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Urban Infrastructures' maturity and the age(s) of maintenance

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Abstract

This chapter challenges the idea that infrastructure maturity would be a phase of urban and infrastructural stability. In an increasing number of countries, mainly but not restrictively in the global North, the combination of infrastructure's ageing and degradation, budgetary constraints and rising environmental issues has gradually shifted professional and public concerns from extension to repair and upkeep. This heralds what the authors coin an 'age of infrastructure maintenance', which dramatically contrasts with the modern infrastructural ideal. Drawing from the analysis of French water networks maintenance and asset management practices, this chapter investigates what this age of maintenance concretely encompasses, highlighting two main challenges a maintenance-centred and maturity-focused perspective raises for utilities, namely practices of knowledge production and forms of infrastructures valuation.

How to theorise infrastructures development? The three-phase model in question

When trying to theorise the development of infrastructures, research in infrastructure studies has long demonstrated that the evolution of a technical network that has proven successful could be modelled thanks to a logistic function, $x = \frac{1}{1+e^{-\lambda t}}$ ¹, better known as an S-curve (Dupuy, 1991, 2011), which broadly highlights three distinct phases (Figure 7.1) that mirror a certain form of interaction between technology, institutions and users. The first phase refers to the times of *innovation* and creation of the network, the second, marked by a rapid increase, represents the moment of *extension*, and the last one sees the curve reaching a plateau and is generally considered a phase of *maturity* of the network.

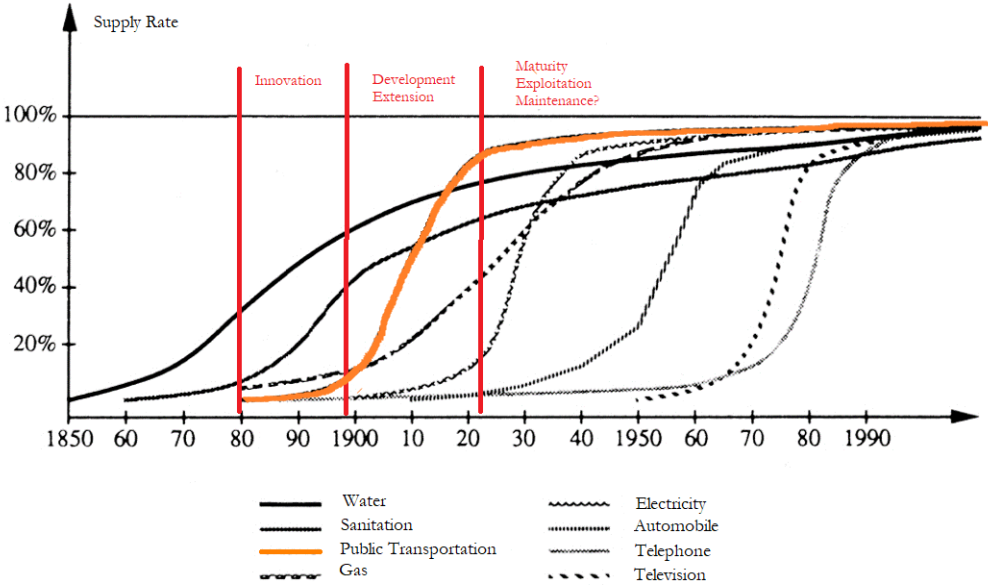


Figure 7.1 *The evolution model of urban technical networks and their various phases* (Source: The authors, adapted from Dupuy 1991 and Offner 1993).

In many regards, the scholarship has concentrated on the first two sections of the curve, though. The extension of networks has become a topic in itself, constructing a fairly future-oriented and growth-oriented narrative (Owens, 1986; Tarr and Dupuy, 1987; Domenech et al., 2013), and a vast range of research has documented in detail how innovation and extension combine (e.g., Coutard et al., 2005). ‘Maturity’, on the other hand, is a phase during which most scholars assume that infrastructures are seamlessly ‘managed’ or ‘exploited’ (Offner, 1993). Such a focus is also manifest in the studies of so-called Large Technical Systems, which Thomas Hughes (1987) famously initiated by identifying five distinct, though sometimes overlapping, ‘phases’ (invention and development, transfer, growth, competition, and consolidation) that stop short of accounting for what happens in the mundane life of ‘mature’ infrastructure. As Jane Summerton (1994) reckons, when asked about the seminal book she edited, *Changing Large Technical Systems*: ‘We sometimes seem to view ‘mature’ large technical systems as invulnerable, embodying more and more power over time and developing along a path whose basic direction is as foreseeable as it is impossible to detour’ (Summerton, 1994, p.56).

