to protest lavish spending for the Olympics, and then the kinds of heavy handed military repression that had transformed those protests into a the Tlatelolco Massacre. They mobilized to demand housing, transportation and services. As Mexico was forced to refinance with the IMF and implement radical austerity measures, city residents became increasingly active in urban social movements (see Davis 1994).

Reflections on earthquake experiences are also, inevitably, reflections on these conditions. They pit the solidarity and mutual assistance demonstrated in the wake of the earthquake against state emergency responses that not only seemed slow and ineffective, but that were framed by other principles and practices which made the earthquake and recovery from it so challenging; a state which was corrupt at worst, in dire straits at best.

While the immediate solidarity of recovery work dissipated as the earthquake subsided into memory, it, and its corollary of revealed government incompetence, continued to do political work. In the 1985 event, people worked with each other, independent of the federal government. The Partido Revolucionario Institucional (PRI) at the time had strong control over elections in federal executive and legislative branches and nominated leaders of the Federal District of Mexico City directly. The processes of getting services, securing representation, or attaining public office was a matter of clever social maneuvers and enrolling powerful allies.[13] Many commenters argue that after 1985, taking a corrupt government to task and even formally ousting the party that had held the presidency since 1929 became imaginable in new ways.

After 1985, political transformation was slow. It was not until 1997 that leadership of Mexico City became an elected office[14] and until 2000 that the PRI party was unseated for the first time in 71 years. The political shift began with the destabilization of PRI control over federal government. First, in 1988, unpopular Salinas was nominated as and achieved the presidency, beating leftist PRD Cuantemoc Cárdinas possibly through or at least with the support of election fraud.[15] A massive amount of legislative seats were seized by opposition, and the PRI's hold on national government became a good deal less sure. The

[13] According to Claudio Lomnitz, "Mexico has never had a state that was strong enough to provide services universally. In this context, corruption and other market mechanisms easily emerge as selection criteria" (2001, 60).
[14] As Heather Levi recounts in her wonderful ethnography on, of all things, Lucha Libre (2008)
[15] Most observers of the 1988 election believe that the PRI engaged in fraudulent practices. Some PRD figures among them believe that Cárdenas actually won.
Most, however, although agreeing with charges of fraud, believe that Salinas actually did win but that his percentage of the total vote was lower. (Camp 1999, 185- 186)

PRI reasserted its hold in 1991 congressional elections, but in 2000 the nation's second-ranking party, the Partido Acción Nacional (PAN), gained the presidency.[16]

The political change had its limits. Free market structural adjustments continued after the earthquake. In 1986 the de la Madrid administration signed the General Agreement on Tariffs and Trade (GATT), and his successor Salinas de Gortari negotiated Mexico's entrance into the North American Free Trade Agreement, both of which furthered the program of trade liberalization set by the IMF. The PRI has remained a strong party in local office and congress, and has reasserted its influence in presidential policy, but its hold in government is different than once it was. Clientelist relations, so often a component the practices indicted as corruption, are no less essential to the functioning of power, and have hardly been replaced by transparent democratic processes (see Lindau 1993, Fox 1995, Hilgers 2011). But if telling the story of 1985 is a political act, then it is the kind of political act that charts changes in the Mexican political imagination. The cartoonist Alberto Beltrán told Poniatowska that “Humans do not change only because an earthquake has shaken the earth… Mexican society moves slow, little by little, not in leaps” (Poniatowska 1999, xix).

Conclusion

One testimonio of the 1985 earthquake declared:

> Today, now that you have this book in your hands, ours will be another city, another country, and that change is not due to a building that no longer exists, or the school that had to be remodeled… The Mexico you observe is that of solidarity, uniting

[16] During this time, contenders for state or national office have increasingly campaigned outside of Mexico’s borders to solicit support from influential migrant populations (see Goldring 2002), but the complexity of political representation in Mexico remains similar to the one that the 85 survivors critiqued.

> hearts, wills, efforts sweat and energy to be different, but, ultimately, to be" (Colección Reportaje nd: 124[17]).

Accounts of the 1985 earthquakes often recount the scope of this volunteerism and discussions of its potential revolutionary power are not uncommon. These popular theories about the effects of disaster recovery have been deeply important to the politics of the moment.[18] While the physical aftershocks of the 1985 earthquakes continued for nearly a year, reverberations of this new experience in Mexican state institutions have lasted considerably longer; as I have argued in this chapter, however, these effects were framed by material and social action and conditions which were at work long before the earthquake started.

In the wake of the 1985 earthquake, Mexico City became a national and, indeed, international reference point for working through public needs and institutional response. The earthquake has left traces all over the city, some subtle and some powerful. It transformed Mexico City physically, and the physical conditions of possibility for its effects, are just as political as those for the ways in which the quake was taken up to indict the state and celebrate volunteerism and political organization. In fact, they are doubly so: produced

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[17] "Hoy que usted tenga este libro entre sus manos, la nuestra será otra ciudad, otro el país y no en función de un edificio que ya no existe, o de la escuela que hubo de ser remodelada, sino de la capacidad de ayuda, de entrega de unidad que cada mexicano entregó sin fingidas modestias. El México que usted observa, es el de la solidaridad, el que unió corazones, voluntades, esfuerzos, sudor y energía para ser diferente, pero finalmente ser" (Colección Reportaje nd, 124).

[18] The attention that paid to mutual aid in the wake of the 1985 earthquakes itself is nothing unusual. William James wrote after the great San Francisco quake of cooperative industrious and "universal equanimity" (1911). Anthropologists who study disasters have been documenting the conditions of public life in the context of disasters since the middle of the 20th century in the hope of discerning patterns in community responses to disaster (Steward 1941, Belshaw 1951, Demerath and Wallace 1957, Vayda and McCay 1975).

through a history of empire, conquest, and hydro engineering, these unique conditions have also provided powerful conditions for thinking through contemporary geographies of scientific knowledge and its circulation.

The bulk of this dissertation addresses seismicity after 1985, framed by the events and material propensities detailed in this chapter. As I will discuss in the coming chapters**,** political contests over the distribution of power and safety is at stake in ongoing work around Mexican seismicity. An unpredictable and deeply dangerous phenomena, the very instability of the earth has motivated the integration of new technological tools into disaster prevention and framed contests among the experts who imagine, build, and maintain these technologies. Ongoing technoscientific attention to seismicity in Mexico are motivated by the disasters of the past and the threat that others loom in the future, but, as I will demonstrate, they engage with the instabilities of subterranean Mexico, knowledge projects, and state institutions in other ways, too.

In this chapter I have introduced the unavoidable historical political seismicity in Mexico. These histories often come to overdetermine discussions of seismicity in a city that is profoundly seismically sensitive. However, new technoscientific interventions have been making decisions about ongoing seismicity crucial. Earthquakes have marked seismically active areas not only, as the above suggests, in revealing "mistakes and careless design," bu**t** providing the basis for a variety of assessment of what, exactly, were mistakes, as well as motivation for new kinds of attention to seismic motion.

Chapter 2

THE PRODUCTION OF EARTHQUAKE EMERGENCIES

When loudspeakers issued an earthquake warning at 11:44pm on the evening September 29, 2015, I was in bed but writing emails, with two throw pillows propping up my head so that I could make out the screen without glasses. The apartment around me was lit entirely by the streetlights out on Plaza Popocatepetl and my monitor's glow.

It was quiet, and then it wasn't. A digitized male voice was repeating the words "Alerta Sísmica" and siren I had only heard before in demonstrations was warbling from somewhere outside. It was an emergency, and in this chapter I will consider what kinds of things that might mean in the context of earthquake early warning technology.

I was up fast. I found two left shoes, a heel and a flat, then cast around, until I found the pair for the flat one. These had laces. Laces had to be loosened for the shoes to go on. I put my feet in them but didn't tie them, and thought about my laptop, the last time I'd backed it up, if I could afford to lose it if the building came down. I couldn't quite recall which pocket of my wheeled luggage I'd put my passport in, and I wasn't sure if I should commit to searching all of them. Maybe I'd put it in the backpack instead, and that was in the far corner of my ad hoc guest room and full of the week's dirty laundry. The siren continued.

Enrique, on whose inflatable mattress I was staying, called to me from the bedroom down the hall. Was this scheduled? He was yelling to be heard.

No, it couldn't be, I replied at volume, grabbing a coat and the smart phone that was charging beside it. Massive public drills happen in Mexico City every year,[19] but for all these may catch people by surprise in the moment, they are well-publicized beforehand. These things take a great deal of preparation behind the scenes, too. I was sure that the earthquake was real. The passport I would leave. The laptop was still on the mattress, and I'd leave that, too. Where was my wallet?

At the door I met Enrique, and then, a moment later, his wife Beca, in her black bathrobe and feathered black slippers, holding their two small dogs in her arms. I was wondering about the wisdom going back to see if I could grab my wallet after all when the siren stopped.

The quiet was jarring. We waited there, in the landing of their building's wide stairs. I counted seconds in my head. I knew that the siren should have continued to sound until the quake was over, but the loudspeakers were newly integrated into the public earthquake early warning system and it was possible that they would not follow the same rules as the radio broadcasts I was more familiar with. Regardless, the early warning could give us, at the absolute most, a bit over a minute's advantage before an earthquake could travel from the most distant of the Sistema Alerta Sísmica Mexicana's sensory field stations all the way

[19] As will be discussed in the final chapter of this dissertation.

to Plaza Popocatepetl in the center of the Mexico City. We were approaching that outside time limit if we had not already passed it, slow as we were to assemble at the door, but I hadn't felt anything.

I was visiting Mexico City for a series of meetings and events on seismic engineering and earthquake safety clustered around the thirty year anniversary of the tragic 1985 Michoácano earthquake, a deadly seismic event that not only shook buildings but also resonated through politics, regulation, and disaster prevention policy throughout Mexico. While the 1985 event and the possibility of another like it is what we talk about when we talk about earthquakes in Mexico, events like the one on the September 29th are far more common experiences; earthquakes large enough to trigger the earthquake early warning system, but too small for people in many parts of the city to feel.

In the days that followed, the early warning siren that sounded from the loudspeakers was a topic of significant interest among most of the people I spoke to, over and above the "seismic community," that is, the community of multidisciplinary experts concerned with earthquake risk mitigation, that I was in the city to visit. There was, moreover, worry about real physical harm that might prove to be contingent on the night's disturbance, eventually, if users hear a siren and, expecting nothing but imperceptible motion, and find themselves instead shaken violently.

An earthquake early warning is a tool built to intervene on users in just "one moment," one moment in a long string of them, each of which allow opportunities for choices that may diminish risk.[20] In this chapter I focus on that "moment," the handful of seconds of early warning that users can have, and the multiple emergencies it can present. For all that the utility of the moment depends upon preparation and practice, having dogs and shoes ready to go, laptops and wallets either easy to hand or left behind without a thought, it is the moment itself which is mobilized when experts discuss earthquake early warning technologies and policies, in Mexico and outside of it, to promote the technologies, to plan interventions, and to make claims about emergency's meaning.

Here I consider this "one moment" as an emergency, how it comes to be understood as such, and the kinds of interventions that then come to be thinkable and even necessary. The unique qualities of this "moment"— its promises, its very real dangers, and, as I will demonstrate, contests around them— are made possible by the earthquake early warning technologies and the social practices around them. By describing these ethnographically and with reference to archival material, this chapter offers insight into the production of emergencies.

There will be no disasters in this chapter. However, the threat of disaster haunts the emergencies I want to discuss here, and as such they are necessary to unpack. The classic (and highly-disputed) definition of disaster is Charles Fritz's:

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[20] "one moment" are the words of Dr. Sergio Puente Aguilar, voiced in an interview I conducted in 2014. Puente, a researcher and professor at the Centro de Estudios Demográficos, Urbanos y Ambientales at El Colegio de Mexico and the author of a number of works on risk in urban Mexico (see Puente Aguilar 1999 and 2013). Puente was on the scientific advisory committee of CIRES, but though he hosted long meetings about the Sistema Alerta Sísmica Mexicana, he considered the earthquake early warning to be one mode of intervening on earthquake risk management among many.

[a]n event, concentrated in time and space, in which a society, or a relatively self-sufficient subdivision of a society, undergoes severe danger and incurs such losses to its members and physical appurtenances that the social structure is disrupted and the fulfillment of all or some of the essential functions of the society is prevented (Fritz 1961, p. 655).

Kathleen Tierney, a sociologist and doyenne of disaster studies, considers the temporality typically ascribed to this sort of "concentrated" event in three parts. **"**Disasters," she summarizes, "are characterized as having a beginning (the period of onset), a middle (the emergency period), and ultimately an end (when social life returns more or less to normal and when recovery takes place)" (Tierney 2007, 509). These stages can be mapped on to earthquake action in relatively straightforward ways. When plates or faulting slips, the period of onset has begun. The emergency period may include the moment the quake is felt, as stable ground turns vibratory and structures resonant, and some natural upheaval encroaches on human life. In its aftermath, injured people are rescued and treated. The end of a disaster is time for rebuilding, healing (perhaps taking preparatory action, like moving or reinforcing structures, to foreclose another disaster), and so forth**.** It provides, if nothing else, an encouragement to think of different parts of disasters as distinct; the beginning, middle and end related but not identical, separated by time and distance to some unclear degree but laminated together in significance.

Tierney herself highlights the limitations of this three-step process for approaching recurrent disasters and the conditions, structures, and forces that make disasters possible and channel their effects.[21] The way that these steps chop up events and foreclose causality is analytically troublesome. Neither complex (as in Fortun 2001 or Petryna 2006) events, anticipatory work (as in Collier 2008, Lakoff 2008, Anderson and Adey 2011; Deville, Guggenheim and Hrdlicková 2014, Choi 2015) nor the larger-scale logics that frame their fearsomeness and both enable and foreclose possible responses (as in Massumi 2005, Davis, 2007, de Goede and Randalls 2009; Masco 2014) can be easily accommodated here.

Challenging the discrete three-step model of disaster's strictures of temporality and causality has opened up spaces for thinking otherwise about what makes disaster. In what has become a key collection in disaster studies, Anthony Oliver-Smith and Susanna Hoffman write "disaster becomes unavoidable in the context of a historically produced pattern of 'vulnerability,'" (2002, 3), structures of social life and the built environment (histories of which I will discuss further in the final chapter of this dissertation).

This approach to the social production (sometimes "construction") of disaster focuses on the conditions of possibilities of disastrous outcomes.[22] Growing out of a long tradition of cultural ecology, particularly Julian Steward's writings on resource availability and distribution and relation between environmental conditions and cultural traits (1955,

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[21] Tierney writes that research on extreme events was often guided by what she called "realist assumptions," that "researchers took for granted that disasters do exist out there as distinct events…realist and event-based perspectives continue to dominate the field" (Tierney 2007, 506). Hold this in contrast to the model used Mexico City's Ley De Protección Civil (discussed in the final chapter of this dissertation) in, for example, Chapter 1 Article 54 (published in the Gaceta Oficial on 8 July de 2008, expanded in Article 74 of the same document), which figures the temporality of earthquake disasters as requiring "1. Prevention; 2. Attention in emergency; 3. Recuperation." While this latter model also addresses a discrete emergency event, it calls for work to avoid disaster before it happens.

[22] see overviews by Oliver-Smith 2002 and Tierney 2007, Walker and Cooper 2011 offer an excellent history of resilience in cybernetic social science; and Rodriguez-Girault, Tirado and Tironi 2014 reflect on these models from STS perspectives.

1968) as well as later scholarship that was more concerned with the malleability of environmental hazards, these efforts share a concern with identification and measurement of the components of social and material conditions to describe systems. These components, related as they are, might be modified to make hazards like earthquakes less deadly or disastrous. This model makes it imaginable that elements of complex systems can exist in dynamic balance; under ideal conditions, an earthquake might not be such a radical upheaval for human life.[23] These models generally focus on conceptualizing potential for catastrophic impact of material hazards on human life. The material, social, and technical production of the conditions for conceptualizing these systems and their impacts fall outside of the scope of many such projects.

This research on material and social conditions of disaster has been deeply influential for policy internationally, as I describe in the final chapter of this dissertation. However, focusing on expert practice as well as on the dangers upon which such practices might intervene allows me to resist the temptation to naturalize the meaningfulness of events, or, indeed, the eventfulness of seismicity.[24] For this chapter, I follow the Mexican seismic community's encounters with, and deployment of, emergencies, drawing on participant observation at research conferences and meetings; discursive analysis of social media, ordinary conversation, and formal political speech. Embedding myself in the day-to-day practices of Mexico's seismic experts, I seek to understand how ideas about social and

[23] Also see Rappaport 1967, Vayda and McCay 1975.
[24] Their status as event is, after all, fraught: the threshold at which emergency becomes disaster is, for Adi Ophir, ambiguous for several reasons: "because it is not clear where exactly the line should be drawn…. because the line may be crossed at any given moment due to accumulation or acceleration….because it is never certain whether identifying, determining, or declaring the threshold is a matter of recognizing a fact or fulfilling a duty" (2010, 72).

material world are produced through practice. In this, my research resonates with projects characterized as “post constructivist” STS scholarship.[25]

While an emergency is a sudden disruption, an event for which urgent response is necessary with potentially serious consequences, it is also hard to get traction on what else it is and may be. “’Emergency' is now the primary term for referring to catastrophes, conflicts, and settings for human suffering.” Craig Calhoun writes in a piece on the subject. He understands it to have “rough cognates such as 'disaster' and 'crisis’,” but, he writes. “Use of the word focuses attention on the immediate event, and not on its causes" (2010, 30). Be that as it may, the emergency event is shifting, contingent; its definition, temporalities, and the kind of action it can make imaginable or possible changing with technologies and ideas about what is avertable and what, simply, is not.

In the three sections of this chapter I draw encounters with documents, at conferences in Mexico and California, in coffee shops and homes, as well as in my primary field site at the headquarters of the NGO which developed and maintains Mexico’s earthquake early warning system, the Centro de Instrumentación y Registro Sísmico (or CIRES) in Mexico City.

In this chapter, I describe the production of earthquake emergencies in the context of, with, and alongside earthquake early warning systems, how “a moment” is made a possible site

[25] As defined by Knox and Huse, post-constructivist studies “have contributed to an increasing recognition that both ‘the social’ and ‘the material’ or ‘the natural’ should not be used as explanatory resources, but must instead be studied empirically and by way of the practices that constitute them” (2015, 8).

for intervention, and some of the consequences of certain configurations of materials, technology, and social life which have developed in the context of such a moment. In the first section, I discuss the histories of earthquake early warning around the world and some of the earthquake emergencies that they attend to and make possible. Here, I particularly highlight how certain qualities of users and earthquake emergencies come to be important technically and rhetorically in Japan, California, and Mexico. I then shift focus to the development of the Sistema Alerta Sísmica Mexicana to attend to how the kinds of earthquake emergencies experienced by one particular type of user came to be theorized and designed for, with ongoing effects. I go on, finally, to describe the experience of a new kind of earthquake emergency made possible by ongoing seismicity, new kinds of earthquake early warning technology, and the sociality around it: the emergency of a misfire.

If we understand artifacts to have politics, as Langdon Winner proposed (1980), it does not follow that the details of these politics, their arrangements of power, subjectivity, intervention, and are necessarily singular nor precisely consistent, especially when the artifact in question is multiple, emerges in different technical and social contexts, and takes on different forms inscribed with different priorities, capabilities, and limitations. In this chapter, I am interested in pursuing the implications of this multiplicity by attending ethnographically to practices around earthquake emergencies. Here, I surface the ways in which experts connect earthquake early warning system function to threats to users in order to investigate the nature of the earthquake emergencies that these systems make possible in Mexico and elsewhere, in relation to major earthquakes, everyday seismicity, and events *about* earthquakes, like the one that pulled me off my air mattress in September 2015, tripping over my own feet and frightened, but never shook me at all. I seek to highlight how emergencies are materially, socially, and technologically produced, and, as such, how they are contingent, plural, and contested**.**

Too often in the seismic community and in research on the topic, the relation between earthquake and disaster are not examined. Here, I do just that, considering how different earthquake early warning technologies are built around differently-imagined earthquake hazards and differently-figured users, and the kinds of emergencies that they subsequently make possible**.** When the meaningfulness of emergencies is investigated rather than naturalized, the production of relation between cause and effect, for all its fractured relations, demands, and tensions, can be addressed, too.

Multiplicity of Earthquake Early Warning Systems

In September 2014, a year before I was roused from my air mattress in Plaza Popocatepetl the third International Conference on Earthquake Early Warning began with an invocation of the dead. "Mexico City," seismologist Richard Allen told assembled policymakers, geophysicists and engineers from around the world, "has a warning system, built after ten thousand people were killed in 1985…. The question is therefore what would it take to build a public earthquake early warning system in the US. " Earthquakes are still unpredictable, but geophysicists are able to forecast likely sites of violent ground motion. California is one of them, and as of March 2015 the estimated likelihood of a magnitude-8 earthquake in the next 30 years has increased from about 4.7 percent to 7 percent.

Californians are furthermore asked to expect a magnitude-6.7 quake (like the deadly Northridge quake of 1994) to occur every 6.3 years somewhere in the state.[26] Earthquake early warning system advocate and then-California State Senator Alex Padilla followed Allen's lead in his own remarks, saying: "I don't want to be here after the next big one wondering why we didn't implement a system when the technology existed." He, like the many earthquake experts he was talking with, oriented his comments around a major quake in which lives might be at stake, glossing over the ways that such a technology would entail making decisions about users and priorities that would be by no means automatic or without consequence.

A series of politicians and experts mobilized death, injuries, and financial losses from quakes fading in memory and the one that had shaken Napa only a week before the conference (making significant damages to its wine industry though, thankfully, no lives were lost).[27] Doing so, they mobilized what Didier Fassin (2007) might call a politics of life— that is "politics that give specific value and meaning to human life" which takes saving lives as its object and involves, as it does so, practices evaluation and legitimation (2007, 500).[28] The speakers also engaged with risk in a mode similar to what some have called the "precautionary principle," in which taking action even in the face of some uncertainty is understood to be necessary, especially in the context of extreme or "total" threat. Earthquakes were also addressed in terms of surprise effects. The Napa quake caused all

[26] The 30-year period over which was chosen because it is the average length of a single-family mortgage.
[27] See de Goede and Randalls 2009, Dupuy and Grinbaum 2005.
[28] "They differ analytically from Foucauldian biopolitics, defined as "the regulation of population," in that they relate not to the technologies of power and the way populations are governed but to the evaluation of human beings and the meaning of their existence" (Fassin 2007, 500).

the windows of an airport to shatter. Experts were woken up in bed by the shaking if they neglected their own warnings systems, or by their alerts, if they'd set them, regardless of where they lived.

Framing the need for the earthquake early warning system, a USGS representative discussed annual losses from earthquakes in financial terms, citing a FEMA number. 56% of annual earthquake losses in the United States happen in California, and 77% of them happen on the west coast, he explained. He noted that if just a small percentage, just 0.7%, were offset, the alert would be cost effective. Required impact, he added,[29] need only mitigate 3% of annual human losses to be considered cost effective. How an earthquake early warning system might mitigate 0.7% of non-human losses was not yet clear, since how industrial and infrastructural users would engage with the early warning was being left up to them, the users, to determine.[30] How exactly it could mitigate human losses was more easy to imagine, but no less open at the moment of his talk. Social scientists, he explained, were working on the problem of human users (Hall et al. 2014).[31]

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[29] Somewhat apologetically, as people in the seismic community often tend to when they use money for its properties of commensuration, especially in, I suspect, disciplinarily mixed audiences.
[30] Tierney suggests that " property damage is constructed as an essential element in disasters because that is the perspective of institutions charged with their management. Presidential disaster declarations, which are the principal vehicle for the provision of disaster aid, are triggered by physical loss assessments and estimates of human needs (e.g., temporary shelter and housing) resulting from disasters" (2007, 508).
[31] I met one other social scientist at the meeting; a policy maker, and not one doing any sort of systematic study. This "social scientists" seemed to me very likely to be less about real people doing work than a matter of work that someone else, hopefully someone with a constellation of expertise that might be recognizably different from that of people working on other parts of this project, would do that would allow informed decisions to be made. As news articles charting the development of the system indicate that while it is able to register earthquakes, it is still largely unfunded and little information about how outreach will work has been made public.

The rhetoric that introduced and motivated discussions in the meeting was about a big earthquake, but these calculations incorporated impact of smaller quakes, rendering effects of ongoing seismicity to systems and structures. Within the percentage of nonhuman land human losses that might be mitigated hid any number of decisions to be made, and their complexities and impacts for users could not be easily addressed in the format of the talk.

Users are key to earthquake early warning systems, and although the there is every indication that users of the ShakeAlert system that Allen and Padilla (now California's Secretary of State) hope to build could be quite diverse, they are largely undefined in their particularities. Users have been productively considered to be "a generalized formulation produced for purposes of establishing contrasts between insiders and outsiders" by (Grint and Woolgar 1997, 77) with more or less "strategically vague" qualities (Suchman 2007, 193). These users have been very different.

In September 2014 in California, users were defined as "people and things." Their wellbeing, and the integration of earthquake early warning systems into their ordinary lives or function to preserve it, is of pivotal importance, but for all the utility of an earthquake early warning system may be predicated on users, users can encounter seismicity (ordinary or massive), and, indeed, early warnings, in radically different ways. The articulation "people and things" suggests the ways that the users of earthquake early warning systems and the ways that systems can be designed around and frame emergencies for them, can vary— but at the same time, building a simple dichotomy to suggest this variety may flatten the differences which make a difference: "people" and "things" are, as I will demonstrate, not just two categories for this kind of system, but many. Design decisions which privilege certain kinds of people and things and allow them to represent the whole category of those which it might be possible to warn risk making other people and things, and other ways of being warned, invisible.

For their part, Allen and his team have installed ShakeAlert in San Francisco's public transit system and are beta testing it with a number of humans, too— largely tech and seismic-savvy earthquake experts with high speed internet connections. They have not published on the identity or demographics of these test users. Instead, they primarily write about registry and analysis subsystems, leaving the intricacies of users, training, and alert dissemination aside. Allen's laboratory and extensive publication record are testament to ShakeAlert's development, but as I suggest here, that development should be understood to both frame potential uses and respond to them. Much scholarship on alerting is applicable to slower phenomena, and suggests guidelines simply inapplicable to disseminating alerts for earthquakes (see Mileti and Sorensen 1990, Sorensen 2000) and while recent communications scholarship has engaged with the possibilities of rapid alert communication through Twitter and other social media (see, for example, Sutton et al. 2014 and 2015), there is not much evidence of the ShakeAlert team's engagement with this material. How their alert will be disseminated, that is, the priorities, processes, and means by which users will be brought into relation with system components and made aware of oncoming earthquakes, is still, at least officially, undefined. This California system is projected to cost $38 million dollars for a build out over the course of 5 years, and $16 million dollars per year. This, however, again divides education from the technical, as training and outreach costs are largely not included.

Padilla's statement about the necessity of implementing a system when the technology already exists, then, while rallying, cannot be understood as entirely the case. There certainly are a number of earthquake early warning technologies that exist, and even a network or sensors, algorithms, and communication systems built particularly for the types and sources of earthly motions that his constituents in California experience. At the conference in 2014, I saw many connections between the experiences and technologies discussed by the assembled experts. Nonetheless, each is different, responding to different seismic systems, different structures of funding and technoscientific expertise, and framing different kinds of emergencies. Earthquake early warning technologies do exist, but California's earthquake early warning does not.

"Can you imagine," Mayor Ed Lee of San Francisco repeated, later in the morning, talking about potential applications of earthquake early warning systems for the public, industry, and emergency response. Imagination was indeed a key element of the conference, both in terms of the potential fruits of expert labor and, in a darker sense, in terms of its stakes. In this section, I will discuss the different ways that emergency has been explicitly imagined around different kinds of early warning systems, highlighting the multiplicity of temporalities, subjectivities, and possibilities that can be produced alongside and through this technology without necessary reference to seismicity at all. I then contrast different kinds of technologies that frame earthquake alerting and earthquake emergencies in particular, primarily in Japan, California, and Mexico. As I do so, I draw attention to how technoscientific intervention in earthquake hazard is figured differently even in and among systems designed around seismic hazard, and might produce different kinds of encounters with the seismic world. Finally, I describe how treating the plurality of approaches to earthquake early warning as a single type of endeavor can make certain differences and similarities in the approaches of Mexico and the nascent California system obvious, while concealing others. difference between systems making certain assumptions about where politics lives possible and can hide others.

With this section, I challenge the idea that earthquake early warning is a single technology, and bring historical and technical evidence to bear on the project of attending to the production of earthquake emergency, contesting approaches to earthquake hazard and disaster prevention that do not adequately grapple with the complexity of defining a hazard or intervening upon it.

Particularities in early warning systems

Early warning systems are best applied to hazards that are possible to forecast but not predict precisely: earthquakes are excellent examples, but others include air quality issues, extreme weather, floods, fires, mudslides, epidemics, and even slower phenomena like famine and desertification can be made to trigger warnings before they are likely to become dangerous to populations. They have similar goals, or similar enough, although the research on the social components of outreach which most accumulates in CIRES archives is often focused on slower hazards than earthquakes which destabilize the material world in essentially different ways than earthquakes do. A brief overview of early warning systems and the ways they are often understood to intervene on hazards is, at this point, necessary.

Earthquake early warning in the ways it is practiced today is, in general, much younger than warning against these other threats, and is pertinent to relatively few places in the world. The minutes of warning that a flash flood might allow for is long in comparison with the kinds of time constraints that earthquakes and earthquake early warning designers place on this particular kind of warning work. The emergencies that these conditions afford operate on different timescales than those precipitated by an earth in motion. While studies can provide programmatic statements and principles, the material, social, and technical relations that make earthquakes meaningful escape and confound the insight of this research even as earthquake early warning work is guided by it.

Early warning systems, broadly, have been called "essential investments that protect and save lives, property and livelihoods, contribute to the sustainability of development" and are "far more cost-effective in strengthening coping mechanisms than is primary reliance on post-disaster response and recovery" according to the Hyogo Framework for Action (UNISDR 2005, 5, an issue that has been taken up again in 2015's Sendai Framework for Disaster Risk Reduction).[32]

[32] The latter of which is considered to be far more focused on risk than the former; see Maskrey 2015.

These systems may well provide ways to deal with emergencies for those who cannot prevent them, particularly low or medium-income nations, and sometimes construct knowledge about the material world around them. UN advocates of early warning systems note that poor people come to suffer from hazards disproportionately—[33] they are, first, more likely to be in dangerous places, and second, less likely to have the illusive tools of robust coping mechanisms that are often called, in policy literature, "resilience." These are qualities that allow a community to feel a crisis less intensely, or to return quickly to health after ward. As Roberto Barrios points out, "It is also noteworthy that much of the literature on resilience prioritises concepts borrowed from economics as a means of representing the qualities that help communities survive catastrophes" (2014, 329). In the absence of resources to design better cities and support the most marginalized residents to forestall the worst effects of a hazard, early warning systems can at least allow users time to take what steps are possible to keep themselves safe or reduce a hazard's impact on themselves and, by extension, their community.

This strategy for disaster prevention is, it should be stressed, not the only one that the UN advocates. Early warning systems are part of a complex of strategic technical and regulatory measures recommended, many of them folding other actors into protecting people and things from harm; in this most "cost-effective" strategy, however, alerted users may be on their own to make decisions and take action. This, however, is contingent—their effectiveness not just a matter of their own sensible liberal individuality and capability, but on the early warning system in question's accurate recognition of hazardous

[33] see United Nations International Strategy for Disaster Reduction 2005 and 2015.

phenomena (on this troubling assumption, see Farías 2014) and effective communication about it.

Just as recognition is complicated, so is effective dissemination, as the seismic community describes warnings and outreach or education conducted about them. Modes of dissemination are built around ideas about users communicated to— and who or what they might be, and what they might be disposed to do, have been sites of contention and reevaluation in the context of early warning systems of all kinds. For example, discussions about how likely publics are to panic upon receiving a warning are perennial, despite the general consensus among researchers that panic and post-disaster lawlessness and shock responses are largely myth. This kind of threat, however fantastical, raises the stakes of getting warning right for policy makers. According to the principles and guidelines established by Denis Mileti and John H. Sorensen's extensive review of early warning systems for all manner of phenomena, good alert messaging should contain "consistent, accurate, and clear information; guidance on what to do; risk locations; and confidence or certainty in tone" and must "come from sources that the public view as credible" (1990, 2-10). The production of that credible information and guidance should, they stipulate, be calibrated to users and their needs, and offered if possible by multiple sources with as much information as possible. Not only has communication by authorities, particularly using social media, come to be understood as necessary to early warning (as evaluated in work on the use of Twitter for emergency communication by Sutton et al. 2014 and 2015), but community members' work to fill gaps in information communicated by official media (as in Sutton, Hansard, & Hewett, 2011).

Earthquake early warning systems have been developed in the context of both celebrations of the general utility of early warning and this ongoing research into its effective application. The principles developed to guide early warning in general (Mileti and Sorensen's compendious 1992 literature and system review is still generally cited, representing best practices, though new media has allowed for new strategies, as Sorensen 2000 indicated when he revisited the topic). Although there are a wealth of investigations on effective warning dissemination as alerting strategies (the former, qua Sutton, Hansard, & Hewett 2011, contains more substantive information than the latter), these efforts are only sometimes partially useful in the case of earthquakes.

Material on other kinds of early warning projects was well stocked in many CIRES director's offices and referred to regularly in our conversations. However, its applicability was always partial, largely due to the temporalities over which earthquake early warning was designed to function. Earthquakes are generally understood to move too quickly to make it possible to disseminate the kinds of substantial amounts of information through multiple official sources, as Sorensen and Mileti (1990) and those who've followed them suggest—though, I will describe later in this chapter, some of that received wisdom is being challenged. Regardless of emerging challenges, the general state of things is that the prodigious research which has been undertaken on warning dissemination has been taken on indifferently by designers of earthquake early warning systems. They are well-known, but what standardizing effects that these best practices might have are lost in the affordances and limitations of encounters with seismic phenomena themselves. Earthquake early warning remains plural, and not only with respect to dissemination practices.

Plurality in earthquake early warning systems

While the speed and scale which characterize earthquakes have informed the design of earthquake early warning technologies, these technologies also reflect a variety of ways that earthquakes, the emergencies they can cause, and potential system users can be parsed. Earthquake early warning applications can look very different as they entangle the technical and social worlds of both operation and of users, which themselves take very different forms. While technical challenges of rapid sensory, analysis, and communication have been substantial and often take center stage in conferences and publications on earthquake early warning systems, these different models of alerting are built around different ideas about earthquakes, users, and facilitate different kinds of encounters between them. In the history of earthquake early warning, there are clear examples of different approaches.

An educated public was included alongside electrical signals and church bells in the speculative 19th century proposal generally regarded as the first published outline of an earthquake early warning system[34] (Cooper 1868). The bell-ringing that Cooper imagined would rouse a population en masse and spur them to action. Despite this early scheme, no "regional" earthquake early warning system[35] of this type were implemented until nearly

[34] Cooper 1868.
[35] The P and S waves which comprise earthquakes move through the earth at different speeds, depending on the composition of the crust or mantle through which they travel. Some alert systems

one hundred years later. The first one was not even public, but instead an automatic process which would slow Japanese bullet trains rather than allow them to be jolted off its tracks at high speeds (Nakamura 1988). It was only shortly thereafter when Mexico's system went live and went public.

While Mexico and Japan were the first nations to develop earthquake early warning technologies, these tools have also been implemented in many places in Western Europe, as well as Romania and China (though not always for public use so much as industrial automatic functions).[36] Systems are currently under development in Chile and Nepal, and, of course, California.

These kinds of technical systems suggest different orientations toward population, authority, and communication. Cooper's signal was to be broadcast through sound from a central site to an educated public within earshot: alert was to be demarcated by territory; by nearness to a resounding bell. Japan's system, limited at first to triggering basic decisions about slowing the bullet train, however, focused on safety and automatic processes for publics that might find themselves either speeding toward a derailment or slowed safely.

Mexico's system, like Cooper's idea and the bullet train application, has largely involved a simplified action: an alert, a distilled warning designed into a system. A bell rings, an alert

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may use on-site warning to register when the quicker P wave reaches a single site and produce a warning before the secondary and larger S wave of an earthquake arrives. See Allen, Gasparini, Kamigaichi, and Bose 2009.

[36] No European system is public.

sounds, or a train slows: this is one simplified action triggered by a signal about an oncoming quake. This has not been the case elsewhere, and both Mexican and Japanese systems allow for other kinds of uses. The public Sistema Alerta Sísmica Mexicana signal that the NGO CIRES developed and maintains for the Mexican state includes information about level of quake intensity ("moderate" or "strong") as well as location of the signal that first sensed the earth motion. But trends are changing.

While Cooper proposed an earthquake early warning system over one hundred and fifty years ago, he did so in relatively simple language of electrical signals and church bells. It was not, however, until a great deal of automatic processes had been made possible that a system like the one he described was actually built. These included processes that would make an earthquake distinguishable, and quickly, from the background ground motion created by a passing truck,[37] and those that would make its size calculable quickly.[38] These processes, along with techniques for connecting sensory stations to target process or servers, were only really developed in the middle of the 20th century. The designers of the Sistema Alerta Sísmica Mexicana were trained at one of the first laboratories to network stations telemetrically.[39]

[37] Key work is documented in Lee, RE Bennett and KL Meagher 1972, Allen R 1978, McEvally and Majer 1982. They wrote about developing methods for quickly identifying earthquakes and defining them from background noise, though could not yet determine magnitude.
[38] Documented in Nakamura 1988, Espinosa Aranda et al. 1989, Espinosa Aranda et al. 1992.
[39] Humberto Rodriguez, their supervisor and the developer of the SISMEX system on which they worked, described this work in an interview with me as a matter of using cold war technologies for peace.

These problems have been the focus of further development as earthquake early warning systems. More recently-designed systems, perhaps most visibly ShakeAlert in California, have been developed in academic geophysics departments. These are built to be precise about the earthquake data they provide users and to interact with users to some extent, at least letting them set location and preferences for the alerts they receive, as well as to be ever faster. Systems like Japan's current system and the nascent California ShakeAlert are now designed to give complex, constantly updated information about not only the source of the quake but subsequent fault ruptures and likely intensity of shaking where users are, responding to earthquakes as events that unfold and cascade.

ShakeAlert will collect and share information about quakes all up and down the west coast of the US in real time, but integration into outreach has been patchy. Few sites for earthquake early warning have the affordances that Mexico does; with its rich, populous and powerful city located at a distance from quakes that would allow warnings to be particularly useful and have provided a huge engine for earthquake early warning adoption.[40]

The ShakeAlert project is attractive enough to get politicians involved, and integrates nicely into a space of seismic imaginary in which California is on the edge of the "big one." There are substantial histories of narratives, tools, data, and experiences that might allow the US west coast in general, and California in particular, to grow an earthquake early warning system with more ease than other sites. The area is seismically active, and accruals of

[40] As discussed in the first chapter of this dissertation.

knowledge, money, population, and stories have made its seismic activity charismatic. It seems likely that it will be fully functioning soon, but nonetheless bears noting that the ShakeAlert system is not yet alerting despite a 2014 legislative approval and some limited state funding and that users, and mechanisms for reaching them, remain undefined as of April 2016. Despite how easy it is to imagine a massive quake in California and the damage it could cause, enrolling support has still been a challenge.

Mexico's system, far less scientifically ambitious than the one that California has planned, is nonetheless fully in operation, detecting quakes and broadcasting earthquake early warnings much faster than the California model system can;[41] a fact that one presenter at the 2014 meeting opened by then-Senator Padilla actually forgot when crediting his inspiration for public earthquake early warning. Citing the work of Japanese and Californian experts rather than that of the Mexicans, he made it clear where this kind of technological innovation was imaginable and how the currents of international knowledge flows are generally understood to move. Sitting with the CIRES team in the audience, I was restive. They had complained about this sort of thing before.

When it was time for CIRES Director Espinosa Aranda to present on the Sistema Alerta Sísmica Mexicana on the second day of the 2014 conference, he not only not only discussed how CIRES's algorithms functioned technically but displayed a rendering of the system's function during the Good Friday earthquake. Alongside a stylized diagram of the energy of a magnitude 7.2 quake move from its epicenter off the coast of Guerrero which made it to

[41] It takes the Mexican system 3 seconds and the California system 7 seconds as of 2015 (Strauss et al. 2015).

