Re-Engaging Technoscience in and beyond Science and Technology Studies

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Abstract

This *Crossing Boundaries* celebrates 20 years since the foundation of STS Italia, the Italian Society for the Study of Science and Technology, reflecting its ongoing commitment to disseminating STS and critical perspectives on the relationship between science, technology, innovation, and society, both in academic contexts and among the general public. Promoted by the Editorial Board of Tecnoscienza, this contribution brings together three authoritative voices exploring new frontiers in Science and Technology Studies. Barbara Allen examines the role of participatory science in environmental justice, highlighting the importance of involving local communities in scientific knowledge production. Barbara Prainsack proposes the use of systematic utopian imagination as a method to critically rethink technological futures, emphasizing the role of solidarity. Lucy Suchman offers an incisive critique of military datafication, questioning the epistemological premises of data collection and use in security contexts. Together, these contributions challenge traditional STS boundaries, proposing innovative approaches to re-engage with technoscience in ways that promote justice, equity, and critical reflection.

Keywords

participatory science; utopian imagination; data critique; environmental justice; solidarity; military datafication.

Environmental Justice, Participatory Science, and Policy Change

Barbara Allen

In reflecting on the potential value of Science and Technology Studies (STS) ideas to shape public discourse and policy change within environmental justice spaces, the primacy of participatory science as a mechanism for change, looms large. From issues of trust to deciphering opaque code and large data sets, including the public in a substantive way is key. To understand the rise of participatory science in addressing hazard problems in vulnerable communities, it's important to understand the complicated interrelationship between institutionally produced science and less formal ways of understanding the environment and human health. Public participation as a mode of shaping science aligns with the growth and popularity of engaged scholarship in the STS community as evidenced, in part, by the robust display of work in *Society for Social Studies of Science* (4S) "Making and Doing" program which is in its 10[th] year.

1. The Problem of Science in Environmental Justice Debates

Science has played an important role in environmental concerns and controversies over the past few decades, often as a pivotal element in regulatory decision-making. For this reason, unpacking the construction and use of science in environmental disputes provides a powerful lens for making knowledge inequities visible, particularly in polluted and vulnerable communities. The struggle for scientific knowledge has been well documented in the Environmental Justice (EJ) movement, predominantly in case studies where residents have formed alliances with scientists and experts to speak out against their exposure to toxic substances such as industrial and agricultural pollution (Allen 2003; Liévanos et al. 2011; Ottinger 2013; Harrison 2011; Brown 2007).

For residents of polluted places, science is often a barrier to having their voices heard – that is, the science produced by government agencies or corporations is a hurdle that citizens must confront to overcome. This idea of science as a barrier leads to three main issues of public disconnect in contested environments. First, the science that becomes regulatory science has little or no input from the people that live there. Residents typically have neither formal training nor a transparent mechanism to enter the regulatory science world. Furthermore, what knowledge they do have does not easily conform to the frame of decision-making science (Kimura and Kinchy 2016; Suryanarayanan and Kleinman 2013). Whatever policy input mechanism that might be provided for them as "participants" is often perfunctory and of little consequence in the final decision – they are only there to ratify what regulators have already decided, lending the facade of public acceptance (Irwin 2005). Second, excluding the empirical insights of residents from regulatory science creates a credibility gap, engendering further distrust on the part of the public (Wynne 1996). The science that is acceptable for official purposes is often socially remote and contextually segregated (Harding 2015; Nowotny et al. 2001), having little relationship to the lived experiences of citizens in contested environments. Third, the science that the residents desire – science that answers their questions about *their* health and environment and frames *their* empirical "lived" evidence in regulatory-relevant terms – often does not exist: it remains "undone science" (Hess 2016; Allen et al. 2017).

2. The Participatory Science and Policy Change Conundrum

Counter to the science disconnects mentioned above is the increased interest in participatory science among government agencies, NGOs, environmental groups, and the public. Participatory science functions as an umbrella concept for a wide range of activities and modes of engagement, including "citizen science" (Irwin 1995; 2015), "street science" (Corburn

2005), "popular epidemiology" (Brown 2007; Allen 2003), "consensus conferences" (Guston 1999), and "crowdsourcing" (Haklay 2013), to name a few. These cover an array of different practices and understandings about what lay people's contribution to science is or could be, ranging from citizens functioning as a collection apparatus for carefully circumscribed projects to the collaborative shaping of research questions, methods, and even data analysis. What "demarcates citizen science activities (of whatever sort) from more conventional science is that they build not only on the active participation of citizens but, also, and explicitly, *on their expertise*" (Irwin 2015, 35, *emphasis in original*).

Epistemic modernization (Hess 2007; Moore et al. 2011) has emerged as a counter to the closed practices producing state and corporate science, whereby lay-people and social movement groups participate in shaping science and the scientific agendas that impact them (Hess 2016). When people for whom science matters most can participate in shaping or making science, this leads to greater social and place-based contextualization of knowledge. Some science studies scholars argue that deeply situated science that includes the social distribution of expertise is often more empirically reliable, yielding higher quality, socially relevant results (Harding 2015; Nowotny et al. 2001).

