12. Producing (urban) contingencies

Infrastructural interrelations in Hamburg

Lena Enne

Introduction

Contingency lies at the heart of infrastructural configurations such as Hamburg's gas, water, and sanitation systems. On the one hand, supply networks are designed not only to provide urban societies with water and energy but also to prepare those societies for unexpected events. In Hamburg, for example, the introduction of a networked water supply in the 1840s delivered drinking water to citizens and industry while also ensuring a sufficient supply of water for the fire brigade to respond to potential fires. Similarly, the concurrent construction of a sanitation system helped prevent disease and – being a mixed system – was also intended to drain stormwater away from the densely populated inner city, thus preventing floods during heavy rainfall. On the other hand, and on a more abstract level, infrastructures are themselves highly contingent configurations. Urban infrastructures in cities of the Global North have often been viewed as distinct objects following a clear, linear path of development aligned with the modernist ideal of continuous technological progress. More recent understandings, however, following the 'infrastructural turn' (Amin, 2014; Coutard and Rutherford, 2016) in the social sciences, emphasize the relational and processual nature of urban infrastructures. These newer approaches reject teleological conceptualizations and instead foreground the historical and geographical situatedness of infrastructural development. Within this framework, infrastructures are seen as contingent configurations where different materialities and temporalities intersect, forming what scholars call *infrastructural palimpsests* where the new does not simply replace the old but where temporal, material, and cultural aspects are

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layered on top of each other, producing unforeseeable relational processes (Graham and Thrift, 2007; Moss, 2020).

Building on this image of the palimpsest, this chapter traces the contingent nature of infrastructures by researching Hamburg's gas, water, and sanitation networks. It explores different dimensions of infrastructural interrelation based on two examples of a particular infrastructural form: the supply tunnel, in which various underground supply infrastructures are bundled within a single accessible conduit. One example was executed as an experimental project on a street in Hamburg's inner city in 1892; the other was a planned but ultimately unrealized component of the current large-scale inner-city development 'Grasbrook', a new urban quarter now under construction. Through the discussion of these two cases, this input demonstrates how different infrastructure sectors relate to each other and to broader urban processes. Using research on maintenance and repair practices as an empirical and analytical entry point, the chapter reveals how a historically informed examination of infrastructures uncovers the interdependencies among different sectors as well as their evolution over time. It also shows how infrastructures are deeply embedded within broader urban dynamics, generating various forms of contingency and necessitating efforts to govern them. Understanding these processes is central to questions of urban future-making as it helps urban professionals to navigate and anticipate complex uncertainties in times of mounting socio-ecological crises.

The chapter is organized into three parts: Following a brief introduction covering conceptual foundations, research gaps, and methods, it presents the historical and contemporary cases of the supply tunnel, tracing the specific contexts from which each emerged. It then analyses the different dimensions of infrastructural interrelations that arise from these examples – namely spatial, temporal, and institutional entanglements – and examines the resulting practices of cross-sectoral organization, coordination, and cooperation. In doing so, this chapter shows how contingency not only emerges from specific historical contexts but is also produced by the entanglement and interrelation of different infrastructure sectors and how utility services try to manage these contingencies.

By exemplifying the contingent nature of infrastructure through examining Hamburg's gas, water, and sanitation systems, this chapter contributes to infrastructure and urban research in three ways. First, it advances the theorization of infrastructures as processual rather than as fixed, distinct entities, challenging narratives of linear and progressive development. Instead, it il-

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lustrates how (dis)continuities within infrastructural development and complex interdependencies, such as the ones outlined here, can only be understood in light of the specific historical, spatial, and socio-political contexts in which they emerge and play out. Second, it offers a methodological contribution, highlighting the importance of historical analysis in urban research for understanding the contingent character both of infrastructures and of cities more broadly. Third, it contributes to the emerging but still under-researched field of cross-sectoral analysis in infrastructure studies. Although the significance of cross-sectoral approaches has been acknowledged in theory, empirical studies that examine multiple sectors together remain rare.

Researching the infrastructural nexus

While most infrastructure studies have historically focused on a single sector, contemporary approaches increasingly emphasize the importance of examining the interconnected nature of different infrastructural configurations (Monstadt and Coutard, 2019), a perspective traceable to early social studies of infrastructure. Susan Star, for example, in her ethnography of infrastructures, highlights 'embeddedness' as a defining feature of infrastructure. She argues that infrastructure is 'sunk into and inside of other structures, social arrangements, and technologies' (Star, 1999: 381) and that it 'does not grow de novo; it wrestles with the inertia of the installed base and inherits strengths and limitations from that base' (ibid.: 382).

Today, a key concept in the study of multiple infrastructure sectors is *nexus thinking*. It emerged during the last two decades as a framework for describing and understanding interconnections primarily between the water, energy, and sometimes food sectors (Monstadt and Coutard, 2019). Concerned mainly with identifying synergies and minimizing tensions between the sectors and aimed at informing management and policy-making, this concept has been criticized for its overly techno-positivist orientation. By prioritizing efficiency measures, nexus thinking often overlooks the complex socio-material interdependencies that extend beyond resource optimization and fails to account for urban space as the key arena where these interrelations as contingent processes unfold (Williams et al., 2014). Instead of embracing contingency, traditional nexus thinking seems to negate highly complex infrastructural interrelations, reducing them to mere input-output calculations.

