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Loft Working
Urban manufacturing spaces in North American cities

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Turin, May 15, 2019

Summary

Urban manufacturing is the ‘oldest, newest thing’ going on in cities. It proceeds from the evolution of the oldest and the newest development of cities and industry. In the North-American context, industry emerged contextually as rural and intra-urban trend. Rural areas soon turned into suburbs, thus making industry a metropolitan issue made of urban and suburban locations. After becoming a predominantly extra-metropolitan matter for a long time, manufacturing has also re-emerged as a metropolitan and urban trend. Urban manufacturing has taken shape within urban areas as a dense network of small/medium enterprises that operate in supple, peer-to-peer, decentralized networks of research, development, production, assembly, and distribution.

For long, ‘reindustrialization’ narratives have focused on retaining large-scale standardized manufacturers, for whom it makes no sense to stay in cities. But innovation and economic trends move at a much faster pace than the physical city. When the attention on urban manufacturing finally arose, it revealed a plethora of unplanned or overlooked forms of making that had already made their way into an often-unprepared city through the reoccupation of vacant spaces. Different forms of production superpose and reshape the physical legacy left behind by the course of different economic trends and industrial paradigms. A first wave of reuse for production roots in the 1980s when cities were progressively oriented toward service economies. Then, a second wave emerged in reaction to the Great Recession, along with the spreading of technological innovations that have been consistently disrupting industrial and economic paradigms. What started as a last attempt to endure in cities by firms increasingly pushed to the fringe, it has then turned into a strategic choice.

Today, firms set their workspace inside leftover buildings to take advantage of the contextual opportunity for a good location, access to affordable spaces, and renting rather than buying or building new – hence ensuring more flexible commitments with one location as well as investing fewer resources in space. Urban manufacturing firms can usually adjust to almost any lofty space with no special requirements: the physical space remains determinant, but it has to weigh as little as possible in economic terms in favor of innovation, knowledge, and location. Also, the transition to a factory intended as a digital object has accelerated the trend.

Urban manufacturing reshapes urban contexts in two steps. First, it reduces different building typologies into left-as-loft spaces able to adapt to a wide variety of economic and human activities. Lofts are open, generic, rough, and defined by their capacity in terms of space, location, and infrastructure – rather than a form or a function. Then, lofts are reconfigured as working lofts. Firms project and adjust their production process into the real space through a series of spatial actions and architectural devices that expand loft's capacity, both in its performance and quantity. By being affordable, disposable, occasional, distributed throughout metro areas, and diversified in their capacity and potentials, lofts have been the supporting system of urban manufacturing dynamics that move within fuzzy boundaries of formal/informal, public/private, global/local, temporary/permanent, non-profit/for-profit.

Loft working heads towards multiple resolutions: reactivating a latent structure by turning it into a flexible and adaptable empowering tool (the loft); giving space to income- and job-generating economies (urban manufacturing); reconnecting a lost piece of the urban fabric with the city' and metro's socio-economic dynamics (placemaking). A process still under development that cities would be able to fully capture and take advantage from only through undetermined and unfinished strategies.

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Chapter 1

Introduction

In advanced economies, new technologies and ongoing transformation in the industrial sector are deeply influencing how we make things and carry out innovation as well as how we consume. During the last decade, Saskia Sassen and other researchers[1] have been observing the increasing convergence of different forms of production to cities: artists, artisans, traditional manufacturers, makers, phoenix industries, reshoring companies, R&D hardware-oriented companies, specialized small-scale enterprises, etc. Today, these different forms of making happening within the urban fabric are generally recognized as urban manufacturing. These changes are extremely relevant in contexts like the US whose industrial sector – historically characterized by large-scale companies – is slowly reconfiguring as a distributed scenario of deeply networked small and medium enterprises and carrying out research, development, production, assembly, and distribution. Smaller but also cleaner and smarter factories allow an ever-increasing number of production processes to be compatible with the urban environment. The reconfiguration of the industrial scenario calls for a deep reconsideration of the set of infrastructures and spaces that could be able to support such transformation. Urban manufacturing has made its way through an often-unprepared city by reoccupying those disposable and affordable spaces left behind by the same industrial and commercial dynamics.

From artists squatting in a 1960s New York to contemporary projects, adaptive reuse practices have been turning abandoned buildings – appointed as places of crisis – into empowering platforms for all the unforeseen, unplanned human activities. Urban manufacturing's new old factories make no exception. Too often former industrial spaces are considered a fair fit just for conversions to 'higher' uses (residential, office, commerce), informal occupations, temporary events or irremediable ruination. However, it is exactly in leftover spaces,

[1] For instance, see: Sassen, "Cities Today;" Helper et al., *Locating American Manufacturing*; Mistry and Byron, *The Federal Role*; Christopherson, "Manufacturing: Up from the Ashes."

disregarded by mainstream real estate and commercial trends, that we can observe the shaping of some of the major transformation going on in advanced industrial sectors. As at today, urban manufacturing is a metropolitan matter: it has been reshaping as an advanced sector, with the advanced part lying in the production process, the final product, the business model, or the economic paradigm. Firms serve the service industry and produce customized products in unitary or small-batches through just-in-time/just-in-place systems, so they need to operate in dense networks and in proximity to customers, services, complementary businesses, and other manufacturers.

The research investigates the shaping of urban manufacturing in a selection of North American post-industrial cities. Here, the research focuses on the most recent reconfigurations of the city-production relationship. Despite coming a long way since the first industrial revolution and even before, technological innovations and other socio-economic transformation in production-consumption dynamics make the observed phenomena a trend still under development, characterized by experiences sometimes at their very early stage. Architectural and planning issues represent just part of the matter, but too often they become just the passive background as a result of economic and political choices. Understanding the phenomena not only as an economic dynamic but also as a complex socio-spatial issue has been recognized by researchers and advocates as the real challenge for cities.[2] Rethinking production in cities could be the opportunity to take on some of the major challenges facing the 21st-century city: persistent unemployment, inequalities, isolation, resource depletion, and physical growth based on overtaxed and outdated 20th-century infrastructures.[3] Production in cities means not only innovation, talent attraction, investment, or jobs. It also demands tackling, for instance, needs for affordable housing, well-functioning infrastructures, public transportation, as well as the development of adequate educational programs and workforce training, business development initiatives and other services. A city committed to retaining space for income-generating activities (including urban manufacturing) is therefore committed to tackling socio-economic inequalities and environmental sustainability issues.

The investigation starts from the hypothesis that the urban industrial legacy, and more in specific the physical legacy of spaces and infrastructures, has been playing a key role in processes of retention/reintegration of urban manufacturing into the urban fabric. The research moves within the disciplinary boundaries of architecture and urban design. It starts from a set of questions specifically focused on the role of space at the building and city scale, as well as on how human and economic activities act in space:

[2] Hatuka and Ben-Joseph, "Industrial Urbanism," 11.
[3] Hajer, "Curator Statement," 14–16.

- What forms of production can be found in cities? And what types of industrial businesses?
- Where does urban manufacturing locate and distribute throughout cities and metro areas? Which form of production for which context?
- What processes and practices lead to the shaping of spaces of production in cities today? What are the key players in these processes?
- What is the role of the physical legacy (space and infrastructure) in the shaping of urban manufacturing? What are the relationships between production (content), the physical legacy (container), and cities (context)?
- What do people do when they set their workspace in a space where they can do almost anything they want?[4]

To address these issues, the investigation has been developed starting from the observation of an extensive selection of case studies, identified as places where one or multiple forms of production were occurring within the urban fabric. Case studies have been analyzed through the redesign of their spaces of production as well as through interviews and fieldworks to understand the spatial practices that lead to the shaping of places of production in cities and the different actors involved in the process. Therefore, the investigation has started from the observation of urban manufacturing workspaces and how they organized, to then enlarge its scope to the context to understand where they locate and why.

All case studies result from practices of adaptive reuse of leftover industrial/commercial buildings in urban areas. Despite the variety of contexts, actors, and forms of production, what bonds these experiences together is the way existing spaces and infrastructure are conceived and interpreted. Urban manufacturing reshapes urban contexts in two steps. First, it reduces different types of former industrial/commercial buildings into open, generic, rough, and (hopefully) affordable spaces. These left-as-loft spaces are characterized by their ability to adapt to a wide variety of economic and human activities. Secondly, from an open and generic loft to a working loft. Urban manufacturing activities project their production process into the real space and adjust it through a series of spatial actions that expand lofts' capacity in terms of performance and quantity. They allow production processes to configure in their most efficient layout given the capacity of the loft and through the employment of fewer resources and modification as possible.

These spatial practices chain along with adaptive reuse experiences through the *fil rouge* of the loft. The term loft intended as a generic open space emerged during the 19th century with the definition of the typology of industrial lofts. Lofts were rough non-special purpose spaces designed to house a high variety of industrial activities.[5] The term gained new attention in Sharon Zukin's loft living.[6]

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[4] The issue has been often addressed concerning forms of living as well as artistic and cultural practices. On the contrary, forms of working and, more in specific, forms of making are rarely taken into consideration.

[5] See: Bradley, *The Works*; Rappaport, *Vertical Urban Factory*.

She observed the shaping of new living, cultural, and socio-economic models within those same industrial lofts deprived of their industrial content. Stewart Brand[7] observed a similar process happening in Low Road buildings; low visibility, no style, disregarded leftover spaces allowing creativity, innovation, and irreverent ideas to express freely. Baum and Christiaanse[8] extended the idea of loft to any built or open space in cities that have a strong and stable identity for the city while simultaneously being dynamic in accepting programmatic and semantic changes. This research recognizes the loft as that suspended moment when space is turned into an open and generic system, thus allowing space to better express its intrinsic potential and act as a platform of emancipation to every upcoming purpose. The use of 'open' and 'generic' intentionally recall Rem Koolhaas' Generic City and Richard Sennett's Open City. Lofts are open non-linear systems made of ambiguous edges, incomplete forms, and unsolved narratives.[9] Also, they are spaces in-between the "liberation from the straitjacket of identity" and "either being completely solved or totally left to chance."[10] They are the way through which urban material economies have been taking shape in an often-unprepared city. This research has identified this spatial practice as loft working (fig. 1.1).

Loft working heads towards multiple resolutions. First, reactivating a latent structure by turning it into a flexible and adaptable urban infrastructure and empowering tool (the loft). Then, giving space to income- and job-generating economies (urban manufacturing). Lastly, reconnecting a lost piece of the urban fabric with the city' and metro's socio-economic dynamics (placemaking). Loft working has developed in cities punctually, one loft at a time, through the occasional convergence of interests and resources in favor of production in one specific spot. Increasingly, this ensemble of single places is growing into a distributed and dynamic network. This research reveals the role of lofts in cities; as enduring socio-economic tools for the germination of the new, alternative, rough, and the uncertain that move within fuzzy boundaries of formal/informal, public/private, global/local, temporary/permanent, non-profit/for-profit. These intrinsic compelling dualities represent an opportunity for cities to take a step forward in their effort to address increasing complexity, diversity, inequalities, and rapid transformations. Purpose of this research is to reveal logic and processes behind loft working to support the improvement of planning tools and urban development strategies.

[6] See: Zukin, *Loft Living*.
[7] See Brand, *How Buildings Learn*.
[8] See: Baum and Christiaanse, *City as Loft*.
[9] Sennett, "The Open City," 8–14.
[10] Koolhaas, "The Generic City," 1253.

The thesis first focuses on the evolution of factories as building typologies, production process, and organizational form between Europe and the US. Chapter 2.1 analyses how industrial spaces have been evolving passing through different stages of industrialization: from craftmanship (tools, manual work), mechanization (steam power), electrification, automation (information technology and electronics) and finally autonomization (IoT, cyber-physical systems). The relationship between content and container have been transforming along with the idea of the factory: from the factory as a machine (rational and functional) to the factory as a system (flexible and sustainable) to the future digital factory (adaptive and resilient). Consequently, chapter 2.2 glimpses into a possible future for the manufacturing sector in the US proceeding from significant evolutions in companies' organization, innovation models, and production processes. The section finally reflects on the role of urban spaces and architecture in the shaping of the distributed manufacturing scenario depicted by specific research.

The third chapter analyses the relationship between the city and industry. Chapter 3.1 observes the evolution of non-linear tensions between places of living and working in North-American cities. Industrialization in the US reflects a unique evolution of the concepts of 'urban,' 'suburban,' and 'metropolitan.' Industry emerged contextually as rural and intra-urban fact. Rural areas soon turned into suburbs, making of industry a metropolitan issue made of urban and suburban locations. By the second half of the 20th century, industry had become a predominantly extra-metropolitan matter and had remained so throughout the following decades. Today, after a long declining period, metropolitan and urban manufacturing has turned its decreasing course up to a positive trend, but this time the difference between urban and suburban is much more nuanced. Chapter 3.2 defines urban manufacturing and describes the context within which it has been emerging. Reshoring policies, the maker economy, phoenix industries, advanced manufacturing, sustainability and environmental awareness, technological innovation; they all contribute to the reconfiguration of production in cities.

The following Chapter 4 analyses nine urban manufacturing workspaces located inside seven buildings in five US cities. These case studies are representative of the places of production visited during the field trips reported in Appendix A. Each case study is analyzed, through texts and graphic materials, in its production process, workspace organization, reuse process, location, and citywide context.

Starting from the case studies analysis, Chapter 5 presents the general finding on the loft working scenario in cities. First, it traces the social, cultural and economic framework within which urban manufacturing has been reshaping in cities as an adaptive reuse practice. Initially emerged as a way for manufacturers to endure in cities (essential for their business) despite being forced to marginal disregarded urban areas, today the practice reflects the willingness of firms to invest fewer resources in infrastructure – increasingly less determinant in the production process – and more in talent, innovation, and location. Then, it describes processes, issues, variables, and actors that lead to the shaping of production spaces in cities. The description starts with considering the agents of change and contextual variables that influence the process. Many possible combinations of type of business, space, and settlement determine the different ways in which loft working can occur in cities. Then, it assumes the perspective of owner/managers and manufacturing firms to understand practices and architectural design choices that determine the reconfiguration of spaces first for general purpose and then into urban manufacturing workspaces. Finally, it analyses how companies interact with the urban context and how their business and locational strategies might affect cities. Chapter 5.2 identifies the conceptual and theoretical framework of loft working practices that allow the shaping of workspaces by expanding the capacity of open generic left-as-loft spaces. Finally, Chapter 6 envisions possible applications and future development of the research.

Methodology

Literature analysis, fieldwork, and case study investigation through design represent the main body of techniques employed by this research. Field trips have been conducted in three different times between August 2016 and April 2018:

- August-November 2016: fieldwork in Pittsburgh,[11] New York, Detroit, Chicago, San Francisco, Los Angeles.
- March-July 2017: fieldwork in Pittsburgh, Detroit, Boston, Somerville, New York.
- April 2018: fieldwork in Somerville and Haverhill.

For each city, fieldworks consisted in:

- Visiting different facilities and project among which selecting the most significant ones for the purpose of the study.
  Overall, over 80 spaces between companies’ studios, factories, and project sites have been visited. Sketches, pictures, photos, maps, and personal observations have been primary tools for the acquisition of information and knowledge in each case study. Privacy and safety issues, as well as the lack of archival materials, have been a recurrent obstacle in the retrieval of original drawings and materials, making it almost always impossible.
- Interviewing many people (around 80) involved in different parts of the investigated phenomena: company owners, workers, local administrators, for-profit and nonprofit developers, planners and architects, researchers, professors, experts, and advocates.
- Collecting materials, data, and bibliographic references.

[11] Part of the interviews and site visits in Pittsburgh in September 2016 have been conducted together with Prof. Roberta Ingaramo from the Politecnico di Torino

Despite possible changes that could have happened, the case studies are presented at their stage of development at the time they were observed – between August 2016 and April 2018.

The 50 most interesting case studies visited during the field trips have been reported in Appendix A. Here, for each project, the report outlines the basic information on the building and the reuse project, a selection of photos, and the 3-axis description of the company (see description in the graphic method).

Among the 50 case studies, nine companies located in seven different buildings have been analyzed in Chapter 4, where case studies have been grouped by city. In this case, each case study is introduced by a description of the company and the reuse process of the building. Then, starting from its location and zoning designations, the research reflects on the relationship of each project with its context as well as on planning tools and policies that might affect urban manufacturing dynamics in that city. The graphic analysis recalls this structure by analyzing through design the citywide context, the reuse project, and the workspace.

The graphic method

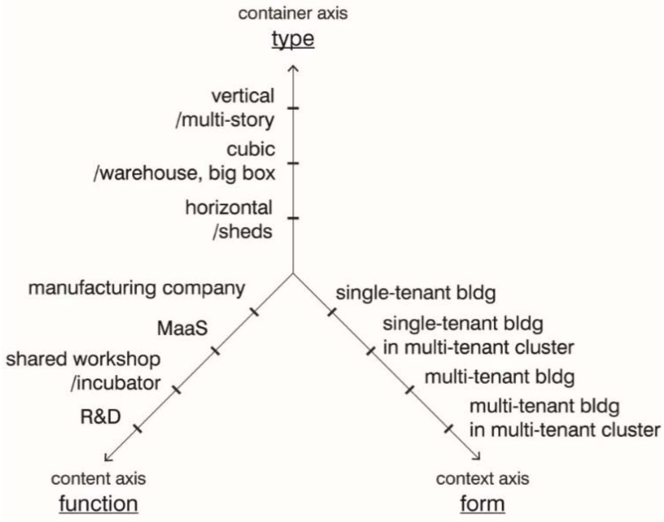
a. *Industrial (City).*
   Map of the city showing: industrial land and other zoning designations that allow industrial uses, main transportation infrastructures and commercial ports, and the location of the places of production analyzed.

b. *(Neighborhood). Accessibility and footprints*
   Maps showing the built and street patterns at the neighborhood scale. The street pattern also indicates the blocks designated for industrial or mixed uses, while the un-shaded blocks are designated predominantly for residential uses.

c. *(Company). Spatial strategy.*

   c.1. City-Production.
   It represents the relationship between the production space and its urban context, in some cases subdivided between 'public city' and 'entrepreneurial city.'

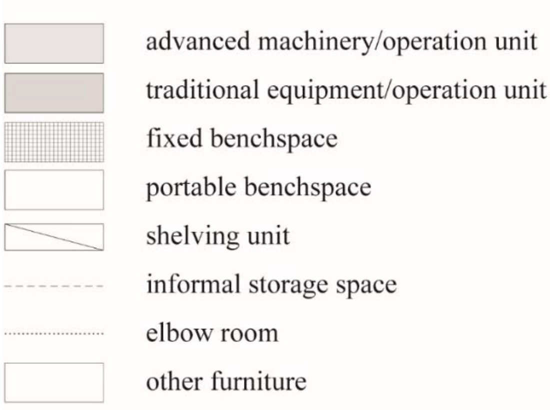
   c.2. 3-axis form-type-use.
   The diagram describes from which combination of types of enterprise, building, and settlement the case study has resulted.
   Content axis: it describes what function or type of business is using the space.
   Container axis: it represents the type of building where the function has set, roughly subdivided between vertical, horizontal or cubical development based on the direction of development of the building.
   Context axis: it observes in how the content settles and take shape within the urban fabric.



c.3. Diagram.
Schematic representation of the spatial strategy employed by the new content/user to reconfigure space, starting from a 'left-as-loft' container. The diagram abstracts the strategy based on one of the three main building typologies identified by the research (see 'container axis' in the previous analysis).

c.4 Plan and Section.
Representation of the reuse project. Starting from the building plan and section when reduced at its left-as-loft status, the drawing shows in yellow the additional elements introduced by the current user used to modify the use of space.

