WHAT IS INFRASTRUCTURE?
ORIGINS, TURNS AND CONTINUITIES OF THE CONCEPT

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This article explores the history of the concept of infrastructure, from its origins in 19th-century French railway legislation, its adoption as a metaphor for characterizing the social world, to its international expansion in both military and civilian domains. Delving into the manifold meanings and contexts in which the term is employed, the author unveils a genealogy that weaves continuities with translations and transfers, marking its journey across diverse disciplinary, geographical, and political contexts.

**Keywords:**
Public works, railways, management, history, infrastructural turns

**Infrastructure: a Legal and Material Metaphor, not a Fad**

*Roads, bridges, and highways through which goods and people pass daily are a persistent and omnipresent reality that resulted from the constant facility and network construction that order flows of transit and organize a daily life that has been internalizing fixed dimensions. To understand all this materiality, the concept of “infrastructure” has become widespread in the last decades, as a kind of “spatial kit” that includes fixed installations, complex sociotechnical systems, and a set of rules to guarantee access to various users that must be regulated (Van Laak, 2001; Flyvbjerg, Bruzelius & Rothengatter, 2003; Cassa, Schwanen & Shove, 2018; Hein, 2018; Frischmann, 2012). This concept has been extended to understand more immaterial and informal aspects of social life as reflected in new critical studies on heterogeneous infrastructures and their adoption by historians as a “new fashionable vocabulary.” (Ernstson & Nilsson, 2022; Bridges, 2023) However, the increasing broadening of the meaning of infrastructure makes it necessary to reconsider what was the core of its definition and its subsequent journey before reaching the social sciences, politics, and history. In this regard, although there is a certain consensus in pointing its origin in French railway engineering, “infrastructure” was not really a “technical” jargon but an administrative concept to delineate the limit between private and public investment. And its translation and subsequent use in English in the twentieth century gave it an operational character associated with large military operations, with tensions between what “installation,” “network,” and “systems” mean.*

The Immobility Attribute and Basic Definitions

*For Fernand Braudel (1968:74) the totality of history could be understood as an “infrastructure of relationships” which is produced by layers of slow history with thousands of levels of time as depth, a persistent semi-immobility. Immobility, as a heuristic resource, allows us to understand the transformations of space through the construction of terrestrial transport networks that have historically accumulated and sedimented. This attribute of immobility also allows us to understand infrastructures as testimonies of flows and as a support for the contemporary information society. (Plassard-Buguet, 1989; Prelorenzo, 2007; Castells, 2000:446) But what is infrastructure's basic meaning? For Latour (2005:194) terms such as “general framework,” “infrastructure,” “armature” have been borrowed from technical activities to vaguely indicate the social world’s structured interactions. Dictionaries do not necessarily reflect when a concept was created, but they can help us to understand when the word was in public use. The Spanish Royal Academy (Real Academia Española, RAE, 2022) defines “infrastructure” as: “Underground work or structure that serves as support to another” and as a “Set of elements, endowments, or services necessary for the proper functioning of a country, a city, or any form of organization.” In English, The American Heritage Dictionary (2022) defines it as both, “facilities” and as “An underlying foundation or foundation, especially for an organization or system.” In order to cover the entire history of infrastructure in the United States, engineer and historian David Petrovski (2009:370) developed a definition of his own: “[infrastructure] connotes the bottom of a society’s physical improvements and denotes public works (i.e., improvements and systems such as roads, bridges, airports, water supply, and waste disposal.)” He locates its antecedents in the Roman roads, but the word “infrastructure” in English is*
recent: it emerges around 1927 but did not appear in dictionaries before World War II. This absence before 1945 in the United States could be explained because there was already a legal definition in the so-called “Essential Facilities” doctrine of 1912, established by the Supreme Court to settle a controversy over the cost of the construction and maintenance of railroad bridges in Saint Louis, Missouri, to get across the Mississippi River. The river’s magnitude made it impracticable that each road or company could cross it with its own bridge, forcing the creation of an “American” legal metaphor to give the attribute of public good to a private facility that was a natural monopoly in order to regulate open access (Churella, 2009:109).

On the French account, Ashley Carse (2017:27-39) indicates that the word infrastructure had its origin in engineering and in the nineteenth century French railway policy. It subsequently migrated to military use until reaching the social sciences to explain physical assets, systems, and worldviews, and to help us understand the current world as an underlying framework of heterogeneous elements adjusted to a calculated order. Other authors indicate that, by 1875, it was already frequently used for railway activities in France (Van Laak, 2001:370).

