Constructing a City: The Cerdà Plan for the Extension of Barcelona

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This article applies a constructivist perspective to the analysis of a town-planning innovation. The so-called Cerdà Plan for the extension of Barcelona was launched in the 1860s and gave this city one of its most characteristic present features. For different reasons it can be considered an extraordinary case in town-planing history, though almost unknown to international scholars. The authors analyze the intense controversy that developed around the extension plan and the three technological frames involved. Finally, the relationship between power and technology is discussed. The sociohistorical account is used to illustrate a specific concept of power, to be used in a politics of technology.

As soon as the news of the government's long-desired permission to pull down the wall was known, there was a general rejoicing in the city, and its shops were emptied of pickaxes and crowbars overnight. Almost every citizen rushed to the wall to participate in its demolition, either by using the appropriate tools or by supporting orally those who were actually doing the work. The wall was, probably, the most hated construction of that time in a European city.

It was Barcelona in 1854.

Unlike Berlin's wall, the walls of Barcelona did not split the city in two. They surrounded the whole city and were a sort of stone border between Barcelona and the rest of the world. Unlike Berlin's wall, the walls of Barcelona were too big and too resistant—not only in the physical sense—to come down in a few days. It took twelve years to pull them down, which is not a long time when we remember that they had stood erect for nearly one and a half centuries.

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The Wall

At the beginning of the eighteenth century, Spain was immersed in a succession war between the Habsburgs and the Bourbons about the Spanish throne. During the two previous centuries Catalonia had been in decline, and most of its local political and cultural institutions were suppressed by the central Spanish government in Castile. Opposed to the Bourbons' traditional trend toward strong centralism, the Catalans declared their loyalty to the Habsburg pretender Charles III and signed a treaty with England that promised them some naval support against Philip V, the other party in the conflict. Unfortunately for Catalonia, the latter happened to be the winning side.

Barcelona, the capital of Catalonia, surrendered to Philip V in 1714 after thirteen months of brave and somewhat kamikaze resistance of its citizens. The Catalans were to learn soon what their betting on the wrong side of the war entailed. Two years later, the new Spanish king promulgated the Act of *Nova Planta*: the act completely abolished the remaining political framework of Catalonia, so that it could be governed directly from Madrid. A new and severe tax system was imposed. In an explicit program of cultural repression, the government imposed a general ban on publications in Catalan and the closing of all Catalan universities.[1]

The technical shape of society was also checked. An enormous military engineering project was launched to put the city under continuous surveillance of the Bourbon troops. A huge pentagonal citadel, designed by the Flemish military engineer Prosper Verboom, was built near the harbor to dominate the city. The army thus could bombard any target within Barcelona with heavy mortars. A high wall, fortified with bastions and fronted by a moat, zigzagged from the western face of the citadel up the north side of the city, around its back, and down south again to the port, meeting the sea at the ancient shipyards. This way, Barcelona became an enormous fort in which the military installations covered almost as much space as the civilian buildings.

The result of Philip V's project was to enclose Barcelona in a rigid straitjacket of stone that prevented any further civic expansion and industrial development. The walls soon became the main urban problem of Barcelona, and the whole military complex remained a hated symbol of Castilian rule for a long time.[2]

The walls were not only a physical obstacle for the city's extension but also a legal one. Construction was prohibited in the so-called firing range—a series of overlapping semicircles with a radius of some 1.25 km and their centers at different points in the fortifications. This firing range created a no-man's land outside the walls covering almost 61 percent of the territory

within the city limits. In the nineteenth century, with the walls still there, it was impossible to propose any town-planning idea without making simultaneously an implicit political statement. One's personal attitude toward the walls revealed much of one's political position.

By the middle of the nineteenth century, living conditions in the city were dreadful. The population density, with 856 inhabitants per hectare, was the highest in Spain and one of the highest in Europe; the average population of Paris was, for instance, under 400 inhabitants per hectare. The average living space for workers was about 10 m^2 per person. This extremely high density, a bad water supply, and a poor sewer system made for atrocious conditions of hygiene. Different epidemics broke out in 1834, 1854, 1864, and 1870—each time killing about 3 percent of the population. Between 1837 and 1847, the average life expectancy of men was 38.3 years among the rich classes and 19.7 among the poor.

Nevertheless, all the different Spanish rulers since 1718 took great care of keeping the walls upright, until they were demolished in 1854-1868. As late as in 1844 the General Captain—the highest political authority for Catalonia—still resorted to the "right of conquest" to solve town-planning questions, and he declared states of siege or exception to conclude the many proletarian riots, which often raged through the city.

Technology Studies and Cities

In 1979 the *Journal of Urban History* published the first special issue on the city and technology. A new research agenda emphasized the importance of examining the "intersection between urban processes and the forces of technological change" (Tarr 1979, 275). More precisely, the main purpose of these urban historians was to study the *effects* of technology on urban form. Researchers studied the role of technologies like street lighting, sewage, or the telegraph in the processes of geographical expansion of cities and of suburbanization. Technology was analyzed as a force that shaped society and the cities, but its own character and development were regarded as rather unproblematic and even autonomous; this new trend in urban history was similar to the early work in technology studies.[3] However, the view of technology in urban history has experienced a similar change as it did elsewhere. This new orientation is apparent in most contributions to the second issue on the city and technology of the *Journal of Urban History*, published eight years later (Rose and Tarr 1987). The emphasis is now on the role of politics and cultural norms and values in the shaping of urban technological systems. Urban technology is now put into the broader context

of urban culture, politics, and socioeconomic activities (Rosen 1989). Technology is considered to be socially shaped, at least partially; it is no longer treated as a given, unyielding, and *exogenous* factor framing other dimensions of life in the city (Konvitz, Rose, and Tarr 1990).

Nevertheless, a particular subject still seems to be left aside: the actual shape of the city did not receive much attention in most of these studies. Town planning is not included among the "hard" technologies worthy of study, and the city itself remains a mere unproblematic physical/social *locus* for their implementation.

Historical studies of town planning do not show an agreement on the nature of town planning in the nineteenth century (de Solà-Morales 1992). Some authors adopt a rather standard technological determinism and see town planning as merely an organizational response to the new imperatives and constraints offered by new technologies (Giedion 1941); others embrace a social form of determinism, emphasizing socioeconomic rather than technological forces (Mumford 1938, 1961). When ideological shaping was analyzed, town plans came to be classified along the reformist-utopian dimension (Piccinato 1973). Finally, some authors stressed the autonomous development of the "technical" core of town planning and argued that the physical shaping of space cannot be fully explained by appealing to any set of external social, economic, or political factors (Torres 1985). Such a technical core of city planning is not considered to be legitimate subject matter for sociological inquiry.

