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Our knowledge of knowledge infrastructures: Lessons learned and future directions

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# Our Knowledge of Knowledge Infrastructures: Lessons Learned and Future Directions

Report of Knowledge Infrastructures Workshop, UCLA, February 26-28, 2020  
Funded by the Alfred P. Sloan Foundation, Data and Computational Research Program

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Release Date of Report: June 5, 2020

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## Abstract

The Knowledge Infrastructures Workshop conducted at UCLA in February 2020, and funded by the Alfred P. Sloan Foundation, revisited the goals and findings of the 2012 workshop held at the University of Michigan. Thirty scholars, from a diverse array of disciplines and backgrounds, charted a course for the next decade of KI research. Such infrastructures are increasingly fragile, and often brittle, in the face of open data and open source, the demise of gatekeepers, and shifting public and private boundaries that redistribute power. Participants identified new methods and new opportunities for studying KI. Among the many scholarly products they proposed are publications, grant proposals, conference sessions, and workshops on the role of libraries in data services, the death and afterlives of KI, misinformation and disinformation in KI, KI in the Anthropocene, “N simplish rules” to grow and sustain KI, university capacities for KI, designing sustainable KI, and inclusion of underrepresented groups in the design of KI. The report, position papers, and other materials will be maintained at the KI workshop site, <http://knowledgeinfrastructures.org>.



*Figure 1: Group photo of workshop participants.*

## Workshop Background and Goals

Eight years ago a group of scholars from science and technology studies and information studies gathered at the University of Michigan to discuss “knowledge infrastructure” as an intellectual construct to study modern processes of knowledge production (Edwards et al., 2013). The 2012 workshop drew upon Edwards’ (2010) definition of knowledge infrastructures (KIs) as “robust networks of people, artifacts, and institutions that generate, share, and maintain specific knowledge about the human and natural worlds.” In this framing, the distinguishing features of a KI are ubiquity, reliability, and durability: when a KI breaks down, it results in social and organizational chaos. A KI is not one system, it is instead a multi-layered, adaptive effort in which “numerous systems, each with unique origins and goals, which are made to interoperate by means of standards, socket layers, social practices, norms, and individual behaviors that smooth out the connections among them” (Edwards et al., 2013). This framing aimed to capture routine, well-functioning knowledge systems such as the world weather forecast infrastructure, the Centers for Disease Control, or the Intergovernmental Panel on Climate Change.

The report of the 2012 workshop, titled *Knowledge Infrastructures: Intellectual Frameworks and Research Challenges*, highlighted seven challenges facing KIs, which are embedded in “a world of abundant information, hyperlinked ideas, permission-free resources, highly public interaction, and massive, unresolved disagreement” (Edwards et al., 2013):

1. Constant renegotiation of what counts as knowledge products, and of the divide between knowledge producers and consumers
2. Changing roles of tacit knowledge and common ground, as KIs are experiencing a reduction of face-to-face interactions, and an increase in online-based, long-distance collaborations
3. Risks of data commodification, misinterpretation, and misuse, as data sharing and reuse practices are adopted across domains
4. Redefinition of what counts as facts, as data science methodologies uncover patterns that cannot be fully explained (i.e., the “causation vs. correlation” argument)
5. Emergence of new modes of knowledge assessment, as a consequence of massive shifts in publishing practices
6. Need for funding and vision for sustainable KIs, as knowledge products are not stable entities but ones that change, evolve, and potentially break over time
7. Realizing the role of standards and ontologies in both constraining and empowering production of novel knowledge

From February 26 through 28, 2020, we convened a second workshop to examine the current state of knowledge infrastructures and to plan for the next five to ten years of research by charting future directions and forming a cohort of researchers to explore those directions. We addressed two goals.

**Goal one: Lessons from the field.** The first day of the workshop was dedicated to analysing empirical case studies, or “Lessons from the field,” that report on, problematize, exemplify, or depart from the seven challenges of KIs identified in the first workshop. We invited participants to submit 1,000-word thought pieces. These were intended to address KI cases such as these:

1. Repurpose data and code from multiple sources, in unexpected applications

2. Rely on decentralized, large-scale collaborations between people from different backgrounds and with diverse sets of expertise
3. Lead to instances of misleading or improper use and reuse of knowledge products, in particular data and code (e.g., Facebook’s emotional contagion studies)
4. Engage with analytical practices that can result in unfair, black-boxed, unaccountable predictions (e.g., bias in machine-learning)
5. Propose new modes of knowledge assessment, such as practices of pre-publication hypothesis recording, pre-prints publishing, post-publishing peer review practices
6. Design strategies for sustainable KIs, such as digital libraries for long-term access to research data
7. Deploy standards and ontologies to the goal of enabling interdisciplinary data reuse and knowledge production
8. Engage with the ethical and moral dimensions of generating and archiving data about protected populations and the role of KIs in ethically/unethically policing access to data

**Goal two: Future directions.** In days two and three, workshop participants charted a course for the next decade of knowledge infrastructures research. These are among the open questions posed for discussion:

1. What can new directions in infrastructure studies contribute to understanding contemporary KIs, in theory and practice?
2. How do KIs differ from other kinds of information-based infrastructures?
3. What happens when KIs interact with other infrastructures (e.g., digital media, private sector, markets, etc.)? Can KIs be studied in isolation?
4. What features and challenges of KIs are emerging that were not previously identified in the first report? How can we go about studying them?
5. How do we conceptualize the ends of infrastructures – monsters, zombies, feral, ruins?

### **Scholarly Foundations for Knowledge Infrastructures**

Edward’s definition of knowledge infrastructures has been subjected to centrifugal pull of KI, with Jackson (2014) highlighting the role of maintenance and repair in KIs, finding parallels in infrastructure studies with feminist scholarship on the ethics of care (Mol, 2008; Tronto, 1993) as central to the maintenance of human relationships. Media scholars have pointed to the “platformization” of knowledge infrastructures, where “platforms” are defined as business-driven, modular systems whose “affordances support innovation and creativity, yet simultaneously constrain participation and channel it into modes that profit the platform’s creators” (Plantin et al., 2016). Famous attempts to turn KIs into platforms include the Google Books project, which started in 2004, and, more recently, the emergence of AI-driven platforms for scholarly communication (Posada & Chen, 2018). Both of these reframing of KIs extend, and in subtle ways challenge, Edwards’ original definition.