However, in the 1879 French Academy’s dictionary the word did not appear and was not incorporated until the 1935 edition and is in force to this day. Thus, infrastructure is understood as the set of foundations and earthworks of a road or railway construction that includes embankments and trenches, engineering structures, and level crossings. Together with this, it also entails the facilities and equipment that allow the technical and economic activity of a community, and, in the military field, all the facilities and organizations necessary for the activity and maintenance of an armed force in a territory. Moreover, the 1935 edition indicated that, in Marxist doctrine, it was an “underlying structure” that underpinned a manifest reality, as a set of economic conditions considered as the basis of the institutions, the state apparatus, and the ideology that constitute the “superstructure” (Académie Française, 1935). Taken together, the basic definitions converge on an underlying foundation of a space created by a calculated design.

The French Origin: The Administrative Separation Between Soil and Technology

Formally, the 1825 English railway began as a means of transport and as the first modern socio-technical system, which installed its tracks on the ground. Hence, it created the first “network” industries such as water, telegraphs, gas, trams, and electricity forcing governments to make regulations for their passage through the territory (Marx, 2010:567; Millward, 2005). But, unlike the pioneer countries in the railway development such as Great Britain and the United States in which private capital led its expansion, the French state assumed a leading role in the promotion and orientation of the railway lines. With a specific development, l’infrastructure resorted to law, economics, and theoretical and practical knowledge to finance, trace, design, construct, operate, and maintain public works.

Since 1827, the French railway lines were built following the British model of short journeys to meet a punctual economic activity. This logic changed following the debates and local tensions about the rise of capitalism and the state since the eighteenth century. The thinking of Count Claude Henry de Saint-Simon (1760-1825) and the role of the engineers of grand schools such as the École Polytechnique and École de Ponts et Chaussées, as well as Saint-Simon’s disciples and disseminators, were decisive in this. Saint-Simonianism conceived of a mixed economy with public roads fulfilling both a material and political role in centralizing state power under a general conception of network economy (Caron, 1997; Lalévéé, 2023). Another relevant intellectual and political actor was Alexis Victor Legrand (1791-1848), an engineer trained in both Écoles, who in the 1830s was a state councilor and deputy, as well as general director of public works, a sort of embodiment of the synthesis of engineer and politician rationalities (Smith, 1990; Picon, 2002:238).

In 1837, the parliamentary commissions began defining the criteria for issues such as franchises to import the rails of what was called the road’s “superstructure.” It was during the prelude to public discussion of the bill on February 15, 1838, where Legrand made an explanatory statement based on the main ideas of the network’s “structure” that would link Paris with the main cities as a central-radial system, also known as the “Legrand star.” In the discussions from April to May 1838, the coordination with the companies in charge of the “superstructure” was defined, being the state responsible for providing the “infrastructure.” Everything culminated in the law of June 11, 1842, which made a distinction between “the execution of earthworks and engineering structures” and “the purchase and laying of the rails, the purchase of the machines and the operation.” The first would be paid for with state funds and the second, the “superstructure” comprising rails, rolling stock, and operation, would be provided by the private company (Picard, 1884:89, 96-100, 279-283, 241-244).

The concept, however, was confined to legislation as evidenced by the fact that, in an 1861 railways dictionary, only the word “superstructure” was defined as “an administrative term of little use” on the work carried out on the embankment (Cousy de Fageoles 1861:358). But it was extended to other standards such as the works of neighborhood roads with little academic use (École Nationale des Ponts et Chaussées 1859, 1866, 1895). Engineering courses at the École des Ponts began with the fundamentals of embankment construction [Fig. 01].

From the administrative point of view, it was slowly incorporated into engineering, which indicates that in its genesis it was not a technical jargon. In French engineering treatises of the 1890s, the railway was defined as a metal carriageway of rails mounted on a platform on the ground constructed by earthworks, entailing embankments, ditches, tunnels, underground works, bridges, and viaducts which constituted the “infrastructure.” On this road, the “superstructure” was mounted with the industrial equipment of rails and sleepers, accessories for track changes, crossings, signs, stations, yards, and rolling stock for commercial exploitation (Moreau, 1898).

Because of its origin, linked to a metaphor closer to the legal and political sciences, it demonstrated an early potential to characterize the social world since 1897.

Early Use in the Social Sciences by Marxists

The 1935 French definition highlighted the use that Marxists had given infrastructure to understand it as a set of economic conditions considered as the basis of institutions, the state apparatus, and ideology. This was not a development of Marx but of the disseminators of Marxism who, in the late nineteenth century, employed the infrastructure concept to point to a generic material basis of society that determined the social superstructure. In 1859, in the preface to A Contribution to the Critique of Political Economy, Karl Marx (1981:4) used a more architectural and constructive term when referring to a set of production relations that form the “economic structure of society”, which is the real basis “on which a juridical and political edifice rises.”