The greater part of this article presents a brief sociohistorical account of the extraordinary case of Barcelona's *Eixample* (extension), almost unknown to the international[4] and, until very recently, even to Spanish scholars (although in this case by deliberate self-censorship). To avoid the different forms of reductionism and determinism that pervade historical studies of town planning, we will use a constructivist approach (Pinch and Bijker 1987; Bijker 1987). Town planning is understood here as a form of technology, and the city as a kind of artifact.

The last part of the article examines a specific conception of "power" that builds on the constructivist approach in the study of technology and gives more explicit attention to the relation between power and technology. The more important features of this concept of power are illustrated with examples taken out of the extension case.

This article is a preliminary report on an ongoing research project in which two specific sociohistorical cases are studied, one being the extension plan for Barcelona (Aibar 1995) and the other—in the field of coastal engineering—the Delta Plan (1957-1986) for protecting the Dutch coast against the sea (Bijker 1993). The comparative analysis of the two cases is ultimately

directed at addressing again the politically relevant issues that formed the starting point of much of recent science and technology studies, two decades ago (see also Bijker 1995b).

The Struggle for the Extension (1854-1860)

The first project for the extension[5] of Barcelona was designed by Ildefons Cerdà, a Catalan civil engineer and former progressive deputy in the Spanish Parliament.[6] This preliminary plan (Cerdà [1855] 1991a) was at first well received by the city hall and the (progressive) Spanish government. But the new city council, appointed in 1856 as a consequence of a conservative turn in government, decided to charge a municipal architect—Miquel Garriga—to develop an alternate project.

Jurisdiction over the extension issue was at that time concentrated in the Ministry of Development—the main redoubt of the governmental civil engineers. Seeing the favorable attitude of the ministry toward Cerdà, the city council began to claim municipal jurisdiction over the extension and decided to propose an open competition to choose the best project. Nevertheless, in June 1859, just before the deadline of the competition, a Royal Command issued by the Ministry of Development approved Cerdà's new version of the project (see Figure 1)[7] and announced a forthcoming bill for the execution of the city extension, once the engineer had presented the economic plan still in a provisional stage. The city council and the Catalan branch of the Moderate Party interpreted that decision as a centralist political imposition over the local administration and strongly reacted against it. As a concession, the ministry allowed the city council to select a number of projects to be compared with the one approved.

While Cerdà was still busy with the urban regulations and the economic plan, the competition's jury announced that the winning project was the one presented by the architect Antoni Rovira (see Figure 2). The city hall sent its representatives to Madrid to negotiate the government's approval of Rovira's plan. By that time, another ministry entered the arena. The Home Ministry, irritated by the Ministry of Development's full support for Cerdà's plan, claimed to have jurisdiction over city plans, municipal regulations, and urban policy, and over the expropriation of land that was necessary for public works. This interministerial squabble was closely linked to a professional rivalry between civil engineers (mostly represented in the Ministry of Development) and architects (dominant in the Home Ministry).[8]

Eventually, the Royal Decree of May 1860 offered a compromise solution: it did confirm the approval already given in the Royal Command of June

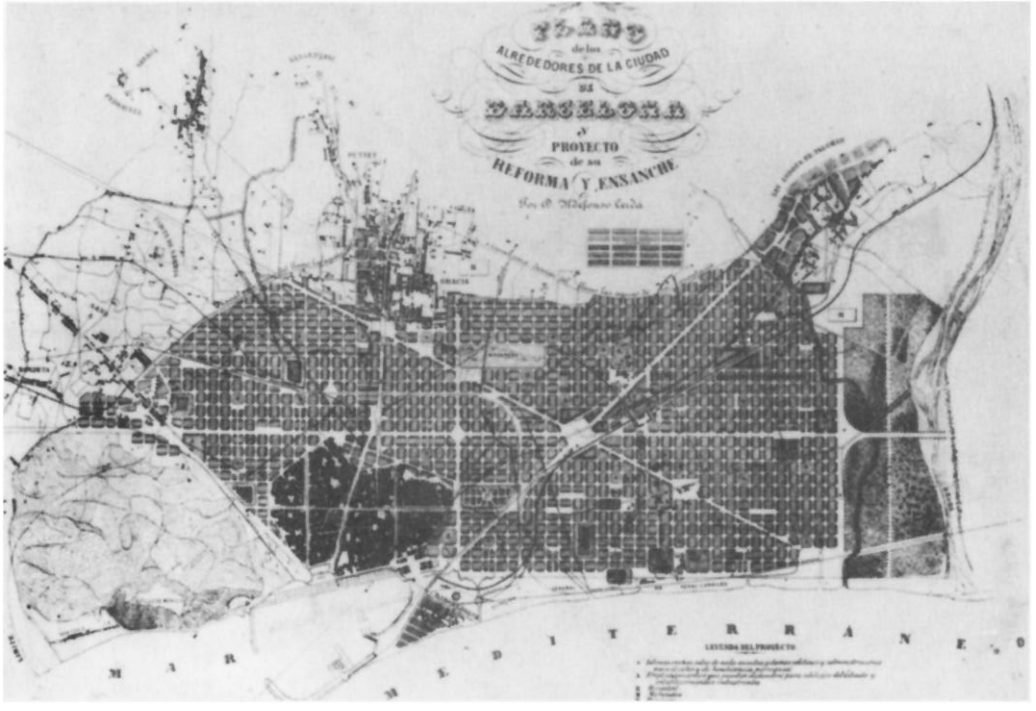

Figure 1. Ildefons Cerdà's extension plan approved in 1859.
NOTE: The old city is the small area in the left corner.
SOURCE: Photograph courtesy to the Arxiu Fotogràfic de l'Arxiu Històric de la Ciutat de Barcelona.