Mexico City at 9:27 AM on April 18, 2014, the tall and careful engineer showed a video of a newscast happening simultaneous to the movement on the map. First the alert went off. Then the studio began to shake. The image was elegant, despite Espinosa Aranda's stilted English.[42] Mexico's earthquake early warning system works, and while new applications are still being imagined, the kinds of responses to earthquake emergencies that the Sistema Alerta Sísmica Mexicana makes possible speak, and sometimes shake, for themselves.

Espinosa Aranda might be overseeing the oldest public earthquake early warning system, but the kind of example that it might set for the US scientists wasn't always entirely clear to his listeners. How could Mexican emergencies, and Mexican tools—produced as they were in the context of Mexican inequalities, funding limitations, and infrastructural deficits—guide the approaches to hazards in other, richer places? The techno-optimism strongly exhibited in many presentations I saw and conversations I had seemed to make such questions hard to think through. Technoscientific tools seemed charismatic enough themselves to enroll funders and users without explicitly incorporating them into design decisions. A year later, the Californian system was still not funded, and techno-optimisms among the experts designing it could not quite disguise the complex politics of knowledge that seemed to make developing an earthquake early warning system as difficult in the wealthy US as it was in Mexico— though Californian experts, unlike their Mexican counterparts, were not quite ready to call their challenges "political."

[42] Lingua franca in international seismic engineering and science discussions. Espinosa Aranda, of course, reads both English and Spanish, but the skillful ways that he plays with language and references in his native tongue are not as available to him in English; a real loss for his listeners.

The seismic community does politics

While seismologist Richard Allen was mobilizing the same kinds of arguments about stakes he had 2014, at another meeting of the seismic community in September 2015, he was using slightly different rhetorical strategies. Here he was not talking about the specter of a great disaster or injuries caused and money lost in a recent quake but, instead, drawing on information about the particular types of injuries that the confluence of earthquake energy and the configurations of built environments had caused Californians in the past, the good that an earthquake early warning system in California could have done then, and the good it could yet do.

Citing evidence from the Northridge and Loma Prieta earthquake, Allen pointed out that more than half of the injuries in both had been generated from falling objects, particularly non structural elements.[43] Now the effects of earthquakes on people at risk had been quantified and grounded to certain kinds of structural threats. The particular qualities of seismic emergency involved in earthquake early warning projects and their challenges can come to be concealed in discussion that posits an earthquake early warning as obviously necessary. Here discussions of sensory technology and analysis largely took center stage, deriving their authority from techno-optimism authorized by a politics of life in which detailed issues of the distribution of risk and safety were made invisible. When Mexican experts discussed how they had navigated the development of an earthquake early warning system, the vast gulfs in knowledge and experience which divided experts in California from those on Mexico became clear.

[43] See Shoaf, Sareen, Nguyen, and Porter 1998, Porter, Shoaf, and Seligson 2006.

Allen and his team had flown out to Mexico City for an event in memory of the Michoacano earthquake of 1985 in a modern conference center on the south side of the National Autonomous University of Mexico. The conference was designed to bring engineers, policymakers, and geophysicists together, notably trans disciplinary for this community. For an entire day of the two-day event, the West Coast team sat in a small room with alerting experts including a British entrepreneur, a Japanese engineer, Mexican engineers, technicians, and geophysicists, and myself, a US-based anthropologist. Their presentations covered the recent developments of their algorithms and data work, and moved between English and Spanish-language.

These talks were followed by questions about data derived from seismic sensors, strategies for analyzing it, and the applications of these processes, some quite direct but not unusually so for the genre. Had kind of data been considered? Or another? Why was such a calculation necessary? It was the first presentation in the career of one CalTech doctoral student, and she had to respond to several questions with simple agreement and without extra information: it would be interesting, yes, but she had not yet had time. Another presenter from the University of Washington was challenged on his data practices, particularly the depth he calculated, by the Berkeley scholars who designed the algorithms he was using. He was limited, he explained, by his capability to play with the very tools that they had developed and were constantly updating. "I don't think we'd do that without your permission," he told them, laughing.

In the day's conversation, sensory data and its analysis were topics of presentations. There was no other section here for policy or dissemination concerns regarding earthquake early warning. These were, then, rolled up into the discussion time scheduled after presentations, giving them the aspect of issues of secondary and contextual importance.

After a series of talks the floor was opened for discussion. Dr. Osario, as he was wont to do, explained in English that the Mexican system was a matter of engineering, not science. "It's not very accurate." He said. "We know. Everybody knows." The Sistema Alerta Sísmica Mexicana was not built to communicate precise information, and carefully left that scientific work to the Sistema Sismológico Nacional, the National Seismological Service. The CIRES representatives talked about alert broadcasting instead of official quantification of earthquake size: about radios, televisions, and about the loudspeakers across Mexico City which would soon be incorporated into early warning practice and the apps who were alerting in what they regarded as deeply problematic ways. They discussed drills, education, critiques and political debate.

Enrique Guevara, an engineer and longtime leader in Mexico's seismic community, commented to the Californians: "Maybe it's very difficult for you to understand Mexico's culture." He remembered how Mexico's Sistema Alerta Sísmica was first made public: "They were interviewing the governor of Mexico City. And he said that they had been working with CIRES on this alert system and they said, hey, and why don't you do this publicly? And then it was decided, in the news, to make it public. I think that would not happen in the US. But that's the way it happened here."

The Californian project was nascent in comparison, and its designers had no similar experiences to draw into conversation with Guevara's point. “We’re working on it!” said Dr. Peggy Hellweg, another seismologist and member of the Berkeley delegation. The Berkeley team could only wish that someone in authority would get so solidly behind their project. But that was not what Guevara was getting at.

“People were not educated.” He continued “But they started the early warning system.”

Dr. Osario picked up the thread of conversation. “This happened in Mexico City. Mexico City gave an alert and *then* tried to educate the people. Oaxaca educated for a year, and then gave an alert.”

“Which was better? Oaxaca or Mexico City?” Allen asked.

The response was obvious to Osario, as it had been to Guevara when he’d started the story. “Oaxaca for sure! You have to indicate before you do anything!” The government’s sudden interest was not all it was cracked up to be. The Mexicans knew firsthand the trouble with navigating these violent tides of political will which had placed them as engineers in the position of issuing warnings to an unprepared population and made them very conscious of the scope and limits of their project and how it was integrated into the political and social world. The pressure of state interest might cause their service to be less than well received by a population unprepared to take advantage of it.

For Californians, who still had not acquired the funding that they would need to get their project off the ground nor that which would be necessary to maintain, all this did not seem to be immediately and obviously bad. Their challenge was something else— a lack of interest appreciable enough to make their system really flower.

As we walked through the convention hall afterward, stretching our legs in diffuse light after hours watching power point presentations and appreciating that the smell of the nearby agricultural school's experimental fields had somewhat dissipated,[44] visitors from California told me that they were glad they hadn't had the kinds of problems and politics that the Mexicans had. I had reason to be skeptical of this, however, when we began to discuss their test users. In the fall of 2014, news networks had picked up stories that Long Beach would be a test community for the alert. I had been particularly interested in following these developments, trying to mobilize southern Californian contacts to learn more about what that would mean and even, when I had the opportunity, moving to the city for a few months as I began work on my dissertation and waiting for more news. Anyone at City Hall that I could get on the phone was polite but evasive, and no further news articles had been forthcoming.

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[44] A foreign geophysicist now teaching at a Mexican university had, when the smell hit, suggested that this was exactly what was wrong with Mexico. He loved being in the country, and felt there was real opportunity there. The problem is, he said, that people simply didn't plan. If the university or the designers of the new convention center had thought twice about the fields, they might have positioned the new convention center differently, or at least might not have installed systems to circulate air that wreathed us suddenly, one and all, in the scent of barnyard animals and their shit. The importance of this oversight was driven home later, when another out of town visitor noted that he hadn't realized that the smell had been syphoned in from outdoors and had, instead, assumed that it was coming from another expert whose entrance into a conversation had been poorly timed to say the least.

When I asked about Long Beach, the Californians groaned. It had all been a mistake, they explained: Long Beach was no more or less a test community than Los Angeles or San Francisco. Each had been allowed access to the earthquake early warning app not yet in distribution, but unlike the other cities, someone at Long Beach had decided to go public. This, they explained, had caused a great deal of conflict with California Governor's Office of Emergency Safety (CalOES) which was committed to a very calculated public launch. In comparison, San Francisco's integration of the earthquake early warning system to automatically slow BART trains had been operating smoothly both technically and in the public.

They were preparing for a complex public of their own, and the configurations of power as well as geophysical activity in California meant that state and national agencies might dictate how users could be integrated into their earthquake early warning. Decisions about utility, or simply the readiness of a major city's public transit system, meant that San Francisco was really more of a test community than Long Beach.

Ideas about the emergency that an earthquake might present, what kinds of things could be done to prepare for it, and what kinds of things a system should in no way do, inform earthquake early warning projects. Conferences allow space to meet and discuss the development of these analogous but not identical technoscientific tools and their implementation. These exchanges reflect complexity of the meaningful relations between the material, technical, and social in earthquake early warning systems.

Users and Emergencies in Mexico

In the 2014 meeting in Berkeley, half of Espinosa Aranda's presentation on the Sistema Alerta Sísmica was turned over to an Israeli-born engineer named Ifraim Patel. Full of energy and in a shirt with his company logo embroidered on it, Ifraim (who had been whispering commentary to me up until that point) bounded on stage and introduced himself.

He stood beside a radio receiver, about the size of a brick, which had been set up on a tripod before Espinosa Aranda began to speak. It was a hard beige plastic, with a small screen and a long antenna. It did not have the kind of elegantly designed exterior that I knew other businesses to be developing,[45] but it was the radio that CIRES supported, made and distributed by companies that the NGO had worked closely with. This was a radio I had been handed before, in CIRES offices and in the offices of the radio's users. Beside the tripod, Patel began to talk about his work with CIRES, and the differences between their project and the one that the Californian experts had set out for themselves, producing an early warning technology leaving open the means by which it could be disseminated.

“As you notice," he said, "Mr. Espinosa and his team are in charge not only of detection but also of the warning to the public. They are tasked by the government to do that.”

This is a good summary of the position in which the CIRES engineers find themselves in, though not entirely happily. CIRES is a NGO supported by the state, an NGO that is integral

[45] Grillo, a radio receiver in production, is lovely.

to public disaster prevention. It was developed as an organization which would design and maintain instrumentation. However, as the Mexican state has done little to implement their technology, make it available, or educate the public about it between the early 1990s and 2015, the roles that Patel outlined had come to include not just developing technology to register and analyze earth motion and disseminate alerts, but also to advocate for the system and perform outreach and education with users, too.

Patel's portion of the presentation was sunny. It was half exposition and half sales pitch. He highlighted the challenges that CIRES had with dissemination; not originally the role of an instrumentation NGO but one for which they had found themselves responsible. He told the assembled experts about being brought on in 2007 to help develop a radio that would be less expensive to build and maintain than the massive "cabinets"[46] that CIRES had installed in many schools, radio and television stations, and government offices.

The radio that he was displaying— or rather, its forbearers, as this was a recently reconfigured model and slightly smaller— had lowered the barrier to entry and made it feasible for smaller companies and even families to have an earthquake early warning system in their homes.[47] It had a distinctive warble that would activate rapidly with the Sistema Alerta Sísmica Mexicana warning signal and continue to sound until the seismic hazard had passed. Similar systems could be designed for California, he explained.

[46] "Gabinetes" in Spanish— and at about two feet by three feet of metal, they do look like cabinets.
[47] The "cabinets" had cost upwards of 20,000 pesos, nearly $2,000 USD in 2006 before the introduction of these newer, cheaper, smaller radios. They were an impossible expense for all but the largest organizations. The little radios, on the other hand, could cost as little as $1,500 pesos (although this is second hand. Their price when acquired from official sources shifts, and is not generally disclosed to the public.

Patel addressed an audience in need of alerting. The radio could be adjusted, he told them. For California, he had a few suggestions for setting changes— Mexico was, after all, a very differently seismic place— but that his radios could be made to respond to other kinds of emergency signals, too. His talk stood out. No one else was trying to convince the assembled experts to buy, at least not so overtly.

Patel's team At Hoc is based in Northern California, and the radio that they have produced for Mexico, in partnership with local vendor, is called by the acronym SARMEX for Sistema de Alerta de Riesgos Mexicano, or Mexican Risk Alert System. It operates on common alert protocols developed by NOAA in the US, and can be used to receive other kinds of alerts broadcast on those channels.[48] The relationship between this commercial enterprise and CIRES is clos and nearly ten years old. Its ongoing nature attests to the complexity of making an earthquake early warning available publicly.

In 2006, when the Mexican government had finally decided invest in distributing radios for earthquake early warning on a large scale, nothing like the small SARMEX radios existed. A CIRES engineer began to develop options for receivers that would facilitate large scale investment and distribution and which would not require a technically trained team to install and maintain. Eventually Patel and At Hoc[49] were brought on board to build the first 25,000 radios that the federal government had ordered.

[48] While Mexico has tropical storm and tsunami early warnings, but these were not at first broadcast on the same emergency frequencies that SARMEX receives.
[49] Then called Alerting Solutions.

CIRES's board of directors was convinced that this kind of activity was outside of the organization's mandate. One of the engineers who had developed the radio plans left CIRES to start a for-profit company that would have these radios built by Patel's organization and sell them to the government and, eventually, to the public, too. The Mexican government eventually bought many more than they had first ordered, and a Mexican company called MDreieck contracted with Ad Hoc to sell them in places where CIRES was broadcasting.

The complexity of this arrangement, the apportioning of NGO and for-profit entanglements in facilitating the dissemination of first equipment for an earthquake early warning and then the earthquake early warning itself, does not emerge as a matter of assigning roles along clearly determined lines. Instead, it indicates the ways in which making an earthquake early warning available to users has been subject to technical and organizational contingencies, unfolding even fifteen years after the Sistema Alerta Sísmica Mexicana began to be offered to the public.

What Patel was displaying at the conference in 2014 was less the function of his radio than its versatility and utility, playing a recording of timed beeps to demonstrate just how much could be done with 10 seconds of warning. His talk was non-technical, and stood out for that. It offered, however, a reminder that the very existence of alert dissemination could not be taken for granted.

In this section I address the formation of Mexico's system and the particular kinds of politics that may not have been thoroughly clear to Californian experts. A riot of interests articulate different kinds of tensions here, following contingent and then channelized ways of thinking about users and their vulnerabilities.

Here, I describe how experts have designed the Sistema Alerta Sísmica Mexicana[50] to bring users into new kinds of relations with seismicity. I focus on the ways in which this ongoing inclusion has been informed by pervasive ideas about how of suffering or learning from emergencies might be mapped onto soils, built environments, and publics. I then describe dissemination, via "cabinet," SARMEX, and other modes of outreach and what the ongoing maintenance work this alerting infrastructure has meant for CIRES, nominally an arbiter of earthquake early warning efficacy. I offer a granular account of who users might be and how the system came to be designed for certain kinds of subjects, pushing back against the simplified politics of life deployed so easily in the techno-optimistic earthquake early warning conferences I have described. While I am very sensible to the heady promises of earthquake early warning systems for disaster prevention, in this section I describe the messy and uneven way that the Mexican seismic community has been able to make new and potentially life-saving ways of encountering earthquakes possible—at least sometimes, for some users.

[50] While my main focus is on the experts who designed and manage earthquake disaster prevention tools, I am nonetheless respond to concerns like those articulated by Heath, Knoblauch, and Luff who note "By extricating tools and technologies from the circumstances of their use, we not only lose sight of the practicalities which can lead to, and account for, the character of particular documents, but render epiphenomenal the socially organized resources which make the particular tools and technologies what they are" (2000, 310).

The Users

Mexico City's most sensitive zones are common knowledge, though, broadly speaking, and unlike many high-risk areas across the world, they[51] are a mix of wealthy and poor places. Parts of the Zonas de Lago are called La Condesa and sit on the near west side of the city in a conglomeration coffee shops, bars, and dog parks, and other parts have become the city's historical center. Both are covered in thriving businesses and support vast flows of money. Parts of the Zonas look different, though. One, Iztaplapa, to the south and east, has become so known for its highest crime rates that people incorporate a word for a disfiguring physical or moral blight into its name and call it "Iztapalacra."

In a city which has been subjected to rigorous seismic "microzonificación,"[52] it is important to note that discussions about Sistema Alerta Sísmica Mexicana utility aren't usually made to map onto place, nor even to seats of authority. A decision was made quite early on that earthquake warnings could not be disseminated only vulnerable places in Mexico City.[53] I am told that this was a response to concerns about disturbing the residential or commercial livelihood[54] of the areas at particular risk. It also meant that broadcast media could be easily incorporated into alert dissemination and that state agencies could side-step the very public political pitfalls around any official work, with 1985 quake still a frighteningly recent memory, to divide those areas who would receive alerts from those

[51] United Nations International Strategy for Disaster Reduction 2015.
[52] Refers to the practice of characterizing "micro zones" of soil within geographic area according to their response to seismicity.
[53] The Director explained in the 2015 meeting.
[54] I have heard stories of large scale maps of the destruction of the city in the wake of 1985 which appeared and then vanished, never to be seen again.

that would not be alerted.[55] However the decision came to make sense to policymakers in the early 1990s, it meant that earthquake early warning dissemination, even when very little was done, could not be distributed along axes of that kind of physical vulnerability.

Instead of dangerous locations, then, earthquake early warning has been designed around locations where particular kinds of ideal users can regularly be found; users that are not only vulnerable, but undeniably deserving of protection, uniquely capable of taking action in emergencies, and themselves likely to do ongoing doing earthquake early warning education in their communities. CIRES representatives and earthquake early warning advocates would discuss the utility of warnings in hospitals, emergency service providers, or industry, but it was the undeniable trend in my fieldwork that students (often children explicitly, though universities have been well-integrated into the system) were to be understood as key users of the Sistema Alerta Sísmica Mexicana.

From the very early days of Sistema Alerta Sísmica tests, early warnings were made possible in schools for the safety of children. This makes a great deal of functional sense with respect to the qualities that emerge in the Sistema Alerta Sísmica Mexicana today: it is simplified and broadcast without much associated information, and its effective requires training on site. Children could be taught, and they could be drilled in what they had been taught. The system even issues two levels of warning, one broadcast in advance of moderate-level earthquakes especially for the use of schools. In Mexico City, “preventative” alerts are issued for moderate quakes, triggering warnings in radio receivers with certain

[55] A distinction that might incorporate information about the build environment as well as soil properties

settings engaged that are indistinguishable from those triggered by larger earth movement. This gives students a higher degree of protection than the rest of the population as well as opportunities additional opportunities to practice their safety procedures for quakes they might not even feel, depending on their location in the city.

School children have been the main experimental population for the alert as well as the ideal user as the system developed in the 1990s. Experimentation here was not a systematic pursuit, and the wellbeing of children is not an issue that brooks much trial and error. My assessment should not be read as a critique of scientific practice, or an argument that the focus on schools was in any way rushed. Instead, I believe the central importance of schoolchildren for the Sistema Alerta Sísmica to be the result of an accumulation of engagements including data and interest from schools. The stakes of protecting children were, and are, high, and keeping them safe was a goal which, from a political perspective at any scale, was largely unassailable.

In the contingent development of the system for users, though, the focus on schoolchildren was largely due to the work of one particularly industrious woman: Elia Arjonilla Cuenca, a dynamic sociologist and activist who's studied and designed earthquake safety in the Mexican school system. Arjonilla no longer goes to many earthquake early warning events. Her work has changed, and she is semi-retired. In the 1980s and 1990s, however, she was an active member of the seismic community driving disaster prevention policy.

In a family of geophysicists and part of the seismic community[56] by association before she became so by her own inclination, she was not just possessed of the training in sociology and public health necessary to organize studies and advocate for public safety in particular ways, but she was socially positioned to take advantage of technical and political talk in sobre mesa conversations after meals and benefit from invitations to events in the wake of the 1985 quake and the re-evaluation of safety procedures which came afterward.

She had something else, too: the social currency of status as a mother, whose work as an "ama de casa," caring for her family and arranging for their wellbeing, had a moral power. When Arjonilla says she was a "madre de familia" or "mother of a family," which she often did in the course of our interviews and a talk I attended, I do not understand her to be denying the importance of her training in public health and sociology, or even her organizational skills and tenacious work ethic to the influence she came to have.[57] She is instead talking about a kind of authority and energy that gave her access to draw upon that training to take what she learned from the seismic community, whose professional spaces she describes as almost uniformly male, and make use of it first in her children's school for their benefit and then more widely.

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[56] Similar to what Stallings (1995) calls the "earthquake establishment," a professionalized social movement.

[57] This power is one that has a lot to do with the Mexican concept of "ama de casa." Not strictly synonymous with the English-language "housewife," "ama de casa" doesn't bear histories of postwar US employment politics and does not foreclose extensive work outside the home. Instead, it implies power over the home and responsibility for its condition and that of the family that resides within it (often by way of the effective management of labor done by hired household staff). It is a role of mature feminine authority that can be extended out of the casa proper and into the world.

In 1985, when the Michoacáno quakes struck, Arjonilla had children enrolled at Colegio Madrid, an upper-middle-class k-12 educational facility in Mexico City near Xochimilco and on soil of the seismically sensitive kind. Her extended family was soon deeply involved in the seismic community working busily at UNAM and the Mexico City government to understand the seismic territory on which they lived in new ways based on their recent experience and rebuild structures and regulations light of new knowledge. The quakes had damaged her children's school quite badly, and parents of the 3000 Colegio Madrid students were asked to take part in a Comisión Voluntaria de Seguridad de Padres de Familia.

Arjonilla took that post-earthquake volunteer job, along with Rosa Melgar, another parent. Their committee looked at the earthquake procedures in place at other schools and developed plans to implement the very best of them as a Programa de Seguridad for the school. Arjonilla and Melgar were co-authors with two US-based disaster researchers on an English language report on the Colegio's recovery in 1986 (Gratton, Their, Arjonilla, and Melgar 1987).

When other parents scaled down their involvement and she kept working, for other schools, the education ministry, and then eventually CENAPRED, the Center for Disaster Prevention.

In an earthquake in 1995 she was able to compare responses in a school which used the Sistema Alerta Sísmica to one which did not. Interviewing students in similar structures which had experienced similar shaking, she found overall that the Sistema Alerta Sísmica had allowed one school to follow its safety procedures without difficulties and had allowed the earthquake emergency to produce less tension and disruption than had been created in the other. While she argued that earthquake early warning necessitated "solid planning and preparation on the part of the community" (1998, 3). [58]

She was critical of the implications of the way that technical experts dominated dissemination,[59] writing that CIRES was "expert in questions of monitoring, detection, and alerting, in merely technical terms" but it did not have "the perspective of other disciplines necessary to promote an optimum collective response" (1998, 2-3). These would include large scale systemic education and outreach and better emergency training for all.[60]

This research work was only sizable study about the utility of the earthquake early warning in maintaining physical and mental wellbeing, in changing the way the emergency of an earthquake is experienced by allowing users to anticipate it by a few seconds and, as Arjonilla's assessments suggest, mitigating the trauma of the unexpected event. It done in schools, was followed, years later, by the only systematic academic study of user knowledge, authored by Gerardo Suarez, David Novelo, and Elizabeth Mansilla ten years later, in 2009. Geophysicists were involved in this latter study along with a social

[58] "Sólida planeación y preparación por parte de la comunidad."
[59] "La entidad técnica es, evidentemente, experta en las cuestiones que competen al monitoreo, detección y alertamiento, éste en términos meramente tecnológicos. Sin embargo, carece de la presencia y el aval políticos que requiere la administración del recurso y tampoco tiene la perspectiva de otras disciplinas, necesaria para promover una respuesta colectiva óptima."
[60] To be discussed further in the final chapter of this dissertation.

scientist,[61] and it was published in a technical journal—[62] involving the "perspective of other disciplines" to some extent. This study did not focus explicitly on schools, but nonetheless a majority of respondents were school administrators.

Their findings were not far off what Arjonilla's critique predicted. Education was lacking, or rather, was always partial. Among the users they surveyed, the vast majority of whom were affiliated with schools, these later researchers found that people did not accurately understand how earthquakes worked, or, more worryingly, how the Sistema Alerta Sísmica worked and the standards against which it should be assessed. Training was lacking, too. "Many of the users claimed to have received no support to develop or implement procedures for evacuation or civil protection in case of emergencies" (Suarez et al. 2009, 713). Increased education and outreach was not pursued by government agencies until the contract with Ad Hoc in 2007 (which only materialized in 2011), and in the opinion of many of my informants, it is still not pursued substantially today.

Contingent as it is, this general broadcast model, uncoupled from the soil's seismic sensitivity and the different threats to life and wellbeing that might be posed by different environments, stuck. Responsibility for sensible use and training appropriate to the particular soil and built environment was often left in the air. While systematic information is not available, it seems likely that training was more often undertaken in situations in

[61] Mansilla, who was training in geophysics but had social science experience, too.
[62] Seismological Research Letters, a geophysical journal that publishes work without what my informants would call "theory"— and is thus accessible to both scientists and engineers. It has been a key site for scholarly communication about earthquake early warning among the Mexican and international seismic community.

which populations were particularly teachable and vulnerable, and which were directly overseen by Arjonilla as she gained power in the public school system, than in other situations. This remains the state of things, as the Mexican state authority has taken on and truly advocated the Sistema Alerta Sísmica Mexicana in limited ways. Although some equipment producers and CIRES agents do give training and consult with users, differences in users' subjectivities and situations, and their attendant capabilities and needs, particularly in the general public, do not often receive significant attention. Arjonilla's advocacy for students was powerful, and in the absence of other kinds of users with their own advocates, the user imaginary that informs the Sistema Alerta Sísmica bears evidence of design around their capabilities and vulnerabilities.

CIRES was, and is still, the gatekeeper for any kind of access to the signal; the only provider of the earthquake early warning, the only provider of the means to register it, and too often a main provider of earthquake emergency education[63] (though engineers expressed significant frustration to me regarding the latter condition).

The Equipment

Use was thinly spread for much of the life of the Sistema Alerta Sísmica Mexicana. Before the massive government assisted dissemination small radio receivers, there were only 230 registered users of the Sistema Alerta Sísmica radio receivers in Mexico City (including 25

[63] Earthquake emergency education often comes to be defined as education about how earthquakes work as well as practical strategies for self-protection in the event of quakes, such as good responses to the Sistema Alerta Sísmica. I will discuss these interventions more extensively the final chapter of this dissertation.

television and radio stations and 76 schools).[64] These were CIRES's direct clients—organizations with large radio receivers installed and maintained by CIRES engineers, arranged carefully, often with rooftop antenna, to receive signal in the dense urban spaces in which line of sight could not be guaranteed. Sistema Alerta Sísmica Mexicana's signal was not be a feature in many experiences of earthquake emergencies at all.

Its presence was growing, though. As of 2014 there were 403 of these "cabinet" SASPER receivers in Mexico City and surrounds— almost twice as many Sistemas de Alerta Sísmica Personalizadas as there had been five years previous. These were still designed, built, and maintained by the same team of CIRES engineers and technicians who had always been responsible for these systems, though new members had joined to keep up with demand. "Cabinets" of first and second-generation technology, these were kept active through ongoing cycles of personal attention. Schools have these devices, but also large and small companies, banks, government offices and courtrooms. Each has to be visited three or four times a year by technicians to prevent problems; to make sure that electrical infrastructure in the places in which they're set up are not slowly draining their backup batteries, that users have reported problems, and that they have indeed seen to all the problems.

Technicians go out alone to maintenance visits or to set up drills every day, leaving CIRES headquarters with tools in the early morning in branded cars or, if they get in too late to requisition a car for themselves or are headed somewhere without parking, on public transit. They go in pairs to fix something or relocate parts of the receivers: the loudspeaker,

[64] Suarez et al. 2009.

antenna, or the “cabinet” itself. Teams of three or more go for installation. They move from one user to another, circulating, testing, connecting, writing reports, reassuring and training users. Their time is saturated. They are trying not to take on new clients. They are simply making sure that those who do have SASPER receivers, however few they might be and wherever they might be in the alert signal’s range will receive that signal and will be prepared to take action when they do.

The work that technicians do is partially oriented around outreach, but there is another team at CIRES who are completely occupied with these tasks. At CIRES headquarters, a handful of people[65] sit at computers a floor on the office below the space that these technicians use as a home base. The computer stations redecorated with little rubber toys, with notes, with tools and snacks stashed in desk drawers. They, unlike many of the engineers at CIRES, work not just from time to time at these desks. Their desks make it clear. They listen to English-language rock hits from the 1980s and 1990s as they work, chatting occasionally, both chipping away at projects and ready to respond to emerging needs and manage emergencies for the system, press, and events. This is Research and Outreach.

This kind of labor has become essential in new ways as interest in the earthquake early warning has grown and as potential misunderstandings and system interface problems have proliferated. Together, this team operates the front and backend of CIRES’s online presence, making sure that data about and from stations are automatically displayed and

[65] Primarily women; while most CIRES departments are mixed-gender, usually women are in the minority in technical spaces. This is an exception.

are accessible to users, but also developing blogs, tweeting, facebooking,[66] staying on top of representations of Sistema Alerta Sísmica Mexicana's presence in the media. They design outreach and education materials, and sometimes operate educational programs.

This outreach work has come to bear particular weight. The Sistema Alerta Sísmica Mexicana, like many interventions into earthquake risk management and other parts of Mexico's ever incipient "Cultura de Protección" (discussed in the final chapter of this dissertation) is understood to necessitate a great deal of training to use correctly, and use is growing.

After around 2010, innovations in receiver technology coincided with the violent earthquakes and tsunamis in Chile and Haiti in 2010, and then the Japanese Tohoku quake in 2011. These seismic events resonated with outstanding Mexican fears about safety, and user saturation began to change, as did the availability of the Sistema Alerta Sísmica signal. In this wave of interest, CIRES's old forms of user interaction have been intensified with new technical work both on the receivers themselves and in user outreach. By 2011, programs organized by the Mexico City and federal government distributed over 90,000[67] dedicated radios, produced by At Hoc (then Alerting Solutions) for MDreieck, to schools and state agencies.[68] Additionally, new kinds of technologies and interests have brought new users and new technical agents into relation with the Sistema Alerta Sísmica and its

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[66] Incredibly important for Mexican organizations— a great deal of internet connectivity is done on the platform of Facebook.

[67] Suarez and Garcia Acosta 2014.

[68] A former disaster prevention official explained this to me as an effort to build seismic networks in Mexico more generally, with a gift of $57 million pesos to CIRES and another $83 million to UNAM.

signal, and new, increasingly-observed regulations require businesses of a certain capacity in high-risk zones in the Mexico City area to purchase and install some form of radio receiver.[69] This has meant new kinds of management for CIRES engineers, who still oversee both the signal and its interfaces with other systems, and who have been responsible for most of the public outreach around the signal since 1991.

It has also meant new trouble; trouble regarding outreach and training given new opportunities to flourish. When a warning is broadcast on television or radio, it can be accompanied by some contextualizing information. This information might include basic education about how it is that earthquakes sweep through the earth from a hypocenter far away to shake Mexico City and about the level of precision that the Sistema Alerta Sísmica Mexicana is capable of. Oaxaca broadcasts their alert from a handful of loudspeakers scattered across the vulnerable city, and as of September 2015, Mexico City followed suit, connecting 8,200 public loudspeakers to the Sistema Alerta Sísmica Mexicana. Unlike school children, people living in range of the loudspeakers' sirens would not be regularly drilled by school administration or benefit from having a teacher to coach them through taking cover or evacuating. The city, however, offered little in the way of additional education for the new encounters that residents were going to begin to have with earthquakes.

[69] Norma Técnica Complementaria al Reglamento de la Ley de Protección Civil del Distrito Federal 2010.

Users are increasingly diverse, and may encounter an earthquake early warning in similarly unpredictable built environments. Those who acquire a radio receiver might also need to know how to treat their equipment properly and identify errors, or place it so that features of the built environment do not block activation signals. Interaction with them is also an opportunity for education about responsible action in case of an earthquake, particular to the sort of structure and site that users occupy. Although CIRES and the company MDreieck both do educational work when they set up a receiver for a new client, the proliferation of users has not included a proliferation of this kind of education— or at least, not in a uniform or documented manner that CIRES engineers can review and approve.

In the case of the state's 2011 intervention Sistema Alerta Sísmica Mexicana access, the actual mechanism of distribution of the 90,000 radios that the federal and city governments purchased is unclear. While some agencies are strict with training, others are certainly not. Training is not the only thing under contention, but actual use is similarly questionable. I was shown many radios still in their boxes on tours of government offices in 2014, and heard the kind of gossip about substantial theft and illicit sales that are neither verifiable nor unbelievable.

CIRES is still an independent NGO working under contract with the state—a distinction that is more than simply administrative when state funding and promotion of the alert can be uncertain from year to year. State support means not just contracts, but the kind of inclusion out of which strong ongoing collaboration is built: in conferences and committees, state-sponsored earthquake drills, and outreach efforts. CIRES's partner company MDreieck may sell radios tuned to pick up the Sistema Alerta Sísmica's signal fast and emit an official earthquake warning sound, but other emergency radios on the market can pick up NOAA-designated frequencies that CIRES broadcasts. While some of these radios have CIRES approval, some relate real conflict over the level of involvement, conceptual and fiscal, that CIRES engineers want to have in their technology and businesses.

The above only refers to a portion of the new alerting modes on offer, which expose the Sistema Alerta Sísmica Mexicana to new kinds of interface trouble. The growth of use cases has been a great boon, but also can make earthquake emergencies baffling for untrained users who are not prepared to make sense of the early warning or take appropriate action when they hear it. CIRES is still the arbiter of good alerting,[70] but its ability to exercise the power of that role is being greatly reduced. As use grows and subsidiary systems multiply into a multiple, semi-integrative system of systems, and their modes of addressing earthquake emergencies— and, indeed, the character of emergencies themselves— multiply too.

New Earthquake Emergencies

Before the loudspeakers on Plaza Popocatepetl issued an earthquake alert in September 2015, I had never taken emergency action because of an earthquake early warning. I had, however, had an opportunity— of a sort. Just two months before I went to the conference

[70] As members of that organization and of the government understand it.

in Berkeley to learn about international earthquake early warning technology, on the afternoon of July 28, 2014, thousands of people in Mexico City alone rushed out of buildings to safety when an earthquake alert warbled from personalized SkyAlert smartphone apps after 12, 16:54 pm. I was not among those who evacuated.

We certainly received the alert at the offices of CIRES, where I was observing a meeting that afternoon. We did not, however, hear any of the distinctive warning tones that would sound from the equipment around us if the sensors to which it was connected registered significant earth motion. It was immediately clear to us that SkyAlert's warning, disseminated via their smartphone app and personalized to the needs of its users, was a false one. There would be no earthquake. Instead of leaving the building or taking cover, we waited, alert not to earth motion but to responses from across Mexico City metropolitan area to the SkyAlert misfire.

While this may have been horrifying for my informants at CIRES, it is far from exceptional. Technical systems and acts of persecutory communication both are complex and subject to trouble as they summon people to act.[71] Michel Callon, considering this and other kinds of performativity, writes that "the general rule is a misfire" (Callon 2010, 164). He stresses that what he would call a successful perlocution, that elicited the desired effect, is a rare thing that depends on complex conditions coming into alignment. In the case of earthquake early warning, this would mean that users took action (running or take cover, which, as I will discuss in the next chapter, may not be very likely) in advance of an earthquake.

[71] The alert is a form of perluction, which might entail a speech act or, more broadly, a performance with the goal of effecting further action (Austin 1962).

Writing about a plurality of frameworks in economics not unlike those offered by the seismic community for technoscientific interventions to prevent earthquake disasters, Callon suggests that misfires make it possible to enact certain kinds of politics by distinguishing between multiple strategies. "perlocutionary performativity… generates issues that lead to the explanation and discussion of the politics that it implies. Discourses draw boundaries, exclude and reject, and it is in these mechanisms that the political dimension lies" (Ibid: 165).

Misfires in earthquake early warning can be no more surprising than they are in the economies Callon describes. While the parts of Sistema Alerta Sísmica under th**e** control of CIRES can be understood to be quite well-functioning,[72] in the broader, semi-integrated system by which earthquake early warnings are communicated to users, problems in integration, priority enter the picture. As such is the case, in this section I will discuss this misfire as not an unusual event but a perfectly ordinary one which holds the potential to become disastrous for earthquake early warning and its users.

Integration problems between the different technologies involved in earthquake early warning are common. This was not, for example, the first false alert propagated by an app in the year I was in the field. These misfires demand immediate, emergency action like any earthquake early warning, especially of those not surrounded by equipment which can authenticate its message.

[72] Although this is not un-debated, as I discuss in the third chapter of this dissertation

Members of the seismic community understood their stakes to be similar, too— a matter of life and death. Users who do not expect an alert to be reliable may not, in the future, respond effectively to hearing an one, they explained. Furthermore, misfires put the project of earthquake early warning at SkyAlert and CIRES both at risk, dependent as they are on the appearance of reliability for contingent public and state support.

The stakes of the loss of reliability motivated conversation in the after the SkyAlert misfire, considered through the prism of ongoing tensions between the developers of different earthquake early warning technologies. “I think that this could have been a huge coincidence, [or] it could have been something very evil,” one alerting expert told me. This statement and others like it prompted me to tell the story of where the misfire found me often in the weeks and even months which followed it. People were especially interested to hear about the reaction of the CIRES directors to SkyAlert's misfire. After attending to the commentary on the event unfolding in their own social world and through the media, several wondered if perhaps the false alert had been orchestrated by CIRES engineers to discredit SkyAlert, which relied on reputation to sell its app.

In this context, sabotage became a reasonable explanation for the misfire, and signals what serious business the misfire was. People tweeted memes which read "This is why I didn't download the fucking thing"[73] and berated SkyAlert on their social media. "I deleted the app and never downloaded it again," one fellow academic commented to me. If a CIRES engineer had sent a particular kind of signal knowing the ways that SkyAlert computers

[73] “Por eso no me baje la chingadora!”

were programmed to read CIRES codes, he or she could have been sure of a misinterpretation and maintain plausible deniability, certainly.[74]

However, the grounds upon which CIRES engineers challenged the SkyAlert's work— their concern for the reputation of alerting in general an effective tool— would make such sabotage a dangerous proposition. As much as their different priorities had made a positive relationship and well-integrated technology impossible, CIRES engineers understood that their service would suffer for the misfire just as SkyAlert's would. Their relationship with client cities was far from secure, and contracts had to be resigned yearly, and could not afford to suffer. Suffer their reputation did—while many headlines announcing the false alert specified SkyAlert's culpability, others simply gave readers notice about an error in the alert, more generally speaking.[75]

The kinds of emergency that emerge in concert with these misfires come to incorporate the stakes of life and death in their own ways. These are in some ways anticipatory, but to call them only anticipatory is to neglect the immediate impacts of the misfire, some of which may be quite a bit more urgent than anticipation of the next big one. In this section I will discuss how the affordances of seismicity and its dangers have made possible multiple technoscientific priorities and practices in the seismic community. The misfire was produced in this context, and here I explore first its production and then the kinds of

[74] Coherence with organizational goals does not seem to be necessary to support suspicions, and concerns about sabotage, whether stemming from personal dislike, professional rivalries, alliances with rivals, or these factors in mysterious combination are not unusual.
[75] "Falsa alarma de sismo provoca estampida en inmuebles de la capital", "Error en alerta sísmica causa desalojos en DF," "Por qué sonó la alerta sísmica? SkyAlert y CIRES difieren" are all headlines in major Mexican news outlets which suggest either shared or generalized culpability.

emergency it produces. Misfires are, after all, nothing unusual in any system, particularly in the context of efforts so diverse and contested as those which constitute earthquake early warning. In a sense, here, emergencies are not just produced, but they can ramify and transform. One kind of emergency, an alert, can come to be another kind of emergency, with respect to future earthquakes or the physical toll of fear. I do not treat this event as a disaster with obvious and automatic negative implications. Instead, I unpack how such an event can come to be understood as meaningful with respect to earthquakes and other kinds of dangers.