KI itself has been broadened in other directions by Edwards (2017), who has posited knowledge infrastructures as a way of knowing, or accounting, for carbon use in the Anthropocene, and Bowker (2016) who asks how knowledge infrastructures are both formed by and formative of our knowledge practices. Boyer (2017) similarly conceptualized energy infrastructures as a system that accumulates and concentrates energies, unleashing them to uncertain effect. To



stimulate dialogue, the workshop will put these issues on the table and place them in conversation with recent literature in anthropology and sociology that introduces new concepts in infrastructure studies, such as temporality (Appel et al., 2018; Bowker, 2015), ruination (Howe et al., 2016), and suspension (Gupta, 2015). The political stakes involved may be most apparent at the starting and ending points of infrastructure (Harvey & Knox, 2015; Larkin, 2013).

## Workshop Design and Organization



Figure 2: Gatekeeping breakout group signs in Carnesale Commons at UCLA. Photograph by Keith Locantore.

We conducted the three-day workshop at UCLA with 30 scholars (including ourselves) that formed new relationships and furthered existing relationships.

### **Position Papers**

As means to facilitate meaningful conversations and form fruitful relationships, we distributed this set of questions in advance, to which each participant responded in a brief (1,000 word) essay.

1. What are the most urgent research questions to address about KI? Why?
2. Identify or describe a KI whose survival is under threat.
  - a. What led to these threats? Over what time frame?
  - b. What actions or changes in circumstances might lead to its survival?
  - c. What will be gained or lost, by whom, if this KI fails to survive?
3. How do KIs spread information? Misinformation? Alone and in combination with other infrastructures?

The essays were posted on a private area of the workshop website (modelled on (Howison, 2016)) for comments and reflections, to serve as a starting point for workshop conversations and breakout groups. For those who opted in to publishing their position papers, in initial or revised form, these essays are posted in the [University of California eScholarship repository](#) and linked from the workshop [website](#).



Figure 3: Workshop participants listening to Devan R. Donaldson. Photograph by Keith Locantore.

### **Workshop Organization**

The three days were organized in units that would facilitate the workshop goals (Appendix 2 contains the full agenda).

#### **Day 1 (Wednesday, February 26, 2020):**

The first morning was critical for setting the tone, scope, goals, and process of the workshop. Christine Borgman and Josh Greenberg first laid out our goals and plans, then Paul Edwards, who led the 2012 workshop and coined the term *knowledge infrastructures*, offered reflections on where the field and concept are now.

The remainder of the morning was devoted to three breakout groups based on the three themes of the 2012 report.

1. How are knowledge infrastructures changing?
2. How do knowledge infrastructures reinforce or redistribute authority, influence, power, and control?
3. How can we best study, know, and imagine today's (and tomorrow's) knowledge infrastructures?

We assigned participants to these three groups based on prior coding of their workshop papers. The three groups were led by workshop organizers Borgman, Darch, and Pasquetto. These groups later reported out briefly on their discussions about how these themes have evolved over the last eight years, as summarized below.

**Theme 1: How are knowledge infrastructures changing? (Moderator: Borgman; Notetaker: Washington)**

The theme 1 group assessed how knowledge infrastructures have evolved since the 2012 workshop. We discussed how objects and issues have changed, with new foci such as open data, open source, open development, platforms, artificial intelligence, and a general movement toward online activities. Second, we identified new problems that have arisen in KI, such as resource capacity, skills gaps, decontextualization, demise of gatekeepers, decreasing role of libraries, shifting boundaries, vertical integration, and enclosure movements. Third, we grouped themes of changing KI. These included shifts in existing actors such as policy makers, libraries, museums, and standards. Governance and participation were broad themes that included factors such as small science with big data, agency, power, control, space for multiple knowledges, and recruiting effort. We returned to Paul Edwards's theme of "KI truces" to ask about access, interoperability, and inclusion. Lastly, we attempted to sketch the KI we want. Future goals include questions of speculative KI (with reference to science fiction), alternatives to surveillance capitalism (Zuboff, 2019), open and participatory governance, mobilizing forces concerned with privatization and monetization of KI, knowledge truces, and resurrecting the role of libraries in gatekeeping.

**Theme 2: How do knowledge infrastructures reinforce or redistribute authority, influence, power, and control? (Moderator: Pasquetto; Notetaker: Wofford)**

The participants of the theme 2 session discussed how science infrastructures can operate under conditions of "scarcity," where scarcity is intended in terms of funding, resources, time, and personnel. We asked questions such as: Given that the stability of the last 10 years is gone, how can scientists obtain the resources and sustain the relational network necessary for building and maintaining science infrastructures? Is "patronage" the right funding model? How will systems of governance and economic systems navigate scarcity? We discussed these questions from the assumption that decisions are made differently under condition of scarcity. An obvious move that we should expect would be toward efficiency. Under scarcity, every decision is high stakes and it is necessary to focus on short term goals. We should also expect resource concentration and internal redistribution of personnel. Will pro-social behavior decline? We also acknowledge that there has never been anything robust about KI, not even in times of abundance. Instabilities are built into KIs since their inception. However, while KIs always tend to be fragile, in conditions of scarcity, their brittleness becomes more apparent. We also discussed generative aspects of scarcity. Scarcity/fragility can be generative for some KIs, but not for everyone. Finally, the group agreed that "studies of KI under scarcity" should be a line of research going forward, and that studies of KI should enter in conversations with the political economy and the behavioral economics fields.



