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COMMENTARY



## Urban and Infrastructural Rhythms and the Politics of Temporal Alignment

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### ABSTRACT

To date, urban research has paid little attention to the role of urban infrastructures in shaping and ordering urban temporalities. I contend that the study of infrastructures offers a powerful lens for understanding the reciprocal relationship changing infrastructural and urban temporalities as well as the power-driven processes of temporal alignment and realignment. Approaching time through the empirical study of infrastructures, I argue, reveals how contemporary infrastructural change is entangled with—often conflicting—orientations to the past, present, and future. At the same time, it uncovers how temporal ordering and reordering processes by socio-technical systems not merely reflect, but also enable, constrain, and preconfigure contemporary and future urbanism. Specifically, periods of infrastructural change, crisis, and failure reveal various temporalities, asynchronisms, and misalignments that are otherwise invisible or neglected but are crucial for the broader understanding of urban change and its governance.

### KEYWORDS

Temporalities; temporal layering; urban and infrastructural rhythms; temporal alignment

## Introduction

When thinking of urban infrastructures' characteristics and impacts, what first comes to mind is their embeddedness in and shaping of urban space as well as their networked spatiality. Accordingly, urban infrastructures and infrastructural change have been recognized as one of the most powerful lenses for deciphering the dynamic, relationally constituted, and variegated processes of spatial development. Infrastructures not only have specific spatialities and mediate space, however; they also have variegated temporalities and mediate time. Obviously, conceptualizations of time are not a novelty in urban studies but have inspired new intellectual traditions in time studies and time geography. Accounts of time–space compression, just-in-time production, societal acceleration, “flexibilization,” and “simultaneization” have become commonplace in urban studies, highlighting in particular the influential role of modern transportation and communication infrastructures. Furthermore, reductionist views of absolute, quantifiable time independent of human action have been widely criticized, while the socially constructed,

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contextual, and relational character of urban temporalities has been emphasized (Besedovsky et al., 2019). Similar to space, time does not exist independently from social processes and contexts; it is experienced locally, leading to heterogeneous, coexisting temporalities or phenomena of “pluritemporalism.” Whereas urban studies have started to draw more attention to the temporalities of cities (e.g., Besedovsky et al., 2019; Lefebvre, 2004), urban infrastructure studies have remained mostly generic in describing the role of technical infrastructures in mediating time and have mostly engaged with diachronic accounts of infrastructural temporalities.

The objective of this paper is to assess recent scholarship on time geography, science, and technology studies (STS), anthropology, and history of technology to outline avenues for future research on urban and infrastructural temporalities and infrastructural change. I argue that urban studies of infrastructures offer a powerful lens for understanding the reciprocal relationship between infrastructural change and changing urban temporalities as well as the politics of temporal alignment and realignment. My argument is twofold: first, infrastructures bridge timelines—from the past to the present and from the present to the future (Howe et al., 2016), as they “project into the future the socially constructed characteristics acquired in the past when they were designed” (Hughes 1987: 77). Second, urban infrastructures enable or constrain certain socio-material rhythms which are important for understanding urban temporalities and urban change. In particular, periods of infrastructural change, crisis, and failure reveal various temporalities, asynchronisms, and misalignments that are otherwise invisible or neglected but are crucial for a broader understanding of urban change and politics. I conclude by summarizing key arguments and by pointing to avenues for further research.

### **Urban Infrastructures as Multilayered Inscriptions of the Past, Present, and Future**

Multiple studies on the history of technology have shown that the temporality of urban infrastructure development differs greatly from a linear and sequential march of progress. Instead, much emphasis has been put on the stabilization, durability, and obduracy of urban infrastructures once they have matured and have become deeply entrenched in the urban fabric. Once consolidated, it seems that infrastructures develop self-reinforcing mechanisms that, over time, restrict choices of infrastructure design. In this sense, infrastructures bridge timelines from the past to the present and future.