The potential disaster of a misfire

When the CIRES central server sent out an ordinary test message just after noon on July 28, 2014, that message was misinterpreted by the server's counterpart in the SkyAlert office. Within five seconds the false alert had begun to circulate. Immediately thereafter, misfire, CIRES engineers worked to distinguish themselves and their system from SkyAlert in social media by calling the app's lifesaving tools into question. Even as they did so, they were in a sort of agreement: the misfire, people allied with both CIRES and SkyAlert told me, was a product of poor priorities which, in turn, led to bad engineering choices (on the part of CIRES according to SkyAlert's supporters, and vice versa). The details of their explanations differed, but for both groups the problem was to be understood not just a matter of system integration, but as one of priorities—and it had the potential to be disastrous for each as well as for their users.

SkyAlert and CIRES experts have built their earthquake early warning technologies around the same stakes: SkyAlert's CEO, Alejandro Cantú, called his app a “potentially life saving device.” Engineers at CIRES explain their own work similarly, saying that “the proposition is to save lives,” or “lives are at stake.” The July misfire was only one of many indicators of how far the premises of their approaches, as well as the technologies they use, diverge. These divergences are so significant that CIRES has long declined to endorse or support app use at all.

By the time of the misfire, two technologies were tightly entangled, however poor their interface. The Sistema Alerta Sísmica that CIRES engineers oversee was designed to broadcast its alert to the public, and designed, furthermore, to be picked up and spread by any systems capable of doing so. It not only enables such systems as SkyAlert’s to pick it up and pass it along, but relies upon such interventions. Though television and radio outlets as well as dedicated radios have been distributed by the Mexico City government to many schools, government buildings, and emergency services providers, there are many who cannot be reached, particularly at night when few televisions and radios are on. Apps offer an alternative.

Apps give those who are not near the dedicated radios distributed by the government and sold by MDreieck and other companies[76] the opportunity to be warned of earthquakes before the shaking starts. Since 2010, millions of Mexicans have been particularly eager to

[76] These are sold at ever-more-affordable but still prohibitive costs (as of June 2015, price might range from $1,300 for an new radio and installation to $100 USD for a used off-brand receiver, though a home receiver to be priced at about $25 is currently in the works). Meanwhile, Mexican minimum wage, even in expensive areas like Mexico City, is under $5 USD/day.

download applications developed to put earthquake early warnings on their smartphones. Though the smartphone is a more expensive tool than a radio, population and personal alerting have not developed along distinct class lines exactly. Smartphone use is high in Mexico and growing fast,[77] and around one quarter of people in the nation or more, depending on use practices, have access to them.[78]

This proliferation of users and technologies has presented a challenge to previous modes of approaching users. At the time of the misfire in 2014, SkyAlert was only just rolling out an entirely new Japanese scale for rendering earthquake intensity into the user controls to provide increased information. Cantú explained, simply, "I let them know what they want. It's not about me *deciding*." He went on, "We're providing information, we're providing them with things they want to know. […] So, we let them choose."

An alert from SkyAlert, then, would depend on users' settings: About what location might they want to hear? Did they want to be alerted for Shindo[79] 3, in which items around them would rattle, Shindo 5, in which hanging objects would swing violently, or Shindo 7, in which they would themselves be thrown by shaking? Shindo provides a way of discussing

[77] In 2014, Mexico had something like 33.3 million smartphone users (GSMA 2013).
[78] Many Mexicans that I encountered in my fieldwork used a personal app and relied upon broadcast earthquake early warnings, too. The poorest people in Mexico, of course, might never hear either. They are still unlikely to have smartphones or be in places from which they can hear broadcast alerts if their televisions or radios are not on. The work that alerting different kinds of users does, then, cannot simply be imagined in terms of outreach to different individuals: rather, different models.
[79] Shindo is literally "degree of shaking, is used in Japan and Taiwan today. It was developed by the JMA in the late 19th century.

the empirical effects of shaking for users that is unconnected to moment magnitude of the quake at source.

Those who received the SkyAlert misfire message would not have had access to the full range of settings, but plans were in motion to provide them. More recently, after the quake that roused me from my inflatable mattress in September 2015, users peppered SkyAlert's twitter account with questions. They wanted to know why SkyAlert had not activated on their phones when the loudspeakers had broadcast a siren, and why SkyAlert was calling a quake a "Shindo 3" while the National Seismic System had measured it as a magnitude 4.8. This is a personalization of the alerting experience that involves its users in new systems of knowledge that, if not deeply complex, are certainly likely to be unfamiliar. Shindo is Japanese, and carries a certain high-tech cachet as such, but was still strange to many users; a wholly new way of rendering intensity for users more used to communication about earthquake happening in a language of "Richter scale" and "magnitude" that was, at best, somewhat unreflective of the actual shaking that they might be experiencing away from epicenters of seismicity that they experienced, at worst, completely misrepresenting the scale on which seismic energy they felt could be measured. SkyAlert represents Shindo intensities graphically by colorful circles of multiple sizes in the app interface to help users better understand their significance.

The CIRES approach to alerting practice and priorities is radically different. The NGO has for years overseen the distribution of simple, general messages to users who happen to be in an area that contains a radio or television, a loudspeaker, or a dedicated emergency radio receiver. Some users have the capability of dictating the magnitude of the earthquake to which they will be alerted, but they are government clients, and make decisions for whole cities. Often the information they get is nothing more than that an earthquake is on its way. CIRES engineers have opted for a simplicity and make clear, simultaneous general broadcasts.[80] A warning from the Sistema Alerta Sísmica Mexicana includes three pieces of information: precise time, area reporting quake, and whether the quake sensed is medium-sized, or large. Most receivers simply activate in a loud, warbling siren.

In the wake of the SkyAlert misfire, the engineers at CIRES did not confine their efforts to distance themselves from SkyAlert to the issue immediately at hand. To preserve their reputation and popular trust in their work, they identified other issues that they regarded as unambiguous black marks against SkyAlert, specifically regarding the temporality of the company's alert messaging. “The #SkyAlert #SkyalertApp is not well-integrated,” they tweeted and posted to Facebook. “Lags have already been identified. They do not disseminate the alert simultaneously to their subscribers.”

SkyAlert's data indicate that the false alert reached less than half of their 1.5 million users in the first 5 seconds, and had still not reached all of its users after 15 seconds.[81] The trouble is not just the significant limitation to what a user might do to prepare, though, CIRES engineers explain: the lag itself is also unpredictable. Unofficial tests indicate that even when smartphone app operators send out an alert quickly, people may receive the

[80] Albeit one with subdivisions, as schools are alerted at a lower level of seismic activity than anyone else.
[81] Information courtesy of Alejandro Cantú, interview with author.

alert minutes later, long after a threatening earthquake has passed. Just as misfires could both make the earthquake early warning system seem inaccurate, but so could lags if they were to sound after a quake with no other earth motion forthcoming. Technical production of unreliability could happen, they understood, in many ways.

While CIRES engineers have explored the possibility of a broadcast-to-mobile technology, bowing to the popularity of the app (SkyAlert is, after all, the most downloaded app in Mexico's history), they have had little luck. Phones are capable of receiving broadcast messages, but this lag is not something that can be engineered away on the side of the app developers without work on the part of telecommunications agencies. The cellular and data networks of Mexico do not facilitate massive broadcasts that would alert any smartphone in the area. Instead, apps can only send messages in batches, and this can have real effects on how quickly earthquake early warnings get through to users. CIRES engineers are troubled by the unreliability of this lag and its power to confuse, directing people to expect an earthquake after one has already passed or to mistrust the efficacy of a system that alerts one person before and one after dangerous earth motion. If lives are at stake in the correct use of the earthquake early warning, then by this logic lives could be at stake in the lag.

The fact that the lag cannot be engineered away is not up for debate, but whether it matters or not is. Cantú argued that, whatever the lag in SkyAlert's system, its success should be judged in light of something else entirely: "I'd rather alert 1.2 million people than three hundred thousand." In other words, a for him, a lag in warning hardly matters when the alternative is alerting fewer users. Assessment, in light of these different ways of figuring earthquake early warning success is complicated and inconclusive. It is unclear which service is best for a public, or, indeed, what qualities and needs people who become earthquake early warning system users might have. When alerting means relying on limited dissemination infrastructure, decisions about reaching them are both necessary and hard to evaluate.

Users, however, have ways of pushing back and introducing entirely new emergencies, with new stakes for their wellbeing, into discussions about earthquake early warning.

A misfire's implications

The misfire was inevitable if considered as a product of technical and social organization, requiring only a small external push— a test message sent at just the wrong moment— to become an emergency whose true impact might not be felt until a massive earthquake shakes the city. The misfire constituted an upheaval, not just to ordinary daily activity, but to understood good function of the Sistema Alerta Sísmica Mexicana and SkyAler**t.** The event came to be meaningful: threatening, and sometimes promising in the lives of users immediately.

In the wake of the misfire, state functionaries publicly took SkyAlert to task[82] for their complicity in this potentially dangerous event. Not only is social media increasingly a means for communication by authorities (as evaluated in Sutton et al. 2014 and 2015), they

[82] Including the national communications commission.

provide a community means of sharing information that could mean the difference between life and death (Starbird & Palen, 2010), and filling gaps in information communicated by official media (as in Sutton, Hansard, & Hewett, 2011). Social media can even support forms of self-care for resilience during and after events (see Kaufmann 2015), and indeed, it did here. The misfire was serious and merited the attention of people unconcerned with the ongoing sales of an app or the reputation of the Sistema Alerta Sísmica Mexicana.

On twitter and Facebook, commenters berated SkyAlert for scaring them; for creating a panic that might itself be dangerous to their health and well being. "YOU'LL GIVE ME THE SUGARS!!" read[83] one tweet in all caps, riffing on a classic joke from 1970s Mexican sitcom *El chavo del 8*. Others were not trying to be funny: "YOUR ALARM IS BULLSHIT. IT ONLY SCARES PEOPLE,"[84] Scaring could have consequences, both the aforementioned "sugars" (diabetes, which is popularly understood to be caused by stress and fright)[85] or heart attacks. These comments may have been deployed hyperbolically, but they do display a real sense that fear can have unpleasant effect, and that the affective condition that warnings produce can be both powerful and deeply unpleasant even without an earthquake.

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[83] "ME VA DAR LA AZÚCAR!!"

[84] "UNA PORQUERIA SU ALARMA. SOLO ASUSTAN A LA GENTE"

[85] Poss and Jezewski 2002 on some Mexican American ideas about the connection between fright and diabetes; Arthur J. Rubel has worked extensively on the concept of the "susto" or "fright" and its physical effects, see particularly articles published in 1960 and 1964. Weller et al. 2002 offer a more contemporary overview.

Some tweets mentioned encounters with old traumas, too, and the experiences of people who still suffer from their encounter with the 1985 quake.[86] If an earthquake had in fact happened, it would have been culpable for the alert, the resurgence of old traumas. People were frightened of seismicity, and understood encounters with this fright to consequences even without any physical shaking. Perhaps its seriousness could be related to past experience or to education; if this is the case, the nation and the city in particular have provided residents with many experiences to motivate ongoing trauma. Alert responses, however, rely on so much more than knowledge and experience. While previous experiences can lead to better awareness and preparation it can also be associated with avoidance or optimistic expectations Readiness to take full advantage of alert is a matter of preparedness, and it relies on to so much more than presence in a hazardous space, as Landeros-Mugica, Urbina-Soria, and Alcántara-Ayala (2016) and Heller et al. (2005) point out, reviewing substantial research in order to do so. Awareness of hazard is no guarantee of interest in readiness

The evidence offered by social media suggests that the misfire did not cause trouble for everyone, though. Some members of the general public were unruffled. "Thanks for the warning… Personally, I prefer a false alert to never having alerts at all,"[87] wrote one commenter on SkyAlert's Facebook page the day it happened. "It worked as a drill,"[88] wrote another. The alert, here, is made part of a regimen of training for speed and organization in evacuation; an opportunity to rehearse for a more dangerous earthquake, running through the physical steps and the tension of an unexpected experience so that, in the future, one is

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[86] "ojo hay gente grande muy afectada desde el 85 no sean así."
[87] Muchas gracias por el aviso....en lo personal, prefiero una alerta en falso, que no tener alertas nunca,"
[88] "Sirvió de simulacro."

more likely to know what to do and, moreover, to be able to do it confidently. This sort of response is recommended by many experts, but not, for all that, necessarily common among the general population.[89]

People also complained of irresponsible alerting, and the kinds of effects that this misfire could pose to future responsiveness. At CIRES offices and outside them, I was drawn into a number of conversations about the negative effects of "crying wolf"[90] could have. Experts and friends alike told me, worriedly, that they were concerned that in a real earthquake they would be slow to take cover or evacuate if they doubted the veracity of an alert. The[91] emergency would be delayed, really blossoming into crisis when Mexico City experienced a large earthquake and people, expecting another misfire, neglected early warnings and came to be hurt because of it.

Public earthquake early warnings use techno-scientific means to give users a chance for speedy action in the case of quakes. If people are not interested in taking that action, then the value of the "advantage" they provide decreases tremendously. Apps provide a new way for many to encounter the Sistema Alerta Sísmica Mexicana, and to begin to think about the socio-technical assemblage of the system and how the moment of the alert could be related to a large quake that may yet happen, is very likely to happen sometime soon. This quake is the one that threatens, and the one that people not habituated to taking immediate action on hearing an alert could suffer from.

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[89] Goltz and Florez 1997, Mileti and Sorensen 1990

[90] The same phrase is used in Spanish, "llamar lobo", along with a reference to the story of Peter and the Wolf.

[91] This, notably, is the same critique that Ordaz et al. level against the vagaries of CIRES's algorithm.

Emergency responses, especially responses to quick-moving hazards like earthquakes, are generally understood to work best when they are trained into the body and come to entail simple and unconfused physical reactions to certain stimuli. This is the one of the reasons that drilling and similar exercises have come to be so important in emergency preparation. It provides an opportunity to rehearse crisis, to condition embodied and mental responses, and to encounter tools and techniques of safety intimately.[92]

The truly dangerous hazard in which the earthquake emergency of the misfire might be part, then, was not the misfire itself (although it had been an unpleasant experience with real consequences for some). The hazard was an earthquake that was forecast, was inevitable, but might come at any time. Users were proliferating, and socio-technical interfaces were doing the same. This kind of misfire might have been produced in the context of ongoing conflicts, but its status as an emergency had to do with these proliferations in the context of unpredictable but certain material danger.

Conclusion

A massive earthquake has not, at the time of this writing, struck Mexico City or any other Sistema Alerta Sísmica Mexicana users. It is a constantly looming threat there, as it is in California and other sites along the Pacific Ring of Fire, and consequently often deployed as part of the politics of life that champions of earthquake early warning draw on to make cases. In critical attention to hazards, a tendency to focus on major quakes and their

[92] As in Davis 2007, Lakoff 2008, Anderson and Adey 2011.

dangers may be perfectly reasonable, but can make the relation between earthquakes emergencies and negative outcomes seem unnecessary to unpack.

The emergency on the night of the 29th of September in 2015, with which I began this chapter, was not an earthquake. Enrique, Beca, and I were not thrown off balance by the upheaval of what we had thought solid, and sent rushing about not knowing when it would stop or in what condition the material of our lives would be when it did. Something had happened, something that many people felt desperately worried about, deploying some of the same concerns about "crying wolf" that followed the SkyAlert misfire a year before.

There was indeed an earthquake on the evening of the 29th, an event of magnitude 4.6 about 49 kilometers from the city of Ometepec, Guerrero, according to a report from the Servicio Sismologico Nacional issued the next day. Measuring earthquakes precisely is not a process that can happen quickly, and though it was small it still triggered the Sistema Alerta Sísmica Mexicana. It was not quite large enough to be felt on the first floor of a building over La Condesa's sensitive soil, but it was perceptible in some parts of Mexico City.

The material truth of earth motion alone, however, was not enough to account for the responses I saw when I returned to my inflatable mattress and laptop that night. There I scanned twitter and Facebook messages for more responses, reading about how people had become bodily caught up in the Sistema Alerta Sísmica Mexicana. In the next few days, I read articles about "crying wolf" or a mis-calibrated system and their real dangers. This chapter has been an effort to think about how those dangers as well as the dangers of immediate seismic action can both be hazards on which an earthquake early warning system intervenes, for all that the former cannot strictly speaking exist without such a system.

Emergency and disaster are, after all, not necessarily the same. In this chapter I have set disaster and its threats aside to focus on emergency. Emergency has to be produced, making "one moment" on a seismically unstable soil significant, and making possible and even necessary not just conceptual relations between alert and seismic threat, but also actions to forestall that threat's potential impact. Emergencies, I have shown, can be technoscientifically mediated, and different technologies can make different kinds of emergency possible. Emergencies can even come to be emergencies themselves, when an alert misfire motivates not just fright and quick action, but worry over health effects, responses to future alerts, and even the future of the public earthquake early warning system.

Some kinds of technoscientific disaster prevention presume that hazards like earthquakes simply exist in the world, and can become less deadly through intervention. This model informs not just certain disaster scholarship, but also the kinds of techno-optimistic innovation which might develop public earthquake early warning technology to save lives without attention to publics or alert dissemination issues, considering managing "politics" around implementation an issue for poor nations. In the ongoing development of

California's earthquake early warning technologies, however, this approach is just as unwieldy as it would have been in Mexico.

Earthquakes do not simply exist, but are made to matter in certain ways. The emergencies which happen in the context of earthquake early warning systems are not the same as those which might happen without it. Technologies, particularly mediating technologies, have their own effects, designed into them and enacted through their use. Earthquake early warning technologies like the Sistema Alerta Sísmica Mexicana can be built for ideal users, and decisions made around them come frame ongoing applications, making some uses, and user needs, easier to deal with than others.

As earthquake early warning technologies have proliferated in Mexico, the potential differences in technologies built for users figured with different needs and capabilities can be seen in sharp contrast. It is difficult to discern which approach to alerting is superior when priorities regarding simplicity of messaging, lag, and mass outreach are so radically different. Here, too, the ordinary potential in any system for misfires can mean that the earthquake emergency of an alert can come to be other kinds of emergency, too: an emergency for user health or for public earthquake early warning itself. These emergencies come to be urgent in the context of threatening earthquakes and instabilities around practices and priorities in the seismic community.

On the 30th of September, at 12:25 in the afternoon, I heard the siren from the loudspeakers again. I was riding the city Metrobus north on Insurgentes, and watched out the window to see people file out of government buildings when they were warned of what was eventually determined designated magnitude 5.5 quake. "The alert went well," commented Carlos Valdes, Director of the Center for Disaster Prevention, (CENAPRED),[93] though a friend told me privately that the responses that they saw were mixed; that he had seen a coffee shop full of people barely look up.

If any encounter with seismicity by way of an alert could be an emergency, then public preparation is necessary for more than earth motion. The alert itself requires the kind of education and training that critics of Mexico's earthquake safety program have been advocating for years. The people who tweeted about drills and their response time were making a meaningful connection between the alert and a future earthquake that was very different in its implications from that of those who simply cursed the shock or who worried over credibility, and that difference could have material implications for them in a violent quake. Making emergencies into opportunities for system users may require introducing new kinds of public outreach and education into the social, institutional, conceptual, and material elements at work around them.

Certainly it has been my experience that my own encounters with seismicity have been transformed over the course of my research, and perhaps the experience of those who have one way or another been drawn into this ethnographic inquiry with me. Enrique messaged me on WhatsApp soon after the earthquake of the 30th. "You are now the principle suspect of producing earthquakes! I am sure you are playing with the thingie to see how we, your

[93] See AnimalPolítico 2015.

lab rats, react!" When technology, seismicity, and social practice make new kinds of emergencies possible, I was, in my encounters with the alert, as much a lab rat—or rather, as much a part of a complex material, technological, and social relations through which seismicity is made meaningful—as he.

Chapter 3

MEASUREMENT AND THE MOVING EARTH

An earthquake is a matter of energy, built up in a fault or at the interface of tectonic plates and then released, suddenly. It dissipates into the ground and travels through whatever materials it encounters: water, rock, soil, concrete, buildings, bodies, air, and into the social world. Preliminary P waves move at the speed of sound. Secondary S waves move more slowly, though the qualities of the material that they move through will change them. Some of these materials will absorb the force of a quake, and some will resonate with it, intensifying it.

There are signals which move faster than earthquakes. Radio waves, for example, are light waves, and as such move nearly 900,000 times faster than earthquakes do, depending, of course, on what they move through: mainly air thickened with water or empty of it, though trees, buildings, and bodies communicate radio waves, too. Radio waves can reach from sensory stations along the curve of the earth to population centers faster than earthquakes can, and the fiber optic systems that CIRES engineers are currently negotiating access to can make the connection better, clearer, more reliable.

The utility of the Sistema Alerta Sísmica Mexicana that the 70-some engineers, technicos, and administrators at the NGO CIRES designed and maintain is essentially dependent on the time in which such calculations can be performed. Alerts can only provide short ventajas, or "advantages" of time, the size of which are dictated by the time that it takes for earthquakes to travel at speeds of up to six kilometers per second[94] from origin site to where the a system's users (government, commercial, and individual) are located.

When presented as above, this seems a matter of mathematics, but, as Maurer (2006) notes, we cannot simply assume that we know what numbers are doing. The Sistema Alerta Sísmica Mexicana and its utility are both products of complex quantification work, and very social.

They rely not just on cognitive tools of quantification and measurement, but facilitate, as Helen Verran writes, "materialized relations" (2010, 171). Here, the means and meaning of quantification is multiple, subject to and product of approaches, tools, rationalities that allow it to work and do work for the engineers who developed it, advocate for it, and use it in late 20th and early 21st century Mexico—and, crucially, that multiplicity has become a site of ongoing political contest.

Speaking with people at CIRES, reading their papers and reports, and attending meetings with them, I found the measurement that informs the mechanism and utility Sistema Alerta Sísmica Mexicana to be more than a matter of modern truth claims. These methods for stabilizing facts and producing value are contested in both their processes and results, and have ramified into social distinction work. The methods of measurement and analysis I

[94] The P and S waves which comprise earthquakes move through the earth at different speeds, depending on the composition of the crust or mantle through which they travel. While primary P waves move at approximately the speed of sound, stronger and slower S waves move at close to 60 percent of that speed.

encountered in text, document-packed offices, and bright meeting rooms were always a matter of some debate about how seismicity could be figured. There were other ways to go about this process or define that, and even the basic elements long decided upon and built into physical infrastructure were still subject to rethinking even if they could not easily be remade. For all this debate, the methods I encountered were no less a matter of "moral economy" than more monolithic (or at least generalized) structures of knowledge: ""historically created, modified, and destroyed; enforced by culture rather than nature and therefore both mutable and violable; and integral …." as in Daston (1995, 7), though not precisely a matter of what she calls "*scientific* ways of knowing" (emphasis mine). For here, both in producing valuable seconds of warning before earthquakes and in work to make those seconds valuable, "science" is taken up advisedly. In a technoscientific intervention into experience of earthquakes for the purpose of disaster prevention and saving lives, instabilities in priorities and practices are sometimes couched in disciplinary differences. Particularly, an opposition between "science" and "engineering" practices is one of the key ways that my informants parse and claim authority in the context of the multiple, sometimes mutually exclusive approaches to earthquake early warning that various experts in the seismic community may advocate.

Engineering here, they argue, is practice and orientation toward problem solving as well as a social identity defined by such orientations. When practice, fact, and the value of technical endeavor comes to be at issue, what is at stake is "a politics," in the words of Helen Verran, "over what there is and who/what can know it" (1998, 238). In this case, politics is in developing and contesting ways register significant seismic motion appropriate for earthquake early warning. For my informants, such politics crystalize data practice along disciplinary lines, and their engineering priorities allow them to "know" earthquakes—at least for the purposes of early warning—better than scientists can. The stakes are high for them when early warnings could mean life and death for users, but, as I will argue, the value of an early warning is not always clear. Nor is the distinction between science and engineering, for all that it is useful to think with**.** The advantage time of an early warning is, for these reasons, not only the product of unstablizable difference—continuing to be greater the farther from the epicenter one travels—but also itself unstable, mutable, unsettled.

This chapter owes a great deal to ethnographic work on number and value in everyday practice, the claims that quantification can be used to make, and the meaningful social relation it can materialize (as in Verran 2010)—and provide means for taking social as well as technical action. It builds on Lave's contention that situated practice is not just an issue in "unschooled" mathematics. She writes that "situated practices involving quantitative relations, including academic mathematics, differ in meaning, power, and relational embedding in all manner of enterprises" (Lave, 2010, 189, also see Guyer, Khan, Obarrio 2010). Here, I consider the situation the quantitative work that has come to be key in the seismic community's efforts to advance, debate, and transform earthquake early warning in Mexico.

In this chapter I follow some of the practices and uses of quantification, measurement, and analysis that engineers at CIRES undertake themselves and advocate for, both to other experts and to users, in order to make the Sistema Alerta Sísmica function as effectively as possible (for a given set of goals). By this labor and the work that it enables, the people I'll describe enact a politics of knowledge.

I argue here that reflecting on, performing, and communicating about quantification and its uses is a key way in which engineers attempt to intervene on how others relate to earthquakes. In the first section of this chapter, I lay out a history about how the earthquake early warning has been built and come to constitute a new way of experiencing seismicity. I highlight the development of this technoscientific tool and its priorities over time. In the second, I take more care to focus on the instability of the practices and goals that members of the seismic community advocate for and how the Sistema Alerta Sísmica Mexicana and the advantage time it offers are taken up by users. Throughout, I highlighting how the experts who have overseen the development of the earthquake early warning system from CIRES articulate a place for themselves as *engineers* and their work *as* engineering.

Tracking how seismicity comes to "count," so to speak— or, perhaps more to the point, the ways in which my informants work to measure them, analyze them and then to make the resulting information really significant for users in— provides an important opportunity to reveal the politics at work in the technological mediation of seismicity**.** In the context of the earthquake early warning system, measurement and analysis of ordinary seismicity are both essential and up for debate; key issues for experts concerned with earthquake early warning and technoscientific disaster prevention more broadly**.** In the following chapter I will deal extensively with an everyday way that experts attempt to laminate authority and legitimacy onto what Fortun and Fortun have called their "care for the data" (2005).

Making Alerts Count

The “ventaja,” or advantage, of time an early warning can provide is matter of a lucky inequality. The speed at which an earthquake can be registered by a sensor in a field station, information about it can be processed and a signal can be transmitted to a relay station and then a central hub, the signal can be compared to signals from other nearby stations, and then finally distributed to users is greater than the speed at which the destructive S wave of an earthquake can get from its origin point to a population center. Over distance, the difference between the two grows rather than shrinks.

The Sistema Alerta Sísmica Mexicana can be understood to take advantage of the difference between the one and the other, making hay out of the way the former lags behind the latter. It began with sensory devices and the development of knowledge for research purposes.

The value of that advantage of time seems inherent (especially with the kinds of words that are used to refer to it), but is nonetheless a complex construction. Making it useful has been a matter of social and epistemological work. It benefits from interpretation with the economic concept of arbitrage, that is, a financial strategy which involves using a price difference between markets for gain, in order to explain the mechanism of the production of more time and to highlight the problems that CIRES engineers have had convincing others of its utility.

In work on what he calls “a situation in which the different temporal properties of economic knowledge and action become visible to actors themselves” (2003, 256), Hiro Miyazaki describes arbitrage as a practice by which technically savvy agents sell and buy the same asset in two different markets at the same time, exploiting their differences and relying on faith in the stability of various markets and, furthermore, providing rich metaphors for thinking about other kinds of time. He uses ethnographic attention to open up “the question of when and how temporal incongruity becomes evident from the viewpoint of market participants and what uses they make of the incongruity “(2003, 256). I follow him, considering the work around this window to be a matter of arbitrage in time.

Of course, the differences between radio and earthquake waves won’t stabilize—there is no end-point like the arbitrageurs imagine they are helping to bring about by “arbiratinging out differences” or closing arbitrage opportunities. The differences between radio and earthquake waves will increase over distance and time, and exploiting the difference will not act to reduce it. Though the divergences between the time produced by the Sistema Alerta Sísmica Mexicana and market strategies are quite important, thinking with arbitrage allows me to call attention to the way that the value of the window in earthquake early warning can be understood as both self- evidently obvious and socially produced, and to which it depends on integration into the ordinary practice of others. I suggest that what Miyazaki calls “the explicit construction of temporal incongruity as an opportunity” (2003, 256), which in finance generates value by closing off arbitrage opportunities, here instead generates value by closing off periods of inaction.

I use this idea from financial markets which is informed by naturalized rationalities of equivalency and value to provoke attention to the pragmatics (cf Maurer 2006) of time in the Sistema Alerta Sísmica Mexicana. Time is an issue that, for all its essential nature to earthquake early warning, has been remarkably shifty in everyday use: persuasive, but not necessarily valued the same way in all systems, nor taken up as expected by users. If the value of the advantage is that it provides time for users to ready themselves, then more of an advantage might mean more time for careful evacuation; time to leave slowly and calmly, and, as a catchy song about earthquake safety released at the time of my fieldwork explained, "shut off water, shut of gas, and turn off lights."

What does making oneself ready in the face of an oncoming earthquake mean to various agents (engineers, advocates of potentially integrated systems, or individual users) and how is the value of that activity related to the advantage time offered by the Sistema Alerta Sísmica Mexicana? This is a matter of exploiting difference to technoscientifically mediate encounters with earthquakes. Decisions regarding analysis of sensory data about seismic energy, and the ability, or even interest, of users has been importantly implicated in efforts to make earthquake early warning count. How advantage time comes to be valuable to users is not always clear. For the various members of the seismic community invested in disaster prevention, making it possible has proved a challenging operation indeed.

The value of time

The story of the development of the Sistema Alerta Sísmica history was, as Armando Cuéllar explained to me in one meeting, more like a twisted ornamental bamboo plant than a straight branch. Cuéllar was himself somewhat of an historian of CIRES, and told its stories in his dissertation work and as Director of the Research and Outreach Department. If he was concerned that other interviewees were providing me with Whiggish oral histories and documents which would support them, he need not have been. The stories that the old guard had to tell about beginning to recognize and exploit difference between the speeds at which radio and earthquake waves moved through the world did not begin with the idea of earthquake early warning, but instead with the development of expertise, social networks, and technologies which would not come to be enrolled in time arbitrage until many years after their invention. Making advantage time was not, in other words, an original goal of these technologies.

In 1973 Dr. Humberto Rodriguez and his students at UNAM's Engineering Institute used funding from the United Nations Development Program to buy a set of seismometers and accelerometers and build a telemetric system sending a stream of information about earth motion over radio to a basement lab at UNAM (see Figure 3.1). Synthesizer circuits powered by Rodriguez's own interest in music and his students' labor, multiplexed radio signals and a constantly-spinning reel-to-reel enabled easy data collection and digitization. SISMEX, the Sistema de Información Sismotelemetrica de México, is still running, and has since then, operating anywhere between 5 and 14 field stations to obtain the kind of detailed seismic data that the Sistema Alerta Sísmica's operators at CIRES avow as "scientific" and outside the scope of their work.

Figure 3.1. Spacial distribution of SISMEX sensory stations, courtesy of the Sistema de Información Sismotelemetrica de México.

Many of the senior directors and advisors of what would become CIRES were Rodriguez's students, and had run this system and written about it, designed programs or circuits for it as academic projects. CIRES's Director, Juan Manuel Espinosa Aranda, wrote his Master's thesis on it. He had significant expertise in the measurement of earthquakes and the maintenance of seismic sensory technology when Mexico City was funding a new data collection initiative in the wake of the unprecedented 1985 earthquake.

CIRES was developed as one of many seismological projects oriented toward both policy and science. It had sister organizations, Centro de Investigaciones Sísmicas (CIS) and Centro de Estudios Prospectivos (CEPRO), which were built up as when it was under the auspices of the Fundacion Javier Barros Sierra. The Foundation itself was named after a well known civil engineer with a powerful influence on Mexican policy and education, and the tasks given to the newly-minted NGO CIRES involved the development of a network to follow in his footsteps.[95] It was tasked with installing a network of 40 acellerographic instruments in the soils of Mexico City to measure the specific seismic effects it was subject to.

Espinosa Aranda and his early CIRES team were focused on the development of the Red Acelerográfica de la Ciudad de México (RACM). Funded by Fondo Nacional de Reconstrucción for Mexico City and administered by Consejo Nacional de Ciencia y Tecnología (CONACYT), it was up and running by 1987, collecting data already. Measuring seismic effects around Mexico City would allow researchers and engineers to better understand the city's curious geological disposition and inform new building regulations. The RACM still collects detailed data about ground motion. It remains viable and grew alongside the Sistema Alerta Sísmica in the 1990s, and its data is available on the CIRES website and, at request, in large data sets for scientists. RACM is, however, no longer the sole and central project of the organization. CIS, CEPRO, and even Foundation Javier Barros Sierra no longer operate at all.[96]

As they built the RACM network, the engineers and technicians of CIRES narrate a realization— an opportunity to do something that did not involve the accumulation of data useful for the kind of careful-measuring scientific endeavors that Osario mimed for me at

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[95] At least with respect to building a tight relationship with Mexico City's Ministry of Public works and UNAM; less so with respect to his involvement with the student protests of 1968.
[96] CIS was incorporated into CIRES in 2003, the other two dissolved.

all. Soon, CIRES engineers developed a new (with their own resources, their historical documents are careful to specify) and presented a Sistema de Alerta Sísmica (SAS) for Mexico City to the Secretaría de Obras of the Departamento del Distrito Federal (DDF) in December of 1989.

This new system used telemetric connection between field stations and Espinosa Aranda's "empirical" algorithms to distinguish between different intensities of ground motion very quickly, without collecting data on them at all. Efforts at data collection were continued with RACM and the Sistema Acelerométrico Digital para Estructuras (SADE), but CIRES engineers were now "measuring like engineers," as Osario described it to me, and developing methods to produce time for users rather than data.

This transition meant a reorientation toward time: no longer were CIRES engineers focusing primarily on developing and managing instruments to collect data which included accurate time measurements.[97] Now they were also making a system of instruments that, through its connection, could exploit a *difference* in time.

With substantial support of the charismatic Mexico City head of government Camacho Solís, the city had an official earthquake early warning system in 1993 and budget to continue. However soon after, in 1996, the Mexico City government structure changed and, furthermore, Cardinas of the PRD party unseated the PRI in local elections. In the

[97] Synchronized time had been a particular innovation of SISMEX's system and had been the key that truly allowed the measurements taken by its network to be used to learn about the exact speed of various seismic waves through Mexican geology and, in this way, infer the properties of subterranean soils with some detail.

subsequent shakeup, government agents changed, new efforts had to be made to justify the Sistema Alerta Sísmica Mexicana and secure backers. As CIRES engineers learned, the utility of this kind of time (time-as-advantage) was less obvious to many than the time-as-data that they had been collecting as part of RACM.

An engineer's algorithm

The Sistema Alerta Sísmica operates by means of fast-acting algorithm, a constantly edited and re-edited set of calculative processes built into circuit boards at field stations and which had been refined over years. The first algorithm was developed in the late 1980s by Director Juan Manuel Espinosa Aranda (not insignificantly referred to by his employees as El Ingeniero, the Engineer).

An earthquake is a matter energy— a fault or a plate interface which has held steady under the slow build of impossible weight gives out, in a moment, slipping and releasing it all through the earth. This energy has patterns. It is these patterns that made midcentury earthquakes distinct from bomb tests to snooping seismologists, and which allowed the United States' universities to develop powerhouse earth science schools with military funding. It is these patterns that facilitate sensory equipment around the world to provide "smoking gun" proof of nuclear armament courtesy of the never-fully-ratified Comprehensive Test Ban Treaty. These patterns also make Sistema Alerta Sísmica Mexicana algorithms possible.

The way that the energy released in an earthquake's waves changes depending on the size of the quake. That is to say, a small-magnitude earthquake's waves will be distinct from a large one's, and both will be easily discernible from the lack of motion which precedes them. Measuring and analyzing ordinary seismicity as well as large earthquakes have offered physical affordances for the analysis that the earthquake early warning system depends on.

As the magnitude of an earthquake is not easily measurable in any other way, the quickly discernible differences in the waves relate to each other is nothing short of a stroke of luck. They were not, however, transparent or obvious; their differences are distinct to particular origin sites, and an earthquake tearing out of the dangerous and active interface between the Cocos North American and North American plates off of Mexico's West demanded particular technology and calculative practices to reckon with effectively. While other innovations made this possible, CIRES's Espinosa Aranda and a Japanese engineer named Nakamura seem to have arrived at this unique application independently[98] in the late 1980s as solutions to their particular problems.[99]

When Espinosa Aranda began to play with this data in the late 1980s, he had a degree in electrical engineering and experience working with an earthquake sensory system for UNAM's Engineering Institute. He and an assistant, a graduate student at the Geophysics Institute, developed a way to discern distinct patterns of small, medium, and large-

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[98] Key work is documented in Lee, RE Bennett and KL Meagher 1972, Allen R 1978, McEvally and Majer 1982. They wrote about developing methods for quickly identifying earthquakes and defining them from background noise, though could not yet determine magnitude.

[99] Nakamura 1988, Espinosa Aranda et al. 1989, Espinosa Aranda et al. 1992.

magnitude earthquakes emerging from the coast— the region from which an unprecedentedly large and destructive set of earthquakes had shot out of in September 1985 to shake the buildings and politics of Mexico City only a few years before.

They had to work from the evidence they had to develop a mode of distinguishing the small, medium, and large quakes that the coast could produce. There was not a great deal data to draw from in the first place: maybe 100 readings from the same place, many of which they had to discard. Although they were after a tool for the region that the 1985 quake emerged from, in the hope of preventing another disaster, they had to discard the data from that quake itself. The sensory device had been too close to the rupture, and had only recorded part of the energy released. They did the job with data they kept, I was told, just fourteen readings. From those they were able, not only to find patterns, but to establish the kind of relational rule that could be built into a circuit board: if the energy of the P wave and S wave relate as *so,* trigger an alert. If the energy of the P wave and S wave do *this* instead, do not.

The algorithm worked (though it took more than ten seconds), but the geophysics student could not remain involved. This kind of research was not what his advisors wanted of him. He had to drop out of the project; the calculations and materials might have been recognizable to his discipline but the data being used and the kinds of models rendered from it were not.

The advantage of time

By way of these measurements and analysis which took ordinary seismicity as well as large quakes into account, the Sistema Alerta Sísmica could produce an advantage— seconds in which users might know an earthquake was on its way before the ground began to shake. How that advantage might be used, though, would be a matter of social and technical work; effective integration into existing infrastructures for action and decision making. These infrastructures were both conceptual and physical: a matter physical systems and habits of mind. After a year of practice operation and debugging, the Sistema Alerta Sísmica was introduced to more experts, including policy makers, anthropologists, representatives of public utilities, local institutions of higher learning and emergency services professionals.

In this series of meetings in early 1992, an attendee referred to the principles on which systems were built and on which they operated as a matter of "philosophy." He explained that putting the temporal advantage offered by the Sistema Alerta Sísmica to use for Mexico City's water, phone, gas, or electrical systems might require serious reorientation of priority.

The four meetings took place over three months and hosted a rotating group of attendees. The minutes of these meetings still exist in a surprising number of their archives— unusual in my experience. Thanks to the many participants who seem to have taken these meetings and their effects seriously, the minutes of these meetings are entered in the stacks of the CENAPRED library on Delfin Madrigal in working class Colonia Pedregal de Santo Domingo and in the quiet Modernist CIESAS library in Tlalpan. They are, perhaps least surprisingly, in CIRES's online collection of PDFs. Recorded in these minutes are the text of presentations, debates, and overviews; if not complete, than detailed enough that the impatience of participants with each other at various moments becomes legible, as do excitement and sometimes confusion.