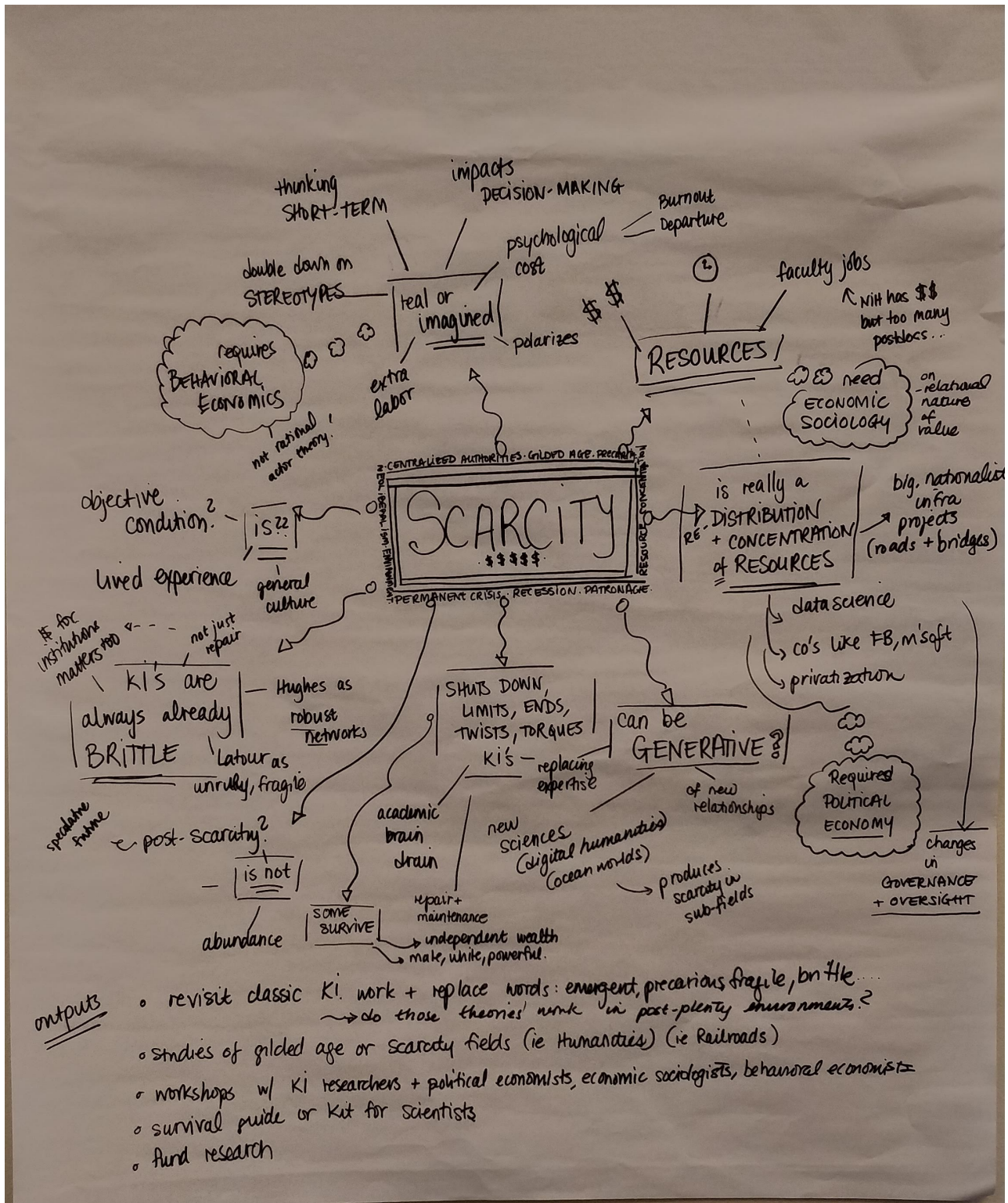


Figure 4: Diagram of scarcity in knowledge infrastructures drawn by Janet Vertesi. Photograph by Irene Pasquetto.

**Theme 3: How can we best study, know, and imagine today's (and tomorrow's) knowledge infrastructures? (Moderator: Darch; Notetaker: Locantore)**

The theme 3 discussion began by considering whether, and why, our current approaches to studying KI prevent us from recognizing some forms of KI. The concept of KI was initially grounded in the sciences, and in particular with respect to cyberinfrastructure and digital forms of knowledge production. Most empirical studies of KI have continued to focus on the sciences. However, it is important to identify and study what may be considered less “legitimate” or more incipient forms of KI. We then discussed what barriers exist to studying a broader range of KI. One is temporality – much humanities research unfolds on a longer timescale and across networks that are looser than in much of the sciences, which may mean that KIs are stretched too far for us to observe. Further, it is important to emphasize the physical dimensions of KI and the phenomena they encompass. We also addressed issues of scale, to shift emphasis away from taking KI projects as units of analysis, and towards networks or ecologies. Finally, we discussed the importance of reasserting the relational quality of KI, rather than studying large technical systems, as it provides a richer set of resources for imagining KI. It is important to avoid falling back on a managerial understanding of KI, which obscures effects on the people who are on the receiving end of KI capacity.

After lunch, we had the first three lightning talks (five-minutes each) by those who volunteered (See Appendix 2 for speakers and talk titles).

Wednesday afternoon was devoted a field trip to the Petersen Automotive Museum, a rich site of knowledge infrastructures. The Petersen also offered a direct complement to the 2012 workshop field trip to the Henry Ford Museum in Dearborn, Michigan. For our event, we provided participants with a “scavenger hunt” to engage them in seeking KI in the museum (see Appendix 4). Dinner was served in the museum restaurant.