While metaphors of path dependency and inertia have explanatory utility to account for the difficulties of radical infrastructural change, they downplay the dynamics and malleability of infrastructures and the dual temporality of infrastructures as “always already there yet always an unfinished work in progress” (Edwards et al., 2009: 365). Attempts and strategic guidelines to achieve fundamental transitions have thus attracted much attention in research and policy practice, often driven by the societal need to address socio-ecological challenges. However, radical transitions from an old to a new system seldom succeed. The problem is not only that specific components of infrastructure systems often lag behind in innovation processes and are “out of sync” with other components (Hughes, 1987). Instead, infrastructural change is often less linear and sequential, occurring instead as an incremental, intermittent, reversible, and dyssynchronous process composed of multiple temporalities (Anand, 2017).

In particular, debates in STS have drawn our attention to infrastructural change resulting from many slow, gradual changes instead of from a few (extensively planned) rapid system shifts. Studies point to incremental change practices of “adapting, tailoring, appropriating, tuning, modifying, tweaking, making, fixing, monitoring, maintaining, repairing, hacking, vandalizing and instrumenting” (Karasti and Blomberg, 2018: 240). In order to operate over long periods of time, infrastructures need to be constantly retrofitted and changed to meet new contingencies. Rather than focusing on path dependencies or radical transitions from one system to another, attention should, therefore, focus more on continuous and gradual infrastructural change and the incremental layering of “old” and “new” socio-technical components over longer periods, during which other components of incumbent infrastructure systems persist (see also Monstadt and Wolff, 2015).

Particularly insightful for the understanding of infrastructure temporalities is the concept of layers of time introduced by the historian Reinhart Koselleck in the 1980s as a critique of sequential and linear conceptions of history. The concept is apposite for infrastructures, as they reveal “multiple historical times present at the same moment, layer upon layer pressed together, some still volatile, others already hardened” (Koselleck, 2018: viii). In this light, contemporary infrastructures can be understood as representing different temporal contexts, or as *sedimented layers of time* with new socio-technical elements being superimposed on existing ones (Weber, 2019; Engels, 2020). The multiple layers of time refer to each other in a reciprocal way, though without being mutually dependent (Koselleck, 2018: 4).

Apart from its explanatory value for the relationality of different infrastructural times, the metaphor of time layers is also useful to explain *polychronic processes* of infrastructure development (Weber, 2019: 112). As David Edgerton (2006) shows, at no time has only the latest technology been used; rather, infrastructures of a time always represent a panorama of old and new, which do not necessarily merge but coexist. Technologies in use appear, disappear, and reappear—sometimes in forms of coexistence of old and new technologies, in other cases resulting in hybrid forms or “creole” technologies from different times. Hereby, innovations do not simply result in incumbent infrastructures being replaced with new ones, but usually add to existing infrastructures and imply new forms of appropriation, interference, and conflict (Edgerton, 2006).

An essential dimension of the heterogeneous time layers of infrastructures is that their past and present time layers also *project into the future*. Infrastructures have always been important not just for what they did in a particular past or do in the present. Urban infrastructure design and development are saturated with prospective claims for the future that signal the aspirations, expectations, and imaginations of societies, or of their leaders, or can be seen as “promises made in the present about our future” (Appel et al., 2018: 19; 27). As imaginaries of smart, circular, or resilient cities demonstrate, such representations of the envisioned, expected, or desired future develop performativity, influence technology developers, and mobilize infrastructure stakeholders in industry, politics, and research, as well as economic, cultural, and social resources (Weber, 2019).

Finally, to understand the temporalities of infrastructures, it is important to consider their “*afterlives*,” as their materialities may survive long into the future, even after infrastructures have fallen out of use. Some abandoned infrastructures from the past still

shape our contemporary infrastructure landscapes due to their material obduracy. In the Anthropocene, the ecological impacts of infrastructures—ranging from the manifestation of resource scarcities to the degradation and fundamental remodeling of the planet’s bio-geophysical composition and processes—will persist for many generations and will long outlive existing infrastructures (Appel et al., 2018). In this epoch, the afterlives of infrastructures are increasingly developing performativity. Hence, numerous contemporary infrastructure innovations in climate adaptation such as drought or flood risk management, the remediation of contaminated sites, or carbon capture and storage are targeted at mitigating the socio-ecological consequences of infrastructure paths taken in the past (Weber, 2019).

