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RESEARCH ARTICLE

Urban temporal infrastructures in nineteenth-century Paris

Mustafa Dikeç

RISE Research Institutes of Sweden, Urban Development Unit, Lund, Sweden
Email: mustafa.dikec@ri.se

Abstract

The nineteenth century was an era of rapid urban growth, increasing temporal awareness, and a rising demand for precision. Time measurement and display became particularly important in this context, not just for scientific or military purposes, but also for administrations, businesses and for the general public. There was, however, one significant problem: making all the public clocks show the same and correct time, which led to the development of urban temporal infrastructures as symbols of urban modernity and a source of civic pride. This article presents an account of the origins of two temporal infrastructures in Paris, focusing particularly on the electrical network devised by the scientists of the Paris Observatory.

Urban temporal infrastructures in nineteenth-century Paris

How can we make our public clocks show the same and correct time? This was a question that preoccupied many a city government in the nineteenth century, a period marked by rapid urban growth, increasing temporal awareness, and a rising demand for precision in time measurement and display.[1] Especially in the second half of the century, making all the public clocks show the same and correct time became not only a preoccupation, but also a source of civic pride for city governments, at least in the large metropoles of the Western world vying with each other in their pursuit of modernity.

Paris was one of those metropoles that was struggling to synchronize its public clocks under the gaze of a 'clockwatching public'[2] and an unforgiving press that reported any failure with unswerving sarcasm. What made Paris distinctive was that two competing systems operated during the same period, using two contemporary

[1]P. Galison, *Einstein's Clocks, Poincaré's Maps: Empires of Time* (London, 2003); S. Kern, *The Culture of Time and Space 1880–1918* (Cambridge, 1983); A. McCrossen, *Marking Modern Times: A History of Clocks, Watches, and Other Timekeepers in American Life* (Chicago, 2013).

[2]M.J. Sauter, 'Clockwatchers and stargazers: time discipline in early modern Berlin', *American Historical Review*, 112 (2007), 685–709.

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technologies the rivalry of which went beyond clocks: electricity and pneumatics.[3] Paris thus saw the installation of two temporal infrastructures, one regulating the city's clocks by electricity, the other using compressed air to power clocks installed on streets by a private entrepreneur. The aim in this article is to provide an account of the origins of these two temporal infrastructures. I focus mainly on the electrical network with a 'contextual approach',[4] thus joining a strand of scholarship in technologies and practices of time regulation and distribution in nineteenth-century cities[5] that emphasizes the social, cultural and urban factors, as well as the broader landscape of technological use, rather than focusing on innovation and linear progress.[6]

My use of the term 'modernity' follows McCrossen's, referring 'to the set of conditions that required constant, precise, and standardized timekeeping, and to the consequential emphasis on speed, urgency, contingency, and simultaneity'.[7] I also emphasize, however, the term's connotations of change, progress and freedom. In their quest to be modern cities, Paris and others were not only responding to the set of conditions noted above; they were also aiming to become centres of change and progress that defined the ethos of modernity.

Temporal infrastructures, and infrastructures in general, resonated strongly with this ethos as integral parts of 'networked cities'.[8] Infrastructures 'simultaneously shape and are shaped by – in other words, co-construct – the condition of modernity', providing 'the stable foundation of modern social worlds'.[9] The nineteenth-century development of new urban infrastructures in Paris was part of a 'progressive rationalization of urban space' under the impulse of modernity.[10] Although Paris' water, sewage, canal, street and lighting infrastructures have received considerable scholarly attention,[11] its temporal infrastructures, and more broadly 'temporal

[3]M. Dikeç and C.L. Galviz, '"The Modern Atlas": compressed air and cities c. 1850–1930', *Journal of Historical Geography*, 53 (2016), 11–27.

[4]P. Brey, 'Theorizing modernity and technology', in T.J. Misa *et al.* (eds.), *Modernity and Technology* (Cambridge, 2003), 33–71, at 46–7.

[5]I. Bartky, *Selling the True Time: Nineteenth-Century Timekeeping in America* (Stanford, 2000); H. Gay, 'Clock synchrony, time distribution and electrical time-keeping in Britain 1880–1925', *Past & Present*, 181 (2003), 107–40; P. Payer, *Die Synchronisierte Stadt: Öffentliche Uhren und Zeitwahrnehmung, Wien 1850 bis heute* (Vienna, 2015); D. Rooney, *Ruth Belville: The Greenwich Time Lady* (London, 2008); D. Rooney and J. Nye, '"Greenwich Observatory time for the public benefit": standard time and Victorian networks of regulation', *British Journal for the History of Science*, 42 (2009), 5–30; Sauter, 'Clockwatchers and stargazers'; see also I. Bartky, *One Time Fits All: The Campaigns for Global Uniformity* (Stanford, 2007); and V. Ogle, *The Global Transformation of Time, 1870–1950* (Cambridge, 2015), for a global perspective.

[6]Rooney and Nye, '"Greenwich Observatory time for the public benefit"'.

[7]McCrossen, *Marking Modern Times*, 17.

[8]R. Dennis, *Cities in Modernity: Representations and Productions of Metropolitan Space, 1840–1930* (Cambridge, 2008).

[9]P.N. Edwards, 'Infrastructure and modernity: force, time, and social organization in the history of sociotechnical systems', in Misa *et al.* (eds.), *Modernity and Technology*, 185–225, at 186.

[10]M. Gandy, 'The Paris sewers and the rationalization of urban space', *Transactions of the Institute of British Geographers*, 24 (1999), 23–44, at 35.

[11]D. Bocquet *et al.*, 'From free good to commodity: universalizing the provision of water in Paris (1830–1930)', *Geoforum*, 39 (2008), 1821–32; Gandy, 'The Paris sewers'; B. Landau, 'La fabrication des rues de Paris au XIXe siècle: un territoire d'innovation technique et politique', *Les annales de la recherche urbaine* (1992), 57–8; D. Pike, *The World beneath Paris and London, 1800–1945* (Ithaca, NY, 2005); D. Reid, *Paris Sewers and Sewermen: Realities and Representations* (Cambridge, MA, 1991); R. Williams, *Notes on the Underground: An Essay on Technology, Society and the Imagination* (Cambridge, MA, 1990).

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infrastructure' as a focus for research, has been neglected. Temporal infrastructures deserve the attention of urban historians since public clocks and time regimes were important temporal and spatial references in everyday urban life.