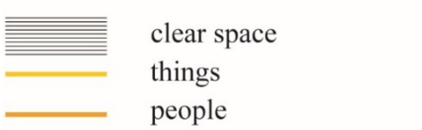
d. *(Company). Axonometric view of the workshop.*
The spatial organization is broken down into typical elements, whose size, amount, and distribution depend on the nature of the business – e.g., human/machine intensive, type of product, way to produce it. Different types of *operation units* and *organizers* are represented with their elbow room. *Operation units* include technology-based operations carried out by a machine supported by human expertise (machinery), and hand and tools operations (workbenches). *Organizers* are different architectural elements employed to organize or define the use of space: shelves, racks, storage spaces, desks, or other office-like furniture. Also, the drawing shows in yellow the additional elements introduced by the current user used to modify the use of space. For instance, partition walls, new volumes, mezzanines, or other elements can be employed to confine, reduce in size, subdivide, organize, or infrastructure space with supply routes.



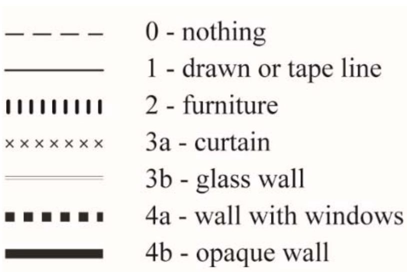
d.1. Organizers.
Abstraction of the main organizers employed to reconfigure space.

d.2. Operation units
Abstraction of the main operation units found in the workshop.

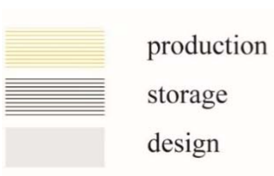
e. *(Company). Workshop layout*. It represents a schematic layout of the different operations and uses as well as goods and people flow.



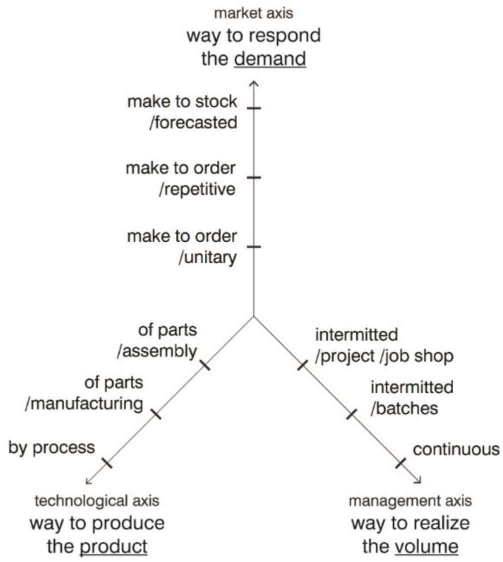
It also displays the degree of separation between spaces and operations recognizing seven types of thresholds.



f. *(Company). Diagram of uses*. Schematic representation of the distribution of uses that distinguishes between production, storage, design, and eventually technical/service room.



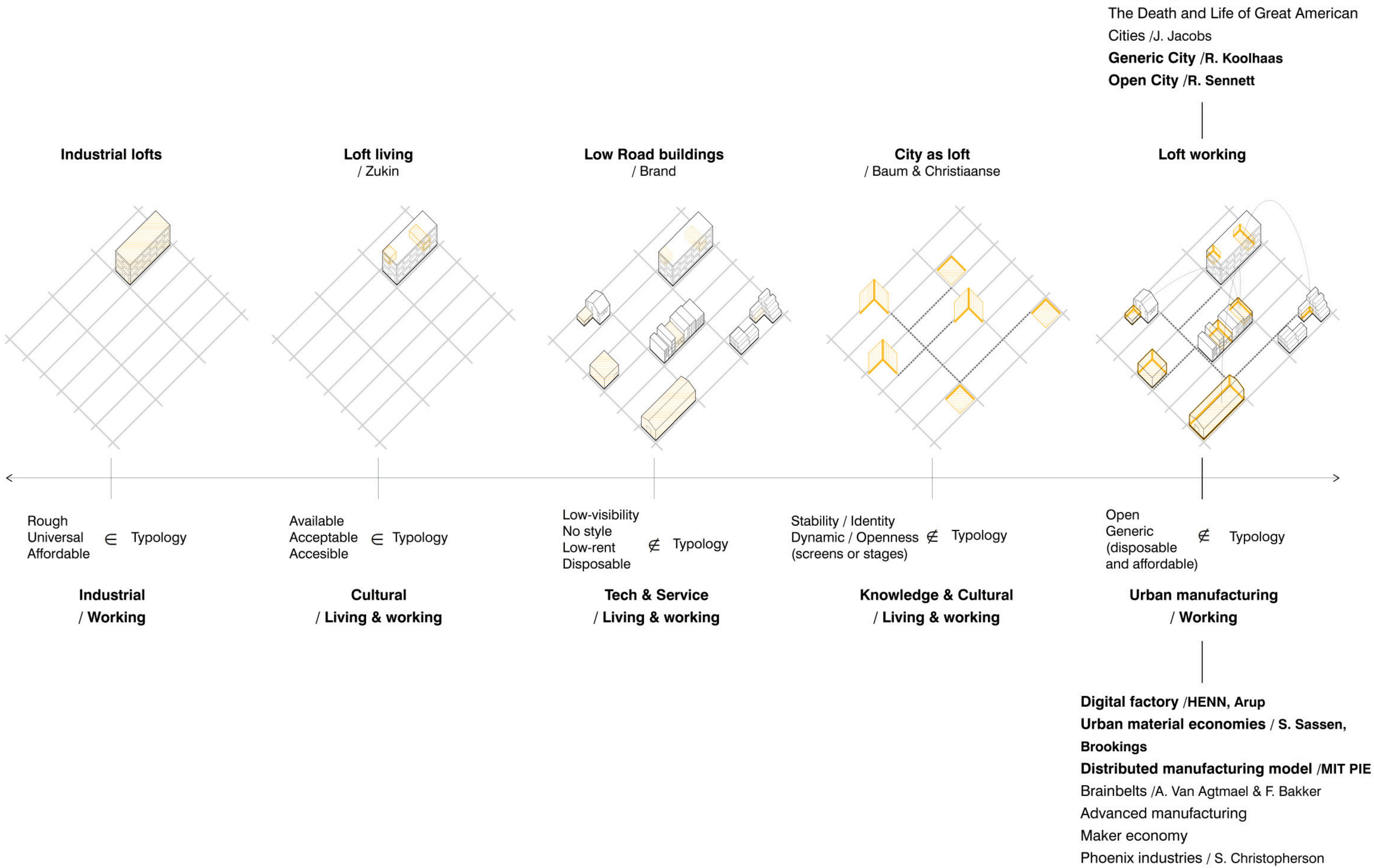
g. *(Company). 3-axis classification of production*[12]. It classifies production systems based on three axes that reflect how companies respond to the demand (market axis), how they produce their product (technological axis) and at which volume (management axis).



h. *(Company). Data table*. The table reports some basic quantitative data on the use of space. For instance, it indicates the amount of space occupied by production, design, and storage both in square meters and in percentage over the total amount of space.

[12] Classification first introduced by Brandolese et. al. in 1985 retrieved from Cuomo et al., *Dalla strategia al piano*, 213–223. Original source cited by Cuomo et al. from which the scheme has been retrieved: Armando Brandolese et al., "Analisi dei sitemi di produzione manifatturiera," Finanza Marketing e Produzione-Rivista dell'Università Bocconi, Anno III, no.1 (1985): 65–97.

Figure 1.1. Research framework: evolution of the loft



Chapter 2

Space and architecture in the development of industrial paradigms

2.1 Evolution of industrial buildings: from the workshop to the digital factory

The evolution of industrial spaces has always been influenced by different factors: innovations in production, technology, or building construction, labor issues and the organization of work, trade infrastructures, policies, and economic trends. From an architectural standpoint, there was no defined factory building type before mechanization. Yet, the development of different industrial sectors with their production, distribution, and consumption logics, have led to the buildout of a wide range of industrial spaces; workshops, cottage shops, studios, factories, warehouses, silos, cold storages, industrial plants, power plants, data center, wholesale malls, etc. Some of them have turned into architectural typologies with their specific path of development.

This section generically refers to the evolution of the factory as a typology, especially between Europe and the US, passing through different stages of industrialization: from craftmanship (tools, manual work), mechanization (steam power), electrification, automation (information technology and electronics) and now autonomization (IoT, cyber-physical systems).[1] The relationship between content and container have been transforming along with the idea of the factory: from the factory as a machine (rational and functional) to the factory as a system (flexible and sustainable) to the future digital factory (adaptive and resilient).

[1] Reynolds, "Innovation and Production," 30.

Early factories in the 19th century: between generic and specific

Hans-Ulrich Kilian[2] recognizes the archetypes of factory buildings in three preexisting structures: (1) grain mills, for the vertical multi-story factories; (2) iron-cast bridges, for the possibility to build freely spanned factories through reticular structures; (3) railway station sheds, for the longitudinal development through the modular repetition of structural elements in single-story industrial sheds. These structures influenced the evolution of industrial buildings before 1900.

Grain mills in England represent the archetype of the early factories built by the rapidly growing textile industry, always in need of larger and stronger building to house the advent of mechanization. The 1718 five-story silk mill in Derby, England by John Lombe "epitomized the new factory type"[3] (fig. 2.1): buildings with three or four stories, a strong basement, and a timber frame built over it. By the end of the century, cast-iron had replaced timber first in the internal structural elements to create more open spaces, then in the loadbearing framework inside masonry walls. The iron bridges developed in the late 18th century in England and the US proved the possibility to set up structures entirely made of iron.[4] For early multi-story factory buildings, the loadbearing iron-cast structure integrated into brick masonry walls became the innovative support system, like in the 1799-1804 Salford Twist Mill in Manchester by Mattew Boulton and James Watt, and in the 1805 spinning works in Glasgow by Henry Houldsworth[5] (fig. 2.2). It was only in later factories that it started being visible on the exterior, like in the 1824-1830 Sayner Hütte (foundry building) in Sayn in the Rhineland designed by Karl Ludwig Althans[6] (fig. 2.3). The development of the iron construction techniques for suspended trusses made possible to overarch always larger spans with king- and queen-post roofs mostly employed in the new railway station sheds. Almost contemporary was its employment in factory buildings where the cast-iron framework eventually became the only loadbearing element on the façade.[7] Although buildings like this were the exception at the time, in the 1860 Boat Store in Sheerness naval dock "the spaces between the supports (were) infilled with metal-clad boarding and long windows to form an

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[2] Kilian, "Industrial Building Before 1900," 14–39.

[3] Kilian, "Industrial Building Before 1900," 16.

[4] Between 1775 ans 1779, the first cast-iron bridge was built over the Severn at Coalbrookdale by Abraham Darby and John Wilkinson. The bridge spanned a distance of 30 m. For further information, see: Jüttner, "History of industrial buildings," 11; Kilian, "Industrial Building Before 1900," 14.

[5] Joedicke, "Industrial Building and Architecture," 11.

[6] Joedicke, "Industrial Building and Architecture," 11; Jüttner, "History of industrial buildings," 12.

[7] Two main example of railway station sheds reported by Kilian are the 1888 Central Railway Station in Frankfurt with three connected large-span curving framed arches made of iron trusses, and the 1835 Euston Station in London with a king- and queen-post roof. The author also reports some example of industrial buildings employing for the first time this construction technique; one example is the 1834 Factory for Maudslay Sons & Field in London. See: Kilian, "Industrial Building Before 1900," 14; 16; 35.

early panel cladding system"[8] (fig. 2.4). The 1851 Crystal Palace in London by Joseph Paxton and the 1889 Galerie des Machines in Paris also contributed to the lightening of structures. They became the expression of new possibilities, in construction technologies, offered by industrialization. Their importance lies in the way they were conceived: a relatively fast assembly of prefabricated parts based on a grid, plus the introduction of a completely new iron and glass architectural quality.

During the 19th century, the "image of a mill as a multi story building erected to house textile manufacturing operations replaced that of the mill as a small structure at the side of a stream in which flour was processed. The textile mill was a building type carefully adapted to the machinery it housed."[9] At that time, the textile industry was the only sector taking place inside a dedicated industrial building: the multi-story textile mill became a standard type of building. On the contrary, there were no specific building typologies for other industries, and the terms used to refer to their factories were a reference to the manufacturing activity carried out rather than to the architecture housing it.[10] Small operations, characteristic of the 19th century, arranged their plant layout inside buildings originally erected for other purposes: "blacksmith shops, barns, and sheds were converted to manufacturing use, as were older dwellings, commercial buildings, and even schools and churches."[11] Among other reasons, the textile industry was a more mature sector compared to others in terms of mechanization and technological advancement, so first-stage operations would have first to evaluate the business' feasibility and its possibility to expand before eventually investing into technological innovations and ad hoc industrial buildings.[12]

Proceeding from the same three archetypes, two other types of industrial buildings were developed besides textile mills: industrial lofts and production sheds. Together with powerhouses, they represented the industrial typologies composing the works in 19th century industrial America.[13] Production sheds, also called 'iron-mill buildings,' 'steel buildings,' or shops were one-story industrial buildings expressively "engineered for manufacturing purposes through the careful design of its framing, walls, and roof."[14] If production sheds were tailor-built for a specific product and production process, conversely industrial lofts were generic multi-story buildings built for no special purpose. Industrial lofts or

[8] Joedicke, "Industrial Building and Architecture," 12.

[9] Bradley, *The Works*, 29.

[10] Bradley, *The Works*, 4–5.

[11] Bradley, *The Works*, 25–26. Bradley also reports few examples of conversion from other use to industrial: a residence converted into a saddler's workshop and warehouse in 1804 at Water with Fletcher Streets (Manhattan), a former church converted into a warehouse in 1867 in Vestry Street (Manhattan), and a public school converted into a carriage manufactury on Staten Island. See: Bradley, *The Works*, 26; note 1 chater 2.

[12] Bradley, *The Works*, 28.

[13] In her glossary dedicated to the terminology of industrial architecture, Bradley specifies how, during the 19th century, the term 'works' was adopted in the US to indicate almost all type of manufacturing operations. See: Bradley, *The Works*, 25–53; 269.

[14] Bradley, *The Works*, 38–39.

‘store and loft’ were developed to serve commercial, storage, and manufacturing uses: generally used by many different activities, in other cases were entirely occupied by one operation and adapted to its particular needs.[15] Typically in the US, lofts sided textile mills in the definition of the multi-story industrial stock in industrial cities and ports. “During the early twentieth century, industrial engineers emphasized the proper design and construction of a general type of loft building (a universal space plant), one planned to meet the general requirements rather than to address the particular needs of any one business. […] Industrial lofts erected in cities were standardized to provide commercial and industrial space at economical cost.”[16] For instance, Rappaport reports that “between 1901 and 1910 there were over 800 loft buildings erected in Manhattan between eight to twenty stories tall used for many smaller manufacturers such as garment, printing, paper bags and boxes, flowers and feathers, textiles, woodwork, hats, and glove manufacturing.”[17] Likewise, in many other early 20th-century North American industrial cities loft buildings were erected in large amounts as no special purpose flexible workshop “so that companies could begin incrementally with short-term investments. Participating companies were able to network and to build upon adjacent manufacturers’ skills and experience.”[18]

The daylight factory: the ‘master-machine’ with a ‘typical plan’

At the turn of the century, almost simultaneously in Europe and the US, reinforced concrete started finding full employment in industrial buildings. In 1902 in the US, Ernest L. Ransome patented a new structural engineering method in reinforced concrete that, after its first employment in the 1902 United Shoe Machinery Company, found full expression with Albert Kahn’s early factories[19] (fig. 2.5–2.7). Reinforced concrete had many advantages: great load-bearing capacity and resistance to vibration; high resistance to fire and the high humidity found in textile mills; also, it was more affordable than the other construction materials. The development of reinforced concrete structures led to the definition of the daylight factory, with two different variations of it. First, the multi-story building where the production process could be vertically organized under one roof, initially taking advantage of gravity-driven systems. Second, the roof-lighted

[15] Bradley, *The Works*, 29–30.
[16] Bradley, *The Works*, 33.
[17] Rappaport, *Vertical Urban Factory*, 89.
[18] Rappaport, *Vertical Urban Factory*, 89.
[19] The introduction of reinforced concrete as a new construction technology in industrial buildings started around the same time in Europe and the US. It was patented in 1892 by the engineer Fraçois Hennebique in Europe, wherease in the US it was first employed in 1895 and then patented in 1902 by Ernest L. Ransome. While Hennebique’s patent included just the monolithic floor, Ransome was able to employ reinforced concrete into the whole construction process, therefore patenting the entire structural frame. Based on these experiences, in 1903 Albert and Julius Kahn patented the ‘Kahn System of Reinforced Concrete’ which was largely employed and perfected in Kahn’s industrial buildings. The 1905 Packard Factory n.10 was the first factory for the car industry to employ this system. For more in-depth information see: Banham, *A Concrete Atlantis*; Kaag, “Industrial Building 1900-1930,” 44–62.

multi-bay single-story horizontal building better suited for housing heavy machinery that found full development especially after the introduction of the mechanical conveyor belt in 1913. The multi-story vertical factory was based on a structural grid of ‘mushroom’ columns and flat slabs[20] with loadbearing external walls reduced to a reinforced concrete frame and extensive windows between structural elements. It was not until the 1930s that the external façade stopped being a loadbearing element as a result of a step back of the supporting columns from the perimeter, leaving the slab cantilevering from the last support out to the façade.[21] With a layout made of horizontally interconnected workplaces, the single-story horizontal factory offered more flexibility to production. Also, it provided for a greater amount of daylight coming from the north-facing sheds. This variation was initially developed using reinforced concrete frames. Later on, the introduction also of steel frames gave way also to modular longitudinal steel-framed workshops (fig. 2.8).

Despite some exception, before the daylight factory most of the industrial buildings still referred to classical or vernacular architectural forms and styles. The advanced construction engineering methods were concealed in brick masonry walls. The modern factory introduced to rational and functional forms. “In addition to the elementary form, structure seen as identical with the form was the theme of building in the first half of the twenties.”[22] Industrial buildings became places of innovation. Factory design was the occasion, especially for young architects,[23] to experiments new framed structures, spatial concepts, aesthetics, and the relationship between internal and external spaces. “They invented an industrial architecture that still serves as a model today. The persuasive effect of simple forms with clear, clean lines and geometries were the foundation stones of this new form. […] The very experience of industrialization, the prefabrication of

[20] “‘Mushroom’ or flat slab construction takes its name from the distinctive form of its columns and the absence of expressed beams. […] this construction mehod appeared simultaneously in Europe and the USA, but again with significant variations. In 1908, in Switzernald, Robert Maillart introduced a two-axix system, the structure flowing continuously form column to floor slab. Conversely, in America in 1909, Philip J. Turner proposed a four-axis design for the head of the column which incorporated extra diagonal and ring reinforcment.” Kaag, “Industrial Building 1900-1930,” 50.