**Day 2 (Thursday, February 27, 2020):**

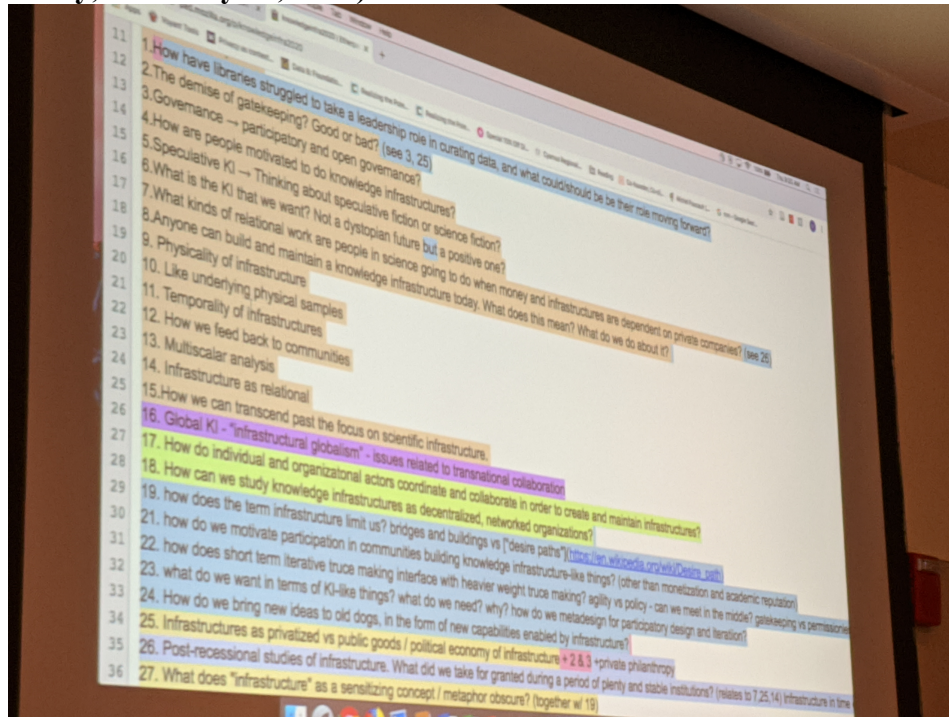


Figure 5 Brainstorming breakout groups on projector. Photograph by Keith Locantore.

Our second day was conducted as an “unconference,” based on topics emerging from the Wednesday sessions and conversations throughout the field trip and meals. We interspersed three breakout sessions, with up to five concurrent groups, with two sets of lightning talks. Participants were instructed to propose topics that would lead to a specific outcome such as a paper, conference session, grant proposal, or other scholarly product. These sessions were moderated by participant volunteers. Brief summaries of these topics and reports from their organizers are in Appendix 3.



Figure 6: Workshop participants listening to Steve J. Jackson summarizing the labor & livelihoods breakout group. Photograph by Keith Locantore.

At the end of the day, participants came to Prof. Borgman’s home for a locally catered “taco extravaganza” in the backyard. We had exceptionally warm weather, even for Los Angeles, which encouraged leisurely discussions under a California winter sky.

**Day 3 (Friday, February 28, 2020):**

We concluded the workshop with a writing day, which was a tremendous success due to the groundwork laid in the prior two days. Based on the morning’s organizing session, participants self-organized into a total of seven groups over two sessions. Each of these seven groups outlined a scholarly product and made commitments to conduct them. Our conference website will host the groups to the extent feasible, allowing individuals to work in private and post as appropriate. We created a large number of online notes and reports in multiple sites, including Google Documents and Presentations, Etherpad, and Hackpad. Our work from the first two days was consolidated into eight scholarly products, as discussed below.

**Scholarly Outcomes from the Workshop**

The workshop outcomes are in two categories. The first was to forge relationships among a new cohort of knowledge infrastructure researchers. While this outcome is difficult to measure, the richness of the discussions, the exceptionally high degree of interaction among the participants, the number and quality of topics addressed, the commitments to writing projects from the workshop, and the rate of compliments received by the organizers all attest to our success in achieving our goal of community building.

The second outcome is a set of reports (starting with this document), journal articles, conference papers, conference sessions, grant proposals, and blog posts in venues such as *Medium* and *The Conversation*. Future collaborations among the participants also are expected.

The eight outputs listed below were produced on the final day of the workshop. Participants opted into multiple projects, whose membership may change, thus names are not included here.



Figure 7: Breakout group listening to Anne L. Washington. Photograph by Keith Locantore.

### 1. “N simplish rules” to grow and sustain knowledge infrastructures

Building on the popular “ten simple rules” papers, but with greater flexibility in scope and format, this paper will formulate guidelines to grow and sustain open knowledge infrastructure projects. Each rule or guideline would include examples of existing knowledge infrastructures that exemplify these rules. The “paper” will be a living document updated regularly to reflect what KIs are and are not working in different communities. The goal of this paper project is practical impact on people thinking about community structure and design of open infrastructures.



*Figure 8: C. Titus Brown presenting a slideshow on N Simplish rules to grow and sustain knowledge infrastructures. Photograph by Keith Locantore.*

### 2. Designing sustainable knowledge infrastructures

We will write an opinion piece on the need to design sustainable knowledge infrastructures, using a point vs. counterpoint argument. While holistic planning remains valuable, top-down approaches lack flexibility. Contingency planning is also important for knowledge infrastructures. Thus, we recommend breaking down constituent parts of KI to identify where design interventions will be most effective for sustainability.

### 3. Death and afterlives of knowledge infrastructures

This topic will be addressed in a workshop proposal and an art installation, tentatively titled “Death, change, and afterlives: Knowledge infrastructures in transition.” Scholars in CSCW, infrastructure studies, and STS are proficient in describing how things begin, including processes of ideation, development, initial funding, innovation, and implementation. Relatively less attention has been paid to the latter phases of infrastructural lives, such as how infrastructures lose momentum, funding, personnel, etc. Little guidance is available for those facing the “sunsetting” of a KI, software obsolescence, or loss of other infrastructural elements. Challenges faced as infrastructures end also include migrating data and workflows, and navigating organizational, social, and emotional fallout. The initial workshop will be



clustered around position papers, with the goal of constructing guides for knowledge infrastructures in transition. Outputs may include materials for coping with knowledge infrastructure death, implications for design of afterlives, and a typology of endings. Among the communities to engage in these topics are the American Geophysical Union, Society for Preservation of Natural History Collections, and the Research Data Alliance. The funding proposal will prioritize participation of junior scholars and underrepresented groups.