Temporal infrastructures were integral to displaying and sensing modernity, not just through their connotations of precise, regular and standardized timekeeping (which implied scientific progress and excellence, as well as rationality and order), but also because of their association, as infrastructure, with change and progress. As Larkin argues, infrastructures can provoke awe and 'affectual commitment' that derives from a belief that 'by promoting circulation, infrastructures bring about change, and through change they enact progress, and through progress we gain freedom'. Infrastructures thus 'create a sensing of modernity, a process by which the body, as much as the mind, apprehends what it is to be modern, mutable and progressive'.[12]

The raison d'être of a temporal infrastructure is to provide a unified, precise time regime. The growing interest in such infrastructures in the second half of the nineteenth century was driven not just by scientific concerns, but also by the necessities of geographically and temporally dispersed financial markets (which required accurate and reliable timekeeping), as well as by the regulation of certain activities in everyday urban life.[13] Although the archival sources on time regulation debates do not explicitly mention such activities, we know that from the mid-1870s onwards, regulation of prostitution and alcohol sales was on the agendas of Parisian officials. The regulation of such activities had a strong temporal dimension, specifying the hours when prostitutes were not allowed on the streets and public spaces, as well as for search warrants for officers to legally enter lodging houses.[14]

What happened in Paris followed a trend shared among the prominent European cities of the period, which 'turned time over to their astronomers' to substitute mean time for true time.[15] True time (or solar true time) can be measured with a sundial, by observing the sun's passage. However, since the earth's orbit is elliptical and its axis of rotation is inclined, the length of a solar day shows variations during the year. When these variations are corrected, we have mean time (or solar mean time). This correction is made by having 'the yearly sum of the daily differences between the actual sun's time of transit and noon as shown by that clock equal zero', with the goal of having the clock 'agree more or less closely with the sun'.[16] With the recognition of the variations in true time and the advances in time measurement and display, several large cities of the continent began to replace true time with mean time on their public clocks – Geneva and London in the late eighteenth century, Berlin, Vienna and Paris in the early nineteenth century.[17]

[12]B. Larkin, 'The politics and poetics of infrastructure', *Annual Review of Anthropology*, 42 (2013), 327–43, at 332 and 337; R. Mrázek, *Engineers of Happy Land: Technology and Nationalism in a Colony* (Princeton, 2002).

[13]D. Rooney, *About Time: A History of Civilization in Twelve Clocks* (London, 2021).

[14]A. Corbin, *Les filles de noce: misère sexuelle et prostitution au XIXe siècle* (Paris, 1982); J. Harsin, *Policing Prostitution in Nineteenth-Century Paris* (Princeton, 1985).

[15]Sauter, 'Clockwatchers and stargazers', 696.

[16]Bartky, *Selling the True Time*, 9.

[17]G. Dohrn-van Rossum, *History of the Hour: Clocks and Modern Temporal Orders* (Chicago, 1996); Sauter, 'Clockwatchers and stargazers'.

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The substitution of mean time for true time, however, made the temporal question a spatial one as well: how could mean time be distributed to the public clocks spread throughout the city? No matter how accurately measured, mean time only made sense if it were shared. The challenge was to find ways to effectively diffuse the mean time from the observatory to the city.

The Paris Observatory takes the initiative

In his 1854 report on the activities and initiatives of the Paris Observatory (then called the Imperial Observatory of Paris), Urbain Le Verrier, the newly instituted director of the Observatory renowned as the co-discoverer of Neptune, noted the discrepancies in the clocks of the city: 'The famous Delambre related that, in the capital itself, he heard one day various clocks strike midnight for nearly three-quarters of an hour. Such deviations no longer occur since the substitution of mean time for true time: yet, the clocks of Paris still show very frequent and very noticeable discrepancies.'[18]

Nearly three decades later, the situation had still not improved: 'It is four o'clock for at least half an hour in Paris', the daily *Le Temps* wrote in an 1880 article devoted to time distribution in Paris.[19] This, however, was not for lack of effort. The Observatory had already experimented with using the telegraph line that connected it to the Telegraphs Administration to electrically regulate a clock set up at the Central Post.[20] Le Verrier's proposal in the 1854 report was to expand this system into a network with clocks located at key sites in the city:

> The clockmakers of the capital, and even those from neighbouring cities, often come to the Observatory to take the time, which is indispensable for them to check the workings of their precision devices, or to adjust properly the clocks entrusted to them. We have frequently been told that it would be very useful to facilitate this service by installing a suitable signal in the very centre of Paris. The Greenwich Observatory drops a large ball, placed in the Strand and visible to all observers, every day at a specific time. The use of this ball has the disadvantage of giving the time only once a day, or at most a very limited number of times. It seemed to us that one or more clocks placed at the Stock Exchange, at the Hotel de Ville, and reproducing exactly, by using electricity, the exact time of the Observatory clock would be more advantageous. There is no reason why these shouldn't be multiplied, installing as many as one would like within the city.[21]

Paris had switched to mean time in 1826, and the Observatory, as Le Verrier noted in his report, provided time to clockmakers twice a week, on Tuesdays and Fridays between 1 and 3pm. This service was extended in 1877 by the installation of a clock at

[18] *Annales de l'Observatoire impérial de Paris*, U.-J. Le Verrier, *Rapport sur l'Observatoire impérial de Paris et projet d'organisation, 1854 décembre* (Paris, 1855), 49. Jean Baptiste Joseph Delambre was the director of the Paris Observatory from 1804 to 1822. His participation in the expedition to measure the meridian between Dunkirk and Barcelona in order to define the metre is told in K. Alder, *The Measure of All Things: The Seven-Year Odyssey and Hidden Error that Transformed the World* (London, 2002).

[19] 'La distribution de l'heure dans Paris', *Le Temps*, 17 Mar. 1880, 2.

[20] Le Verrier, *Rapport sur l'Observatoire impérial de Paris*, 46.

[21] *Ibid.*, 48.

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the Observatory gate (Figure 1), regulated by the Observatory's precision clock.[22] However, there was no network to regulate the public clocks of the city. Furthermore, despite the change to mean time, the canon at the Palais-Royal still announced noon based on solar true, rather than mean, time.[23]

An 1888 book on horology reports that the attempts to install electrical time networks in Paris date back to 1852, to two unrealized projects proposed by clockmakers Paul Garnier and Breguet.[24] The former proposed a circuit, with lines placed in the sewers, that would be regulated by a central clock placed at the Tour Saint-Jacques, a historical monument in central Paris. Four illuminated dials would be placed on this 50-metre tower, while the other dials would be located on the city's significant buildings, such as the Town Hall, Val-de-Grace, lycée Louis-le-Grand, Sorbonne and Palais de Justice. Breguet, on the other hand, proposed to divide the city into circuits to avoid the risk of a total shutdown of the network in the case of an electricity line rupture. As we will see below, the Paris Observatory's temporal network would adopt the same principle, with an eastern and a western circuit.

Let us go back to Le Verrier's 1854 report, which suggests that he had already discussed his time network idea with the then prefect, who had assured him of the administration's support, including the permission to place the lines underground to

Figure 1. Parisian clockmakers taking time from the Observatory.
Source: Musée Carnavalet.

[22]L. Kerst, 'Les horlogers de Paris à l'Observatoire', *Le journal illustré*, 33 (1877).

[23]J. Gapaillard, *Histoire de l'heure en France* (Paris, 2011).

[24]C. Portal and H. de Graffigny, *Les merveilles de l'horlogerie* (Saint-Laurent-le-Minier, 2016; orig. publ. in 1888).