For participatory science to simply advance an ongoing project is one thing – but "generating whole new knowledge structures and cognitive frameworks is quite another" (Irwin 2005, 3). In many communities facing environmental injustices, local residents have expressed their concerns about water and air quality, often related to concerns about health, but little changes. Giving voice to their concerns does not necessarily lead to structural and/or policy changes. The regulatory and political system is unjust, in part, because it does not "recognize" (Fraser 2009; Young 1990) their observations as sufficient justification for action to address pollution. Instead, their concerns are often refuted by regulators using quantified state science deemed valid by government agents. Even in cases where locals employ citizen science, like collecting air samples as evidence of poor air quality claims, their efforts or "voices" are diminished by regulators as "non-standard" or not "scientific" (Ottinger 2010). Given the uphill battle communities have "confronting" science that does not match their observations, what kind of work is needed? How can engaged scholars working on the ground with communities do to change the structural dynamics of knowledge – and better yet the environmental outcome?

3. Strategies for Effective Participatory Science

Engaged research around environmental justice issues, particularly environmental health, has had a mixed record of success. Davis and Ramírez-Andreotta (2021) address the question of effective strategies of participation for environmental justice by systematically analyzing over 150 case studies. To assess effective engagement, they examined both the dynamics of academics working with communities as well as the types of participation involved with communities. They were particularly interested in projects that led to structural change such as policy enforcement or revision, public service provisions, or increases in political power. From the case studies they theorized over 20 participatory catalysts for structural change in EJ engaged research including: i) study design and research questions informed by members of the community; ii) inclusion of a community advisory/review board; iii) data collected from more than one source, such as including both quantitative and qualitative data; iv) data "translated" and made more accessible for the community, the press and decision-makers; and v) decision-makers involved at some point in the process.

Translation of data and participatory science output is important for both local communities and state agents. For example, facilitating data interoperability (Göbel et al. 2017) is a way to "further leverage the power of scientific data for structural change" such that it can be translated for regulators and policy makers (Davis and Ramírez-Andreotta 2021). Additionally, collecting and analyzing the same kind of data that regulators use to inform policy decisions is also key in effective participatory science (Allen 2018). As an example, in my participatory research, we "workshop" epidemiology-based health data, inviting local focus group input and reflection from the people whose health is represented by the data. The participatory process of workshopping aligns with science communication research on attention and motivation (Lupia 2013). People have greater capacity (and working memory) for the understanding and personal processing of science if it connects to both: i) people's preexisting beliefs or empirical observations and ii) concrete events or outcomes that impact their lives or those that they care about (Lupia 2013). Strong participatory science, is both science that is trusted and used by regulators for policy purposes *and* science that is trusted, informed by, and used by residents to successfully pressure policy change (Allen 2020; Allen et al. 2019).

4. Scientific Citizenship

In concert with engaged scholars and participating communities, science allied agencies and institutions must realize their own cultural limits, and that they need to be structurally and cognitively open to new forms of knowledge and participation (Leach et al. 2005). The scholarship on participatory science for policy relevance in the environmental justice arena can be seen as a repositioning of "citizen science" to include official government science made more relevant through the deliberative processes of citizens. Participatory science in this instance is an "engagement object" to alter "the dynamics of trust and authority" (Kleinman and Suryanarayanan 2020, 687) in the coproduction of knowledge between state scientists and the lay public.

In the environmental justice arena, participation furthers the scholarship on scientific citizenship through which institutional approaches are made more inclusive, even transformed, via new kinds of "questioning communities" (Irwin 2015). This justice-oriented approach to scientific knowledge is part of emerging scholarship in STS calling for "generative justice" (Eglash 2019) and "generative projects" such that "scholars are learning and creating for and with non-academics in ways that highlight the many kinds of epistemologies, technologies, and labor that make up technoscience, and contribute to its reorganization" (Moore 2021) and to larger structural change.

Working towards epistemic justice through participatory science is supportive of an emerging "scientific citizenship", part of the process of reframing civic institutions and institutional approaches to doing science toward not only being more inclusive, but to also be open to new kinds of "questioning communities", a move that can strengthen both science and democracy (Irwin 2015).

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Systematic Utopian Imagination: A Case for Building Futures

Barbara Prainsack

Looking through the "most read" and "most cited" sections of leading STS journals, it is apparent that STS scholarship has its finger on the pulse of many societal developments. There is a lot of work on data practices and ethics, on robotics and artificial intelligence, as well as on public participation and engagement. At the same time, some of the keywords that I normally encounter, many times a day, in newspapers, magazines, and podcasts, are almost entirely absent. In a total of 200 STS journals' top-ranking papers in several journals, the term *climate* appears twice; *democracy*, or *democratic* comes up three times, and *autocracy* not at all. The reason for the latter could be that the term is mostly used in political science, but still: considering that the climate crisis, along with the decline of democratic values and respect for human rights[1], are among the most pressing challenges for societies across the globe – and given that science and technology play a role in both – the absence of an explicit engagement with these concepts is puzzling. How does this reflect on STS' engagement with current political and economic challenges? What, if anything, could STS scholarship do better?