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While engineering research has long focused on the interdependencies of large-scale infrastructures, often conceptualizing them as 'systems of systems' (Eusgeld et al., 2011), within the social sciences this subject remains both empirically and conceptually underexplored. On a smaller spatial and temporal scale, however, there is a growing interest in studying multiple infrastructures within a single research framework, as exemplified by the 2019 special issue of *Urban Studies* on interfacing infrastructures. In their introduction, editors Jochen Monstadt and Olivier Coutard highlight the relevance of this approach, arguing that urban infrastructures today exhibit 'an increasingly "nested" character with interacting resource flows, technological interconnections, operational and financial interdependencies, and manifold governance interfaces at multiple scales' (Monstadt and Coutard, 2019: 2192). These characterizations resonate with Stephen Graham and Nigel Thrift's (2007) conceptualization of infrastructures as palimpsests – a concept that captures the multilayered nature of individual supply infrastructures and enables an analysis of the temporal and material entanglements within and between multiple infrastructural systems. Tim Moss (2020) has demonstrated this approach in his historical study of five infrastructure sectors in Berlin, which, despite the relevance of an integrated approach, remains one of the few comprehensive cross-sectoral analyses spanning a broad timescale of 100 years. What seems missing however, is the question of how infrastructural professionals engage with the contingencies that emerge from the temporal and material multilayeredness of different infrastructure sectors.[1]

In order to understand how infrastructural contingencies emerge from specific historic, spatial, and socio-political contexts, how they play out across different sectors, and how infrastructural professionals manage them, this chapter draws on a mixed-methods approach. It combines material derived from extensive archival research, from qualitative interviews with managing employees of Hamburg Gasnetz, Hamburg Wasser, and HafenCity Hamburg GmbH, and from short participant observations of and ad-hoc interviews with maintenance crews.

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[1] See Ian Scoones (2024) for an analysis on how infrastructure workers – which he calls 'reliability professionals' – manage uncertainty. He is, however, not focusing on a cross-sectoral perspective.

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Failed experiments: Infrastructure supply tunnels in Hamburg

Supply tunnels, also known as utility tunnels or media channels, are accessible tunnels that carry various utility pipes, including sewage, water, electricity, district heating, and telecommunication cables. The main advantage of this infrastructure over traditional methods of burying pipes and cables beneath streets or footpaths is their accessibility for workers, allowing for inspection, maintenance, repair, or the installation of new infrastructure. Unlike the traditional approach, which requires digging up the street in the event of breakdown, supply tunnels enable easy access without construction work and its associated traffic disruptions. While some major cities, such as Prague, have extensive networks of these tunnels, most supply tunnels are constructed on a smaller scale in municipalities such as Jena or for specific needs, such as those of hospitals.

The following examples of supply tunnels from Hamburg are also small-scale interventions. In 1892, a tunnel was implemented as an experiment in a single street in Hamburg's inner city; over 100 years later in the 1910s, the revival of the idea of bundling different supply infrastructures within one accessible tunnel was framed as an 'infrastructural innovation' designed to serve a neighbourhood currently under construction. In the following sections, I will introduce both cases: the historical experiment and the resurgence of the idea in recent planning, focusing on the urban context and the discussions surrounding the planning and implementation of these supply tunnels.

The historical experiment in Kaiser-Wilhelm-Straße

Hamburg's infrastructural history is closely tied to the Great Fire of 1842, which destroyed much of the inner city and laid the foundation for the city's infrastructural development. In the aftermath, gas, water, and sanitation systems were planned and built from scratch, along with a new urban layout. A key figure in this reconstruction was the English engineer William Lindley, who drew on his knowledge of London's infrastructure as a reference for his plans for Hamburg (Schubert, 1997). Lindley also considered implementing subways in Hamburg – here, 'subway' in the sense of structures similar to supply tunnels that integrate various services into a single, oversized sewer-like system (Figure 1). However, due to high construction costs, he abandoned this idea and chose the traditional method of burying the pipes underground (Merckel, 1910).

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Figure 1: Example of subway based on Lindley's proposal for Hamburg.

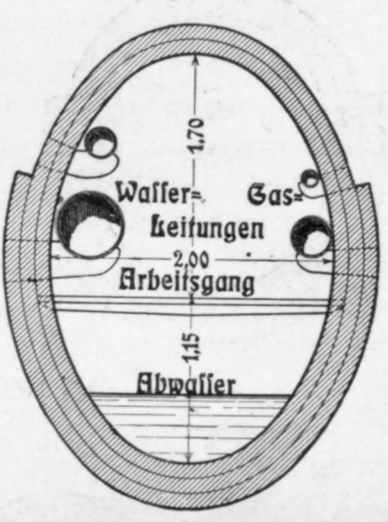

Abb. 14.
Subway nach Lindley.

Source: Merckel, 1910: 13.

In 1890, the idea of bundling various supply infrastructures gained renewed traction through a talk by Berlin's building director, James Hobrecht, at a meeting of the Association of German Architects and Engineers in Hamburg. His lecture, titled 'The Modern Tasks of Metropolitan Road Construction with Regard to the Accommodation of Supply Networks', addressed the integration of utility networks into urban planning (Hobrecht, 1890). Hobrecht expressed concerns about the increasing density of underground infrastructures, which made it difficult to add new supply services and caused frequent traffic disruptions due to maintenance work. To address this issue, he proposed two solutions: first, creating a standardized street section with designated spaces for each supply service beneath the road; and second, constructing a single, accessible tunnel to contain all pipes and cables. This tunnel would not only organize the chaotic layout but also reduce the need for constant excavation and minimize ongoing traffic disruptions by allowing for direct repairs (ibid.).

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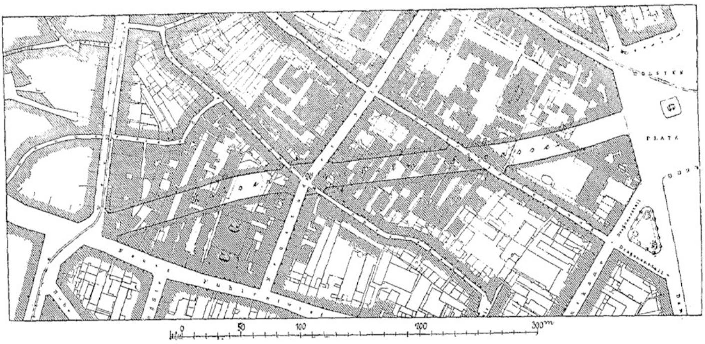
Following Hobrecht's talk, the idea of the supply tunnel began to gain political momentum – although Hobrecht himself voiced scepticism regarding the feasibility of such constructions in Hamburg. Upon a request of the Bürgerschaft, a political entity within Hamburg's governance structure, it was ultimately decided to test the construction and operation of such a tunnel as an experimental project (Roeper, 1893), which, if successful, could result in further construction of such tunnels: 'If the currently proposed experiment with a utility tunnel yields particularly favourable results, the further construction of subways on suitable streets will not be ruled out.'[2]

The newly established Kaiser-Wilhelm-Straße in Hamburg's Neustadt was selected as the location for the experiment. This street was created through a so-called *Durchbruchsanierung* in the middle of the densely populated alley quarters (Figure 2). This type of urban redevelopment, primarily driven by private investors, involved the purchase of land and buildings which were subsequently demolished and reconstructed along newly built streets before being sold at a profit (Schubert, 1997). The construction of Kaiser-Wilhelm-Straße, however, was initiated and executed by the state due to a lack of interest from private investors (ibid.).