A relatively young Juan Manuel Espinosa Aranda introduced the Sistema Alerta Sísmica in the first meeting. I read his explanation with interest, much less practiced in 1992 then than it has come to be today, but already clear and detailed. He explained that "if the occurrence of the event can be confirmed during the first 20 seconds, we can be informed with 60 seconds in advance of strong seismic wave that hit Mexico City" (Fundacion Javier Barros Sierra 1992, 8). For the rest of the meetings, those "60 seconds" stood for the advantage that the Sistema Alerta Sísmica could offer, though it would be by no means the same for each earthquake the system alerted. It was what Lampland calls a provisional number (Lampland 2010), unstable, but a reasonable estimate—hardly the kind of precise number that might be used in a scientific assessment, but a number that could nonetheless garner results. It was, in what I came to understand as true engineering style, good enough to suggest the order of magnitude at hand; as exact as it needed to be and no more.

Over the course of the meetings, which were themed around presentations by various experts, participants voiced optimism about the promise of Sistema Alerta Sísmica and the advantage of 60 seconds it could give them. However, faced with the needs of the organizations whose representatives were assembled at the meetings, the advantage time proffered was vacated of utility. In the proceedings, everyone assembled seemed to agree that the alert should be at the disposition of as many people as possible, especially those an areas at elevated risk from earthquakes.[100] They also agree on the core necessity of training for proper response to the alert and integration of the alert into procedure.

Each system representative in attendance presented a laundry list of their challenges, with particular reference to experiences with large earthquakes in the past — no surprise, as experiences with violent quakes were strong motivating factors in the development and funding of this new technoscientific tool. While quakes were threatening, the Sistema Alerta Sísmica's seconds could not allow for the kind of prevention that advocates may have hoped. Although some parts of utility and emergency service systems were situated in high risk locations and were sufficiently organized to provide training for using the Sistema Alerta Sísmica, the time frames upon which their systems were organized and the orientations toward seismicity that they had been shoring up since the 1985 quake could not take up the 60 second advantage promised by the Sistema Alerta Sísmica.

Mexico's national electric service, CFE, could not use the Sistema Alerta Sísmica in their technical operations at all. A representative reported that "the measures that are adopted in case of an earthquake are corrective; that is to say, the damages are evaluated and are corrected after the disaster, not before" (Fundacion Javier Barros Sierra: 8). Keeping electricity on allowed other services to function, which could be particularly important in an emergency. Many private companies had developed complex normal and emergency processes requiring steady voltage, too, and this should not be undermined. Electrical

[100] Area here means geographical area of Mexico City, which can be divided into rocky, transition, and soft soil, each with its own distinct seismic response. Soft soil is often cast as the most dangerous and rocky the least.

service should never be interrupted; and if an earthquake produced damages in generation or distribution systems they would be repaired as quickly as possible. Suddenly interrupting service was not something they had built their technology to handle, and, anyway, accidents during repair of the system during the 1985 earthquake were minimal.

The water utility service and telephone system representative responded similarly: it was much better to keep operating if undamaged. Even though the national gasoline company's wide network made shutting down operation impractical, PEMEX's representative wanted the Sistema Alerta Sísmica for administrative offices.

In the end, only two organizations seemed to want to integrate the Sistema Alerta Sísmica into anything but staff evacuation: Seguro Social, Mexico's public health organization, could use the early warning to get support systems like generators up and running and to take appropriate precautions for patient care. Mexico City's subway system could use it to slow down trains so that they wouldn't jump rails when shaken. The advantage offered by the Sistema Alerta Sísmica was not useful for the temporalities and philosophies on which many of Mexico City's public utilities operated, though water could be contaminated and electricity and gas could cause deadly fires in earthquakes. After these meetings the Sistema Alerta Sísmica was understood to produce advantage on human time scales—humans who, it is worth noting, could be trained to shut off lights and gas lines. Even if advantage time could be maximized, the warning did not have significant value for most of the organizations represented at the meetings. The advantage it offered was no advantage for them at all.

The different critical systems discussed in the previous section value warning time differently than the designers of the Sistema Alerta Sísmica had assumed they might. Today the alert remains largely human-focused, as I discuss in the second chapter of this dissertation. While seconds of advantage that the Sistema Alerta Sísmica could gain through arbitrage can be understood in terms of its potential benefit to users, negotiating what that means is also subject to significant and ongoing debate. This debate has particularly been couched around disciplinary claims to authority by the system's designers at CIRES.

On Measuring and Measurements

Dr. Osario groped his way around the room theatrically, handspan by handspan. He had traveled a great deal, as many geophysicists of his generation had, taking one of his degrees in Mexico and another in a Canadian University of Alberta department before working for Mexico's Federal Electrical Commission, which he continued to do before he took a very active retirement as an advisor at CIRES and a professor at UNAM. He knew a few things about communication in a second language and its difficulties. He put effort into making this point very clear.

Look, he said. I'm measuring like an engineer now. And now, like a scientist.

He collapsed the wide span of his hands. He had been lining them up one after another after another, thumb to little finger to thumb again, to describe the length of the wall with the standard of his body. The wall itself was in a small common area or large landing between offices, containing not just us but a shared copy machine, an overcrowded pasteboard bookshelf, and an overhanging monitor display. On the word "scientist," he changed his whole bodily orientation toward the space, getting up close to the wall to mime micro-distinctions, no longer referencing a handspan but instead an imaginary ruler. While engineers are interested in functionality, he explained, scientists want precision in their data.

Abby, who did administrative work in the Communications department upstairs, stepped carefully around us to use the copier. Osario pushed his big glasses up his nose and continued to expand on his point. His voice filled up the small space, drowning out the ordinary office sounds of the work going on work around us.

We had been talking about Sistema Alerta Sísmica Mexicana and the data it produced when he decided to press the wall into service as illustrative tool for a point that needed to transcend any communicative gaps that my Spanish language skills and technical knowledge might make. I had by this time developed a small trove of stories about conflicts between various experts in Mexico City research, particularly between scientists and engineers, and there was perhaps less of a gap in understanding than a hunger for more illustrations of how these differences could be thought of. The stories I had collected had fewer divergent political affiliations than I would have expected. In my early fieldwork, I had asked questions about party allegiances among experts to make sense of the alliances that informed Mexico's notoriously nepotistic elite. The space that PRI, PAN and even PRD political parties might have filled in these narratives were instead often oriented toward differences in discipline. These differences were never dry, though. While the engineers I spoke to used "engineering" and "science" to label affiliations, the things they told me about were full to bursting with sour grapes, technical ignorance, and unhealthily Freudian relations with intellectual parental figures.

The basic dichotomy that Osario presented me with was a common way of parsing politics of knowledge. Orientations toward engineering or science were made to cleave an epistemic divide between the people currently in charge of the Sistema Alerta Sísmica Mexicana and their more informed and powerful critics, and explain contested claims of authority. This divide which was related to me more frequently than any other explanation for disagreements around the system: a simple difference in orientation toward priorities about the information that the system might be made to detect and process and the data it might generate. The people I spent most of my time with at CIRES self-identified as either engineers or technicos, technicians. Téchnico might sometimes be used to indicate a person who does practical maintenance and upkeep of technology, but at CIRES might mean people who had less formal education and thus comparatively diminished status and opportunity to advance professionally, though their experience and knowledge might be similar. Some of the engineers at CIRES were researchers, but they were not scientists, though several had identical training to people outside the organization that they would identify as such.

Scientists want to know precisely what size an earthquake is, and want devices to produce as much precise information as possible. That, Osario argued, is not the kind of work that the alert system should be doing. Precision doesn't matter here. The people who run the alert were doing engineering, and they had practical goals. They wanted to know if an earthquake was going to be big, medium or small. While magnitude calculations can take hours or even days to resolve, distinctions between big, medium and small can be done quickly and, if not perfectly, then effectively enough for the task at hand. “Engineers do not want magnitude data,” said Osario (and not for the first time). “They want to know if people should *run*.”

Osario himself might have taken up the mantle of science if he so chose. He had earned a PhD in seismology with a specialization of geotechnics in 1984, but his orientation toward practical knowledge, toward problem-solving, made him an engineer. He had, besides, an old affiliation with UNAM engineering department and a long-term friendship with Sistema Alerta Sísmica Mexicana developers.

Osario had watched the system grow since the late 1980s, and explained that there had been two ways of misunderstanding it. The public, he told me, misunderstands through bad communication. Scientists misunderstand because the system is not precise. Scientists and engineers, I was given to understand, were two kinds of experts who thought with and against each other. Earthquakes do not determine these technoscientific subjectivities, but, for many of the engineers I was asking questions of, they were key to performing and interpreting subjectivities, particularly their own and their resources for contesting the kinds of authority that rival experts might claim.

In this section I will discuss how the seismic community, particularly those at CIRES who have developed the earthquake early warning system and have maintained it for almost twenty-five years, approach the multiple approaches to measurement and analysis of earthquakes which are afforded by Mexico's ongoing seismicity. I first describe how some expert modes of analysis may make others, regardless of effective performance, invalid. I then discuss debates regarding the components of good performance in earthquake early warning. Finally, I return to users to demonstrate that the ways that users interact with the alert may call into question the self-evident utility of "advantage time."

The simplicity of Osario's dichotomy of measurement and analytic practices disguises the diversity of issues under debate, and the variety ways in which engineers by training orient toward disciplinary identities. With issues which cluster around the difference between and utility of what has been described to me as "precision" and "accuracy," earthquake energy sets appropriate measurement, analysis, scholarly conversation, and use of technoscientific disaster prevention into social motion.

The donkey who plays the flute

Armando Cuéllar was not affiliated with CIRES when the first model and subsequent algorithm was built, or when the twelve original field stations of the Sistema Alerta Sísmica had small computers bearing that algorithm installed in them. But Cuéllar, a young and dynamic engineer with substantial training in mathematics and well on his way to a doctorate in geophysics, works on algorithms for them today. I spent a great deal of time in his office, surrounded by binders and paper, between bookcases and still-boxed equipment.

Cuéllar makes new models for sensory stations in new places and developing new algorithms to analyze earthquake energy faster and more efficiently. While the original algorithms took more than ten seconds to work, his take three. He talks about them at conferences, standing in front of graphs and fielding questions from geophysicists in Spanish and English about what he's made. It takes serious work to gain traction for both him and the kind of calculative work that he champions.

When he told me about the first algorithm, Cuéllar was in the middle of writing about it—of laying out a dissertation chapter on with what, precisely, early algorithms meant and how they worked. That first model did not account for a mass of data, incorporating neither thousands of simulated quakes nor readings from around the world. It was a matter of just fourteen, he told me; abnormal, in the world of geophysics, but enough for the engineers Sistema Alerta Sísmica. The graduate student assistant who had helped Espinosa Aranda on with the original model could not see the project through. It was not the kind of thing that his advisors wanted from him. It was not, properly, science. Nearly thirty years later, Cuéllar is revisiting this territory.

Cuéllar was a particularly important figure in the science and engineering divide at the moment I visited; a mathematician and engineer by training, he had been working for over a decade with the engineers at CIRES and had been recruited for doctoral study at the Geophysics Institute at renowned university, UNAM. While some of his committee had been recruited from CIRES, his direct supervisor, Gerardo Suárez, was no engineer. He was an exacting geophysicist with significant institutional and political pull; a former dean of UNAM's prestigious Facultad de Ciencias and a former UN official. Cuéllar's dissertation committee was what amounted to a bridge between engineering and scientific pursuits. It was what Galison (1997) might call a "trading zone," a place for different ideas and priorities to be exchanged. It seemed, at times, exhausting.

A particular challenge of writing about the algorithms of the Sistema Alerta Sísmica Mexicana for geophysicists, Cuéllar explained to me, was the matter of theory. Theories are associated with universal law. Theories make attempts at explanation, and geophysicists want to include all possible data in their work as long as the readings are correctly understood. Engineers, on the other hand, can work with careful selections, approximations. There's a limit to the detail that they need.

In her work on the history of geophysics, Naomi Oreskes writes "*All* models are open systems. …Alas, no model completely encompasses any natural system. By definition, a model is a simplification – an idealization – of the natural world. We simplify problems to make them tractable, and the same process of idealization that makes problems tractable also makes our models of them open. (Oreskes, 2003, 17)

Indeed, the problem that Cuéllar faced was that the engineers clashed with the science of geophysics in certain conventional data practices, among which might be counted the use of more than a handful of readings (however localized effects could be understood to be) and efforts at identifying universal rules (however those might come to be disproven).

The algorithms by which computers in the Sistema Alerta Sísmica Mexicana field stations distinguished small, moderate, and large quakes were informed by nothing like geophysics practice of geophysical theory. Espinosa Aranda had not used data from earthquakes around the world to develop a general equation for the energy released by earthquakes everywhere. In fact, no one Cuéllar knew of had developed an explanation of why these differences might have come to be. The original algorithm and those which built on its insights were empirical, built on a radically local model derived from only a handful of local quake readings, and it worked. They had been tested extensively, of course, and they worked. They had been tested extensively, of course, and they worked. No one at CIRES had, however, published any claims regarding *why* they did so. It was, Cuéllar told me, empirical work.[101]

This empirical work had to be reviewed and made legible and auditable in the context of a geophysics dissertation, though, and this required reference to a process that simply had not informed its production. There was nothing in the original process that a scientist

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[101] Empiricism, in its long history, has been multiferous (Daston 1995) and may be understood as reference to authoritative power of certain witness accounts (Daston 1988, Shapin and Schaffer 1985, Haraway 1997). Here, in a sort of inversion, the validity of a quantitative practice and the authority of its author/witnesses is being propped up with reference to "empiricism," which here is constructed as an alternate form of authoritative knowledge.

would recognize as theory, Cuéllar explained, but theory was what his dissertation advisors were demanding of him. His ability to master scientific language of universalism here would be key to the dissertation, and would allow him to make legible a certain kind of technoscientific expertise and truth claim that he cared very deeply about, and support its veracity and power in new and important venues.

"Es como un burro que toca el flaute." He told me regretfully, after reviewing some of the deeply impressive "empirical" work that CIRES engineers had done on the algorithm. "It's like a donkey playing the flute. No one notices that he does it very well. They're surprised that he does it at all."

The white box and authority

As conscious as the CIRES engineers were of their system's heterogeneity (Law 1987), algorithms were a site of particular attention for system developers. It was in algorithmic techniques that innovation would happen when experts put thought into better earthquake early warning procedures.

In light of this general insight and the ongoing discussion of its techniques, Sistema Alerta Sísmica Mexicana algorithm might well be considered a sort of "white box" (Lepinay 2011) for alerting. That is to say, an algorithm here is the opposite of the famous "black box" of physics and STS, which enfolds processes that do not need to be detailed. An algorithm's operation is not to be bracketed off and set aside; instead, what that it does has been and continues to be subject to constant unpacking and reformulation.

Depending on the choices of algorithm designers, the tiny computers in CIRES field stations can act at different speeds to process different input from different sensory devices. This sensory input will then become different kinds of information. This information can then be taken up in different ways. All of this is up for debate, critique, and refinement, both within the CIRES laboratories and in the larger expert community concerned with the Sistema Alerta Sísmica's alert functions and to claims about the efficacy and importance of certain kinds of expert practice.

What kinds of priorities should dictate changes in the algorithm is, then, a matter of significant discussion, but that discussion is not a free-for-all. Members of the seismic community—particularly the engineers at CIRES— draw on distinctions between "science" and "engineering" to explain different priorities and definitions that can, in their disjuncture, make the Sistema Alerta Sísmica Mexicana an exemplary system which has experienced only one missed event and one false alert in the first years that it was operational (see Espinosa Aranda et al. 2009) or a troublesome and dangerous one.

Indeed, in 2007, five scientists published an article with the pointed title "The seismic alert system for Mexico City: An evaluation of its performance and a strategy for its improvement" calling for an utter overhaul of the Sistema Alerta Sísmica's algorithms and their priorities and undermining its utility—dangerous business for a system that is on year-to-year contracts with government clients and remains the only one of its kind. The article was in the *Bulletin of the Seismological Society of America*, a well-respected English-language publication which demands the kinds of “scientific” disciplinary approaches to data and theory that, together, make it unlikely that the engineers on whose work the article comments might publish there themselves. It is a scientific journal, in other words, and the paper’s authors were doing scientific work. Looking at information from the Sistema Alerta Sísmica and from the magnitude assessments that geophysicists eventually generated about the fifty-seven earthquakes that the system alerted over thirteen years, they noted that forty-two of the quakes were not the magnitude that the algorithm had indicated that they would be. In fact, it was common for a quake that the Sistema Alerta Sísmica algorithm to fall outside the rough distinction that engineers had given to what they designated "moderate" quakes (greater than or equal to magnitude five and less than six, and subject to a “restricted” warning dissemination in schools and emergency services agencies) and "large" quakes (greater than or equal to magnitude six, and disseminated widely). It was, the scientists wrote, “poor performance” (2007, 1720). The “failure and false alert rate is high” (2007, 1728).

Table 1
Performance of the Seismic Alert System for Mexico City (August 1991–July 2004)

			“True” Magnitude* Distribution of the Events		
Type of Alert Issued	Magnitude Estimated by the SAS That Formed the Basis of the Alert	No. of Alerts Issued	$4 \leq M < 5$	$5 \leq M < 6$	$M \geq 6$
Restricted	$5 \leq M < 6$	46	27	12	7
Public	$M \geq 6$	11	4	4	3

*True magnitude refers to M_w from Harvard CMT if available; otherwise it refers to the magnitude reported by the Mexican Seismological Service (SSN).

Figure 3.2. On Sistema Alerta Sísmica and its precision (Iglesias et al. 2007).

Others, though, report otherwise. The organization that runs the Sistema Alerta Sísmica Mexicana reports that they issued 140 earthquake early warnings with for more than 5500 detected quakes with only one missed event and one false alert in the first years that it was operational (see Espinosa Aranda et al. 2009). The warnings had been issued, and people had been able to decide to run. From the engineers' perspective, the precise magnitude of the earthquakes involved was beside the point.

Publishing can be an act of political persuasion and “enrollment”, with citations to make the processes and facts produced more persuasive. Indeed, poorly integrated into state safety procedures as it is, many do not need encouragement to think of the Sistema Alerta Sísmica Mexicana as failed or in some way non-functional. However, these problems are not about the algorithms themselves, but rather a matter of the social systems of technoscientific expertise in which they are situated and which make them possible. This becomes, then, a problem that is no longer about different approaches to quantification and algorithm development, but spreads by way of scientific authority into policy worlds and, from there, public safety– because while the scientists are talking about numbers, they are using the terms “failure” and "poor performance"—which are important ones to the state agents on whose ongoing, half-neglectful support the system relies.

Some of the "strategies for the system's improvement" proposed by the authors of the article were impractical for funding reasons. Others, resistant engineers explained to me, would have diminished the time that users might have to run. They could not and would not implement them. In the precarious world of disaster prevention, these efforts to assess and govern the Sistema Alerta Sísmica were more of a challenge to its existence.

In contests over appropriate measurement and analysis, the disciplinary efforts undertaken by scientists and engineers to define effective data and data processing practices—in effect, to stabilize seismicity for the purposes of public disaster prevention—are ongoing. Politics of knowledge here are caught up in claims of authority made with respect to rendering, analysis, and discourse around seismicity which vary between disciplines. The contests here demonstrate how seismicity itself comes to be effectively multiple for the purposes of disaster prevention, and the challenges that this multiplicity presents. The value of the advantage time they are producing to human users, and how the idea of advantage can adhere to seconds between alert and quake, is not only troubled in measurement and analysis.

Value of advantage

When humans make use of the time advantage allowed to them by alerts, they can destabilize the basic premises of the kind of time arbitrage work by which the Sistema Alerta Sísmica Mexicana produces valuable time. The earthquake early warning system takes advantage of the temporal difference between radio time and temblor time. While the engineers assumed that that time gap, properly conveyed to the people about to experience an earthquake, gives them time to "run," for the people themselves the time gap's utility depends on different things—for example, their sense of the hazards posed wherever they are when they hear it. Putting the alert into use can mean quite a bit more than the kind of alternatives that were suggested in the 1992 meetings; not simply in terms of the ways in which it might be made to be valuable but also in terms of the basic nature of the time that arbitrage between earthquake and radio waves can give users.

In the 1992 meetings and in my conversations with experts over twenty years later, the advantage offered by an earthquake early warning system was a matter of potential activity that could be undertaken in the moments between the alert's dissemination and the beginnings of the motion of the earthquake it indicated. This activity could involve taking shelter, stopping work, or simply preparing to take speedy action as soon as the earth quiets. Human encounters with the alert, however, the advantage it offered was not contained neatly within the boundaries of alert and earthquake, troubling the assumption that time might be valued in a regular and ordinal manner. Here, while it seems that some warning is more valuable than no warning, it does not at all follow that sixty seconds is more valuable than fifty.

This assertion demands some qualification. More warning may give people time to perform more operations, as suggested by the kinds of training that many receive in school or at work. However, the assumption that actions in response to the alert will, or even should, be performed before the earthquake that announces can be felt is a leap of logic inconsistent with practice.

For example, one afternoon my friend Enrique—not part of the seismic community, but a keenly interested observer— heard the alert on the radio in his car announcing an oncoming quake. He was in a safe space, and he had called his wife Beca to pass on the information about the oncoming earthquake. Beca was writing in a cafe and continued to type while waiting to see if she would feel any motion. They had, by this time, heard a great deal about the Sistema Alerta Sísmica from me. Relating the story later, Beca interpreted made Enrique's call out to be more of a comment on the occasion hearing the alert I was always on about than a warning for her.

Beca related her next moves with relish. On the phone with Enrique, she told me, she had waited and waited. Eventually the lamps above her had begun to sway. "I'd have had plenty of time to get out to the street if I needed to," she explained, and Enrique agreed.

They had lived in Mexico City for most of their lives, and were accustomed to these things. "It all depends on the type of building," Beca said. "In this one, exit would have been easy if it was necessary." Indeed, she argued, there was plenty of time for her to assess the severity of the earthquake herself and act before things got dangerous. This may seem to be a request for more information in line with the proposition of certain members of the seismic community. However, given the variety of ways that the soil and rock under Mexico City may react to seismic motion, I suspect that it should be read as such only cautiously. Beca wanted to wait and see how the quake would shake her, and assessed her environment to be not immediately likely to threaten her— in fact, it was such that a swift exit after the earthquake began would be perfectly possible. To her practiced eye, waiting for information about how her particular environment would experience the earthquake (a kind of information that no broadcast alert could communicate to her) was no dangerous undertaking.

Her "wait and see" approach was not isolated.

I have described the social production of emergency in the second chapter of this dissertation, highlighting the variety of responses people may have to the alert. Here I want to make it clear that those responses may not adhere to a kind of timeline that would make more advantage time necessarily more useful than less advantage time is. During the Good Friday quake, a Mexican newscaster on a Televisa, a station long recognized for its resistance to broadcasting the earthquake early warning, noted that the earthquake early warning has started to sound in the news studio, and that he did not feel "anything whatsoever," although some of his coworkers had exerted. He continued to narrate as studio lamps began to shake. "It's very strong," he said, eventually, before segueing to another newscaster and signing off with a breathless "I'm going to leave… I'm going to leave."

The video of this response circulated around the office and was used in a number of presentations. How could a newscaster not understand that the necessary action to take was an immediate evacuation? Half the comments on the YouTube page were about how brave he was, but to CIRES engineers he was setting a bad example.

The value that inheres in advantage times, then, is somewhat less clear than it might at first seem, and are a key subject on which the engineers at CIRES clash with users in their understanding of the utility that they provide can do. Ongoing work to lengthen advantage times relies, in part, on ideas about how time is valued and, more broadly, what it might mean to make an earthquake early warning for human use, and, indeed, produce the kind of users that can take advantage of the early warning. I do not debate that the new ways of encountering earthquakes that the technoscientific earthquake early warning system facilitates are potentially life threatening; nor, even, that people can potentially do more to make themselves safe with more advantage time. I only emphasize, here, how the advantage time that earthquake early warning facilitates may not be as universally valuable to users as the experts debating its production may assume.

Conclusion

Seismicity is unpredictable, the product of energy released by complex geophysical processes through varied underground materials. Its energy and material effects are the subject of substantial and robust research, and seismicity can come to matter in this expert work and for disaster prevention and risk management in many different ways. The affordances of seismicity, and its threats, mean that choosing between different ways of measuring and analyzing it has come to be high-stakes proposition. As the Sistema Alerta Sísmica Mexicana has developed, their modes of measurement and valuation have brought members of the seismic community into serious conflict.

In this chapter, I have described incompatibilities between engineering and scientific modes of quantification and styles of evidentiary claims and how they display disciplinary approaches to problem solving. Different approaches to data care and use are taken up by technoscientific experts to make earthquake early warning systems, and I have tracked how they, and their differences, come to be practiced and explained in the context of this promising technology.

The life-saving promises of this technology depend on effective arbitrage of the relative speeds of earthquakes and radio signals to produce advantage time. Maximizing the time that users have to react, whether or not it is in keeping with the ways in which the advantage of early warning time is valued, has been a key goal for CIRES engineers as they quantify quakes, unpacking and repacking the "white boxes" of their algorithms. This advantage time should allow system users to take significant risk management actions. Different members of the Mexican seismic community, who might trade advantage time for increased precision in data analysis, are often still of the opinion that earthquake early warnings can be useful precisely because of the value of advantage time. However, the time that they allow users can only become truly valuable when it is integrated into systems of practice, mechanical or social. The value proposition of the advantage time is by no means intrinsic.

While in this chapter I have discussed how measurement and analysis of seismicity facilitates the production of advantage time, I have also demonstrated how practices (and the description of practices) around this kind of technical work have come to be a way in which expert members of the seismic community produce their authority and explain debate at once. Earthquakes themselves are unruly actors here; their physical effects lend themselves to many different kinds of legitimate authority claims and even alert uses.

Chapter 4

MANAGING SENSE IN A MORE-THAN-SEISMIC ENVIRONMENT

When earthquakes are present to Mexicans in a new way, new kinds of disaster prevention are possible. These promises rely on the development and maintenance of a physical technical system. Its extension is a matter of strategy, surprise, and above all, work. The engineers of CIRES explain their practice as empirical and problem-oriented, and making a working early warning system has been, for them, a matter of addressing challenges to an integrated network and individual field stations as they emerge and become pertinent. In order to communicate simply about earthquakes and reckon with seismic instabilities, engineers engage with complex environments, though. Although they are making earthquakes sensible in a new way in population centers, their efforts depend on the ability to evaluate and incorporate diverse environmental conditions into their technical design and their maintenance practices.

Managing this expansive physical network means that all sites are made relevant to the center and vice versa, integrating labor happening in CIRES's bustling Mexico City headquarters with that of the field teams who drive out across Central and Southern Mexico to visit the NGO's 98 field stations for repair or maintenance. Any field site requires specialized instrumentation designed for, deployed, and maintained with the particular hazards and affordances of these varied environments: the potential that earthquakes will shake them violently, or that field stations will be damaged by storms, salt air, and social unrest. They must, nonetheless, be managed *en masse* from one central site. The everyday management of this network requires engagement with these environments; efforts to register them but also to make them make sense all together, and in this chapter, I argue that doing so is a matter of managing sense and sense-making practices around seismicity and other hazards.

The designers of this system, a dozen senior engineers and advisors, met almost every week in rigorously-paced "Directors' Meetings." These meetings were generally contingent on the presence of CIRES Director Juan Manuel Espinosa Aranda. People would pour in at around noon, the most senior around a central table, the least sitting back along the walls. Técnicos, as low ranked technical staff without an engineering degree were called, did not generally attend. We who did brought notebooks and, if we were expected to speak, notes.

One particularly fearsome administrator would move the assembled officers and advisors of Design, Administration, Communications, Informatics, Research and Outreach departments through their updates along with those involved in the few CIRES projects unrelated to the Sistema Alerta Sísmica. He had a list of names and items, and would move along at a quick and commanding clip: asking for an update on a co-worker's health before calling on a senior advisor to discuss an interview with the press, asking a department head to explain his newest tweaks to an algorithm in detail, then an ongoing regulatory reform project before turning to another to tease out details about the negotiations of a deal with a new city interested in becoming a user with an alert which attuned signals from the Sistema Alerta Sísmica Mexicana to its own geophysical needs. Each item would be discussed for a few minutes, largely by the senior members of the room: What had been found to be troubling the station in Guerrero? Was Michoacán still too riddled with narco violence to send a maintenance team to visit?

On my way to these meetings, I could sometimes watch lower-level engineers and técnicos load up trucks and double check their equipment in the cramped parking lot behind the yellow outer walls of CIRES headquarters. Although these teams would try to leave early in the morning, they might still be loading trucks as midday approached. They and their coworkers would move back and forth, up to their third floor office space, into storage in a spare office on the ground floor, and back with supplies. They knew more or less what equipment he would need for each station they planned to visit. Field teams left with detailed information about the condition of field stations, after all, communicated by the automated systems of the stations themselves in their twice-daily check-ins, and about sites for any new stations that needed to be installed to develop the growing network. But they also knew that what they would find field stations was bound to be surprising; that in order to alert users effectively, they would need to deal with the unpredictable challenges of a more-than-seismic environment, including but never limited to problems related to the seismicity that their system was designed to register and analyze.

Expecting to be surprised, these men would bring more than they have reason to believe they need. They won't fix anything in the field— better to replace it wholesale and minimize system down time. They organize great spools of cable in the beds of their white CIRES-branded trucks beside large tool boxes, and bring components enough to replace anything that could possibly be broken, malfunctioning, or approaching that condition: the cables, of course, radio transmitters, and even the tiny computers programmed with algorithms which can distinguish significant earthquakes from seismicity that would be insignificant for earthquake early warning efforts.

Trucks were loaded with things necessary to gain access to the far-flung and remote stations: money for food, beds, and sometimes gifts or rent for local community members. Field teams generally need to bring keys to open the chain-fences which ring field stations to protect them from wildlife and thieves, if locals haven't taken on care-taking roles at stations. They need keys for locked boxes of sensory equipment, big umbrellas for shading their work in sun and dripping rain, climbing gear for ascending radio towers to adjust cables or mounts on solar panels, and cameras to take photos of everything for later analysis and to illustrate their stories. Sometimes they bring geophysicists, especially if they are siting new stations; these come with yet more equipment.

In the buildings around the little parking lot, stories about the field circulated in meetings and conversations along with other kinds of evidence of it: careful reports, certainly, but also radio signals, acellerograms, real damaged circuit boards in need of repair, and photos of grinning men and oversized lizards, impassible roads, and rusted solar panels. I had the assembled directors' permission to sit in on weekly Directors' Meetings, but not to join field teams on their repair and maintenance trips. Only a few did; perhaps half a dozen individuals in total, all men. Their supervisor had once done work on field stations, but she explained that she was happy to send young men out into the field now rather than go herself. She was going to Directors' Meetings now and had other responsibilities. It was dangerous in the field, too. Like her, then, I relied on the evidence at CIRES headquarters to understand the extension of the network as a whole in Mexican territory and how stations sat in their particular places, tracking successes and failures on network maps in CIRES headquarters (see Figure 4.1)

Figure 4.1. Still of a recording of how a map rendered an earthquake on April 18, 2014, courtesy of CIRES.

These maps chart the topography of a system, its variety and constancy, and are simple indicators of complex work. Arranging these maps is a matter of arranging facts[102] in space, of surfacing some issues and backgrounding others. Representations of the Sistema Alerta

[102] see Law 2002 on spatiality of ideas and networked relations; though the shape and dimensions of networks are often referred to in ANT work, as in Latour 1993.

Sísmica Mexicana and the territories through which it stretches contribute to the experience of both office and field. They are tools for system management, and suggest stories, encounters, too big to represent but nonetheless circulating through the office spaces, laboratories, and meeting rooms of CIRES headquarters too. In this chapter, I will argue that what CIRES engineers and técnicos are doing with all this is a kind of topography, making sense of seismic and other-than-seismic Mexico in relation to the network that they manage.

Topography is a term which plays on the linked acts of drawing maps and knowing territory as well as recent discussions, particularly in cultural geography,[103] about topo*logy.*[104] This treatment of spatiality has produced analyses which highlight the textures, qualities, transforming and transformative encounters with rich and engaging worlds[105]. These orientations grow from 18th and 19th century mathematics[106] and more contemporary thinkers.[107] Topology means grappling with heterogenous encounters and emerging, transforming relationships between nodes, data, or sites— literal or figuratively

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103 See Lury, Parisi, and Terranova 2012, which argues convincingly that topology is, and has been, an influential orientation even in conversations in which it is not explicitly named

104 While ANT language seems an obvious choice for discussing networks, it is somewhat more awkward a tool to address a network set within and sometimes sensible to external factors. Additionally, I want to be very careful in this discussion not to elide different kinds of agencies and forces, to have care with the categories that the Sistema Alerta Sísmica Mexicana has been built and maintained with. As Secor notes, "geographers drawing on ANT have variously argued that size, scale, cities, and even space itself are merely 'network effects'" (2013, 435).

105 This is not simply landscape work, though it is based on eminently political assembly features (see also Rose 1993, Ingold 2001, Tilley 1994). The observer, here, is more than an onlooker. Wylie describes this difference as "the conditions of possibility of gazing upon landscape" (2006, 519).

106 Euler's work is brought in (as in Shields 2012), but it is mostly with the later non-euclidean work of Gauss, Reimann, and Klein and then Poincaré that are cited as foundational mathematical topological theories (Merzbach and Boyer 2011, Martin and Secor 2014)

107 including Deleuze 1993, Deleuze and Guattari 1988, DeLanda 2002, Massumi 2002, Serres and Latour 1995, Sloterdijk 2011.

spacial systems for which there is no significant "outside." Celia Lury, Luciana Parisi and Tiziana Terranova describe diverse topological modes of ordering the world and analyzing it, writing that through this accumulation they "make and mark discontinuities through repeated contrasts" (2012, 4).

As it happens, topologists are interested in networks; indeed, ANT is a commonly-invoked ancestor in accounts of the gradual emergence of topological analysis.[108] However the networks that they describe through a topological lens seem alien, if not to my experience, then certainly in the context of my ethnographic research. Lury, Parisi, and Terranova hold up the example of high-tech social networking, which can "exceed the common representation of networks as two-dimensional graphs composed of nodes and edges" (2012, 19) and in which distinctions between on- and offline might be confounded. John Allen writes about placing emphasis wholly on the "substance of the connections" in order "to think about networked relationships as mutable and shifting…" (2011, 289). These are quite simply not the networks I am looking for. This is not to say that the components of the Sistema Alerta Sísmica Mexicana are less than "mutable and shifting." However, and quite crucially, the every-day labor of CIRES engineers and técnicos is largely focused on limiting these qualities or at least controlling their perceptible effects within the system.

Topography is being, while topology promises to engage with dynamisms of becoming (as in Martin and Secor 2014). Topography, whether a used to describe arrangements concepts in relation to each other, physical features in the world, or practices involving either, is a

[108] Lury, Parisi, and Terranova 2012, Allen 2011, Secor 2013, Dixon and Jones 2015, Ruppert 2012, Lash 2012, Marres 2012, Latham 2011 among others.

matter of the known, categorized, and fixed.[109] An example of topographic state practices is a census which "produces the fiction of the nation as a finite, unified, homogeneous whole in terms of the addition of discrete households or individuals: 1+1+??" (Lury, Parisi, and Terranova 2012, 13).[110] Here difference and internal shifts are elided or made uncountable. Topography often appears in these articulations as a trap or a too-easy way of thinking that must be avoided in order to develop really contemporary theories of knowledge and power in space.[111] While, indeed, configurations of power and knowledge may have turned to the topological in some places,[112] this is hardly a universal constant. Furthermore, managing accumulation to, as Lury, Parisi and Terranova write, allow 1+ 1+ 1 to accrete and unify,[113] to embed systems into natural or cultural environments, as Nichole Starosielski describes (2015)—or to make seismic readings from very different sites come to make a sensible earthquake early warning system— is no small thing.

In this chapter, I explore the labor of topography, the ongoing work of managing sense in the Sistema Alerta Sísmica Mexicana as it extends through, develops in, and registers

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[109] for Lefebvre 1991 it features in the trialectic of "lived, conceived, and perceived" space, and was used not only to define exercises of top down state power but to produce oppositional accounts. See also Martin and Secor 2014, Dixon and Jones 2015.
[110] they were summarizing research by Ruppert (2012).
[111] Secor and Martin, at least, are fully aware that this does a disservice to topography and (mere) being as well as to the larger project of its standard bearers; they find Deleuze's engagements to be far richer, and write "At worst, the dichotomization of these two kinds of space reintroduces into spatial theory a host of dualisms that post- structuralist theory has sought to deconstruct" (2014, 11). Elden contests the methodological and analytic utility of this forward-moving project (2011), as do Paasi (2011) and Dixon and Jones (2015).
Nonetheless, topography provides a useful contrast (which only sometimes exhibits the qualities of a straw-man) for some researchers.
[112] as topologists provide ample evidence that this is the case (see Mezzadra and Neilson 2012, Allen 2011, Coleman 2011, Harvey 2012, Ruppert 2012, Dixon and Jones 2015)
[113] For that matter, to make discrete households equivalent is a great deal of work indeed (see Daston 2008, Guyer 1997).

phenomena about more-than-seismic environments. I discuss system maintenance in the context of these environments to position the development and use of knowledge— about the seismicity that the system registers and analyzes and more—at the very center of my discussion. First, I focus on considerations of the system from the center of its technical network, describing it as a whole and how social pressures and techno-politics along with the action of tectonic plates and faults underground have been made to inform the development of the Sistema Alerta Sísmica and continue to frame its futures. Then I discuss its component sensory stations in situ, considering what type of place the "field" in which they sit can be understood as before highlighting how the physical and social environments encountered there come to be understood as problems to be intervened upon. Finally, I address work on the network in the context of the onslaught of frightening violence that has recently haunted some of the most seismically active territory in Mexico. Attempts to manage how the network, its stations— and the field teams who work on them— respond to and engage with these forces have been particularly demanding.

The work of this earthquake early warning system is eminently material. Making earthquakes available to user communities through the alert means that the technological network and the people who work in it have to manage sensation. They do so in terms of seismicity, certainly: first determining appropriate station locations, then registering and analyzing seismic motion for the purposes of broadcasting alerts about moderate or large earthquakes. But in these more-than-seismic environments, téchnicos and engineers have to manage other kinds of sensation, too. They reckon with the effects of environmental phenomena on field stations for ongoing design refinements to the system itself and their maintenance policy, and need to manage how people notice and make sense of their presence when they go to the field. In rural Mexico, this latter issue could have impact not just on the system's function but for their very lives. The environments that the Sistema Alerta Sísmica Mexicana extends through contain mutable forces, beings, and effects which are laminated, differently scaled, mutually intruding, mutually productive. This topography project, then, is not so from ethnography— a matter of having and making sense of encounters in order to produce new ones.

Working on the network

In the Portales-neighborhood buildings from which CIRES operates, work and conversations are punctuated by beeps and echoing electronic voices, and performed under and with reference to flat screens glowing vividly with maps and system information. The kinds of encounters with seismicity that the earthquake early warning makes possible rely on the sensory management that happens here and the fieldwork that is coordinated from these noisy rooms.

The "cerebro" or central control and registry system used to monitor the connections between Sistema Alerta Sísmica Mexicana stations, manage their signal distribution, and occasionally give a high-tech backdrop to an interview or meeting, was in a set of buildings that I came to regard as the main one of the two formerly-residential homes CIRES owned. These buildings, a front and a back structure with a parking lot between, had been the first acquired. Behind a private security guard, these buildings housed the people who dealt with the stations as they were: people who worked for the departments of

Communications, Informatics, Research and Outreach, and the high-level administrators and advisors all worked out of them, as well as those few engineers involved in siting and maintaining sensory devices that had little to do with the earthquake early warning system.[114]

In this set of buildings, screens displaying the status of the Sistema Alerta Sísmica Mexicana superimposed on a Mexican map were on every floor , and mechanical voices resounded at all times, framing a constant encounter with the distant field stations. Every 6 hours each station is contacted by the central computer, triggered to respond in order to make sure that, if there was seismic activity to register, analyze, and potentially alert users to, the stations were ready for it. In this response CIRES engineers gauge field station function and calibrate the connections between them. In my time at CIRES, "REPORTÁNDOSE" would resound in a masculine and mechanical voice through the speakers around the office. "Reporting!"

