The role of electronic communications during the pandemic

In normal times, electronic communications are, of course, a great convenience to most of us, providing information, connectivity to family and friends, access to on-line commerce, and many forms of entertainment.

Electronic communications play a much more important role in off-nominal situations. During fires, civil unrest, local emergencies, and so forth, such electronic communications form the backbone of response planning, coordination, and management. That is how data are gathered that allows the appropriate authorities to understand the evolving problem, to craft a response, to implement the response, to gather additional data that can be used to adjust the response, and so forth.

In fact, in certain types of emergency situations, recovery is simply not possible without such electronic communications. For example, the Electric Infrastructure Security Council [https://www.eiscouncil.org/] has analyzed events that could cause large-scale (sub-continental- and continental-scale) outages of electric power; if such a large-scale outage were to come to pass, it is literally impossible to re-start the electric power grid without some form of electronic communications.

Events that were identified by the Electric Infrastructure Security Council as potential triggers for such large-scale power outages include cyber attacks on electric power distribution equipment, and electro-magnetic pulse events (which can be both natural, and human-induced). In their book "Electric Infrastructure Protection (E-PRO) Handbook III"[Paul Stockton, editor-in-chief; Paul Stockton and Neil Siegel, authors. Electric Infrastructure Security Council, 2018. The chapter on emergency electronic communications systems is available at https://neilsiegel.usc.edu/contributions-to-the-literature/] they describe the scenarios that can cause such large-scale outages (which they call "black sky events"), and describe a set of policy and technical steps by which both the likelihood of such events can be lessened, and also by which – in case such an event happened – recovery can be implemented faster.

In fact, the key technology that they describe for facilitating recovery in the event of such a black-sky event is an emergency communications system that would survive such an outage, and be able to operate for a material period of time even in the absence of electric power from the regular power grid. The ability to have such an emergency communications system would save hundreds of thousands of lives, by enabling far-faster recovery. So, electronic communications systems can be more than a convenience and a source of entertainment!

Let's look at the role of electronic communications systems in the current Covid-19 pandemic. Let's consider the management of the actual pandemic first. Data must be gathered, processed, and distributed, not only to public-health, medical, and political personnel, but also to the general public. People need/want to know information about daily new cases, daily new deaths, local hospital capacity, and many other items. The hospitals must be prepared to coordinate with each other; perhaps one hospital is full, and new patients must be diverted; there are many other ways in which hospitals must coordinate. In Los Angeles, where I live, in order to create additional hospital capacity, local hotels have been converted to isolation wards, where patients who test positive for Covid-19 but (at least, for the present) are asymptomatic or do not require any extensive medical treatment are kept. This procedure – which is very important, because it materially reduces the demand for beds within the actual hospitals – requires electronic

communications to new locations, ones that are not traditionally a part of the medical system. Testing for Covid-19 is also generally done at locations that are not a part of the traditional medical system, such as parking lots that offer drive-up testing; people do not even leave their cars. Many other improvisations to improve medical capacity, and to optimize utilization of trained people and facilities, are underway, and all of these require electronic communications for planning, monitoring, and management.

Note that these improvised extensions to medical communications and data system must still comply with existing laws and regulations regarding patient privacy and the security of medical records in electronic form.

Only a small portion of the population is actually sick with Covid-19 at any given time, but almost all of us have been affected by safer-at-home orders, orders closing schools and businesses, orders changing the way that other businesses operate, and so forth. This aspect, while not directly a matter of healthcare or public health management, literally affects nearly everyone in the world at this time. Let's consider the role of electronic communications in this aspect of the pandemic.

According to data about surges in on-line ordering, many people are ordering groceries on-line, and having those groceries delivered directly to their house. Another method that is increasing in popularity is ordering groceries on-line, and then driving to the grocery store, where the groceries are brought out to your car, and placed into the trunk (boot) of your vehicle, without you ever having to get out of the vehicle. Public health authorities have indicated that both of these methods to acquire groceries are safer than going to the grocery store yourself. Purchasing groceries on-line was not a widespread phenomena in my area before the Covid-19 outbreak, so this is an example of a new adaptation, and of course, this mechanism only works when there are reliable electronic communications systems in place.

At present, I am a professor of engineering at a university, and in the spring 2020 semester, I was teaching two undergraduate classes. These were being conducted as traditional in-person classes, each with 35 students. The students and I enjoyed meeting face-to-face, and were moving appropriately through the class materials.

In early March, of course, all that changed: the university mandated that as of 11 March 2020, all classes would be taught exclusively on-line. Fortunately, I had taught on-line before, and was able to make the change. Of course, teaching on-line depended *entirely* on electronic communications. One aspect that was very important but not obvious at the start (at least, not to me!) was that my students would quickly be dispersed; the university no longer thought that it was safe to have large numbers of undergraduate students in their fairly high-density on-campus housing. So, students moved home; more than 80% of my undergraduate students were U.S. citizens, and so moved to various places around the U.S., but the remainder of my undergraduate students were citizens of other countries, and some of them elected to return to their home countries. Suddenly, not only was I teaching on-line, but I had students spread across the globe, some literally in time-zones 12 h different than Los Angeles, and some in locations with less-than-optimal internet connection.