Figure 2: Planning of Kaiser-Wilhelm-Straße.



Source: Roeper, 1893: 18.

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[2] Mitteilung des Senats an die Bürgerschaft 1892, Staatsarchiv Hamburg, Abteilung Finanzdeputation I–III, Nr. 3222. All non-English quotations have been translated by the author.

Major debates ensued regarding which infrastructures should be included in the tunnel. A particular point of contention was whether to incorporate gas, given its associated risks, a topic that was intensely discussed within the international engineering community. One engineer is even quoted as saying (in English): 'The day upon which these pipes are placed in the sewers, I shall not go into them without having made my will previously' (Hobrecht, 1890: 354). The initial proposal to build two tunnels – one on each side of the road, with one containing gas and the necessary ventilation and the other without – was ultimately dismissed due to financial constraints; instead, it was decided to test both versions in one tunnel, separated by a door (Roeper, 1893).

Construction began in 1892 with the tunnel being directly attached to the cellar walls of the adjacent buildings enabling the direct connection of households to the supply lines without the need for additional trenches (Architekten- und Ingenieursverein zu Hamburg, 1914). Ultimately, the tunnel spanned 450 metres in length, 3 metres in width, and 1.7 metres in height (Figure 3). Shortly after its completion, however, there was a consensus against constructing additional tunnels due to the 'exorbitant construction costs' (ibid.). But it was not only the high construction costs that were cited as an argument against further tunnel construction elsewhere in Hamburg. Particularly the accessibility for workers – a key argument put forth by proponents of the tunnel – was scrutinized from the outset, with concerns raised about the potential damage to the pipes by workers: 'Moreover, strict supervision is required for all workers operating within the utility tunnel to prevent any damage to the exposed pipes and cables, which are normally protected underground' (Roeper, 1893: 26). Evaluation during the tunnel's operation was also not favourable. An article from 1962 by the head of Hamburg's building authority, while acknowledging the decline in construction sites required to maintain the pipes and cables, expressed similar concerns regarding safety:

> It has been shown that even with a tunnel of this type, cross excavations to supply the neighbouring properties cannot be avoided. Additionally, many other disadvantages have emerged, primarily due to the varying characteristics of the different pipes (e.g. explosion risk, heat sensitivity of the cables). Furthermore, water pipe bursts can disrupt the operation of all pipes. For this reason, there are no plans in Hamburg for such structures again. (Willigerod, 1962)

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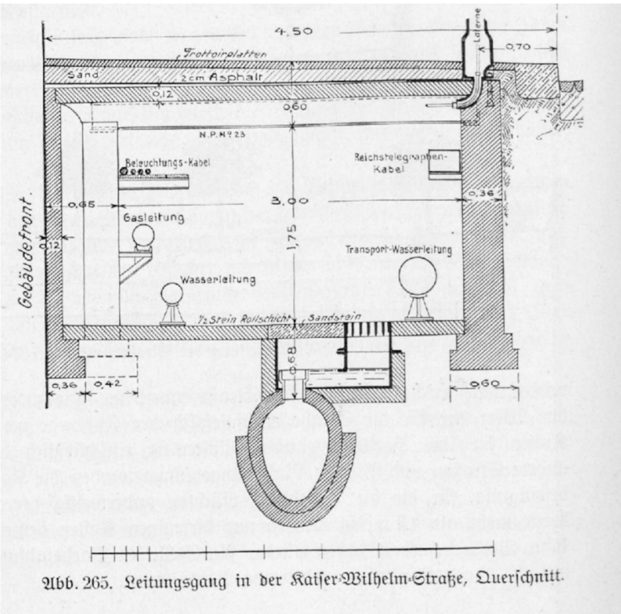
The tunnel at Kaiser-Wilhelm-Straße was in operation until 2022, when the city decided to fill in most of the 450-metre-long structure, as renovating the still-functioning but structurally unsound facility would be too expensive. Only a small section was preserved for heritage protection purposes (Ulrich, 2022).

Figure 3: Section of the finished utility tunnel in Kaiser-Wilhelm-Straße.



Source: Architekten- und Ingenieursverein zu Hamburg, 1914: 154.

Contemporary infrastructure planning at Grasbrook

The statement made by the head of Hamburg's building authority in the 1960s, that no such supply tunnel structures would be built in Hamburg again, held true until the planning of the Grasbrook project began in the 2010s. Grasbrook is a major urban development project in Hamburg, located along the southern banks of the Elbe River, facing the well-known HafenCity district. Both Grasbrook and HafenCity are inner-city developments that form part of Hamburg's