Maturity here is essentially seen as a stable phase, too stable sometimes, as emphasized by the idea of ‘obduracy’ that was later attached to it (Hommels, 2005). As Andrew Barry had it,

‘Early research in STS was focused primarily on the design and development of new infrastructural systems, and had less to say about their ongoing evolution in a technoscientific society’ (Barry, 2020, p.97). Interestingly enough, when contesting these accounts for being too linear, Benjamin K. Sovacool and his colleagues (Sovacool et al., 2018) add intermediary phases that highlight, again, periods of important changes (reconfiguration and contestation) before insisting on the moment of decline.

One such focus on either dramatic changes or stubborn stability, and this relative lack of interest in maturity in itself, undoubtedly owes much to the place of global North infrastructures in the early literature on urban infrastructure and large technical systems and its connection with the ‘modern infrastructure ideal’ (Furlong 2014). In the global South, infrastructures and urban services have generally been described as perpetually unstable (Anand, 2017), essentially non-linear and transient (Guma, 2022) and always ‘in the making’ (Gupta, 2018; Baptista, 2019). In contrast, the quasi-universalisation of urban infrastructures in rich northern countries has reinforced their taken-for-grantedness and limited the questioning of their functioning. In this chapter, we would like to unpack such a partition, which assumes that urban infrastructures in the global North, when reaching a certain stage and undergoing a form of routine, are functioning almost as an independent unit. Recent works have explored facets of infrastructure maturity in (post-)industrialised regions, and unfold the subtleties of what we propose to term an ‘age of maintenance’, both reflecting emerging public concerns relating to observed forms of infrastructure dereliction and contributing to a redefinition of the infrastructure itself, its management and its politics.

Troubled ages: infrastructure maturity as a sociomaterial, political and ecological issue

The very notion of infrastructure maturity imparts some ambivalence that requires further scrutiny. In the terms of innovation economics, the adjective ‘mature’ is associated with a form of steadiness. To describe a network as mature is to assert it is settled and does not undergo major new transformations. This partly accounts for the lack of attention to these infrastructures on the part of their urban users, regulators or owners such as local authorities or utilities (UKWIR, 2011). Recently, though, infrastructure maturity has become an object of academic, political and operational interest, as it is at the intersection of three processes whose combined effects contribute to a somewhat new problematisation and reshaping of infrastructure management.

The first of these processes pertains to age and taps into the sociomateriality of infrastructures. Ageing infrastructures are of growing concern in the global North, while *the obsolescence of numerous infrastructures* is becoming more and more obvious as dramatic and emblematic accidents multiply (affecting railways, bridges, electricity or gas networks), and alter infrastructural imaginaries (Henke and Sims, 2020). Observing infrastructures through their potential obsolescence is nothing entirely new, as this was already an important issue in a first version of the scholarship on infrastructure crisis in the early 1980s, which was predominantly associated with a ‘backlog of maintenance’ (Hanson, 1984) and echoed similar discourses in professional milieux as early as in the late 1970s in Western Europe or in the US (Humphrey et al., 1979; Beyeler and Triantafillou, 1987; Barraqué, 2003). This discussion even reached the shores of the political debates in the early 1990s to denounce the decay of an infrastructure seen as a metaphor for the dereliction of the state (Everett, 1996; Leid, 2008), making infrastructure crisis and fiscal crisis somewhat synonymous. Until recently, however, this issue of ageing has been predominantly captured in the academic literature by economic-centred approaches (Brown and Willis, 2006; Ge and Asgarpoor, 2012), around models that determine theoretical lifespans, calculate the economic need for replacement of pipes and

conduits (Park, 2011; Hartman and Tan, 2014), and result mainly in the design of optimisation strategies (van den Boomen et al., 2019). Yet these approaches restrict infrastructures to inert objects with deterministic trajectories, largely ignoring any form of practice that could thwart the ageing process (by accelerating or mitigating it).