STS is deeply political, in the broad and the narrow sense of the word. As Charles Thorpe noted, at the very minimum, STS is political in that it addresses ideologies and practices that "technologize the political order" (Thorpe 2008, 65)[2]. And STS is political also in other ways (see also Brown 2015; Simmet 2025). It often gives a voice to groups and perspectives that would otherwise remain unheard. Moreover, while many other disciplines treat technologies mostly as vehicles of progress, STS scholarship is attentive to the nuanced and at times contradictory effects that technological practices have on the distribution of power and agency. Digital innovations, for example, besides having brought tangible benefits, also entrench inequalities. Digital payment systems for the "unbanked", or educational apps for girls in gender-segregated societies, increase the agency of people, but they often also stabilise the oppressive systems that have limited their agency in the first place. STS scholarship has made great contributions to our understanding of the specific dynamics that lead to the inequalities that are coproduced with technological practices – and that are implicated in almost all societal crises. STS work has troubled assumptions in mainstream political discourse about "good" v. "bad" technologies, and challenged the idea that "innovation" is necessarily a solution for societal problems (e.g., Pfotenhauer and Jasanoff 2017; Jasanoff and Kim 2019; Birch and Muniesa 2020). It has also added nuance to hegemonic narratives about the contributions that technological innovation is making to our economies. For example, STS scholars have argued that a major part of innovation in recent decades has increased capital gains more than it has contributed to the rest of the economy[3], and drawn attention to "the dark side of innovation" (Coad et al. 2022; see also Vinsel and Russell 2020; de Saille and Medvecky 2020). While innovation that creates public value is as important as ever, there is a large part of innovation that does not do that – and that exacerbates societal problems and inequalities rather than mitigating them. By drawing attention to these nuances and tensions, STS scholarship invites us to imagine technology use that promotes justice, inclusion, and solidarity, rather than economic profit and growth (e.g., Benjamin 2019; 2024).

At the same time, many STS scholars have been hesitant to spell out these imaginations. Analyses within the sociology of expectations, for example (Brown and Michael 2023; Van Lente 2012; Borup et al. 2006; see also Tutton 2017) have shown how techno-solutionist expectations can cause tangible harm (see also Paskins 2020). These and similar insights have made many STS scholars wary of utopian thinking. Utopian thinking, so the argument goes, obscures the complex, contingent, and deeply political nature of sociotechnical systems, or oversimplifies societal challenges (e.g., Benjamin 2019; Sovacool and Hess 2017; Winner 2020[1988]).

By prioritising idealised futures over the messy realities of the present, utopian thinking risks perpetuating harm and sidestepping necessary debates about justice and inclusion (see also Sand 2019).

There is much to be said for skepticism of a kind of utopian thinking that lets corporate or academic elites choose the futures that are worth creating on behalf of everyone else. I also echo the call of STS scholars for grounded, context-sensitive approaches that prioritise the lived experiences of diverse communities over abstract, one-size-fits-all solutions. But I still believe that these concerns should not stop STS scholars from formulating alternative visions. Because of the way in which STS is intrinsically political, because of the attention to the subtle mechanisms of empowerment and disempowerment that are arguably at the core of STS, STS scholarship is uniquely placed to engage in systematic utopian imagination.

1. Utopia as a Method

Something important gets lost if we stop creating alternative visions altogether. The work of Ruth Levitas (2013) is instructive for how this can be done without stepping into the traps that STS scholars rightly warn of. Rather than as the drafting of uniform visions of ideal societies, Levitas sees utopian thinking as a tool for reflecting on possibilities for change. For Levitas, utopia is not an end point, but a method of creative reimagination. Using utopia as a method can help to find solutions that do not merely replicate the assumptions of the existing system, which often caused the very problems that are now to be solved (see also Liboiron 2021; Thaler 2022). Utopia as a method is like cutting loose a balloon that is tethered to the ground. While the view from the balloon is initially limited to the immediate environment, once the string is cut, the horizon widens.

There are ways to prevent the balloon from drifting away. Building upon Levitas' approach, Hendrik Wagenaar and I suggest systematic utopian imagination (SUI) as a method comprising three steps (Wagenaar and Prainsack, *under review*): the first step involves describing the existing reality and identifying what holds it in place. It is an empirical endavour during which we ask: what assumptions stabilise the *status quo*? Which of these assumptions have become so ingrained in our thinking that we no longer question, or no longer even see them?

The second step is the development of alternatives. For example, once we have established that what holds the current data economy in place, next to the overarching political and economic power of technology companies, are the assumptions engrained in Western categories and instruments of data governance, we ask (Prainsack, *in press*): what would happen if we had a different notion of personal data that did not consider people only as atomistic individuals, but as relational beings (see also TallBear 2011)? What if we regulated data use that benefits people dependent on income from work differently from data use that benefits only capital owners? As noted, this exercise is not about professional experts deciding on everyone else's behalf which alternative is the right one. It is about opening a process of – ideally collaborative – reflection on what better ways exist to solve a specific problem or organise our societies. Who would benefit from these alternatives, and at whose cost?