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better isolate them. The project did not see the light of day, but Le Verrier was undeterred. Two decades later, he relaunched the project for the regulation of public clocks in Paris with a letter addressed to the prefect of the Seine, dated 10 July 1875. The project to regulate Parisian public clocks, he noted, had previously been 'approved in principle', but its implementation had to be suspended due to 'the events', which, given the context, must refer to the change of regime, the Franco-Prussian War, the Paris Commune and, possibly, his removal from office in 1870, only to return three years later.[25] This time, however, the timing was right: the Paris Observatory was a shining star as it had played a key role in the unification of weights and measures with the signing of the Convention of the Metre in May 1875, and the World's Fair of 1878 was approaching. If all the public clocks in Paris showed the same and correct time, this would be yet another scientific success to prove the genius of French scientists to the world, especially in the wake of the French defeat of 1870.[26]

Le Verrier's letter stated that the Observatory had been working on the regulation of clocks, and that they now had a precision clock (*pendule*) installed in the catacombs, where the temperature and atmospheric pressure remained constant. This clock was connected to the clocks in the Observatory, and made them run regularly so that 'they all show absolutely the same time to the second'. The Observatory was now in a position to engage in a project that went beyond its walls, and made the public clocks of Paris 'work in a synchronized manner and with a precision superior to what we are habitually used to'.

Attached to Le Verrier's letter were the minutes of a meeting of the Council of the Paris Observatory, where the project was discussed and approved before being submitted to the prefect. The project involved the extension of the system used to regulate the Observatory clocks to the city by installing controlling clocks at the Stock Exchange, Hotel de Ville and other places to be designated by the city. These clocks would be regulated by a precision clock placed at the Observatory's basement, and they would, in turn, regulate a network of clocks in the city. The clocks to be used for regulation, however, had to be able to work independently in the case of an interruption of the Observatory connection. The council noted that these controlling clocks would 'require a level of perfection that is not common among the ordinary products of the clock industry'. A competition for the construction of precision clocks would not only solve this problem, but would also be 'an excellent means to reawaken the taste for precision among clockmakers, which was abandoned by the necessity to produce cheaply for the market, by putting them in a place to create magnificent timepieces similar to those that have made the reputation of their predecessors'.[27]

[25]Le Verrier to Monsieur le Préfet du Département de la Seine, 10 Jul. 1875, Archives de Paris, VONC 219.

[26]On the Convention of the Metre, see Galison, *Einstein's Clocks, Poincaré's Maps*. A general account of the Paris Observatory can be found in J. Lequeux and L. Bobis (eds.), *L'Observatoire de Paris: 350 ans de science* (Paris, 2012). For a scholarly account of the Observatory and its place in the city, see D. Aubin, 'The fading star of the Paris Observatory in the nineteenth century: astronomers' urban culture of circulation and observation', *OSIRIS*, 18 (2003), 79–100. See also the account by a contemporary astronomer, which shows the prominent place the Observatory had as a public institution in the Second Empire: 'Today the Paris Observatory is one of the most important establishments judging by the staff it employs and its budget'; R. Radau, 'L'Observatoire de Paris depuis sa fondation', *Revue des Deux Mondes*, 73 (1868), 764.

[27]Conseil de l'Observatoire de Paris, Présidence de M. Le Verrier (not dated, but likely 1875), Archives de Paris, VONC 219.

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Le Verrier, therefore, asked the prefect to name a commission to oversee the organization of a competition and his time regulation project in general, echoing the council's fervour for the French clockmaking industry in his letter: 'If the City of Paris is willing to accept these proposals', he wrote, 'it will find the opportunity to give a new and fruitful impetus to the art of clockmaking which has made the reputation of many a French artist'.[28]

Le Verrier was not alone in contemplating how to get the public clocks of Paris correct and synchronous. Shortly before his 1875 proposal, Adolphe Alphand, Paris' director of public works, had asked the chief of Battalion of Engineers, Mr Guyard, for a report on the 'regulation (*remise à l'heure*) of all the clocks in Paris'.[29] Guyard submitted his report on 22 May 1874, which was then forwarded to an inspector at the Paris Directorate of Public Works for a summary and evaluation.[30]

Guyard's principal aim was to assure 'a uniform distribution of time' for all the monuments and train stations of Paris with a network divided into five independent sections, all of which started from the Stock Exchange and travelled towards the city's main train stations. He, however, also pointed to the possibility of extending the system for the 'delivery of this uniformly regulated time' to all 'private establishments' requesting this service, 'like delivering water and gas, and thus creating a new source of revenue for the city'.

Guyard had reservations on the use of electricity. Since electrical currents were subject to disruptions, it would not, he thought, be possible to use an electrical system to 'regularly have the exact time without worrying about a complete interruption'. However, an electrical system could be used 'to make disappear the imperfections of ordinary clocks' and to make them show the time 'as good as fine clocks (*régulateurs*)' by using a system invented by the respected clockmaker Breguet.

The inspector was not convinced. He maintained that electrical currents could effectively be used to make the system work, but he was worried that the system would be too costly to operate. He also was not sure if the system could be extended to other clocks. How the system could be used for clocks fixed to a post or a wall was clear enough, but it was hard to see how the electrical current could be transferred to 'mobile clocks', such as those placed on fireplace mantels or furniture, some of which were covered with metallic decorations or 'globes'.

While raising these issues, the inspector's focus was not on the possible private uses of this system, but on the feasibility of Guyard's proposal for the regulation of the clocks at the 164 cab stations.[31] Under the existing system, these clocks cost 2,500 francs per year for maintenance, rewinding and regulation. According to the records, their variation was not more than one minute in four days. Guyard's system would more than double this cost. And, if it were to be applied to the clocks of Parisian train

[28]*Ibid.*

[29]Alphand had previously worked closely with Haussmann for the renovation of the city. He became the city's director of public works in 1871 under the new regime, the Third Republic.

[30]Rapport de l'Inspecteur chef du service, 'Mr Guyard Chef de Bataillon du Génie propose un système pour le réglage des pendules par l'électricité', Ponts et Chaussées, Direction des Travaux de Paris, Service du Contrôle des Voitures Section (Paris, 8 Aug. 1874), Archives de Paris, VONC 219. The account below draws from this report.

[31]Public cabs, called *voitures de place*, were stationed at municipal cab stations, and were an important source of tax revenue for the city. For an account of nineteenth-century cabs, see N. Papayanis, *The Coachman of Nineteenth-Century Paris: Service Workers and Class Consciousness* (Baton Rouge, 1993).

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stations and monuments, the annual cost would be about eight times more than the cost of the existing system. Based on these observations, the inspector proposed that the current system be preserved.

The inspector's work was overseen by the chief engineer, who added a note of approval at the end of the report. He noted that the 600 clocks of the Grand Hôtel were once regulated using Breguet's system, which was also what Guyard had proposed in his report. However, the application of this system produced 'such anomalies' that they had to abandon it and revert to ordinary means, with the added hassle of having to remove all the lines and devices. If the application of this system in such a limited space had failed, the chief inspector wrote, then it was not evident that Guyard's proposed system, which extended to the whole city, would succeed. Even if it succeeded, he concluded, the cost would be 'out of proportion with the results obtained'.