To conclude, one of the merits of recent infrastructure studies is their substantive contribution to a more nuanced understanding of the multilayered temporalities of infrastructures. Infrastructural temporalities, as Timothy Moss argues, can best be described as “conjunctions of continuity and change,” (Moss, 2020:20) or as shaped by long-living, durable technologies, and socio-technical path dependencies on the one side, and, on the other side, as real-time projects always evolving through frequent (re)design, maintenance, repair, and innovation. In infrastructural transformations, we can observe that infrastructural temporalities are more than merely chronological but that heterogeneous layers of infrastructural times become intertwined: infrastructural pasts are inseparably and constitutively inscribed in present and future infrastructure generations and even in “infrastructural afterlives;” old infrastructural arrangements resurface in the present through forms of juxtapositions or hybridization of old and new socio-technical arrangements; and expected, imagined or promised infrastructural futures are performative for past and present decisions. In other words, contemporary infrastructural change is entangled—often conflicting—with orientations to the past, present, and future. Further engagement with these complex temporalities is, however, needed to nuance accounts of infrastructural change and, more broadly, to open up new ways of thinking about urban temporalities and their mediation through infrastructures.

### Urban Infrastructures as Mediators of Urban Rhythms

As highlighted above, previous research has considerably advanced the understanding of diachronic temporalities of infrastructures. In contrast, the heterogeneous rhythms and time regimes of infrastructures and the way they mediate everyday urban rhythms have received relatively scant interest in scholarship on urban change (see Jalas et al., 2016). These temporalities mostly fade into the background and surface almost exclusively in periods of infrastructural change, crisis, and breakdown, when they delay or derail other urban processes. As highlighted by Paul Edwards (2003: 188ff, 195), infrastructures “allow us to control time and space” and “possess the power to shape human time, shaping the preconditions under which we experience time’s structure and its passage.”

Urban temporalities can scarcely be imagined without the use of technology. The patterning of urban temporalities can be seen as an effect of the co-evolution and mutual adjustment of infrastructural rhythms and the practices of everyday urban life over time: energy systems have uncoupled urban rhythms from diurnal and seasonal cycles, allowing a “colonization of the night” (Melbin, 1987 cited in Edwards, 2003: 11) and

of seasonal climates. Telecommunication infrastructures have created a sense of simultaneity across huge distances and transportation infrastructure have transformed the human experience of time and space. Finally, recent ICT developments hold the promise of enabling new real-time temporalities by measuring, monitoring, and regulating infrastructural flows through city-scale Internet of Things infrastructures (Coletta and Kitchin, 2017) that respond to temporally shifting demands, unlock new forms of load management in real time, and synchronize service provision by distributed infrastructures.

Popular accounts of infrastructures and urban temporalities have frequently portrayed this relationship as a one-dimensional and universal process of acceleration, simultaneization, and synchronization of urban life through technology. However, this neglects the ambivalent character of infrastructural temporalities that enable and constrain and synchronize and desynchronize. For example, although the automobile has helped save time, it has also worsened urban traffic congestion and increased waiting time, yet it has increased commuting and leisure horizons and therefore “explodes the list of effective claims on your time-budget” (Rosa, 2017: 41). In addition to such “*temporal rebound effects*” (Rosa, 2017: 41), infrastructures often result in unequal and dissonant temporalities that are refracted through differentiated access to and affordability of infrastructure and determine whether, when, and to whom modern mobility, water, or electricity are available (Appel et al., 2018: 6). In most cities in the Global South, residents invest much time in accessing (and accumulating the means to afford) basic infrastructure services; their daily experience of infrastructural temporalities mismatches those of neighboring wealthy communities and, more broadly, the temporal expectations of capitalist labor markets. But low-income communities in Northern cities are also barely able to keep pace with the accelerative effects of infrastructures to the wealthy. Most strikingly, unhoused people require considerable time budgets for traveling, communicating, and sanitary needs. And yet the ways in which the temporal opportunities and constraints of infrastructures are unequally distributed and how their accelerative effects can rebound have attracted scant attention from infrastructure scholars.