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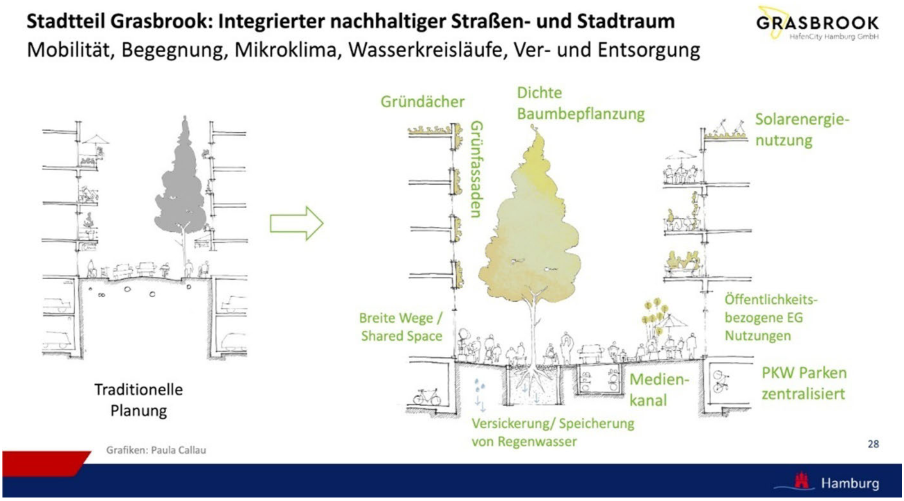
broader strategy to create new residential and commercial spaces while revitalizing former industrial areas originally belonging to the harbour. According to HafenCity Hamburg GmbH (HCH), the development company responsible for managing the overall planning and realization of these projects, Grasbrook is intended to be a model for sustainable urban living, with a focus on 'modern infrastructure, environmentally friendly designs, and mixed-use spaces' (HCH, n.d.).

Figure 4: 'Innovative' infrastructure planning at Grasbrook.



Stadtteil Grasbrook: Integrierter nachhaltiger Straßen- und Stadtraum
Mobilität, Begegnung, Mikroklima, Wasserkreisläufe, Ver- und Entsorgung

GRASBROOK
HafenCity Hamburg GmbH

Traditionelle Planung

Gründächer

Grünfassaden

Dichte Baumbepflanzung

Solarenergienutzung

Breite Wege / Shared Space

Öffentlichkeitsbezogene EG Nutzungen

Mediенkanal

PKW Parken zentralisiert

Versickerung/ Speicherung von Regenwasser

Grafiken: Paula Callau

28

Hamburg

Source: Grasbrook Forum, 2 November 2020.

During the initial informational events held between 2019 and 2020, the concept of a *Medienkanal* (media channel) was introduced to the public as a key component of the project's infrastructure planning. The proposal aimed to centrally supply the new neighbourhood through a 2 km long tunnel, integrating water, wastewater, electricity, district heating, cooling, and potentially telecommunications. Although labelled a 'physical innovation',[3] this tunnel conveys the same function as the historical structure at Kaiser-Wilhelm-

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[3] Stadtwerkstatt Informationsveranstaltung, 18 September 2019, Hamburg.

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Straße: combining different supply services within one accessible infrastructure building (Figure 4). Some of the arguments in favour of the media channel at Grasbrook mirror those discussed regarding the historical structure. Notably, accessibility for maintenance and repair, along with the potential reduction of future construction sites, was also a central consideration, similar to the discussions surrounding the planning of the historical tunnel.

In addition to the similar discussions regarding maintenance and reduced future construction work, the need for openness regarding future developments was a central argument for the implementation of a supply channel in Grasbrook, framing it as strategy for enhancing resource efficiency and fostering change and innovation, anticipating future uncertainties:

> Given the increasing pace of change and ever-shortening innovation cycles in all areas of technology and society, a permanent and barrier-free accessible media route within an infrastructure tunnel could be a logical step towards improvement. […] Such a development would also provide a locational advantage for the implementation of innovative technologies and the establishment of companies whose future needs remain uncertain. (HCH, 2022: 80)

This emphasis on sustainability and innovation as key arguments for the development of the media channel was reinforced by an employee at HCH responsible for infrastructure planning at Grasbrook. In an interview in spring 2024, he highlighted the efficient use of space by installing all utility grids within a single tunnel, rather than occupying the entire road cross-section with separate supply and disposal infrastructures (interview, 19 March 2024). By concentrating all the pipes and cables within one structure, more space would be available for maximizing root and rainwater retention areas. At the time of the interview, the tunnel was, as he explained, only a so-called preliminary project – a stage even earlier than a feasibility study. During this phase, the development company HCH invited various stakeholders to explore the potential for constructing such a tunnel at the Grasbrook development. These stakeholders included Hamburg's publicly owned water, wastewater, electricity, and district heating providers, as well as other municipal actors involved in the planning and construction of such systems. Within this preliminary phase, the team at HCH systematically gathered all available information on utility channels and compared it with other alternatives based on technical, economic, and ecological criteria in order to convince both the supply services and political

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stakeholders to adopt the project. This evaluation, for example, weighed the higher construction costs of the tunnel against the potentially lower maintenance costs, hoping that the initial investment would be offset by reduced long-term expenses (ibid.).

Eventually, in summer 2024, the decision was made against the media channel, as the high construction costs could not be justified politically, especially during a time of budget constraints, as the HCH employee explained. However, that same interviewee noted that the process of evaluating different options highlighted the benefits of compact installation, which has now become the preferred approach, where infrastructures are installed closer together compared to the traditional method that utilizes the entire cross-section of the street (ibid.).

Cross-sectoral contingencies: Dimensions of infrastructural interrelations

The examination of the historical supply tunnel experiment on Kaiser-Wilhelm-Straße and the recent attempt to implement a similar structure within the Grasbrook development highlights the challenges arising from the interrelations between different infrastructure sectors, specifically the spatial organization of underground infrastructure, the coordination of maintenance needs, and the cooperation across sectors. In the following, I first demonstrate how the need for spatial organization of infrastructures is addressed and what opportunities and challenges arise from this organization. Second, I illustrate how the spatial proximity and varying material conditions of different infrastructures necessitate ongoing coordination between utility services. Lastly, I examine how institutional cooperation at various levels attempts to manage the contingencies emerging from these infrastructural interrelations.