In 1929, the French historian Henri Sée (1892-1966) pointed out that the word infrastructure had been used by historical materialists to distinguish a generic material basis of society that
Terrassement. - Profils types... Les profils types généralement adoptés comportent, pour la voie unique, une largeur de plateforme de 6 mètres, dont 1 mètre de ballot et 1 mètre d'accotement de ballast ; il reste ainsi 1 mètre pour le talus de ballast et la banquette.

Pour la voie double, les deux voies sont d'abord de manière à avoir 2 mètres de liberté entre les bords extérieurs des rails. La distance entre les axes des deux voies de trouve ainsi fixée à 3 mètres. Des travaux d'implantation ont été effectués à Santiago, Chili.

En admettant un accotement de voie de 1 mètre et une largeur de champignon de 0,80 mètre, la largeur totale de la plateforme doit donc être de 9 mètres. Sur les lignes les plus importantes, la distance entre les champignons des rails était de fixée à 1 mètre. L'entraînement d'accotement est donc sur ces lignes que 3 mètres, qui ne laisse qu'un peu trop faible, puisque la largeur du gabarit est de 3 mètres. Il est donc augmenté cette entramée, toujours les frais que cela est possible. Par contre, en poids pour les lignes secondaires, réduise la largeur de l'accotement de ballast à 0,50 mètre, et la largeur de la banquette à 0,70 mètre. Sur les lignes les plus importantes, la largeur de la plateforme est de 5 mètres. Cela est un peu faible, mais dans de bons terrains avec du bon ballast, on peut s'en contenter.

Dans les terrasses montées dans le rocher dur, on adopte un profil spécial en prononçant le ballot jusqu'au rocher, et en assurant l'accotement des eaux par des rieurs. On diminue ainsi le culot des terrasses. Il ne faut pas toutefois arriver moins de 3 mètres entre les axes de la voie et le pied du talus du rocher.

Tranchées. - L'inclinaison des talus de ballot est variable selon la nature du terrain. On donne généralement aux talus le suivant ordinaire:

- rocher dur : 1/4 et exceptionnellement 1/5
- rocher ordinaire : 1/2
- terre de bonne qualité : 5/4
- argile : 3/4, 4/4 et même 2/4

(1) D'après les règles fixées à la conférence de Borne, la largeur de la voie, mesurée à l'intérieur des champignons des rails, peut varier de 1 mètre 35 à 1 mètre 70.
01. El terraplén, ícono de la infraestructura, en los cursos de ingeniería en la École des Ponts et Chaussées en 1921. / The embankment, an infrastructure icon, in engineering courses at the École des Ponts et Chaussées in 1921. Fuente / source: "Terrassements". Fonds Ancien et Archives Paris Tech. (Descubes-Desgueraines, 1921).

determines the social superstructure. Georges Sorel (1847-1922), a French socialist and founder of revolutionary syndicalism, used the concept in this sense in the preface to Antonio Labriola's 1897 book *Essays on the Materialist Conception of History* to refer to the mediations of what he called “economic infrastructure,” while also stating that Marx was not responsible for the simplifications and determinisms of historical materialism (Sorel 1897:8). Sorel had graduated as a civil engineer in 1867 from the École Polytechnique, and worked on roads and bridges reflecting in his social writings his work process between design and application.

Throughout the twentieth century this view became more rigid and geometric, between a higher and a lower level. The economic anthropologist Maurice Godelier (1978) characterized infrastructure as a combination of three types of material and social conditions to reproduce social existence: 1) ecological and geographical conditions; 2) productive forces with different labor processes; and 3) social relations of production. In any case, there is a difference between conceiving infrastructure as a given and static nature, or as an embankment built with a defined route.

The subtle French intellectual pollination of Marxism, predates the radical turn the concept would take with both World Wars and the Cold War during the twentieth century.

A “New” French Word for Military Spending and Civilian Use

The First World War (1914-1918) created a fundamental change in our understanding of transport due to the great effort made to mobilize troops and resources. In this context, the impact that the American Expeditionary Force had is worth mentioning when, between 1917 and 1918, it managed to transfer two million soldiers and their equipment 5,000 km away from its territory. Once in France, the Force had to transfer personnel from U.S. railroad companies putting them in charge of adding hundreds of kilometers, operating 1,791 locomotives and 26,694 cars, until reaching 83,000 workers and technicians under military control (Hutchins 1952; Reutter 2004; Goldfeder 2006). In addition, American military engineers worked with the French on multiple technical and personnel training aspects, facilitated by old ties to the great Écoles (Lofgren, 1992; U.S. Army Corps of Engineers 1998:27, 146).