[114] What had been a 1920s-era home was now refitted for office use. Painted plaster moldings and marble floors encased functional composite wood tables, bookshelves, and mismatched office chairs. The front of the two buildings is much finer than the back one, with a skylight and a sort of copula lighting a meeting room. It was, during my fieldwork, entirely devoted to meeting spaces and higher-level executive offices. The rearmost building was, on the other hand, completely given over to functionality, built out and redesigned as necessary. Both were maintained by an ever-present cleaning staff, and though neither were ever dirty, but this second building was certainly not elegant. It was lined in book cases, run through with wires, and stacked in binders, tools, and well-sorted components and materials. It had heavy wooden doors and marbled floors, but fewer moldings. There were boxes stacked in corners and someone had stuck what looked to be a ska band's logo sticker on the entrance to the Research and Outreach department's offices, and the workstations of the Communications department were decorated with well-worn lists and guidelines pinned to cork boards.

This was answered by beeps and a higher-pitched voice, female-sounding. The second voice would name of one of the 98 field stations around the country.[115] It echoed through everything that happened at the center's two main buildings. It informed and provided a backdrop to conversations and work. If a station failed to respond to the signal and check in, it was readily apparent to anyone listening—but nobody could listen closely at all times. When I spoke with and worked beside engineers and técnicos, I saw the tones neglected. Useful, but not demanding of attention.

Screens on every floor organized this information, and they framed the information practices and sociality by which the extensions of the Sistema Alerta Sísmica Mexicana were made sensible in CIRES headquarters, and should be made visible for analysis as such (as in Ziewitz 2011). The information displayed on these screens were also displayed at CENAPRED, the National Center for Disaster Prevention to the south of the city , as well as all the other centers from which field station signals had to be processed and turned into warnings. There was a small screen displaying this information in a server room in Oaxaca City, and though I never saw them, I understand that there were more in other Protección Civil offices of CIRES user governments;[116] in Puebla, Morelia, Guadalajara, Acapulco, and Chilpancingo.

The screens in CIRES were not small or tucked away in a corner of a building, as the one I encountered in Oaxaca City was. CIRES engineers were, after all, responsible for the

[115] Field stations are named with reference to their location, generally for nearby communities.
[116] Outside of Mexico City, the screens were attached to systems called EASAS or Emisor Alterno de Sensor Alerta Sísmica.

ongoing design and maintenance of this system. This is what their users paid them for.[117] On every floor, flat displays were suspended high on walls where one viewer's head could not obscure another's view. There we could see how the various stations were responding in text at the side of the screen and in their colors, neon green for the functioning ones and red for the recalcitrant, picked out and alight. Looking at the display, we could read the town names we were likely to hear soon, the names we had not yet heard but should have, and even see which stations were presently detecting seismic activity. These changing maps, developed by in-house designers and software engineers, were updated automatically, in real time. Superimposed on a map of Mexico were lists, updates, and legends for those who forgot what triangles and circles of various colors might mean.

People did not watch these closely unless an earthquake was making its way across the country. According to a survey I administered early on, they were doing work in the laboratory, testing, filing forms, reading academic and media articles, preparing talks, tweets, or blog posts. They were sitting at their own computers or at work benches. If an alarm signaled an oncoming earthquake of any size, everyone would congregate around the screen and watch the representation of the quake expanding concentric circles and stations registering motion.[118] By and large, though, the beeps and voices were back grounded to other work.

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[117] Or, in Oaxaca's case, promised to pay— the state was years behind at the time of my fieldwork, though CIRES engineers continued to maintain not just the network of stations throughout the state (which could benefit client cities besides Oaxaca) but also the city's EASAS.
[118] Even if an oncoming quake was going to be large enough to require actual evacuation, a computer engineer told me, the engineers could be sluggish, used as they were to watching the advance of earth motion represented in yellow ripples across deep green Mexico.

Maps and beeps provided a constant encounter with the network's integration and system's integrated work managing sensation. In the elegant downstairs, a display featuring the map by the side of the cerebro itself. This room was used to show off the system, and here the old house hadn't been outfitted as haphazardly and functionally as it had in other rooms. Colored wood inlaid in patterns marked the tables, and folding plastic chairs, while sometimes necessary for larger meetings and events, were kept out of the way in boxes. On one table was an impressive bound document containing accelerograms of every seismic event that the Sistema Alerta Sísmica had ever detected in any of its incarnations. Basic information about the system, unnecessary to anyone really familiar with it, was on the wall. Here the system map was not a tool for engineering but a tool for demonstration, a backdrop and context for larger events and meetings with outsiders.

In this section, I address how the network has come to form the topographic arrangement that it has, managing sensation in order to function— that is, to develop a system which, in an utterly reliable and apparently straightforward way, produces early warnings when significant earthquakes are eminent. Measurements of the scope of earth motion, the acceleration of a site or the magnitude of energy that a seismic event releases allow seismic phenomena to be quantified and mapped; and, in this way, calculated, forecast, and even alerted. The extension of this network requires grappling with more than just the treatment and value of geophysical data. It has meant managing all the network's components so that, though they are unavoidably individuated (placed in different conditions, sensitive to different seismicity, comprised of different technologies) the system as a whole relates to Mexican territory uniformly, making earthquakes sensible to users in new ways. This topographic work is a proposition which demands consideration of more-than-seismic environments.

Siting a sensory network

Mexico City's relation to unquiet interfaces between tectonic plates and active faults has been strong and serious. It is this relationship that the Sistema Alerta Sísmica Mexicana was developed to intervene upon and change radically by making seconds of warning possible, using existing technology for mediating and translating releases of seismic energy and building upon it. However, warning and its uses are often social, and the everyday work of developing and maintaining this system has been a matter of strategically managing both technical connectivity and popular trust, without which the alert cannot effectively a connection across Mexico between a at-risk users *there* and the variable seismic *elsewheres* that send them quakes.

In wake of the massive 1985 earthquake which took Mexico City by surprise, geophysicists used records to forecast the next massive quakes which might effect Mexico City (a project I describe in greater detail in the first chapter of this dissertation). They identified a zone located along the Pacific coast of Guerrero state, from just south of Acapulco to Papanoa, and called it the Guerrero Gap or Brecha de Guerrero. While sites all along the plate interface nearby had generated large quakes within the years on record, the space between the two communities in Guerrero had not. Models of physical processes demonstrated the likelihood of a large quake in the area (see Singh and Ordaz 1994), and, indeed, the Sistema

Alerta Sísmica was first built to include this area within the span of 12 field stations in order to alert users when it was about to happen.

On my first day at CIRES, I was given copies of the documents that motivated the development of the Sistema Alerta Sísmica Mexicana. Director Juan Manuel Espinosa Aranda presented me with a folder of contemporary information when I came in. At the end of our first meeting, though, he escorted me down the stairs to the main lobby of CIRES headquarters for more historical material. The administrator had left for the day while we had been talking, so he stepped behind her heavy wooden desk to dig a spiral-bound photocopy out of filing cabinets behind it.

It was titled the "Declaration of Morelia" and had been published in 1986, a year after the disastrous earthquake and three years before work on the Sistema Alerta Sísmica was to begin. It laid out in no uncertain terms the belief of the Mexican Geophysical Union, a group that counted among its members most, if not all, of the active earth scientists in the nation, that there was a high probability of another large earthquake soon. The authors of the document identified a place along the Costa Grande of Guerrero (helpfully identified as between longitudes 99.8 and 101.0 west) that had a significantly high probability of a large seismic event, and called for the attention of the President of the Republic of Mexico, state governments, the expert community, and the general public (see Union Geofisica Mexicana 1986). Funding was limited, and this, Espinosa Aranda explained to me, was why the Sistema Alerta Sísmica's 12 original field stations had been arrayed as they were (see Figure 4.2).

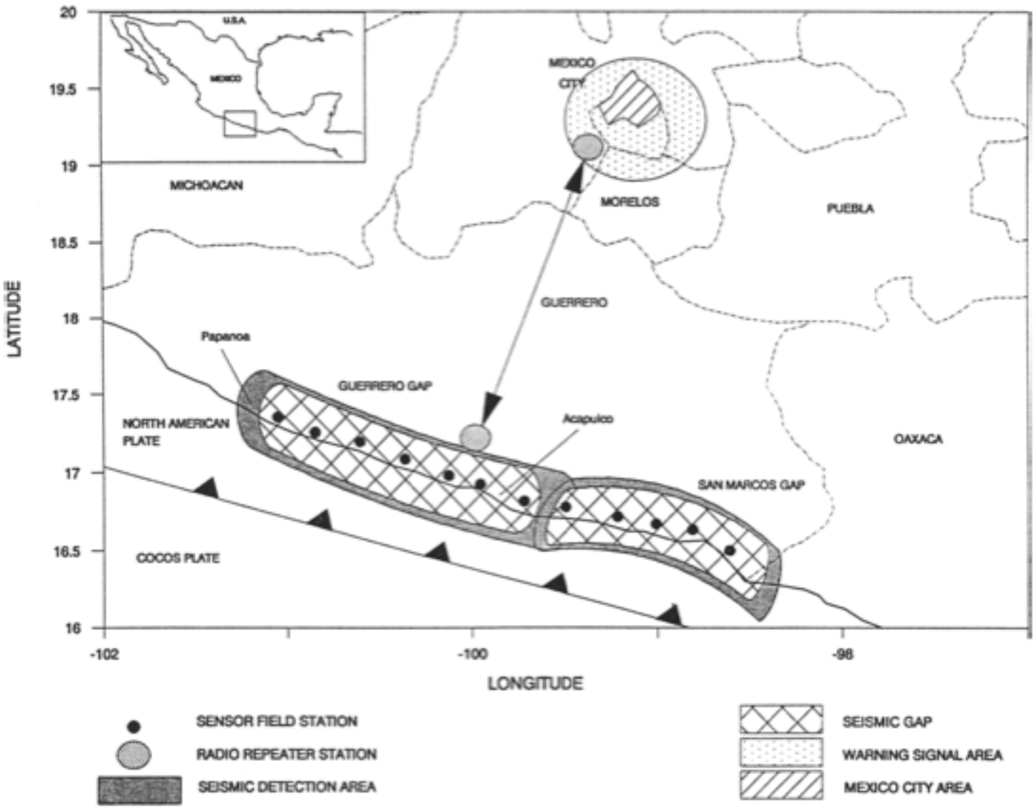

Figure 4.2: A map of the Guerrero Gap and original Sistema Alerta Sísmica Stations (Espinosa Aranda et al. 1995).

Geophysicists are no longer sure that the Guerrero Gap will produce a big temblor. It was much-discussed in the 1980s and 1990s, but might well have released its energy in a so-called slow or "silent" earthquake[119] (Dragert, Wang, and James 2001) but has not yet shaken Mexico City violently. Others, however, have. The choice to site the original stations on the Guerrero coast meant that some earthquakes that did shake Mexico City which could not be detected. Geophysics knowledge is developing, and the hazard that they had first deployed field stations around simply never appeared. Their lack left the system exposed to reputational risk as smaller earthquakes shook Mexico City without warning.

[119] In which pressures are released over hours or even months and differently detectable than the kind of motion we generally identify as an earthquake.

The design of the earthquake early warning system has relied on geophysical forecasting. Changes in geophysical understandings of the seismic environment and ongoing limitations to technoscientific forecasting have meant that the Sistema Alerta Sísmica Mexicana's reputation was troubled from the start. Its designers' efforts to consistently and simply transform the ways that Mexican users encountered seismicity, integrating early alerts into the experience and facilitating safety measures, was hindered by the lack of uniformity in the Mexican territory's geophysical disposition and the presence of earthquakes that the system could not alert.

A functioning network

When CIRES engineers explain the technical qualities and spacial extension of their seismic sensory network, they often reference the well-documented propensities of the seismic environment of Mexico, how people perceive this seismicity through the Sistema Alerta Sísmica Mexicana, and how they come to think about the system's function in this context. In other words, in order for the system to produce the new kind of encounter with seismicity for people in user communities, it has to be both technically effective and legible as such. While for the purposes of technical work, clearly there was a difference, the engineers understood themselves to be practical problem solvers. Reputation issues, then, had to be integrated into the very structure of the Sistema Alerta Sísmica Mexicana.

CIRES's origin as a NGO rather than a government entity is traced by some participants to concerns with maximizing system up-time. Aside from issues of staff turnover with changing government regimes and unpredictable budgets, being a government agency would have meant, when CIRES was founded, being subject to massive strikes and union action. The people and state agencies interested in developing what then was a network of seismic sensory devices designed to collect detailed data on soil conditions around Mexico worried that their field stations would be allowed to fall out of operation without teams able to go and service them at any time. This concern only became more serious with the development of the Sistema Alerta Sísmica Mexicana, which depends on constant readiness. The stations had to be constantly active in order to effective just as they had to be sited throughout Mexican territory.

If a station is down and a significantly sizable earthquake is not alerted, then that is a technical failure. But there was another kind of risk that a system replete with technical failures ran, and it had to do with ongoing popular support and contracts from user communities. The system's reputation is understood to articulate with its failures and successes. It was the risk of another "big one" that motivated the development of the network, its extension along the coast and down through the sierra that crossed the country. A quake could happen at any time.

The early goals that defined the siting and extension of field station network might have had to do with the worst earthquakes that were likely to have effects for Mexico City, but by 2013 and 2014 the approach to seismicity that defined CIRES's interventions were oriented around a more complex set of goals: now the system was to alert its user communities to as many quakes as possible that fell above government-mandated thresholds of moderate (that is, between magnitude 5-6) earthquake size[120] (the effects of which I describe in the second chapter of this dissertation, which focuses on emergencies).

Engineers had come to see the reputation of their system as crucial to maintain alongside its technical function. The technical and social reliability of the system were both necessary to making the system seem consistent and uniform—to collapse transformation into a flat topography, and, furthermore to protect its reputation for malfunction. One CIRES engineer told me, “it takes a lifetime to win people’s confidence and a second to lose it,” and this, indeed, was the general sense around the office. Every earthquake within the mandated thresholds had to be alerted. A strong reputation was essential for public trust and for the system to maintain its status in effective earthquake early warning, but it was easy to lose.[121]

Those first decades, in which the system oriented around warning Mexico City of oncoming earthquakes consisted of only 12 stations along the Pacific Coast, are still understood to have been a problem for the system’s reputation. The Sistema Alerta Sísmica in those days began to be called “la alerta que no alerta,” or “the alert that doesn’t alert,” and not just because of several early technical failures. Earthquakes came from beyond the system's sensory reach to shake the city, and it caused confusion, especially when Mexico City's Protección Civil was doing little education or outreach about the alert and its capabilities.

[120] These thresholds were set at these levels by Mexico City, and make communication about the alert troublesome because magnitude is a measurement of an earthquake at its source, not a measurement of how a client city might experience an earthquake.
[121] I discuss how the stakes of public trust have motivated schisms between CIRES and those who would retransmit their signals on smartphone apps in the second chapter of this dissertation, which focuses on different kinds of earthquake emergencies.

CIRES has year-to-year contracts with the governments of its user communities. Maintaining the reliability of the system was crucial if the Sistema Alerta Sísmica Mexicana was to persuade user communities of its ongoing utility and, in this way, guarantee the existence of a potentially live-saving public disaster prevention tool for another year. I saw the implications of this history during my fieldwork; mentions of my research were often met with disbelief. People would ask: "Does that system even work?"

The problem was not only doubters. A recent phone survey undertaken on the part of MDreieck, a commercial company which manufactures emergency frequency radio receivers, informed them that few people only 16% of the 1028[122] people surveyed really know that an alerta Sísmica, any alerta Sísmica, exists. When I asked the engineers, técnicos, and administrators at CIRES about their knowledge of the Sistema Alerta Sísmica Mexicana in an anonymous survey, thirteen of the twenty-eight respondents who had become involved after the system was operational reported that, they had never heard of it until either they, close friends, or family members began to work at CIRES.[123]

A network of "obsolete" technology

The field stations which comprise this network are very much alike: 6x6 meter squares of poured concrete ringed by chain link fences. Inside this, radio towers, maybe 60 meters tall, with tiny solar panels mounted upon them rise over metal boxes of computer equipment.

[122] Data from the commercial study was presented to CIRES engineers in 2014 but has not been published.
[123] This is not, of course, counting those who had been involved from the very beginning.

Everything is painted in red and white. The photos on promotional materials and on the website (see Figure 4.3) show the painted metal framed against wild spaces. The network of Sistema Alerta Sísmica Mexicana stations has developed over decades, marked by slow changes to extension of the network and technology that the station houses. CIRES engineers' commitments to certain design principles are cast in sharp relief when compared to the priorities embodied in the current Mexican government's techno-optimism.

Figure 4.3. El Carrizo sensory station, courtesy of CIRES.

In 1989, the system was launched with 12 stations. Ten years later in 1999, a parallel system of 37 stations was built in the southern mountains for quake-prone Oaxaca City, and in 2005 it was united with Mexico City's Sistema Alerta Sísmica. Together they were the Sistema Alerta Sísmica Mexicana, with a combined network of 49 stations. The system, now rendering alerts for more than one population center, kept growing. By 2013 and 2014, when I did ethnographic fieldwork, there were 98 stations live and more planned, and Puebla, Morelia, Chilpancingo and Acapulco now also had dedicated alerts centers sensitive to quakes liable to effect them.[124] Work was underway to place them in Chiapas and Veracruz to south of Mexico, and the maps of the system on display on screens around CIRES headquarters were dotted with potential sites as well as active and inactive stations, with new kinds of algorithms and sensory technology to deal with the deeper quakes emerging out of the mountains along the 18th parallel.

The stations are positioned under certain constraints: they must be on hills to facilitate line-of-sight radio transmission, on stable soil, and around 25 km from the nearest other stations so that any registry of earth motion can be double-checked. Stations must be near places likely to produce significant seismic motion but not too near; able to detect them but far enough from the likely focus of a quake to get substantial readings. For most of the life of the Sistema Alerta Sísmica Mexicana, the range of each of the stations have been about 100 km.[125]

The network, however, may suffer from shifting politics of novelty. Its expansion was being developed against the backdrop of another project: a similar system operated by the state. Peña Nieto's government was making noise about building its own all-hazards early warning system while I was in the field, having gone so far as to issue a call for proposals. This system would not just integrate the existing earthquake early warning with state-run

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[124] These are still so new and have been developed in a moment of such increased activity that they are not written into many of pages on the CIRES website as of 2015.
[125] Depending on the depth of the quake.

systems monitoring a variety of other hazards,[126] but would build them up from scratch. Part of the agenda of a presidency trying to push a high-tech Mexico,[127] this potential displacement was concerning. It might go nowhere, CIRES engineers and outside observers alike told me, but it very well might mean trouble for the Sistema Alerta Sísmica Mexicana.

Peña Nieto's Mexican state is notoriously enamored of equipment and processes about which CIRES engineers have grave and pointed doubts. Agents of the state would want something new, to prove the good that they were doing for Mexico. They would want something name-brand, manufactured elsewhere. CIRES engineers associated this kind of overkill with some of the scientific critiques that the Sistema Alerta Sísmica Mexicana had sustained. Critiques of the algorithm that Iglesias et al. had published in 2007 had also recommended that higher resolution sensory stations be incorporated into the system (as I describe in the fourth chapter of this dissertation, which focuses on the more-than-seismic environment). In the article, Iglesias and his co-authors had raised questions about the lack of distinction available in CIRES readings and the tendency toward imprecision on lower magnitude quakes that could be solved with such an equipment change. Engineers at CIRES were not convinced of the utility of such a change then nor are they now.

A state system would likely include the newest accelerometers, capable of generating the most detailed information about earth motion possible. Engineers at CIRES suspected that

[126] Sistema de Alerta Temprana para Ciclones Tropicales is largely managed by the Sistema Nacional de Protection Civil.

[127] The Peña Nieto government was actively reorienting the Mexican state agenda with respect to styles of technological intervention with directive policies such as the Estrategia Digital Nacional to further the adoption and development of information and communication technologies in Mexico.

politicos would to be convinced to use 32 bit acellerographs— the most advanced available— and capitulate to arguments that cast the Sistema Alerta Sísmica Mexicana's network of lower-resolution accelerometers as old and out dated. 32 bits of information is simply unnecessary, though, they explained to me. An acellerographic with that resolution might allow finer-grained information about minor seismicity, but it was a poor tool to apply to the job of earthquake early warning. That kind of information about small earthquakes was unnecessary for a project to which small earthquakes were quite simply insignificant, and useful readings of moderate to large earthquakes did not require such technology.[128]

A 12 bit acellerograph is perfectly effective for the Guerrero coast, where quake epicenters tend to be reasonably close to the shore and not too deep. In Chiapas, 16 bit or 18 bit acellerographs would definitely do the trick, I learned. The depth of seismic activity and distance from the sensory devices determined to some extent the kind of technology that might be necessary to draw on, and my informants were firm on the subject. Finding the right kind of acellerograph for the job at hand was one of the ways that engineers at CIRES distinguished themselves from technically illiterate policymakers, whose priorities were quite simply suspect, and from scientists who were not thinking in terms of practical problem solving.

[128] The magnitude scale commonly used to treat earthquake sensation is logarithmic, and while detecting information about a magnitude 1 or 1.5 quake might require finer instruments, that is not the case for a magnitude 6 quake.

When engineers at CIRES talked about inevitable troubleshooting, they drew out bathtub curves freehand, as I have below (see Figure 4.4) and gestured at binders of CIRES error records. New high-tech equipment, especially the kind manufactured wholesale elsewhere, would never provide engineers with the troubleshooting information they would need to open the devices up and fix problems, even though it might render the kind of data that scientists generally regarded as desirable.[129] So why replace well-known devices, whose particularities had been well explored, with relatively unknown ones, however high their branded reputation? Why make the people of Mexico pay again for a new earthquake early warning system that may not function?

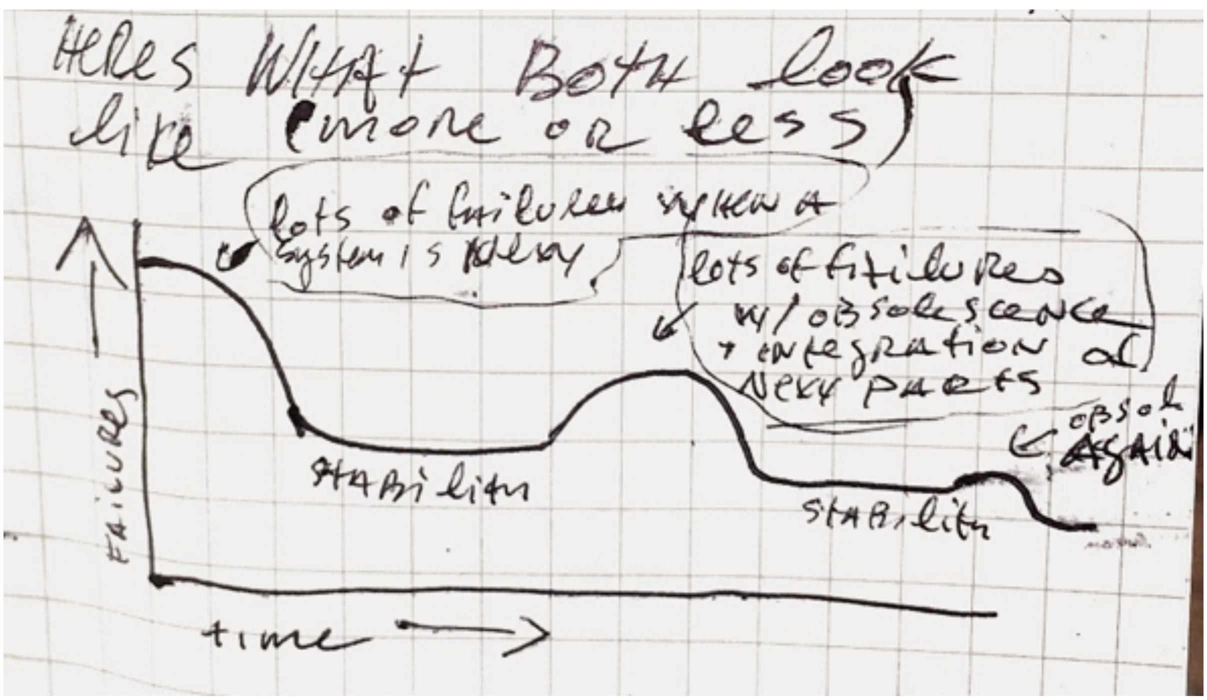

Figure 4.4: Bathtub curves from author's field notes.

[129] see the chapter on measurement, in which I describe the ways in which CIRES engineers characterize scientist orientations toward data.

New equipment would have errors, and might not be up to field conditions. More data might take longer to collect, might not be able to be sent so quickly. These are the technical issues. The Sistema Alerta Sísmica Mexicana was imagined in the late 1980s, and was designed to run in challenging material conditions and with minimal reliance on underdeveloped power and telecommunication infrastructures of rural Mexico. At stake in the state's proposal to develop a new high-tech system was more than just the displacement of CIRES, then; such a system was liable to fail in unpredictable ways and put people at risk.

CIRES field stations have changed over the decades; algorithms have changed, the system has gained redundancy, weatherproofing has been maximized and power needs have shrunk. However, these changes are developed and implemented slowly, within the constraint of technologies that are already well-understood.

“Si funciona, es obsoleta,” Armando Cuéllar, an engineer involved in designing the algorithms for field stations, told me, reflecting on CIRES's "laws." This might translate as “If it works, it’s obsolete,” or, perhaps better, “if it’s obsolete, it works.” If technology was no longer new and exciting, then CIRES engineers could begin to be confident in its reliability in the field, its ability to perform under the less than advantageous conditions of Mexican territories in the past well-proven. It could be managed, could resist revealing the changing effects of equipment-environment interactions in system errors. Choosing and developing technologies which were appropriate for the challenges of seismic Mexico were not, though, all that was necessary to cultivate the kind of reputation that the Sistema Alerta Sísmica Mexicana desperately needed.

Making it possible for the fame of the Sistema Alerta Sísmica Mexicana to grow productively, that is, for its use and sensory network to expand effectively, engineers at CIRES navigated technical politics to make information about seismic dispositions of territories selectively sensible. The challenges that must be addressed or backgrounded when considering the whole system as a whole, comprised of various kinds of field stations (labeled in Figure 4.5 as ESDECAS or Estaciones Sensoras de Campo Autónomas), signal repeaters (ESREPES or Estaciones Repetidoras), broadcast centers (ESCERE/EASAS or Estaciónes Central de Registro/Emisores Alterno de Sensor Alerta Sísmica) currently live and in planning, are quite different than those which emerge in the managements of its component parts.

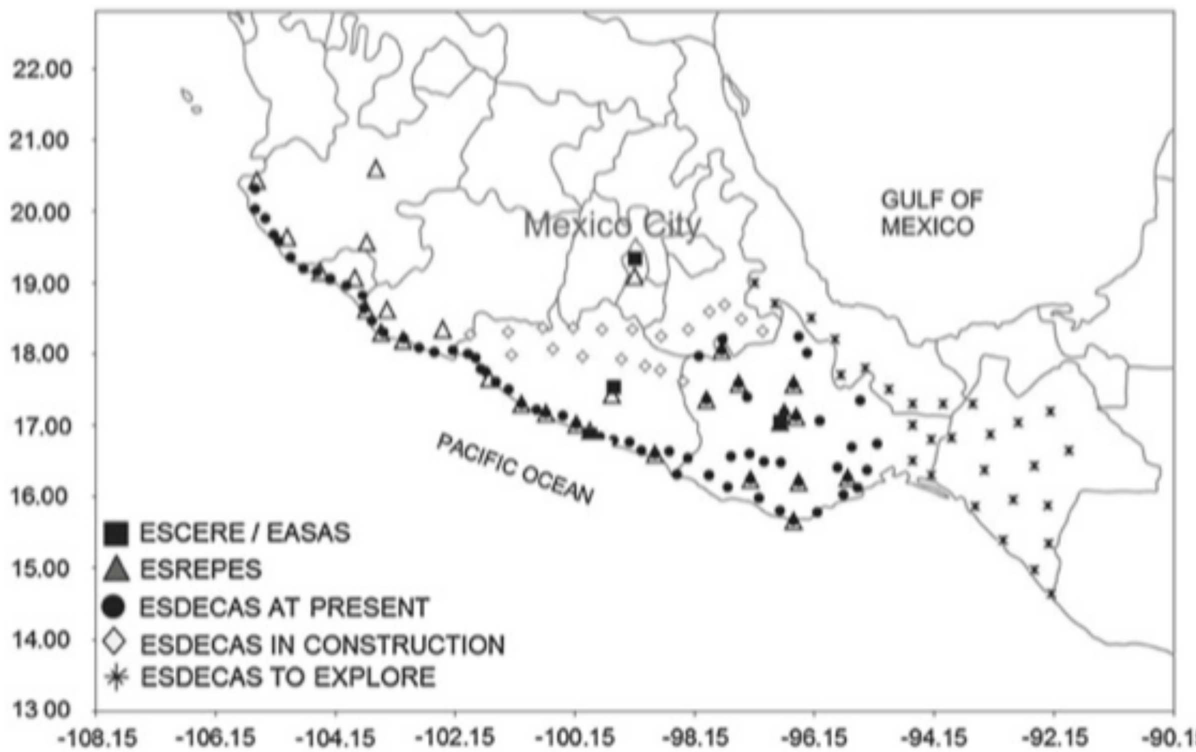

Figure 4.5. Map of Sistema Alerta Sísmica Mexicana stations at the time of my fieldwork, (Cuéllar et al. 2014).

"It's really different when you go into the field." Rufio Pérez said. A téchnico without the degrees an engineer might have but with more experience than most (as his coworkers made sure to let me know), he had been doing fieldwork for a dozen years. He had not seen the first stations built, but had been involved in developing the Sistema Alerta Sísmica para la Ciudad de Oaxaca in the early 2000s (now integrated into the Sistema Alerta Sísmica Mexicana), and was participating in the second wave of system expansion. He had traveled to stations in many different conditions. He had been around longer than most of his coworkers in the Communications Department, who tended to be young, just a few years out of school or wrapping up their community service in advance of graduation. He'd had plenty of opportunity to explain field trips before. "When you go out," he said, "it's another thing."

Work in the field

When field teams come back to CIRES, their stories and photos are on display along with more formal reports. This display is not just for curious anthropologists, who peer at computer screens and ask how that photo came to be, or that other one. They are for coworkers, too. When I sat down with one man to talk about the field, inevitably another would join, and another, and passing team mates and coworkers would throw in a remark or two, a you-should-ask-him-about or a jibe. They came home with various kinds of evidence of remarkable developments in the field, but had to manage its status as evidence for ongoing station design and re-design.

The photos that field teams showed were illustrations of some of the particular challenges and pleasures of their fieldwork. These images were mostly of men in baseball caps and T-shirts, waving at the camera or intent on colorful wires and circuit boards. Representing the work done was important; was necessary for documentation of every step of their work and for simple reference points in stories. With their stories about siting and maintaining stations, they let those of us who stayed in Mexico City engage with both the difference of the field from the places we occupied and the particular kinds of physical and social qualities of the varied territories that they encountered.

Working to manage the new ways of perceiving a seismic environment that the Sistema Alerta Sísmica Mexicana offers has meant encountering rural Mexico and managing, or at least engaging with, the powerful forces that structure human life and device function in rural Mexico. The environment here comes to be parceled out and encountered in terms of threats to station function and to good maintenance. It is told as it welled up, crept in or crashed down upon field teams, interrupting and, when possible, integrated into their careful management of the elements of the system.

From my usual desk in the Research and Outreach department I listened, fascinated, to one engineer's litany of animal encounters for a friend whose desk job kept her rooted in CIRES's headquarters. She shared her well-maintained stash of candy while he showed us shaky, too-green photos on his smartphone of an iguana that seemed to want to throw itself beneath the tires of the CIRES truck. He flipped from one photo to the other, and soon it was not lizards we were looking at but photos of his round-cheeked son.

Several times during my visit, field teams gave formal presentations of their experiences for their department or even the organization at large. These were part of an effort to familiarize their coworkers with different kinds of labor that comprised system maintenance. Attendance was optional, and at one presentation, I saw a dozen variously lower and higher- ranked members of CIRES staff came to listen, maybe a sixth of the total number of people who worked at the organization. In a small room with chairs and jokes about paperwork owed and equipment to buy, people filtered in, greeted each other, and sat down, alert, to watch and ask questions. The stories presented in this venue were official and involved explanations of the status of the stations under development that were grey dots on the ever-present system extension display maps and overviews of technical process and regulation. They were illustrated with photos of circuit boards being investigated, removed, and replaced as well as men scaling radio towers. Even here, we learned that field trips rarely proceed in an orderly way. The presentation ended with the unexpected and the nontechnical, or not strictly technical: with photos of mudslides and allusions to encounters with crocodiles (unlikely as that may be).

José, an animated young man who often led field teams, put stations at the center of his stories, and discussed hazardous environments in selectively conglomerative ways. For example, anthropogenic problems like vandalism threatened stations just as meteorological conditions did, and extortion and key management could be just as time intensive as poor road quality.[130] This is not an unusual way of approaching field stations and their challenges; even in early reports on the system, "vandalism" (read: theft) and "extraordinary natural phenomena" were cited as the principle causes of Sistema Alerta Sísmica failure (Jiménez et al. 1993, 634).

In this section, then, I attend to the way that a constantly transforming more-than-seismic environment can be dealt with in a sensory system that designed to address some of its changes. I highlight how this network's function means managing sensation so as to

[130] While disaster studies scholars have pushed and debated the necessity of folding "vulnerability" into considerations of environmental risk, highlighting the long term effects of poverty, damaged or poor infrastructure, trauma and other factors as well as problematic "resilience" (Barrios 2014), this approach to conditions is largely absent here. Vulnerability and resilience to earthquakes are simply not a main concern for field teams, since the communities in the field are not system users. They are, instead, often figured as impediment or assistant to the project.

provide alerts to user communities regarding moderately-sized or large earthquakes while making other environmental issues invisible to users. These issues include, as I describe in the next pages, not just ongoing low-level seismicity that stations are designed to discern from threatening quakes, but economic inequalities of Mexico and their effects, property ownership and access issues, and the field stations' becoming-with this environment alongside lightning storms, theft, and corrosion. This process is a matter of, as I have suggested, managing sense to make the challenging topology of Mexico into topography that is coherent, clear, and simple. Field trips were narrated, at least at CIRES headquarters and in my presence, as encounters with the parts of the environment that prove themselves significant to the extension of the network of stations and system function.

Las provincias

The men who comprise CIRES field teams are, largely, city people. They are not, however, from one of Mexico's smaller cities, designated "colonias magicas," "magical towns," for tourists, or from one of its up-and-coming tech or commercial centers. They are from Mexico City. They are not "chilangos," either, come to the capital with only pesos enough for tortillas and forced to substitute chile sauce for substantive fillings. These are real Mexico City residents, a significant number of whom were born in the Distrito Federal de la Ciudad de México or in Mexico state, just outside of the city's[131] boundaries.

Pérez drew on his long experience to describe going to the field as an encounter with "a world that we don't know." A field trip meant a journey to the altiplano of western and

[131] 32 of 75 CIRES employees were surveyed and provided this data; of the 12 members of the communications department who participated, 11 were born in Mexico City.

central-southern Mexico, or what some of his coworkers simply called “the provinces.” "The provinces," or "las provincias," is not respectful language.[132] It has colonial overtones, dating not just to the Spanish Empire but also the Roman, referencing both subdivision and subjugation of territory to a central authority. The use of “las provincias," which is common and casual in Mexico City, highlights the marked difference between the nation's packed, powerful, and comparatively wealthy capitol and the bulk of Mexico, the vast network of places that its wealth relies upon and about which its leaders make decisions.

In the earth sciences, "field" designates places in which qualities of the earth or its motion are revealed and come clear to expert observers. The field is where the ground has been cleaved, where epicenters are, and where the stations that respond to seismic action must be located. Indeed, they go to the field in service of population centers— not only Mexico City, anymore, but for the handful of cities who pay to sustain the Sistema Alerta Sísmica Mexicana. The places that they visit cannot be user communities, but are instead “station sites.” Difference is built into the network.[133]

CIRES teams might go on little trips in Mexico City or just outside of it to fix any number of mechanisms, but when they were said to go on field trips, they could only be going so far from the city that they could not return to their homes at night to sleep. Going to the field often means spending time in rural places with, in Mexico at least, poor, highly indigenous

[132] Politically adept historians of science at UNAM have carefully explained to me, lest my Spanish become ruder yet, I should not incorporate this into my vocabulary.
[133] The exception of Acapulco and Chilpancingo; both places that host field stations and are user communities—however, these are the two wealthiest and largest cities in Guerrero and their status as CIRES clients as well as field station sites is a separate matter.

populations. When “las provincias” can be taken to be to some extent synonymous with “the field,” it indicates certain things about the symbolic categories of Mexican territory.

On rural Mexico, anthropologist and voice of *indiginismo* Gabriel Bonfil Batalla has argued that cities are often places where what he calls the "imaginary Mexico" and its ideas flourish. "The city was the bastion of the colonial order. The invaders established their privileged space of dominion," (2004 [1987] :47) he writes, and it is this colonial order and its followers in the centers of power that have made the natives of Mexico a homogenized "indian," rather than a variety of different peoples (Ibid: 76).

I take his concerns are indicative of a necessary rebuke to an official post revolutionary discourse in which peasants were “ignorant, illiterate, traditional, of largely Indian origins, and economically backward because they lacked entrepreneurial spirit” (Nugent & Alonso 1994, 227). While I am uninterested in pursuing issues of authenticity here, the flattening of non-DF difference that Bonfil Batalla highlights is important; confronting difference in a nation where modernity and tradition carry heavy symbolic loads. Canclini García also explores these concepts in his work on the hybridity of the nation (1995). Though he has some trepidation about mapping modern or traditional ways of life cleanly onto to rural and urban spaces, writing that approaching "rural or inherited customs" and their resistance to urban customs as a concern of the sixties and seventies,[134] while he wanted " a more open way of thinking that includes the interactions and integrations among levels,

[134] While this may well be a move to position himself against, among others, Bonfil Batalla, who was an active participant in these discussions in the seventies and eighties, the latter scholar notes the rural in-migration to cities means that his traditional “Mexico profundo” is to be found in the very den of “imaginary Mexico.”

genres, and forms of collective sensibility" (1995, 9) that might consider how tradition and modernity and associated concepts and practices come to be at play, clash, and sometimes sustain each other.

Conceptually and ethnographically, then, rural and urban Mexico need not be opposed, but “las provincias” nonetheless reference a homogenized type place: indigenous, poor, rural, underdeveloped, and out of date, standing in opposition to Mexico City's white and mestizo, rich, urban, and developed modernity. Although other cities (Guadalajara, for example) are gaining power in Mexico's new digital industry, it is Mexico City whose cosmopolitanism is set off by the otherness of the rest of the nation, which is referred to in passing as, simply, Mexico. The pattern of central city coordinating “planetary system” of surrounding communities as a trading and power center has a long and varied history of Mesoamerica (Wolf 1959, 17), Mexico City's centrality has transcended functional and reached the status of another sort of world, subject to complex forms of economic and cultural exploitation that Rodolfo Stavenhagen called "internal colonialism" (1970, 257). The history of rural disenfranchisement, consolidation of urban power, and ultimately unsatisfactory agrarian reform in Mexico is a long one, older than the nation itself, and informs the vast inequalities in the distribution of wealth in the nation today (Assies 2005, Wolf 1969; Zamora et. al. 2004)

Mexico City is certainly a powerful site in the popular imaginary (Tenorio Trillo called it an "alive historical actor" in his 2013 history). Colloquially it is sometimes not just an actor, but a Monster. But rural Mexico also has charisma, and places around it have an otherness that scholars with their shifting tools are confronted with, a site of economic, cultural, social and political difference and change that Mexico City residents and foreign scholars alike seem to be constantly pulled to encounter and explain.[135]

Often my questions about training for fieldwork could not be answered. People were selected for teams based on capacities they had demonstrated in their other work, but many of the skills they needed to face the field could only be taught through direct experience with its challenges. The engineers and técnicos did not describe their encounters with each other in the field as exactly comfortable. “You literally sleep with them, wake up with them, eat with them, laugh with them, get angry with them…. you have to have tolerance," Pérez told me. He went on, though, "You begin to notice that it's like an extension of your family."