[21] Walter Gropius and Adolf Meyer pioneered the curtain wall construction technique in the 1911-1916 Fagus Factory in Alfeld. For the first time, a glazed façade was hanging in front of the intermediate floor and the steel-frame structure allowed for a column-free corner so that the glazed curtain wall could wrap around it.

[22] Jüttner, “History of industrial buildings,” 13.

[23] In his introductory chapter, Jürgen Joedicke describes how Walter Gropius obtained the commission for his first building as an indipendent architect, the Fagus factory, just based on a letter of presentation. In the same passage he also reports: “similar opportinities were also opening up at this time to other young architects, who were now given the chance to put their ideas into practice. Looking back in later years, Hans Poelzig – who built the water tower at Posen in 1911 and a chemical plant at Luban in 1912 – declared: «It was precisely those architects – because they turned their backs on the historical architectural style and weren’t allowed to participate in official architecture, in so-called fashionable building projects –who escaped to industrial building. They were not already been tilled, where no preconceived stylistic opinion prevailed».” (see fig. 2.13) Joedicke, “Industrial Building and Architecture,” 13.

components, was carried over into the building themselves."[24] While praising industrialization, architects and engineers introduced new structural forms to overarch ever wider spans, they pushed forward the strength and expressive possibilities of steel and concrete, and tested new fabrication methods and engineering solutions allowing for ever lighter structural elements and modular systems. Even if these developments led to very different formal results, the main purpose behind the factory design was to create a functional and logical architecture able to better respond to the need for functionality, light, ventilation, and the improvement of the quality of workspaces (see fig. 2.9–2.17).

Since the beginning of mechanization,[25] factory buildings had evolved from just housing a defined relationship between human and machines, to being active cooperators in the production process where first the single operations then also material-handling became automatized processes. Finally, the factory became the key parameter of the completely automatized production machine together the social components, the 'human machine.' Plant layout and the design of the building were a consistent part of companies' investments; they were part of the process of planning the production process and business plan to guarantee the maximum efficiency and control of profits, workers, and workflow. The factory became the 'master machine.'[26] Before the daylight factory, industrialists did not think to the factory as much as an expandable plan to suit variations in production size or needs, whereas it became one of the most important factors to take into account throughout the 20th Century. This shift is represented by Marullo[27] through the analysis of Albert Kahn's industrial architecture, from the introduction of the 'Kahn System of Reinforced Concrete' (see footnote 19) until the 1940s. Kahn reduced the factory plan at its simplest form, or 'typical plan;' "a coherent, flexible, and reproducible scheme, constructed from homogeneous envelope, a technical core, and a minimum of support that achieved maximum profit from tacit human potential, which could be altered by those in charge or the acts of employees themselves as an instrument of control and emancipation"[28] (fig 2.18). As suggested by both Biggs and Marullo,[29] the factory plan becomes the layout where the parameters of production are logistically displayed and organized to avoid any waste, dysfunction, or worker insubordination.[30] In the 1914 New Shop at the Highland Park Ford Plant, Albert Kahn designed a sophisticated variation of the daylight factory. Autonomous production principles

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[24] Ackermann, "Industrial Construction and Architecture," 66.

[25] The story of mechanization in North America started in Delaware in the 1780s, when Oliver Evans built an automatic flour mill that replaced workers with machines and guaranteed a high level of control over production. But the real first step into mechanization in the US was in the textile industry in the 1790 with the construction of the Slater's first spinning mill. For more in-depth analisys see: Biggs, *The Rational Factory*, 1-54.

[26] Biggs, *The Rational Factory*, 49.

[27] Marullo, "The Typical Plan," 216–260.

[28] Marullo, "The Typical Plan," 218.

[29] Biggs, *The Rational Factory*; Marullo, "The Typical Plan," 216–260.

[30] For a more in-depth understandig of the evolution of the factory as a form of control and society organization see Darley, *Factory*, 40–73.

were integrated into the building by embedding the conditioning and ventilation systems directly within the structure. The complex resulted into a series juxtaposed parallel reinforced concrete frames with completely clear open floors intermitted to distribution bays with cranes for vertical distribution of materials and railway terminals for shipment. The daylight factory resulted from the combination of mass-production principles; “power, accuracy, economy, system, continuity, and speed – with a mobile, teachable, and massive workforce […] as part of the production machinery, moving homogeneously at a standard velocity.”[31] The factory was not just a rational support for production, but it became the function it performed. Inside the Ford River Rouge Complex in Dearborn, Albert Kahn designed horizontal modular steel-framed single-story buildings that could be strategically expanded or rearranged based on changes in the assembly line, therefore avoiding every inefficiency. By extending these functional and rational principles to the entire production, distribution, and consumption system, the ‘typical plan’ turned an urban planning principle to be applied to the entire plant. Industrial plants included different factories, transportation lines, railways commercial terminals, and connections to national and international commercial routes. They resembled a self-sufficient city without any dependency on suppliers, material shortages or other market instabilities.[32] During the 1930s, with Ford expanding overseas and becoming an efficient global company, the increasing number of factory commissions pushed Kahn to develop a systematic and faster design process subdivided into coordinated departments, each one specialized and dedicated to a single aspect of the project. This system led to the development of an established ‘company design-syntax,’ “a limited set of typical plans and protocols to allow a wide and rapid layout deployment that could meet many industrial situations. The factory plan, in a sense, became an algorithm for creating space according to configurable parameters that could be shaped, stressed, reduced, or specialized depending on circumstances.”[33] In projects like the 1935 Chevrolet Commercial Body Plant in Indianapolis, the 1936 De Soto Press Shop and the 1937 Chrysler’s Half-Ton truck Plant in Detroit, the typical plan became a clear open floor based on a grid on 12x12 meters with no difference between width and length structural potentials or limitations.

From generic shed to generic systems

If until the 1930s factory design pointed towards creating the most rational and functional workspace by exploiting natural light and ventilation, toward the end of this period factories started integrating within the structure electric lighting, air-conditioning, and ventilation systems that, by that time, had been improved in their performance and reliability. Therefore, the production process and consequently the factory design gradually stopped depending on weather

[31] Marullo, “The Typical Plan,” 224.
[32] Marullo, “The Typical Plan,” 242.
[33] Marullo, “The Typical Plan,” 247.

conditions or any other external natural factors. During World War II, this opportunity, together with the need for economical, efficient as well as dispersed and disguised industrial spaces, marked a drastic inversion of the creative factory design trends; “factories became sealed sheds built for speed and as basic generic wrappers for machines, rather than a factory as a machine.”[34] Wartime architecture, along with the logistics of mass manufacturing, contributed to the building of delocalized, horizontally spread generic sheds, often resulting in poor and banal architectures with no relationship with the context whatsoever. Starting from the 1960s and throughout the second half of the 20th Century, factories turned once again to be places of innovation for the application of technology – soon to be paralleled by sustainability – to buildings construction. The modular open plant layout became the structural planning concept for flexible and variable industrial needs. The work of architects like Metabolists, Archigram, Buckminster Fuller, Richard Rogers, Norman Foster, Renzo Piano, and Fritz Haller defined a new ‘high-tech’ paradigm made of lightness, pragmatism, transparency, and flexibility.[35] Proceeding to the increasing integration of service supply routes and technical equipment in the design process seen, for instance, in Kahn’s factories, during the second half of the 20th Century the factory started being conceived as an increasingly automated and autonomous system. The aims of reducing weight, costs, and internal load-bearing elements by covering even larger spans mixed with a whole new set of requirements due to the introduction of shorter product lifecycles and increasingly flexible manufacturing system (e.g., Toyotism, lean manufacturing, just-in-time). Therefore, the factory resulted from the application of technology to the design and construction process to fulfill industrial requirements; economic efficiency, flexibility of use, fast construction times, and the integration of the building services engineering within the structure.[36] The 1961 shed for an electronics company in Los Angeles by Craig Ellwood and the 1964 production facility for electrical appliances in Chicago by C. F. Murphy introduced the concept of multi-functional shed[37] (fig. 2.21). Both projects were simple enclosed squared spaces with artificially lit and ventilated interiors that allow maximum flexibility in the use of space as well as in its extension. The aim of eliminating almost any vertical loadbearing element within the production space have led architects and engineers to experiment with tensile structures as well as combination of construction materials for finding more extense roof solutions. For instance, like in the 1961 extension of the Haramachi print works by Kenzo Tange (fig. 2.22) or in the 1967 textile factory in Moriyama by Ebihara Architects, where lattice-steel roof combined with reinforced concrete beams to cover larger spans. The 1965 Reliance Controls factory in Swindon by Team 4 and the 1966 warehouse in Genoa by Renzo Piano worked with prefabricated modular solutions to ease possible extensions of the facilities without disrupting

[34] Rappaport, *Vertical Urban Factory*, 331–332.
[35] Rappaport, *Vertical Urban Factory*, 332–338.
[36] Knippers and Hub, “Load-bearing Structures,” 37.
[37] Kaag, “Industrial Building 1930-1970,” 80–81.

the existing operation (fig. 2.24–2.25). By becoming a modular system, the multi-functional shed also became cheap and easy to build. The work of Fritz Haller for USM U, like in the 1964 Office Furniture plant in Münsingen (fig. 2.23), is emblematic of the shift in the way industrial buildings were conceived: from modular component systems to a systematics for buildings. Building with system means applying a 'general solution' to a specific situation.[38] The 'general system' is made of a series of parameters, rules, and regulations that define how parts can relate or adapt to each other in a modular way to respond to very specific requirements of production. This could happen either at the structural level, e.g., different sites, heavy machinery, vibrations, structural deformations, or in terms of internal condition and performances, e.g., control of air room temperature and humidity, or a correct contaminated waste disposal.[39] This system distinguishes between load-bearing structure and envelope. Both elements have a high repetition factor and work with prefabricated building components. The envelope could be solved through closed or transparent facades, gateways, and skylight, opaque or variable roofs. Through the envelope, the factory establishes its inside/outside relationship, the general outlook, and relationship with the context as well as the workplace ambiance.[40] On the other hand, the structure outlines the building's typology, or 'general systems,' by distinguishing between multi-story structures, based on relatively small grid frames braced at compact cores, and low-rise industrial halls, favoured by manufacturing as they consist of structural portals based on a larger grid, covering very wide spans depending on the material employed – timber, concrete or steel.[41]

In projects like the 1967 electronic components factory in Longarone by Bruno Morassutti and the 1970 Dundalk cigarette factory by Michael Scott, the roof, portion of the structural planning module where all the supply routes are housed, started acquiring more relevance until standing out as a technical installation and service supply room (fig. 2.26). The structural element, turned also into the service infrastructure, eventually emancipating from the rest of the envelope, like in the 1973 warehouse, exhibition, and office building designed by Renzo Piano for the furniture company B+B Italia in Como (fig. 2.29). Here, "a continuous web of space-frame trusses is wrapped right around the building to create a single volume, 30 meters wide and 60 meters long, sandwiched between a structure which doubles as a service supply zone, allowing services to be supplied

[38] Haller, "Building with system," 31

[39] Haller, "Building with system," 31; Daniels and Kast, "Building Services Engineering," 45.

[40] Fuchs, "The Envelope of Industrial Buildings," 41–44.

[41] According to Knippers and Hub, multi-story buildings are usually based on 7x7 m or 7x14 m grids, while the most economically efficient grid for single-story industrial halls type ranges between 14x14 m and 24x24 m. Larger grid dimensions may result uneconomical overall, while smaller grid dimensions may be an obstacle for flexible production layouts. Regarding the reachable spans, timber structures can span up 35 m; pre-cast concrete structures can span up to 24 m, 40 m with pre-stressed concrete girders; while steel trusses can span over 100 m with cross-frames and reticular structures. See Knippers and Hub, "Load-bearing Structures," 37–40.

to the space from any direction."[42] In following projects like in the 1976 PA Technology electronics company near Cambridge by Piano and Rogers and the 1980 Cummins engine factory in Shotts by Ahrends Burton & Koralek, this process was pushed even further. The structural/service infrastructure elements also included all the spaces dedicated to functions requiring smaller-sized rooms (offices, distribution elements, technical rooms)

Throughout the following decades, factory design continued on this path of development of low-rise industrial halls. Due to the emergence of lean non-linear production layout, the factory floor partially loses its hierarchical structure in favor of more horizontal open organizations.[43] The structure acts as infrastructure and the structural module as the organizing principle. Since the early 1980s, sustainable issues started influencing industrial design. "Architects followed ideas from research into solar gain, building recycling, and the initiative of 'long life, loose fit, low energy,' as coined by Welsh architect and then Royal Institute of British Architects (RIBA) president, Alex Gordon (1917-1999). Gordon equated the idea of 'loose fit,' originated by architect John Weeks in the 1960s, with the potential for building reconfiguration and adaptability, which becomes today's challenge for a sustainable method of building, especially for the energy-consuming factory."[44] This way of thinking evolved into the concept of an 'industrial ecology,'[45] first referred to closed-loop manufacturing systems, then furthered by Tibbs who proposed in 1992 the integration of six principles to the management and technical sides of an industrial business. Among them, more relevant to factory design were: the creation of closed-loops of waste emission and recycling that would use one industry's waste into a resource for other industries; balancing industrial input and output to natural ecosystem capacity; the dematerialization of industrial outputs, for instance, by employing environmentally friendly materials; incorporating sustainable patterns of energy producing, supplying, and distribution within the industrial ecology.[46] Consequently, between the 1990s and the beginning of the 21st century, the work of different authors and environmentalists contributed to the diffusion of cradle to cradle, life-long or upcycle, principles in the industrial sector as well as in construction, consumer economies, and in general in people's culture.[47]

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[42] Kaag, "Industrial Building since 1970," 97.

[43] For more information on production processes and spaces of flow see: Cuomo et al., *Dalla strategia al piano*, 189–228; Rappaport, *Vertical Urban Factory*, 338–341.

[44] Rappaport, *Vertical Urban Factory*, 338.

[45] Robert Frosch and Nicholas Gallopoulos, in their article "Strategies for Manufacturing" (Scientific American 261; September 1989, 144–152), developed the concept of industrial ecosystems, which led to the term industrial ecology. Their ideal industrial ecosystem would function as "an analogue" of its bio-logical counterparts. This metaphor between industrial and natural ecosystems is fundamental to industrial ecology. In an industrial ecosystem, the waste produced by one company would be used as resources by another. No waste would leave the industrial system or negatively impact natural systems." Garner and Keoleian, *Industrial Ecology*, 3.

[46] Tibbs, "Industrial Ecology," 170–178.

[47] To deepen this topic see: Brand, *How Buildings Learn*; Stewart Brand, *Whole Earth Discipline. An Ecopragmatist Manifesto* (New York: The Viking Press, 2009); Michael Braungart

The latest generation of factories has been addressing sustainable and ecological issues. For instance, by revitalizing existing industrial buildings rather than building new ones, or by designing green and sustainable factories that aim for zero-emission or produce their own energy then sharing excesses with other companies. Other than flexibility and sustainability, the latest factories have been pursuing a certain degree of spectacle and consumption of production addressed through architectural features, location choice, or also companies' marketing strategies.[48] If until a few decades ago industry had gone head-to-head with pollution, noise, unhealthy, and exploitation, today's factories are presented as 'cleaner, smarter, and smaller' spaces of production that, once again, can be compatible with denser contexts and other uses, even residential environments – hence with cities. This is due to the increasing application of sustainable and ecological thinking at different levels of the business – e.g., company's ethics, products life-cycles, energy-efficiency, waste recycling – as well as an always wider diffusion of advanced technologies in production processes, like robotics and additive manufacturing.

The digital factory

The use of cyber-physical systems is what defines the so-called industry 4.0,[49] characterized by mass-customization, just-in-time/just-in-place production, lean manufacturing, small-batch production, etc. It finds in the 'smart factory' or 'digital factory' its supporting infrastructure. The set of requirements the future factory has to respond to is already quite defined. Elisabeth Reynolds defines smart factories as distributed production units efficiently producing small quantities by using "data-driven manufacturing intelligence throughout their operations across the entire factory and networks beyond the factory walls."[50] Based on existing case studies, Nina Rappaport envisions future vertical, dense, and hybrid urban factories: layered factories or vertical production systems housed in multi-story buildings, perhaps mixed with other uses or even housing. Industry will also be transparent, in its corporate ethics and to the public through industrial tourism. Companies will be 'glocal,' for instance producing and supplying products locally as well as referring to global markets through network-platforms. Finally, the industrial ecosystem will reconnect with urban distribution and logistics infrastructures currently dismissed or under-used.[51] Henn's research

and William McDonough, *Cradle to Cradle. Remaking the Way We Make Things* (London: Vintage Books, 2008, first published 2002), Kindle; Michael Braungart and William McDonough, *The Upcycle. Beyond Sustainability – Designing for Aboundance* (New York: North Point Press, 2013), Kindle.

[48] These issues are addressed by Rappaport in her chapter "Contemporary Factory Architecture." See Rappaport, *Vertical Urban Factory*, 342–431.

[49] Reynolds, "Innovation and Production," 30.

[50] Reynolds, "Innovation and Production," 30.

[51] For a more in-depth understanding of Rappaport's research on future factories see: Rappaport, "Vertical Urban Factory;" Rappaport, *Vertical Urban Factory*, 434–457; Rappaport, "Hybrid Factory | Hybrid City," 72–86.

recognizes in urban organizational systems of existing metropolis the model to create 'production boulevards' through the continuous improvement of supplier networks' communication, performance, and processes.[52] Also, the future factory will evolve following the growing scope of application of robots, for instance in mobility, in assisting technicians to perform specific tasks, or in their application in the service and communication sectors. "The factory of the future must be highly flexible to accommodate a wide range of floor layouts, production systems, alterations and extensions. Material flows are organized around mobile transport units, similar to the organization of bits and bites on a circuit board."[53] Furthermore, a high level of sustainability will be pursued by "the utilization of wind power, solar power, geothermal energy and biomass production. The factory of the future will be reminiscent of a power station which stores excess energy in the local power grid and acts as a buffer during energy peaks. These measures will be further supplemented by integrating closed water cycles and recycling raw materials"[54] (fig. 2.36). Finally, Arup research presents the factory of the future as a digital factory, adaptive and resilient. The creation of a digital factory model through building information modeling (BIM) allows to pre-visualize possible factory reconfiguration based on real-time responses to market and supply chain disruptions and variations. The digital model will integrate building and structural components with production layouts, energy, and resource flow. Going even further, "BIM can also identify and create efficiencies in the design of multiple factories across a portfolio of assets. A library of digital factory content and components can be used to quickly assemble a factory design from a toolbox of standard components."[55] The same research also envisions bi-directional factory design, focused on assembly and disassembly cycles of modular and flexible systems. "Improved adaptability and flexibility will also mean that factories can be constructed from modular components that are easily disassembled and relocated. Modular structures can be expanded quickly and easily to meet changing spatial requirements. Tented factories, for example, can be used for extra capacity or as stand-alone moveable facilities"[56] (fig. 2.37). Cuomo et al. resumes the digital factory in three paradigmatic changes: 1) production locates where consumption happens; 2) knowledge travels, not products; 3) production is a bottom-up process where you add functions and uses to materials.[57]

The century-long process of lightening the economic and physical weight of the factory finds in the smart digital factory its best expression. If the modular building systems of the 1960s were in any case destined to leave a footprint once dismissed, the cited studies would suggest a sort of footprint-free mobile factory increasingly dependent on its location and ecosystem rather than the

[52] Henn, "Factory of the Future."
[53] Henn, "Factory of the Future."
[54] Henn, "Factory of the Future."
[55] Arup, *Rethinking the Factory*, 41.
[56] Arup, *Rethinking the Factory*, 43.
[57] Cuomo et al., *Dalla strategia al piano*, 202–203.

characteristics of the physical space. Therefore, rather than a typology, a construction system or a form shaped after the production flow, the digital/smart factory resembles the cloud or network of physical and digital operations and flows (of people, things, and information) that contextually happens at a local and super-local level, and it can eventually adjust to different type of spaces and places.