Organizing networks underground: Spatial contingencies

One of the original motives for constructing a tunnel to spatially bundle the pipes and cables of different infrastructure services in the late 19th century was to better organize the limited underground space. As centralized infrastructure networks expanded throughout the city, this space became increasingly crowded with pipes, cables, and network equipment. This growing density posed challenges not only for construction but also for ongoing maintenance

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and repair. To accommodate the continuous increase in infrastructure density, efforts focused on organizing the spatial arrangement of pipes and cables directly when burying them underground. An unwritten rule generally guided the layout of utility services at the beginning of the 20th century: Sewage channels were typically placed in the centre of the road, while water pipes were laid on the right side and gas lines on the left, both positioned beneath the sidewalks (Stübben, 1907). However, this approach was not legally enforced; apparently, a rhyme was even in circulation that humorously critiqued the inconsistency in pipe placement, underscoring the gap between planning ideals and practice: 'Das Siel zuerst, das Wasser drauf, das Gas zuletzt – so hat es die Vernunft gesetzt / das Gas vorab, das Wasser dann, der Sielbau hinterher – so macht es häufig folgeschwer der Ingenieur!' (ibid.: 422).[4]

Not to rely on informal guidelines, Hamburg's utility services, in collaboration with the construction authority, addressed these issues by developing a standardized road section with dedicated pathways for each service. This process was initiated by the gas utility and is notably linked to the maintenance of their underground network. In a letter to the construction authority, the head of the gas utility complained that his workers struggled to access gas pipes due to new postal infrastructure laid directly above or near the gas lines. This complaint, made in July 1910, led to a series of meetings with representatives from the gas, water, and postal services, along with the building authority.[5] They were aimed at coordinating different supply infrastructures within the roadbed and eventually produced a scheme to regulate the exact depth and spatial arrangement of various pipes and cables (Figure 5). The final plan, approved in March 1911, still guides infrastructure work today and laid the groundwork for formulating standards and norms now applied nationally to facilitate not only the installation of pipes and cables but also their ongoing maintenance and repair.

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[4] An English gloss might roughly read: 'Sewers first, then water laid, and gas comes last – so reason's made / Gas before, then water's run, sewers built when all is done – Such careless order, fraught with woes, is how the engineer oft goes!'

[5] Staatsarchiv Hamburg, 321–2 Ausarbeitung eines Schemas für die Anordnung der Leitungen im Straßenkörper 1910–1935, Nr. 1684.

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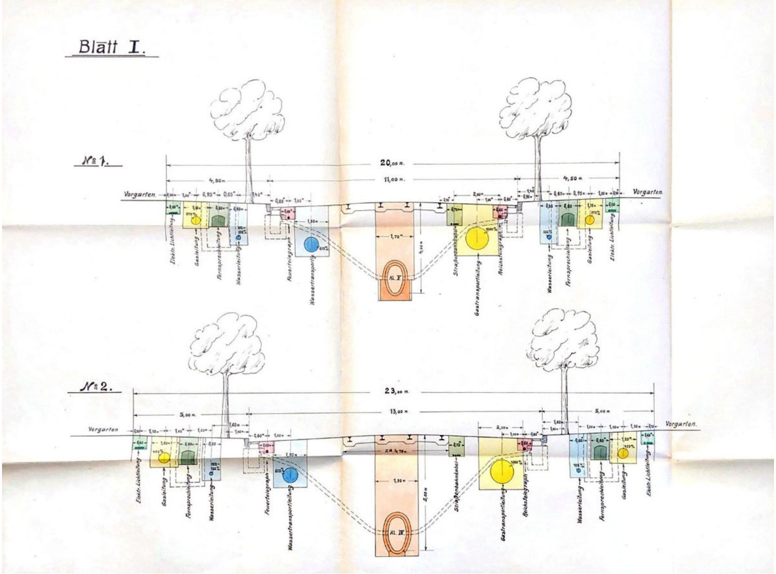
Figure 5: Plan for the layout of pipelines in the street space, 1911.



Source: Staatsarchiv Hamburg (see footnote 5).

The routing plan has been in place for over a century, but the number of providers using street space to supply the city has steadily increased. This rise, particularly due to the rollout of new telecommunication infrastructure, has made it increasingly challenging for workers to access sewers, gas, and water pipes. An employee from Hamburg Wasser described the situation as follows:

> What has changed significantly in the last 100 years is the density of cables in the streets. We can hardly find any free routes. It's really crazy, the cable bundles we have to crawl through. We are one of the deeper ones at a depth of 1.5 metres. […] And all the new telecommunication companies just blindly throw their cables on top of ours. They obtain these excavation licences and route instructions, but nobody checks. […] Then, years later, when we need to access our pipes, we can't reach them because they didn't comply with the plan. So that's really … You have to look at it this way: The ground is full of rubbish. (Interview, 9 June 2023)[6]

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[6] All interviews were conducted in German and have been translated by the author.

The high density of pipes and cables beneath city streets results not only from the addition of new services but also from the retention of older pipes and sewers, which are often left in place after being decommissioned, further limiting available space. In some cases, these older structures are repurposed, creating a different kind of spatial infrastructure entanglement where old structures serve as conduits for newer utilities. For example, in 1998, Hamburger Gaswerke sold their decommissioned gas pipes to Deutsche Telecom.[7] Also in the 1990s, Hamburg Wasser founded servTEC, (Hamburg Wasser Service und Technik GmbH) a subsidiary that offers both active and decommissioned sewer networks for the installation of telecommunication cables (servTEC, 2023). This approach not only reduces the need for excavation but also facilitates easier access for inspection, maintenance, and repairs, much like a supply channel. Although the wastewater network's extensive reach and structure facilitate faster and more cost-effective installations compared to traditional methods, one of the engineers overseeing sewer construction and rehabilitation at Hamburg Wasser remains somewhat sceptical about this strategy:

> This is not my area of expertise, but my impression is that the euphoria we once had is waning again, due to the potential for disruption. For example, we had a case where someone was renovating our sewer, installed an inliner [a tightly fitting skin that is inserted into an old sewer to repair it], and forgot that the telecommunication cable was also there. Of course, that's a disaster. We always want to prevent too many people from handling our sewers. […] In this respect, we tend to say it's better to think about whether you can build in a confined space or find ways to facilitate joint construction. However, if it becomes too cramped, then you encounter the disadvantages again. (Interview, 30 June 2023)

The considerable density of infrastructure beneath Hamburg's streets continues to pose significant risks for the structures. Employees from both Hamburg Wasser and Gasnetz Hamburg have raised concerns that a major threat to their networks comes from other companies operating nearby. This often results in pipe breaks, either from direct force applied by excavators or pickaxes, or because the ageing pipe material cannot withstand excavation work and the resulting ground movement (fieldnotes, 8 February 2024; 18 April 2024). This risk

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[7] Geschäftsbericht Hamburger Gaswerke GmbH, 1998.