'Awakening the French taste for precision'

Guyard's proposal was thus rejected. Le Verrier's, however, was received favourably, and a Clocks Commission was created by an 1875 decree. The commission was tasked with examining Le Verrier's proposal to install a system of electrical regulators in order to 'ensure the regular and identical (*uniforme*) working of public clocks in Paris'.[32] Le Verrier himself was a member of the commission, as well as of the sub-committee created to organize the competition for the construction of precision clocks as per his recommendation in his 1875 letter to the prefect. In May 1876, Le Verrier wrote to the prefect to inform him that the sub-committee's work was completed.[33] All that was needed now was the approval of the municipal council. The prefect immediately wrote to the municipal council and made a case with a sense of urgency:

> Among the improvements demanded by the Parisian population, one of the most useful would definitely be the regularization of the functioning of Paris' public clocks. Several cities of the provinces and abroad nowadays have electric regulation systems to ensure the regular working of their clocks. It is important for the City of Paris, when the big international competition [World's Fair] of 1878 opens, not to be placed, in this respect, in a situation of obvious inferiority.[34]

The prefect's note also emphasized the importance of organizing a competition for the construction of precision clocks 'in order to foster emulation among clockmakers

[32]Préfecture du Département de la Seine, arrête, 11 Aug. 1875, Archives de Paris, VONC 219. The commission was chaired by the prefect himself, and included, among others, Director of Public Works Alphand, the renowned architect and municipal council member Viollet-le-Duc, and the clockmaker Breguet.

[33]Le Verrier to Monsieur le Préfet, 7 May 1876 and 12 May 1876, Archives de Paris, VONC 219.

[34]Le Préfet de la Seine, Installation d'horloges de précision sur divers points de Paris, Mémoire au Conseil Municipal, 30 May 1876, Archives de Paris, VONC 219. This is the draft version of the prefect's note, prepared by the Directory of Works and marked 'urgent' with a blue pencil. Another document in the same folder confirms that the final version of the note that was sent to the municipal council was dated 13 Jun. 1876; Préfecture du Département de la Seine, Extrait du registre des procès-verbaux des séances, Conseil Municipal de la Ville de Paris, séance du 24 juin 1876.

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and to awaken their taste for precision too often sacrificed to the necessity of selling cheaply'. Once these clocks were installed, they would 'provide the clock industry with the precise information that it needs and that it currently is obliged to go and fetch at the Observatory'.[35]

The matter was discussed at the municipal council's 24 June 1876 meeting, where the renowned architect Viollet-le-Duc presented the project for organizing the competition. Four clocks would be selected from this competition, which would then be used to regulate the clocks of Paris by providing 'the true and synchronous indication of time'.[36] The first of these clocks would be placed at the Observatory, connected to the three others by an electrical circuit, even though the latter would also be able to function independently. These three clocks would be placed at the Stock Exchange, Conservatoire des Arts et Métiers and Saint-Lazare train station.

Viollet-le-Duc's presentation to the municipal council repeated, almost verbatim, the concern with the clockmaking industry that was expressed both in the prefect's note and the minutes of the Council of the Paris Observatory presented above: this competition would result in 'provoking the emulation of clockmakers and awaken in them the taste for precision, too often sacrificed to the necessities of selling cheaply'. There was also evidence of a worry about national and international reputation. Both the commission and administration, the minutes of the municipal council show, were concerned with the approaching World's Fair of 1878. In terms of time precision, Viollet-le-Duc maintained, 'Paris cannot be…in a state of inferiority, not only regarding the other European capitals, but also some of the main cities of France.'[37]

Yet Paris was already 'in a state of inferiority' when it came to regulating public clocks. Electrically regulated clocks were introduced in Brussels as early as 1857. Berlin had its first electrically regulated clocks by 1870.[38] London's Standard Time Company had provided the city with a time distribution service since 1876.[39] Within France, Lille's train station clocks were regulated by a system devised in 1855, and the City of Lyon managed to successfully regulate its clocks in 1856 by a system installed by Breguet.[40]

This preoccupation with inferiority was perhaps aggravated given Paris' self-image, in the eyes of its scientists and administrators, as a city of progress under an 'intensified self-awareness of modernity' during the second half of the nineteenth century.[41] This increasing self-awareness also coincided with the administration's increased sensitivity to 'public awareness of problems concerning the physical infrastructure of everyday life', and its determination to resolve them with scientific expertise.[42]

[35]Le Préfet de la Seine, Installation d'horloges de précision sur divers points de Paris, Mémoire au Conseil Municipal, 30 May 1876, Archives de Paris, VONC 219.

[36]Conseil Municipal de Paris, Séance du samedi 24 juin 1876, procès-verbal, 507.

[37]*Ibid.*, 508.

[38]Bazaar Committee's minutes, sub-committee on clocks, 27 Apr. 1906, minutes of the Glasgow Corporation, April 1906 to November 1906 (Glasgow, 1906), 1410.

[39]Rooney and Nye, "'Greenwich Observatory time for the public benefit'".

[40]F. Hope-Jones, 'Electrical time-service', *Journal of the Institution of Electrical Engineers*, 142 (1900), 119–40; J. Mascart, 'Remise en état d'un réseau horaire dérangé par un coup de foudre', *Bulletin astronomique*, 32 (1915), 229–37.

[41]Gandy, 'The Paris sewers'.

[42]D.S. Barnes, *The Great Stink of Paris and the Nineteenth-Century Struggle against Filth and Germs* (Baltimore, 2006), 63.

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The press could be unforgiving when this image was threatened, as evidenced by the following newspaper article published in the wake of the inauguration of another time network in 1880 that, unlike the project conceived by the Observatory scientists, used a pneumatic system:

> This system has been successfully in use in Vienna for the past three years. We should note that Paris only decides an improvement when it has been tested elsewhere. It only had gas after London, tramways after Brussels, bateaux-mouches after Lyon, steam pumps after New York, underground telegraph after Berlin, and practical telephony after Japan. That's why Paris calls itself the city of progress and we are all proud to be Parisians.[43]

Let us go back to the project initiated by the Paris Observatory. Following Viollet-le-Duc's presentation, the Paris municipal council approved the project. A prefectural decree was published in July of the same year, outlining the rules for the competition. The rules reflected the nationalistic and scientific concerns that had driven the project since Le Verrier's earlier attempts. The very first rule indicated that '[o]nly French-built clocks [would] be admitted'. The clocks were required to have an electric interrupter, and show 'the exact time', marking seconds as well, with a variation of no more than three milliseconds over eight days. This requirement seemed excessive, especially for clocks that were likely to be affected by variations in temperature and vibrations. The City of Paris would buy the top four clocks, paying 5,000 francs for each. In addition to this, the maker of the first placed clock would receive an additional 3,000, the second an additional 2,000 and the third 1,000 – totalling 26,000 francs.[44]

The competition, however, failed to meet the expectations. Only four clocks were entered, and merely two of them were judged good enough to satisfy the requirements defined by the Observatory scientists.[45] Furthermore, the objective to sort Paris' clocks out before the World's Fair was not achieved; the results of the competition were announced only two months before the Fair opened, making it impossible to install an electrical time regulation network to make the city's public clocks show the correct time synchronously.