When these CIRES teams set out for the field, they are enacting an encounter with an other; with places significantly different (very different in ways that have come to be significant) from the ones they are accustomed to. The field was explained to me as place for education and team solidarity as people learned from each other to deal with the environments facilitating, incorporating, and troubling the stations that they needed to manage.

Access

"The first thing that we're confronted with in the field is access to the places in which we have equipment. Because there are places that are very hard to get to." Pérez explained in

[135] Albeit often incoherently, as Cynthia Hewitt de Alcantara demonstrates (1984).

one of our early conversations, framing the experience of field trips. He'd had plenty of opportunity to observe. It was certainly true that most field stories were punctuated with recitations of trouble reaching stations. Roads are shut for protests, they wash out, or are simply in bad condition, requiring slow and careful navigation. When locals are integrated into the maintenance of field stations, they can be impediments, too.

Field stations are positioned on hilltops, and accessing them, legally and safely, took a great deal of skill and experience. Field teams would not, normally, allow accessibility to figure into decision-making regarding station sites. Before they had trucks that could handle mountain roads, they had to hike; remote station sites were simply necessary to a functioning early warning system. Issues that confounded or enabled easy travel to the field station locations were nonetheless important aspects of narrations of the experience of going to the field, and, similarly, informed the choice of field workers, and the work they did there.

Many of roads that led from highways to rural communities and then up to stations were barely maintained if maintained at all. Access is difficult everywhere. Engineers and técnicos showed me photos of unpaved roads illustrate anecdotes about speed and mobility in the context of what Dalakoglou and Harvey have called the "paradigmatic material infrastructure of the twenty first century" (2012, 459). The roads they drive over were not always rocks, loose gravel or sand. Sometimes they are mud, water, and boulders.

I teased José, the team leader, about having trick driving skills that would not be out of place in Hollywood or a car commercial, but, indeed, he said, it was what he'd had to learn on the job. While there is not a great deal that CIRES's massive white Chevrolet trucks cannot handle, any presentation that the field teams give is liable to be punctuated by shots of them stopped by landslides or struggling up something that might have supported a whitewater rafting trip more easily than four wheels, no matter how well tuned.

The places that CIRES field teams drive to may not have electricity of functioning sewer systems, much less hotels, so field teams will stay in bigger towns or cities at night and then travel to two or three stations each day that they are out.

I never saw more than one or two photos illustrating social work that field teams do to get to those places. Siting was, after all, not just a matter of finding someplace geologically appropriate on a hilltop within reasonable distance of other stations. Access to the land had to be obtained legally, in line with local land laws.[136] This was a matter largely left in the hands of the young technicians and engineers who would be returning to these sites again and again as members of field teams.

The basic process of siting a station was the same everywhere: "Measure, get permission, try to get the connection to work in the right frequencies at that point." Sometimes this involved working with an earth scientist, which necessitates extra labor. After that's completed, José says, "the second process starts: one has to solicit permission."

[136] Which could vary significantly, especially on ejedal territory common in Oaxaca.

CIRES teams used to go out to potential field sites with people from Protection Civil, officials employed by the individual state agencies. They soon stopped that. They were better on their own. Protection Civil agents change from government to government, and what infrastructure or food subsidies are promised or begun under one administration are sure to be cancelled in the next. They've got a terrible reputation, and the CIRES engineers did not want to share it.

So without them, field teams would establish contact with local leaders, identify land owners, and make deals. That can take time and effort, too. People in some places have had bad experiences, and landowners or ejidatarios are resistant. Pérez recounted the experience of siting stations in communities in the Oaxaca mountains with long experiences of urban exploitation. "Everything that we're doing is for the City of Oaxaca." He would tell them "So it's not for your town, here, but perhaps one day you'll visit Oaxaca or have a kid that studies there, or another family member there. And for those people, who are in Oaxaca, this will be of service to them." He understood their hesitation, he told me.

CIRES might pay a small fee to soften a landowner or community's disposition. I was told that 18,000 pesos for the property or the "derecho de uso de suelo indeterminado," was not uncommon. The organization would often also fund a project to improve the relationship with locals: computers or projectors for classrooms or furniture for school administrators. In some places, they would or contract with a local official to keep an eye on the station. The engineers and técnicos I spoke with were straightforward about the extra pesos that they were given to facilitate friendly relationships, framing them as contributions and acts of good faith, though they understood that the money could also read as bribes.

Once a station is sited, field teams work with local contractors to pour concrete, erect the tower. But relations with communities did not end. Where someone on-site was left responsible for the field station, often they would keep the key, and for each maintenance visit, CIRES teams would then have to search them out before identifying themselves and showing ID before they could get access to the stations. This process can take hours.

Other communities renegotiate when stations are already in place, suddenly demanding monthly rent for access to a field station. "First the lana, the money, then you go up. If no, then you can't work." Jose had recently been told. He had not had it at the time, he was asked, but told me that a few thousand pesos was a relatively small amount in the scheme of things. The station in question was already sited, and it would have been no small thing to neglect a station. The system required that stations stay up and running. He got the funds from CIRES and brought it on his next visit, paying backlogged fees that had accrued as he did, maintaining a good working relationship to the extent that he could.

Field teams are trick drivers, ambassadors, negotiators. They are engineers first, doing what engineers need to do.[137] They are solving access problems so that they can set up and maintain stations. The material presence of these stations in complex environments offer

[137] As described in the chapter on measurement, this identity is no small thing and at CIRES involves focused orientation toward certain kinds of problem solving.

their own challenges for the production of a system which simply and reliably registers earth motion and alerts users to earthquakes.

Stations in the field

In early days of the Sistema Alerta Sísmica, the system failures which structured the development of effective field stations were do a diverse threats including: "power supplies, frequency shift in radios, radio interference, software errors, vandalism, and mechanical failures due to hurricane" (Espinosa Aranda et al. 1995). While the risk of earthquake informed the system's existence in general, field station design and procedures have been shaped by technical issues with equipment that was not yet fully known as well as external anthropogenic and environmental challenges that the field posed.

Field stations are sited in challenging conditions: along the coast of Guerrero and Michoacán, temperatures can range from the upper sixties Fahrenheit to the nineties year round, with high humidity and salt from the ocean. The mountains form a sort of barricade between tropical climates and places that can claim, at least, dry winters. Coastal storms blow in from the west every year in the summer and fall, and violent thunderstorms pour water and electrical charge on field stations. In these storms, lightning is drawn to the high metal towers which tie field stations on their hilltops to relay communication stations and, eventually, the central computer in CIRES headquarters.

Lightning strikes can cause serious electrical problems. Field stations run off batteries charged by small solar panels, and a power surge could mean a false alert or could disable a station. This kind of phenomena found its way into terse descriptions in conference papers and technical articles about system components because, in the early days of the Sistema Alerta Sísmica Mexicana, lightning strikes were a main cause of failures (Jimenez et al. 1993).

To the south, the Oaxaca mountains are inland and don't suffer the same storms, although the weather is much the same: tropical spaces out of which mountains rise to drier, higher ground. Stations there are subject to some of the same slow threats that those on the Pacific coast can be: Insects and animals can chew at wire casings, hives of bees or wasps can take up residence on solar panels, and moisture can foul electronics. Theft, too, has been an ongoing problem. The solar panels of the field stations are particularly attractive.

Some threats to the system are exotic even after years of this kind of work. In the Communications department office I saw photos of a four-year-old solar panel rusting completely away. It wasn’t near the coast, so the going theory was that the fumes from a cement factory nearby did it. It was an environmental hazard to the station, as surprising as it was.

Components tested in the laboratory might not work in the field for no real reason. Pérez told me that there had been times that he had taken equipment from the laboratory "seen it put together, transformed, prepared, and then you get there to install it and it doesn't work. So you try the card, you try it and it's good, but it's missing something, it wasn't double checked…" He brought his coworkers into the story, getting theatrical. "And who's testing these cards? Daniél! " Daniél, passing by, laughed.

"Everyone participates." Pérez continued. "It's a shared responsibility, though. Everyone's involved."

Encounters with all these factors that led to a seasonal and regular maintenance schedule of 3-4 visits per year, including visits in the wake of significant earthquakes to collect data from the memory of the device. In each, the young men in teams from Mexico City move out to the field and back before and after rainy seasons to prepare stations for violent weather and to fix any problems before they get bad enough to impact system up-time and a practice of checking and rechecking equipment.

Stations "have been designed for low-impact damage due to adverse climate and lightning. All systems operate in an inert atmosphere to avoid corrosion failures" CIRES engineers summarized in a system report (Espinosa Aranda et al. 2009, 696). The design of field stations themselves has changed over the years, in response to encounters with environmental hazards. It become airtight, for one thing, and solar panels became smaller and more subtle. They run on as little power as is possible, lengthening the life of components and reducing the need for the kind of showy photovoltaic cells attractive to thieves.

Field stations are as sealed off from the environments into which they are set as sensory and communications systems can be. They are insulated to their surroundings, physical and social. Some corrosion they cannot hide from—it happens as the steel fastenings become-with sea salt or cementería fumes in the breeze—but the functioning computers that make the systems work are protected in bubbles of gas, sensible only to energy from their batteries, check-in requests from the cerebro in Mexico City, and the earth motion on which they run algorithmic processes. Lightning still strikes but the stations have been reworked so that their components cannot be transformed by electrical charge or, for that matter, the desperate power or monetary needs of locals who might put a photo voltaic cell to use or sell.

Even with all these precautions and designed protections, unanticipatable errors are still understood to be possible— and these could not just mean that one station goes out of service, but could also entail the generation of false seismic readings of the sort that could threaten system reputation. In light of this kind of hazard, protocol dictates that any earth motion that a station reports must be confirmed another field station. While a station's integration into the environment of the field (and vice versa) is minimized, its integration into the sensory system of multiple stations is maximized. A field station functions in concert with other field stations, and while each is sited and maintained carefully in light of the conditions around it, it is only with others in its network that it functions.

In the field, everyone works. Daniél, hanging around after Pérez had drawn him into our interview, told me that sometimes he would be up a tower working in horrible wind and rain and he would ask himself what the hell he was doing there. "I could be in my house, watching TV… what am I doing here?" But then, he said, he would realize that he was working for a common goal, "as big as the seismic stations."

The kinds of environment that field teams encounter as they service stations is not to be understood, exactly, as part and parcel of seismic phenomena so much as threats to network detection of seismic phenomena. Earthquakes here are not approached as part of a "commotion," as Conevery Valencius notes they were in early 19th century US (2012), nor a factor in animal behavior as in contemporary international fascination and traditional Japanese theory (Clancey 2006). They are not taken as part of the same meteorological systems as the weather as in Aristotle's *Meterologica*, the work of many of his ancient Greek contemporaries (or even the outsider science of the well-interviewed Mexican Gabriel Curiel Flores).[138]

Certainly the folds of mountains in Guerrero, formed at a tectonic interface and with ongoing pressure, might be understood to have formed the coastal curve that figures the push of winds, the channels of air currents and pressure makes violent summer storms possible and creates conditions for both quakes and the seeping salty damp that corrodes equipment, and even offers little affordances for urban centers (Wolf 1959);[139] these complex geophysical and economic geographies are not, however, integrated wholesale

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138 See his blog "Predicción Cientifica de Terremotos" particularly a letter to a meeting at CENAPRED and another to Mexican president Peña Nieto, published in August of 2012. Also, for an indication of the substantial response to this work, see Sanchez 2011 Cuervas 2013.
139 More citations here, I think, to indicate how scientists might cast the geophysical dynamics of such an environment.

into the kind of work that field teams do, or the environments that they encounter. They are not scientists, expanding models or building theory.[140] Their presence in the field is predicated on the project of early warning, not on research, and other hazards they encounter are confounding factors which demand the replacement of parts and design changes, their ability to do their jobs.

Like everyone else, I ate up the stories of the field with their dangers, solidarities, and purpose. While the teams turned stations glowing red on the map to bright green, they were having complex encounters with environments very different from that in which CIRES headquarters was comfortably situated, and like everyone else, I used the stories that field teams produced them to understand what environmental features might be significant to the Sistema Alerta Sísmica Mexicana's extension and to make sense of Mexican territory in terms of the particular problems stations encounter.

By and large, the stories that we heard at headquarters involved thorough engagements with rust, mud, or storms, and were offered up photos of the problem and solution arrived at. They could be managed, evidence could be collected for systematic understanding of the challenge, and perhaps some strategy for preventing future trouble could be integrated into the design of the stations or of system-wide maintenance practices. Some the encounters that characterized field work, though, could not be known so directly, or recorded so clearly.

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[140] CIRES engineers define scientists strategically through their approach to data and theory and their lack of focus on problem solving, see the chapter on measurement.

Hostile Territories

The fall of 2014, my fieldwork, and, indeed, sense of rural Mexico was heavily inflected by a story that had not emerged from work on Sistema Alerta Sísmica Mexicana field stations, but resonated frighteningly with what field teams had been telling me. 43 "Normalistas," students in training to become rural teachers at the highly selective and activism-oriented Ayotzinapa Normal School, had gone missing in Guerrero state on September 26. They had been headed to Mexico City to commemorate the Tlatelolco Massacres with thousands of others there. They had entered Iguala, a city of something like 110,000 in northern Guerrero. They had somehow been involved in an attack by scores of uniformed municipal police and masked men which had resulted in the injuries of twenty and deaths of six others. And they had not left, or at least, no reliable evidence of their exit could be found aside from the mutilated body of one of their compatriots, marked in ways distinctive to assignations performed by groups which have been called organized criminals, cartels, gangs, militias, or simply narcos.

The responsibility for their disappearance was laid at the feet of a local mayor and his wife (she was hosting an event that night), municipal and federal police, a locally-stationed Mexican Army battalion, and Guerreros Unidos, a violent narco group whose leader is said to be the brother of the mayor's wife. The search for their bodies churned up many corpses that are themselves unidentified, highlighting the violent and unstable underworld that has, in a great many other places that CIRES field stations have been erected, become integrated into structures of power.

As the news about the missing Normalistas began to accumulate in national and international news venues, with half-guessed connections and emerging incongruities, escaped mayors, mistaken identities, unaccounted for army participation, and bodies that remained frustratingly absent for months,[141] it seemed as if it was another nation that was being reported on.

While my informants were saddened they were not, I think, surprised. Sometimes, through a sort of triangulation of rumor and news, the stations don't quickly flip from the red of "out of service" to green of "active" on the massive digital maps around them. Sometimes CIRES teams manage sensation by staying away from damaged stations so as not to be caught up and made, themselves, a kind of evidence.

One field station was out of commission for many of the months I spent visiting CIRES headquarters. Situated in some of the most violent space of Caballeros Templarios cartel and various subsidiary groups and self-defense organizations was unresponsive to the Sistema Alerta Sísmica's check-in protocol throughout 2014. Despite this constant reminder, despite the priorities of CIRES, field teams have not gone to fix it. Center directors deemed it simply too dangerous. They did not explain it with mapped death tolls, but with evidence—what field teams had seen, or thought they had seen, in these spaces, coupled with confused news reports and rumor.

[141] The ongoing permutations of this gruesome and confounding case are detailed perhaps most cogently in English series of pieces in the New Yorker by Francisco Goldman (including Goldman 2014), as well as reporting by John Gibler (2015).

They talk about encountering trucks of armed militants and being struck with both confusion and certain, terrifying knowledge: "you realize that your family is at home, your dad, your mom, your brother, and you realize that in a second you can lose all that, right?" one young man said. "Being committed to your work, it carries other risks that you might not see until they happens to you."

The crucial thing about the stories that CIRES teams brought back from the field about these hazards is how curtailed the encounters were compared to those they had with other hazards in the field. They seemed less like engagements with hazards than glances-off, turnings-away. Someone saw a truck full of men with guns. Someone saw a landing strip in the middle of nowhere. They had glimpses of danger, and when they identified it, field teams moved away quickly. More intimate experiences were foreclosed through quick thinking.

There is a tension here, as the topographic work that field teams and engineers at CIRES do to manage the effects of the more-than-seismic environment on the Sistema Alerta Sísmica Mexicana all depend on evidence. That is, in order for the system to allow users to experience earthquakes in new ways and consider alerts reliable, CIRES engineers manage earthquake sensation. They document access challenges, fees paid to landowners, and the effects of various environmental conditions on the stations themselves and work hard to consider these in design and maintenance while making them functionally invisible to users. Field teams even document station conditions and their own repair work with photographs so that engineers in CIRES headquarters can better understand how the stations are fairing and make design changes to the stations and maintenance practices if necessary. However, when it comes to this kind of danger, evidence is the last thing anyone wants to collect. They hope to minimize the impact of violence to the homogenous function of the Sistema Alerta Sísmica Mexicana, but they do not investigate it in the same systematic ways that they might inquire into land use or corrosion, or take photographic proof home. Here, the management of sensation means managing the ways that the field teams themselves can be detected by certain people and organizations.

The rural Mexican spaces that field teams move through are marked by shifting, increasingly dangerous social relations that bear thinking about not just as a site of criminality but as a new and particularly gruesome form of governance. These become, in stories, just-dodged danger, and encounters with “La realidad de nuestra país”; "the reality of our country”; a truth the size of which could be suggested by even short encounters, but the details of which they hoped to escape.

Indirect encounters

Organized criminal groups have become increasingly and publicly violent in the past fifteen years,[142] spectacular in their claims to space[143] as they leave grotesquely mutilated bodies of some victims to be found. They have also become increasingly integrated into rural

[142] In 2000, Mexican president Vicente Fox responded to increasingly public internecine battles to make the Arellano Felix Organization a law enforcement target.
[143] Goldstein defines this kind of spectacular display as a “visually arresting and attention-getting” (2004, 3) and an “instrument for cultivating inclusion through establishing control of … space by parties both authorized and insurgent” (2004, 4).

economic life and formal structures of power.[144] Guerrero and Michoacán are among the states in which these groups have made themselves most evident, and the necessity of managing encounters there have become essential for engineers, technicians, and anthropologists involved in the Sistema Alerta Sísmica Mexicana. Guerrero and Michoacán happen to be over a particularly active and violent tectonic plate interface, which has had serious effects for Mexico City before and has been watched for years as the probable origin of the next massive earthquake that the nation will suffer. And the danger that those hazards present— to field teams, to vulnerable populations they can protect and those they can't— unfold in very different ways.

By the time of my fieldwork, where once there was the Guadalajara cartel, and then Sinaloa, Juarez and the Arellano Felix Organization, now there were Juarez Zetas to the north and east of the nation, Cartel del Golfo in small pockets, Cartel de Sinaloa all around, Cartel de los Beltran Leyva switching affiliations from Sinaloa to Zeta and splintering. Maps in news outlets told me one thing and another. Where La Familia had dominated Michoacán and Guadalajara, they were now splitting into the Caballeros Templarios and other, less known groups.

The Guerreros Unidos were a splinter group of Beltran Leyva, as were Los Rojos, the group they mistook two busses of students for in late September 2014 when they attacked (see Crowley 2014, InSight Crime 2015) Self defense leagues had sprung up by the score (see Asfura-Heim and Espach 2013). They could be violent, too, and their tactics

[144] so much so that Barrios 2015 suggests discussing narcosovereignty rather than organized crime, as this power not only maps to territory but has its own distinct spectacle of enforcement.

indistinguishable from those of narcos themselves. So these were Mexican rural spaces: variously the territory of mafias, cartels, narcos, gangs, splinter groups, enforcers, or self-defense squads. Some of these titles contradicted others, but knowledge of these groups was always partial, and they themselves disintegrate and transform with a regularity which makes firm knowledge, much less clear mapping of influence, much more difficult than mapping seismic influence and or observing environmental effects in the field.

In the years since Calderón declared an overt and militarized war on narcos in 2006, organized crime around narco and paramilitary groups have proliferated in rural Mexico, and when the Peña Nieto regime opted not to continue that war by such direct means, the violence did not precisely end. That drug war and its ongoing effects has cost over 85,000 lives (Human Rights Watch 2013), though the number is sometimes given as high as 100,000. In this this new moment, organized crime has become entangled into not only in rural economies but also structures of formal governance in complex ways, as Trejo (2016) has documented. These groups not only provide rural jobs, but they back candidates, collect taxes, enforce order.

While death rates have reportedly fallen since Peña Nieto took office in 2012 and ended the war, disappearances are still high, and their operations are distinctively showy and callus, often using bodies to make their presence and will known: decapitations, mutilations, often left in highly visible places as well as kidnappings for ransom, disappearances, and comparatively simple murder. Ongoing failure to identify bodies of the missing 43

Normalistas and the easy escape of “el Chapo,” a Sinaloa leader, has made it clear that the Mexican state's knowledge of narco activities is dangerously partial, too.

The risks in the field, then, had the power to do more than surprise CIRES teams. In Jalisco, one engineer told me, "we were exploring and accidentally came upon a hidden narco landing strip." They fled. There were many things like this, he explained, in which he and his team simply didn't know either "exactly what we were getting into and with whom we were getting into it."

CIRES officials made decisions about going to fix stations or leaving others be by trial and error. "There’s no manual, no guide that can tell you, here it will be like this or here it will be like that." CIRES station protocol was developed to take evidence into account—and not just evidence that appears obvious to field teams, but rather evidence rendered to people who have not been to the field or seen the stations, people who stay in Mexico City headquarters and consider the network as a whole. The system had not expanded by heeding pushback, and there was simply no real form to give it besides trial and error. Some plans for stations had indeed been discarded, but only when field teams went to stations to see narcos disguised as soldiers at army checkpoints, who stopped, threatened and questioned them. Others had been discarded when community members told them about terrible exploitation, robberies, kidnappings and murders that they suffered. "This is how we indirectly realize how things are," he said. Field teams pass those realizations on to each other and to the engineers at CIRES, but not with the kind of evidence that they could put in a field guide or manual for negotiating other environmental challenges.

Part of a violent environment

Somewhere in the Mexican sierra, within the borders of Michoacán or Guerrero or both, there are radio towers stretching up to sky painted red and white. Behind chainlink fences, they boast tiny photo voltaic panels and sit on concrete bases with inset locked metal boxes filled with instruments. None of the keys that field teams carry are likely to work, nor do CIRES trucks carry replacements for their contents. They are on hilltops, a fair distance from rural towns but within range of some sort of access roads, if only the kind of dirt tracks that high powered trucks and hikers can manage.

They are very like the seismic sensing field stations that CIRES has had built across Mexico, matching in color and in details of composition that they pass. The boxes are placed just so, the towers painted carefully. But they are not Sistema Alerta Sísmica Mexicana stations.

These stations are good replicas, as far as anyone could tell me, though the boxes that should open are welded shut. Instead of seismic sensory works inside they are set up (and one assumes maintained) with communication equipment—to facilitate communication between members of organized crime or paramilitary groups in the mountains, where there are no cell towers to be found.

José explained that he was giving a talk for community members at the Infrenillo station when someone asked his team to demonstrate station maintenance routines. They did, gamely, opening up the fence and then the locked metal box of seismic sensory equipment to show off the circuit boards that CIRES builds in its Mexico City offices. When locals saw the equipment, he says, they were surprised. It was different it was from what they had seen elsewhere, they told him, when an army sergeant had found something like it in the mountains and leveled it with dynamite. Out of the rubble of this destroyed station had come very different batteries and transmission equipment.

"That’s how we knew," he said, "that those guys were cloning our field stations."

José calls the copy-cat stations clones, and assumes they are narco in origin— a safe assumption based on the evidence available. His name for them resonates with science fiction uncertainties about identity; about origin, and about capacity (though as scholar Sarah Franklin noted in her 2007 book, clones are so much more than that). They are copies of CIRES field stations, certainly, but they are more than that. Where they come from cannot be precisely known, at least not safely. What kinds of system they might be part of, or what kinds of work they might have been developed for, is similarly impossible to get any real information about. Further, they are "transformational elements" just as Dolly the Sheep was (Franklin 2007, 4). They mean something about the environment that José and his coworkers try to manage with respect to the Sistema Alerta Sísmica Mexicana. They make the parts that they cannot sense in the normal way, that is, the places that they cannot go to check and maintain things and cannot get seismic sensory data if a station fails, available, in some way, to understanding.

The tower found by the army in Michoacán came down. Others, he is sure, are still out in the mountains, responding to a complex of seismic and social hazards by becoming a sort of semiotic parasite (as in Kockelman 2010) on the official image of the CIRES field stations. Here, the field stations that CIRES engineers and técnicos are treated as a part of rural Mexico; one that can offer camouflage and may go unnoticed by authorities or rivals. Even though they are set up to sense and resist becoming with the corrosive air, economic struggles, and lightning strikes, field stations and CIRES presence are productively integrated into the environments they occupy.

And this is not just a play on the meaning of the field station and its integration into a welter of external systems that CIRES engineers try to take one challenge at a time. The work of mounting cloned stations is just as real as that of siting and maintaining seismic sensory stations, and José had heard from former contractors, engineers and architects, who had been contacted and asked for quotes on making stations just like Sistema Alerta Sísmica in the mountains. His teams have found stations torn open as if by a storm and evidence that someone had taken measurements of the equipment inside.

The violent environment is sensing right back at them. This is not a risk that is calculated, like the statistical likelihood of a major earthquake originating from one area or another in the next years could be calculated. Managing sensation in the more-than-seismic environment has meant more than attention to what is and is not to have effects in the Sistema Alerta Sísmica Mexicana by registering and parsing seismicity or maintaining stations in good working order, but about reckoning with the ways in which the system and the field teams who maintain it might, themselves, be detected and involved in the projects of others. For all their work to manage its effects and flatten changing conditions into a topographic network for seismic sensory conditions, field teams and the stations they manage remain in the thick of hazards that are sensible, and sensing, in other ways.

Conclusion

Trucks just back from the field were often spotted with mud. They might have bright rain jackets hanging from their rearview mirrors. Sometimes hiking boots and even socks were spread in the sunlight, too, drying. After a dozen days in driving from station to station repairing and replacing and negotiating the sites of others, the field teams would put their equipment away, report to their supervisors, their coworkers, and me.

“Where were you this time?” I could ask the men as they unpacked equipment. They were not on a timetable at the end of a field trip in the same way they were when setting out.

“In a cyclone, nearby and then in the Yucatán all weekend. It was raining when we arrived and raining when we left.” Pérez told me once, pausing to talk and gesturing at the man who was helping him bring equipment back into the building from the truck. “But maybe he was just dreaming of cyclones. He slept all the way there and back.” I laughed and so did they, the evidence of the fierceness of the storm harder to perceive in the yellow Mexico

City sun than it had been for them when they were avoiding wrong turns rain-blind in the territory of a cartel, navigating up sliding dirt roads, or with damp fingers fumbling wires.

Soon someone would have scrubbed the trucks clean and fixed what they could. In an organization full of electrical engineers, broken tail lights did not stay broken very long. Regardless of what had knocked a wire loose, dirtied the paint, broke an axel, or cracked a windshield, the evidence of its impact was erased from the trucks. Their causes, however, could have ongoing effects for the ways that engineers and technicians approached fieldwork, and for the system that they worked on.

The maintenance of the Sistema Alerta Sísmica Mexicana's network of field stations that they participate in serves to make the system constant, simple, a sort of infrastructure for the transfer of information about moderate or large earthquakes. But this is not how the system is discussed at CIRES, where the complexity of the more-than-seismic environment has to be managed in order for clear and consistent alerting to be possible.

The CIRES engineers who stay in headquarters and the fieldworkers who go out to service stations made their interactions with this network and, for that matter, with user community governments, users, and Mexican territories sensible to me just as they made earthquakes sensible to users. Seismicity and other environmental conditions are deeply challenging, and the Sistema Alerta Sísmica Mexicana is not quite simplified enough that any user community will be alerted in advance of any earthquake that shakes it. With various kinds of sensory encounters, they work to make it simple *enough* to function as a seismic sensory network—that is, a h topography of technological network and territory, tectonic plates, mountains, provincias with their problems, cities, officials, and technologies; all traceable with reference to ever-present screens bearing glowing maps, as well as reports, photos, and stories. All these are caught up in their efforts to manage the effects of more-than-seismic environments, into the welter of which their work on seismic instability brings them.

Chapter 5

DISASTER PREVENTION AND THE MEXICAN SECURITY APPARATUS

As September approached in 2014, the CIRES Research and Outreach department began to put together materials to address the 1985 earthquake that ripped inland from the Cocos subduction zone in 1985, bigger than anything else on record for Mexico City. The anniversary of the disaster on the 19th of the month called for blog posts and a swell of outreach about history and the stakes of seismic safety. Their careful efforts articulated the environmental system models that inform disaster prevention today.

Government authority, legal institutions, built environments, and residents were unprepared for earth motion of that intensity, and the team at the NGO prepared blog posts and pamphlets to address its effects on all of them, in detail and with simple examples for ready public consumption. They developed a list at a meeting a month in advance of the anniversary of the quake and wrote it up in marker on the white dry-erase board in their little office: alongside more usual information on the soil of Mexico City area, on how earthquakes happen, what to do in case of a quake, and the technologies that support or interface with the Sistema Alerta Sísmica Mexicana that CIRES endorsed, on other CIRES projects, their September blog and Facebook posts would cover damages incurred in US dollars, lives lost, numbers of bodies and buildings harmed. They would explain emergency action, the risks that earthquakes pose, and give some sense of how they thought seismic energy should be measured. They would detail, furthermore, the ways that this disastrous event had provided motivation for a radical and intentional restructuring of the Mexican security apparatus, and called into being new institutions charged with conducting the everyday physical safety of the population—or rather, conducting the ordinary conduct of Mexican citizens through new institutions. They would explicitly describe how this restructuring still centralized of Mexican power and knowledge about disaster prevention but now figured "culture"— that is, ordinary practice— a key site for state intervention, as well as an explanation for the failures of those projects.

The six members of the Research and Outreach department joked, not un-bitterly, about how reports of the number of lives lost in 1985 remains unstable. It has been revised downward, by various sources, from an early 35,000 to 5,000 official documented deaths. Graciela Campos, a computer engineer, suggested that next year the state might suggest that no lives were lost at all.[145] A coworker outdid her, explaining that they would hear soon that nothing had happened at all, and that the institutions still around today could credit their existence, not to the earthquake, but, like UFOs and ghost sightings, to nothing but "swamp gas."

Whatever estimates the next years hold, the effects of that massive quake entailed significant death and destruction as well as transformations in political structures and institutions. The quake informed the very existence of the organization the Research and Outreach team worked for, so they added to that to the list of things they would blog about: deaths, injuries, damages, the outcomes of elections, new state and NGO organizations.

[145] The team did not, suffice it to say, circulate the state-sanctioned number.

They brainstormed books on the earthquake that they might recommend to readers, listing testimonios and pieces on remembrance like journalist Elena Poniatowska's famous *Nada, Nadie.*[146]

Campos suggested adding regulatory reform to the list. "OK, well, we have construction regulation now… " she offered— but no. Armando Cuéllar, trained in structural engineering, clarified. That wasn't quite the right way to put it. Regulation had existed before, and good regulation, developed for the worst seismic activity that had been predicted for the Mexico City. It had simply been insufficient to the magnitude 8.1 earthquake that shook Mexico City on September 19, 1985. The quake and its impacts had unsettled accepted knowledge and made it necessary to reconsider earthquakes themselves and regulation around them. Its very existence provided new information about seismicity, and the complexes of administration, research, regulation, and practice that were developed in its wake made it possible to develop and mobilize new kinds of knowledge about such hazards.

The 1985 earthquake is generally understood to have produced important effects in many different areas of life, even if popular understandings of their scope differ. Campos's first articulation of regulatory action echoed others I heard in Mexico City from members of the and people who simply lived with the possibility of quakes and in the context of the organizational and political effects of the 1985 disaster: there had not been regulation before 1985, and now either it still doesn't exist, finally exists, or has been reformed, and

[146] Published 1988 in Spanish and widely circulated in Mexico and outside of it, described in more depth in the first chapter.

(regardless) somehow is not practiced sufficiently, either through a paucity of enforcement, out-and-out corruption, general ignorance, or a concatenation of the three.

The meaningful seismic instabilities that Mexicans experience happen in the context of ideas about how to limit the negative effects which have been built into and contested through technoscientific expertise, for all that the priorities and practices which inform disaster prevention efforts are not entirely stabilized. Throughout the bulk of this dissertation, I have focused on the politics of knowledge entangled and entailed in emergencies, environments, and even forms of measurement as earthquake early warning technologies make new kinds of encounters with the unstable earth possible. In this chapter, I will focus on the policy setting in which these efforts have been taking place; highlighting the practices and ideas regarding complex systems in which hazardous environments are not the only elements and making changes in the social world can prevent disaster.

The 1985 quake did quite clearly transform Mexican federal governance and local practice in Mexico City. The leadership of Mexico City became a separate democratically-elected office,[147] the reigning PRI lost its hold on lost the presidency.[148] More pertinently to earthquake safety, a National Protección Civil agency was developed, manifesting complex ideas about disaster prevention and risk management that had been circulating in international expert communities. Through it, new annual emergency recovery funds were

[147] For one delightful description of how this national drama played out with masked wrestlers, see Levi 2008.
[148] As described in the first chapter.

created. Through it, structural engineering regulations were transformed in Mexico City and, consequently,[149] around the nation. Research networks were funded, sometimes with Protección Civil's support, and earthquake drills sprung up, often with that new system's coordination. A Sistema Alerta Sísmica for Mexico City was funded, too, alongside it, and eventually expanded. But for all that, and as much as the effect of the disaster on extant political structures has made ongoing attention to earthquake disaster prevention, or at least risk management, a real political priority shadowed by real consequences, the ongoing effects of these reforms: restructurings and novelties uncertainly integrated into power structures and the daily experience of experts and members of a general public alike. In the lived world that disaster prevention efforts have been designed to organize, they are multiple, partial, inconsistent.

In disaster prevention work, politics of knowledge are enacted around state institutions and their intervention. After Foucault, I consider these ongoing, concerted efforts to perform public disaster prevention to be a matter of security. In his lectures on Security, Territory, and Population, Foucault defines security, writing "...security...tries to work within reality, by getting the components of reality to work in relation to each other, thanks to and through a series of analyses and specific arrangements" (2009, 47). Security, then, deals with "possible events;…the temporal and the uncertain, which have to be inserted within a given space; the space in which a series of uncertain elements unfold" (2009, 20). State efforts to attend to these events; to minimize the uncertainty of them as much as possible and intervene upon them in ways which might be effective regardless, have

[149] As other cities borrow its structural engineering regulation without regard to its actual material pertinence (a common practice)

involved efforts to conjure a national, integrated security apparatus of institutions, regulations, practices, and material conditions.

The 1985 quake comes to be remembered in institutional efforts to make components of reality, from state agencies to everyday practices, to work in relation to each other in light of the violent earthquakes that are possible. I seek here to highlight the complex of long-term integrated institutional and conceptual work that flourished in the wake of the earthquake, still motivated by the disastrous legacy of 1985 and the futures that such violent upheaval suggested, which frame the conditions of the Sistema Alerta Sísmica Mexicana and other ongoing work with unpredictable earthquakes large and small. This work has involved concerted efforts on the part of many members of the to make functional connections between state and policy structures and the practices and conditions experienced by Mexicans in their daily lives; that is, to make Mexico's post-1985 security apparatus effective for disaster prevention.

A security apparatus is a matter of epistemological, material, and administrative elements and agents working in coordination. Foucault and others have noted the power that danger can have to effect governmentality, and find state power a place in daily life.[150] In the lectures which came to be his work on bio-power, Foucault considered danger to be a key mechanism of the enactment of power. As he put it:

[150] In Agamben's state of exception, for example, a moment of emergency can lead to a "temporary suspension of the rule of law on the basis of a factual state of danger… given a permanent spatial arrangement, which as such nevertheless remains outside the normal order" (Agamben, 1998, 96)

Individuals are constantly exposed to danger, or rather, they are conditioned to experience their situation, their life, their present, and their future as containing danger…. In short, everywhere you see this stimulation of the fear of danger, which is, as it were, the condition, the internal psychological and cultural correlate of liberalism (2008, 66-67).

While danger (or the perception of it) has been important for bringing into alignment new and powerful ensembles of technologies, agents, materials, and practices,[151] the integrated security apparatus that Protección Civil is designed to conjure is far from simple. Certainly, large-scale coordinated systems[152] can make possible vast integrated configurations of power and sometimes violence[153] in the intimate life of ordinary people. Joseph Masco, for example, describes ways in which "the counterterror state, like the countercommunist state before it, attempts to install through domestic affective recruitments a new perception of everyday life that is unassailable" (2014, 7). Vivian Choi has, in fact, described how an early warning system like the one I discuss in this dissertation is integrated into a complex of what she calls the anticipatory state politics of Sri Lanka, setting its futures in the context of rationalities which inform other work (Choi 2015). However, in the face of that coordination, the trouble of what Masco calls "attempts" at installing a new perception of everyday life can be allowed to take an analytic back seat.

[151] Agamben's begins with some event that occasions temporary state action while Foucault's is simply ongoing, a conditioned experience.
[152] As Stephen Collier points out, Foucault gives us the tools to think through a "system of correlations" and "heterogenous ensembles" (2009)
[153] Masco 2008, Davis 2007, Pain and Smith 2008, Anderson 2010, Masco 2014, Fassin and Pandolfi 2010, Massumi 2005.

In the two sections of this chapter which follow, I seek to give an account of an unstable and only partially integrated Mexican disaster prevention efforts in which earthquake early warning is only one project among many. I describe how Mexican disaster prevention efforts were transformed by an earthquake in 1985 and subsequent institutional interventions were made to orient to the kinds of ongoing danger that earthquakes are understood to pose, considering, as I do so, not just the coordination of a security apparatus, but the contingency and trouble that define this coordination. In the first section, I discuss the National System of Protección Civil, an institution which has been developed since 1985 to conduct Mexican disaster prevention and risk management efforts. In the second section, I consider the interventions into everyday life that this institution and associated projects and practices rely upon.

This chapter addresses the Mexican security apparatus, but it is not just a Mexican story. The models of intervention used here draw on and implicate international disaster prevention work. As "disaster" is defined in terms of a hazard's impact on the social world, disaster prevention strategies have come to figure social practice as a key site for attention. When enacted in concert with politics of knowledge which locates relevant technoscientific expertise for disaster prevention at a center of power like Mexico City, "culture" becomes not just a way of thinking about vulnerabilities and resiliencies that can be intervened upon (a role it often plays in such contexts), but also, finally, necessary explanation for the failure of these interventions.

Institutions

The library of Mexico's National Center for Disaster Prevention, called CENAPRED, is small but robust with policy reports, scientific papers, outreach materials, games, maps, guides, pamphlets, and conference proceedings. Some material is bound. Some is photocopied. Most is in Spanish, though some is not. There are reports on seismicity, commentary, collected volumes, conference proceedings, and eye-catching ephemera in the little library's catalogue. They were authored by assorted agencies, produced in house, or accumulated, slowly, through meetings and events, reports and committees. The number of documents was astonishing to me, profligate, and they are significant not just in their content but in their profusion. This was especially the case when their number was set against the relative emptiness of the library users' office. This I shared, from time to time, with university students completing the public service requirement for graduation by laboring at one internal CENAPRED project or another. If there was an archive fever to be diagnosed (aside from my own eagerness to find in its collection materials a narrative order around the security apparatus of post-85 Protección Civil) it was for producing, storing and stocking material, for sequential accumulation, and the authority and power that such a stock suggests and locates in CENEPRED headquarters in the south of Mexico City, near the UNAM campus.[154]

[154] Derrida indicates that an archive (or, rather, the Greek notion of *Arkhē*) might be understood to contain two "orders of order" which he calls sequential and jussive; commencement and commandment. These signal, respectively, an emphasis on origins and beginnings (from which, one assumes, the archive grows, and which its materials illuminate) and authority (which the archive, right or wrong, gives to its users and its keepers) (1995, 1). See also Bowker 2005.

My encounters with texts there were also encounters with the intellectual heritage that disaster prevention draws on explicitly—some of them cultural ecologies or cybernetic models of environmental relations between social, material, and technical elements. Knowledge about them was assembled in centralized archives in ways that seemed to resonate with my own sometimes giddily acquisitive ideas of archive and archiving (as in Bowker 2005). This centralization articulated a Mexican politics of knowledge that sited authority (and interventions to govern complex systems) in Mexico City institutions and technoscientific expertise.