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has been documented as early as 1855, when issues with the close spatial proximity of different supply infrastructures within the roadbed emerged. During this period, the gas company – then still privately owned – experienced frequent gas leaks caused by the expansion of the sewer system (Pens, 1937).

These examples illustrate how the finite space for underground networks necessitated a systematic spatial organization of various infrastructures. They demonstrate how the spatial proximity of infrastructures presents both opportunities and vulnerabilities for the networks which are not always predictable and have to be managed on various levels.

Coordinating maintenance rhythms: Temporal and material contingencies

The vulnerability of the networks, stemming from their close proximity, underscores a second aspect of infrastructural entanglements: the temporal and material interrelation of various infrastructure systems. The different sectors are linked not only spatially but also through the various materials that are part of their configurations and which pose different risks. These risks are associated with both the medium supplied by the pipes (gas, water, electricity, etc.) and the physical materiality of the structures themselves (steel, concrete, etc.), an interrelation that makes it hard to anticipate possible outcomes in case of dysfunction. For example, discussions regarding the inclusion of gas in the historical tunnel dominated considerations in the 1890s, whereas the evaluation of the tunnel in the 1960s assigned major risk potential to the possibility of water pipe bursts. Discussions about the new supply channel also focused on the material properties of the various mediums and the risks arising from their close installation. For example, a foreman at Hamburg Wasser expressed scepticism about the supply channel concept for Grasbrook. While he recognized that having all pipes accessible would facilitate maintenance and repairs, he was particularly concerned about the risk of a pipe burst potentially causing a short circuit that could disrupt all interconnected infrastructures. Similarly, another worker at Hamburg Wasser raised concerns about water quality. He noted that water pipes are typically installed at a specific depth to protect them from freezing in winter and overheating in summer. In a shared channel, he feared that temperatures would rise significantly, which could promote germ proliferation and negatively impact water quality and safety. Others highlighted concerns about the potential for corrosion due to condensation accumulating on the bare pipes (fieldnotes, 8 February 2024).

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The material relations between different sectors extend beyond the cases of the supply tunnels. A notable example of such interrelation is the use of grey cast iron pipes, a historical type of piping produced during the 19th and early 20th centuries for the transmission of water and later gas. The advantages of grey cast iron included relatively low production costs and quick manufacturing. After World War II, these pipes became widely used in Hamburg for the reconstruction and expansion of the city's water and gas networks. However, it was later discovered that they were particularly vulnerable to breaking under external pressure due to their microstructure. This issue was identified as early as the late 1950s, leading Hamburg's gas and water supply companies to stop using grey cast iron pipes in favour of newly developed, more flexible pipes made from ductile cast iron, which is less prone to breakage. However, the gas and water networks, having both initially used the grey cast iron types of pipes before shifting to other materials, are now facing similar challenges: relatively new pipes installed in the 1950s that frequently fail. A worker from Hamburg Wasser noted that these grey cast iron pipes are among the worst in their network, breaking more easily than some pipes that are 150 years old (fieldnotes, 8 February 2024).

However, the strategies for addressing these material conditions differ from sector to sector, primarily due to the particular medium distributed and the resulting risk assessments. While the gas utility largely replaced its grey cast iron pipes with more durable materials by the early 2000s (interview, 13 June 2023), the water utility continues to struggle with frequent breakages of pipes from that era.

The problems with ongoing excavation work for maintenance and repair were also a central argument for constructing the historical tunnel in Kaiser-Wilhelm-Straße and played a key role in planning the Grasbrook tunnel. By providing easy access to pipes and cables within a shared structure, the tunnel would eliminate the need for continuous street excavations by various utility services, each operating on its own maintenance and repair schedule. Pipes and cables need to be repaired at different times, and maintenance rhythms vary between sectors. For instance, gas infrastructures require a more frequent and rigorous inspection cycle compared to water and sanitation networks. While a potential dysfunction in a water pipe may first be observed for a while, repairing gas pipes is more immediate (interview, 6 March 2024). The varying demands of infrastructure maintenance contribute to ongoing traffic disruptions, which have become a significant political issue in Hamburg. Through these disruptions, the usually invisible underground systems become visible

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on a wider urban scale, turning the necessary construction work into a central topic within the city's political discourse (Drieschner, 2024).

Workers from gas and water services have expressed that they often face conflicting objectives in their maintenance and repair efforts where the importance of a functioning supply is undermined by other aims. In particular, the traffic regime, which prioritizes uninterrupted circulation, seems to create the most friction. A leading employee at Hamburg Wasser noted: 'In this city, the main issue is transport. Transport is prioritized over the provision of public services' (interview, 9 June 2023). Another employee acknowledged the unsolvable character of these conflicts: 'It is also understandable that there are, of course, conflicting political goals that cannot be resolved. I simply can't ensure that the traffic on the road runs perfectly and at the same time stand on top of it with my construction site. It's an unsolvable problem' (interview, 30 June 2023).

A major frustration of employees at Hamburg Wasser and Gasnetz Hamburg is that they have felt that public and political perceptions often overlook the efforts made to coordinate traffic management with the growing need for infrastructure maintenance and repair. According to them, enormous amounts of effort and time are being dedicated to coordinate these processes, whereas this effort seems not to be recognized at all (interview, 30 June 2023). One employee at Hamburg Wasser for example, highlighted the challenges of communicating the necessity of ongoing maintenance and the resulting construction work to the public: 'People only see that the road is being dug up, closed, and then dug up again six months later. They don't understand that different suppliers with varying needs are behind it' (interview, 9 June 2023).