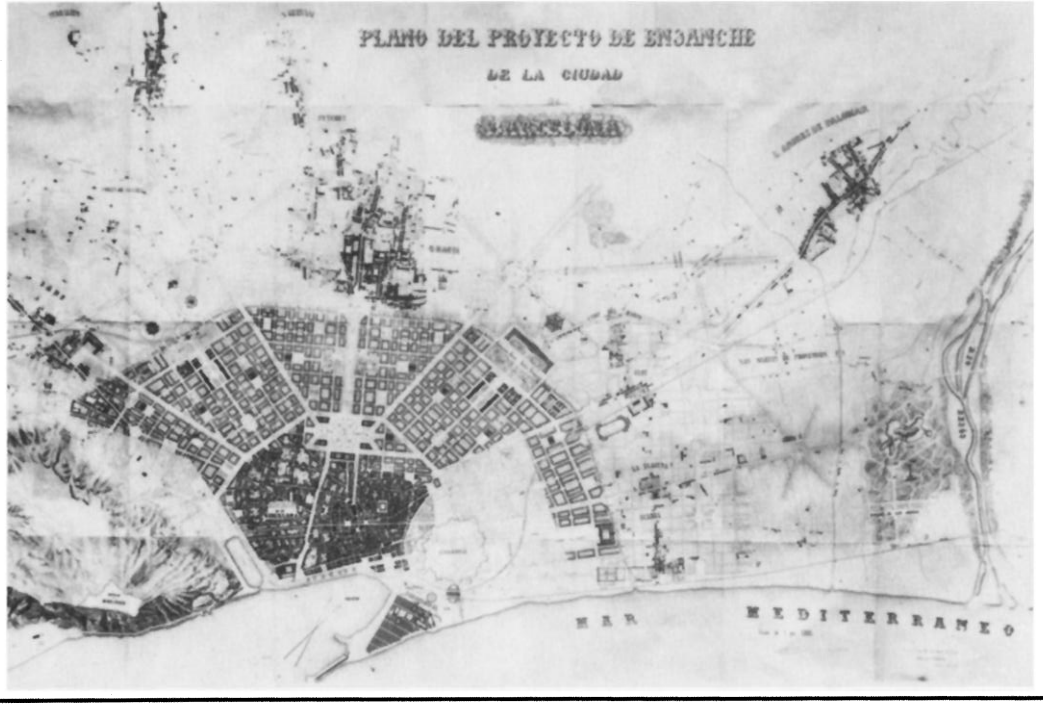

Figure 2. Antoni Rovira's extension plan, 1859.
SOURCE: Photograph courtesy to the Arxiu Fotogràfic de l'Arxiu Històric de la Ciutat de Barcelona.

1859—that is, of the plan and the report—but the new regulations and the economic plan (Cerdà [1860] 1971b, [1860] 1971c) were not approved. All new constructions were to obey Cerdà's plan in terms of alignments and gradients, while in other matters, the previous municipal bylaws would remain in force.

The Controversial Issues

The final Royal Command did not put an end to the public controversy over the extension. The controversial issues involved many technical details of the project and were used by the different relevant social groups—Cerdà, the city council, the Spanish government, the civil engineers, the architects, and the land owners—to strengthen their role in the implementation process and gain control over the shaping of Barcelona.

Unlimited versus limited extension. For the city council, the *unlimited* character of Cerdà's plan was an important matter for concern. Cerdà's extension spread beyond the actual municipal limits of Barcelona.[9] Since the new conservative regime in Spain implied a centralist revival, the city council thought that a plan affecting other municipalities would be the best argument the government could have to gain full control over the project (Grau and López 1988, 195).

The economic issue. Cerdà's plan, with streets of 35 m wide,[10] required many *expropriations* and, consequently, a huge amount of compensation payments according to the current law. Since the city council could hardly afford such a financial operation, Cerdà suggested the creation of a large private enterprise of the land owners that would manage the urbanization and building process in the Extension—a common procedure used by railways companies. For the city council, that meant another way of loosing control over the project.

Moreover, Cerdà had always coupled the extension outside the walls to the reform of the old city. Unfortunately for his plan, the property owners of the Old Barcelona were not very keen on big reforms because of the expropriations involved (Comisión Permanente de Propietarios [1860] 1971). As a consequence, the city council, trying to avoid any conflicts with the powerful property owners of the old city, preferred to support projects that kept the reforms in the old city to a minimum, such as Garriga's and Rovira's plans. Moreover, these plans proposed narrower streets for the

extension—10 to 15 m wide—so that expropriations, there too, could be reduced.

Extension versus foundation. The jury's verdict in the competition praised Rovira's plan, for it maintained that "the extension of Barcelona will follow in the future the same laws as in the past" (Junta Calificadora de los Planos [1859] 1971, 486). In other words, it was conceived as a *conservative* town-planning innovation: the extension was thought to continue the urbanization process from the old city. Rovira's plan was therefore designed as a radial extension around the old urban structure that remained at the very center (see Figure 2).

When Cerdà presented his first proposal in 1854, he did not use the word "extension" for his plan: he talked instead of the "foundation" of a new city.[11] In fact, Cerdà's plan treated the old city as a mere *appendix* to the extension. Unlike in Rovira's plan, the reform of the old city was designed from the point of view of the extension. This was exemplified by the creation of a new physical city center (*Plaça de les Glòries Catalanes*) far from the old town (see Figure 1).

Hierarchy versus regularity. In Cerdà's project, almost all streets were straight and distributed in a regular geometrical grid with perpendicular intersections (see Figure 1). The city blocks all had the same octagonal shape.[12] According to Cerdà, this regular distribution was mainly aimed at avoiding privileged building zones.

The architects' projects, in contrast, carefully planned a hierarchical extension spread out from the axis of the *Passeig de Gràcia*[13]—a big avenue already used by the Catalan bourgeoisie as a distinct leisure space. Social differences were thus to be established from the very beginning. In fact, Rovira's plan—as well as Garriga's—proposed a concentric distribution of social classes, from a residential center, suitable for the high bourgeoisie, to the outskirts intended for the industry and the workers' housing (García 1990a; Sagarra 1990).

Architects versus engineers. The conflict between civil engineers and architects[14]—very intense in Spain since the 1840s—was also highly influential in the controversy over the extension. At first sight, discussions were about conflicting professional competencies: mainly the scope of both fields regarding the construction of particular kinds of buildings and public works.[15] However, as the controversy developed, other issues came to the fore and showed deeper problems; the situation soon exceeded a simple professional

conflict. Discussions turned on a *science versus art* conflict. Moreover, the growing technical role of engineers was associated with the industrial revolution and thus with the emerging class of the industrialist bourgeoisie. The architects, on the other side, remained affiliated to the older aristocratic class of land owners. By virtue of these relationships, engineers managed to gain a progressive halo, while architects remained anchored to a conservative political frame (Lorenzo 1985). This remarkably strong tie between professional competencies and political positions became so apparent in Spain that for a time, every change of regime toward the right was almost automatically followed by closing the School of Engineers or dissolving the Association of Engineers (Miranda 1985). Progressive governments, in turn, were inclined to transfer some of the architects' privileges to engineers.