The second process relates to the budgetary constraints affecting public finances, up to the production of an ‘austerity urbanism’ (Peck, 2012), and epitomises a political dimension of the reshaping of the infrastructural question in its maturity phase. It takes the form of *underinvestment in infrastructures*, be it in the quality of their construction or in their maintenance. This has been regularly demonstrated over the last decades by reports of professional organisations such as the American Society of Civil Engineers and their scorecard showing the growing deterioration of existing and mature infrastructures (ASCE, 2019). In numerous industrialised countries, a number of actors, of all political persuasions, thus consider that a large part of the infrastructure, and notably urban infrastructure such as road, water or energy systems, is in an advanced state of deterioration as a result of a long neglect (Knowles, 2017; UKWIR, 2011; Maurey, 2017; Solé-Pomès, 2023). This alteration reinforced by budgetary restrictions may take variegated declensions and display regional nuances, as in Germany where regions are diversely affected by deferred maintenance policies due to financial constraints².

The third process has ecological roots and pertains to the *acceleration of environmental crises*, which are increasingly questioning the still largely linear and materially heavy metabolism of many infrastructural systems (Coutard, 2010). These crises resonate with the idea that the material- and resource-intensive nature of a networked urbanism is inherently problematic and fairly unsustainable environment-wise (Monstadt, 2009, Coutard and Florentin, 2022). They echo the growing literature on unequal environmental exchange (Hornborg, 2009), whose application to infrastructure studies leads to question the specific if not ontological contributions of infrastructures to these environmental transformations (Lopez, 2019) and their capacity of adaptation (van der Wal et al., 2021). The environmental pressures linked with these climate-related perturbations also tend to significantly increase the vulnerabilities of numerous infrastructures and accelerate their degradation. This has been epitomised in several occasions such as in the case of the 2017 and 2018 Californian wildfires mainly due to the combination of climate change effects and fairly neglected infrastructures of the electricity utility PG&E (Melo, 2020) or in the Day Zero crisis in Cape Town, where important droughts highly disturbed the functioning of water infrastructures and shed light on its poor maintenance (Millington and Scheba, 2021).

The coalescence of these three processes constitutes a locus of transformation of (urban) infrastructures, hence producing new ‘infrascapes’ (van der Wal et al., 2021). The troubles generated by ageing and deteriorating infrastructures suggest that, far from being a time of mere stability and unquestioned routine, infrastructure maturity can be a phase of tensions and uncertainties (Figure 7.2). This combination accentuates and highlights processes and issues that are overlooked in the traditional sociotechnical regime (Monstadt, 2009) by altering the functionalities of the networks and their capacity to provide sociotechnical solutions to urban problems (Coutard and Rutherford, 2016).