In order to coordinate these conflicting objectives within Hamburg's infrastructure planning and operation, various tools have been developed. Apart from a coordination office (*Koordinierungsstelle*) located within the city's administration, whose role it is to oversee the construction applications of different supply services, there is also the cooperation project Hamburg Infracrew, through which public utility services (including traffic), city districts, and the port authority bundle their construction measures, coordinate their construction scheduling, including traffic concepts, and perform their services on a joint construction site (LSBG, n.d.-a). Another attempt to coordinate construction work more efficiently is an online tool called ROADS, which is used to coordinate not only the locations but also the timelines for various construction projects. The goal is to minimize the impact of these projects on traffic flow (LSBG, n.d.-b).

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However, although the need for coordination resonates with gas and water utility workers at various levels, the workers all stress that it is not as straightforward in practice as in theory due to the diverging needs and regulations of different sectors. The physical proximity of different networks does not automatically translate into common temporalities concerning maintenance and repair. Aimed at being based on objective decision-making, the coordination of infrastructural maintenance and repair is a continuous negotiation process between different needs and goals. The supply of fresh water and gas, as well as sanitation, stands in direct competition with the smooth flow of traffic and the expansion of public transport and bike routes. Additionally, more than just the gas, water, and sanitation sectors are involved. Coordination must consider not only the diverse needs of all supply and transportation infrastructures but also the varying organizational and ownership structures behind each project, along with different types of urgencies based on material needs and political prioritization, creating a complex web of interrelations.

Cooperating across networks: Institutional contingencies

The different infrastructural sectors are related not only spatially underground and temporally by their maintenance and repair rhythms but also on an organizational level. Examining both the historical and present-day utility tunnels reveals the needs, possibilities, and limits for cooperation between the city and different sectors. The historical tunnel was a state-led experiment implemented in the broader context of an also state-led urban renewal project. Similarly, the idea for the present-day tunnel was initiated by a state-owned company that planned to execute the tunnel within its own large-scale urban development project. Although in both cases most of the included infrastructure sectors were state-owned companies, questions regarding the distribution of responsibility and the limits of the state's agency arise.

A central concern in the discussion on utility tunnels is whether the operator of the tunnel can compel privately owned service providers to install their pipes and cables within the tunnel. In his above-cited lecture on utility tunnels in 1890, Hobrecht explained the procedure in the city of London, which mandated utility services to install their pipes within such tunnels:

> After some initially unsuccessful attempts, a law was finally enacted: the Metropolitan Subway Act of 1868. […] Under this law, gas, water, and telegraph companies were required to lay their pipes in these subways. A fine

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> of 20 pounds was imposed for each instance where the pavement was later broken open there. If pipes that had already been laid in the road embankments were relocated to the subways, this was done at the expense of the Board, which was also responsible for maintaining the ventilation and structural integrity of the subways. The individual lines within the subways were to be maintained by the respective companies under the supervision of an official of the Board. (Hobrecht, 1890: 355)

In Hamburg, more than 100 years later, similar concerns emerged regarding the Grasbrook tunnel. An employee of HCH noted that while the state-owned utilities designated to supply Grasbrook (water, electricity, and district heating) have been included in the planning process, there is no established legal framework to compel privately owned services, such as telecommunications, to install their cables and pipes within such a channel (interview, 19 March 2024).

Another significant obstacle, despite the involvement of primarily state-owned supply services in both cases, was the absence of a unified public institution (*Stadtwerke*) to coordinate the implementation and manage the operation of the tunnel. Hobrecht himself highlighted at the conclusion of his lecture that it is crucial to collectively organize the various supply networks: 'In large cities, it finally seems essential that the management of various utility services, at least as far as the supply networks are concerned, is consolidated under a single technical authority' (ibid.: 387). The lack of such an authority and the resulting unresolved questions regarding the operation of the Grasbrook tunnel have emerged as a key obstacle to its implementation (interview, 19 March 2024). Aside from questions regarding the organization of cross-sectoral projects, the main concern about the operation of utility tunnels revolves around the assignment of responsibilities. One worker at Hamburg Wasser expressed concern about the utility tunnel at Grasbrook: 'It's nice that we can potentially go there and fix a pipe or so. But that also means the workers of the other services can go there. And if something happens, who is responsible?' (fieldnotes, 8 February 2024).

Questions of responsibility also extend beyond the context of these tunnels. The close proximity of underground networks often results in accidental damage to other pipes during maintenance and repair operations. During my time with the maintenance crew from Gasnetz Hamburg, they responded to a report of 'coating damage' made by a private construction company. Coating damage refers to the harm done to the protective coating of a steel gas pipe, of-

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ten caused by tools during trench digging. One of the workers, explained that, in the past, the company responsible for the damage was required to cover the repair costs. However, this practice was discontinued as it discouraged the reporting of such damages. Under the older system, instances of corrosion often went unnoticed for years, and the subsequent repairs for such corrosion proved to be significantly more expensive than the costs of immediate repairs on the gas network. Nowadays, more damage reports are submitted, yet repairs are also carried out more promptly (fieldnotes, 18 April 2024).

In general, coordination and cooperation among publicly owned companies tend to be more effective than between public and private entities. A managing employee from Hamburg Wasser explained that this is largely due to the ease of legal collaboration when both utilities are publicly owned. Since publicly owned utilities adhere to the same standards and follow similar procedures, coordination becomes much smoother (interview, 19 July 2023.). Additionally, state-owned providers exhibit a stronger sense of responsibility and continuity compared to younger, privately owned services, as one employee managing water grid operations stressed: 'We [the publicly owned service providers] also have conflicts over routing and so on, but it's a long-term approach. I think that's what it's all about. You always meet twice' (interview, 9 June 2023). Another employee echoed this sentiment, noting that communication and collaboration are significantly easier now that all suppliers are publicly owned, especially compared to the period when gas and electricity services were privatized: 'Even if it's just that you see people's phone numbers and can call them. The barrier is much lower, which is much better' (interview, 30 June 2023). This was not always the case, as most employees at Hamburg Wasser and Hamburg Gas recalled that cooperation between gas and water was very advanced before the privatization of the gas utility in the early 2000s. However, communication broke down when gas grid operations were outsourced during the privatization process. Today cooperation between the sectors is again back on the agenda. This cooperation extends, for example, also to practical levels: When supply lines cross waterways, they are mostly mounted to bridges. In these instances, Gasnetz Hamburg, which has the most frequent inspection cycles, takes over pipe inspections for other services (interview, 1 February 2024).