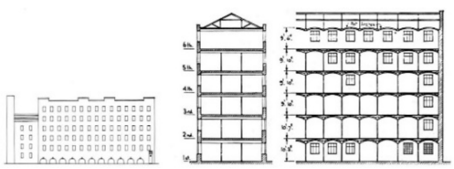

Figure 2.1. Silk mill in Derby (1718). Figures extracted from: Ackermann, *Building for Industry*, 17.

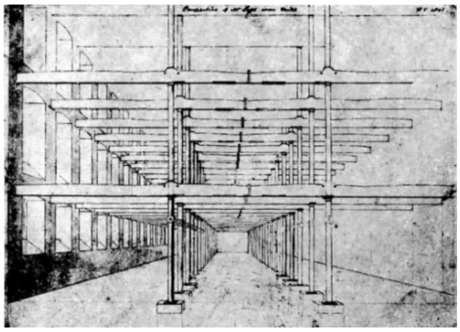

Figure 2.2. Twist Mill in Salford (1799-1801). Figure extracted from: Ackermann, *Building for Industry*, 19.

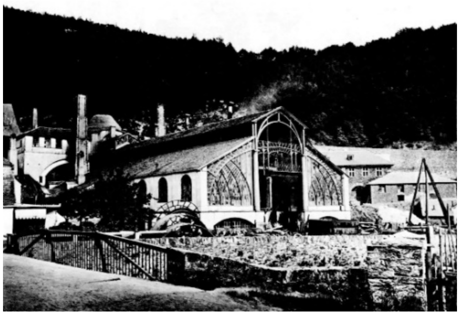

Figure 2.3. Foundry at Sayn (1824-1830). Figure extracted from: Ackermann, *Building for Industry*, 21.

Figure 2.4. Boat Store in Sheerness naval dock (1860). Figure extracted from: Darley, *Factory*, 110.

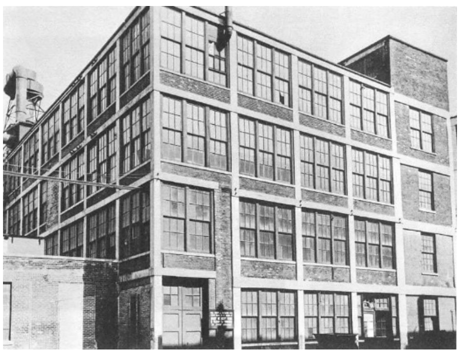

Figure 2.5. Packard Factory n.10 by A. Kahn (1905). Figure extracted from: Marullo, "The Typical Plan," 225.

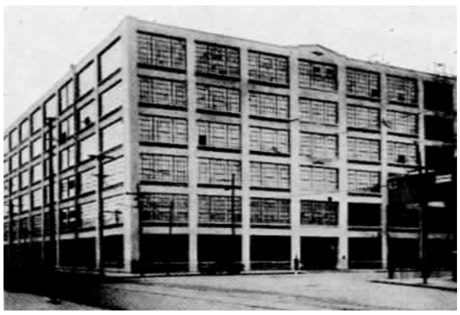

Figure 2.6. Manufacturing and Assembly building of Geo N. Pierce Arrow Plant in Buffalo by A. Kahn (1906). Figure extracted from: Ackermann, *Building for Industry*, 47.

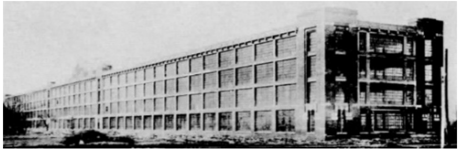

Figure 2.7. Old Shop at the Ford Highland Park Plant in Detroit by A. Kahn (1910). Figure extracted from: Ackermann, *Building for Industry*, 47.

Figure 2.8. Pirelli & Co. Cable Factory in Villanueva by Robert Maillart (1914). Figure extracted from: Ackermann, *Building for Industry*, 60.

Figure 2.9. Lyon abattoir by Tony Garnier (1909). Figure extracted from: Ackermann, *Building for Industry*, 59.

Figure 2.10. Esders Clothing Factory in Paris by Auguste Perret (1919). Figure extracted from: Ackermann, *Building for Industry*, 59.

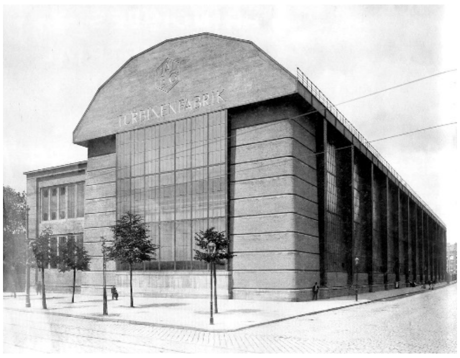

Figure 2.11. Turbine factory in Berlin, by Peter Behrens (1909). Figure extracted from: Adam et al., *Industrial Buildings*, 10.

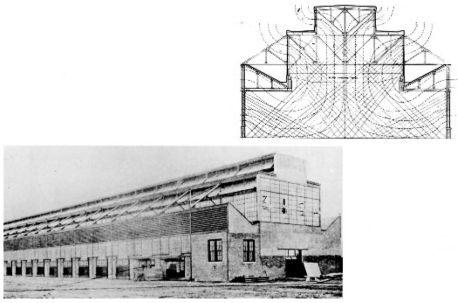

Figure 2.12. Packard Motor Company cast-iron processing shop by Albert Kahn in Detroit (1910). Figure extracted from: Ackermann, *Building for Industry*, 55.

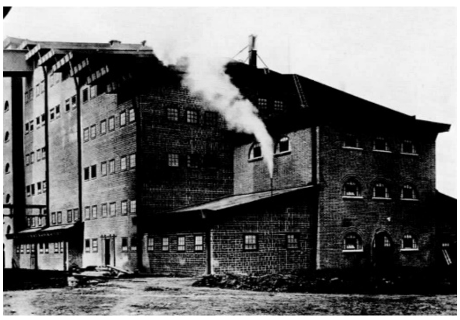

Figure 2.13. Chemical Factory in Luban, Poland by

Hans Poelzig (1911-1912). Figure extracted from: Ackermann, *Building for Industry*, 56.

Figure 2.14. Fagus Factory in Alfeld by Walter Gropius and Adolf Meyer (1911-1916). Figure extracted from: Rappaport, *Vertical Urban Factory*, 147.

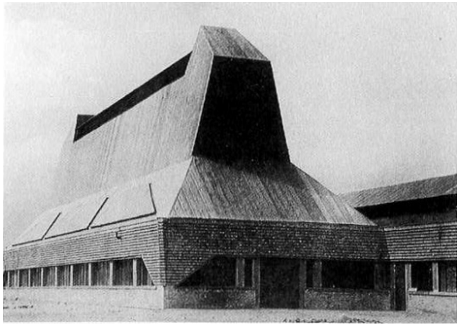

Figure 2.15. Friedrich Steinberg hat factory in Luckenwalde, Germany by Eric Mendelsoh (1921-1923). Figure extracted from: Rappaport, *Vertical Urban Factory*, 144.

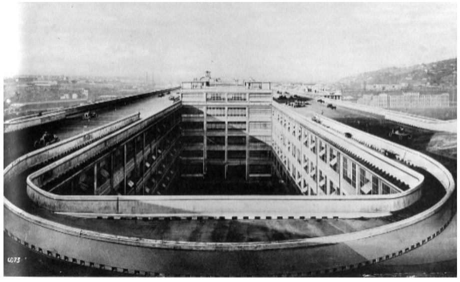

Figure 2.16. Fiat Lingotto factory in Turin by Giacono Mattè-Trucco (1913-1923). Figure extracted from: Rappaport, *Vertical Urban Factory*, 133.

Figure 2.17. Van Nelle factory in Rotterdam by Johannes Brinkmann and L.C. van der Vlugt (1926-1931). Figure extracted from: Darley, *Factory*, 123.

Figure 2.18. New Shop at the Highland Park Ford Plant by Albert Kahn (1914). Figure extracted from: Rappaport, *Vertical Urban Factory*, 159.

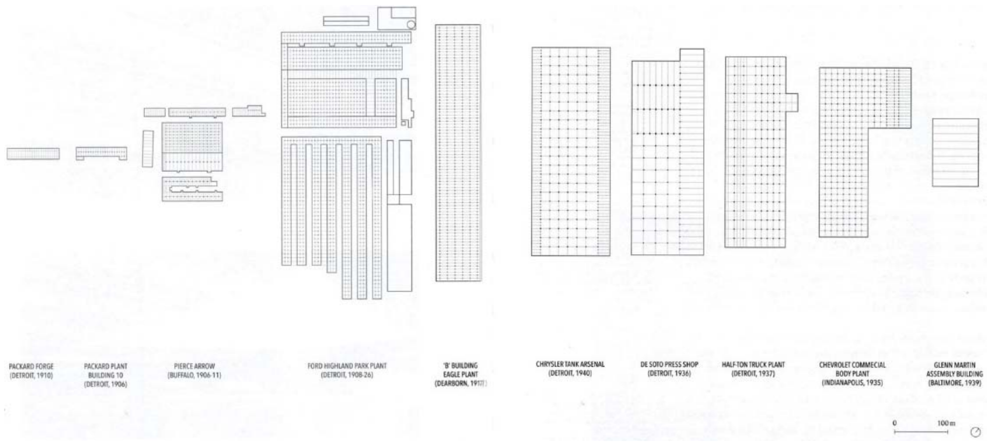

Figure 2.19. Evolution of the 'typical plan' in A. Kahn's factory design. Figure extracted from: Marullo, "The Typical Plan as Index of Generic," 252–253.

Figure 2.20. Boots Pure Drug Company in Beeston, England by E. Owen William (1927-1933). Figure extracted from: Darley, *Factory*, 124.

Figure 2.21. Reconfigurable shed through movable partitions designed for an electronics company in Los Angeles by Craig Ellwood (1961). Figure extracted from: Ackermann, *Building for Industry*, 80.

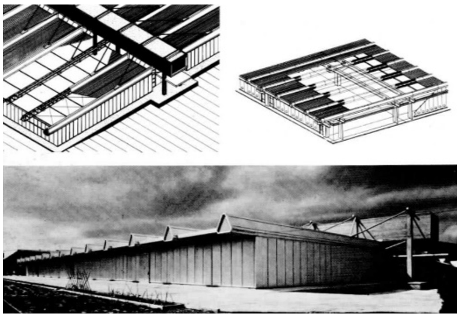

Figure 2.22. Extension of the Haramachi print works by Kenzo Tange (1961). Figures extracted from: Ackermann, *Building for Industry*, 86.

Figure 2.23. USM Haller in Munsingen by Fritz Haller with Paul Schaerer (1964). Figure extracted from: Adam et al., *Industrial Buildings*, 30.

Figure 2.24. Reliance Controls factory in Swindon, England by Team 4 (1965). Figure extracted from: Darley, *Factory*, 132.

Figure 2.25. Warehouse in Genoa by Renzo Piano (1966). Figure extracted from: Ackermann, *Building for Industry*, 84.

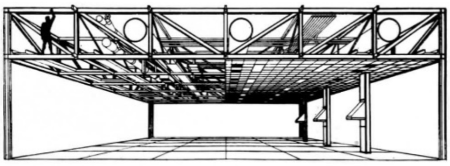

Figure 2.26. Dundalk cigarette factory by Michael Scott (1970). Figure extracted from: Ackermann, *Building for Industry*, 88.

Figure 2.27. Olivetti factories at Crema Scarmagno and Marcianise by Marco Zanuso and Antonio Migliasso (1970). Figure extracted from: Ackermann, *Building for Industry*, 90.

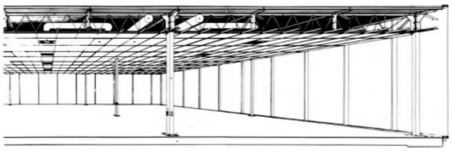

Figure 2.28. IBM Cosham by Norman Foster. Figure extracted from: Ackermann, *Building for Industry*, 95.

Figure 2.29. B+B Italia warehouse, exhibition, and office building in Como by Renzo Piano (1973). Figure extracted from: Ackermann, *Building for Industry*, 97.

Figure 2.30. Renault Distribution Center in Swindon, UK by Norman Foster (1982). In Adam, *Industrial Buildings*, 91.

Figure 2.31. Mors Distribution Center in Opmeer, Netherlands by Benthlem Crouwel Architekten (1988). In Adam, *Industrial Buildings*, 94.

Figure 2.32. Wilkhahn Assembly Hall in Bad Münder, Germany by Thomas Herzog (1993). In Adam, *Industrial Buildings*, 102.

Figure 2.33. Kaufmann Holz AG Distribution Center in Bobingen, Germany by Florian Nagler (1999). In Adam, *Industrial Buildings*, 75.

Figure 2.34. Aplix Factory in Le Cellier, France by Dominique Perrault (1999). In Adam, *Industrial Buildings*, 157.

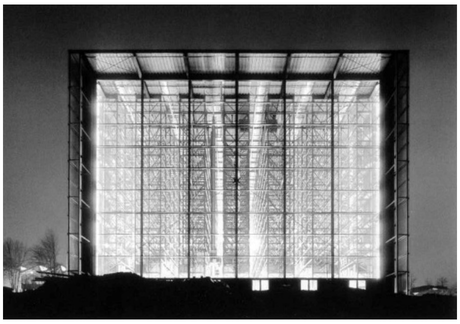

Figure 2.35. Ercho Leuchten High Bay Storage in Lüdenscheid, Germany by Scheider+Shumacker (2001). In Adam, *Industrial Buildings*, 68.

Figure 2.36. Project of the Factory of the Future by Henn architects. Figure retrieved from: Henn, "Factory of the Future."

Figure 2.37. Project of digital factory, Arup. In Arup, *Rethinking the Factory*, 47.

2.2 Toward future manufacturing models

Supple, peer-to-peer, decentralized networks of research, development, production, assembly, and distribution are recognized as the characteristic organizational form of 21st-century production.[58] Proceedings from significant evolutions in companies' organization, innovation models, and production processes, the chapter glimpses into a possible future for the manufacturing sector in the US to finally reflect on the role of urban spaces and architecture in the development of this scenario (fig. 2.38).[59]

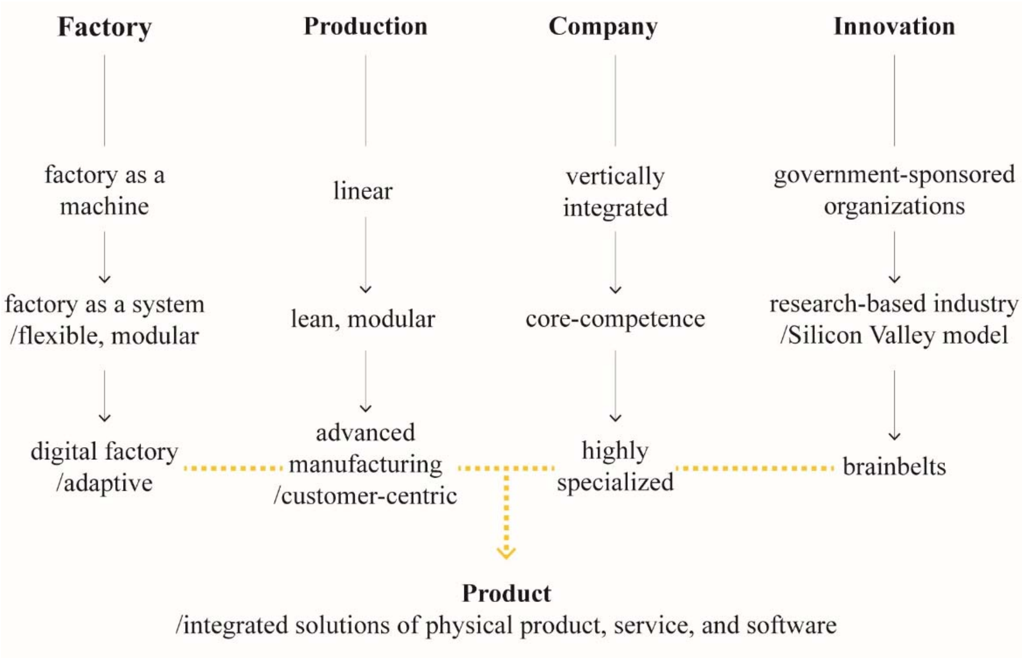

Figure 2.38. Schematic representation of the evolution in companies' organization, innovation models, production processes, and factory design.

Companies and innovations

From the mid-19th century on, American companies have gradually expanded the range of functions carried out under the same roof, from product design to final delivery, until growing into 'multidivisional, manager-run enterprises' controlling important sectors of national markets.[60] After World War II, these

[58] Mistry and Byron, *The Federal Role*, 8.

[59] The chapter is mainly based on reports and publications coming off or supported by the Brookings Institution and the Massachusetts Institute of Technology – i.e., the MIT Task Force on Production in the Innovation Economy, Brookings' Center for Technology Innovation, John Hazen White Global Manufacturing Initiative, and Metropolitan Policy Program. See also the research conducted by McKinsey&Company, Deloitte US and its Center for the Edge, and the Boston Consulting Group on advanced manufacturing and the innovation economy in the US.

[60] Berger, *Making in America*, 44.

same companies restructured as vertically integrated enterprises, extending their ownership also to upstream and downstream functions, reducing their need to rely on suppliers or external factors.[61] Under this configuration, manufacturing was an integral part of the business model. Companies controlled almost the entire industrial process: research, design, development, fabrication, packaging, testing, sales as well as the production of many parts and components employed in their products. While enlarging their domain's perimeters, they were also able to control suppliers and prevent the advance of competitors.[62] Changes in global markets and technology have had a deep impact on these American companies. From the 1980s on, these same organizations started to break-up their range of activities and focusing only on a narrower set considered as 'core competence.' This has led to the restructuring of companies' boundaries by closing or selling every activity not part of the 'core' – with manufacturing being one of the first to move out to domestic or foreign contractor plants. This has also been a consequence of the possibility, due to digital technologies, to physically separate early-stage R&D, design, and prototyping from manufacturing while still being able to closely control product's manufacturing and quality.[63] With contractor plants increasingly moving to low-wage countries, shipping turned into an important section of business organizations. Due to these changes, domestic manufacturing has been left with a fragmented scenario of asset-light companies. Most of today's American industrial landscape consists into a network of small, specialized firms, which manufacture customized products made in small batches, or they focus on innovations of products, technologies, and manufacturing processes.[64] Once vertically integrated companies and global corporations still rely on these domestic firms and start-ups to build up their research portfolio and start new streams of innovation.[65] American research-based companies that work in close collaboration with universities, venture capital firms, governmental institutions, and entrepreneurs embedded within the so-called 'brainbelts,'[66] are

[61] In the previous chapter on the evolution of industrial building it is possible how this trend translated into architecture into Marullo analysis of Ford's 'typical plan' – from a functional layout resulting from the parameters of production, to an urban planning principle, and finally to a 'company design-syntax.'