The third step – and one which is specifically aimed to prevent the balloon from drifting away – is the development of concrete policy instruments to implement these better alternatives, and to "test" them with people who have practical experience. If we decided, for example, that a more relational understanding of personal data would be desirable, what legal and policy changes would it need to realise this?

Step 1	Deconstruction	What holds the status quo in place?
Step 2	World Making	What alternative futures would be better, and why? Who would benefit, who would be disempowered?
Step 3	Institutional Design	What instruments and measures would it take to realise these alternative futures?

Table 1.
Three steps of systematic utopian imagination (source: author, inspired by Levitas 2013. See also Wagenaar and Prainsack, *under review*).

2. The Role of Solidarity in Systematic Utopian Imagination

Some STS scholars may be put off by the explicit normative thrust of this endavour. Even those who do not shy away from being normative may worry about "locking in" specific futures by formulating explicit visions of how things could be different. For many, an important concern will be the tacit ways in which futures that seem desirable to many will still disempower some. When SUI is used in policy making, the process of developing possible alternative futures should be deliberative, meaning that it should include a broad range of voices speaking from different places in society (Wagenaar and Prainsack, *under review*; see also Parthasarathy 2025). When the creative imagination of alternative futures is used by academics, this is typically not feasible. In this situation, taking a solidarity-based perspective can help. Solidarity, understood as practices by which people support others who they take to be like themselves in a relevant respect (Prainsack and Buyx 2011; 2017)[4], can be a helpful starting point for visions of a better future.

Solidarity is different from other prosocial practices in that it builds on what people have in common instead of what sets them apart. While this does not mean that solidarity neglects or denies difference, it means that among all the things that separate people, the things that bind them together become the "design principles" for practices, policies, or institutions. An example are universal healthcare systems that provide services to people based on need, despite the fact that everyone – due to different life circumstances and biological factors – has different risks to fall ill. Here, the "design principle" – the thing that binds people together – is a shared human vulnerability to disease or injury. Another example are farming communities that share harvesting work. The shared feature that gives rise to solidarity here is that everyone needs help getting their harvest in on time, a task that often exceeds the capacity of individual farmers.

The result is a system of mutual support, of indirect reciprocity, that builds on this shared characteristic, despite all the differences that exist between farmers in terms of their economic and political power, their social standing, or other factors that matter in other domains of life.

How can solidarity help with SUI? By focusing on things that people have in common, rather than on what sets them apart, solidarity can help to realise future-building "at eye level". Solidarity builds on the needs that everyone has in common, rather than being dominated by the preferences of those in the most powerful positions. While it is not an absolute safeguard, and while exposing suggested alternatives to public deliberation and scrutiny is still necessary before visions of alternative futures are implemented at the level of policy, taking a solidarity-based perspective can help to reduce the risk that utopian thinking excludes marginalised or dissenting voices in pursuit of a vision shaped by the loudest voices. Including a solidarity-based perspective into exercising utopia as a method can be a corrective to our unconscious acceptance of the divisions that ruling elites are imposing on people[5].

3. Countering Elon's future

I had worked on the notion of solidarity for over two decades without making the connection to utopian thinking. Like so many STS scholars, the concerns about the pitfalls of utopian thinking prevented me from embracing it. It was while working on an article for this journal (Prainsack 2023) that I understood what we are losing if we give up on utopias. I was inspired by Daniel Susser (2022, 297-298), for example, who warned that, if we do not create alternative visions of a good technological future, all we can do is mitigate the harm of the vision of tech corporations. From Linsey McGoey's work on strategic ignorance I learned about the political dangers of silence (McGoey 2012; 2019). I also heeded Jana Bacevic's words (2021), who said that, to muster the strength to act upon the present, we need a vision of a future that is worth acting on (see also Bell and Mau 1971; Tutton 2023). I have also been inspired by Ruha Benjamin's work on imagination (Benjamin 2024), which treats imagination as a collective political resource to shape socio-technical futures. Like Levitas, rather than offering a fixed blueprint for an ideal society, Benjamin calls for a continual contestation and creative engagement that empowers communities to envision alternative futures centered on equity, accountability, and justice. In this way, imagination transcends mere escapism to become a transformative ethical imperative that challenges the status quo and amplifies marginalised voices in particular.

By explicitly formulating alternative visions, we open them up for scrutiny by others. We also make ourselves vulnerable. It may seem safer to remain in the realm of the empirical or stick with abstract conceptualisations. But if we do not actively spell out desirable futures, others will do it for us. These others are likely much more powerful and have vested interests in practices that maintain the status quo – or even change it in such a way that it exacerbates current problems. The visions of tech entrepreneurs that are currently shaping policies are exacerbating the climate crisis and catalysing the transformation of the remaining liberal democracies into electoral autocracies. The United States are but only one example of a country that demonstrates the effects of placing tech entrepreneurs in charge of world-making.

Building alternative futures could, I believe, be seen as an activity at the core of STS. As John Law put it, "[t]hings never have to be the way they are. That is the point of this STS of method" (Law 2017, 49).