**4. Misinformation and disinformation in knowledge infrastructures**

A journal special issue is proposed, to invite papers that take infrastructural perspectives on misinformation and examine how scholars of knowledge infrastructures are contributing to the study of scientific misinformation. Specifically, the issue will seek new perspectives on the provenance of false or misleading scientific claims, with a view to understanding how KI have altered the landscape within which such claims are generated or validated. For example, free or inexpensive commodity tools such as open-source statistics packages and spreadsheets have made it possible for actors with relatively limited knowledge and skills to generate data analysis, graphs, and figures that are nearly indistinguishable from professional scientific output. Open data and open code have increased transparency yet have also created conditions under which poor interpretations of data can multiply. Little is known about the provenance of misleading scientific claims upon which misinformation narratives rest. Which open data and software packages are science skeptics using to make their claims or construct “alternative facts”? Where do they find these data? How are data and software manipulated for political goals? How are “alternative knowledge infrastructures” built and maintained? When and how do these infrastructures relate or overlap with “official” KIs?

**5. Knowledge infrastructures in the Anthropocene**

A workshop is proposed to assemble corporate and academic participants at senior levels to discuss carbon footprints of KI. Participants would include researchers involved in environmental policy, information science, and others who manage intersecting infrastructures. Among the questions to be addressed are these: When and why do infrastructures use data to reduce their carbon footprint? What will the next generation of philanthropy look like? To lay the foundation for such a workshop, organizers will conduct a review of existing projects and promote the topic via blog posts.

**6. University capacity and outsourcing of knowledge infrastructures**

Decisions made by universities about services they provide, and how, receive little public documentation. Universities are outsourcing a growing portion of their KI capacity to the private sector, such as email, cloud services, course management systems, library databases, and academic personnel services. The more diverse array of services outsourced, and the greater the array of vendors involved, the less coherent and interoperable the university’s KI may become. This project envisions a website, or a case study report, consisting of brief descriptions of cases where academic institutions have either outsourced capacity or explicitly kept capacity in-house. Of particular interest are cases where outsourcing has broken down, such as PG&E cutting power to UC Berkeley for eight days in 2019, and when institutions have had to reacquire capacity, like Cornell ending their food service contract and providing their own food services. We will use these cases to explore how university KI capacity is changing, and influences on labor, professions, education, and work.

**7. Libraries and service units in today’s universities**

A blog post, Medium article, or other short communication will discuss how service unit expertise (libraries, research computing, etc.) can meet the new demands of data services. Although policy regarding data management has changed, the infrastructure has not kept pace. The piece will position libraries as a place where knowledge infrastructures are changing rapidly, thus leading to new collaborations, labor, and opportunities for research. The proposed publication will address the following questions: How can libraries continue to have an impact on quality control? What is quality control in a dis-intermediated world? How do libraries situate to other infrastructures? The piece will end with a discussion of needed change

**8. Expanding representation in open infrastructure projects**

This project will develop a slide deck, and later a course syllabus, to address how open infrastructure communities are governed and to develop strategies for including a diverse array of perspectives. A central goal is to promote strategies for building more inclusive participation, and thoughtful means to eliminate bad actors. The group identified ten commonly heard arguments for excluding underrepresented groups from open infrastructure projects. In response, they identified talking points to deflate those arguments, which are buttressed with data and references to reliable sources. The set of materials would be disseminated as a presentation, which could later become a course syllabus.

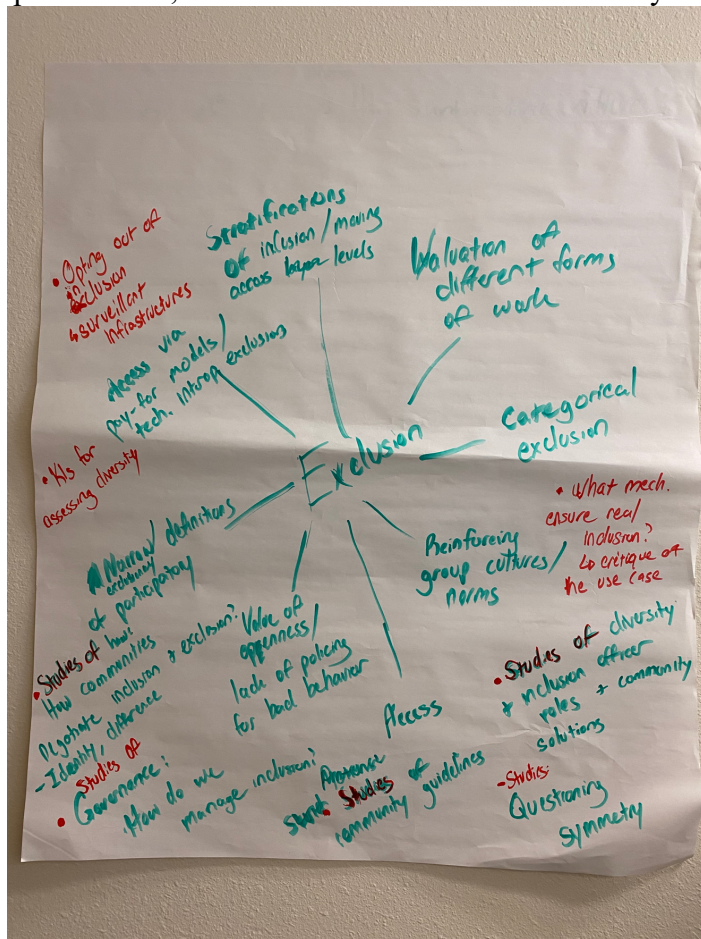


Figure 9: Diagram of different forms of exclusion in open infrastructure projects. Photograph by Morgan Wofford.

## **Summary**

The 2020 Knowledge Infrastructures Workshop at UCLA met its ambitious goals of assembling a diverse cohort of scholars interested in reflecting upon and advancing the state of the field. After two years of planning, we attribute our success first to the advance work of carefully identifying appropriate people and topics, providing explicit instruction to participants for developing a short position paper, to the commitment of our participants in reading background materials and each other's papers, and to effort devoted to workshop process. The balance of formal and informal time together, long breaks for discussion, distinct goals for each of the three days, a field trip to reflect on KI, and a focus on concrete deliverables from our time together all contributed to an effective scholarly contribution to the field.