[62] European and Japanese companies presented other models of vertical integration still referring to mass consumer markets. For instance, compared to large American companies, Japanese enterprises established a different relationship with capital markets and suppliers as well as within the internal organization: flatter hierarchies of authorities, trust- and loyalty-based labor relations rather than contracts' terms-based. Both in Europe and Japan, large companies were sided by clusters of specialized small and medium firms that based their successful long-term collaborations on trust as well as on their close proximity to customers, markets, institutions, educational programs, and other services. All three business models were centered on manufacturing. Equally, all three models were strongly hit by the upcoming changes in global markets. See: Berger, *Making in America*, 45–46; Cuomo et al., *Dalla strategia al piano*, 190–198.

[63] Berger, *Making in America*, 46–51.

[64] Berger, *Making in America*, 55.

[65] Berger, *Making in America*, 55–56.

[66] The term 'brainbelts' is used by Agtmael and Bakker to indicate former rust belt areas across North America and Europe that are repositioning globally at competitive levels through smart innovation networks and advanced manufacturing development. The 'brainbelt' discourse

responsible of the development and commercialization of a vast amount of innovations. As we will see in the following passage, with advanced manufacturing systems leading to the merging of hardware and software development, digital innovations are increasingly linked with physical products and manufacturing processes. That is one of the trends feeding the narrative, sometimes exaggerated or misconceived, of the manufacturing comeback. Agtmael & Bakker defines brainbelts as a 'tightly woven, collaborative, open ecosystem of contributors, supporters, and suppliers.' De-siloed organizations and individuals operate out of three principles: focus, openness, and trust. Each actor focuses on one specific activity, discipline, or operation, so they need to openly share knowledge and expertise to make the process work. Also, trust is ensured by the mutual dependency and demand for a close collaboration for a common purpose. Co-location and proximity to other contributors of the ecosystem is a key aspect of brainbelts.[67]

Production and factories

With firms structured as vertically integrated operations, production consisted into a series of consecutive steps separated in time and space: row material acquisition and storage, manufacture of individual components, assembly and subassembly in multiple stages, final inspection, storage of the finished goods, and finally distribution. This linear organization of production, characteristic of mass-production, was scheduled to issue a small variety of standard products based on sales forecasts (make to stock).[68] With the deverticalization of companies and the transition to flexible and lean manufacturing systems,[69] production resulted from the sophisticated integration of production planning, scheduling of operations, and supply chain management: purchase of material and parts from suppliers and temporary storage of them into buffer stations, assembly in multiple phases, continuous monitoring of quality, and then distribution. Responsiveness to demand is key and firms, while narrowing their set of competence, have increased the variety of products. The assembly line is

frames within the development of the Innovation Districts, modelled after the the Silicon Valley way of clustering entrepreneurs, startups, business accelerators, incubators, and capital investors. According to the Brookings Institution, innovation districts are the consequence of a changing geography of innovation, from secluded industrial districts and research parks to dense clusters of research-based labs and firms, institutions, universities and incubators, as well as housing, retail, and offices. See: Van Agtmael and Bakker, *The Smartest Places on Earth*; https://www.brookings.edu/innovation-districts/.

[67] Van Agtmael and Bakker, *The Smartest Places on Earth*, loc. 268–514.

[68] Berger, *Making in America*, 155.

[69] In the US, The Fordist production model was first questioned during the 1970s. What followed was a deep transformation of production logics that transitioned to lean manufacturing systems. Lean manufacturing was developed after the Toyota Production System (TPS) invented in Japan by Toyota's engineers during the 1940s-1950s. According to Cuomo et al., due to its intrinsic logic and to its increasing spread to international markets, the lean manufacturing system has consistently accelerated outsourcing and offshoring trends, leading to the revolution of companies' structure as well as of the global industrial scenario during the 1980s-1990s. See: Cuomo et al., *Dalla strategia al piano*, 189–220.

organized to respond in real-time to customized orders in different market segments (make to order and just-in-time production).[70] Today, new technologies are moving production toward advanced manufacturing models focused on customization, localization, complexity, and quality.[71] In its 2011 report, the PCAST defines advanced manufacturing as "a family of activities that (a) depend on the use and coordination of information, automation, computation, software, sensing, and networking, and/or (b) make use of cutting-edge materials and emerging capabilities enabled by the physical and biological sciences."[72] The MIT-PIE research group conceives advanced manufacturing as "the creation of sustainable capabilities to make successive generations of integrated solutions coupling production of physical artefacts with services and software. The sustainability, efficiency, and rapidity of producing these generations will increasingly draw on custom-designed and recycled materials."[73] Reynolds also specifies that advanced manufacturing is "less susceptible to competition from low-cost locations because either it uses a high degree of information technology (IT) in its products or processes, and/or it employs workers with higher skills, often measured by the number of scientists or engineers."[74] In advanced manufacturing systems, technology is the "interface between the innovation system and industrial production."[75] New technologies enables new classes of products, new niches and industries, new flexible manufacturing processes, and improve productivity and flexibility in existing large-scale manufacturing processes. For instance, engineered materials that don't exist in nature are opening new possibilities in biomedical applications as well as potentially reducing the number of operations in a production line. Ultraefficient processes, automation and continuous manufacturing in batch size of 'one' are blurring the boundaries between fabrication and assembly. Also, new electronics technologies (like 'printed electronics') are defining a whole new spectrum of applications to physical objects, enabling the merging of hardware and software components into a single product.[76] The 'advanced' and innovative factor can be found not only in new products but also in the transformation of old industries, in the production process, as well as in business plans and management methods. In fact, the

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[70] Berger, *Making in America*, 155.

[71] Van Agtmael and Bakker, *The Smartest Places on Earth*, loc. 515–535.

[72] PCAST, *Report to the President*, ii.

[73] Berger, *Making in America*, 158.

[74] Reynolds, "Innovation and Production," 27. For the definition of these characteristics, Reynolds cites Susan Helper, Timothy Krueger, and Howard Wial, *Locating American Manufacturing: Trends in the Geography of Production* (Washington DC: Metropolitan Policy Program at Brookings, 2012), https://www.brookings.edu/wp-content/uploads/2016/06/0509_locating_american_manufacturing_report.pdf.

[75] Berger, *Making in America*, 158.

[76] More specifically, the MIT recognizes seven categories of emerging technologies: 1) nano-engineering of materials and surfaces; 2) additive and precision manufacturing; 3) robotics and adaptive automation; 4) next generation electronics; 5) continuous manufacturing of pharmaceuticals and biomanufacturing; 6) design and management of supply and distribution chains; 7) green sustainable manufacturing. See: Berger, *Making in America*, 156–161; Reynolds, "Innovation and Production," 26–27.

emphasis put on sustainability and efficiency – underlined by MIT's definition – results not only from the employment of new technologies but also from the embracement of circular economies' and sustainable life-cycles' principles, leading to innovative paths, for instance, in material and waste recycling and upcycling, and the use of renewable energies.[77] Compared to other production systems, advanced manufacturing results from a series of parallel and equally important steps happening among an interconnected and cooperative network of physical assets, people, and information, both within firms as well as distributed among the entire value chain. Firms are 'customer-centric:' relationships with individual customers start during the design phase with the highest levels of customization – indeed, allowing small batch as 'one' – and continue after the sale through services and software integrated within the physical product.[78]

Throughout the late 19th and 20th century, it is possible to read an inevitable parallelism in the development of the factory as production and organizational model and the factory as architecture and construction model. From the organizational standpoint, we see the transition from an integrated factory (vertically integrated enterprises producing in linear and Fordist systems), to a modular factory (core-competence firms with lean and flexible production systems), and finally to the digital factory (specialized firms producing through smart manufacturing technologies).[79] Equally, from the architectural standpoint we see the design concept shifting from the factory as a rational and functional machine to control production, to the factory as a flexible and sustainable modular construction system to adjust to production needs, and finally to an adaptive and resilient digital factory to connect and locate production within the right ecosystem.

A possible future of distributed small-batch manufacturing

Berger recognizes the question of how in the future these new technologies will turn into production systems as the main critical issue of advanced manufacturing in the US.[80] The MIT-PIE research envisions a manufacturing world of distributed small-batch manufacturing as one of the possible outcomes. Along with technological innovations, the scenario proceeds also by a series of existing realities that have already enhanced deep transformations. Zara, Alibaba, Ponoko, Proto Labs, the less-than-truckload LTL technology and the Kiva Systems used by Amazon are just some of the example presented by the research: "[…] in a number of growing sectors, we are already seeing major processes of fragmentation at work that involves many of the same mechanisms and technologies that we can conceive as having the potential of transforming

[77] Cuomo et al., *Dalla strategia al piano*, 206–211.

[78] See: Berger, *Making in America*, 155–158; Cuomo et al., *Dalla strategia al piano*, 198–206.

[79] Cuomo et al., *Dalla strategia al piano*, 198–206.

[80] Berger, *Making in America*, 161.

manufacturing."[81] Additional pieces can be found among the set of case studies observed by this thesis: for instance, Plethora, Flex Innovation Lab, and Fictiv in San Francisco. Fictiv is the Airbnb of manufacturing. Through their software, they connect customers who need fast manufactured parts with the local network of inactive machines' owners that can rapidly provide them. Customers vary from designers, small firms, and startups to large and established firms who currently have no capacity to prototype new products – hence their ability to innovate relies on their local industrial ecosystem. On the other side, the providers of this 'manufacturing service' could be contract manufacturers, firms with a temporary underused set of machinery, or also individuals who own, for example, a 3D printer and use it to produce both pieces for themselves as well as for other businesses. Fictiv's software is also a design tool that supports the transformation of parts from digital to physical objects. Equally, Plethora uses its platform and design software to automatically prepare the uploaded models for manufacturing (real-time manufacturability and price feedback) and convert them into instructions for its factory. With its system, Plethora can provide on-demand rapidly manufactured parts by producing in-house and by avoiding the time-consuming quoting and feedback process between customers and suppliers. Flex Innovation Labs is shaped after similar basis but declined as an incubator for manufacturing businesses (startups as well as established firms) and as a prototyping lab for products, production processes, and assembly lines development.[82]

According to Berger, even though some efforts would still be needed to transform this vision into a real manufacturing system, these experiences have marked out significant innovations, being them specifically in the production system or in the business model. Among the ones that are likely to affect manufacturing the most: the fragmented approach, the reduction of scale, the shortening of the path between producers, services and consumer, and last, the possibility to customize the output.[83] The distributed small-batch manufacturing scenario consists of two main phases: production and distribution. Production would be a service (MaaS manufacturing-as-a-service)[84] forecasted by small manufacturers distributed around the world through a democratized procedure:

[81] Berger, *Making in America*, 162. See also pp. 161–171 for a more in-depth explanation of the cited examples.

[82] See: https://www.fictiv.com/ (Fictiv); https://www.plethora.com/ (Plethora); https://flex.com/connect/innovation-sites/san-francisco-california-invention-lab (Flex Innovation Lab).

[83] Berger, *Making in America*, 164.

[84] Despite the controversies around this term and its meaning, a positive outcome might be the possibility for a broader spectrum of firms to access advanced manufacturing technologies due to the changes of investment logics (pay-per-use and shared use rather than consistent upfront capital investment). Also, it could open new business possibilities both as a provider as well as a user of this manufacturing service.

"In a world of fragmented production, when a company needs a part, it does not build a factory. Rather, it taps into a national network portal and places a computer-aided design (CAD) description of the part it desires, and the numbers it needs, on the portal. […] Meanwhile, software systems from small manufacturers around the country prowl the portal looking for parts to bid on. […] Small manufacturers can produce only small numbers of parts, so many small companies might be necessary to meet the customer's total needs. Software in the portal, perhaps with manual selection from the customer company, selects the ensemble of companies that will manufacture the run. […] Companies that are chosen then receive detailed CAD files. The files contain everything from dimensions to tolerances to surface finish requirements. The small manufacturers swing into action and rapidly bring their own special techniques into play to manufacture the parts. Some companies may have jigs from a previous job that fit just right. Others may have faster or more powerful machines better suited to manufacture the parts in question. In this massively distributed, massively parallel way, parts are rapidly manufactured around the country.

The parts are electronically verified for quality. […] Parts are then shipped back, not with point-to-point couriers, but with a loosely knit peer-to-peer shipping network whose vehicles plying across the country sell every last empty cubic inch of space to a 'shipping passenger.' Rather than going through a predetermined shipping route, parts reach the final customers through a dynamic route. The shipper and the customer can track parts and know where they are at any point in time. In this world, factories would usually be virtual, not captive. Capacity would be flexible. Small businesses would compete by innovating and anticipating better. Like the Internet, this would be a resilient and adaptive system."[85]

Then, the supply chain would mirror the concept underlying the internet (pocket-switch-network) turning into a 'supply internet;' fast, flexible, resilient, and scalable – likewise communications.

"A supply carrier in this world would be a vehicle that happens to have capacity to carry goods: an individual truck or a car, for example. A supply router would be a drive-through

[85] Berger, *Making in America*, 164–165.

> warehouse that can quickly identify and deliver packages to a carrier.
>
> […] Consider a truck owner who has finished delivering goods from Boston to New York. Her truck is equipped with radio-frequency ID (RFID), a technology that automatically tracks inventory, and GPS, which determines her location. She is a member of the peer-to-peer shipping service of our new world, and her truck communicates with the service headquarters to indicate how much room she has on her truck, where she is, and where she is heading next. As she turns to head back to Boston, she receives a message on her smartphone alerting her to a new shipment opportunity for taking goods back to Boston. The message indicates that a supply router warehouse on the Bruckner Expressway has a package that will fit in her truck, to be delivered to Boston. She heads out of New York and pulls into the specified supply router warehouse, which has several pickup lanes not unlike a drive-through restaurant or gas station. The package she will be picking up has already been positioned at Lane 8, and as she arrives, an arrow on her dashboards directs her to Lane 8. A worker at Lane 8 quickly opens the back of her truck and carefully places the inventory in the truck. The RFID system in the truck and the warehouse confirm the transfer. The driver now leaves the supply router warehouse, heading toward Boston with her 'hot-potato' inventory. As she approaches the greater Boston area on Route 90 E, a signal on her dash reminds her to take the exit for the supply router warehouse in Framingham. There, the process is repeated in reverse – the package is removed and RFID systems confirm the transfer. A fee for the transfer is meanwhile automatically credited to the driver's account."[86]

As underlined by the research group, this is just one of the possible scenario for the future of manufacturing, and it would take significant advances in technology, policies, and critical mass to realize. Also, this model could not be attractive for large-scale manufacturers, producing a very limited variety of products in large bulks. The same would be for manufacturers whose production process requires highly specialized plants or special operation environments. On the contrary, the distributed manufacturing scenario would look very feasible for firms producing a high variety of products in small batches, or very complex products with a high degree of customization.[87]

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[86] Berger, *Making in America*, 171–172.
[87] Berger, *Making in America*, 167.

From the architectural standpoint, the scenario makes very few references to spaces or places. Yet, it is possible to sense a need for a different use of existing technologies as well as for a different set of infrastructures. For instance: a 'supply router/drive-through warehouse;' data centers to support the 'national network portal' of manufacturers; the 'peer-to-peer shipping service;' small industrial spaces for small manufacturers; and also different vehicles other than trucks as part of the shipping networks. The existing realities at the base of the formulation of this scenario introduce innovations in technology or management models. From many North-American urban areas – like those observed during the field trips – it is possible to extract additional examples of innovative or alternative use of existing spaces and infrastructures. For instance, dismissed malls have been turned into data centers, commercial properties into industrial warehouses, warehouses into maker spaces, university labs into workforce development centers, and former single-tenant factories into multi-tenant hubs of manufacturers, creative offices, business incubators, artists, and shared workspaces. This may suggest that the fragmentation and distribution is, in fact, a redistribution over existing legacies – also implied by overlapping of rustbelts and brainbelts found by van Agtmael & Bakker. Also, reading through most of the reported research on the future of manufacturing and spaces of production, the increasing gravitational pull of urban areas on at least a share of the manufacturing sector can be tangibly sensed. A gravitational pull caused by a number of reasons: from the intrinsic nature of advanced manufacturing systems to the need of proximity to talent, innovations, universities, and capitals but also customers, suppliers, and competitors. Future factories' performances, characteristics, and needs for deep interconnections with a network or ecosystem (brainbelt) have been extensively remarked. Conversely, issues concerning the type of architecture or built space needed to efficiently organize production processes are quite scant. This might indicate a consistent loss in relevance of the characteristics and forms of the physical space, as long as it guarantees a minimum set of requirements. For instance, safety, light and ventilation, connectivity, spaces and infrastructures for logistics, location, and as few boundaries and interfering elements as possible. This option suggests a tension between the role of space in the shaping of advanced manufacturing and that of generic industrial lofts in the development of the emerging industrial sector during the 19th century in US cities.

Chapter 3

The shaping of urban manufacturing in North American cities

3.1 City-industry dynamics

Considering in general Europe and North America, the conventional image of the city-industry relationship sees a progressive decentralization of industry from urban cores to suburban areas caused by companies' gradual expansion in size and domain, and the transition to low-cost cars and trucks transportation modes. These evolutions have increasingly loosened the connection between industry and cities, with manufacturing exiting cities, regions, and eventually countries. This dynamic is usually framed into four main steps: (1) the merchants' town; (2) the industrial city; (3) the search for an ideal model of industrial city; (4) the deindustrialized city, which eventually transitions into a post-industrial city.[1] Before the mid-18th century, the main form of production in merchants' city "was artisanal manufacturing in individual households; therefore, manufacturing activities were closely integrated with other parts of everyday life, specifically residential and commercial activities."[2] Between the 1750 and 1880, with the development of the textile industry and steam production technologies, industrial cities emerged both as new urban agglomerations as well as from pre-existing merchants' towns or small villages.[3] Cities offered to industry labor pools, transportation hubs, capital,

[1] Hatuka and Ben-Joseph, "Industrial Urbanism," 11–13.

[2] Hatuka and Ben-Joseph, "Industrial Urbanism," 11. See also: Jacobs, *The Economy of Cties*, 3–84; Sennett, *The Craftsman*.