One of the intellectual debates informing a more nuanced conversation on how urban temporalities are mediated by infrastructures in situated and unequal ways, on the polychronicity of cities and the temporal mismatches has been going on in rhythm studies. In particular, Henri Lefebvre’s (2004) work on urban rhythms—conceptualized as “localized time” and “temporalized place”—offers key analytical concepts for uncovering the multiple, often neglected temporalities of cities that combine, overlap, dissolve, and recombine; how they can consolidate temporal orders; but also, how their interaction can provoke mismatches, conflict, or dissonance. More recently, Lefebvre’s work has also inspired the study of infrastructural rhythms and how they structure time (Jalas et al., 2016; Coletta and Kitchin, 2017; Elsner et al., 2019; Engels, 2020). Hereby, the temporal regularities of infrastructures are shaped by and, in turn, help to frame and support ongoing processes in the city in some form of navigable order. The mostly hidden infrastructural rhythms (e.g., timings of public transport, or a universal access to energy or water services) shape urban rhythms of commuting, hygienic practices, working, or heating and cooling. They allow urban processes “to unfold in predictable and routinized ways across spatially and temporally distributed sites” and “establish structures of

convention and expectation, allowing actors to mesh and coordinate otherwise disparate temporal flows” (see Steinhardt and Jackson, 2014: 134).

The temporal orders of cities rest on temporal patterns of infrastructures whose expected availability of services at any time requires that multiple activities be scheduled accordingly. Infrastructural rhythms can only become opaque and unnoticed background of urban features if practices that match fluctuating demand and supply become routine. Thus, specific temporalities have always been an essential part of urban infrastructures’ DNA, e.g., shaped by shifting availabilities of essential natural resources and the characteristics and velocities of infrastructural flows, life spans and aging of material components, investment cycles and market temporalities, fluctuating diurnal and seasonal demand, and varying political and juridical temporalities. Over time, these temporalities condense into temporal patterns that support regularities of everyday practice and routines—e.g., to manage shifting loads, maintain, repair, and renew facilities, or to order everyday user practices. Such rhythmic properties of infrastructure carry implications for the organization of social life and encode and enforce certain kinds of urban rhythms.

But temporalities of cities are not solely stabilized, routinized, and patterned as an outcome of infrastructural temporalities. Instead, entrenched infrastructural rhythms—especially at their points of intersection of different infrastructure domains—can just as often cause dissonance or arrhythmia and hereby disrupt, slow down, or derail rather than support a seamless flow of urban life. In particular, infrastructural disruptions such as electricity blackouts, water shortages, or cyberattacks offer insightful snapshots of urban rhythms. They can reveal not only how temporal orders in cities are mediated by infrastructures but also the interdependency of infrastructural rhythms themselves. For example, a minor, four-hour blackout in Amsterdam in January 2017 exposed the precarious rhythms mediated by electricity: not only were 365,000 households disrupted in their daily morning routines of having breakfast, reading the online news, showering etc.; train traffic was seriously disrupted throughout the country and commuter traffic badly affected for almost the whole day; district heating systems could not be restored until long after the blackout; moreover, many telecom towers broke down, slowing down the responsiveness of emergency services. Such disruptions reveal urban rhythms and processes of temporal alignment that are usually hidden by functioning infrastructures. Furthermore, they reveal how small events can rapidly escalate into multiple infrastructure failures at varying speeds and durations and result in temporally fragile urban rhythms (see Trentmann, 2009). Finally, they indicate temporal misalignments between the preparedness for failure, its recognition, and the enactment of appropriate responses across infrastructure domains (see Anderson, 2016).