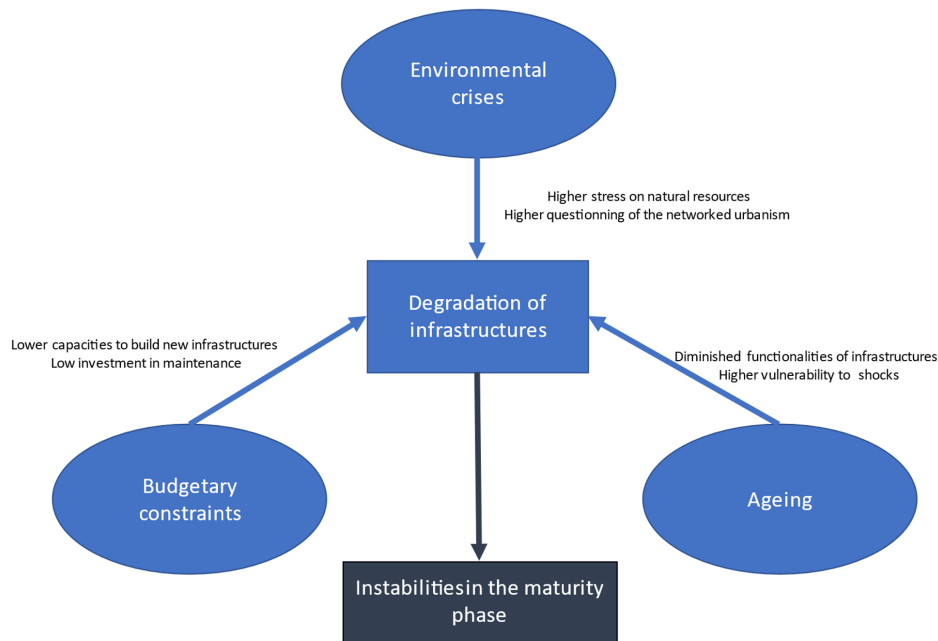


Figure 7.2 *The threefold crisis of infrastructure maturity*

Among the displacements resulting from these combined processes, a crucial one is the reconsideration of infrastructure maintenance, which has become an increasingly pressing concern in recent years. Infrastructure maintenance is consubstantial to the history of infrastructures (Henke and Sims, 2020) and was, at times, even considered as the main task to ensure the persistence of the infrastructural materiality (Lesieur, 2022). One can also find countless reports on roads, water or electricity networks, railway systems dating back up to the mid-nineteenth century stressing the potential physical, economic or political risks relating to the neglect of maintenance and more generally of the operation of infrastructure systems (Chatzis, 2008). Yet, mainly due to its humdrum and unspectacular nature, and in spite of the numerous alarming professional reports on the matter, infrastructure maintenance has remained a blind spot in infrastructure studies for years (even in texts explicitly aimed at enriching our understanding of infrastructure maturity such as Sovacool et al., 2018), in contrast with projects of infrastructural development and the ‘modern infrastructural ideal’ they are carrying along. The complex amalgam of material, budgetary, and environmental constraints in contexts where the access to networks is close to universal invites an increasing number of scholars, experts and utility managers to reconsider and value existing ‘mature’ infrastructures.

In the rest of this chapter, we investigate these emerging concerns for infrastructure maintenance. This, we contend, will help to apprehend the third section of the S-curve as a moment of the life of the network during which, in spite of conventional wisdom, ‘something’ does actually ‘happen’. We suggest that, more than a phase of maturity, which in some works is mainly presented as an intermediary phase between expansion and decline (Offner, 1993; Sovacool et al., 2018), these times may be understood as an age of infrastructure maintenance.

To do so, we will draw on the case of French water supply systems (see Box 1), a sector that has been emblematic of the networked city since the beginning of the industrial era, and in which maintenance has increasingly become a pressing concern. In France, where the domain has undergone important governance restructuring, these concerns have recently crystallised in a specific model that articulates the ideas of asset management and stewardship under the

moniker *gestion patrimoniale*. Even though generally translated into ‘asset management’ the expression encapsulates issues and practices that go far beyond the mere financial aspects to which the notion of assets is often reduced. It requires from water utilities the development of an ‘ambitious’ form of maintenance, which aims at emancipating from the pace of repetitive episodes of rupture or breakdown followed by repair interventions, and leads them to make maintenance not only an operational intervention but a strategic and planned practice that entails the elaboration of specific forms of infrastructural labour, knowledge and care. The model of *gestion patrimoniale*, we believe, provides a fertile site for identifying key issues in infrastructure management in the age of maintenance.

Box 1: A survey within French water networks in transitions

Our analysis rests on the observation of the transformations experienced in various territorial configurations within French water networks, which largely epitomise the new infrascapes presented above.

This 18-month survey was rhythmised by ethnographic observations of interventions on technical equipment with utilities representatives and a bit more than one hundred interviews with various stakeholders in eleven water services of variegated forms in terms of size, ownership (public/private), density (urban, suburban or rural areas) as well as physical constraints (mountainous, coastal, etc. contexts). Through this, we documented contextualised differences and variations of *gestion patrimoniale* strategies and practices; we also observed in these different configurations an increasing focus on water networks maintenance by the utilities themselves, and the reordering of some utilities’ strategies around maintenance activities, which can be considered a sign of a ‘patrimonial turn’ (Denis and Florentin, 2020), i.e. the reconsideration of what makes infrastructures.