[3] See: Benevolo, *Le Origini dell'Urbanistica*, 13–60.

and other resources to flourish.[4] With the rise of industrial cities and the unprecedented migration of population toward cities, the concept of 'urban' – in opposition to 'rural' life - started emerging.[5] Industrial cities played a significant role in the process of cultural change. They were places of acculturation, development of traditions, and cultural consolidation of knowledge, craftsmanship, community sense, and governance systems.[6] Along with that, industrial cities were also places of poor living conditions, pollution, nuisance, and chaos.[7] Therefore, the following period, 1880-1970, is characterized by the search for an ideal industrial city.[8] Many plans and urban planning theories emerged with the intent of reorganizing cities in their industrial, residential, and recreative uses: Tony Garnier's industrial city, Ebenezer Howard's garden city, company towns, Modernists' zoning plans, and other Euclidean zoning practices are just some examples. Somehow, in some ideal industrial city, industry got forgotten. It was gradually shaded from the city until being barely considered as a part of the urban plan.[9] Finally, from the 1970s on, the increasing loss of industrial land in favor of commercial and residential uses have led to the deindustrialized city:[10] "deindustrialization reshaped the geography of industry. For example, storage and distribution facilities were often located in the hinterlands, where land values are the lowest, whereas industrial parks tended to be located in the suburb or on the periphery of the city."[11]

Despite some commonalities, spatial dynamics between city and industry has been extremely diversified among different geographies, depending on economic and political processes – both at the local and global level – as well as by technological advances in the production process. The unique development of urban settlements and planning practices in North America, as well as the evolution of the concepts of 'urban,' 'suburban,' and 'metropolitan' have been defining much less linear tensions between places of living and working (manufacturing jobs). Industry emerged contextually as rural and intra-urban fact. Rural areas soon turned into suburbs, making of industry a metropolitan issue made of urban and suburban locations. By second half of the 20th century,

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[4] See: Hatuka and Ben-Joseph, "Industrial Urbanism," 10–24; Rappaport, "Vertical Urban Factory."

[5] On the emergence of the concepts of 'urban' and 'rural,' and the tensions between cities and rural areas in relationship to economic development see: Jacobs, *The Economy of Cities*.

[6] Hoselitz, "The City, The Factory, and Economic Growth," 170–171.

[7] See: Salzano, "Fondamenti di Urbanistica," 35–68.

[8] See: Benevolo, *Le Origini dell'Urbanistica*, 61–116; Rappaport, Vertical Urban Factory, 62–113.

[9] Rappaport defines 'process removal' this progressive segregation, from the early 20th century on, of factories from the daily urban life. See Rappaport, *Vertical Urban Factory*, 84–94.

[10] See: Rappaport, *Vertical Urban Factory*, 238–259.

[11] Hatuka and Ben-Joseph, "Industrial Urbanism," 11; 13–21. In the same paper, the authors identify three contemporary spatial prototypes of industrial spaces resulting from the evolution of the city-industry relationship: (1) the integrated industrial space, where living and working spaces are in symbiosis; (2) the adjacent industrial space, where living and working spaces are separated but close to each other and highly connected; (3) the autonomous industrial space, where living and working spaces are separated by strong and intentional physical boundaries.

industry had become a predominantly extra-metropolitan matter and had remained so throughout the following decades. Today, after a long declining period, metropolitan manufacturing has turned its course up to positive growth. This time, the contrast between urban and suburban is much more nuanced, hence turning metropolitan manufacturing into an 'urban' matter. "As cities have grown, layer upon layer of suburban development has been added to the built-up area, leaving former outlying districts well inside the metropolis and often erasing in the process historical patterns of expansion by dispersion. After many years, it is easy to mistake the older edge cities and secondary nodes for part of a single 'central city.' Modern metropolitan areas are so huge that even large and distant suburban edges of the past, such as Brooklyn, Oakland, or South Chicago, are now deeply embedded in the structure of the city. The study of North American urbanization thus requires a model that begins with the simultaneous march of industry and cities outward, rather than a two-stage process of building a dense concentration of activities in the core in the nineteenth century and then decanting them in the twentieth."[12] Due to the political and geographic history of the United States, the following observations mainly concern Rust Belt cities and, to some extent, some West Coast cities like San Francisco and Los Angeles.

Rural and intra-urban manufacturing in the mercantile city

The pre-1840s American society was predominantly rural. The United States was an agricultural economy, and the textile industry was located in rural areas near waterfalls, with mill towns rising on the rural landscape. Mercantile or commercial cities based their economy on wholesaling-trading and retailing, whereas manufacturing activities, mostly small-scale unmechanized and artisanal production units in family households and workshops, played a subsidiary role in the urban economy. Intra-urban production was a very heterogeneous scenario of commerce-related manufacturers and local consumers-serving artisans located on pedestrian paths, commercial routes, and harbors. Pred recognizes three categories of intra-urban forms of production in the mercantile city: entrepôt manufacturing, that processed imported raw materials; commerce-serving manufacturers, that responded to commercial demands (e.g., shipbuilding, coopery, printing); finally, all the remaining local-market and consumer goods manufacturers serving the local population (e.g. paint, glass, beer, furnitures, clothing, carriages).[13] Even though these decades would have been extremely favorable for industry to expand in cities – as it happened elsewhere – in some of the largest US mercantile cities there were contingent factors that negatively influenced the growth in size and number of manufacturing activities.[14] For instance, before the intense migrations of the 1840s, people left with no job in cities tended to migrate to rural areas

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[12] Walker and Lewis, "Beyond the Crabgrass Frontier," 22.

[13] For a more in-depth analysis, see: Pred, *Sviluppo industriale e sviluppo urbano*, 181–289; Pred, "Manufacturing in the American Mercantile City," 320–325.

[14] Pred, "Manufacturing in the American Mercantile City," 312–320.

where it was more likely to find a new one. This created occasional labor shortages for urban manufacturing that had to rely on unskilled workers, often unprepared to work in a workshop or factory. Inefficient production conditions were also worsened by the slow adoption, due to their cost, of innovations like the steam engine or the factory system. Also, merchants and banks (the capital suppliers) were not too sympathetic at the beginning: they preferred to purchase land rather than investing in the development of large-scale and capital-intensive urban industries. On the other hands, small-scale manufacturing had lower threshold requirements and was more likely to keep going since it needed smaller capital investments.[15] Despite its dynamism, this sector of small-scale urban manufacturers still had to compete with the limited commercial infrastructures in the pre-railroad era (hence limited market areas), extensive local markets of imported goods, and an urban population with an overall low purchasing power.[16]

If the factory system still had to reach the mercantile city, by the 1830s the textile industry at the urban fringe had already developed its own factory as a production unit. Beside its reliance on natural resources, mills were established in small villages or rural areas also for moral reasons. The city and the 'urban' condition were already to blame for vicious and immoral lifestyles, while a 'rural' setting would encourage an upright way of living.[17] "Denying city status to industrial centers was a strategy for portraying them as fundamentally rural settings with unnaturally large but still-transient populations. Just as parks and 'rural cemeteries' alleviated the crowding in commercial cities during these decades of rapid growth, nature comforted the eye in industrial towns. […] A twofold argument for the mill towns contended that pastoral surroundings would temper industrial ugliness, while industry made the beautiful landscape useful."[18] Also, these industrial jobs were considered a temporary solution while pursuing the acquisition of an agricultural dwelling. Mill owners built cottages and boarding houses close to the factory that would then be rented by workers.[19]

The transitional period 1840s-1860s saw intensifying the debate on the possible industrial or agricultural future of American economy. Industry was contextually located in urban centers as well as on their rural fringes. In parallel to the development (until now rather slow) of urban manufacturing, factories requiring larger buildings or specific natural resources, mill towns/neighborhoods, and noxious and polluting activities developed scattered on the fringe alongside

[15] Pred, "Manufacturing in the American Mercantile City," 312–313.

[16] According to Pred, the few urban industrial establishments that had already employed new technologies (mechanization) in their production process were relatively small (fewer than 200 employees) unspecialized firms. See: Pred, "Manufacturing in the American Mercantile City," 316; 319–320.

[17] Wright, *Building the Dream*, loc. 1081–1089.

[18] Wright, *Building the Dream*, loc. 1106.

[19] Wright, *Building the Dream*, loc. 1114.

textile mills, still with no sign of industrial districts or clustering forms.[20] "Rural dominance however, was to be of short duration. Subsequent to the financial panic and depression of the late 1830's a series of developments, which had previously been set in motion, began to gain the momentum that ultimately shifted the locational spotlight of manufacturing from a rural to an urban proscenium. The railroad network, which consisted of a mere 2,800 miles of disjointed trackage in 1840, mushroomed into a well-articulated system exceeding 30,600 miles in 1860 and began to facilitate the long-distance raw material assembly and finished product distribution which was so vital to urban-industrial growth."[21] Finally, the Civil War contributed to the definitive development of the industrial sector. The rural natural setting praised by early factories grew into an industrial suburb and industrial towns with ever noisier polluting factories. In central cities, with production gaining momentum as an urban economy, the traditional production unit – the artisan shop where production, sales, and residence coexisted – was sided by a more expanded workshop where innovations like the steam power, mechanized handling systems, and the American system were increasingly employed. "The expanded workshop assembled large numbers of workers, that is, between fifteen and fifty people, under one roof. These workshops were frequently located in older buildings, particularly warehouses, of the city's central area, where rents were relatively low and accessibility to merchants and to transportation for materials was excellent"[22] (industrial lofts). Despite the apparent chaos of the dense commercial city, some functional separation and land use differentiation had already started as a consequence of, for example, the rising cost of land in central areas, space shortage for expansions, the emergence of business centers, and clustering trends of manufacturing businesses.[23] Also, along with waterways, the new railway infrastructure became an additional development route for 'non-urban' industrial activities. "To summarize, the mid-century city contained a mixture of small traditional shops and larger warehouse workshops, of handicraft productions and steam-powered factories, and of core concentration and peripheral locations. The differing scales, forms of organization, and locations among the various industries created a pattern that did not conform to the well-known structure of manufacturing in either the commercial or the industrial city. Localization by new complementary manufacturing activities suggests the growth of industrial districts"[24] at the urban fringe.

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[20] On the development on urban manufacturing during this transitional period and the following shaping of urban industrial districts see: Muller and Groves, "The Emergence of Industrial Districts," 34–37; Walker and Lewis, "Beyond the Crabgrass Frontier," 16–31.

[21] Pred, "Manufacturing in the American Mercantile City," 307.

[22] Muller and Groves, "The Emergence of Industrial Districts," 36.

[23] On early clustering, segregating, and functional separation trends see, for instance, the cases of shipbuilding, printing and publishing trades, and baking activities in New York reported in: Pred, "Manufacturing in the American Mercantile City," 325–337.

[24] Muller and Groves, "The Emergence of Industrial Districts," 37.

Industry does not locate in the city, it helps create the city:[25] metropolitan manufacturing

The period between the mid-19th century and the 1920s saw the emergence of industrial cities both out of the mercantile city as well as new urban settlements out of small villages, mill towns, or single factories on the rural landscape[26] – soon to become suburban. It was a period of rapid urban and industrial growth, during which outward flows and city build-up led to the structuring of multi-nodal metropolitan systems[27] where production had to be found both within urban cores as well as in suburban areas. The city-industry relationship turned into an intra-metropolitan issue.

Since the 1850s there had been "extensive population interaction between city and suburbs."[28] The urban population was growing at an impressive rate already since the 1840s, but after the Civil War suburbs started exploding too. From the 1870s on, the paths of development previously set by industry were soon followed by residential development. Industrial outward flows started in different ways: as private assemblages of land at the urban periphery, as company towns/neighborhoods managed by a single company, or also as planned industrial parks where land was prepared by developers and authorities for future occupation.[29] "Manufacturers were able to build larger and more sophisticated factories containing the latest organizational forms, catering to widening markets along the transportation networks passing through the suburban fringe. Not only was suburban land cheaper and easier to build on; it was more removed from centers of labor discontent. In addition, a few large firms often stimulated further growth, contributing to a virtuous circle of expansion."[30] Despite a higher degree of freedom, suburban manufacturers were still part of a metropolitan system where they could benefit from the advantages offered by central cities (agglomeration economies, infrastructures, workforce, innovations, etc.). As suburban industry went shaping, urbanization followed – not without financial speculation, uneven development, and segregating forms. "The property industry […] has been particularly inventive in creating complete urban environments, from the housing tract to the regional mall to the industrial park. These condensed pieces of urbanity can be set down in the greenfields like seedlings, helping the city take root more quickly in fringe areas."[31] If pre-Civil War suburbs were for the wealthy who can afford costly commutes to the city, from the 1880s on, with

[25] The title intentionally quotes Walker and Lewis, "Beyond the Crabgrass Frontier," 21.

[26] Hoselitz, "The City, The Factory, and Economic Growth," 168.

[27] For a more in-depth understanding of the development of American industrial metropolis through industrial outward flows and city build-up see: Walker and Lewis, "Beyond the Crabgrass Frontier," 20–27.

[28] Lewis, "The Changing Fortunes," 575.

[29] Walker and Lewis, "Beyond the Crabgrass Frontier," 29–30.

[30] Lewis, "The Changing Fortunes," 585–586.

[31] Walker and Lewis, "Beyond the Crabgrass Frontier," 26–27.

the development of railway systems and electric streetcars,[32] public transportations became faster and affordable to the middle-class and the working population too. Suburbs became the preferred living solution for families looking for more privacy, space, and safety while escaping from unhealthy, dangerous, and uncomfortable central cities. The exception were those wealthy families who chose to live in the emerging apartment-hotels and tenement buildings fascinated by the technological features and services that these living solution could offer. Otherwise, cities were left to segregated immigrants, blacks, and low-income population.[33]

Suburbs developed as a mix of residential areas, industrial districts, single factories, industrial complexes, or also as industrial towns and suburbs with a vibrant mix of industry, residential, and commerce (e.g., Brooklyn). The scenario also included wholesale and commercial buildings, malls, wholesale shops, and business parks; they housed economic activities deeply linked with production, consequently following similar paths of development. The consolidation movement that saw the annexation of suburban territories to central cities strengthened the structuring of metropolitan systems. “It is generally recognized that pre-1920 annexation had an important impact on the changing character of metropolitan society and politics. Political incorporation was a vital component of central-city population growth and the ensuing metropolitan balance of city and suburb. […] From New England’s Boston to California’s Los Angeles and San Francisco, central cities before the 1920s expanded by taking over industrial suburbs.”[34] Cities not only enlarged their population and gained factories providing manufacturing jobs, but they also strengthened the circulation of people, goods, and knowledge through ever denser infrastructural networks – at the metropolitan level – of railways, transportation hubs, and other commercial routes. Annexing suburban fringes allowed cities to maintain their industrial competitiveness also during the interwar period when central-city manufacturing started to decline. Also, annexations ensured cities available land to expand in the

[32] In 1882 the cable car was first introduced in San Francisco as public transportation systems. It was soon followed by the installation of the electric trolley in 1888 in Richmond (Virginia) and the elevated railroad in 1892 in Chicago. “By 1890, fifty-one cities had installed electric streetcar lines; five years later, 850 were in operation, with service covering ten thousand miles. ‘Streetcar suburbs’ sprang up along all these routes.” Wright, *Building a Dream*, loc. 1703–1712.

[33] The severe housing shortage and unaffordability for these parts of the population pushed families to convert existing warehouses, breweries, and other types of residences from single-tenant properties to multi-family tenements. See: Wright, *Building a Dream*, loc. 1894–2019. On the emergence of the new residential typology of the apartment-hotels, see; Wright, *Building a Dream*, loc. 2216–2462.

[34] Lewis, “The Changing Fortunes,” 573–576. Among the most noticeable annexation cited by the author there are: in 1867 and 1874 the annexation of, respectively, Roxbury and Charleston to Boston (+90 km^2); the 1889 incorporation of the Calumet district to Chicago (+324 km^2); the 1898 annexation of Brooklyn, Queens, and Richmond to Manhattan; between the 1990s-1910s, Los Angeles acquisition of Wilmington, Burbank, San Fernando, Inglewood, Pasadena, Malibu, San Gabriel (+813 km^2). Other cities like Detroit and Pittsburgh by 1920 had incorporated consistent amount of territories through a series of small annexations happening almost every decade.

long term; investments for new industrial spaces attracted not only additional manufacturing activities, but also housing, commerce, and new infrastructures.[35]

The turn of the century saw the transition to a consumption society where modernization and Taylorist principles started influencing every aspect of daily life. Metropolitan areas were developing rapidly, with suburban areas growing twice as fast as central cities.[36] Progressive Era's regulations, zoning plans, and building ordinances started focusing more on the human condition through the improvement of standards of living and housing accessibility – sometimes too much to the detriment of industry and the working landscape. In the 1920s, architects, urban planners, and designers were dominating the scene of cities and suburbs by developing urban models and plans for cities' 'beautification' and rationalization.[37] They designed ideal suburban neighborhoods where families could own their private house (not just renting it from the company they were working for) to conduct an ideal suburban lifestyle. During these years, the predominant urban model was the Chicago School ecological theory of the city "focused on the urban core, the distribution of land uses around the center, and the sequence of land-use change as the city expanded. Unfortunately, this model set the priority of social geography over the industrial location in urban studies, fixed the image of land-use rings, emphasized segmentation rather than unity of employment and residence, and established the idea of city growth as a process of decanting the core. The leading study of suburbia in the 1920s similarly enshrined the notion of residential periphery and industrial core."[38] Ultimately, planned residential suburbs where planners and architects were involved, were already able to keep industry (increasingly larger, more noxious and polluted) and the workplace separated from the residential area. The distance further increased, physically and conceptually, with the diffusion of cars as a preferred transportation system. On the contrary, other suburban areas where architects and planners were not involved still maintained, for necessity or powerlessness, their proximity with industrial activities. In general, small towns and suburban areas were highly affected by early-20th-century zoning regulations in their city-industry relationship. They prevented the construction of houses next to noxious factories, but they also banned the location not only of heavy but also of light industry and commerce from residential areas.[39] Equally, in central cities planners

[35] Lewis, "The Changing Fortunes," 575–585.

[36] The 1920 census registered that for the first time the majority of the American population was living in urban or suburban areas, rather than rural. See: Wright, *Building a Dream*, loc. 3108.

[37] For more detailed studies on the historical development of American cities between the late-19th and early-20th century, framing the emergence of planning practices and urban theories within the American sociopolitical context, see: Ciucci, Giorgio, Francesco Dal Co, Mario Manieri-Elia, and Manfredo Tafuri, *The American City. From the Civil War to the New Deal*, trans. Barbara Luigia La Penta (Cambridge, MA: The MIT Press, 1979).

[38] Walker and Lewis, "Beyond the Crabgrass Frontier," 17.