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Notes

[1] Globally, the proportion of the population living in democracies is steadily declining. At the same time, the quality of democracy in many countries is also deteriorating. According to the V-Dem study, which measures democratic development using over 600 indicators, countries such as Hungary, Türkiye, and India are no longer democracies but electoral autocracies – countries that still formally hold free elections but lack other essential characteristics of democracies, such as academic and press freedom or an independent judiciary (Nord et al. 2024). Globally, 40 countries are currently transitioning from democracy to autocracy.

[2] In Thorpe's words:

> The political concerns of STS have pivoted around the formulation and criticism of liberalism. Liberal values of individualism, instrumentalism, meliorism, universalism, and conceptions of accountability and legitimacy have been closely related to understandings of scientific rationality, empiricism, and scientific and technological progress. (Thorpe 2008, 63)

[3] For example, if a car company, whose main business model was the sale of cars, begins to generate a significant portion of its profits through mortgages or leasing contracts, this is an instance of financialisation. Companies are transformed from entities that produce goods or services into vehicles for maximising financial profits (see also Lawrence and Laybourn-Langton 2021). The logic of finance is penetrating into more and more areas of society and even into the personal lives of many individuals. Social and economic justice and public interests are subordinated to financial goals. Financialisation has increased the indebtedness of private households and forced public institutions such as housing companies, care facilities, or universities to change their business models to borrow money from global investment banks (Smyth et al. 2020, 8; see also Wagenaar and Prainsack 2021).

[4] The commonalities that are recognised by people as a basis for solidaristic action are not necessarily "objectively" existing characteristics. Instead, they are features that we have learned to attribute to ourselves and to others. They are lenses through which people have come to see reality and that make it more or less likely that they recognise similarities with others. A person who grew up in a society that taught them to think of a person with different religion as their enemy, for example, will find it much harder to see commonalities between them and these others than someone who grew up in a context where similarities between all humans, or even all living entities, were emphasised.

[5] I am grateful to Carrie Friese for helpful discussions on this point.

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Injurious Orders and the Question of Data

Lucy Suchman

This contribution to *Crossing Borders* is a call to question the figure of "data" in the armamentarium of in/securitization. It builds on scholarship at the intersections of STS and critical security studies, in the context of military operations characterized by expanding infrastructures of datafication and the automation of targeting. Located within a history of discriminatory ordering, the systems of categorization that enable data-driven targeting are deeply implicated in the regeneration of configurations of enmity that justify further warfighting. Critical destabilization of those systems and practices is a necessary element in interrupting the perpetuation of militarism and the political and economic investments in its expansion.

1. Before Data

Published just over twenty-five years ago, the book *Sorting Things Out: Classification and its Consequences* (Bowker and Star 1999) examines the primacy of regimes of categorisation in practices of social ordering, enabled by the building out of data-driven information infrastructures. Bowker and Star demonstrate the non-innocence of classificatory practices in cases ranging from the determination of causes of death, to valuations of labour in the medical workplace, to systems of racialized discrimination in apartheid South Africa. Each of these, they argue, operates to reproduce systems of hierarchical difference. Long an apparatus of imperial and colonial domination, the differential valuation of life and labour has been further amplified and accelerated through computationally based techniques and technologies of discriminatory social sorting[1].

The premise that data exist prior to their "collection" and that everything can be rendered as a data source aligns with a wider colonial imaginary of data naturalisation (Ricaurte 2019). But as famously observed by Bowker (2005, 184), "raw data is both an oxymoron and a bad idea". The proposition that data were ever "raw" is one way in which data are framed as independent of context (Gitelman and Jackson 2013, 8). Figured as already delineated into units of information, "raw data" suggests a form of naturally occurring resource awaiting extraction and refinement (Monteiro 2020). Data refinement includes the statistical transformation of traces of past events into predictions of probable futures. The word "traces" here, frequently passed over in the rush to address the proliferating consequences of datafication, is key. Even more than previous documentary media – the written account, the photographic image or recorded video – data in the form of the marks left by digitisation beg enormous questions of interpretive translation. To become the input to analysis through computational statistics, earlier forms of documentation in written accounts or cinematic media require rendering into machine readable form. This process exemplifies what Foucault names "the sign system that linked all knowledge to a language and sought to replace all languages with a system of artificial symbols and operations of a logical nature" (1994, 63). Requisite practices of "data reduction" are fraught with judgements that determine what is made to count. The work of data's "cooking" begins, moreover, before these processes of translation, in the design of devices for the generation of relevant signals and protocols, and the interests that inform them.

It follows that in analysing knowledge practices we need to start, as Gitelman and Jackson suggest (2013, 3), before rather than with data. In pursuing historical epistemologies of datafication the question is how situated, material conditions of knowledge production constitute their subjects and objects in ways that haunt the technologies through which those subjects/objects are translated as data. Pushing further on the observation that "the logical and ontological boundary of machine learning is the unruly subject or anomalous event that escapes classification and control" (Pasquinelli and Joler 2020), we could say more fundamentally that the limit or boundary of technologies of data generation and analysis is the necessary translation of any specific subject or event into a member of a standardised and normalised class, against which the unruly subject and anomalous event become legible. The aggregated discreteness and abstracted homogeneity of each "datum" is what makes data calculable. Taken together, data erase the multiplicities and noncoherence of the worlds that they claim to represent (Law 2004).