The World's Fair brought another possibility for Paris to make its public clocks show the same time. As the director of the engineers' union reporting on the Fair wrote, 'one of the most interesting inventions among the wonders of the Exposition' were the pneumatic clocks exhibited at the Austrian section.[46] The clocks belonged to the *Société d'horlogerie pneumatique* from Vienna, and won the Silver Medal in their division.[47] They had already been operational in the streets of Vienna since February 1877, and now the company had plans to install a similar system in Paris.[48] Indeed,

[43]'La distribution de l'heure dans Paris', *Le Temps*, 17 Mar. 1880, 2–3.

[44]Préfecture du Département de la Seine, Programme d'un concours pour la construction d'horloges de précision (Paris: Imprimerie centrale des Chemins de fer, 1876), Archives de Paris, VONC 219.

[45]Tresca to Monsieur le Préfet, 25 Feb. 1878, Archives de Paris, VONC 219. Le Verrier passed away in 1877.

[46]A.F. Noguès, 'Les horloges pneumatiques à l'Exposition universelle', *La Nature*, 10 Aug. 1878, 271, 161–2.

[47]Exposition universelle international de 1878 à Paris, Catalogue officiel publié par le Commissariat général, tome V. Sections étrangères (Paris, 1878), 110.

[48]For an account of the system in Vienna, see Payer, *Die Synchronisierte Stadt*.

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the pneumatic clocks were already patented in France before they even started to operate in Vienna.[49]

Just two days after the closing of the World's Fair, one of the owners of the *Société d'horlogerie pneumatique* of Vienna, an engineer named Victor Popp, obtained an authorization from the prefect to install pipes in the sewers for a one-year trial of the pneumatic clock system in Paris.[50] This was followed by a prefectural decree a year later upon the recommendations of the Directorate of Public Works.[51] The clocks would be candelabra clocks, providing street lighting as well as time in 15 locations in the 1st, 2nd and 9th *arrondissements* of Paris, as proposed by Popp in his application for authorization.[52] As the engineer of the report for the Directorate of Public Works wrote, these locations were 'judiciously chosen', and satisfied aesthetic, functional and infrastructural concerns.[53]

There were now two competing time distribution services in Paris: one operating by electricity, the other by compressed air; one undertaken by French scientists and clockmakers anxious to 'reawaken the taste for precision among [French] clockmakers', the other by an Austrian engineer and entrepreneur; one aimed at regulating the clocks to the second, the other to the minute; one trying to regulate the clocks in the city's already existing landmark buildings, the other serving the parts of the city that were closely associated with the booming fin-de-siècle Parisian life.

Electricity versus pneumatics

Although Popp was authorized to install his pneumatic clocks for a one-year trial period, the city continued to support the project led by the Observatory. It was, however, still not clear which system would work best for Paris. The options included not just systems adopting different technologies (electricity versus pneumatics), but also those using the same technology in different ways (using electricity to power or to regulate the clocks). The prefect thus tasked the Clocks Commission with examining different options that could provide a solution to 'the problem of unification of time in the City of Paris'.

The commission submitted its report on 22 January 1879, noting the significance of the problem as 'no longer a purely scientific question, but a practical one'.[54] Of the three systems examined, the two that were based on the principle of regular mechanical action were rejected. Such systems used energy, provided either by electric

[49]*Bulletin des lois de la République française*, 394 (1878), 747.

[50]Préfecture du Département de la Seine, 'Essaie d'horloges pneumatiques. Etablissements de tuyaux dans les égout. Autorisation accordée à M. Victor Popp', 12 Nov. 1878, Archives de Paris, VONC 20.

[51]Préfecture du Département de la Seine, 'Essaie d'horloges pneumatiques. Etablissements de cadrans luminieux par substitution à des candelabres du service public', 28 Nov. 1879, Archives de Paris, VONC 20.

[52]Popp obtained the authorization in what looked like a shady business operation, which caused conflict with Carl Albert Mayrhofer, his Viennese business associate and inventor of Vienna's pneumatic clocks. On Mayrhofer, see J. Graf, 'Eine phantastische Luftnummer: Carl Albert Mayrhofer, Erfinder der pneumatischen Uhren', *Deutsche Gesellschaft für Chronometrie. Jahresschrift*, 55 (2016), 101–18.

[53]Direction des travaux de Paris, Service de l'éclairage, Rapport de l'Ingénieur ordinaire, 'Essaie d'horloges pneumatiques. Etablissements de cadrans particuliers', 8 Aug. 1879, Archives de Paris, VONC 20.

[54]Projet d'unification de l'heure dans Paris, Rapport de la Commission des horloges, 22 Jan. 1879 (not paginated), Archives de Paris, VONC 20.

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currents or compressed air, to power the clocks and make them work, rather than to regulate them.

The first of these, called 'chronometric counter', used a main clock to send electric currents to the network at regular intervals, every minute usually, to make the hands of the connected clocks move. This system was used in Neuchâtel in Switzerland, and Brussels, Ghent and Liège in Belgium. Although they seemed to work with 'adequate regularity', the commission did not recommend such a system for Paris. One reason was that in this system, if the mechanical action – moving the clock hand – produced by the electrical current failed even once, all the clocks would be behind. This could happen to different clocks at different times, and so they would not show the same time. Worse still, if the electricity was cut, because of an accident with lines or because of a problem with the battery, then all the clocks would stop. Moreover, the adoption of this system required the replacement of all the existing clocks, including their bells and chimes, with electric clocks, which would cause considerable disruption and expense.

The second system rejected by the commission was based on the same principle – regular mechanical action – but used compressed air instead of electricity as the driving force. The commission maintained that the reasons behind the rejection of the first system applied 'even more forcefully' to the 'pneumatic transmission of time', which was, at the time, being tested in Paris, as we saw above:

> The commission, while acknowledging the talent necessary to implement this idea, while having the greatest interest in the trials currently taking place in Paris, is unable to recommend the generalization of this system. The causes for compressed air operated clocks stopping simultaneously or malfunctioning would be the same and would have the same effect as is the case with electric clocks; this system entails the removal of the current clocks and their chimes. The use of compressed air even has, when compared with electricity, several specific disadvantages: from a precision point of view, we should fear the influence of leaks from the pipes; besides the time necessary for the transmission of movement from one end of Paris to the other, would be around 20 seconds.
>
> In terms of expenses, the installation of the air pipes and compression machines is significantly more expensive than that of telegraph wires and batteries.[55]

Having rejected these two systems, the commission opted for a third system which was based on regulation, or fine-tuning, of the existing clocks, themselves capable of functioning independently. The key difference here was that the driving force – electricity, in this case – was used for regulating, rather than operating, the clocks. One advantage of this system, according to the commission, was that even if the regulation was interrupted because of an accident, the clocks would continue to function 'without disrupting the habits of the public'. The system to be adopted had to allow, in the case of a malfunction of the regulating system, the dials to still mark time and the chimes to still be heard, so that, they wrote, 'the malfunction of the clocks go unnoticed, without disrupting the habits of the population'. In other words, it was better to have a slightly 'wrong' time than to have no time at all.