[39] "At the suggestion of local manufacturers, Berkley, California, banned all new residential construction in industrial areas, thereby reducing the stock of convenient housing for workers. […] Planners wrote eloquently of the 'natural' separation of residential, commercial, and industrial areas. […] In the suburbs, the banning of light industry and commerce reinforced a strictly

and architects supported "the effort of wealthy communities to segregate the city by economics, as well as by use […]. Without the land made available to them (due to zoning excluding industrial uses), no incentives to remain in the city, as well as raising taxes, many manufacturers decided to find new sites elsewhere – often with government support – and so the process removal of industries away from the public view became a standard."[40]

Decentralization and nonmetropolitan manufacturing

If the pre-1920s gave a consistent push to American industrial development, the interwar period was generally characterized by stagnant growth, further worsened by the Great Depression. After growing at a slower pace during the first two decades of the 20th century, central cities saw the beginning of their definitive declining path, ultimately evident in the 1950s-1970s, with critical losses in the wholesale and light manufacturing sector. Contextually, after the rush of the previous years, the development of suburban manufacturing significantly slowed down. This early industrial decline (occurred unevenly throughout industrialized America) changed its course with WWII during which wartime needs temporary revived the sector. These same necessities, along with defensive reasons, marked a significant change in the metropolitan urban-industrial relationship, enhancing an extensive industrial dispersal outside metropolitan areas. "The secrecy of both the product and method of production was paramount to success. […] the manufacturing areas around shipyards and ports during the war were abandoned as manufacturers were advised to move inland for security. […] planners encouraged moving industries to areas of 50,000 people or less, to maintain a 4.8 kilometer radius around a plant for safety. The dispersed industry required larger expanses of land than previously needed, for a new kind of industrial buffer zone."[41] This dispersion, that started during wartime but stretched all through the following decades, also met industrial requirements for ever larger production spaces as well as logistics and goods distribution needs of an already globalized manufacturing sector.[42]

The dispersed model also suited an increasingly suburban American society, based on cars and on the radical separation of living and working places – connected by new automobile infrastructures always reaching for more remote

residential flavor. Zoning boards relegated luncheonettes, clothing stores, garages, and movie houses to commercial strips on the outskirts of the subdivision, although 'neighborhood' grocery stores and a few shops were permitted within the residential enclave. […] Reliance on the private automobile became even greater as planners laid out arterial roads that connected the strictly residential neighborhoods with large shopping centers and workplaces." Wright, *Building a Dream*, loc. 3396–3405.

[40] Rappaport, *Vertical Urban Factory*, 91.

[41] Rappaport, *Vertical Urban Factory*, 109.

[42] The development of a global industrial sector was fostered by the shift to shipment system based on standardized containers (first introduced in 1956) and a highway-based truck transit system. The new production and trade logics found in dispersed and horizontally spread generic sheds the perfect industrial typology. See: Rappaport, *Vertical Urban Factory*, 238–248.

areas.[43] What followed was an equally extensive residential dispersal expanding way beyond the metropolitan fringe. After a postwar period characterized by a critical housing shortage, the 1950s-1960s saw the boom of construction both through federal housing programs as well as private initiatives. The dominant model was the secluded suburb of detached private houses with an explicit separation from commercial strips and working places.[44] The geography of suburban and rural areas was completely transformed by the "emergence of a shocking phenomenon called, variously, Exopolis, Postsuburbia, or Edge City. These new employment centers at the metropolitan rim – the product of a decade of booming growth, property speculation, and large-scale development, with concomitant dispersal of industry, offices, and retail malls – were treated as something entirely new rather than as the latest episode in a long-running story of North American urbanization."[45]

The 1960s were also years of crisis and intense activism for cities: riots, social and political tensions, severe abandonment and decline, reckless urban renewals,[46] demolitions, and speculative reconstruction. Paramount urban studies conducted during these years by Kevin Lynch, Lewis Mumford, Jane Jacobs, Herbert Gans, and many others[47] started to slowly awaken a new sensibility toward cities and the urban. In the following decades, the rediscovered interest in urban lifestyles led to the development of alternative forms of living such as housing co-ops, dense mixed-use, multi-family complexes, apartment buildings, etc. The urban industrial legacy left in cities by deindustrialization processes soon became the cradle for new cultural movements and adaptive reuse practices. Nevertheless, it was also a reflection of urban decay, social discontent, and unemployment. After the 1960s, suburban manufacturing started declining as well, first in favor of nonmetropolitan manufacturing and then, after the 1979 peak of manufacturing jobs (19.4 million),[48] toward non-unionized states and eventually foreign countries. The ICT revolution led the industrial sector to think that geography and

[43] With the 1956 Intensive Highway Act started the construction of a largely Federal-financed interstate highways system. The new infrastructures connected existing urban areas with rural sites, soon to become places of suburban residential, commercial, and industrial development. In addition, Federal subsidies helped the decrease of transportation costs, thus furthering decentralization.

[44] This model became representative of a defined suburban lifestyle and cultural identity to aspire to as a form of social integration and acceptance.

[45] Walker and Lewis, "Beyond the Crabgrass Frontier," 18.

[46] The 1954 Urban Renewal Act inaugurated a long season of speculative 'slum' and 'blighted' labelling of consolidated (sometimes informal) neighborhoods to justify their demolitions to make space of more remunerative buildings with no financial risks (luxury apartments, convention centers, office buildings etc) giving back to cities 'wealthy' tax bases – hence used also as a displacement tool for specific parts of the population.

[47] For instance, see: Kevin Lynch, *The Image of the City* (1960); Lewis Mumford, *The City in History* (1961); Jane Jacobs *The Death and Life of Great American Cities* (1961); Herbert Gans, T*he Urban Villagers: Group and Class in the Life of Italian-Americans* (1962), and *The Levittowners* (1967); Christopher Alexander, *A City is Not a Tree* (1965); Robert Venturi and Denise Scott Brown, *Learning from Las Vegas* (1972); Reyner Banham, *Los Angeles: The Architecture of Four Ecologies* (1971).

[48] Data from Helper et al., *Locating American Manufacturing*, 3.

location do not matter that much for manufacturing.[49] "During the 1980s and 1990s, metropolitan areas lost manufacturing jobs more rapidly than nonmetropolitan areas and the 100 largest metropolitan areas lost them more rapidly than smaller metropolitan areas. […] The long-term decentralization and de-metropolitanization of manufacturing jobs could have several causes. Among these are a long-term decline in transportation costs, public subsidies for highways, manufacturers' desire to avoid the costs of environmental remediation associated with centrally located 'brownfield' sites, urban and suburban zoning that became increasingly restrictive for factories, and manufacturers' desire to avoid more heavily unionized metropolitan and central county locations."[50]

Urban industrial spaces are places of crisis

The end of the 20th century has been characterized by cities' efforts to rise again as strategic economic places by diversifying their previously industrial-based economy. The praised transition of cities to post-industrial or service-based economies – acknowledged only between the 1990s and 2000s – has frequently proceeded from investment in the education, innovation, or financial sector started back in the post-war decades. Overall, these processes have enhanced positive regenerative cycles that have brought new attention to cities and new urban population – positive outcomes sometimes equally sided by displacements and unfair distributions of benefits.

In this process of transitioning from deindustrialized to post-industrial cities, industrial footprints have been places of crisis[51] where conflictual situation have eventually found either positive or negative outcomes. For instance, brownfield remediations allowed cities to regain land for new urban developments as well as contributed to the formulation of new environmental regulations. The early practice of squatting and informally reoccupying vacant industrial lofts in New York during the 1950s-1960s[52] emerged from specific cultural movements and rapidly evolved into an appealing lifestyle also for non-artists. The trend, soon identified as adaptive reuse, started reshaping zoning regulations until finally

[49] Helper et al., *Locating American Manufacturing*, 10.

[50] Helper et al., *Locating American Manufacturing*, 31–33.

[51] The Oxford English Dictionary defines 'crisis' as "a vitally important or decisive stage in the progress of anything; a turning-point; also, a state of affairs in which a decisive change for better or worse is imminent; now applied *esp.* to times of difficulty, insecurity, and suspense in politics or commerce."

[52] Andy Warhol's Factory (1962-1968) opened at the fourth floor of the former Peoples Cold Storage and Warehouse in Midtown Manhattan is the most acclaimed example. But already in 1951 Leo Castelli organized the 9th Street Art Exhibition inside a building that had been designated for demolition and in 1953 Robert Rauschenberg moved to New York and rented for ten dollars a month a loft in Fulton Street in the Lower East Side. For a more in-depth understanding of the origin and development of adaptive reuse practices as a form of living, a way to read the city, and as a design concept see: Zukin, *Loft Living*; Baum and Christiaanse, *City as Loft*; Robiglio, *RE–USA*; Liliane Wong, *Adaptive Reuse: Extending the Lives of Buildings* (Basel: Birkhauser Architecture 2016).

turning into a 'loft living' market.[53] What started as a necessity – finding affordable space for unplanned uses and alternative forms of artistic expression – evolved into a regularized development practice to reactivate derelict neighborhoods – that ultimately forced out those who triggered it.[54] Yet, informal human activities found in abandoned industrial spaces in cities their platforms of emancipation for alternative forms of living that later influenced formal practices as well. Contextually, the controversies on urban renewal practices and the ineffectiveness of curatorial forms of preservation (restoration, rehabilitation, renovation) led to the development of a more entrepreneurial preservation practice alternative also to demolition and ruination; adaptive reuse. It was intended as a real estate operation merging historic preservation purposes with economic development and community revitalization principles.[55] All these experiences of adaptive reuse have moved between 'high culture/low budget' and 'low culture/high budget,'[56] then crossing the reductive distinction between bottom-up/top-down approaches still very important in contemporary practices. From the 1970s on, different regulations and incentives for adaptive reuse projects were developed. Despite any possible controversy, they still represent a vital resource for developers – and have been employed in most of the case studies reported by this research. Another positive outcome has been the formulation of an alternative development path: the incremental approach allows to start with less capital, less space, and less time to then profitably occupying one part of the building at the time. The re-appropriation of space proceeds stage by stage, based on available resources and contextual needs.[57] On the downside, all these regenerative processes have implied consistent losses in urban industrial land, by converting it to other uses or also by allowing more profitable activities within the industrial zone (like hotels, creative offices) that have consequently priced out enduring urban manufacturers – because even if significantly dried out, the manufacturing sector in cities have never completely disappeared (see for instance the Garment District in New York or the Fashion District in Los Angeles). For instance, in the period 1990-2008 San Franscisco lost over 512 hectares (46%) of industrial land, while New York only between 2002 and 2007 lost over 720 hectares (14%).[58]

[53] Zukin, *Loft Living*, 1–22; 58–81.

[54] Zukin developed the concept of Artistic Mode of Production (AMP) as a strategy for urban conversion. Developers instrumentally use the concentration of art and culture markets and demand for 'higher' uses from the real estate markets to control a specific investment climate. See: Zukin, *Loft Living*, 176–192. More recent research have identified the 6% of creative workers in a neighborhood as the tipping point to start attracting more people, life, and investments. See: Eve Picker, *6% Place* (CityLAB, November 2011); Joseph Cortright, *Creative Neighborhoods* (CEOs for Cities, April 2007). Both documents are can be downloaded on http://www.citylabpgh.org/experiments/six-percent-place/.

[55] Some of the first examples are the Old Corner Bookstore in Boston, saved from demolition in the 1960 and turned into a retail and office spaces, Ghirardelli Square in San Francisco (a former chocolate factory) and the Faneuil Hall in Boston (an historic marketplace) both turned into a commercial and retail complex respectively in 1964 and 1973.

[56] Baum and Christiaanse, *City as Loft*, 24.

[57] Brand, *How Buildings Learn*, 166–208.

[58] Green Leigh and Hoelzel. "Smart Growth's Blind Side," 94.

Today, cities still face tensions in dealing with the remaining stock of industrial land. Smaller cities or less dynamics neighborhoods struggle with abandonment, blight, and disinvestment. They have a hard time in finding investments for conversion to other uses, that can eventually catalyze new investments and people, but they also fail to offer a favorable context of infrastructures and workforce for a possible relocation of industry. Other cities like the previously cited New York and San Francisco, see the convergence of a double struggle: the increasing demand for affordable urban living spaces and the need for jobs and income-generating uses, like manufacturing. On one side, retaining industrial land lessen the space available to be converted into housing, influencing the affordable housing market. On the other side, unconstrained gentrifying processes have created pressures to convert industrial land to more profitable uses like residential or commerce, leading to the shrinkage of available space for essential industrial activities that provide good jobs to those workers responsible for well-functioning urban economies.[59] These dynamics have often turned cities into inaccessible and unaffordable territories. Even smart growth policies and some of the 'best' regenerative plans have favored (sometimes unintentionally) the exclusion of income-generating uses from the plan by failing to recognize the importance of making space for these activities to support growth.[60]

3.2 Urban Manufacturing

Between 1979 and 2010 the number of manufacturing jobs in the US decreased by 40.7 percent. This loss occurred unevenly throughout time, with two more severe waves from 1979 to 1990 and from 2000 to 2010. During this last period, 5.9 million manufacturing jobs were lost, corresponding to a decline of 33.8 percent.[61] Overall, the long course of manufacturing decline plus the recession made of the first decade of the 21st century a plummeting critical period. Yet, some changes in the size and location of manufacturing firms were already visible. Despite the discouraging numbers, by 2007 the US manufacturing sector had already started shifting to what it looks today; a distributed scenario dominated by small and medium specialized firms increasingly attracted to urban locations within metropolitan areas.[62] In 2007, of all America's manufacturing businesses, 36 percent had fewer than 5 employees, 70 percent fewer than 20, and 91.4 fewer than 100.[63] In 2010, the average metropolitan manufacturing plant had 57.4 employees, a number that defines a relatively small-sized plant – the number,

[59] Lester et al., "Making Room for Manufacturing," 295–303.
[60] Green Leigh and Hoelzel. "Smart Growth's Blind Side," 87–103.
[61] Helper et al., *Locating American Manufacturing*, 3.
[62] See: Mistry and Byron, *The Federal Role*; National Association of Manufacturers, "Top 20 Facts About Manufacturing."
[63] Mistry and Byron, *The Federal Role*, 13.

however, varies consistently among different geographical areas, manufacturing sectors, and level of technology.[64] "Plant size matters for the health of American manufacturing because small and medium-sized manufacturers are responsible for designing and producing an increasing amount of the content of manufactured goods. Therefore, in the industrial sector, innovation increasingly depends on the efforts of those companies. At the same time, small and medium-sized manufacturers do little formal R&D and lag in productivity and other aspects of innovation."[65] In 2015, just 1.5 percent of the 251,774 manufacturing firms employed more than 500 people, whereas three-quarters were employing fewer than 20 people.[66] Between 2000 and 2010 metropolitan areas have started losing manufacturing jobs at a slower pace. Even if during the following two years nonmetropolitan manufacturing have continued growing more rapidly, the data on metropolitan manufacturing are important because of the type of activities involved in the trend: mostly small size, technology-intensive, and innovation-based firms. The metropolitan location entails some locational advantages that are key for these firms. The benefits include clustering with businesses from the same sector and related industries, a broader pool of skilled workers, face-to-face networking opportunities, industrial diversity, easier access to suppliers and customers as well as to other auxiliary services like workforce training, educational, financial and legal support, research and engineering consulting.[67] Already in 2007, over one-third of the 51,000 manufacturers with less than 20 employees were located in the ten largest cities.[68] In 2010, metropolitan areas housed 79.5 percent of all manufacturing jobs, 88.8 percent of which located within central counties of these metro areas. More importantly, in the same year metropolitan areas were home of 95.0 percent of all very high-technology jobs, of which almost the totality was located in central counties.[69]

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[64] data from Helper et al., Locating American Manufacturing, 27. The U.S. Small Business Administration defines size standards based on the average annual receipts or the average employment of a firm. The standards vary among the different industrial sectors identified by North American Industry Classification System (NAICS). To be considered a small firm, for most of the manufacturing subsectors the maximum number of employees ranges between 500 and 1,500, while for wholesale trade it ranges between 100 and 250. See: U.S. Small Business Administration. "Table of size standards."

[65] Helper et al., *Locating American Manufacturing*, 27.

[66] National Association of Manufacturers, "Top 20 Facts About Manufacturing."

[67] Helper et al., *Locating American Manufacturing*, 10.

[68] Mistry and Byron, *The Federal Role*, 3.

[69] Helper et al., *Locating American Manufacturing*, 10. The report defined very high-technology industries "as those in which science and engineering occupations (scientists, engineers, engineering technicians, and science and engineering managers combined) account for at least five times their economy-wide percentage of employment." Helper et al., *Locating American Manufacturing*, 7.

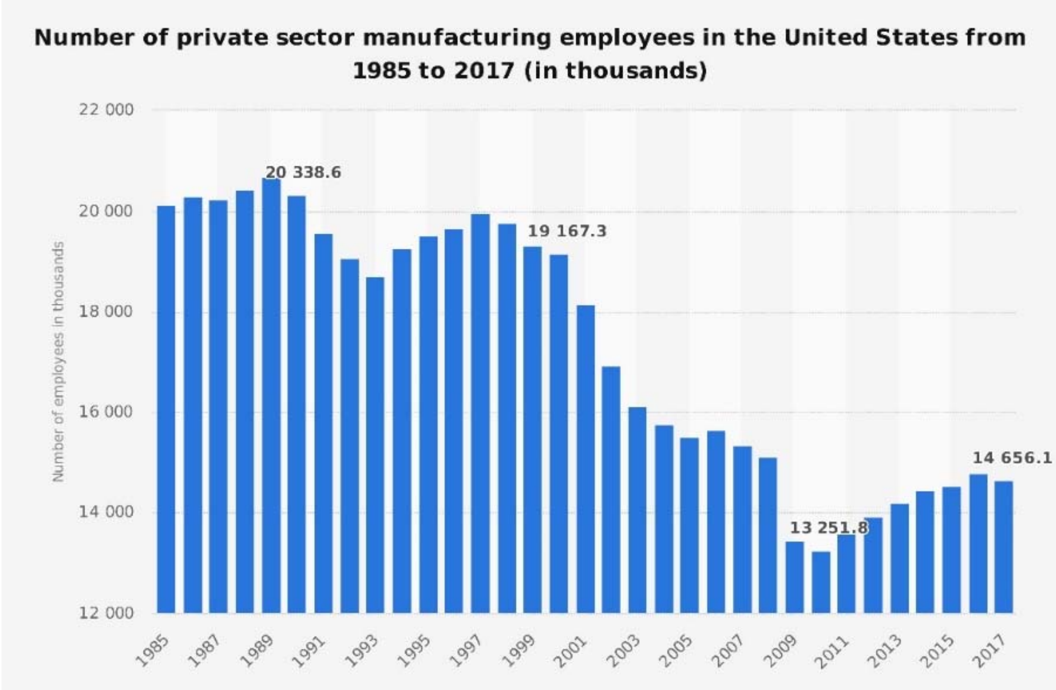

Figure 3.1. Number of private sector manufacturing employees in the United States from 1985 to 2017 (in thousands). Figure retrieved from Statista. Data sources: Bureau of Labor Statistics (unionstats.com)

Since the end of the Great Recession, the manufacturing sector has gained over 1.3 million manufacturing jobs[70] (fig. 3.1). Even though this gain might pale compared to the loss from the heydays of manufacturing, experts tend to depict it as the beginning of a long-term positive trend. Other shifts observed during the last two decades have been nourishing this promising view. As seen in the previous chapters, the bit revolution started in the second half of the 20th century has gradually embraced the atoms, leading to the merging of software and hardware development. High-tech innovations like robotics, internet of things, and additive manufacturing have enhanced new forms of production; first influencing prototyping methods, then defining advanced manufacturing systems. Among other important changes, manufacturing is shifting from mass production to just-in-time/just-in-place and customized manufacturing, as well as from economies of scale to economies of variety. As advanced manufacturing evolves, so does the factory. Places of production are getting 'digital' as well as smaller, cleaner, and increasingly compatible with living environments. These shifts in the industrial sector, along with other socio-political issues, have contributed to the emergence of new advanced manufacturing firms as well as to the embracement of reshoring or kept-from-offshoring strategies by established companies.[71] These activities

[70] National Association of Manufacturers, "Top 20 Facts About Manufacturing."