## **Postscript**

In retrospect, the three days on which we held the workshop at the end of February was the last opportunity for such a gathering before the COVID-19 pandemic became a reality in the U.S. Participants had just arrived in Los Angeles when the virus was declared an epidemic. Despite the lack of official restrictions at that time, we took extra precautions such as providing sanitizer pumps for each table in the meeting room, asking people to wash hands as often as possible, and to be careful about physical contact. No social distancing rules were in place at the time. Participants are continuing to communicate remotely, and we hope that everyone's enthusiasm for collaboration continues, despite the new "shelter in place" reality. We are grateful to have had such an exceptionally rich and productive time with our colleagues when we were able to do so. In reviewing the workshop conclusions two months into the pandemic lockdown period, our findings and recommendations for knowledge infrastructures are remarkably prescient.

## **Acknowledgements**

We are grateful to the Alfred P. Sloan Foundation for supporting the Workshop, and especially to Joshua Greenberg who helped to design and to lead the workshop. His contributions to content and to process were essential to meeting our goals. We also acknowledge the contributions of two of the initial workshop proposers who are not authors of the final report. Bernadette Boscoe chose to be a participant, rather than an active organizer. Michael Scroggins contributed to the development of the workshop but did not attend. Three other participants withdrew for health and family reasons after they had submitted their workshop papers: Geoffrey Bowker, Miriam Posner, and Kalpana Shankar. Keith Locantore, UCLA Information Studies graduate student, was a tremendous asset to the workshop by taking excellent notes and perceptive photos, and by assisting in logistics. Morgan Wofford, UCLA CKI Data Scientist, provided superlative support in developing and executing the workshop, and still had the opportunity to participate fully in our sessions.

## Appendices

### Appendix 1: Workshop Participants

Name	Affiliation	Discipline or Department
Amelia Acker	University of Texas at Austin	Information Studies
Jean-François Blanchette	University of California, Los Angeles	Information Studies
Christine L. Borgman	University of California, Los Angeles	Information Studies
Bernadette M. Boscoe	University of Washington	Information Studies
C. Titus Brown	University of California Davis	Biology
Renata G. Curty	University of California, Santa Barbara	Library
Peter T. Darch	University of Illinois, Urbana-Champaign	Information Studies
Devan R. Donaldson	Indiana University Bloomington	Information Studies
Paul N. Edwards	Stanford University	Science and Technology Studies
Ixchel M. Faniel	OCLC	Research Department
R. Stuart Geiger	University of California, Berkeley	Data Science
Joshua M. Greenberg	Sloan Foundation	Digital Information Technology program
Steven J. Jackson	Cornell University	Science and Technology Studies
Eric Kansa	University of California, Berkeley	Archaeology
Charlotte P. Lee	University of Washington	Human Centered Design & Engineering
Keith Locantore	University of California, Los Angeles	Information Studies
Robert D. Montoya	Indiana University Bloomington	Information Studies
Carole L. Palmer	University of Washington	Information Studies
Irene V. Pasquetto	Harvard University	Shorenstein Center on Media, Politics, and Public Policy
Jean-Christophe Plantin	The London School of Economics and Political Science	Media and Communications
Lindsay Poirier	University of California Davis	Science and Technology Studies
David Ribes	University of Washington	Human Centered Design & Engineering
Andrew L. Russell	SUNY Polytechnic Institute	History
Arfon Smith	Space Telescope Science Institute	Astronomy and Astrophysics
Andrea K. Thomer	University of Michigan	Information Studies
Janet A. Vertesi	Princeton University	Sociology
Jillian C. Wallis	University of Southern California	Health Policy & Economics

Anne L. Washington	New York University	Data Policy
Morgan F. Wofford	University of California, Los Angeles	Information Studies
Ayoung Yoon	Indiana University Purdue University Indianapolis	Information Studies



## **Appendix 2: Conference Agenda, February 26, 27, 28**

### **Wednesday, February 26 - Reflections on the 2012 Workshop**

- 6:30AM - 8:00AM: Continental breakfast available at UCLA Guest House Lobby
- 8:00AM: For those staying at the UCLA Guest House, meet in the lobby to walk or drive to Carnesale Commons
- 8:30AM - 9:00AM: Coffee and tea at Carnesale Commons (Hermosa Room)
- 9:00AM - 10:00AM: Introduction and greetings
  - Greetings from Christine Borgman, Josh Greenberg, and Paul Edwards
    - Reflections on 2012 workshop
    - Overview of workshop goals and organization
  - Three-word introductions from each participant
  - Guidance for first breakout round
- 10:00AM - 10:30AM: Break, transfer to breakouts
- 10:30AM - 11:45AM: Breakout groups
  - Group #1: How are knowledge infrastructures changing?
  - Group #2: How do knowledge infrastructures reinforce or redistribute authority, influence, power, and control?
  - Group #3: How can we best study, know, and imagine today's (and tomorrow's) knowledge infrastructures?
- 11:45AM - 12:15PM: Breakout group summaries from moderators
  - Determine session topics and interested moderators for the next day
- 12:15PM: Group picture
- 12:15PM - 1:15PM: Group lunch
- 1:15PM - 1:30PM: Lightning talks
  - Jean-Christophe Plantin. *The archive as a factory.*
  - Andrew Russell. *Manual labor in the digital age.*
  - Ayoung Yoon. *Community data ecosystem as a part of community KI.*
- 1:30PM - 1:45PM: Instructions for infrastructure scavenger hunt
- 1:45PM - 5:00PM: Depart UCLA for the Petersen Automotive Museum - Infrastructure Scavenger Hunt
- 5:00 PM - 8:00PM: Group dinner at Drago Ristorante (inside Petersen Automotive Museum)

### **Thursday, February 27 - Unconference Day**

- 6:30AM - 8:00AM: Continental breakfast available at UCLA Guest House Lobby
- 8:00AM: For those staying at the UCLA Guest House, meet in the lobby to walk or drive to Carnesale Commons
- 8:30AM - 9:00AM: Coffee and tea at Carnesale Commons (Hermosa Room)
- 9:00AM - 9:30AM: Regroup and brief overview of day's schedule and plans
- 9:30AM - 9:45AM: Separate into breakout groups
- 9:45AM - 11:00AM: Breakout groups #1
  - Group 1: Change in knowledge infrastructures, and infrastructures as decentralized organizations.