Knowledge production and valuation

The emergence of renewed concerns for maintenance in the management of water networks in France has had many interrelated consequences, from the implementation of new engineering processes to the redefinition of institutional responsibilities. In this chapter, we focus on two specific dimensions which highlight how reconsidering maintenance has led to a transformation of urban infrastructures management. The first relies on the production of knowledge around and about infrastructures, the second on processes of valuation.

A renewed knowledge around and about infrastructures

In the management of French water networks, the implementation of an ambitious maintenance model has been driven by a determination to move away from traditional breakdown-centred approaches, which consist mainly in conducting repeated repair interventions as failures occur, limiting maintenance to a short time span. In contrast, the new model draws on a more comprehensive and holistic understanding of maintenance in which repairs are part of a broader approach that favours regular supervision operations and anticipatory interventions. Maintenance, here, is thought as a form of ‘care’ that implies a specific attention to material fragility, beyond the obviousness of breakdown (Denis and Pontille, 2015).

One of the main characteristics of this *careful* approach to maintenance is that it rests on a much deeper knowledge of the infrastructure than is required for ad hoc interventions carried out on an outage-by-outage basis. Nevertheless, cultivating a detailed knowledge of the infrastructure is by no means straightforward, even to those who manage it. Surprising as it

may seem, in most of the territories we analysed, water utilities' staff faced very simple questions, which they actually could not answer. They were not only wondering, 'In what state are pipes or installations?' but also 'What are they made of?' and even 'What is their exact location?' or 'How many structures do we have?', and could not find immediate answers to these seemingly simple questions³.

Such a lack of knowledge significantly contrasts with how infrastructures may have been apprehended in the literature, following the work by Susan Leigh Star (Star & Ruhleder, 1996, Star 1999). Indeed, in her work, Star has insisted on the fact that, while being largely unnoticed and taken for granted by their users as long as they run 'normally', infrastructures are a very noticeable topic for the people who have to take care of them: 'So, within a given cultural context, the cook considers the water system as a working infrastructure integral to making dinner. For the city planner or the plumber, it is a variable in a complex planning process or a target for repair.' (Star, 1999, p. 380). Such a relational perspective aims essentially at highlighting the ordinary invisibility of most infrastructures in the global North. In doing so, it invites researchers to practise 'infrastructural inversion' (Bowker, 1994) in order to fully understand the organisational and political dimensions of infrastructures, that is to render them knowledgeable beyond their taken-for-grantedness. Though extremely valuable, this approach may have suggested to some that, from the point of view of the workers and managers who deal with infrastructures, visibility and knowledgeability were the rule. This assumption, which is rather intuitive, turns out to be less straightforward when it comes to ageing infrastructures, especially when maintenance resources are limited. It seems that, in numerous configurations, infrastructures tend to become largely unknown to a large number of stakeholders, including utility managers, once they have reached the exploitation stage.

The implementation of the *gestion patrimoniale* model has thus had a revelatory effect for those endorsing it, who realised on this occasion how invisible and unknown large parts of the infrastructures have become. This deficit of knowledge is far from being a minor issue that could be solved in a few weeks, as a prerequisite for the implementation of a proper maintenance policy. On the contrary, where this maintenance-centred model has been initiated, the production of valuable and actionable knowledge about infrastructures proved to be a central element of infrastructure management, a utility-wide strategy and a form of investment in itself.

Two kinds of operations have been initiated by the water systems managers who have acknowledged the necessity to significantly reinforce their knowledge about the infrastructure they were in charge of. As a first step, they carried out inventory campaigns aimed at updating the global knowledge about seemingly basic elements such as the number of structures, their type, or the location of network components. In all the cases we studied during our survey of French services, this 'upgrading' program turned more complicated, longer and consequently more costly than originally imagined. This is due to the complex character of the investigations that were conducted to produce or restore a reliable knowledge in a context where a large amount of information about the networks had been accumulated in fragmented and heterogeneous forms (and places), from paper maps and blueprints, to digital but obsolete information systems, through genuine tacit knowledge shared only by a few people without any written traces. Interestingly, this phase did not amount to a 'reduction' process that would have ended in the translation of varied forms of knowledge into standardised datasets and normalised categories. On the contrary, the inventory campaigns were often organised to preserve the diversity of information, gathering not only 'facts' and quantified statements, but also situated and more nuanced accounts, for instance excerpts from interviews with local officials or agents who have dealt with the infrastructure in the past.