The war did not create a new military definition for infrastructure because in the United States the doctrine of essential facilities was still active. The role of the conflict was to establish a first forced interaction between Anglophones and Francophones that led to the transfer of the concept of infrastructure to define military bases and camps, something that would be key during World War II. Thus, the conditions for its gradual adoption in the English language were established, until 1949 when the North Atlantic Treaty Organization (NATO) was created, and the concept migrated and was used by civilian planners (Petroski 2016:14). The word was explicitly used in 1952 by NATO to establish “stronger logistics” in military mobilization with an “Infrastructure Programme” in Western Europe (Hotz, 1953:129; Royal Institute of International Affairs, 1954:86).

In 1954, Lord Ismay, first Secretary-General of the Organization, indicated that the word came from France where it had been used “for a long time” to designate the array of works undergirding the construction of a railway such as embankments, bridges, and tunnels. (Ismay 1954:114)

The incorporation of the French concept into a military readiness was calculated as a strategic advantage with modern “fixed installations” and was part of a larger conception left by the 1947 Marshall Plan to rebuild Europe. Civil infrastructure such as railways, roads, and ports had been included by the reparations commission established at Yalta in 1945 (Kindleberger 1968:370). It should be noted the role that General George Marshall played in 1911 as Secretary of Defense of the United States in the transit from a program of economic reconstruction, without military implications, to one of defense following the demands of the allies. NATO’s infrastructure program focused on expanding new types of fixed assets and systems. In 1954, the program cost £554 million from Norway to Turkey and 56% of it was destined for airfields, 20% for communications, 13.7% for pipelines and fuel depots and the remainder for other projects (Ismay 1954: 134, 123) [Fig. 02].

However, the adoption of the new concept was not easy because of the underlying problems of the infrastructures—their scale, network effect, and coordination of resources. This was highlighted by a professor of the Military Academy of the United States in 1952, while addressing the differences of opinion on the concept given that it didn’t refer to fixed facilities—closer to the American vision—but to more complex aspects of factor planning, enormous resource consumption, and numerous personnel to operate them (Lincoln 1952:440-443). In 1953, *American Speech* magazine considered infrastructure to be a “new word” designating the supranational communication networks and services needed to establish new military bases in Central Europe, and introduced it along with another new word, “welfarism,” which characterized welfare state policies (Russell, 1953:295; Middleton, 1953:434).

With NATO, the infrastructure concept was made public, operational, and incorporated into the military dictionary of the United States, which in 1964 defined it as all fixed and permanent facilities for training or for the execution of operational plans, as well as agreements for their financing. Its operational use also extended to counterinsurgency. One example of this was the research done in 1966 by the American University for the U.S. Army in South Vietnam, which focused on the “insurgent infrastructure,” in order to know how the installations and operations of the guerrilla were configured, which were characterized as an iceberg of political and economic organization of territorial coverage (Conley, 1966:20-21).

The Push for Economic Development

The reconstruction of Europe with the Marshall Plan and its military continuation by NATO at the beginning of the Cold War were decisive in giving a prominent place to infrastructure in the civilian sphere, in an environment of ideological contrast between planning and market deregulation that converged in using the state as a mobilizer of resources (Westad, 2011:5).

One of the economic foundations developed during World War II was the theory of the “big push” proposed by the economist Paul Rosenstein-Rodan from University College in London. He recommended the rapid industrialization of Eastern and Southern Europe to confront communism in the postwar period with a set of investments in industries and transport united by the notion of “public utilities” (Rosenstein-Rodan 1943:208). However, its use in the economy would be gradual and with several twists. One of them was introduced by Albert O. Hirschman (1958:83-84) when he gave a definition close to what he called “social overhead capital” (SOC), as “the capital that provides public services” integrated by the “capitality” and the “public character” of port facilities, highways, hydroelectric projects, among others. In 1962, Tinbergen used it to...
refer to a set of investments in basic industries—especially in energy, highways, and services—which were necessary for the “great impulse” and characterized by their indivisibility and large scale. As in the military field, in the civilian field it acquired an operational character as a recipe for a strong investment in territorial assets and an idea of strength in technical assistance for development (Tinbergen, 1962:17; Ellis, 1961).