Technological Frames

The extension of Barcelona was used by social groups to strengthen their identity, to fight old battles, or to create long-sought opportunities in very different and often incompatible ways. Therefore, different problems were identified, different solutions were envisaged, and different extension plans were made. The city council regarded the extension as an opportunity to regain control over municipal affairs and diminish the centralist intervention of the Spanish government. The Moderate Party—the main political force in the city council—linked the extension issue to a broader long-term confrontation between Spain and Catalonia. Architects were ready to take advantage of the extension to win another battle in their particular war against civil engineers and to defend their alleged historical primacy in town-planning projects. The property owners of the old city regarded the extension with suspicion, because they were afraid the project would devalue their possessions and restrict their privileges—mainly their building monopoly. The Home Ministry, for its part, wanted to control the extension to maintain control over future extensions in other Spanish cities. Finally, the owners of the land beyond the walls were willing to collect the enormous profits expected from the future building and land business.

Interactions between the relevant social groups involved a complex process of alliances, enrollments, and negotiations concerning the extension issue. As a result, a significant redefinition of the social map took place. Some groups acquired a formal and institutional existence (property owners), some withdrew from the race (the Ministry of War), and others split into two (after 1859 the government was no longer a unified actor with respect to the

extension: the Ministry of Development and the Home Ministry took opposite paths). These changes in the social map mirrored the simultaneous semantic constitution of the artifact "extension." Meanings of the extension became polarized in terms of the controversial issues mentioned above. Two technological frames (Bijker 1995b) were thus formed and two contending interpretations of the extension built. For the sake of brevity, we will refer to them as the *engineers'* and the *architects'* frames. The first one produced an unlimited and regular extension, conceived as a new foundation of Barcelona. The engineers' frame involved a serious reform of the old city and a large number of expropriations. It was embedded in civil engineering practices. The architects' frame supported a limited and hierarchical extension, which was conceived as an appendix to the (unreformed) old city and implemented with as few expropriations as possible. This frame was immersed in the architects' traditional town-planning techniques. A third—less apparent—technological frame was being built around the emerging working-class movement.

The Engineers' Frame

The engineers' technological frame can be reconstructed by taking Cerdà's plan as an exemplary project (Bijker 1995b). If we follow Cerdà through the first period of the controversy, the archetypal image of the *heterogeneous engineer* comes easily to mind. While he was busy drawing the layout of his project or writing the economic plan and the building bylaws (a heterogeneous task by itself), he visited members of the state administration, important businessmen in Barcelona, and French engineers involved in the construction of railways to gain their support and test possible resistance. Furthermore, he gathered data to write one of the more exhaustive nineteenth-century studies on working-class living conditions[16] and to draw a highly detailed topographic map of Barcelona. Cerdà always presented his plan for the extension, and more generally his town-planning ideas, as a consequence of this preceding social scientific research.

A key notion in Cerdà's plan is *hygiene*. Cerdà was very sensitive to the hygienist theories developed during the nineteenth century. A significant part of his studies tried to establish a cause-effect relationship between specific features of the urban form and death rates among the inhabitants of Barcelona. The large width of streets in his plan is, for instance, justified by hygienic arguments, and the size of the city block (113.3×113.3 m^2) is set to optimize the living standards, expressed in square meters per person—a 6 m^3 volume of air per person and room became his basic *leitmotif* (Cerdà [1855] 1991a).

Cerdà was also involved in the construction of important railway systems in Spain. Fascinated by this technology—he described a train as "a whole travelling city" (Cerdà [1867] 1971d, 6)—he envisaged a future in which cities would be crossed by big steam-engine automobiles as the main means of transport. As a result, each of the four corners of every block was cut out as a chamfer to make these big vehicles turn easier. Mobility and easy traffic were indeed two main, and maybe the most important, components of Cerdà's plan.[17] They summarized the industrial capitalists' basic needs regarding the extension.[18] Goods and raw materials should be allowed to move quickly through the streets and avenues, avoiding the inconveniences of the narrow layout so characteristic of old cities. In fact, besides chamfers and wide regular streets, Cerdà's plan included big avenues (50 to 80 m wide) to ease the communication between the port and the two main geographical gates of the city. For every street a simple rule was applied: the street was divided into two equal parts, one for vehicles and one for pedestrians.

The engineers' technological frame was thus closely linked to the new capitalist concept of unlimited economic growth, which during the nineteenth century was, for the first time, explicitly associated with the growth of cities. The city was increasingly seen as a factory in which production was to be rationalized. Moreover, during the second half of the nineteenth century, the Spanish state went through a transformation process that made science and technology more important as a basis for a governmental policy aimed at educating and regenerating the social web (López Sànchez 1993, 174). Engineers and hygienists were key members of the new class of technical civil servants who assumed office to fulfill this goal.

The Architects' Frame

The architects' frame paid little attention to mobility and traffic problems. Nor was hygiene an important issue on the agenda. A more *monumental* concern—so apparent in most architects' proposals for the extension[19]—dominated the proposed layout of the city and prevailed over functional considerations. The architects favored techniques of urban control, such as keeping a disequilibrium between center and periphery by building social differences into a hierarchical layout.

The explicit desire to reduce expropriation and to preserve private property was also determinant. Accordingly, architects planned streets that were narrower than those planned by the engineers, and the reform of the old cities was very limited.

The Working Class' Frame

The working-class movement of Barcelona was often praised by international Marxist and anarchist activists and intellectuals (among them, Engels and Bakunin) as the most outstanding example of successful proletarian organization and fighting spirit.[20] Moreover, social revolutions and town-planning issues were perhaps much more explicitly linked in Barcelona than in any other European town. A large number of riots erupted in the city during the extension period, and since the general strike of 1855, the class struggle moved from the factory to the urban space: social conflicts were increasingly *territorialized.*

Although the working class was never granted a voice in the extension controversy, let alone any form of participation in the negotiations about the plan,[21] we can reconstruct its technological frame from the practices deployed and the accounts provided by its social opponents. In broad terms, the working class interpreted the extension not only as a clear attempt to build an exclusive residential area for the upper classes but also as a direct bourgeois attack on the proletarian city in the old Barcelona. Particularly, the reform of the old city was regarded as such an attack because, according to the Cerdà plan, some big avenues would break through the old city as a prolongation of the extension.