In addition to this data collection and recollection, reorganisations were initiated within services in order to simplify and consolidate the circulation of information from intervention sites to central services and GIS departments. This allowed networks managers not only to have a stable and consistent view on their infrastructure, but to constantly obtain updates and corrections directly from the daily maintenance activities, and thus benefiting from the experienced eyes of the agents on the ground, who were asked to share what they discover on the spot about the components of the infrastructure, from their characteristics to their actual state, their history or precise location. More than an external support for future interventions, knowledge generation thus becomes a maintenance activity in itself.

This twofold movement highlights important aspects of what an ‘age of maintenance’ entails in terms of infrastructure management. First, it significantly contrasts with the promises of big data that are generally put forward when it comes to addressing knowledge issues and urban government in the era of ‘smart cities’. Even if some centralised global dashboards may end up being useful in certain cases, the operations at stake in the implementation of a *gestion patrimoniale* model show that the concerns for knowledge production lead to close and repeated (sometimes even physical) contact with the infrastructure components and their socio-material surroundings. Knowledge for and as maintenance rests on a series of actions and gestures that are closing the distance between the material infrastructure and the people in charge of its management. Far from a fully automated and ‘datafied’ supervision, knowledge production in the age of infrastructure maintenance draws on the development of new local activities, instruments and even responsibilities which allow cultivating multiple ways of apprehending and ‘keeping in touch’ with infrastructures⁴.

Second, the move from knowledge-for-maintenance to knowledge-as-maintenance foregrounds the very generative nature of maintenance. Well beyond a routine activity, the management of mature infrastructures can actively participate in the understanding of urban materiality through the generation of information requiring continuous update, such as the location of the pipes and conduits of the different urban networks, or an inventory of their state and a record of the interventions they experienced. This can take various forms: data, maps, pictures, documents, or narratives, all of them supporting the consolidation of knowledge through infrastructure maintenance.

This generative process not only has spatial consequences, but also temporal dimensions and planning implications. Eluding the perpetual presentism of repeated breakdowns, a maintenance-centred management articulates multiple infrastructural temporalities through the production of new knowledge and the implementation of preventive interventions. Indeed, while local enquiries and the production of detailed inventories help make forays into the past, they also fuel numerous projections into the future through works prioritisation and planning, sustained by continuous supervision and the day-to-day attention deployed during repair interventions. The maintenance-centred model of infrastructure management thus reveals that the maturity phase articulates operations with variegated temporalities, giving it a temporal ‘thickness’.

Revaluing infrastructure

The new room made for maintenance, as epitomised in French water systems, has also led to changes in the valuation of infrastructure. As they implemented new ways of taking care of the networks, utility staff gradually modified the way pipes and facilities *count* and *matter*, transforming the role of both infrastructures and utility companies in urban planning decisions. While recent works on infrastructures have argued that the value of infrastructures was increasingly residing in the flux (and less in the material infrastructure) (Rutherford and Coutard, 2016), an age of maintenance seems to revolve around utilities that are reconsidering

their processes, making the infrastructure not only an asset in financial terms, but also a legacy and even a form of sociotechnical heritage.

The notion of *valuation* helps better understand the reconsideration at play. Instead of starting from pre-established fixed values which one would simply manage to perpetuate, valuation is a ‘social practice’ (Helgesson & Muniesa, 2013) through which values are a temporary outcome of heterogeneous processes. Furthermore, in this processual perspective, values are not limited to the strict perimeter of economics and finance. Following Dewey (1939), valuation studies insist on the importance of embracing the twofold signification of the term: the first meaning refers to quantified values and favours comparative operations; the second, encapsulated in expressions such as ‘holding dear’ and ‘prize’, participates in assessing the importance of something (Kjellberg & Mallard, 2013). In the French model of *gestion patrimoniale* we studied, maintenance has found itself at the centre of a valuation process along both dimensions. Its renewed centrality not only obliged people to rethink the monetary worth of water networks but also engaged them in rediscussing the terms under which these infrastructures have come to matter.