A more explicit approach at that time—albeit less widespread—to use infrastructure to trace a route of economic development. In 1966, Reimut Jochimsen (1933-1999), economist, minister, and politician of the former Federal Germany and rector of the University of Kiel, pointed out the conceptual bases of a theory of economic development through the state's endowment of various types of infrastructures in his book Theory of infrastructure. (Universität Siegen; Jochimsen, 1966) In his theorie, he categorized all types of infrastructure into three broad groups: 1) material: immobile capital goods that contribute to the production of goods and services necessary to satisfy basic physical and social requirements; 2) institutional: the formal rules and informal conventions, and the capacities to guarantee and implement those rules; and 3) individual: given by the relevant properties of the working population, special and technical education, as well as its entrepreneurial attitude. The material type was closer to the original understanding of the concept consisting of public administration buildings and facilities, education, research, health, and social benefits, drinking water, waste disposal, and conservation of natural resources (Buhr, 2009:8-9, 14-15).

Jochimsen's contribution was an explicit economic approach but, because of its scarce dissemination outside West Germany, other approaches were more influential. One of them was Rawls's on public goods of great coverage, indivisible, and of an open nature, whose provision had to be structured through a political process rather than by the market. (Rawls, 1995:250)

Ruins, Return to the Strategic and Conceptual Fragmentation

Between the 1970s and 1980s, the concept's adoption advanced slowly in academia and scarcely in the humanities. (Bridges, 2023:1) However, in the United States, the public outcry on the relevance of infrastructure came not from innovation, but from deterioration. In 1981, the study America in Ruins by Choate and Walter of the Council of State Planning Agencies was published, a document in which the term “public infrastructure” was used to avoid the constant repetition of “public works.” Then, in a 1985 report, the U. S. Congressional Budget Office defined “infrastructure” as facilities that had “common characteristics of capital intensity and high public investment at all levels of government” (Petroski, 2016:14-16; Moteff & Parformak:2, 2004:2-5).

After the 1993 terrorist attacks in the United States, the infrastructure concept resumed its military side in the successive federal reports, laws, and executive orders that sought to define the assets that would be considered critical to national security. In 1996, the list contemplated telecommunications, electric power systems, oil and gas storage and transportation, banking and finance, public transportation, water supply systems, emergency services, and government continuity. Later, following the terrorist attacks of September 11, 2001, and the enactment of the Patriot Act, the concept of “critical infrastructure” contained a list so broad that it raised problems with protection coverage, starting with energy production, transmission, and distribution services, through transportation, including railways, roads, shipping ports, and waterways, to the supply of water and food for human consumption. This limitation led to the introduction of the concept of “key resources” in 2003, understood as “publicly or privately controlled resources essential for the minimum operations of the economy and government” and of “critical assets” to concentrate government priorities. (Motteff & Parformak, 2004:5-11)

At the dawn of the twenty-first century, the military content with which it had entered the twentieth century was renewed, although expressing the 1952 limits in the coordination challenges between public and private management of networks, facilities and systems.

Final Considerations

The conceptual trajectory of the word infrastructure from its origin, migration, translation, twists and turns, indicate that it is not just a “technical” term, but rather, a legal metaphor with two basic contents: 1) delimitation of the material areas to coordinate the private and public actors involved in railway construction and operation; 2) the fixed and immobile embankment that separated the “superstructure” formed by the system’s technology and management, as differentiated fields of action of civil engineering, mechanical engineering, and commercial management.

The need to have a concept for the public management of large networks in the United States—the country with the most railway lines on the planet in 1914—resulted in the doctrine of essential facilities of a punctual nature, which was close to the notion of public goods. But it was also a non-technical legal interpretation to regulate a materiality which, by entering in contact with the original French definition, raised a constant tension between what we understand by facilities, networks, and systems. A conceptual tension that was ever present since its use by NATO.

On what has been discussed, we believe it necessary to delve more into issues such as the concept's application in order to better understand the transformations of capitalism before 1929, when infrastructure was still confined in French legislation. Another aspect is the intercultural encounter in military operations during the World Wars, in which the term moved to the civilian world. The approach of Jochimsen, whose work remains in German, untranslated and unexplored, is especially important since it emerged from a country in which the reconstruction of the Marshall Plan and the construction of NATO converged under a coordination of resources and public and private management.

But, given infrastructure's increasing use and its expansion into the immaterial and the heterogeneous, and to better explain the attributes that are closer to the superstructure and to systems, we can still paraphrase Braudel's idea that societies "have their feet on the ground," to refer to a concept that points to a ground built under a calculated and explicit design, which is neither informal nor spontaneous. ARQ

NOTES

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1 “It is as absurd to negligently treat the superstructure as it is to treat that way the infrastructure, which has been done many times. Civilizations have their feet on the ground.” (Braudel, 1968:180)