The working class' technological frame basically consisted of what can be called an *insurrectionary* town-planning perspective because it became especially apparent during riots and strikes. Three main practical strategies can be identified. First, appropriation of streets—inside and beyond the proletarian areas—was directed against the hierarchical class structure of the city. Second, targets of some buildings—police stations, churches, and so forth—were a rather straightforward attack on traditional institutions of social control and a counterpoint to the monumental concerns in the architects' technological frame. Finally, *barricades* were the direct answer to the bourgeoisie's increasing demands of mobility and easy traffic for the emerging capitalist city.[22] Barricades were to the town-planning structure of the city what sabotage or strike was to the production process in the factory.

Attempts at Closure

The "struggle" for the extension of Barcelona can be viewed as a historical episode in which different rival technological frames strive for dominance. In this situation—depicted by Bijker (1995b) as the third configuration of his model for sociotechnical change—comparably powerful relevant social

groups, with their respective technological frames, compete against one another. In such a situation, "arguments, criteria and considerations that are valid in one technological frame will not carry much weight in other frames" (Bijker 1987, 184). During the 1859 controversy, efforts of both sides (workers were kept outside the debate) to achieve some sort of consensus were unsuccessful. The city council and the architects refused to consider the plans in terms of social scientific statistics or data. Cerdà, on the other hand, did not want to engage in a discussion over the artistic or monumental features of his plan. The regular layout of Cerdà's plan was severely criticized by architects because it introduced, in their opinion, a high degree of monotony in the new city. They thought the plan showed little imagination and displayed a purely mechanistic city, in which no artistic considerations had been taken into account. Cerdà, for his part, criticized the architects' plans for their complete lack of "scientific foundation." He argued:

> Hitherto when it has been a case of founding, altering or extending a town or city, nobody has concerned himself with anything other than the artistic or monumental aspects. No attention has been paid to the number, class, condition, character or resources of the families that have to occupy them. To beauty and to the grandiosity of certain details have been sacrificed the political and social economy of the city as a whole or of her inhabitants, which logically should be the departure point for studies of this nature. (Cerdà [1859] 1991b, 329)

In this situation, *rhetorical*[23] arguments became a fitting mechanism. Cerdà, for instance, often resorted to the "scientific foundations" of his plan. Nevertheless, he never showed how the details of his extension could be derived or deduced from his town-planning theory (not to mention the fact that he outlined only the basic trends of this theory and never wrote a complete presentation of it). Let us take a look to the remarkable formula he designed to determine the distance between city blocks (Cerdà [1855] 1991a, 1497):

$$x = \frac{pv - 2bd}{d} \pm \sqrt{\frac{pv}{d^2 f}(pvf - 4bdf - 4b^2 d)},$$

where x is the side of the block, $2b$ is the width of the street, f is the depth of the building site, d is the height of the façade, v is the number of inhabitants per house, and p is the number of surface square meters per person. Without much argument, Cerdà took the values of the variables as $2b = 20$ m, $f = 20$ m, $d = 20$ m, $v = 43$, and $p = 40$, obtaining 113.3 m, the actual distance between the blocks in the Eixample.

Few people in Barcelona know that this formula accounts for one of the most important features of the city. Still, no one knows where it comes from.

Cerdà did not write a single word to explain or clarify its meaning. It can be interpreted as a rhetorical device to *black-box* a particular technical detail, by appealing to the scientific and objective character associated with mathematical representations.[24]

Cerdà's opponents, however, found a more powerful rhetorical tool—much more powerful in Barcelona than Cerdà's appeal to science. Some newspapers started to publish articles in which Cerdà was depicted as a "slave" of the central Spanish government. The Catalan Moderate Party turned the extension plan into a nationalistic issue and Cerdà himself into a "traitor" to Catalonia. This rhetorical argument was quite successful and long lasting.[25] The picture of Cerdà's plan as an attack on Catalonia became a cliché in most of the historical accounts written on the extension. As a result, Cerdà's work was almost completely forgotten, and some of his publications remained lost for nearly a century.[26]

The Implementation Process

It has been proposed that "amortization of vested interests" (Hughes 1983; Bijker 1987) is the stabilization process that often occurs in situations in which no single technological frame is dominant. In such circumstances, no one wins a total victory. In the case of the extension of Barcelona, the Royal Decree of 1860 did indeed offer a compromise solution: Cerdà's layout of streets and blocks was approved, but his economic plan and his building bylaws were ignored. The latter, for instance, were crucial for the development of the extension. They were meant to set the physical conditions for every building in the Extension (the minimum and the maximum height, width, and depth; the ways of joining with neighboring blocks; etc.) and the structure of the city blocks (area to occupy by each block; positions of the buildings; minimum inner space and its intended use; etc.).

Cerdà's building bylaws were considered very demanding: buildings could not exceed more than 50 percent of the block's surface (the other 50 percent should be set aside for gardens), they were allowed in only two of the four sides of the block, they should be less than 20 m high, and their maximum depth varied from 15 to 20 m.

After the Royal Decree a slow process of implementation began, in which a large number of small modifications were introduced, eventually resulting in big changes. Even the approved plan (1859) showed remarkable changes compared with the first version (1855). Evidently, Cerdà introduced them to diminish the resistance by his opponents. The average width of the streets

was reduced from 35 to 20-30 m; the explicit concern with special housing facilities for workers, as a means of achieving a more egalitarian city, was completely abandoned; the depth of buildings was extended to 20 m in all cases; and the former regular distribution of parks (82,35 hectares) and public facilities was not made obligatory (Grau 1990).

Cerdà's position as the governor's expert in charge of the implementation of the extension plan was weakened by the threatening demands of the land owners of the Extension. The land beyond the walls—once cheap and useless—had become, thanks to the extension, an enormous potential source of income as the site for the new city. The owners wanted to control the extension development as much as possible to secure profits. Actually, to promote the building process—deliberately stopped by the land owners during 1861 as a sort of lockout[27]—Cerdà had to give up and accept crucial modifications of his plan: blocks started to be closed (that is, with buildings placed along the four sides); narrow passageways splitting some blocks in two were allowed; and the depth of buildings grew to 24 m, thus reducing the inner garden space.

Another important transformation—against the spirit of Cerdà's plan—took place during the first decades of implementation: a hierarchical structure was superimposed on the regular geometrical grid. The zone around the Passeig de Gràcia was increasingly considered an aristocratic residential space. Land and housing prices were established as a function of their proximity to the Passeig de Gràcia. As a consequence of this slow process, during the 1890s the right (northeast) side of the Eixample had already achieved a higher level of quality than the left side (García 1990a, 1990b). To live in the right side of the Eixample remained for a long time a sign of distinction.[28]

But maybe the most important modifications were the ones introduced in the plan's specifications for the blocks. In that sense, not only was the rejection of Cerdà's bylaws crucial, but it was particularly remarkable that the land owners were powerful enough to act beyond the limits of the bylaws, with no serious opposition from the city council. In 1872, 90 percent of the buildings in the Eixample (about 1,000) were violating the building bylaws. Already in 1890, buildings occupied 70 percent of the block surface on the average—instead of the original 50 percent. The situation was worsened by successive building bylaws, and in 1958 the building volume of the block, that according to Cerdà's bylaws should not exceed 67,200 m^3, reached 294,771.63 m^3.