With a little experimentation, my students and I figured out how to make all of this work, even across time-zones and to locales with slower/less-reliable internet connections. It took a little more of my time (even allowing for the time-savings of not having to drive to

and from campus), but the results were good: the students did as well on their homework and examinations as students from previous semesters.

Here's how we did that:

- I did not use live video of me as a "talking head", or ask my students to use live video of themselves, either; this would require a lot of bandwidth, and would disadvantage those students in locations where good bandwidth was not available [Actually, internet bandwidth in my own neighborhood is only so-so. This is not exclusively a question of "first-world" versus the "third-world"!]. Instead, I "projected" my slides and white-board, and instead of using the audio track over the internet, I used a regular phone line to source my audio track; the students reported that using the phone line as the source of the audio feed worked *much* better that sending the audio track over the internet.

- We handled questions during a class session mostly through chat; the students liked that a lot, perhaps because it allowed them to ask a question privately to me. I could answer the question without having to identify the student that asked it. Or perhaps chat is just a modality that today's students prefer to use. I also stopped frequently and asked for questions.

- We used email to schedule a *lot* of one-on-one phone calls to help students.

- I allowed students to submit partial homework assignments in advance of a due-date, and I would provide them with feedback about whether they were on the right track, and if not, help them determine the appropriate methodology for solving the problem. Of course, I did this before the pandemic, too, but previously, this was mostly handled during office hours, or by short conversations right after class.

- My classes always involve the use of small teams (5 to 7 students). We were able to use the networking tool provided by the university to start a class with everyone (me, the teaching assistant, and all of the students) in a single virtual "room", and when were ready for team exercises, were able quickly to break the class into a number of separate virtual "rooms", one for each team, and then return to a single virtual "room" at the end of the class session, so we could discuss homework assignments, and so forth. When the student teams were in their separate "rooms", the teaching assistant and I were able to move from team to team, dropping in just the way we would in class on each team to take questions and to provide feedback.

- My classes usually involve presentations to the rest of the class by these student teams. We were able to do that virtually, too. In one case, the time-zone change was so extreme that that student elected (with my permission) to record his portion of the presentation, and his team simply played his recording at the right moment in the presentation.

The authorities have asked us to "socially isolate". I hate that term; what they mean is for us to *physically* isolate, so that we do not inadvertently spread disease one to another. But humans need social contact, and this is another role that electronic communications have played during this pandemic. Our family, for example, have held birthday parties, religious observances (e.g., our family's Passover seder), and other gatherings on-line. I have a list of people that I call and/or write to on a regular basis. Thanks to our electronic communication systems, I may be physically isolated, but I am *not* socially isolated!

And of course, we are all interested in overcoming the pandemic, through improved treatment, better interim protections, and vaccines. The research teams that are doing all of these things are operating at least in part in a geographically-distributed fashion, connecting and coordinating their efforts through electronic communications. The limitations of such geographically-distributed science and engineering have been studied; I myself have published papers on the subject ["Collaborative Creation of Engineering Artifacts by Geographically-Distributed Teams", Neil Siegel and Azad Madni, 17th Annual Conference on Systems Engineering Research (CSER). Available at https://neilsiegel.usc.edu/contributions-to-the-literature/.]. Despite these limitations, these teams are moving forward. I myself started a research project on Covid-19 that involves experts from both the school of engineering and the school of medicine at my university; interestingly, I have never met *any* of my collaborators in person! I approached the Dean with my idea for a project, and he introduced me to a key person in another department of the school of engineering, and to the Dean of the school of medicine, and through them, I found my collaborators. All of our planning, coordination, modeling, research, publication, and assessment has taken place over the internet. There are some of our team members who do experimental work, both on campus and in the hospital, and they then bring their findings to the rest of the team via the internet. Someday, I hope to meet all of these wonderful people in person!

I believe that some of these new roles for electronic communications in our lives ought to endure once the pandemic has been overcome. I hope, for example, that more people will continue to work from home for some portion of the time; the in-person contact of physically-co-located work is vitally important to creating good team-work, but the benefits of reduced commuting, less pollution, and better work-life balance provided by home work ought to be retained at some level. The opportunity for geographically-distributed collaboration is profound in fields far beyond the examples that I cited above in engineering, science, and education; for example, my wife teaches dancing; she now has twice-weekly classes with attendees from all over the world. I also would like to see the old model of all-in-person instruction at universities change to a better balance between in-person and remote instruction; students can time-shift lectures, interact with their instructors via chat, and collaborate with other students at a distance for some portion of the time. This will involve significant changes to the economic models of universities that have invested heavily in on-campus housing (e.g., perhaps alternate semesters of in-person and remote); over time, this could significantly lower the cost of college education. I believe that education for younger students should involve more remote learning, too. My niece is taking high-school chemistry this summer; the remote learning model worked far better for her than an in-person model would have, as she benefited enormously from the opportunity to move at her own rate, to re-work homework multiple times, and so forth. Hybrid models of education that blend in-person and remote learning are likely to be superior to today's all-in-person models, with their built-in expectations that every student can learn at the same rate.

Guest Editor Biographies

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