- Group 2: Knowledge infrastructures: Labor and livelihoods
- Group 3: Knowledge infrastructures in a time of scarcity
- Group 4: The role of gatekeeping in today's universities: libraries and service unit expertise
- 11:00AM - 11:30AM: Break
- 11:30AM - 11:45AM: Breakout groups summaries
- 11:45AM - 12:00PM: Lightning talks
  - Renata Curty. *Beyond carrots and sticks: In search for integrative and accountability mechanisms for Research Data Infrastructures.*
  - David Ribes. *Universal infrastructure and specific domains.*
  - Anne Washington. *Libraries, legitimacy, & labels.*
- 12:00PM - 1:00PM: Group lunch
- 1:00PM - 2:15PM: Breakout groups #2
  - Group 1: Gender, exclusion, and the nuances of participatory in knowledge infrastructures
  - Group 2: Science misinformation and controversies in alternative knowledge infrastructures
  - Group 3: The blurring of public and private infrastructures: Outsourcing, neoliberalism, and commercialization
  - Group 4: N simplish rules to grow and sustain knowledge infrastructures
- 2:15PM - 2:30PM: Breakout group summaries
- 2:30PM - 3:00PM: Break
- 3:00PM - 3:15PM: Lightning talks
  - Charlotte Lee. *Dynamics of coordination within and across scales and organizations.*
  - Carole Palmer. *Knowledge infrastructure for qualitative inquiry.*
- 3:15PM - 4:30PM: Breakout groups #3
  - Group 1: Automation and artificial intelligence in knowledge infrastructures
  - Group 2: Knowledge infrastructure truces: Competing claims about knowledge
  - Group 3: Death and afterlives of knowledge infrastructures
- 4:30PM - 5:00PM: Breakout group summaries and plans for the next day
- 5:00PM - 5:15PM: Depart UCLA
- 5:15PM - ?? Taco extravaganza dinner @ Christine Borgman's home

### **Friday February 28 - Collaborations and Writing Plans**

- 6:30AM - 8:00AM: Continental breakfast available at UCLA Guest House Lobby
- 8:00AM: For those staying at the UCLA Guest House, meet in the lobby to walk or drive to Carnesale Commons
- 8:30AM - 9:00AM: Coffee and tea at Carnesale Commons
- 9:00AM - 9:30AM: Regroup and talk from Josh Greenberg and Christine Borgman
- 9:30AM - 10:15AM: Collaboration session #1
  - Output #1: Short communication about libraries/service units in today's universities
  - Output #2: Workshop proposal and art installation on death and afterlives of knowledge infrastructures

- Output #3: Special issue on misinformation in knowledge infrastructures
- Output #4: Workshop about knowledge infrastructures in the Anthropocene including both corporate and academic participants
- 10:15AM - 10:30AM: Reports on collaborations and writing plans
- 10:30AM - 11:00AM: Break
- 11:00AM - 11:45PM: Collaboration session #2
  - Output #5: N simplish rules to grow and sustain knowledge infrastructures paper
  - Output #6: Site to post examples of universities abdicating or retaining capacity and then writing up the cases in more depth
  - Output #7: Opinion piece about designing for sustainable knowledge infrastructures.
  - Output #8: Locked slide deck that is disseminated about deflating arguments that support the exclusion of underrepresented groups from open infrastructure projects that would eventually turn into a syllabus
- 11:45PM - 12:00PM: Reports on collaborations and writing plans
- 12:00PM - 1:30PM: Group lunch and wrap-up
- 1:30PM: Departures of participants
- 1:30PM -5:00PM: Workshop organizers regroup for writing

### **Appendix 3: Day two breakout topic summaries**

These topic summaries are the reports of eleven breakout groups convened over the course of three sessions on February 27. On Day 3, February 28, these were consolidated into the eight scholarly products reported above.

- **Knowledge infrastructure truces: Competing claims about knowledge**

An overarching question to address in KI is how to handle competing knowledge claims. In an environment where KIs are dominated by large players such as Google, Amazon, and Facebook, where can competing knowledge claims be addressed? These conflicts are difficult to discuss, much less reconcile in an environment of Google searching, proprietary algorithms, and results tailored to individual users. More thinking is needed about the concept of “knowledge as truce.” We need more examples of how to reach truces and governance structures for negotiating competing knowledge claims.

- **Death and afterlives of knowledge infrastructures**

Knowledge infrastructure may end for a number of reasons, ranging from lack of funding to being incorporated into other infrastructures. Knowledge infrastructures are inherently fragile and often under threat from lack of funding, planning, or maintenance. Rarely do knowledge infrastructure die utterly; more often they continue in new forms, leaving behind traces, residues, and legacies. Many of these endings are undocumented, as success is recorded, while failure is hidden.

- **Knowledge infrastructures in a time of scarcity**

In the post-recession academic landscape, a permanent crisis caused by financial scarcity appears real. How can KI be studied in times of scarcity? Those responsible for maintaining infrastructures best understand their inherent fragility. The scarcity condition can be generative for new research, drawing upon theories on political economy, behavioral economics, and economic sociology.

- **Knowledge infrastructures, misinformation, and controversies**

Scholars of knowledge infrastructures can contribute to the study of misinformation in a number of ways. One area is to address participatory design of systems with science-hesitant communities. Another example is to apply KI expertise to curate datasets in ways that discourage misuse, both accidental and intentional, and promote understanding. KI researchers also can tackle misinformation by documenting provenance in ways that reveal how stories overlap and inform each other. Provenance documentation also can aid in determining what went right and what went wrong in producing specific information products.

- **Automation and artificial intelligence in knowledge infrastructures**

Artificial intelligence is a proxy for many other technologies and activities. Until recently, knowledge infrastructures were presumed to consist of human beings using technical systems. New technical systems are being given agency in ways not considered in current studies of knowledge infrastructure. These new forms of AI agency reveal how little is understood about how to form and sustain effective interactions between humans and automated systems.

Automation may remove tedious tasks from human control, but more needs to be understood about the consequences of these decisions for knowledge infrastructures.

- **“N simplish rules” to grow and sustain knowledge infrastructures**

Open source communities offer an array of models for developing successful infrastructures. We developed N (currently 24 and growing) rules to grow and sustain knowledge infrastructures. These include rules such as “grow a community worth sustaining” and “anticipate bad actors.” The goal is to make a practical impact on people thinking about community structure and design.