[55] *Ibid.*

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The commission, therefore, approved the system that several of its members had been developing over the years. In this context, the pneumatic system, in particular, seemed like a non-starter; the Clocks Commission consisted of the members of the French scientific and clockmaking establishment, whereas Victor Popp was neither a scientist nor a clockmaker; nor was he a Frenchman, but an Austrian. The pneumatic time network that was installed by his company in Vienna, however, had received favourable reviews. Pneumatic clocks, one reviewer observed, told the time exactly, cost less owing to the simplicity of their mechanism, and they were, unlike clocks connected to an electrical system, immune to the effects of 'atmospheric electricity'.[56] Another noted the disadvantages of electrical time systems compared to pneumatic ones, which included the unreliable workings of electricity generators and the sensitivity of electric lines to their environments.[57] These observations resonated with the general advantages of compressed air over electricity shared by the proponents of pneumatic technologies in the nineteenth century. Compared to electricity, compressed air technologies were simpler and sturdier:

> The difficulties encountered in electrical operations are numerous, and in many cases impossible to overcome. Everything must be guarded with the closest scrutiny, demanding the highest skilled and educated labour; lighting, moisture, etc., are constant causes of trouble; extreme care is required by the operators to avoid receiving the dangerous and often fatal current; the machinery runs at high speed, requiring buildings and foundations of the most substantial construction. Compressed air has none of these difficulties to contend with. The compressor is but little more than a steam engine with one or more extra cylinders and their valves, all of simple design; it runs at safe speeds, is clean, comparatively noiseless, and safe in every way.[58]

As Victor Popp himself wrote, compressed air technologies, due to their design, were simpler: they did not require engineers and a specialist crew for operation and maintenance; 'an ordinary mechanic' sufficed.[59] Furthermore, compressed air provided a reserve of energy that could be stored easily and kept indefinitely with a tightly closed reservoir. It was 'stored, distributed and controlled better than electricity, stream or water', which made 'pneumatic technologies convenient for use in urban networks'.[60]

[56]L. Figuier, *L'Année scientifique et industrielle: ou Exposé annuel des travaux scientifiques, des inventions et des principales applications de la science à l'industrie et aux arts, qui ont attiré l'attention publique en France et à l'étranger* (Paris, 1878), 144–5.

[57]M.E. Vignes, 'Transport de l'heure au moyen de l'air comprimé: les horloges pneumatiques', *La Technologiste: Archives des progrès de l'industrie française & étrangère*, 27 Mar. 1880, 117, 206–7.

[58]'Compressed air vs. electricity', *Compressed Air*, 1 (1897), 179–80.

[59]V. Popp, *L'air comprimé à Paris: sa production, ses applications et son prix de revient* (Paris, 1894), 32. Popp gradually expanded his pneumatic time business and set up a compressed air factory that serviced not only his clocks, but also mills, workshops, restaurants, cafés and cold rooms, among others. The factory was built in 1891 and functioned until 1994. Today, it is a designated national monument, and serves as a school of architecture (*L'École nationale supérieure d'architecture de Paris Val de Seine*).

[60]Dikeç and Galviz, '"The Modern Atlas"', 20.

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Such advantages did not seem to convince the commission members, who had, as scientists and clockmakers, high standards for accuracy and precision (as we saw above with the requirements of the failed competition). Pneumatic clocks could not meet these standards because of their technology. They did not mark seconds, and geography was indeed a problem; the farther the air travelled, the longer it would take to make the minute hand move. In fact, once the pneumatic time distribution system was operational, there was only a four-second difference among the public clocks connected to the network; the ones closest to the distribution centre were two seconds early, and the ones farther away were two seconds late.[61] This, probably, was good enough for the general public, but neither accurate nor precise enough for the Observatory's astronomers. However, as we will see, this quest for accuracy and precision came with a cost. The complicated and delicate mechanisms that were required to meet these standards made the clocks more vulnerable to their surroundings, which was particularly problematic in a buzzing city.

Time centres

The system approved by the commission was ready, as their report put it, to 'distribute time to the second' in the whole of Paris by using special clocks to regulate a network of public clocks. A clock marking the mean time would be placed in the Observatory, and this would be the heart of a network with two closed telegraphic circuits, one to the east, the other to the west, both starting and ending at the Observatory. On these circuits would be installed 12 'time centres' (*centres horaires*) with clocks regulated '*to the second*' (emphasis in the original) by the Observatory clock. Landmark churches, the Stock Exchange, Palais de Justice, Mazas prison and the horse market (which was then in the 5th *arrondissement* of Paris) were the designated locations of these time centres. Regulated by the Observatory clock, the time centre clocks would each regulate a network of up to 40 clocks themselves with lines placed in the sewers, providing 'the exact time' to their surrounding areas 'to the minute'. This secondary network would cover the whole of Paris with clocks installed at the town halls of each *arrondissement* (Figure 2). Thus, the time centres project covered the key administrative, religious, judicial and commercial sites with science – the Observatory – at its foundation.

Excluded from the project were the train station clocks and the 170 clocks of the cab stations. Train station clocks were excluded from the project not because the commission did not recognize their importance for the public, but because they thought it would be imprudent to get the city involved in such a complex issue where mistakes could be deadly:

> We included in the list of the clocks to be regulated none of those located in train stations. This is not because we disregarded the primary interest for the public to know all those clocks show the same time, and the same time as the city's clocks. However, after a careful examination of the conditions of the installation of time service in train stations and all the network which depends on them, the commission found it would be unwise for the city to intervene in a

[61]Résumé des procès-verbaux des séances, séance du 4 novembre 1881, in *Mémoires de la Société des ingénieurs civils*, 36 (Paris, 1881), 511.