2. Data Weaponization

Nowhere is the apparatus of standardisation and normalisation more lethal than in the operations of warfighting. Based on the reproduction of longstanding architectures of enmity, variously figured and enacted, militarism justifies its existence with a promise of security that is endlessly deferred. In the current moment of frenzied investments in algorithmic intensification (AI), a growing number of commercial providers promise to "optimize the kill chain" through expanding infrastructures of surveillance and the machinery of computational statistics required to render data as "actionable intelligence"[2]. To question the premises of these initiatives in AI-enabled warfighting, we need to start with the "input" to the military machine. This includes a challenge to the objectivist onto-epistemology that obscures the messy and unaccountable operations through which persons, relations, and lives are translated as data.

With the rise of "sensor to shooter" imaginaries there is ever greater need to expand the figure of "the weapon" to include datafication[3]. In the martial epistemologies of data-driven warfighting, data are "captured" from the figurative wilds of a world outside the military machine. The primary organs for data capture are sensors. As Reichborn-Kjennerud (2025, 35) explains:

> In the martial world, sensors can be anything from human interrogators, observers, or spies to satellites, cameras, radars and lidars, acoustic buoys, microphones, wiretaps, or pieces of software that "scrape" the digital ecosystem.

A composite of input devices, the sensory apparatus is figured as prior to and independent of the machine that it serves. In contrast, Reichborn-Kjennerud highlights the entanglement of the means of sensing with "specific historical, political, and technological contexts and imaginaries… undergirded by particular epistemological assumptions" (*ibid.*, 34). These assumptions range from the fit between signals and devices designed for their detection, to the relation between machine-readable traces and their assignment of significance through the categorization of persons, things, and events.

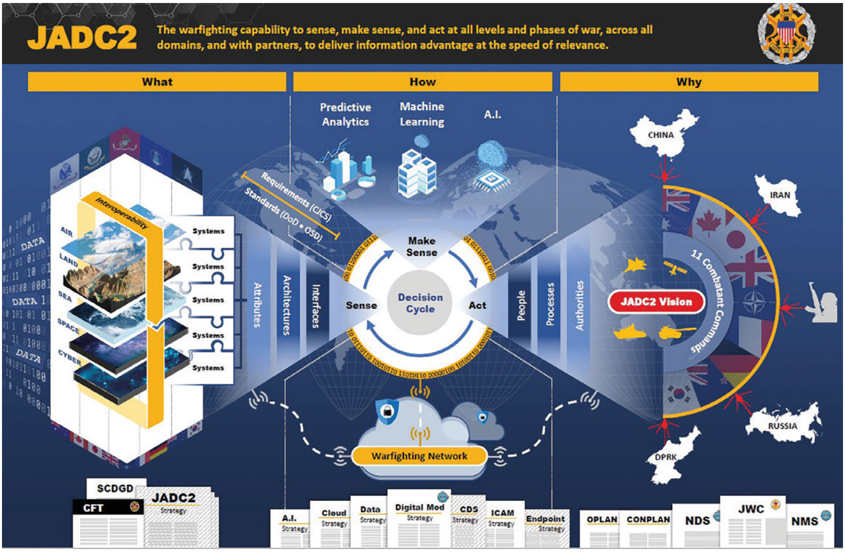

Figure 1.
JADC2 Placemat.

The premise that, rather than being given *a priori*, data are produced through procedures of encoding deeply informed by the purposes that they are intended to serve suggests that we need to look at what happens to the left of data's common diagramming as the input to a machinery of knowledge production. An indicative example might help.

A reading of Figure 1 from the US Department of Defense's summary of the Joint All Domain Command and Control (JADC2) initiative (DoD 2022), titled in a homely spirit the "JADC2 Placemat", is illuminating. We should begin with the leftmost margin of the figure, showing "data" streaming in from the world beyond the frame, channelled into a set of stacks, the general architecture of computing. In this case the stacks correspond to the current sorting of domains of warfighting into territories (air, land, sea, space, and cyber), which together comprise a set of interlocking and interoperable "systems". These input sources are funnelled through the structuring filters of "attributes", "architectures", and "interfaces" to make the results of the data gathering apparatus accessible to decision, an update of the canonical Observe-Orient-Decide-Act or OODA loop. Or more specifically, to the further machinery designed to "Make Sense" of the data through the intercessions of Predictive Analytics, Machine Learning, and the residually floating signifier A.I. The aim of this data processing is the generation of output to be implemented by "People, Processes, and Authorities", comprising the enactment of the "JADC2 Vision" that joins together the 11 Combat Commands to manage the state actors whose positioning as threats provides the justifying grounds for the whole machinery. Floating somewhat ambiguously below and between all of this is the "Warfighting Network", figured as a cross between the iconic tank and the aspirational cloud, all joined together by the dotted lines of electronic transmission. Finally, hovering along the bottom of the frame is the repository of doctrine and at the top the program's aim, that is "The warfighting capability to sense, make sense, and act at all levels and phases of war, across all domains, and with partners, to deliver information advantage at the speed of relevance".