The accumulation of these archives had to be understood in the context of the social relations that such highly centralized authority entailed. Much of CENAPRED's collection does not exist in other collections, or if they do, the overlap is a chance of biography.[155] I found a report on from the early meetings on the development of the Sistema Alerta Sísmica elsewhere, but likely only because it followed participants in the meetings back to their home institutions. Some masters theses written in the 1970s by members of what I have called the "seismic community"—the loosely affiliated group of experts concerned with disaster prevention— were there, as well as filed away in their home departments and, presumably, somewhere in the collections of their now-established authors for no reason that was immediately transparent to me. Some collections written on the 1985 earthquake were in the library at the prestigious Universidad Iberoamericana to the south of the city, nestled in their collection of publications commenting on the state of engineering. I found the most recent versions of CENAPRED's public education pamphlets,

[155] Perhaps "chance" is the wrong word here: what's indicated is the tight and small network of the Mexican elite drawn into the seismic community, and the kinds of institutional work that they do.

slick paper and bright colors, at Protección Civil offices I visited in far to the south in Oaxaca City and in Chilpancingo, the capital of Guerrero State, too.[156]

These last collections, though, were not properly archives at all. They were sites of distribution, primary avenues for these materials to circulate.[157] For this reason, the key questions about "who knows the…archives and who has a right to write about that history and who does not," that Stoler articulated around colonial and post colonial worldings (2011, 138) might here be necessarily transformed and reimagined. Such questions about power and knowledge in CENEPRED and related archives would need to address who has a right to try to ascertain the action and effects of so-called natural hazard, to determine correct emergency response and recovery action, and to produce, disseminate, and accumulate materials about all of it.

Librarians explained that the collection was much informed by material that the scientists and policy makers in the building wanted off of their desks but could not quite throw away. Many of the documents I requested, flipped through, and scanned showed no evidence of having been touched but anyone but the careful librarians in the last years; certainly the little cards that I was instructed to write my name upon were often both aged and

[156] Average budget of MX $700.000 since the early 2000s for educational materials targeting rural population and school children; that is, practical information about structural vulnerability assessment, about making family plans for evacuation, and damage assessment, and reconstruction. (Organisation for Economic Co-operation and Development 2013, 111).
[157] The Organisation for Economic Co-operation and Development report of 2013 confirms what I saw: funding went to production of materials, and their distribution was often done ad hoc (see Organisation for Economic Co-operation and Development 2013, 111).

unmarked. The materials to which they were stuck had mostly been produced by recognized technical experts in conjunction with university or state support.

CENAPRED was, itself, built by the Mexican federal government with assistance from the Japanese in the wake of the 1985 earthquake, part of the slow effort to develop a wholly new national system for attending to hazards in such a way that inevitable earthquakes (and, eventually, volcanoes, chemical spills, fires, droughts, and severe storms) do minimal harm to people, and the various systems upon which their livelihoods depend.

In its goals, organizational structure, and even its name, CENAPRED reflects an orientation toward the conditions of disasters that informed many of the organizations that were developed alongside it. The concept of "prevention of disasters" for which it is named articulates an onto epistemic division between simple "hazards" and the "disasters" they might cause in the social world as it makes similar different kinds of dangerous events experienced by different people.[158] Technically sited on university land, the institutional labor undertaken at and through CENAPRED straddles academic and policy work. Its researchers and functionaries, as early documentation suggests “study the technical aspects of disaster prevention” (CENAPRED 1990), and develop and review policies with reference to their findings. Their work entangled projects as diverse as the production of a national risk atlas, the evaluation of the load bearing capabilities of new materials, and the development of structural regulations, and was, more to the point, involved in risk

[158] About the development of this division in Mexican policy, more shortly. On its functionalist corollaries, see the chapter on emergencies.

assessments, planning interventions, rendering effects of hazards, and considering recovery work.

In order to visit the CENAPRED library, I first needed to check in with armed guards at a desk that changed color with the changing presidential administration.[159] The lobby in which I traded my ID for a badge on a lanyard was high-ceilinged, marble floored, and wrapped in windows. From it, I could see one of the best structural engineering laboratories in the nation down a set of stairs and across a shaded outdoor walkway. The library itself was down the hall from the offices of various officials involved in various administrative and research tasks, beneath a lab with screens on which the various monitoring and early warning systems of the nation were represented.

Researching, participating in committees, education, and outreach, CENAPRED functionaries work with representatives of public interest groups, companies, the government, and technoscientific experts like engineers and geophysicists. In interviews, they described the uneasy way that they found themselves occupying all and none of these subjectivities at once. Their actions to some extent circumscribed by laboratory work, political placements and replacements, and committee decisions which come to be not just about regulatory decisions but about articulating human needs. The excitement that I felt regarding the CENAPRED archives was born of the promise of this nexus of commitments, at which I hoped a coordinated apparatus would become clear.

[159] From PAN's blue in my visits in 2011 and 2012, it became to a more PRI-friendly red by 2014.

It is impossible to address Mexican institutions without, to some extent, conjuring an alphabet soup of agencies, the relationships between and within which are wildly changeable from presidency to presidency. The material output of these continues to accumulate within the CENEPRED library. However, in this section, I will try to render these organizations in more than an elaborate institutional kinship diagramming exercise.[160] Rather than demonstrating what was born of what, their obligations, opportunities, disintegrations, and oppositions, I will describe the development of an inconsistently-related suite of state projects and organizations into which the earthquake early warning system is (partially) integrated and through which issues of emergency, measurement, and even complex environments that I have touched on in other chapters must be negotiated.

Protección Civil emerged in the aftermath of the earthquake of 1985. It was deeply informed by ideas about what hazards might be intervened upon that were circulating in international disaster policy. These ideas create conditions of possibility for interventions that might make risks manageable or governable, and disasters preventable.[161] It manifests

[160] Schwegler 2008 and Hayden 2003 provide excellent models for ways of treating Mexican organizations and the relations in which they are set seriously in anthropological analysis, though, as McKinnon (2013) reminds me, kinship studies in expert and powerful institutional settings can still be very revealing.
[161] necessary for the production of what we might consider, in Foucauldian terms, the milieu upon which action could take place. As he put it in the lectures on Security, Territory, and Population: "The apparatuses of security work, fabricate, organize, and plan a milieu even before that notion was formed and isolated. The milieu, then, will be that in which circulation is carried out. The milieu is a set of natural givens—rivers, marshes, hills— and a set of artificial givens—an agglomeration of individuals, of houses, et cetera. The milieu is a certain number of combined, overall effects bearing on all who live in it" (2009, 21).

a drive toward a coordinated security apparatus made inconsistent and fractured in implementation not just at the spatial periphery of Mexican territory, but in the center, too.

In the next pages, I describe the development of concepts around hazardous environmental systems and its integration into state disaster prevention. Doing so, I explore the heritage of cybernetic thinking which has informed efforts to confront hazards around the world. I draw on both archival and ethnographic research to address the development of the National System of Protección Civil as a formal set of policies, its inconsistent articulations in different Mexican states, and, finally, the difficulties that engineers at CIRES (part of Protección Civil's complex of institutional affines in effect if not name) have had in advocating for regulation reform within it. The organizational structure is treated at length in texts and charts in Protección Civil documents, and available, alongside salary and contact information of functionaries, on the websites that most state-level Protección Civil offices maintain, as well as in a thorough English-language Organisation for Economic Co-operation and Development (OECD) report generated in 2013 (all available at CENAPRED's library). I refer the interested reader to those documents. I will admit that in my fever to accumulate resources relating to documented histories, assessments, and procedures, I have developed a significant collection of my own. What I treat here, instead of the structures and relations so detailed in these texts, are ongoing transformations in ideas about how disasters are produced by social and environmental systems that have flourished in the context of these structures. Protección Civil entails a nation-wide system of agencies, but the knowledge politics it entails are often centralizing, masking deeply uneven implementation. This has troubling implications for places which might have very different institutional capabilities than those imagined in Mexico City.

A National System of Protección Civil

The development of Mexico's Sistema Nacional de Protección Civil (SINAPROC, usually, though I will not refer to it as such here for reasons of clarity) is anchored to events; to sweeping disasters that the Mexican state had to grapple with in the 1980s, to national and international opportunities and pressures.[162] Protección Civil's founding document, the massive report put forward by a subcommittee of the National Reconstruction Commission, called unequivocally for Protección Civil to "protect as well as preserve the individual and society" (1986, 16)[163] in the wake of the disastrous 1985 quake. This document inaugurated an approach to social stability and "perturbatory agents" or hazards that owed a great deal to cybernetic models of systems intervention and which established the bases for the coordination of diverse and autonomous elements and organizations

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[162] It draws upon international institutional ideologies and frameworks which share with it a symbol, too: called "Civil Defense" in English, it was a protocol of the Geneva Convention in 1949 and adopted in different ways across the world since. For the purposes of ethnographic clarity, while this chapter's treatment of other such efforts are confined to the introduction. After WWII "Civil Defense" began to address "natural" disasters as well as militarized threats (as noted by Maskery 2015). Mexico, having never participated in the kinds of exercises that marked US, British, and Canadian encounters with Civil Defense, developed institutions primarily focused on what seems to have been a secondary development in other settings. This should not be regarded as a bifurcation between anthropogenic and natural hazards, as the latter may indeed fall under Protección Civil's remit. Administrative and crisis management structure owes a great deal to Spain, the search and rescue systems from France, and citizen training from FEMA, informants have explained to me. The notion of forming civilian committees to deal with emergencies has been linked by historian Hillel Schwartz to, in the Anglophone world at least, the beginning of the first world war, and hierarchized triage action upon emergency to Napoleonic and Crimean armies (2014).

[163] Much of the story apparently lost, or so certain interlocutors suggested.

which has been preserved to this day. The models that this document and those which followed it rely on are, in this way, both product of Mexican and international trends.

Policymakers involved in its development, many of whom are still available for comment, note that it was not only the product of the encounter with the earthquake, however. A series of floods around Mexico which had killed hundreds and injured or displaced thousands.[164] Millions of liters of gas exploded in Mexico state, killing hundreds. Other earthquakes had disastrous consequences, too.[165] However, the magnitude of the catastrophe in Mexico City there, and the necessity of coordination, was beyond the capability and experience of the authorities and structures that they had previously relied upon. Volunteers and authorities coordinated particularly poorly (see Dynes, Quarantelli, and Wenger 1990).

Protección Civil was built on a directive to attend to "public nuisances and the means of prevention or relief when possible"[166] that dated to that dated to May 1853. In the government of President Benito Juárez, this might have provisions for intervention into various forms of physical and economic welfare. The Mexican Ministry of State and Ministry of Government[167] maintained those responsibilities until the early 1980s, though

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164 En cuanto a las inundaciones sobresalen las de Arandas en Jalisco, en 1980, que causaron la muerte de cien personas; las de 1984, que causaron 12,300 damnificados sólo en el área del Pánuco afectando principalmente a Veracruz y Tamaulipas y, por último, las del río de los Remedios, cercano a la capital, que dañaron a más de 100,000 personas (43).

165 Los sismos continuaron azotando regularmente al país y, en 1980, uno de grandes proporciones provocó varias decenas de muertos y 50,000 damnificados en 300 poblaciones de la República, siendo Huajuapan de León, Oaxaca, el más golpeado (44).

166 "Pestes, medios de prevenirlas y socorros públicos cuando las haya."

167 In accordance with the Law of the Secretaría de Estado of December 31 1917.

they were distributed to different authorities including Federal Public Health, Mexico City Federal District and thirty one state governments. Public safety was defined in the Constitution as primarily the responsibility of the municipal governments in the nation.[168]

The foundational documents of the Sistema Nacional de Protección Civil, then little more than a set of principles, outlined concerns with named the discrete hazards its writers judged Mexico to be particularly associated with: geological, hydro-metrological dispositions of the national territory (earthquakes, storms); chemical and sanitary practices of the population (industrial waste and environmental contamination); and socio-organizational issues (particularly to do with population movements). Public safety remained an issue to coordinate municipally, but coordination—that is, integration of different agency efforts alongside preservation of organizational autonomy— was the new authority's goal (Organisation for Economic Co-operation and Development 2013).

In this original Protección Civil document, "disaster" was defined explicitly as event concentrated in time and space that caused human suffering. This could amount to physical harm as well as harm to social order or systems[169] (1986, 16). Reformers involved in the development of this document wrote that previous efforts did not clearly define the purpose of interventions, but Protección Civil was going to offer clear objectives and

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[168] Municipal governments being one of the three integrated levels of Mexican government along with federal and state, the troubled integration of which have been displayed in the narco-sovereignty of rural spaces discussed in the chapter on the extension of the Sistema Alerta Sísmica Mexicana through more-than-seismic environments.

[169] "El desastre se puede definir como el evento concentrado en tiempo y en espacio, en el cual la sociedad o una parte de ella sufre un daño severo y pérdidas para sus miembros, de tal manera que la estructura social se desajusta y se impide el cumplimiento de las actividades esenciales de la sociedad, afectando el funcionamiento vital de la misma" (1986, 16).

processes.[170] While it was novel in its articulations, its advocates were clear on the need to design a national system that would integrate and coordinate with other kinds of preexisting goals, programs, and efforts.

As such, its structure was designed to be open not just to government agencies at all federal, state, and municipal levels, but to private companies, social organizations, NGOs, and other groups outside of the government, too. This is about the integration of all into an "organic whole" (1986, 19). This effort was articulated with and around an idea of ongoing necessary development to support Mexico's independence from external support (and negotiating the independence and inter-dependence of various state and municipal governments from each other and from federal power) and grapple with extant conditions, which included a lack of resources and cutting edge technology (1986, 60).

The Sistema Nacional de Protección Civil was built on this document and began formally in 1988, with little more than a call for national organization to attend to research around, education about, and preparation for hazards. It has incorporated various agencies to administer funding: in 1997, FONDEN began to do recovery work, particularly on state properties,[171] and in 2004, FOPREDEN began to fund projects to build structural resilience and forestall hazard-related damages. Institutions were developed on to work in concert

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[170] "En un Sistema Nacional de Protección Civil no sólo debe darse el tono, de variedad o la calidad que alientan y estimulan a la población; debe saberse qué se persigue y a dónde se quiere llegar" (1986, 59).

[171] A team of engineers at UNAM help to determine what might be considered to be caused by a particular hazard, drawing on market value and charting ordinary losses so as to know extraordinary ones. FONDEN generally does not fund repair to commercial or private property, but attending to losses in private property and interruptions to trade related to a given disaster provides a good if not perfect way for the severity and reach of disasters can be known.

with these directives, and laws passed in 2000 and 2012 standardized practices on a national level, took some steps toward coordinating varied initiatives, and making available new funding for them.

Hazards and disasters were defined separately in the 1986 document upon the system drew; the difference between potential threats and real appreciable outcomes made clear in language about “regulatory” and “perturbatory” agents (1986, 62) that might prevent or facilitate the transformation of the former into the latter.[172] By 2012, they were not only defined separately, but emphasis on foreclosing disaster was expanding in ways that officials have described, alternately, as changes from “reactive” to “preventative cultures,” and as changes from managing discrete risk to integrated approaches to potentially cascading hazards: both physical and social.

Disaster was now defined as the result of one or more extreme or severe perturbatory agents "concatenated or not,"[173] demanding integrative disaster prevention, drawing together multiple factors of risk origin, multiple levels of government, and multiple strategies to "combat the root causes of disaster and strengthen capacities of resilience"—

[172] “El regulador está constituido por las acciones, normas y obras destinadas a proteger a los elementos afectables y controlar y prevenir los efectos y procesos destructivos que integran el agente perturbador o calamidad. Los agentes perturbadores que dan lugar a desastres son básicamente fenómenos naturales y de origen humano”(1986, 62).

[173] Desastre: Al resultado de la ocurrencia de uno o más agentes perturbadores severos y o extremos, concatenados o no, de origen natural o de la actividad humana, que cuando acontecen en un tiempo y en una zona determinada, causan daños y que por su magnitud exceden la capacidad de respuesta de la comunidad afectada (Ley General de Protección Civil 2012 and 2014).

in advance of, response to, and recovery or reconstruction after a disaster[174] (Protección Civil 2012, 2014). Regulatory agents were still key protecting human life or, at the very least, reducing risks presented by hazards.[175] The definition of disaster, and the means by which it might be avoided, had already been understood to be multiple, but they had been over the intervening years made a matter of increasingly complex and integrative systems.

The language mobilized in Protección Civil's founding documents and their subsequent modifications have their roots in a kind of cybernetic and functionalist logic. The very means by which disaster may be recognized—that is, that it might be somehow beyond the capacity of a community to absorb— marks approaches to events I describe there. The cybernetic language here is less explicit, and less technical, than it was in cases from the 1970s. As articulated in Chilean computer and communication-centered technological work documented by Eden Medina (2011)[176] or the Chinese interventions on population

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[174] Gestión Integral de Riesgos: "El conjunto de acciones encaminadas a la identificación, análisis, evaluación, control y reducción de los riesgos, considerándolos por su origen multifactorial y en un proceso permanente de construcción, que involucra a los tres niveles de gobierno, así como a los sectores de la sociedad, lo que facilita la realización de acciones dirigidas a la creación e implementación de políticas públicas, estrategias y procedimientos integrados al logro de pautas de desarrollo sostenible, que combatan las causas estructurales de los desastres y fortalezcan las capacidades de resiliencia o resistencia de la sociedad. Involucra las etapas de: identificación de los riesgos y/o su proceso de formación, previsión, prevención, mitigación, preparación, auxilio, recuperación y reconstrucción" (Ley General de Protección Civil 2012 and 2014).
[175] "Agente regulador: Lo constituyen las acciones, instrumentos, normas, obras y en general todo aquello destinado a proteger a las personas, bienes, infraestructura estratégica, planta productiva y el medio ambiente, a reducir los riesgos y a controlar y prevenir los efectos adversos de un agente perturbador" (Ley General de Protección Civil 2012 and 2014).
[176] Whose book engages with an "historical moment when government technologists, administrators, politicians, and members of the general public were engaged in an explicit discussion of the relationships between technology and politics and how technologies could be designed or used to enact or embody a political goal" (2011, 7).

that Susan Greenhalgh describes (2008),[177] cybernetic science came to be not only an inspiration but a real conceptual tool for social projects.[178] The kind of work that Protección Civil was developed to is perhaps less orthodox than these projects, especially inasmuch as it owes its systems governance theory to models of disaster developed through cultural ecology and neo-functionalist models of human and environmental relations.

The model of Mexican society and "perturbatory agents" which threaten it that the institutional tenets of Protección Civil have emerged with is one that, as UN Disaster policy official Andrew Maskrey has put it, conceives of a disaster part of a system, "endogenous" to the material and social organization of life.[179] Disaster, here, is entangled not just with earthquakes, but also with other social and physical issues (even, in when risk is to be managed in an integrated manner, with other hazards). The goals of Protección Civil are to render these events sensible and intervene upon them wherever possible.

Protección Civil has developed in order to address disaster as a disturbance in a system, to govern diverse system elements to mitigate risk and potentially prevent disaster. The institutional bases set up to do so, however, are tremendously varied in power and capacity. They include diverse agencies, capabilities, and efforts that Protección Civil serves to bring into relation with each other and whose autonomy it is designed to maintain. The

177 Who describes how three "natural scientists-cum-systems engineers from the defense world began quietly applying their skills to the population question," drawing on training in communication and control of machines to deal with human issues" (2008, 125).
178 Marres writes: "The spread of ideas from cybernetics throughout societal discourses, in the 1990s and 2000s, has resulted in their weakening" (2012, 295).
179 Sismo 85 conference, Mexico City 2015, see the chapter on emergency.

differences between those efforts; their power, their issues of primary attention, and their funding are at times radical.

Placing Protección Civil

On a hot morning before the annual month-long Guelaguetza festival in Oaxaca City in 2014, I watched a dozen staffers moving through the offices of the state's Coordinación of Protección Civil. In the few minutes I waited in the front office for my appointment, I saw several people come in off the street to file paperwork or settle to in on the padded chairs to wait for their own appointments. The administrator in charge of the front desk, looking quite a bit cooler in her sleeveless blouse than I was in my heavier Mexico City meeting gear, dealt with us systematically and efficiently. Oaxaca's Coordinación of Protección Civil was well established. It came to exist relatively early in comparison to similar state agencies, organized as it was in directly upon the emergence of Protección Civil as a national priority, before the 1980s even properly ended. Oaxaca City, where the Coordinación has offices, is a colonial-era city, and its center appropriately beautiful, a collection of narrow streets and painted buildings designated **a** UN world heritage site. It is wealthy place, but structurally fragile. The mountains around it are among the most seismic in the nation,[180] the poorest, and, appropriately enough for a place that celebrates a month-long pre-Colombian festival with traditional dances, music, foods and beauty pageants, is among the most linguistically and ethnically diverse states in Mexico.

[180] Producing, according to some accounts, nearly 30 percent of the nation's quakes (See Gubierno Estatal de Oaxaca 2004). 43 quakes of over 6.5 magnitude are on record in the 20th century.

Though all thirty-one Mexican states and the Distrito Federal have Protección Civil offices integrated into their governance structures,[181] Protección Civil has been institutionalized differently everywhere. There are Ayuntamientos, Coordinationes, Direcciones, Unidades, Institutos, Subsecretarias, and Secretarias in various states' governments. Each of these implies different levels of access to leaders and of influence in decision-making; they are listed in roughly ascending order here. Funding and personnel also varies, though not necessarily in accordance with the status of Protección Civil offices or with respect to with the risk of "perturbatory phenomena" or disastrous fallout from encounters with such hazards that the populations of these states might live with. Protección Civil state offices have legal responsibility for resource coordination and municipal governments have primary responsibility for emergency response. While the most recent Ley de Protección Civil calls for "the synchronicity and consistency of policies of protection of the environment, social development and territorial planning" (Chapter 3, article 7),[182] implementing coordination, emergency response, education efforts, and licensing look very different in each state**.**

In Oaxaca, I was given the sameglossy stapled booklets I was often given in interactions with Protección Civil officials — documents developed at CENAPRED to explain one hazard or another, and the ways that it might be prevented from becoming a real risk, selected to pertain particularly to those issues most pertinent to Oaxaca— as well as an internally-

[181] The Mexico City authority is, in the schema of Mexico's three-level system of government, a state (and its leader a "governor") while its various delegaciónes, often translated as boroughs, are classed as municipal governments with the attendant powers and regulatory responsibilities. There are, then, 32 federal entities in Mexico.
[182] "La sincronía y congruencia con las políticas de protección al ambiente, de desarrollo social y ordenamiento de territorio" (Ley General de Protección Civil 2014).

produced document about Oaxacan earthquakes. State Protección Civil officers have had earthquake early warning capacities system dedicated to Oaxaca City itself since 2003, and I visited the Sistema Alerta Sísmica servers in the back of the Coordinación's offices, enclosed by dark glass panels, beside a screen displaying the status of the loudspeakers that broadcast earthquake sirens through the city.

I toured, too, the more densely occupied municipal offices of Protección Civil, and saw the real stuff of emergency rescue on display: motorcycles receiving maintenance in the driveway, and an organized mix of departmental and various staffers' personal tools on shelves and along walls ready for emergency evacuation or first-aid in the face of the common hazards of earthquake, mudslides, and floods (the threat of hurricane and tsunami were not particularly high this far inland, though they were more of an issue on the state's coast). Few other municipalities in the poor state had their resources, a functionary told me, though they provided assistance when they could.

Oaxaca's Protección Civil offices were not the only ones I visited. I went to Guerrero, too. In sunny Oaxaca, functionaries told me that Guerrero was one of the more respected Protección Civil institutions in Mexico. This power was not, however, immediately visible in its offices. The ceiling of Guerrero's then-Subsecretaria (now Secretaria) of Protección Civil in Chilpancingo drizzled an inconsistent spatter of dirty water that had, when building's drains were clogged in a storm, simply collected on the roof and were slowly filtering down upon us.

Protección Civil functionaries were busy in Guerrero. Like Oaxaca, Guerrero is among the most seismically active and poorest[183] states in the nation. It was the site of the first Sistema Alerta Sísmica field stations, and after Mexico City and Oaxaca it was the next to disseminate earthquake early warnings. It also suffers storms, mudslides, tsunamis, dangers from incendiary materials like the gas canisters people use for cooking, and floods. It was in the middle of the latter when I visited.

There had been a boating accident, and one man was dead while another had been injured. Protección Civil was organizing an airlift evacuation to a hospital, although they did not, themselves, have any aircraft to deploy. The effort was one of parleying the resources of many other organizations: finding an resources and emergency medical personnel, aircraft, an ambulance, a hospital, and bringing them together. While they answered phones and radios and passed on information, and functionaries ducked out of offices to take care of responsibilities.

“We don't have communication.” The sub-secretary himself, the head of the organization, was an energetic and utterly bald veteran rescue worker. He offered a slow list of resource challenges between good humored, patient phone and radio conversations with those emergency workers he could reach. “The paramedics are uncertified….We have one drowned man and we’re looking for the cadaver…. We don't have equipment or people certified in water rescue….” He sent one assistant off to make more calls and another to bring him coffee.

[183] Guerrero’s annual state budget: 5,230,020 miles de pesos in 2014 Oaxaca’s: 8,144,060 miles de pesos. A rich state like Nuevo Leon might have a budget of around twice what these two do.

The sub secretary and functionaries had a great deal of data about the hazards it experienced, and its extreme poverty. They were ready with statistics and, indeed, the same assortment of CENAPRED documents, published throughout the late 2000s and widely distributed, that I had been offered in Oaxaca. “Schools, buildings, or when there are events, well, we put them there,” one functionary told me.

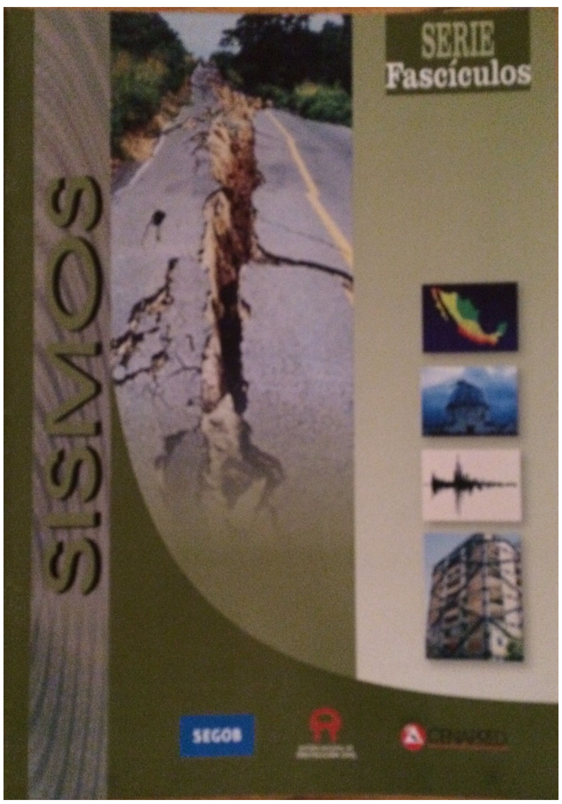

Figure 5.1. Cover of an ever-present CENEPRED outreach documents on earthquakes (CENAPRED 2008)

The documents were useful, to a point. They were certainly good for meetings like the one we were engaged in. But they had their limits. “We have plenty of research.” He explained. “In Guerrero, you have eighty-one municipal governments. If there was a strong earthquake on the coast, buildings in the closest ones are going to have this type of damage, those that are more distant will have that type of damage." The research available is excellent, he went on, and gave him a panorama of the different types of damage that these places might experience. "They propose a method of reinforcement for every one of them. But it's not applied… the studies are there, but really what's lacking is resources."

He went on: "The state of Guerrero has been at the head of seismic statistics... but the research, it's stuck a little. There are many risks, and the research is stuck in this work. The application of programs, the issue of resources for mitigating risks, that's what's lacking."

They could document experience and project likely future dangers. They had done so for CENAPRED's national risk atlas project, coordinating the mapping those natural and anthropogenic hazards that Protección Civil might be concerned with onto the territory in as detailed a manner as possible. They knew that 80% of the state was designated "Zone D," for extreme earthquake risk, and that a great number of the buildings in the state are auto-construction and adobe,[184] and particularly vulnerable to temblors. They knew that September often saw heavy rains and flooding. They could, in short, identify threats, make forecasts, and even consider sites for intervention, but their tools were essentially limited.

While we spoke, the water of the Papagayo river system, whose many tributaries had been filling from the same rains that were seeping through the roof in splatters around us rose, and the injuries on the water were not the only issues that demanded Protección Civil officials' attention.

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[184] CENAPRED 2012.

A local woman stopped in while I sat chatting with functionaries about Guerrero's documented hazards and vulnerabilities. They saw to her needs while I waited with her in the office shared by a handful of functionaries, finding her a copy of a document to prove her residency and allow her to move her family, three children and a partner, from their flooding home until it dried. She would return afterward. Her home was not built to be resistant to flooding, but she didn't have anywhere else to go permanently.

She looked exhausted under careful makeup and her voice was flat. Her children were not yet out of school for the summer. They were out of the house most of the day now, but they would be home every day soon. The water was rising, and would rise further if last year's storms were any indication. "Que feo es Mexico," she commented to me before the functionaries returned. "How ugly Mexico is."

Coordination Trouble

The various administrative and institutional approaches of Protección Civil rely on regulation as well as efforts to coordinate around events and emergency action. Throughout the period of my fieldwork, the staff of the Research and Outreach department at CIRES had been attempting to make several reforms in Protección Civil regulation dealing particularly with a device being sold to businesses and government offices as an earthquake early warning technology, a designation they heartily disagreed with. Despite the centrality of the organization to Mexican earthquake early warning, their attempts to reorder regulation in accordance with their concerns had been unsuccessful. The centralized authority of Protección Civil, even in Mexico City, was inconsistent and difficult to navigate for agents of a NGO ostensibly charged with the arbitration of earthquake early warning.

In his office, trying to get perfectly clear on the details of the mechanism described in an English-language Israeli-copyrighted document for the device, Armando Cuéllar showed me its schematics and involved me in both translation and his frustration. Rigged out with a pendulum set in a sort of bell, the EQ 360 device was is insulated so that it would only sound off if it was is shaken significantly, as an earthquake might shake it with vibration between frequencies 0-14 hz. It was is not an alert but an alarm, he explained: defying all the temporal and sensory definitions that CIRES worked so hard to maintain and promote.[185] It was an alert, he explained, going off when shaking happened, not an alarm of shaking to come. It was designed to ring out when disturbed by the P waves of an earthquake, which travel much faster than the more intense S waves, but much slower than the signals Sistema Alerta Sísmica uses.[186]

This information was not clear in the material that Alta Prevención, the EQ360 device's producers, circulates. There, under the English tagline "Because Prevencion[187] is the best way to save lives," it advertises earthquake early warning technologies which do not depend "on signals from remote sensors," though the explanation is only made clear in a

[185] Also discussed in this dissertation in the chapter on measurement.
[186] Which, as radio and satellite connections, move at the speed of light.
[187] sic

page on the device's specification.[188] Its website boasts of official endorsement by the Mexico City Protección Civil and of certification by experts from UNAM and other universities.

Of these last two claims, the former may be true, but the latter is misleading. Technical reviews exist, though not in the form that marketing material implied. After some experimentation with real earthquakes and a shake table in New York, the researchers in question had found it to be absolutely unsuitable to do earthquake early warning. Cuéllar showed me the report that one of them had provided him with and I saw it myself: there, documented and preserved, were the details of significant testing under different conditions with their comments appended. It was found to react to earthquakes unreliably, even substantially strong ones. They wrote "The system… does not meet with the characteristics credited to it by its producers, who claim that 'it detects mild tremors before a large earthquake occurs.' It does not always work with respect to the principle of early alerting, which consists of emitting a signal before the effects of the natural phenomena might reach a population."[189]

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[188] With disingenuous details; P waves do sometimes move at 13 km/s, as suggested by the website, but only when they're moving through the earth's core. 5-8 km/s is more typical for moving through the crust— an issue that matters when it is the speed of the P wave that determines advantage time.

[189] Evaluation by Carlos Valdés González, Luis Quintana Robles and Arturo Iglesias Mendoza of UNAM number IGEF/DIRE/315/333/08, responding to solicitation SPC/SCPPP/DGP/001733/2008 using resources at both UNAM and in Buffalo, New York; its international assembly itself an indication of the deployment of significant epistemological tools, time, and funding that contributed to an assessment whose impact had been marginal at best.

The assessment was dated 2008, and the substance of Cuéllar's frustration was not simply a matter of misrepresentation in advertising which that were still circulating six years later. I myself spoke to Mexico City officials who had integrated this device into their earthquake preparedness plan, and explained it as complementary to CIRES's Sistema Alerta Sísmica Mexicana. The system was good, but only responded to the sensory evidence of a handful of sensors along the coast, they explained, referencing an understanding of the Sistema Alerta Sísmica that had not been modified with the system's growth since 2005. The EQ 360 device had sensors all around Mexico City, and responded to quakes that might originate in every direction. In fact, I was told, it picked up different earth motions than the Sistema Alerta Sísmica Mexicana did, and one would often respond when the other did not.

I have heard many times in the context of my research that "technology runs ahead of law." Indeed, technologies for earthquake early warning systems may be developing to incorporate educated populations and use emergency broadcast frequencies when, for example, education policies are as yet undeveloped (as in California and Mexico both, at the time of this writing) and regulations policing the use of special emergency broadcast frequencies do not yet exist (as in Mexico). The relation between regulation and technology that is articulated here is worth pausing on.

First, the nature of the law at hand bears attention. The term "regulation" is a bit loose. In fact, it was a "norma" that needed to be changed; that is how Cuéllar would describe where he was working to make it illegal for EQ 360's producers, a company called Alta

Prevención, to advertise itself as an earthquake early warning system. Laws[190] dictate that there must be regulations on certain areas, and these regulations are built of norms. Revising Protección Civil norms, and participating in their development, is a process that happens only partially in public, through means of a series of committees and advocates. These exist at local, state, and federal levels, of course, and trying to effect change in any of these can be a dicey process as the elisions, interactions, and departures of these various bodies and their foci align and come out of alignment.

There was a formal definition of earthquake early warning incorporated into Mexico City's Ley de Protección Civil in 2010. Legally, establishments in high risk zones were encouraged to install some sort of receiver which might receive the Sistema Alerta Sísmica signal. This reform did not, however, exclude what Alta Prevencion was marketing. Seismic alerting was defined as any "warning signal, visual or audio, that destructive seismic waves are immediately forthcoming,"[191] and the characteristics required of alerting equipment had to do only with its "capacity to emit an alert upon detecting earthquakes emanating from epicenters in a 360 degree radius" around itself,[192] that it be reviewed by academic experts,[193] and certain requirements regarding power sources[194] and resistance to tampering. The right of interpreting the norm, was reserved for the Secretaria de

[190] Sometimes he would call it the "normita," a playful diminutive that suggested that he and the regulation had grown intimate in the months of hard work; as if it were his child.
[191] See Gaceta Official del Distrito Federal, August 4 2010, pg 10, glossary of terms
[192] See Gaceta Official del Distrito Federal, August 4 2010, item 5.2.1, the resonance between this guideline and the name under which EQ 360 was marketed did not escape my interlocutors.
[193] Item 4.4.5
[194] See Gaceta Official del Distrito Federal, August 4 2010, items 5.2.2 and 5.2.3

Protección Civil of the Distrito Federal, much to Cuéllar's frustration, and the Secretaria approved the EQ device after several in situ tests in February 2011.

CIRES engineers had begun by trying to coordinate their technoscientific expertise with national regulation, developing criteria for putting earthquake alert systems on the market. These systems would need to be more than just devices which make noise when shaken, but include devices with screens and educational programs about them. They wanted, Cuéllar explained, to make the government the face of reform that would mean that alerts would have to use one copyrighted and standardized siren sound, particular kinds of equipment, and incorporate standardized knowledge about earthquake risk. National-level reform efforts did not work, so they had been pursuing a technical reform under the Distrito Federal's Protección Civil law.

While CIRES engineers may have explained their technological fields expanding beyond spaces where they were firmly constrained by law to me, I suspect that it might also be accurate to say that the regulatory areas which pertained to actions beyond their control were not only not developing as they hoped, nor had the ever been enforced in a way that would bring them into line with the kind of vision of alerting that CIRES advocates.

The coordination of institutions in this security apparatus is by no means straightforward, even at its Mexico City core. In other places, on the periphery of Mexican resources, integrated and effective institutional interventions are even more troubled. Institutional capabilities are limited in ways that are not always clear to the experts producing knowledge and policy from Mexico City and collecting its documentation in archives.

Interventions

I had access to beautiful collections of documents, digitized and physical, through UNAM's Geology and Geography library, its Engineering Institute's stacks and insular basement shelves, in the Center for Research and Higher Studies in Social Anthropology's library in cobblestoned Tlalpan, in modernist Iberoamericana University, and in CENEPRED itself. In the first section of this chapter, I drew on some of these materials to describe Protección Civil institutions and their expansion in the wake of 1985. In this section, I make use of Protección Civil documents as well as interviews, popular press items, and participant observation to address Mexico's ideology of disaster prevention, focusing on the theories of risk that inform the kinds of interventions into daily life that Protección Civil supports and coordinates and within them make space for multiple and contested ways of attending to seismicity. State efforts to assemble a coordinated security apparatus has not only meant collecting data on hazards themselves, but also on strategies to prevent disaster or at least mitigate risk. These have come to figure “culture” as a key site of intervention and a perennial explanation for failures.

The rationality of these interventions was often explained to me by members of the seismic and disaster prevention community in Mexico with an equation, used in many ways but repeated since the 1970s: “risk is a product of hazard and vulnerability," or sometimes written out by an informant interested in being particularly clear: "risk = hazard x vulnerability." These interventions, as inconsistent as they can be with limited resources and what Foucault might call substantial "counter-conduct" (2009, 201),[195] articulate an imperative of social transformation.

This relationship between risk, hazard, and vulnerability is often deployed as a rhetorical device by which social scientists, policymakers, geophysicists, and engineers might all discuss their understanding of the essential role that social conditions and human action might play in risk— and risk, here, should not be read as statistical probability but rather as likelihood of a nasty outcome. The relationship between these three issues suggests that reforms made in regulation or refinements to technical knowledge should be understood in terms of their impact on ordinary Mexicans. When risk = hazard x vulnerability, attention to social conditions become key to diminishing the effect of environmental hazards, anthropogenic or otherwise.[196]

This relationship between risk, hazard, and vulnerability was referenced in conversations throughout my fieldwork, as well as in talks I attended and documents I collected. The relationship (or "the equation," as I soon began to refer to it in my notes) did not take a single form. Sometimes it was a tool suggested for practical evaluation of quantified hazards, risks, and vulnerabilities—there it did tend to bear the mathematical signs of x

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[195] Which might be defined as a kind of resistance without systematic organization or intentionality; an unwillingness or inability to be effectively conducted.

[196] While the term "resilience" is not used here, the understanding the inevitability of vulnerabilities, may nonetheless indicate what Walker and Cooper call a "second-order cybernetics" or "complex systems" theory (2011). They document the emergence of such a model, which does not assume balance is possible as a system's steady state in the 1970s and has moved since into the same international expert spaces in which the equation I discuss here developed.

and = as marks of their straightforward mutual dependence. At other times it was simply a collection of issues, each separately defined, which could be said to have effects on each other; often an argument for the importance of considering ongoing social conditions along with other factors when discussing propensity for disaster.

The ways that risk, hazard, and vulnerability are made to relate in this equation has been more than an argument for analytic attention to social conditions, though. It is, instead, action-oriented. It maps general principles of relation for intervention. When social issues of "vulnerability" come to be of equal standing with "risk" and "hazard," it means thinking through agency in such a way that the three elements might come to be equals. Operationalized or not, this has marked real disaster prevention and risk management interventions. Since earthquakes cannot be stopped, something about social life would have to be changed in order to reduce risk. Ideas about how social life can be changed have varied significantly since the equation was taken up in a UN Disaster Relief Co-ordinator meeting of multidisciplinary experts in 1979.