Apart from such periods of infrastructural failure and disruption, periods of infrastructural change can also reveal various temporalities, asynchronisms, and misalignments that are otherwise invisible or neglected but are crucial for the broader understanding of urban and infrastructural change. An example is the shift toward electric vehicles as an interface between electricity, transport, and ICT systems, which are promoted as a lower-carbon mode of private automobility, at least if they are small-sized and thus more energy efficient, if they are charged with renewable electricity during off-peak hours and if automobile batteries feed back into the grid during peak hours to balance electricity loads. What is presented as a smart solution to



decarbonization comes with considerable challenges of temporal alignment: first, the shift to renewable power generation introduces a certain need to (re-)align electricity systems to natural rhythms, as supply from wind turbines or solar panels fluctuates with changing weather, seasonal and diurnal variations. Second, it requires private automobile owners to charge their cars during off-peak hours and to discharge electricity at peak hours and to (re)schedule their commuting and working hours accordingly. Third, the increasing electricity demands of mobility have to be reconciled with concurrent shifts to the electrification of heating and cooling, and the exploding electricity demand from ICTs, all of which multiply the challenges of aligning fluctuating temporalities of electricity supply and demand. Finally, these shifts require rhythms of investments, operation, regulation of heterogeneous infrastructure domains to be synchronized. Plans to innovate mobility may thus conflict with infrastructural rhythms related to legacy systems that resist change.

The necessarily sketchy accounts above first and foremost call for further research to identify how urban and infrastructural rhythms are (re-)produced through infrastructure design, management, and use, for whose benefit/detriment, and with what potential rebound effects. This is particularly important not only for academic scholarship in time geography and urban studies but equally for urban infrastructure development and planning practice.

## Conclusion

While the changing spatialities of infrastructures and the spatial implications of infrastructural change have attracted much attention in urban studies, this article argues for a stronger engagement with the temporalities of urban infrastructures. Although incomplete, fragmentary, and abstract, the arguments raised in this article demonstrate that there is an urgent need for an increased dialogue to connect time theories with detailed empirical studies on urban and infrastructural temporalities. This does not, however, imply privileging thinking about time over space. Indeed, a focus on infrastructural temporalities is tied to concrete spaces and thus contributes to rethinking spatialization as temporal ordering processes driven by socio-technical systems (Appel et al., 2018). Approaching urban infrastructure studies through the lens of time allows us to outline how these ordering processes not merely reflect, but also affect, enable, constrain, and preconfigure patterns of urban development.

Hereby, a critical engagement with diachronic patterns of infrastructural change can help to nuance existing emphasis on radical socio-technical transitions or on path dependencies, thereby revealing how the old and new are layered, mixed, and juxtaposed and how the often diverging orientations to infrastructural pasts, presents, and futures become entangled and contested in processes of infrastructural change. I have, moreover, argued that urban infrastructure scholarship needs to draw more attention to the heterogeneous rhythms of infrastructures and the way they mediate urban development. Here, the study of the unequal access to accelerative effects of infrastructures, of temporal rebound effects, and of temporal misfits, dissonance, or arrhythmia that challenge the management of cascading infrastructure failures and the enactment (and) acceleration of infrastructural transformations can be particularly insightful.



Yet, knowledge of temporal alignment work that brings otherwise disparate temporalities “into heterogeneous and locally workable forms of alliance” (Jackson et al., 2011: 251) is not well developed. Hereby, the diachronic and synchronic temporalities of infrastructures cannot be regarded as mutually exclusive but as shaping each other. This raises new questions about how the (re-)making of infrastructural rhythms is shaped by the layering of their historicity, present interests, and future expectations. More research is also needed to explore how and which stakeholders use their agency to change temporal rhythms, resolve temporal mismatches, and even use disparate rhythms to their advantage. These questions imply wider and equally challenging questions by whom and through which means are urban and infrastructural rhythms (re-)produced—issues of the politics of temporal alignment and the underlying power structures. Hereby, a socio-technical perspective points to many under-researched topics, such as which rhythms are (and should be) adjusted to which (and whose rhythms to whose)—questions of time control and (re)adjustment that are thoroughly enmeshed with urban power dynamics (see Wajcman and Dodd, 2017; Jackson et al., 2011).

## Disclosure Statement

No potential conflict of interest was reported by the author.

## Note on Contributor

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