Cerdà's plan for the reform was simple but ambitious: three big avenues were to be opened across the irregular web of the old city. It took forty-eight

years to begin the works on the first one. Though the fierce opposition of the property owners is often quoted as the cause of this long delay, we must notice that similar problems arose with the property owners in the Extension. The distinctive problem posed by the reform was that it entailed a confrontation not only with the architects' technological frame but also with the workers'. While the *extension*—as we have seen—could be built with a relatively low level of agreement among the social groups supporting the first two frames, it became clear that the *reform* would only be possible after a solid consensus was achieved between them. The three avenues were not only a means of gaining higher levels of mobility and traffic but also three town-planning incisions into the proletarian fortress. In 1908, when the first stage of the Baixeras plan for the reform—almost identical to Cerdà's project—was finally implemented, the reform was above all a radical attempt to break the working-class hegemony in that area. This hegemony, partially a consequence of the bourgeoisie's gradual moving to the Eixample, was unbearable because it continuously threatened the new capitalist order in the city-factory.[29] The new town-planning pope of the Catalan bourgeoisie during that period, the Frenchman Jaussely, put it this way: "The more complex and multiple are the gears in this factory [the city], the more order is required" (quoted in López Sànchez 1993, 63).

The consensus between the old aristocratic elite and the capitalist nouveaux riches was an essential condition for building the new urban order in the proletarian city. This condition could only be fulfilled when the extension reached a certain level of stability in the Extension area. Then, in 1907, the first stage of the reform started: the opening of the present Via Laietana. But, in July 1909, just when the upper classes were celebrating the demolition needed for the Via Laietana, the workers' town-planning frame spectacularly spurred action:[30] about 7,000 m^2 of paving stones were used to build barricades; many churches, convents, and official buildings were burned down; streets were occupied by the workers; and the city was completely isolated and paralyzed. The urban system collapsed for seven days. The bourgeoisie called it the "Tragic Week" (*Setmana Tràgica*).

Some people argue that the only remaining elements of Cerdà's plan in the present city are the trees along the sidewalks, the chamfers, and the width of (most) streets.[31] In terms of the technological frames we have sketched, the city got the mobility and easy traffic attributes from the engineers' frame,[32] while hierarchy and high density of buildings were achievements of the architects' frame. The traces of the working-class frame can be found in the stormy development of the reform and in the fact that only its first stage has actually been implemented.

Power and Artifacts

One of the most influential views on the relationship between technology and power, during the last decades, has been that of neo-Marxist authors. The idea of technology in classical Marxism was mainly shaped by Engels' particular interpretation of Marxist texts. Engels defended a technological determinist view in which technological development was considered the driving mechanism of social transformations, while, at the same time, technical artifacts themselves were beyond class struggle and power games. Technology was politically neutral and was not shaped by "capitalist" or "socialist" values and interests. Capitalism and socialism were instead "social byproducts" of technology's autonomous development.[33]

Among the first authors to dispute Engels' interpretation were those belonging to critical Italian Marxism,[34] a school of political thought born of the new class conflicts arising around Europe in the 1960s. In particular, Panzieri (1972) claimed that technical and organizational innovations could not be considered neutral, because they *embodied* basic features of capitalist regimes. Capitalist technology was thus shaped by specific control and domination requirements. Basically, capitalism was to be seen as a dual phenomenon: a program of economic exploitation and, simultaneously, a system for political domination in which technology played a crucial role. The new three-stage model of capitalist development was then described as follows: class struggle, crisis (of domination), capitalist restructuring/ technological innovation.

Remarkably, several Anglo-Saxon neo-Marxist authors—among them, Braverman (1974) and Noble (1979)—independently developed a similar perspective in the 1970s and published some widely known case studies in which technical change appeared to be shaped by social and political factors beyond traditional purely economical considerations. Approximately at the same time, the French philosopher Michel Foucault (1975) placed factories in a broader set of institutional techniques aimed at the confinement and disciplining of bodies. The factory was seen primarily not as a locus of economic exploitation but as a domination device—much as Panzieri (1972) had suggested.

From these (independently developed) theories, the so-called *labor process* approach has had the major impact on recent social studies of technology. The work of Noble, for instance, has been regularly cited as an early example of the *social shaping* approach for the analysis of technical change. However, little attention has been paid to the particular conception of power used in these accounts. In fact, the concept of power has only been recently addressed by the new sociology of science and technology.[35]

The labor process approach is mostly based on a classical image of power.[36] According to this image, power is understood as something innate in certain actors—the power holders, the capitalists—and can be stored and exchanged in a sort of zero-sum game. Power is mainly seen as prohibitory or inhibitory and can also be used as an unproblematic *explanans* for the interactions among actors and for the particular directions of technical change.

We prefer to draw, instead, on a different tradition of the concept of power.[37] This second line of inquiry rests on a nonobjectivist perspective. First of all, power is not understood as an immanent property of certain actors but as a relationship between actors. The emphasis shifts from the straightforward identification of power holders to the study of power *strategies*. Power appears as the outcome of those strategies and thus as a result of interactions among actors—and not as the ultimate cause of these interactions. Finally, power is basically understood as productive and facilitative, rather than purely inhibitory.

How can this conception of power be applied to a constructivist analysis of technical change? Historical accounts of the conflict over the extension often found it hard to explain Cerdà's ability to remain upright against the powerful groups and institutions that so fiercely opposed his plan. When Cerdà was "rediscovered" by Spanish scholars a few decades ago, most of them—and especially engineers—depicted him as a genius of town planning[38] as well as an extraordinary engineer and social scientist. A heroic/cognitivist explanation was implicitly used to account for the failure of the classical conception of power as explanatory scheme. In this scheme, the social actors had specific, relatively stable amounts of power that determined their role and influence on the extension. However, we have shown instead that the actors' relative power increased and decreased during the process, depending on the different changes introduced in the project and its implementation. Some few meters added to or subtracted from the width of streets could—and actually did—mean a lot for the power relations between the property owners, the city council, and Cerdà. The technical features of the extension were not the neutral and mechanistic means of merely enhancing existing power distributions. Technology is not simply a medium through which power from an otherwise independent reservoir is mobilized, increased, or exercised.