- **Gatekeeping in universities: Libraries and service unit expertise**

Service unit expertise (libraries, research computing, etc.) lags behind the growth of KI in universities. Students, staff, and faculty alike may turn to “the web” for expert knowledge before drawing upon the resources of their own universities. As disciplines from the sciences to the arts and humanities rely on informatics expertise, the “soft power” of service units (long term budget, attention, practical skill sets) has waned. Researchers need access to more local knowledge for data management, open science, open access, and other infrastructural decisions. This is a time to invest in these service units so they can aid the research community in making effective long - term decisions about sustaining their data, code, instrumentation, and other infrastructure components.

- **Outsourcing, neoliberalism, and commercialization of knowledge infrastructures**

The boundary between private and public entities is porous, requiring delicate navigation. Multiple strategies exist to become gatekeepers of infrastructures and to establish governance mechanisms. Knowledge infrastructures can be viewed as a stack of capabilities that universities support. What happens when parts of infrastructure are handed over from public to private entities? Where do universities abdicate their responsibilities and where do they retain them? What are the trade-offs between these decisions? Private entities are participating in a kind of procurement as innovation.

- **Change and decentralization in knowledge infrastructures**

This group examined how decentralized and networked knowledge infrastructures change over time and how we can study those changes and organizations. Processes of change in knowledge infrastructures can be top-down (funding agencies and leadership) or bottom-up (grassroots), reactive or proactive, ad hoc or planned. Infrastructure is relational but researchers need to study the specifics of those relations. With whom, when, and why is an infrastructure relational? Other research questions include, How can “decentralized” networks become infrastructures? How do actors maintain autonomy while working towards centralization or infrastructural coordination?

- **Labor and livelihoods in knowledge infrastructures**

This group discussed the livelihoods of people doing infrastructure work in regards to sustainability, power, equity, security, and outsourcing. A variety of workers and organizations need to build capacity for maintenance work. How do we make this goal actionable? We first have to identify what positions are actually doing infrastructural work, which is problematic given how much job titles, responsibilities, and descriptions vary. Researchers should attempt to

map career paths and compensation levels of different infrastructural workers moving through different systems. To make knowledge infrastructures humane, it may be useful to develop a taxonomy of perversity in different knowledge infrastructures and to assess the costs of under investing in infrastructural labor.

- **Gender, participation, and exclusion in knowledge infrastructures**

This breakout group discussed longstanding issues about who is supported by knowledge infrastructures and who is excluded. Whose knowledge counts as knowledge? How can knowledge infrastructures be used as weapons to exclude people? Even participatory cultures can be exclusionary when based on normative roles of policing and paternalistic culture. These cultures can be vulnerable to bad actors who take advantage of openness, participatory language, diversity, and free speech.

**Appendix 4: Petersen Automotive Museum Scavenger Hunt**  
**Petersen Automotive Museum**  
**UCLA Knowledge Infrastructures Scavenger Hunt<sup>1</sup>**

Our field trip to the Petersen Museum is an opportunity to explore many intersecting infrastructures, knowledge and otherwise. This scavenger hunt is a means to stimulate that exploration for individuals and groups. Please add questions and ideas of your own!

Knowledge Infrastructure:

- How many different KIs associated with automobiles can you identify?
- What examples of maintenance and repair are evident in each of these KIs?
- How have these KIs evolved over the 200-year history of the automobile?

Politics of KI:

- What car did France give to the leader of another country as a wedding gift?
- What VW bus is on the National Historic Register and why?

History of KI:

- What knowledge infrastructures led to, or ended each of these innovations? And when?
  - The first self-propelled vehicle?
  - The first electric-powered vehicle?
  - Autonomous vehicles?

Standards questions:

- Whose standards, from what KIs, facilitated or constrained the advance of these
  - Electric vehicles?
  - Gasoline-powered vehicles?
  - Flying cars?
  - Armored vehicles?
  - Amphibious vehicles?
- What can custom cars teach us about KI?

Technology for KI:

- What KIs are associated short-distance vs. long-distance racing? Why are they different?
- How has the KI of materials science influence the KI for automotive?
- What KIs are associated with the design of two, three, and four-wheeled vehicles? To what extent do these KIs intersect?

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<sup>1</sup> Compiled by Christine Borgman & George Mood, February, 2020

Miscellaneous and fun:

- What is the most useless car accessory ever designed? (hint: find the car hair dryer)
- Which of these cars would you most like to drive, and why?
  - DeLorean (Back to the Future)?
  - Land Speeder (Star Wars)?
  - Batmobile?
  - How do Low Riders clear the ground?



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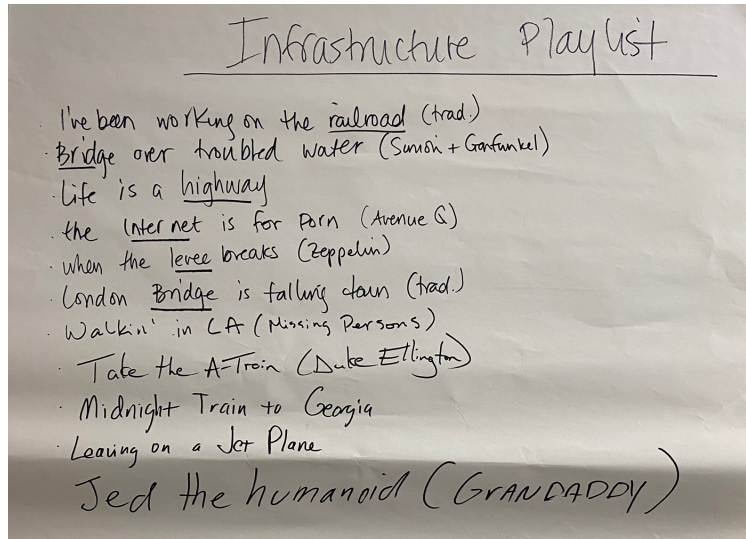


Figure 10: Infrastructure playlist. Photograph by Morgan Wofford.