On the financial level, first, an ambitious maintenance policy proves a complex apparatus that challenges accounting standards. In France, as in many other countries, traditional accounting schemes for urban (public) services such as a water utility distinguish operating expenditures from investment expenditures. In this scheme, most preventive and what we have termed ‘careful’ maintenance interventions fall into the operating expenditure category, while broad replacement programs are conceived of as investment expenditures. This is particularly problematic in a context of financial constraints at the national and European levels with a high pressure put on public administrations and commercial companies to cap if not reduce their operating expenditures, and favour investment. In order to implement a maintenance-centred management – in which numerous mundane practices are considered as ways of diminishing the needs for major investment and the replacement of pipes or networks components is apprehended as only one option among others –, utility companies thus frequently develop forms of accounting *bricolage*.

The practice of tinkering with numbers is nothing completely new and has already been largely documented, notably to show how it can be used to consolidate some organisational processes (Garfinkel and Bittner, 1967) and provide a temporary and conditional framework to enable certain professional practices (Lampland, 2010). The accounting bricolage at play here sheds light on the controversies produced by a maintenance-centred strategy, emphasising a disjunction between the plea for an ambitious maintenance policy (carried by numerous decision makers) and the accounting scheme supporting or, in the case at play, hindering them. Though contributing to making infrastructures last longer, maintenance activities cannot be considered as investment expenditures, showing the limits and possible contradictions inherent to the distinction between operating costs and investment costs. This leads to accounting and operational aberrations, which are strikingly illustrated by the following example of the amortisation dilemma faced by an accounting officer in a water utility. She wanted to insure a water treatment plant that had reached 30 years of age, a fairly old one theoretically. A series of preventive and proactive maintenance interventions had contributed to maintaining the plant in good shape, allowing it to function in an efficient manner. Yet, as the plant was entirely amortised, its net present value was 0, though there was no technical or environmental need to replace it; but no ‘valueless’ item (accounting-wise) can be insured. This led the accounting officer to decide to re-amortise the plant, just to guarantee its insurance coverage. The maintenance-centred approach of infrastructure management thus poorly aligns with a pure financial vision of asset management, and

contributes to blur the boundaries between the classic⁵ accounting categories of operating and investment costs or depreciation value.

Second, this ‘more-than-asset’ valuation of infrastructure has increasingly transformed the position of water networks among urban services, as the people taking care of them struggle for their reconsideration. This process mainly takes place in municipal operational departments where the coordination between utilities has long been asymmetrical, systematically prioritising roads and streets over underground infrastructures (Baldasseroni, 2019). Highly visible, the very surface of urban areas, roads and streets is a particularly sensitive feature of the city that most of the stakeholders have long tried to keep as intact as possible. In this logic, historically, the scheduling of interventions on water networks has predominantly been dictated by external operational calendars that do not reflect the real state of the (water) infrastructure, in particular the planning of road works that has no direct relation with it. An important number of pipes in a relatively good shape were and still are replaced to avoid the necessity of ‘opening the road’ another time. Developing a maintenance-centred approach has transformed (and somewhat re-politicised) the coordination conditions and the regulations between urban services. In this process, water networks managers increasingly demonstrate the value (in its manifold senses) of ‘their’ infrastructure, for which they have gradually planned dedicated works, on which the road authorities have to align themselves (Denis and Florentin, 2022).

With the emergence of such practices pertaining to an age of maintenance, ‘mature’ infrastructures matter in new ways in the urban arena, transforming both their role and that of utilities in urban planning policies and strategies.