The different strategies deployed by the contending technological frames redefined the power relations of the relevant social groups. But is it possible to establish a more precise relationship between technological frames and power relations? For a primary answer, a distinction made by Barnes (1988) between *delegation of power* (as transferring the discretion in the use of

routines) and *delegation of authority* (as allowing direction of routines without discretion) can be useful. Delegations of authority are mainly to be found between actors included in the same technological frame. Thus the governor, authorizing Cerdà to draw a preliminary study of the extension, and the city council, entrusting the municipal architects with the design of alternate plans, are good examples of that mechanism. Delegations of power, in contrast, may happen between actors belonging to different technological frames. Typically, this kind of delegation is made possible by some sort of currency transferable from one actor to another. As we have seen, urban space (through building bylaws) and money (through taxes) were two obvious forms of currency being transferred from the engineers' to the architects' frame.

There is another fruitful point of view for looking at power in a technological context: the semiotic perspective. In fact, a common trend of poststructuralist approaches to the analysis of power has been the emphasis on meaning (representation, knowledge, and so forth) as an instance of power.[39] In particular, it has been argued that *fixity of meanings* represents power (Clegg 1989, 183). In that sense, closure and stabilization strategies used in technological controversies can be interpreted as power strategies, since they are aimed at diminishing interpretative flexibility and fixing an artifact's meaning. From this point of view, the construction of an artifact is simultaneously the building of a semiotic power structure.

Constructing knowledge to "make sense" of outside actors is another way of building the semiotic power structure within a technological frame. Hygienist theories and social science were used within the engineers' frame to explain revolutionary trends (within the workers' frame) as social answers to poor salubrity conditions in the working-class quarters. Radical political behavior was thus reduced to and translated into a basic health problem, the solution of which did not require a global transformation of social order but some *technical* incisions into the urban web instead.[40]

Finally, another aspect of the role of technological artifacts in power games can be displayed by their functioning as *boundary objects* (Star and Griesemer 1989). The exemplary artifacts built under a technological frame are often used for the creation of a boundary between its inside and outside, resulting in the enhancement of its semiotic power structure. Barricades, the most characteristic artifact within the insurrectionary town-planning frame, functioned—also in a rather physical way—as a boundary artifact. Besides their effects on traffic, barricades represented a clear-cut boundary between the proletarian and the bourgeois city. No ambiguous position was possible, no middle term allowed. Either you were on one side, fighting against the

established urban order, or you were on the other, as a bourgeois, aristocrat, policeman, or soldier.[41]

Conclusions

This preliminary application of the constructivist approach to the analysis of a town-planning controversy was intended to draw the city into the limelight of social studies of technology. By considering the city as an enormous artifact, the size and distribution of its streets, sidewalks, buildings, squares, parks, sewers, and so on can be interpreted as remarkable physical records of the sociotechnical world in which the city was developed and conceived. Instead of viewing the city as a mere geographical locus for social or technical phenomena, we have considered it as a powerful tool in building new boundaries between the social and the technical and, therefore, in building new forms of life.

Though some contemporary architects may grant that the final design of a town plan is influenced by social and political factors,[42] we doubt that many would accept that the closer we look into technical town-planning details, the more heterogeneous the elements we find. Technological determinism is still a pervasive discourse for those experts and institutions involved in city plans. The recent plan for the Olympic Village, developed for the last Olympic games in Barcelona, was repeatedly presented to the public as a mere fulfillment of a "natural" trajectory in the urban development of Barcelona.

We have also argued in favor of a new concept of power. Our purpose here was twofold. First, the new concept avoids the usual view of technology as a mere medium or instrument through which power is mechanistically exercised, and it may open a complementary and enriching perspective for the understanding of the sociotechnical. Second, we believe that further analysis of the ways power and technology interact can help to overcome the alleged lack of relevance of constructivist studies for the practical and political problems currently associated with technological development. Using this concept of power to complement the concepts of the social shaping of technology developed hitherto may provide a fruitful basis for investigating *the politics of technology*.[43]

Notes

1. For an English introduction to this historical episode, see Hughes (1992).

2. Some people in Barcelona still toast using the Catalan words "Brindem tot maleint la memòria de Felip Quint!" (We drink a toast to the damned memory of Philip V!).

3. See Bijker (1995a) for a review of technology studies.

4. Among the 1,706 entries displayed in Goose (1992), there is not a single work on urban history devoted the Cerdà plan. Only a few non-Spanish town planners have dealt with it; see, for example, Rossi (1984).

5. We will use "Extension" (with a capital E) to mean the geographical zone in which the city was going to be extended; "extension" will refer to any town-planning project required for that matter; and finally, "Eixample" (Catalan for extension) will denote the specific part of Barcelona that was actually built. We will show that very different extensions were envisaged by different social actors for a similar (although not identical) Extension, while the Eixample came out as the eventual result of the whole historical process. Context or explicit indications will make clear whose extension we are talking about in each case.

6. More detailed historical accounts of the battle for the extension are given in Grau and López (1988), Soria (1992), and Torres, Llobet, and Puig (1985). See also Bohigas (1963), Busquets (1993), Estapè (1971), Martorell Portas, Ferrer, and Otzet (1970), and Permanyer (1993).

7. Cerdà presented this new version together with the two weighty volumes of his *Teoría de la Construcción de las Ciudades Aplicada al Proyecto de Reforma y Ensanche de Barcelona* (Cerdà [1859] 1991b).

8. The architects of Barcelona were the most aggressive in the controversy, notably Miquel Garriga, the municipal architect. See Bonet (1985).

9. The extension, according to Cerdà's plan, was ten times larger than the old city; proportionally, it has been the largest extension ever carried out in a European city (Bohigas 1985).

10. The old city contained 200 streets less than 3 m wide, and 400 less than 6.

11. Cerdà decided to drop that term for strategic reasons, following the governor's advice (Soria 1992, 321).

12. There were about 1,000 blocks, each one size 113.3×113.3 m^2.

13. A virtual continuation of the famous Rambles toward the neighbor village of Gràcia.

14. Different historical studies of this controversy are offered in Bonet, Miranda, and Lorenzo (1985). Similar conflicts between architects and engineers, with similar political connotations, arose in France (see Ingénieurs civils français 1973; Deswarte and Lemoine 1978) and in Italy (see Morandi 1976).