Realisation of the JADC2 vision has been hampered by the relative ease of building out technologies of surveillance compared to the labour-intensive demands of classifying data so that they can be translated into intelligible information. Military analysts bemoan, moreover, the non-coherence of sources, practices, and infrastructures across the U.S. DoD and eighteen independent intelligence agencies. Into this space, defense technology providers offer further technologies for the "fusion" of data sources into a coherent picture of what is euphemistically named the "operational environment" of warfighting. The leading provider of "battlefield AI" is Palantir, founded in 2003 by Alex Karp and Peter Thiel and named after the "seeing stone" in J.R.R. Tolkien's legendarium. In 2024 Palantir secured a $480 million dollar contract with the US Army for its AIPlatform (AIP), a system for command and control aided by so-called generative AI. More specifically, the AIP offers access to an LLM-based back end through a "dashboard" that includes a ChatGPT style conversational interface[4]. Palantir assures its military customers that the platform has been designed to activate data and models "from classified systems to devices on the tactical edge" to maintain a real time representation of the battlespace.

Consistent with prevailing martial epistemology, the "real time representation of the battlespace" promised by Palantir takes relevant phenomena to be prior to and independent of the military apparatus. On this understanding, Large Language Models are "world models"[5]. However, critical analysts and practitioners do not agree with the premise that the computational statistics used to find correlations over tokens in datasets comprise an understanding of the worlds from which those tokens are derived. An alternative analysis is that "As a technique of information compression, machine learning automates the dictatorship of the past, of past taxonomies and behavioural patterns, over the present" (Pasquinelli and Joler 2020). Rather than disinterested prediction, on this view, data-driven securitisation relies upon and reproduces histories of discriminatory ordering.

3. The Limits of Datafication

In 2008 *Wired* editor Chris Anderson infamously declared the "end of theory" based on the proposition that "the data deluge makes the scientific method obsolete". We might rewrite Anderson's dictum as "the data deluge makes the knowledge that is the prerequisite for its generation and interpretation obsolete", clearly a nonsensical statement. Commonly articulated as "bias", troubled relations between computational models and the worlds that they purport to capture are treated as a failed approximation to an ideal of faithful data. In contrast, the critique offered here begins with an acknowledgement of the ways in which all data involve betrayals of the worlds they render[6]. The acts of standardisation and normalisation that are prerequisites to classification and prediction comprise a limit that extends beyond bias (unless the latter is taken as a general term for all forms of ordering). Such an acknowledgement is not a categorical condemnation of datafication, but a statement of its limits and the criteria for its responsible application.

While the intersections between technoscience (a neologism already marking the entanglement of technology and science) and managerialist militarism are longstanding, the present moment is marked by a fever of new investment in the reanimated promise of optimisation through automation. Pasquinelli (2024, 101) proposes that political economic theories provide crucial foundations for tracing the sociotechnical genealogy of current forms of AI and the specific logics of automation that they follow. In political economic theory, Pasquinelli reminds us, it is a commonplace that technology development proceeds in the service of greater speed, more efficient organization, and lower costs (including crucially for labour). Measurement is an essential component across the board, as is the valuation of labour per unit of time. As Pasquinelli observes: "Metrology has always been a political affair" (*ibid.*, 105).

In the face of the premise that "if it's not in principle measurable, or it's not being measured, it doesn't exist" (Bowker 2013), how might we resist? What might be the virtues and strengths of remaining invisible to the machinery of datafication? One path is traced by Natasha Myers (2020), in her tour through Toronto, Canada's High Park. In Myers onto-epistemology "sentience" (rather than sensors), and *not* knowing, are an ethic and a practice. She explains:

> Not knowing is not about cultivating ignorance or indifference. Rather it is a capacious and humbling space that offers some refuge from the hubris of knowledge systems… that are bound so tightly to colonial conquests, discursive regimes, cultural norms, and moral economies that have too long dictated what is good, valuable, and true. (Myers 2020, 75)

This insight is based on Myers' intimate engagement with the life sciences and the more than human world, but most importantly with knowledge practices committed to sustained engagement with their subjects/objects, aimed at coming to know their worlds from within rather than from a distanced vantage point. This is what Myers terms a process of "becoming sensor" (*ibid.*, 76). Myers encourages us to think about the ways in which the sensoria that we inherit from settler colonialism and capitalist extractivism, rather than revealing the world, render worlds illegible. Following Myers' anthropological STS, might it be possible to disrupt the militarist sensorium "in order to cultivate new modes of embodiment, attention, and imagination, and new ways of telling stories about lands and bodies" (*ibid.*, 78)?

As a technoscience of death, military doctrine is replete with calls for "peace through strength" (the latter read as martial not diplomatic), imagined in the current moment as "real-time, decision-quality information advantage in all warfighting domains" and materialized as "a kill web linking any sensor to any shooter" (Berrier 2025). In a model of circular reasoning, warfighting that is faster, more lethal, and more autonomous is taken as an inevitability, a consequence of the very arms race to which it is posited to be the necessary response. This martial epistemology is materialized in the Israeli Defense Force's imposition of a grid over the territory of Gaza, as a device to monitor, measure, and control the spaces, relations, and movements of people (Figure 2).