Conclusion

The maturity phase in the development of urban infrastructures in the global North has long been considered uninteresting, when it was not plainly discarded as insignificant, due to its supposed stability and seamlessness. In recent years, though, the combination of material ageing, financial constraints and pressing environmental issues have acted as tangible factors of destabilisation of ‘mature’ infrastructures. This sheds new lights on the concrete activities and continuous transformations at stake during ‘maturity’, beyond the notions of momentum (Hughes, 1987), obduracy (Hommels, 2005) or decline (Sovacool, et al., 2018). In this chapter, rather than taking stability as a taken-for-granted property of infrastructures of a certain age, and disruption as its counterpart, we highlighted the importance of maintenance, as a significant aspect of these ongoing infrastructural challenges. Too often apprehended as a mundane and insignificant activity in the daily life of infrastructures, maintenance is actually a crucial component of what Barry calls the ‘politics of infrastructure’s *endurance*’ (Barry, 2020, p. 94; our emphasis). This shift from maturity to endurance can also be seen as a way to reframe the very idea of infrastructure’s ageing. What is at play in what we described above is not necessarily the process of ageing of infrastructure per se, and we shouldn’t draw our understanding of maintenance from a too deterministic vision of infrastructures’ trajectories that would in an overly simplistic manner correlate age and decline. Rather, what is at stake is the presence or absence of fairly continuous maintenance-centred processes aiming at making infrastructures last.

This is what we had in mind when claiming that the global North is living nowadays an ‘age of infrastructure maintenance’, during which the ability of infrastructures to persist is questioned, renegotiated and rearranged at various scales. Highlighting some aspects of the French model of *gestion patrimoniale*, we showed that, far from being a simple technical matter, such a question engages the very mode of existence of infrastructures, whose ways of

being taken care of, apprehended, and assessed are profoundly transformed. By insisting on two processes – the production of a renewed knowledge on water networks, and the transformations of their valuation –, we showed that several issues are pivotal to the age of infrastructure maintenance. First, rather than being treated as stable artefacts, only affected by a few breakdowns, infrastructures are here considered as fragile and changing entities, whose perpetuation requires the cultivation of continuous and ambitious maintenance. Second, the new centrality of maintenance engages managers and maintenance workers in inquiries that lead to a progressive redefinition of what concretely composes the infrastructures they are in charge of, and how these infrastructures come to matter. Finally, and consequently, both knowledge and valuation processes initiated by the new positioning of maintenance participate in re-problematising the status of infrastructures in cities, and re-organising the traditional hierarchies both between infrastructures and within a specific infrastructure management.

While using the notion of ‘age of maintenance’, our aim is not to add another ‘phase’ in an evolutionist model of infrastructures development, though. Maintenance cannot refer to an inevitable and clearly identified period of time in the life of artefacts (Denis & Pontille, 2022). Some recent research has shown for instance that maintenance activities have sometimes been the prime determinant of infrastructure management (see, e.g., Lesieur, 2022 on road infrastructure). What urban infrastructures across the global North are experiencing is thus *an* age of maintenance, and not *the* age of maintenance, and recent research exploring its different aspects invites us to investigate the emergent dynamics of ages of maintenance (in a plural declension), which would consist of moments of infrastructure problematisation characterised by the recognition of the pivotal role of maintenance and its various implications.

This last point opens the way to a wider questioning: to what extent do these age(s) of maintenance contribute to the formation of new urban ecologies? How could infrastructure maintenance be articulated to environmental consideration and offer ways to further disengage from the modern ideal of constantly growing or forever stable infrastructures?

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Notes

¹ With x being the supply rate, t the time and λ a parameter representing the characteristics of the type of territory and networks.

² <https://www.westfalen-blatt.de/ueberregional/nachrichten/wirtschaft/infrastrukturwuste-deutschland-wie-berechtigt-ist-die-kritik-1007378>

³ It is remarkable that these practical interrogations, which arose for water systems, echo similar diagnoses for other types of networks such as gas or electricity networks and even *a priori* more visible infrastructures such as roads (Maurey, 2017).

⁴ In the French context, the emergence of these new jobs and activities is also accompanying the development of new competences by the local authorities around infrastructure management, whereas the traditional engineering capacity developed by the national State is progressively disappearing (Barone et al., 2016). The age of maintenance, in this context, is also a time of re-regulation at the local level.

⁵ Yet not so old, as only dating back from standards installed worldwide after Second World War.