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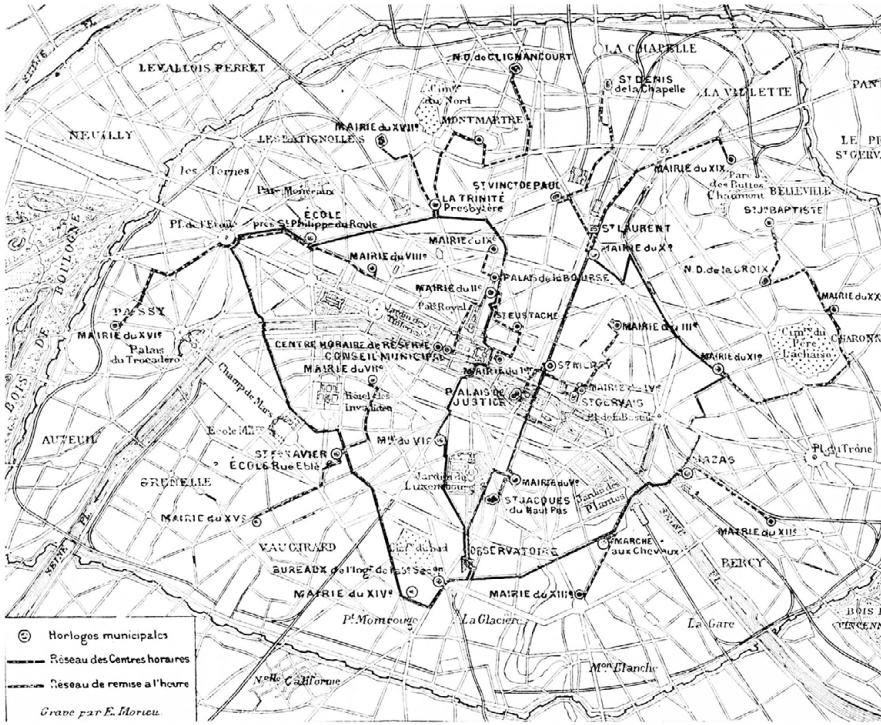

Figure 2. 'Time centres' of Paris.
Source: Wikicommons. Originally published in E.A. Engler, 'Time-keeping in Paris', *Popular Science Monthly*, 20 (1882), 308.

> very complex service with very high stakes, and in which its responsibility, in case of an accident in the regulation of clocks, might be regrettably engaged. It is extremely likely that the train companies, when they see on their doorstep the city's clocks regularly giving time, and all of them the same time, will spontaneously adopt the Observatory time. That day, the unification of time in Paris will be the unification of time in all of France.[62]

The decision to exclude the train stations from the network might have also been influenced by the fact that the railway companies had themselves kept the time in their respective train stations.[63] The exclusion of the clocks at the cab stations, on the other hand, was due to the large sums required for their conversion that would allow them to be regulated with the proposed system. The commission concluded that it would be more economical to replace them with new clocks adapted to the regulation system proposed, but that required further examination. This was a curious exclusion

[62]Projet d'unification de l'heure dans Paris, Rapport de la Commission des horloges, 22 Jan. 1879 (not paginated), Archives de Paris, VONC 20.

[63]See, for example, G. Dumont, *Traitée pratique d'électricité appliqué à l'exploitation des chemins de fer* (Paris, 1885), the chapter on 'Unification de l'heure par l'électricité'. Dumont was the chief inspector for the Compagnie des chemins de fer de l'Est.

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because, as the commission itself acknowledged, these clocks were the most consulted in the city, owing to their number and location.

By the end of January 1880, French science of precision was on the streets of Paris, with six of the twelve time centres fully operational.[64] On 12 February of the same year, the daily *Le Figaro* wrote:

> Is the unification of time in our capital a mere dream? We know that four clocks, the official mission of which consists in giving the exact time of the Observatory, have been functioning in Paris. The first of these is at Arts-et-Métiers, the second on the façade on the school behind the Trinité Church, the third next to Saint-Philippe-du-Roule, and the fourth at the city hall of the 2nd *arrondissement*, rue de la Banque. And yet, we were informed before yesterday by a competent person that on February 10th, the first of these clocks was behind Observatory time by three seconds, the second by twenty-two seconds, the third by twenty-seven seconds, and the fourth by five minutes and twenty seconds. If this is the case, then it was a wise decision to install only four of these clocks, because given the observed progression of delay in these so-called precision instruments, we could end up with a phenomenal imprecision with ten or so of these devices.[65]

The malfunction of the electrically regulated clocks on 19 February was due to the formation of ice in the sewers, which cut the electricity lines, disrupting the service on both the eastern and western circuits.[66] Such a glitch in the workings of the time centre clocks, which were supposed to work independently in case of a disruption (and to continue to regulate up to 40 clocks each) was not good publicity for the city. More complications with the time centres were exposed in the coming months and years. A report on the state of the system from (possibly) the early 1880s opened by stating that '[t]he problem of giving the same time among all the points in Paris is less easy to solve than we tended to believe'.[67] Complaints poured in, which led the director of the Paris Observatory to send a letter to the Directorate of Public Works, asking for an investigation into the disruptions. He complained that the public held the Observatory responsible for each disruption of the electrical transmission of time because of the inscription 'Observatory time' on the time centre clocks. According to the director, this was all Breguet Company's fault, which was tasked with the maintenance of time centre clocks, but which, the director alleged, failed to control the time centres consistently, did not correct delays or fixed glitches, and ignored the Observatory's reports on problems with the clocks.[68]

[64]'L'unification de l'heure', *Le Petit Parisien*, 25 Jan. 1880, 3–4.

[65]*Le Figaro*, 12 Feb. 1880, 2 (under 'Nouvelles diverses').

[66]Tresca, 'Sur le réglage électrique de l'heure à Paris', Institut de France, Académie des Sciences, séance du 22 mars 1880, Archives de Paris, VONC 219. Tresca chaired the Clocks Commission after Le Verrier's passing.

[67]'Unification de l'heure dans Paris', handwritten report, Archives de Paris, VONC 219. The report is neither signed nor dated, but the information contained in it suggests that it must be from the early 1880s.

[68]According to the bill of specifications signed with the City of Paris, the Breguet Company was indeed responsible for the surveillance, maintenance and winding of these clocks. Préfecture de la Seine, Ville de Paris, Unification de l'heure dans Paris, Réseau des Centres horaires, 1er Circuit dit de l'Ouest, Fourniture et installation, surveillance, entretien et remontage des régulateurs centres horaires, Cahier des Charges, 9 Aug. 1879, Archives de Paris, VONC 219.

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A report was prepared in 1887 to respond to the Observatory director's complaint. It turned out the director's claim about the 'Observatory time' inscription on the time centre clocks was not accurate. It was decided earlier that no such inscription would appear on the clocks to avoid precisely the problem alleged by the director. Only one clock, that of Place Denfert, had such an inscription. All the others carried the inscription 'Ville de Paris – Unification de l'Heure – Centre horaire', with no mention of the Observatory. After reviewing some cases of delays, the report identified the main culprit: vibrations caused by urban traffic. It was, therefore, not fair to put the blame on the Breguet Company alone: 'The synchronization of clocks is a very delicate operation', the report concluded. Even if they were kept under constant surveillance, such accidents could happen. There were various reasons for malfunctioning, most of them due to the delicacy of the mechanism and the poor isolation of the lines, but rarely due to surveillance problems.[69]

One thing, however, was clear: there was 'an inherent flaw of the very delicate mechanism of the time centres', as the report had it, which was particularly problematic in areas with significant vibration caused by urban traffic. This is why, for example, they had moved a time centre from rue Victor Cousin to avenue Rapp, where it was on more stable ground. But vibration was not the only cause of disruption in these clocks. The time centre clock that was moved to avenue Rapp was installed too close to the stove of the school canteen, thus suffering great variations in temperature, which disrupted its proper functioning.