We need to ask what kinds of il/legibility these methods of quantification produce. Notably, the Israeli assault on Gaza has shifted the argument for AI-enabled targeting from claims of greater precision and accuracy, to the objective of accelerating the rate of destruction. IDF spokesperson Rear Admiral Daniel Hagari has confirmed that in the bombing of Gaza "the emphasis is on damage and not on accuracy" (Abraham 2023). For those who have been advancing

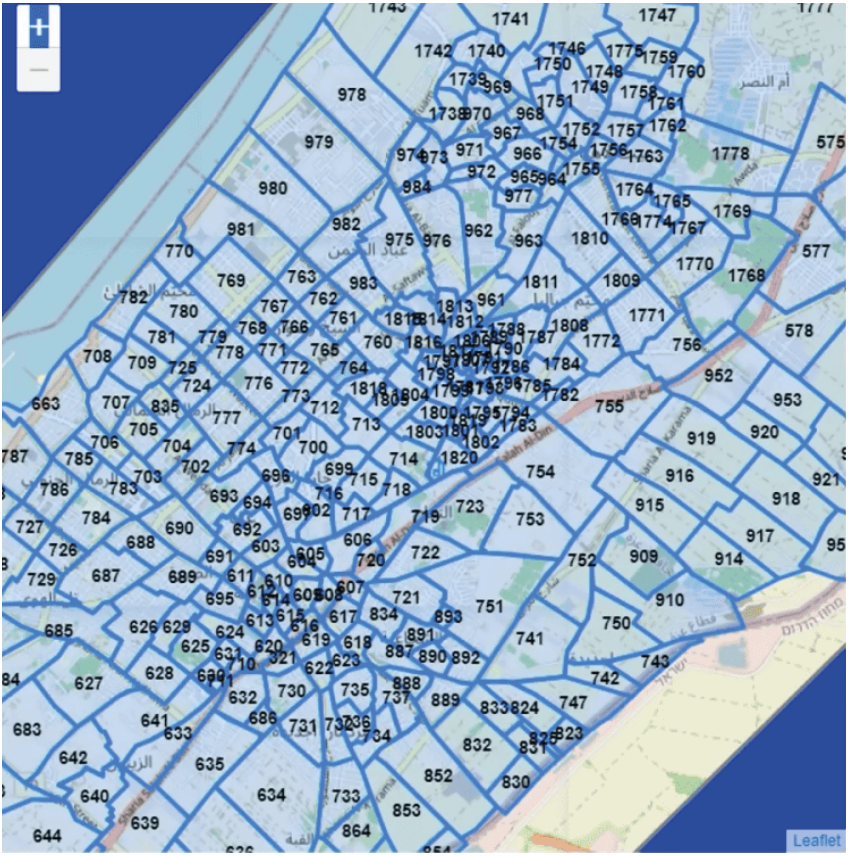

Figure 2.
Grid map of Gaza (see: https://forensic-architecture.org/investigation/assessment-israeli-material-icj-jan-2024).

precision and accuracy as the high moral ground of data-driven targeting, this admission must surely be disruptive. It shifts the narrative from a technology in service of adherence to International Humanitarian Law (IHL) and the Geneva Conventions, to automation in the name of industrial scale productivity in target generation, enabling greater speed and efficiency in killing.

Recognizing the limits of its knowledge practices is anathema to the military project, but those limits exist, nonetheless. In *Cloud Ethics*, Louise Amoore writes:

> When machine learning algorithms segment a social scene, generating clusters of data with similar propensities, everything must be attributed. Yet, that which is unattributable does remain within the scene, exceeding the algorithm's ability to show and tell, as well as

> opening onto a different kind of community and a different mode of being together, of being ethicopolitical. (2020, 25)

While we need to pay attention in the current moment to the enormous expansion of signal generating infrastructures we also, I am arguing, need to attend to that which escapes capture by datafication, for better and worse, from complex social relations to the lived experience of those who find themselves at the center of targeted discrimination and the exercise of violent power. The point of this shift in focus is to destabilise the premises through which technomilitarism perpetuates its logics of rational and controllable state violence, while obscuring its senseless and unaccountable injuries. Rather than further accelerate the speed of warfighting, we need to challenge the premise of an inevitable AI arms race and redirect our resources to innovations in diplomacy and social justice that might truly de-escalate the current threats to our collective and planetary security. Scholarship at the intersections of STS and critical security studies provide invaluable resources for that ongoing project.

Notes

[1] For a recent historically informed analysis of these issues in the time of so-called Big Data, as well as movements of resistance and alternative future making, see Chan 2025.

[2] For media coverage of a relevant warfighting exercise see Henley 2025.

[3] On the "sensor to shooter" concept see Wilkins 2024; on the weapon see Bousquet et al. 2017.

[4] See demo at https://www.youtube.com/watch?v=XEM5qz__HOU.

[5] On standard definitions of "world model" in the AI literature see Mitchell 2025.

[6] See Pasquinelli and Joler 2020. For a lucid unpacking of the multiple senses and sources of bias and why problems of discriminatory profiling cannot be "solved" technically, see Crawford 2017.

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