15. Thus, for example, were prisons to be designed by engineers and not by architects.

16. The Monografía Estadística de la Clase Obrera, which was included as an appendix to Cerdà ([1867] 1971d). A short analysis of the relationship between Cerdà and the working class can be found in Benet (1959).

17. In his treatise on town planning, Cerdà ([1867] 1971d) devotes the fourth book to a classification of historical urban forms according to the different means of locomotion (see Domingo 1992). However, Cerdà's plan runs counter to Mumford's idea that "the sacrifice of the neighbourhood to the traffic avenue went on all during the 19th century" (1961, 429). One of the main features of Cerdà's plan was the structure of neighborhoods to be superimposed on the geometrical grid of streets. According to Bohigas (1963), this was the element that places Cerdà over his contemporary colleagues, like Haussman.

18. By the middle of the nineteenth century, the industrial revolution in Spain had only taken place on a significant scale in Catalonia. Because of the magnitude of its textile industry, it was often called the "factory of Spain," and Barcelona "the Mediterranean Manchester."

19. One of the projects presented in the competition, Josep Fontserè's, included two areas of the extension in which the streets drew the emblems of Catalonia and Barcelona, respectively!

20. As the civil governor put it in 1909, "in Barcelona the revolution is never being prepared, for the simple reason that it is always ready" (quoted in López Sànchez 1993, 227). Eventually the process would reach its peak in the Spanish Revolution of 1936, when the workers' movement of Barcelona (mainly anarchist oriented) achieved the most radical levels of social transformation. There is a beautiful literary account of the revolutionary Barcelona, by George Orwell ([1938] 1988), written on the basis of his personal experiences in the city during that period as a member of the International Brigades.

21. The social construction of technology approach (SCOT) has been criticized, for example, by Winner (1993), for being elitist and only capable of giving attention to social groups with a powerful voice of their own. This critique can, of course, apply only if one interprets the SCOT methodology (Bijker 1995b) in a purely mechanistic way. If one sees (constructivist) social studies of technology as a form of interpretive sociology, the same difficulties and opportunities exist as in other forms of qualitative social science. In the case of Barcelona's extension, we could have missed the role of the working class—and be criticized for that. But nothing in our SCOT approach did indeed prevent us from identifying the workers as a relevant social group.

22. The construction of these insurrectionary infrastructures was considered a measure of the scope of revolutionary outbreaks in Barcelona: Engels ([1873] 1969) once said that the city of Barcelona had the greatest density of barricades in the world.

23. "Rhetoric" is used here in the sense of "rhetorical closure of technological controversies" (see Pinch and Bijker 1987).

24. This interpretation is also supported by de Solà-Morales (1991), who suggests that the distance between blocks was determined to fit previous considerations of the layout distribution, making the formula a mere ad hoc construction.

25. Some sixty years after this period, a new Catalan political party—the Lliga Regionalista—still resorted to that argument against centralist rule. Puig i Cadafalch, an outstanding member of that party and a very notable modernist architect, took the issue as a personal matter. He not only made highly negative comments on the plan whenever he could—"the Eixample is one of the biggest horrors of the world; certainly nothing equals it, except in the most vulgar cities of South America" (quoted in Hughes 1992, 281)—but also devoted himself to the task of destroying Cerdà's work. He told his bookseller to get as many copies of Cerdà's treaty on town planning as he could, in order to burn them, and he deliberately designed the Hospital de la Santa Creu i Sant Pau—a masterpiece of Catalan modernism—with a geometrical orientation opposed to that of Cerdà's plan.

26. Born in 1815, he died in 1876 in extreme poverty and went into oblivion. The best available biography of Cerdà is Estapé (1971). Although it cannot be denied that the Spanish government's decision in favor of his plan was partly aimed at keeping down the Catalan bourgeoisie, the picture Cerdà = Central Government *versus* Catalonia = City Council is an oversimplification: not all of the government supported Cerdà's plan, and not all of Catalan society was against it.

27. Cerdà ([1861] 1971a) published a paper on the reasons for that lockout.

28. This "betrayal" of the plan was also linked to another remarkable deviation from Cerdà's project. In fact, the hierarchization process and the contrast between right and left sides were a reflection of a much older asymmetry between the right and left sides of the old city (Cañellas and Toran 1990). The transfer of this contrast to the new city meant that the extension was, after all, developing as an appendix to the old city.

29. During the general strike in 1902, the workers almost took possession of the whole city.

30. The revolt was triggered by the governmental decision to recruit from Catalonia soldiers for the unpopular war against Morocco.

31. For comparative studies between Cerdà's plan and the actual Eixample, see Busquets (1992) and Busquets and Gómez (1984).

32. It has been often remarked that after the final approval, Cerdà devoted himself mostly to the preservation of his plan's layout of streets.

33. See MacKenzie (1984) for a relativization and reappraisal of Marx' technological determinism.

34. *Operaismo* is the Italian word for that perspective. We thank Santiago L. Petit for his useful comments on this point.

35. See, for instance, Barnes (1988), the different contributions in Law (1991), and Russell (1991). A first attempt to provide a concept of power based on and useful for a constructivist view of technology is given by Bijker (1995b). The view we offer here is mostly based on that account.

36. Clegg and Wilson (1991) provide a deeper analysis of the conceptualizations of power within the labor process approach.

37. For a more detailed account of both traditions, see Clegg (1989).

38. See, for example, Soria, Tarrago, and Ortiz (1976). Cerdà did indeed publish his treaty on town planning (1867) before those usually considered as the "founding fathers" of modern town planning: Baumeister (1874), Stübben (1890), Unwin (1909), and so forth. See Bonet (1982).

39. Foucault has often emphasized the links between power and knowledge constitution (see, e.g., Foucault 1966). Barnes (1988) also explores—though in a different way—the connection between knowledge and power.

40. As J. Pijoan, a Catalan advocate of the new town-planning strategy, put it in 1905: "we will build workers' quarters scientifically so that the masses can live comfortably and disciplined" (quoted in López Sànchez 1993, 66).

41. According to Star and Griesemer (1989, 393), another important attribute of boundary objects, perfectly fulfilled by barricades, is that they are "plastic enough to adapt to local needs [. . .], yet robust enough to maintain a common identity across sites."

42. "Anyone who has witnessed the preparation, discussion and approval of a city plan knows that this is both a technical and a political document at the same time" (Soria 1992, 310).

43. Bijker (1995b) argues for STS work that combines three elements—empirical case studies, theoretical reflection, and normative and political analyses of issues in the relations between science, technology and society; the latter can be called "a politics of technology."

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