The avenue Rapp clock is only one of the examples that were cited in an 1889 technical note prepared by Wolf, an Observatory scientist who had been part of the time centres project from the start. Other examples in Wolf's note included the clocks at St Philippe du Roule and the town hall of the 11th *arrondissement*, which vibrated strongly every time a car passed by. The one at the horse market suffered not only vibrations but also variations in temperature. The Trinité Church time centre clock wobbled with every opening or closing of the door of the presbytery. Wolf admitted that there were problems with the time centre clocks, regarding especially their escapement mechanism. Vibrations made the gears skip, which, according to Wolf, was 'impossible in a well-made clock'.[70]

Yet, the time centre clocks continued to suffer well into the twentieth century, until their technology was made obsolete by the diffusion of radio signals. Twentieth-century reports on their functioning indicate that the rupture of cables due to underground works and especially the vibrations caused by heavy urban traffic still disrupted the service.[71] There was even a 1907 proposal to install a special mechanism to the time centre clocks so that when the service was disrupted in a given clock, a

[69]Rapport du Conducteur, Service de l'Unification de l'Heure, 4 Aug. 1887, Archives de Paris, VONC 219. The Observatory director's letter was dated 26 July 1887, and, the report stated, was attached. However, I could not locate it, so my account of the director's letter is based on its summary in this report. Note that there is now a new division at the Directorate of Public Works, 'Service de l'Unification de l'Heure', and the report was signed by 'Le Chef du Service de l'Unification de l'Heure'.

[70]C. Wolf, 'Points sur lesquels doit porter la remise en état des centres horaires.' Wolf's note is not dated, but its date is suggested by a cover letter, 31 Jan. 1889, attached to it. Archives de Paris, VONC 219.

[71]J. Mascart, 'Organes principaux de distribution et de contrôle des horloges synchronisées électriquement', *Bulletin astronomique*, 24 (1907), 161–90; Mascart, 'Remise en état d'un réseau horaire'; M. Frouin, 'Mémoire au sujet de la transmission de l'heure exacte aux administrations et aux particuliers', *Conférence internationale de l'heure* (Paris, 1912), 247–9.

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signal would alert the public that the time indicated was not to be trusted.[72] It seemed, however, that the delicate clock mechanisms required by the adopted electrical system was just not suitable for busy urban streets.

Conclusion

What started with an ambition to display the excellence of French scientists and the craftsmanship of French clockmakers turned into a source of public embarrassment. While the city and the Observatory tried to tackle the problems with their time centres, the pneumatic time distribution network installed by Popp flourished. After a successful trial period, Popp signed a 50-year concession with the city to distribute time to public clocks and private subscribers.[73] Although Popp's clocks did not function with the accuracy and precision desired by the observatory scientists, they did capture the imagination of Parisians with their aesthetics and presence on busy boulevards. Unlike the delicate mechanisms of the time centre clocks, the pneumatic clocks only had a sixty-teeth wheel and a leather bellows that made the wheel advance by one tooth every minute when compressed air arrived and inflated the bellows. This was a simple and sturdy design that withstood temperature changes and the vibrations caused by heavy urban traffic.

Popp's clocks were not perfect either. The system suffered several problems, including pipe thefts, coal shortages and flooding, in addition to the occasional mechanical breakdowns. A review of period newspapers and magazines show, however, that despite their problems, the pneumatic clocks became important reference points in fin-de-siècle Parisian street life, with a mix of mockery and fascination.

The Parisian experiments with time distribution took place in a period of growth in urban infrastructures and civic culture, with water and gas networks, town halls, public museums and libraries rapidly expanding as 'material expressions of civic pride'.[74] Within this context, the consolidation of a reliable civic time regime became a source of civic pride and urban identity,[75] and an objective to be attained by aspiring cities. Somewhat a latecomer to the field, Glasgow, imagined and presented as the 'Second City of the Empire' in the late nineteenth century,[76] even sent a deputation to several western European and American cities in 1905 to report back on their public time services to the specially formed Bazaar Committee on Clocks as part of the Corporation of Glasgow.[77]

[72]Mascart, 'Organes principaux de distribution'.

[73]Convention avec la compagnie générale des horloges pneumatiques pour la concession sous la voie publique des emplacements nécessaires à l'établissement des tubes destinés à la transmission pneumatique de l'heure dans Paris, Conseil Municipal de Paris, séance du samedi 19 juillet 1881, procès-verbal, 94.

[74]Y. Ishibashi, 'Constructing the "automatic" Greenwich time system: George Biddell Airy and the telegraphic distribution of time, c. 1852–1880', *British Journal for the History of Science*, 53 (2020), 25–46, at 36; M. Groten, 'Glasgow's new town hall: imperialism, nationalism and civic pride, 1877–1889', *Urban History*, 48 (2021), 644–62.

[75]Gay, 'Clock synchrony'; A. McCrossen, '"Conventions of simultaneity": time standards, public clocks, and nationalism in American cities and towns, 1871–1905', *Journal of Urban History*, 33 (2007), 217–53.

[76]Groten, 'Glasgow's new town hall'.

[77]Glasgow, Bazaar Committee's minutes.

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'Urban modernity in the late nineteenth and early twentieth centuries was closely associated with advances in science and technology',[78] and modern urban networks were proudly displayed in urban spaces as glorious symbols of modernity.[79] Paris in the late nineteenth century was particularly attuned to this kind of display following the consolidation of the Third Republic in 1870, which marked 'a new epoch…in the history of Paris'.[80] As Landau noted, the public spaces of the Third Republic were defined as places of civic pride.[81] Temporal infrastructures and public clocks, ideally working regularly and synchronously, were parts of this urban landscape.[82]

This story of Parisian time centres and the rivalry between different time distribution systems addresses a somewhat neglected aspect of the histories of urban infrastructures by emphasizing the significance of temporal infrastructures and by filling a research gap in the histories of Paris' infrastructures. Just as '[t]he provision of light, mobility, energy and water form[ed] part of an urban palimpsest in the progressive rationalization of urban space' in nineteenth-century Paris,[83] so did the provision of temporal infrastructures to consolidate a unified civic time regime worthy of a modern city.[84]

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[78]Dikeç and Galviz, '"The Modern Atlas"', 14.

[79]M. Kaika and E. Swyngedouw, 'Fetishizing the modern city: the phantasmagoria of urban technological networks', *International Journal of Urban and Regional Research*, 24 (2000), 120–38.

[80]J. Willms, *Paris: Capital of Europe from the Revolution to the Belle Époque* (New York, 2002), 334.

[81]Landau, 'La fabrication des rues de Paris'.

[82]In her account focused on American cities, McCrossen notes the importance of public clocks in representing public power, authority and legitimacy; McCrossen, '"Conventions of simultaneity"', 222.

[83]Gandy, 'The Paris sewers', 35.

[84]Before the electrically regulated or pneumatically powered public clocks, time balls fulfilled this function. As Rooney writes of the Greenwich time ball of the Victorian era, it made a 'powerful statement…to the world from its commanding position overlooking the River Thames and London's crowded docks: here is progress. Here is modernity. Here is the *future*'; Rooney, *About Time*, 142.

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