This increase in organization, coordination, and cooperation coincides with an ongoing trend of politically implemented mergers among various state-owned supply services in Hamburg. The sanitation authority *Hamburger Stadtentwässerung* (HSE) merged with the freshwater supply utility *Hamburg*

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Wasser GmbH (HHW) three decades ago, in 1995, and the district heating and electricity services were consolidated into Hamburger Energiewerke GmbH following the remunicipalization of the district heating grid in 2019. Most recently, in 2024, the gas and electricity grids were merged to Hamburger Energienetze GmbH. As a result, two major supply entities have emerged: one focused on water supply and wastewater management, and the other dedicated to energy provision and distribution. This evolution suggests a movement towards a more unified structure, similar to an umbrella institution like the *Stadtwerke*.

These examples illustrate how the various infrastructure sectors in Hamburg are interconnected at an organizational level. This interdependence is highlighted by the necessity for collaboration due to spatial proximity, as well as the differing needs and responsibilities associated with maintaining and operating a grid within a broader system of grids. Communication and cooperation tend to function more effectively among state-owned services, and there appears to be a trend in Hamburg towards further integration of these services, as an institution with a comprehensive overview seems to be better equipped to manage the various contingencies that emerge from infrastructural interrelations.

Conclusion

This chapter has analysed two distinct cases of the same infrastructural form: the supply tunnel, which was first implemented as an experiment in the 1890s and then re-emerged as a component in the planning of the current inner-city development Grasbrook. It examined the context and discourses surrounding the planning, construction, and operation of the historical case as well as the considerations that led to the historical tunnel remaining an experiment; it also gave an account of the failure of the present-day tunnel project. From those analyses, this chapter has developed three dimensions of infrastructural contingencies produced by infrastructure's spatial, temporal, material, and institutional interrelations. The first dimension focuses on how various supply infrastructures rely on the same underground space for their networks, necessitating the spatial structuring and organization of various pipes, sewers, and cables. The second dimension considers the differing temporal and material realities of the distinct sectors and their resultingly varied maintenance and repair rhythms. These diverging rhythms have led to ongoing public de-

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bates about the need for cross-sectoral coordination; however, this chapter also highlights the limits of such efforts. The third dimension examines how the unforeseeable and relational processes produced by the first two dimensions must be addressed at a governance level that includes not only cross-sectoral cooperation but also other urban actors and institutions.

These insights exemplify the highly contingent nature of infrastructures and their relation to wider urban processes. They demonstrate how contingency not only emerges from a specific (historical) context but also is produced by the entanglement and interrelation of different infrastructure sectors, illustrating how utility services attempt to manage these unforeseeable processes. Both of these tunnels have been attempts to address the inherent contingency of entangled urban infrastructure systems. The futility of these attempts demonstrates that the complexity of urban infrastructure cannot be resolved by large-scale, overarching plans but rather through small-scale, localized efforts that recognize the socio-material context in which this contingency arises and unfolds. Through such findings, this chapter contributes to infrastructural and urban research on theoretical, methodological, and empirical levels.

Theoretically, this chapter illustrates how infrastructures do not conform to linear narratives of progress and exemplifies their processual nature, as well as the dis/continuities in their development (Gandy, 2014; Moss, 2016). The examples of the two tunnels highlight how organizational concepts and technological advancements can be temporarily sidelined, only to re-emerge after more than a century, still facing similar challenges and concerns arising from the different contingencies generated by the various dimensions of infrastructural interrelations.

Building on these findings, methodologically, this input highlights the importance of historical analysis in urban research. When adopting an ontology centred around the relational and processual nature of the urban, it is important not to view history as somehow finished but as something deeply ingrained in the present and the future in multiple ways. To understand the urban and its infrastructures as a palimpsest of multiple material, temporal, and cultural layers that interact in unpredictable ways, it is necessary to take history seriously.

Finally, this chapter underlines the importance of empirically examining multiple infrastructure sectors, which still comprises a significant research gap in infrastructure studies (Monstadt and Coutard, 2019). To understand the various ways different sectors relate to one another and the resulting

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broader implications for infrastructure planning and operation, it is essential to include various types of infrastructures within one research framework. Analysing Hamburg's infrastructures in this manner, using a particular moment of physical bundling as a starting point, reveals how various forms of infrastructural contingencies cannot simply be resolved by focusing on one sector but must be addressed on a broader level, including other infrastructure services and various public and private entities. In examining these interrelations and the efforts to manage them, this chapter also addresses the lack of research on how professionals engage with urban contingency.

These findings are also relevant for practice. In times of mounting socio-ecological crises, understanding the evolution of infrastructural relations and the im/possibilities to organize, coordinate, and cooperate is more crucial than ever, as it helps urban professionals deal with current uncertainties and anticipate uncertainties of the future – two very central tasks in urban future-making.

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Appendix: List of interviews

Date	**Institution**	**Position**
09.06.23	Hamburg Wasser (water)	Network operation
13.06.23	Hamburg Wasser (water and sanitation)	Network planning
30.06.23	Hamburg Wasser (sanitation)	Engineering, rehabilitation
19.07.23	Hamburg Wasser (water and sanitation)	Infrastructure development
01.02.24	Gasnetz Hamburg	Facility planning and operation
06.03.24	Gasnetz Hamburg	Grid operation and maintenance
19.03.24	HafenCity Hamburg GmbH	Project management

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