At this meeting, it was suggested that across disciplines, it might be useful to standardize language around disaster (see 1979, iv and 6). Risk was defined as "expected degree of loss due to a particular natural phenomenon," earthquake hazard as "the probability F (Y) that a certain ground motion parameter will be exceeded in a period of (T) years" (1979,5), it was proposed that, in the context of the equation, vulnerability could be assessed in scale from

0, no effect, to 1, "total loss" (1979, 5).[197] At that point, this was a matter of interventions into the built environment. While the 1979 meetings proposed to develop methodologies to assist increasingly "disaster-prone developing countries" (1979, iv), most of their suggestions were oriented around planning growing urban spaces—that is, physical and structural remedies that regulation might make to the general changes in spacial use that industrializing nations were, at the time, experiencing.

At the same time that policymakers and disaster studies scholars were expanding what I've called the three-step model of disaster (see the second chapter of this dissertation), they were pursuing new ways of approaching vulnerabilities to it. This certainly meant poverty as well spacial organization;[198] it came to incorporate complexes of ongoing social practices, capacities, relations, and resources.[199] According to Andrew Maskrey, a UN policymaker who began his career as a Peruvian urbanist,[200] this was all part of a sea change in disaster prevention. Experts began to consider risk, that is, expected loss, to be

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[197] In Mexico, I have not seen this operationalization taken up significantly as more than a useful way of illustrating the relationship proposed by the equation itself Arjonilla illustrates it in what was meant to be a took for educators and has come to be used, she says, by administrators.
[198] Only track the emphasis on poor nations in 1979 and in subsequent UN work in United Nations International Strategy for Disaster Reduction 2005 and United Nations International Strategy for Disaster Reduction 2015. Economic work at the University of Bradford and other research centers were tracking economic life alongside vulnerability as early as the 1970s. in its focus on vulnerability by way of poverty reflected in the built environment, the UN meeting was presaged by an article in Nature by O'Keefe, Westgate, and Wisner in 1976, documenting the work of the Disaster Research Unit at the University of Bradford and Institute of Development Studies at Sussex to track disaster economically. They also write that "Disaster marks the interface between an extreme physical phenomenon and a vulnerable human population." The UN did not invent vulnerability by any means, but I maintain that their equation work crystalizes a certain kind of framework for intervention particularly well.
[199] See Hewitt 1983, Wisner et al. 1994, Maskrey 1993, Oliver-Smith 2002.
[200] His career launched by an innovative earthquake vulnerability study he was involved with in the Peruvian National Institute of Urban Development between 1981-83 (see Maskrey 1993, vii).

fully "endogenous" to social life[201] (2015).[202] This, in turn, opened up the possibility that hazards like earthquakes could be not only thought of in relation to vulnerability, but that they could be operated upon and somehow made less disturbing to ordinary life.[203] Latin American policymakers and disaster studies scholars, were key agents in formatting these priorities and concerns.[204]

The equation discussed by UN[205] experts in 1979 and circulated in disaster policy discourse, promoted eventually in the 1990s in a decade of Disaster Prevention designated by the UN.[206] It was articulated what became, in Mexico, the predominant security rationality of Protección Civil. Here it provided a means for thinking not just about structures and physical safety,[207] but about how expert power should scale to ordinary

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[201] This marked a departure from previous disaster scholars who were agnostic about the origin of risk but found research on resulting behavior to “enlarge the social scientists' awareness of the precariousness and flux to be observed even in the most "stable" of socio-cultural systems” (as in Demeranth and Wallace’s ecological disaster studies, 1957, 2).

[202] The shift was hardly universal, and, when he wrote his influential book in the early 1990s, approaches to vulnerability characterized by what he called a spectrum of approaches which included as its poles the idea that "disasters were characteristic of natural hazards" and the idea that they might be a matter of "socioeconomic and political structures and practices," with concern with "construction and settlement patterns" somewhere the middle of the two (1993, 2).

[203] Even in the UN, though, the elements of “vulnerability” and its more positive correlary, "resilience," are in particularly serious flux. The recent Sendai Framework on Disaster Risk Reduction (2015) addresses social and structural issues as part of a single problem: systemically and structurally vulnerable people are disproportionately effected by disaster. This is a significant change even from the focus of the 2005 Hyogo framework which predated it, which focused more on disasters, and demonstrates more attention to ongoing, chronic social issues of poverty (with, again, an emphasis on urban planning issues).

[204] Maskrey 1989 and 1993. Macias Madrano argues that Mexican social scientists only really began to study disaster after 1985 (1999, 16)

[205] Most disaster specialists cite Maskrey as its originator. He published it in 1993. However, in a 2015 talk, he suggested that it was developed at this 1979 meeting. Its author or authors are unclear, but the UN meeting is certainly a key site for disseminating the equation as a tool for value and evaluation.

[206] Described Jesus Manuel Macias as still lamentably technocratic (see 1999).

[207] Though ideas about physical vulnerability due to urbanization would continue to motivate disaster studies scholarship (see Tierney 2007) and policy (United Nations International Strategy

experience and how transformations in everyday practices around factors of vulnerability could then reduce overall risk a territory might be exposed to.

In service of this transformation, the institutions of Protección Civil are not the only ones who churn out materials. The safety certifications necessary for business and school licensing require specialized risk assessments, designated and trained emergency response personnel all heavily documented.[208] During my archival frenzy, I did not just accumulate documents about regulation and research at CENAPRED, but evidence of complicity in them, produced laboriously with charts and photos and up to date designations for responsibility. These documents deal with certifications, with the allocation of training and responsibility, but also with mandated action; with evidence ("evidencias") of what a group is doing to fulfill their obligations. These are also housed in to collections, not at CENAPRED or the other fine libraries I visited, but in the computers of company safety officers, on office bookshelves and filed in municipal and state Protección Civil offices. These documents refer to individual organizations' efforts to comply with increasing Protección Civil regulation. They also illustrate ongoing efforts by Protección Civil to transform Mexican vulnerability.

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for Disaster Reduction 2015). Tierney notes, additionally, that there has been a dramatic growth in college and university programs focusing on homeland security, crisis and emergency management, and related topics. However, the vast majority of those programs is housed in public administration, engineering, geography, and urban planning units, rather than in sociology departments" (2007, 517).

[208] There are many who don't follow the guidelines, in Oaxaca and Guerrero and poorer states as well as in Mexico City. Building owners and businesses, who fall through the cracks or work to open cracks around them. This is common knowledge in the seismic community, and in Protección Civil as well. There is much talk about the trouble of applying regulations. And yet, there are many organizations that do follow guidelines, do have their business licenses approved, and do work assiduously to meet Protección Civil's demands.

In the following pages I will suggest that the Mexican security apparatus as developed and coordinated through Protección Civil institutions, approaches issues of vulnerability through centralized efforts to coordinate diverse ordinary practices. To this end I describe how a nation-wide earthquake drill constitutes an effort to do just this, and then detail the promises of this kind of activity. Finally, I discuss the emergence of a deficit-based idea of Mexican culture and the necessity for "cultural reform" as both goal of a state security apparatus and an explanation for its lack of efficacy of its centralized, poorly-funded efforts. As I do so, I highlight the multiplicity of the agents, ideas, and practices that are more or less coordinated for such activities. I do not seek to weigh in on ongoing debates about the definition of vulnerability and its utility and political implications as a concept (as compared to, for example, that of resilience),[209] a topic of some controversy. Instead, here I document the security discourse and practices that become possible when vulnerability is understood to relate to risk and hazard as described above; when risk is a function hazards which are inevitable and social vulnerability that, whatever it is taken to mean and whatever its implications may be, is not.

Megasimulacro

Most earthquake drills are conducted internally and independently by companies and building managers, if at all,[210] but one large-scale drill is held every year nationwide on the anniversary of the 1985 quake. Called a Megasimulacro, this drill is an opportunity for millions of people in thousands of buildings to participate at once in a planned event. It is

[209] on these debates, see Macias Madrano 1999, Barrios 2014 , Walker and Cooper 2011
[210] counter-conduct is, as I've noted before, the rule rather than the exception

the most orchestrated of the three earthquake drills which are required throughout the year by schools, government agencies, and large office buildings who want to maintain their business licenses and good standing with the national Protección Civil authority, and is executed in a moment when the popular press are filled with information about earthquakes and the 1985 quake in particular. Participating in a 2014 Megasimulacro on the anniversary of the earthquake of 1985, I was able to document one key part of Protección Civil's strategy to produce a culture of disaster prevention and protection with respect to inevitable seismicity.

This started well before the date of the megasimulacro, as there was a great deal to be planned ahead of time. A megasimulacro has a proposition or "hypothesis" designed by Protección Civil. This pulls possible future material conditions into practice by way of blunt metrics, numbers that may have less to do with experience than with general comprehensibility. Rather than an intensity, then, the megasimulacro proposition might detail an earthquake of a certain magnitude at epicenter, which is not discussed in terms of local acceleration but might produce fallen equipment or injuries. The simulated earthquake's details vary across the nation, and potential effects from building to building. They are scheduled in advance and participants are made aware of that schedule ahead of time, though the plans were not necessarily unchanging. The hypothesis for Mexico City was an earthquake of magnitude 7.6 originating near Petatlán, Guerrero on September 19, 2014 at 10:00am, based on quakes that really happened in April and May of that year.

The CIRES signal was to be involved the event, the earthquake early warning siren broadcast from loudspeakers across the Mexico City Metro area in the moment of the Megasimulacro. This would remind people that the Sistema Alerta Sísmica Mexicana existed, help them integrate the alert into their plans for earthquakes, and, moreover, demonstrate Protección Civil's support for CIRES's efforts after the worrisome app misfire described in the Chapter 2. In the days leading up to the Megasimulacro, key questions about when and how this alert would be integrated, and how its inclusion in the Megasimulacro would be advertised were left open. Finally, with three days to go, the few unraveling concrete plans of integrating the earthquake early warning into the Megasimulacro unraveled. A relatively minor app operator called AlertaSísmicaDF issued a false alert, and it was found that the loudspeakers that Protección Civil officials had planned to use to broadcast the earthquake early warning system did not have appropriate software for emergency messaging. Plans to use the earthquake alert in the Megasimulacro were cancelled the evening of September 18, only hours before the Megasimulacro.

In Mexico City alone, 17,000 buildings participated. There was no early warning, but in the minutes leading up to 10:00 everyone in the Torre Latinoamericana, I saw quite a bit of preparative work. The Torre Latinoamericana is Mexico City's oldest skyscraper, finished in 1956. It contains perhaps 20 businesses and its manager Protección Civil had plans in accordance with this number and its structural capacities. Though it is built on some of the most unstable soil in the city, it is also seated on pilings which anchor it to bedrock deep under that top layer of earth. These pilings run all the way up its thin body. It stands tall and apart from other similarly sized buildings, so in quakes, the building sways freely but does not suffer much damage.

Figure 5.2. *left,* the Torre Latinoamericana today , courtesy of Juan Pablo Ortiz Arechiga *right,* the same tower after the 1985 earthquake, courtesy of the Reinsurance Company, Munich, Germany.

Half an hour before the Megasimulacro was scheduled to begin, the tourists at the Mirador restaurant near the top of the building were sent away. An elevator operator had her orange jacket and her emergency supplies nearby. Desks were moved out of the way of the stairs to make the exit easier for everyone who was still in the upper floors of the building. With fifteen minutes to go, I watched a woman do her makeup; after all, she would be well-photographed by news crews and administrators collecting evidence of participation in the Megasimulacro.

Figure 5.3. The particular labors of Megasimulacro preparation, photo by author.

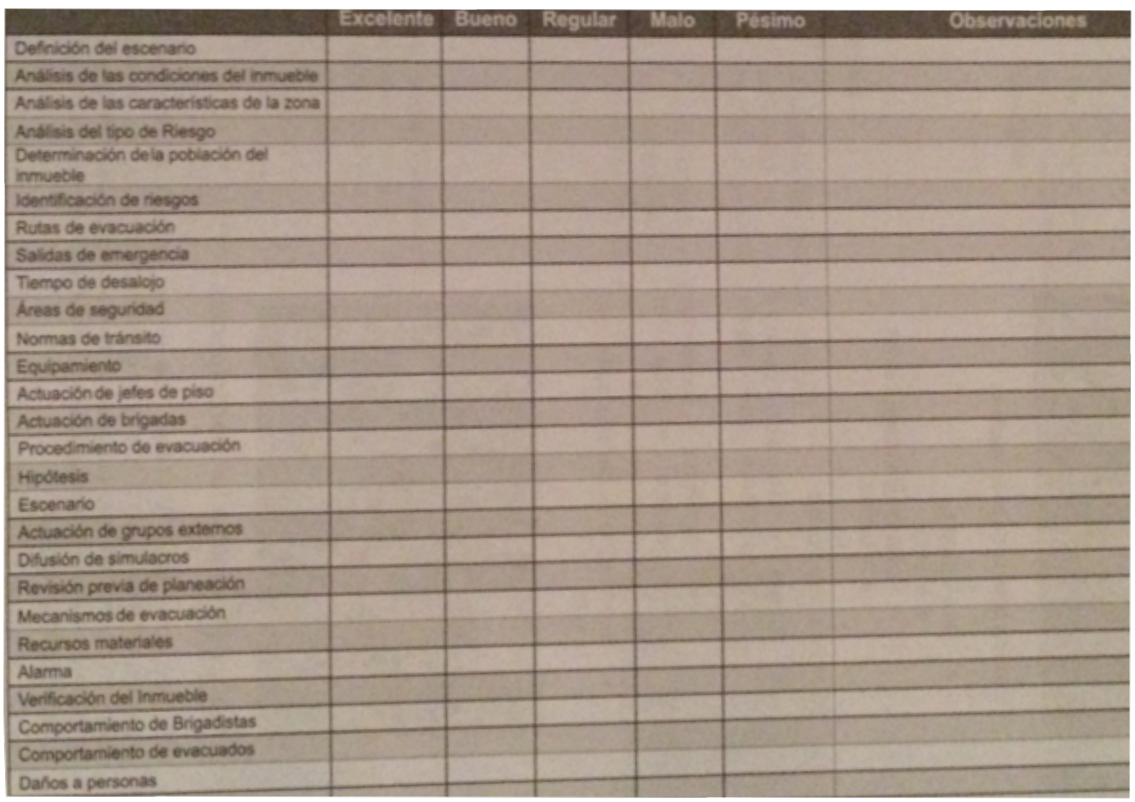
The moment itself came slowly. A few sirens began to ring out, then others. According to the Torre's emergency plan, everyone, from the first floor up, sheltered in place, crouching and protecting their heads for a full minute. Then whistles blew within the building. Following the second phase of the plan, brigadistas, trained Protección Civil volunteers, rallied around the “command center” in the lobby while others led their colleagues the tiny staircase that twisted up to the top of the building , streaming out of the doors and across the street. Brigadistas directed and snapped photos on their phones to compile into reports. Not all came; some people were monitoring necessary systems, and some just refused. Some people do simply refuse to participate in drills, though the regular practice of taking photographs “evidencas” for later audit is persuasive.

Figure 5.4: Evacuated onto a public street still decorated for Independence Day, photo by author.

Most lined up with the rest of their floors to be counted and to hear a little talk on their exit metrics and earthquake recommendations offered by the building's Protección Civil coordinator via megaphone. They had taken 12 minutes and 38 seconds, which, he told them, was not great—though one young woman I spoke with claimed her legs were shaking after running down 20 storeys of stairs from her office, and thought otherwise. They stood there for a while, chatting in the sun. Then they were released, many running off for snacks or a smoke before returning to work.

The Torre Latinoamericana's Protección Civil coordinator was happy that everything didn't go perfectly, he told me afterward. It seemed, though, that he wasn't pleased as he was had been the year that the building-wide communication system failed, or the year that the exit lights went out. If they got everything right, had good participation and a respectable exit time, and there would be nowhere to go and nothing obvious to improve in subsequent Megasimulacros.

Many understand success or misfire in relation to both future hazards and the administrative and organizational cycles of simulacros themselves. A simulacro's success is rated in terms of evacuation time and participation, which are documented in photos and forms:



	Excelente	Bueno	Regular	Malo	Pésimo	Observaciones
Definición del escenario						
Análisis de las condiciones del inmueble						
Análisis de las características de la zona						
Análisis del tipo de Riesgo						
Determinación de la población del inmueble						
Identificación de riesgos						
Rutas de evacuación						
Salidas de emergencia						
Tiempo de desalojo						
Áreas de seguridad						
Normas de tránsito						
Equipamiento						
Actuación de jefes de piso						
Actuación de brigadas						
Procedimiento de evacuación						
Hipótesis						
Escenario						
Actuación de grupos externos						
Difusión de simulacros						
Revisión previa de planeación						
Mecanismos de evacuación						
Recursos materiales						
Alarma						
Verificación del Inmueble						
Comportamiento de Brigadistas						
Comportamiento de evacuados						
Daños a personas						

Figure 5.6. A simulacro audit, photo by author.

With a Megasimulacro, then, the people organizing the Torre's regulatory compliance hope to get a good time on the run through, good evidencias to use to prove their participation. They also hope for unexpected problems to fix which may be related to preparation for future emergencies give them goals for future simulacros, which are necessary administrative next steps and maybe even themselves constitute opportunities for in the moment problem solving that may very well be at the heart of how these drills are useful in and after earthquake emergencies. Though the Megasimulacro has come to be an important and spectacular feature of Mexico's security apparatus, the mechanism by which it supports the production of a culture of disaster prevention or at least self protection is, however, debated.

Effects

"In a drill different scenarios are simulated, as closely as possible to reality, with the end of observing, testing, and preparing an effective response in the face of possible disaster situations" (Protección Civil, 2010). While drills are generally understood to be necessary, there is significant disagreement on what allows them to be effective, whether through the conjuring the details of an emergency event or through the opportunity for developing simple familiarity with the tools, systems, and processes that might be necessary for action in an emergency. While in Spanish, the word generally used for drills is "simulacros," some members of the seismic community involved in Protección Civil prefer the words "ejercicios" or "ensayos," to indicate exercises, rehearsals, or run-throughs, giving the activity overtones of experimentation rather than replication of a potential emergency event. The drills (or exercises, or rehearsals) conducted in the name of Protección Civil regulation differ significantly; some officials convince their colleagues to learn to use fire extinguishers by making a game of it, while some use jam as fake blood and gore on injuries that would allow first aid crews to practice their craft.

Elia Arjonilla, for example, the sociologist whose work was described in the second chapter, was integral in contemporary earthquake disaster prevention design for the Mexican school system. She has been an advisor to the government of Mexico City, to citywide Protección Civil authority, to the national policymakers at the CENAPRED, for the National Institute for Adult Education. She has made a long career of working to make Mexicans more prepared for earthquakes and other hazards.

She explained the practice commonly understood as drilling with reference to her own experience. One of the most effective strategies she had come across was to give children something simple to remember, to come back to. "We taught them 'No corro, no grito, no empujo.' In all Mexican schools: 'No corro, no grito, no empujo,'" I don't run, I don't yell, I don't push.

Learning this phrase, and reciting it can have, she told me, certain effects. A group of students from the high school in which she began her work went on an exchange one winter break to the US. On their airplane were teachers, students, and others unaffiliated with the group. When they were almost at their destination, the passengers were told they would have a dangerous landing and were asked to assume the emergency landing position.

Rather than putting on their seat belts and staying quiet, the passengers began to yell and try to move around, but not the students, she told me. They started saying "no corro, no grito, no empujo." Many passengers were from the US and didn't speak Spanish. The chant was unintelligible to them as well as completely inapplicable to their situation. But the students, and then their teachers, too, chanted louder and louder until other passengers began to calm, quiet, to seat themselves.

The plane landed, and Arjonilla told me that when the students got off all the airline employees applauded them. She was very clear about it: that chant that the students were taught had nothing to do with safety on an airplane but it worked. She was so proud to have collaborated in the design of something that worked so well. She called it a "mantra," which she defined as "a form of self control, but with direction." And though she implemented the mantra model nowhere else, she narrates this, an earthquake less application, as a kind of great, unanticipatable success for her simulacros.

The problem facing people developing interventions like this has to do with making them effective for unexpected circumstances. So much of earthquake safety depends on the particular spot at which a person finds themself when shaken; its underground, its structural properties, the kinds of knowledge they have about the space. In Protección Civil's work to extend the relatively minor power of regulation to address vulnerability, this kind of story highlights the best case—information, experience, and skills garnered from a coordinated intervention that come to be applied and, moreover, made useful in another dangerous situation.

A simulacro, ensayo, or ejercisio, regardless of what it is called, is significantly different from an event (see Davis 2007). As the discussion of drills above should show, the many of the skills necessary for earthquake drills are skills specific to earthquake drills, that involve interacting with certain kinds of audit culture. It is not much more of a stretch to imagine that earthquake drills might become effective in an airplane, or for a fire (as one building's Protección Civil coordinator suggested to me that they were) than it would be if they were useful for real quakes? As far as the mantra goes, also, Arjonilla remembers inventing it after studying Japanese schools, but treats its powers as surprising, and, importantly, not necessarily replicable.

Are people prepared for the places they may be in an earthquake, when responses vary so much depending on the spaces in which they find themselves? Do they know procedures? Are they prepared to operate in states of stress? These are real problems, and simulacros do function to teach real skills. Here, the matter of educating the body and mind seem to have pluripotent promises, although the methods by which they can be achieved are not generally agreed upon. These promises, however, are not easy to achieve.

Culture Concept

The promises of interventions like drills may be pluripotent, but so are the challenges that they combat. Although I often encountered discussion of the relation of vulnerability, risk, and hazard during my fieldwork, the conditions of vulnerability which Protección Civil was designed to intervene with drills and other efforts upon are not limited to the dangers of the built environment and the entailments of structural poverty. When I took my inquiries regarding vulnerability and the conditions upon which drilling and other interventions might intervene to media, Protección Civil offices and events, I did not find the same language of impact assessment and economy that insurance and disaster recovery experts often trade in.[211] Vulnerability was instead a matter of culture,[212] as were interventions like the Megasimulacro.[213] The culture in question was defined in deficit. Ameliorating it was described as key to making Mexico's security apparatus function effectively as well as an explanation for its failure to do so.[214]

"Mexico no tiene una cultura de prevención," or "Mexico doesn't have a culture of prevention," was a common refrain. If it did, integrated disaster prevention would be an altogether different proposition. This deficit model is demonstrated in the interventions designed, conducted, and facilitated by Protección Civil to address vulnerabilities and implicated in policy documents that deal with the subject of risk management and disaster

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[211] FONDEN, for example, uses this kind of calculation. Protección Civil at large, though, does not.
[212] This should not be understood as a departure so much as an extension of these themes. As José Manuel Covarrubias Solís, the director of UNAM's Facultad de Ingenería at the time, wrote in a paper for First National Conference of Universities on Protección Civil, upon listing not only threats to human life but new means of detecting, assessing, and communicating about them: "All of the elements above require a conceptual framework that sets out the system of concepts relevant to the issue of disasters, such as 'danger', 'vulnerability' , 'risk monitoring', 'assessment', 'reduction and control of risks', et cetera. The development of this culture risk prevention ... requires the participation of authorities, academics, and educators, businesspeople and, in general, the whole population; it is a new culture derived civilization we have adopted" (1993, 40).
[213] "Para fomentar la cultura de la prevención, en punto de las 10:00 horas se realizó en la capital del país el megasimulacro de sismo, a 29 años de los terremotos de 1985," read one news article about it in the Informador on Saturday, September 20 2014
[214] "todos los elementos anteriores requiere un marco conceptual."

prevention writ large. It has been made explicit in assessments of their limited success. "Mexico no tiene una cultura de prevención," or statements to similar effect, are to be found often in Mexican popular press articles and editorials published in the last thirty years, especially when the topic at hand has been risk mitigation and disaster prevention. I want to suggest that the deployment of a culture concept here is not filling what Daniel Goldstein has called the "culture 'slot'" ; that is to say, I do not believe that it is "seen as a variable, part of a larger scenario of engagement" (2010, 129). Instead, culture is here made to stand for a whole complex of characteristics which might contribute to vulnerability, including ordinary practices, knowledge, and priorities in decision making.

In Oaxaca, I was told that an uninformed and uneducated pubic is uncultured, and in a cultured public, everyone understands their role or responsibility in the case of a threat. "We cannot predict," an official in the municipal Protección Civil office explained, "but our job is to build a culture." In Mexico City, an outreach educator told me about the nation's condition. "Mexico no tiene una cultura de prevención," he explained. He works with teams of academics and students through the UNAM and Protección Civil to coordinate hazard education programs around the country.

This use of the term "culture" in this context is jarring to me, not just as an anthropologist—we know, after all, that the term is not only our own to think with (see Helmreich 2000). Having circulated through Mexican spaces for several years, I had developed a sense that even outside of the social sciences I could expect the term to carry different kinds of meanings. In a nation in which a significant portion of the population is officially recognized[215] as indigenous and are a particular focus for state intervention,[216] indigineity is often discussed by elite experts and laypeople alike in terms of idiosyncratic ideas, kinship structures, and traditional practices (particularly, but not limited to, craft practices) of various groups. The National Anthropology Museum of Mexico City is a major tourist attraction which displays historical and contemporary artifacts to describe the life ways of people around the nation. In Oaxaca particularly, Guelaguetza is an annual festival of traditional dances which brings people flooding to Oaxaca City every year, and nearly three quarters of municipalities in the state are governed by indigenous rather than Mexican electoral and leadership practices.[217] These are all identified as "cultural" issues and practices at other times and in other places.[218]

However, neither in the busy Protección Civil offices nor those of the outreach educator, made nearly impassable teetering stacks educational tools and dusty boxed equipment, was the culture concept being used refer to diverse human experiences or their extant practices. Experts there did not talk about mounting classes or designing materials that might speak to people in Zapotec, Mixtec, or Tseltal ethnic groups, people who do not speak Spanish or read at all, or even people in remote mountain villages (as much as such communities are marked Mexican academic and popular discourse as radically different

[215] The official tally is somewhere between 10 and 20 percent of the nation. Language use is often used for quantification, and even that presents problems as there are over 68 languages and several hundred dialects on record (International Work Group for Indigenous Affairs 2016 and Hidalgo 2006).
[216] They are found to be less educated and face more significant challenges gaining access to services than other groups in Mexico. in Mexico (Comisión Nacional para el Desarrollo de los Pueblos Indígenas 2006)
[217] See Eisenstadt 2007 and Poole 2006 on "usos y costumers" laws.
[218] I discuss some of the politics of these appellations in the fourth chapter of this dissertation, which focuses on the physical extensions of the Sistema Alerta Sísmica Mexicana.

from those in cosmopolitan Mexico City). It was certainly not being used to describe knowledge or productive habits that people, in small groups or taken together, might already have.[219] Instead, "culture" stood in for conduct that might be conducted, so to speak, through technical intervention.

“Cultura de prevención” is perhaps the most common way to put the elusive set of practices which include preparation, knowledge, and sensibilities which, when modified properly, might reduce Mexican vulnerability to hazards. A "cultura de prevención" refers to general preparation to face challenges of hazards. Articulations I have encountered orient around transformations to built environments and regulations, knowledge about what to do in the event of emergency. Participating and doing well in drills, knowing and implementing general strategies to make buildings safer, and developing emergency plans and the ability to stay calm in an emergency are key activities for fostering this kind of culture.

But there are related concepts, too: A "cultura de Protección Civil" pulls ideas about safety and safety education into as many parts of dail**y** life as possible. It orbits closer to emergency than prevención—a matter of a defined exit route rather than paying up home insurance. A "cultura Sísmica" is one with certain kinds of consciousnesses regarding earthquakes. This concept, at least, according to social scientists and reformers who first considered the application of the Sistema Alerta Sísmica “used to exist in prehispanic

[219] Only one Protección Civil official I interviewed, the experienced and dynamic sub secretary in Guerrero, discussed using special methods to do outreach to indigenous populations, taking their practices and priorities into account.

Mexico" (Fundacion Javier Barros Sierra 1992). A "cultura del riesgo" is similar—one journalist commenting on Mexico's deficits at least noted such a thing might exist in Japan.

There is a "cultura de la seguridad" and a "cultura de autoprotección" too—the reference point of is mutable, depending on the issue of attention. I group these because they emerge similarly in conversations about risk mitigation and disaster prevention. Positive references to these cultures, when they exist at all, are generally restrained discussion of steps taken toward manifesting them.

When Protección Civil documents first laid out the system's guiding principles in 1986, however, the term "culture" was not only a matter of deficit. It was used to reference different ways of being in the world. There, culture was referenced in terms of essential considerations for the design of disaster communication.[220] It had to do with particular characteristics, the conjunction of which would effect how a group of people could respond to hazards. But in the same framing documents, altering culture is also already an explicit concern. Culture is something that can be intervened upon with purpose, to introduce new values, attitudes, and conduct. Culture is the optimal site where an intervention can happen to both reinforce aptitudes that already exist and teach new abilities while elevating "aspiration and creativity" (1986, 101) and, as critic Jesus Manuel Macías Madrano has pointed out, "transfer the responsibility of the authority for the protection of life and property of the society to the disaster threat to the population at risk " (1999, 7). Their

[220] It is perhaps worth noting that one of the only two Protección Civil officials who were forthcoming regarding developing strategies for taking local ideas and practices into account when designing educational interventions was involved in drafting this document.

vulnerability then becomes the product of their counter-conduct, or failure to reform their practices.

In 2012, the General National Law of Protección Civil gained a section referring explicitly to a "Cultura de Protección Civil" in which federal state, municipal and neighborhood authorities are obliged to foment, in the population by encouraging engagement with ideas about hazard and risk in any ways they can imagine. This culture is something which must be brought about. What it is, what grounds it operates on, in these documents—and also in the absolute cacophony of commentary in the popular press—remain open, not entirely unknowable.

I have asked experts in disaster prevention, particularly members of the seismic community, if a cultura de prevención is an achievable goal. They tell me it is. It has not been achieved, though, in the years since either having it or not became a simplified way to talk about vulnerabilities. They are large scale.

"Culture is a bag we can throw everything into," a CENAPRED official responded to my questions regarding the way in which lack, absence, and deficit characterize its deployment. "It can be education, it can be economy… And it's about the future. It can't be something we have."

"Our culture," he went on, "is to identify problems and work for the future." Crucially, officials in Mexico City do not understand themselves to be people without culture. They are not untouched by the problems they diagnose— even disaster prevention experts confess to less-than-perfect prevention practices, they worry about the effects that the corruption endemic among Mexican officials, understood to be so tragic in the context in the 1985 earthquake, could have again. However, through their technoscientific expertise, cultivated and collected in centers of knowledge and authority in Mexico City, they are understood to have the capability to identify problems that other populations do not. It is this knowledge that allows them to imagine interventions on complex social and environmental systems— and as fragmented as the Mexican security apparatus may be, it is somewhat consistent here.

Conclusion

The Research and Outreach department at CIRES was in a small office on the second floor. It was a puzzle to me when I first encountered it; for an organization explicitly dedicated to instrumentation to have an outreach department seemed beside the point, even if, as I discuss in the second chapter, CIRES is responsible for alert dissemination in ways that its counterparts in other parts of the world are not. Nonetheless, the team was there every week during working hours, and someone came in to oversee communication whenever an earthquake early warning was disseminated. They split their working time between educational material and web development, moderating social media and fielding calls from the press as well as questions from inquisitive anthropologists.

In response to my questions, they explained that CIRES was a NGO dedicated to developing and maintaining seismic instrumentation, including the earthquake early warning system and a network of accelerometers arrayed across Mexico City. The organization was developed to support state efforts. This kind of labor, in other wards, was necessary in the context of the many conflicting and semi-integrated programs and processes of the Mexican security apparatus which frame the technoscience and politics of the seismic community. The work that they did to make seismic energy, its carriers, and its effects comprehensible to the Mexican public should have been Protección Civil's.

With that organization's openness and uneven integration of services, however, it was not. The urgency of seismic disaster prevention was real and sensible to CIRES as an organization. Mexicans were vulnerable. The Sistema Alerta Sísmica Mexicana was poorly understood and underutilized, and members of the seismic community were far from unanimous on the practices and priorities that should inform its development and maintenance. CIRES is just one institution included, sometimes and to some extent, in Protección Civil work to coordinate a post-85 Mexican security apparatus. Its partial, occasional integration is symptomatic of ongoing attempts made by the Mexican state to conceive of and coordinate disaster prevention and risk management.

In this chapter I've discussed institutions of Protección Civil and some examples of their interventions into daily life. The approach to hazards that I describe here, which makes social practice the site at which disaster prevention, or at least risk management, can be effected, is by no means limited to Mexico. The notion of disaster which ties environmental and social systems together and offers social life as a site of intervention have been developed in and around policy since the middle of the 20th century, and it is important to consider Mexican Protección Civil in the context of these trends. The development and inconsistent integration of the security apparatus in question has been supported and confounded by distinctly Mexican conditions.

In the context of seismic instability and other kinds of pressing hazards as well as limited resources, when centralized technoscientific knowledge fails to conjure effective disaster prevention or enact persuasive sovereign power, it is culture — everyday social practices and beliefs of Mexican publics— that can be made not just a site of intervention, but explanatory of failures, which are often always already considered to be underway. Earthquake early warning resonates with such priorities. The affordances of Mexican seismicity, and contestations around how it matters allow such technoscientific interventions a kind of integration with the security apparatus— an uneasy one, of course.

CONCLUSION

In May 2016, just as I was finalizing this dissertation, Armando Cuéllar of CIRES sent out an email to a handful of the directors of the NGO, CC'ing me as well as the Research and Outreach team. The subject line read "The alert sounds like this in Gustavo A. Madero." Cuéllar had written a short note about an "important testimony" during an alert on May 8th, and appended a YouTube link.

It had been seven months since I had visited Cuéllar's office, more than two years since I had first sat on his sofa while he sketched out a diagram on scrap paper to explain some phenomena or relation, and perhaps four years since my first encounter with the system maps in the meeting rooms in the front lobby of CIRES headquarters. I have, over this time frame, come to have great hopes for earthquake early warning, in spite of its fraught situation in Mexican disaster prevention. I clicked through, hoping that an "important testimony" would be a demonstration of the alert's utility.

The video starts dark and with a warbling earthquake alert. Something flashes across the frame. A hand, maybe. There is motion in the pixelated dark. A man's voice calls "Earthquake! Mom! Earthquake!" There is more darkness and the sounds of a door opening, movement, a dog's barks, and then the brilliant light of streetlamps on a long white wall. The man filming announces that he's begun to feel the quake. He is standing on a sidewalk in the early-morning dark, panning back and forth with what must he his phone to catch shots of a few of his neighbors, their dogs, a row of cinderblock houses, an expanse of pavement, and street trees shaking in the earthquake. The alarm stops and he asks a neighbor, “Did you feel it?” They talk and laugh. The dogs bark.

Mexico City is still broadcasting the alert from loudspeakers, and has continued to do so although efforts last September were troubled by mixed alert reception. When the loudspeaker broadcast was first introduced in September 2015, people complained about being frightened by an earthquake early alert blaring outside with no earthquake to immediately follow and commentary among the seismic community, media, and ordinary conversation began to reference “the boy who cried wolf.” I had some concern that the broadcasting experiment would be short-lived if people complained of its effects and popular sentiment suggested that the alert could not be relied upon.

As of May 2016, however, the alert broadcasts even in Gustavo A. Madero, Mexico City’s northernmost delegación, which is by no means built on sensitive soil. Alerting strategies proliferate, sometimes ramifying into the production of private alerting services, some into debates about public earthquake early alerting—which are tightly associated. Tensions over who should alert, how alerting should be done, and who should receive alerts have not dissipated.

Seismicity makes plenty of room for different kinds of encounters. The quake that shook Gustavo A. Madero and the YouTube videographer was measured at Magnitude 6 by the Mexican National Seismological Service. A handful of comments told very different stories about it, though. “Where I live, a pendant I have in my room moved a little but only barely…[221]" read one. Another suggested gently that keys and a flashlight might have been more useful to grab than his mobile phone, and that beginning to record video before he had evacuated his house had likely slowed him down.

Broadcasting the alert is bound to catch people in different seismic contexts. Some will feel quakes and some would not. Technological systems will misfire, and public education about seismicity and the alert itself might be lacking or unconvincing. Regardless, broadcasting offers a great opportunity for getting information about oncoming earthquakes to people who could make use of it. Government offices, businesses, and schools might have dedicated alert receivers, and TV and radio stations may pass on the alerts they receive, but those cannot reach everyone, especially not late at night. Alerting apps like SkyAlert are gaining popularity, but even Mexicans with smartphones may not have internet connections, and those who have both may find the utility of the apps hampered by lag. The loudspeaker broadcast was not helpful to people with hearing difficulties, but it is far more inclusive than other options.

I was heartened, then, to see the evacuation that Cuéllar had sent to me; to hear the siren and be taken along with Pedro Nares, who posted a video of his quick evacuation from his Gustavo A. Madero home to YouTube. Mexican performance of sovereignty has, since 1985, integrated seismic disaster prevention as a key element of security apparatus—indeed, as Protección Civil was developed in the wake of 1985 and many institutions for disaster prevention founded simultaneously, seismicity has been a key and formative hazard for

[221] "en dónde yo vivo apenas movió un colgante que tenía en me habitación pero apenas….."

parts of the Mexican security apparatus in some of the same ways that the Cold War or the War on Terror have been for the US.

This has historically been no guarantee that the Sistema Alerta Sísmica Mexicana would have the support of the state, especially in the context of the troubled arrangement and partial integration of security apparatus across the nation. Earthquake early warning has been subject to both of state support and neglect, rolled into complex logics of risk that identify social practice as both a key site of intervention and of necessary failure. For now, at least, the Sistema Alerta Sísmica Mexicana is being disseminated widely in Mexico City—and while that is not the same thing as broad dissemination throughout the nation or even dissemination pared with substantial public education, it is nonetheless a success to be celebrated.

Meanwhile in California, another famously and politically seismic place, a public earthquake early warning system is looking less and less likely. Dissemination is still up in the air, and funding for really launching the system continues to escape the team advocating for its development. The ways that this technoscientific system can transform the experience of earthquakes for users has been held up; seismicity's affordances make such interventions possible but also frame significant challenges for integrated development of a public system. There, insiders suggest that contradictory priorities and approaches will be allowed to flourish in many privately funded and disseminated earthquake early warning systems rather than a single public one.

Seismicity affords multiple approaches to alerting, and as technologies and techniques for sensation, analysis, and dissemination proliferate, political contests over earthquake early warning remain contested, necessary and public. What good alerting looks like is not entirely clear, which makes earthquake early warning a site for divisive ideas about priorities and practices. The pressures and affordances of the phenomena are such that that advantages of one model over another are not altogether clear.

While earthquake early alerting is often discussed in terms of preparation for "the next big one," the technology incorporates smaller quakes in analysis and alerting—and these quakes can themselves produce earthquake emergencies, trouble reputations, or be the basis of claims (or efforts to undermine claims) of authority. Ongoing seismicity is only part of the more-than-seismic environment in which earthquake early warning technology needs to be integrated, though, if it is to register and make sense of seismic motion. Mexican territory is not the only complex context that the Sistema Alerta Sísmica Mexicana has to be integrated into.

In the practices, goals, and contests that make earthquake early warning possible, the ways in which disaster prevention rationalities rely upon and resonate with anthropological figurations of environmental systems to render a complex relation between hazard and human society informed by enlightenment-era models of human agency. These models propose relations between social world and hazardous environmental conditions, figuring disaster as something that intervention in the social world can prevent even if, as with Mexican seismicity, human action is not its primary cause.

Here, seismicity is made to be meaningful as a hazard, though not, as I have argued, in the context of coherent and consistent practices and goals on the part of the technoscientific experts involved. Recent and not-so-recent approaches to the geological world have proposed new ways of thinking life and nonlife, histories of the earth, and laws of physics with geontologies. Thinking about how material, social and technical systems are related has been key to seismic disaster prevention. Significant seismicity, or seismic hazard, is by no means a simple category. Just as disaster has been figured the product of social, material, and technoscientific elements, so to are understandings of seismicity's impacts. Everywhere underground, thermodynamic movement of tectonic plates and the subsequent release of seismic energy through soils, water, built environments, bodies and air is always happening, and while predicting these motions still evades technoscientific efforts, registering and analyzing them, and putting that data to work does not.

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