[71] For more insights on the industrial reshoring topic see: "Reshoring Initiative 2017 Data Report." Accessed October 1, 2018. http://reshorenow.org/blog/reshoring-initiative-2017-data-report-reshoring-plus-fdi-job-announcements-up-2-800-since-2010/; Rumki Majumdar and Aijaz Hussain, "Reshoring manufacturing jobs to the United States: Myth or reality?," *Deloitte Insights*,

have been joining those traditional manufacturing businesses that, for several reasons, have been enduring in urban locations even if often outpriced and displaced to the urban fringe, or even forced to informal settings. Another industrial trend that have been contributing to the growth of metropolitan manufacturing is what Christopherson identifies as 'phoenix industries.' Small and medium-size, rather new, high-technology enterprises rising 'from the ashes' of pre-existing industrial ecosystems (leveraged as 'initial advantage').[72] These firms "benefit pre-existing personal networks, technical skills, and market knowledge that have developed over a long time, the products of investments in R&D and the workforce made during the heyday of American manufacturing, from the 1950s to the 1970s. […] By contrast with their big-firm predecessors, phoenix companies rarely make products that we see on store shelves. Instead, they produce sophisticated components sold to equipment manufacturers, like the high-quality circuit boards certified for use in medical equipment and the defence industry, or sophisticated sensors to measure changes in heat and light used in all kinds of robotic devices. They also design and produce prototypes for products that are then manufactured around the world. They are frequently described as 'enabling industries' because they research, develop, and produce technologies that are used in many different industries, instead of just one. And because phoenix-industry companies work closely with a variety of customers, they are constantly engaged in incremental process as well as product innovation."[73] Exactly like Van Agtmael and Bakker reported an overlapping trend between rustbelts and brainbelts (see chapter 2.2), Christopherson too recognizes in old industrial cities like Pittsburgh, Syracuse and Rochester (NY) the best environment for advanced manufacturing to emerge. "These often-dismissed Rust Belt cities have the assets needed to support process and product innovation, as well as the commercial application of new technologies. […] we need to find ways to build the nascent industries emerging out of the ashes of our old manufacturing base."[74]

The emergence of the maker economy has speeded up significant changes as well, especially in how we make things. Along with sharing and circular economies, makers have progressively blurred the line between consumers and producers, designers and manufacturers – hence between manufacturing and innovation. The maker movement is a global network based on open innovation that has progressively transformed how innovation processes happen.[75] Makerspaces are 'open hardware'[76] workshops that provide access to space, tools, technologies, and engineering services. Because of their openness and

May 25, 2016, https://www2.deloitte.com/insights/us/en/economy/behind-the-numbers/reshoring-manufacturing-jobs-to-united-states.html#endnote-sup-2.

[72] Christopherson, "Manufacturing: Up from the Ashes."

[73] Christopherson, "Manufacturing: Up from the Ashes."

[74] Christopherson, "Manufacturing: Up from the Ashes."

[75] In his book Anderson reports many examples, see for instance Tesla and Local Motors in the chapter "Reinventing the Biggest Factories of All" in: Anderson, *Makers*, loc. 1878–2263.

[76] On the concept of open hardware see: Anderson, *Makers*, loc. 239–303; 1545–1876.

accessibility, they have become places of social empowerment and integration. Throughout North-American cities, the number of open-access workshops is countless, likewise the number of enterprises grown inside them - besides hobbyists and DIY enthusiasts. Workshops range from more standardized layouts, like Fab Labs, to flexible ones where users can modify, implement, and personalized the space based on their specific needs as a local community (e.g., PS:One and Lost Arts, see Appendix A). How enterprises develop out of these spaces varies based on product, location, and mindset. Some maintain R&D and production inside the makerspace: they either continue using the existing tools or add new ones for specific needs, sharing the ownership with the workshop (e.g., Supersmith and Artisan's Asylum, see Appendix A). Others open their dedicated factory: they either move the entire company there or maintain the R&D inside the workshop and move the production elsewhere but in the proximity (e.g., BoXZY case study, see chapter 4.4). Others fail or offshore. Maker and hackerspaces, as well as fab labs and other hardware-oriented hubs, play a key role in incubating would-be manufacturers that grow locally networked and are likely to scale production still maintaining the same industrial ecosystem.[77] The maker movement has also contributed to the increasing spotlight on locally made and artisanal products, which is also representative of a paradigmatic cultural change. The wonder of how things are made have slowly started to arise in people's consciousness, after decades of removing "from the view of the consumer both the difficulties and hardships of the commodity's production, and its distribution networks."[78] This because of issues of sustainability, environmental impact, but also as a form of "fulfilment and expression of self [...] rebranded as DIY."[79]

All these different forms of production converging in cities and metropolitan areas is what Saskia Sassen identifies as urban manufacturing[80] (fig. 3.2). According to Sassen, as a consequence of the urbanizing and growing demand in the intermediate service sector, from the 1980s on cities have risen as strategic places for new economic sectors and creative classes, neglecting those material economies (or urban manufacturing) still essential for dynamic urban economies. "Urban manufacturing has several characteristics: (1) It needs an urban location because it is deeply networked; it operates in contracting and subcontracting chains. (2) It is often fairly customized and hence needs to be in proximity to its customers and needs access to good craft workers. (3) It inverts the historic relationship between services and manufacturing (historically, services developed to serve the needs of manufacturers) in that it serves service industries. […] Once we bring this type of sector into the picture, we can recover

[77] Wolf-Powers et al., "The Maker Movement," 365–376.

[78] Rappaport, *Vertical Urban Factory*, 71.

[79] Robiglio, *RE–USA*, 183.

[80] On the definition of urban manufacturing by Sassen see: Sassen, "Cities Today," 65–67; Saskia Sassen and Romano Prodi, "The Global Slum," The European, November 25, 2010, https://www.theeuropean-magazine.com/saskia-sassen--3/6098-urban-life.

a variety of articulations among economic sectors that are obscured in a 'leading-sector' focus."[81] Additional characteristics identified by Sassen as well as by other studies are: (4) likewise manufacturing, urban manufacturing has a consistent multiplier effect given to the network effect;[82] (5) urban manufacturing firms are sites of innovation and enable the scaling up to commercialization of flow of innovations from R&D sector.[83]

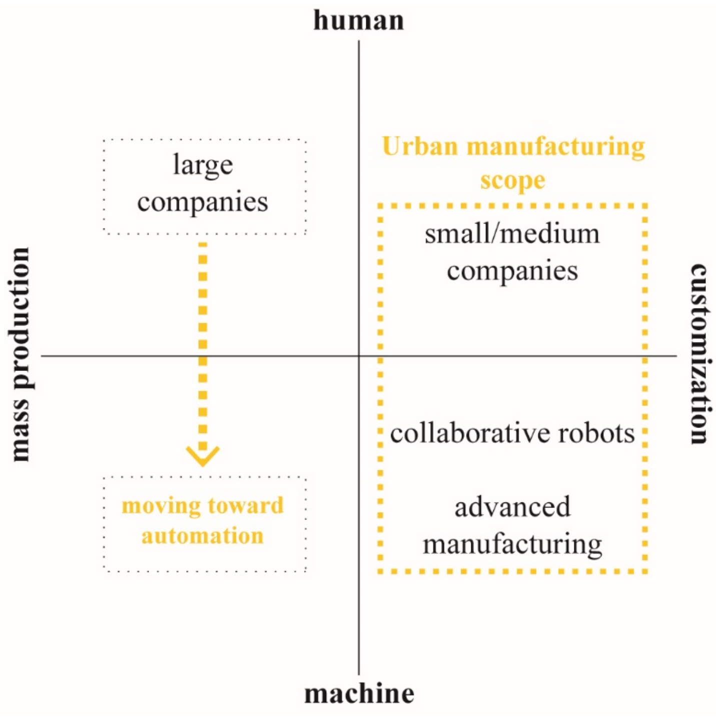

Figure 3.2. Urban manufacturing scope definition. It includes any customized form of production carried out either by traditional or advanced manufacturing processes. Figure based on a diagram realized by Erica R.H. Fuchs (Professor, Engineering and Public Policy, Carnegie Mellon University), in discussion with the author, July 2017.

[81] Sassen, "Cities Today," 65.

[82] "For every $1.00 spent in manufacturing, another $1.89 is added to the economy. That is the highest multiplier effect of any economic sector. In addition, for every one worker in manufacturing, there are another four employees hired elsewhere." These multipliers are expected to grow up to $3.60 and to 3.4 workers (2018 data). National Association of Manufacturers, "Top 20 Facts About Manufacturing."

[83] "Manufacturers in the United States perform more than three-quarters of all private-sector research and development (R&D) in the nation, driving more innovation than any other sector. R&D in the manufacturing sector has risen from $126.2 billion in 2000 to $229.9 billion in 2014. In the most recent data, pharmaceuticals accounted for nearly one-third of all manufacturing R&D, spending $74.9 billion in 2014. Aerospace, chemicals, computers, electronics and motor vehicles and parts were also significant contributors to R&D spending in that year." (2018 data). National Association of Manufacturers, "Top 20 Facts About Manufacturing."

Sassen wrote her paper "Cities Today" in 2009, a period during which urban policies and 'reindustrialization' narratives were still mostly "oriented toward retaining the big, standardized manufacturers (they have more jobs), which were precisely the ones for whom it made no sense to stay in the city: they did not need the urban economy with its multiple supplier and contracting chains and diverse craft talent pools."[84] The same year, while introducing 'Phoenix industries' Christopherson wrote that since the 1990s the policies supporting small businesses have been fading, while favoring multinationals and big old companies that do not represent a viable industrial future to invest in. "[…] innovation policy has too often emphasized science-based research and intellectual property and neglected the downstream, where ideas are turned into products and companies that actually employ people. […] building our industries of the future; that's being done by smaller companies, often located in the same towns and cities as the old-model manufacturers once were."[85] That also explains why, when the attention on small businesses and urban material economies finally arose, the experiences identified as successful were the results of reuse practices rooting back in the late 1970s and 1980s. Here, mission-driven locally-roots agencies have been repurposing vacant industrial structures to give space to small businesses, startups, local producers, and other entrepreneurial activities that were not supposed to thrive in cities because of decades of planning tools focused on holding back industry from cities. Places like the Brooklyn Navy Yard (BNY) and the Greenpoint Manufacturing and Design Center (GMDC) in New York, the American Industrial Center (AIC) in San Francisco, and The Industrial Corridor of Nearwest Chicago (ICNC) in Chicago started paving the way for more recent projects of reuse for production, where the urban manufacturing sector have found space to thrive (see chapter 5).

The potential positive trend in the American domestic manufacturing foreseen by experts is not based on large-scale manufacturers of standardized products that compete based on product prices. It rather focuses on leveraging small and medium firms who take advantage of their proximity to market, designers, highly-skilled workers, customers, and other firms – hence they locate in urban contexts. These firms produce customized high-quality products with a high added value, mostly in small-batches and through advanced manufacturing processes. Among technological and economic reasons, the entrepreneurs' tendency to produce in this fashion has also been fostered by a 'cultural rebellion' against disinformation on products' origins and environmental impacts as well as against standardization and homogeneity of consumer goods. People are increasingly willing to spend more money on products that are unique, innovative, high-quality, sustainable, healthy, locally-made, and traceable.[86]

[84] Sassen, "Cities Today," 69.
[85] Christopherson, "Manufacturing: Up from the Ashes."
[86] Friedman, "The Future of Manufacturing," 337.

In more recent years, planners, economists, and other advocates have started looking at the reintegration of production in the urban context as an opportunity to take on some of the major challenges facing the 21st-century city: persistent unemployment, inequalities, isolation, resource depletion, and physical growth based on overtaxed and outdated 20th-century infrastructures.[87] Production in cities means not only innovation, talent attraction, investment, or jobs. It also demands tackling, for instance, needs for affordable housing, well-functioning infrastructures, public transportation, as well as the development of adequate educational programs and workforce training, business development initiatives and other services. At the origin of this increased attention is the belief that a city committed to retaining space for a wide variety of income-generating activities (including urban manufacturing) is therefore committed to tackling socio-economic inequalities and environmental sustainability issues. Research supported by the Brooking Institution, the Pratt Center for Community Development and the Urban Manufacturing Alliance have studied the positive and inclusive socio-economic impact that could result from sustaining a diversified and vibrant urban manufacturing sector. On the other hand, they also underline severe lacks in data collection, that would help to understand the real share of this set of material economies in urban development processes.[88] Other scholars have explored the topic focusing more on the opportunities lying within the linkage adaptive reuse-urban production. In their analysis on urban industrial stock, Green Leigh and Hoelzel[89] show how multi-story manufacturing buildings with smaller footprint and old warehouses facilities with smaller loading bays can be once again desirable places for manufacturing businesses or other manufacturing-oriented incubators that require for large open, flexible spaces. In the same way, the increasing attention to local urban economies can still find in city warehouses efficient support to storage and distribution of products. Rappaport's research on vertical factories[90] envisions future solution where production spaces hybridize

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[87] Hajer, "Curator Statement," 14–16.

[88] Some important research conducted on urban manufacturing and cities are: Mistry and Byron, The Federal Role; "State of Urban Manufacturing. Understanding the industrial ecosystem in six U.S. Cities." Accessed October 4, 2018. https://www.urbanmfg.org/project/state-of-urban-manufacturing/; Christine Caruso, Mackenzie Keast, Justin Leclair, *Make This City: The State of Urban Manufacturing. How Urban Manufacturing Is Reshaping an Industry, Changing Cities, and Building Economies* (Toronto: Distl, April 2015); Pratt Center for Community Development, *Making Room for Housing and Jobs* (Brooklyn, NY: Pratt Center, May 2015), https://prattcenter.net/research/making-room-housing-and-jobs; Peter Hirshberg, Dale Dougherty, and Marcia Kadanoff, *Maker City. A Practical Guide for Reinventing Our Cities* (San Francisco: Maker Media, 2017), Kindle; Scott Andes et al., *Capturing the next Economy: Pittsburgh's Rise as a Global Innovation City* (Washington: Brookings Institution, September 2017), https://www.brookings.edu/research/capturing-the-next-economy-pittsburghs-rise-as-a-global-innovation-city/; Pratt Center for Community Development, *From Making to Manufacturing: A New Model for Economic Development in Cities and Towns* (Brooklyn, NY: Pratt Center, January 2017), https://prattcenter.net/research/policy-brief-making-manufacturing-new-model-economic-development-cities-and-towns.

[89] Green Leigh and Hoelzel. "Smart Growth's Blind Side," 88–89.

[90] See: Rappaport, *Vertical Urban Factory*, 434–457; Rappaport, "Vertical Urban Factory;" Rappaport, "Hybrid Factory | Hybrid City."

existing urban spaces resulting in vertical working/living machines or working/living integrated system distributed in the city.

Today, the definition of 'urban manufacturing' is often intentionally kept open. "Urban manufacturing is the potent combination of making a (physical) product or good for sale within the urban fabric of a city."[91] It is the 'oldest, newest thing' going on in cities, resulting from the evolution of the oldest and the newest development of the city-industry relationship. Urban manufacturing reflects the organizational form of 21st-century production: supple, peer-to-peer, decentralized networks of research, development, production, assembly, and distribution.[92] It includes a wide spectrum of production or production-related enterprises that tend toward advanced manufacturing systems, with the advanced part lying in the production process, the final product, the business model, or the economic paradigm.

[91] Urban Manufacturing Alliance. "What is urban manufacturing?"
[92] Mistry and Byron, *The Federal Role*, 8–9.

Chapter 4

Urban manufacturing spaces: a selection of case studies

Chapter 3 has analyzed the emergence of an urban manufacturing sector increasingly attracted to urban contexts. The research has investigated different places of production located in the central cities or in surrounding smaller ones in seven different North-American metro areas: Pittsburgh, New York, Detroit, Chicago, San Francisco, Los Angeles, Boston (see Appendix A for the entire list of places visited and people interviewed). Today, these cities are identified as post-industrial economies. Still, they are characterized by a strong industrial past that has left them with consistent legacies; knowledge, workforce, infrastructures, spaces, and services as well as other cultural and financial resources. While they share these characteristics, the cities observed differ in size, relevance in global economic dynamics, and consequently in real estate markets. In this chapter, the research has analyzed case studies in two large central cities with high-pressure real estate market (San Francisco and New York), two medium-sized central cities (Pittsburgh and Detroit), and one small city (Haverhill) whose dynamics have to be read in relationship to the central city (Boston).

In these cities, the research has identified urban manufacturing activities that reflected the business organization and forms of production characteristic of this sector (see chapters 2.2 and 3.2). The investigation has then focused on their location: where, how, and through which process and practice have these different forms of production ended up taking shape in that space and that location?

As suggested by the some of the studies presented in the previous chapters – for instance, Van Agtmael and Bakker with 'rustbelts/brainbelts' and Christopherson with 'phoenix industries' – the investigation highlights the recurrent overlapping between the location of urban manufacturing firms today and the urban industrial geography laid out by pre-1980s industrial trends. Urban manufacturing is emerging in cities by reshaping former industrial spaces. Here, the industrial legacy has been playing a key role in processes of retention or reintegration of different forms of production into the urban fabric.

The chapter analyses the workspaces of nine companies, located in seven different buildings in five of the observed cities. These case studies have been selected among the fifty places of production reported in Appendix A. Altogether, this selection of case studies is representative of the diversified and complex ways in which urban manufacturing can occur in cities. The companies analyzed belongs to very different industrial sector and markets. Heath, Lazlo, Detroit Is The New Black, and The Empowerment Plan are representative of rather traditional manufacturing processes and craftmanship carried out through advanced business model. Carnegie Robotics and BoXZY operates in the robotics and innovation sector, the first one conducting R&D projects at the very beginning of the streams of innovation, the latter by enhancing the commercialization of innovations through its products. Ferra Design and Situ are representative of the advanced fabrication sector. Finally, Southwick produce mass-customized products and it is part of a large multinational corporation.

Each case study is introduced by a description of the company and the reuse process of the building. Then, starting from its location and zoning designations, the research reflects on the relationship of each project with its context as well as on planning tools and policies that might affect urban manufacturing dynamics in that city. The graphic analysis recalls this structure by analyzing through design the citywide context, the reuse project, and the workspace (see Chapter 1 for the graphic method).

4.1 Heath SF Campus, San Francisco

Heath Ceramics

Heath Ceramics is a ceramics manufacturing company based in Sausalito and San Francisco. The company was founded in 1948 in Sausalito by Edith and Brian Heath. In 2003, the design engineer Robin Petravic and industrial designer Catherine Bailey acquired the company, at the time struggling after decades of success. Heath's legacy of designer-manufacturers has been preserved at the core of a renovated business model that integrates design, on-site production and direct selling of dinnerware and tiles.[1]

The old Sausalito facility is still dedicated to the dinnerware production lines. In 2011, Heath signed a long-term lease (terms not available) to expand into the former Mission Laundry in San Francisco's Mission District with a dedicated tile factory, showroom and clay studio that would have employed additional 34 people in its first year of operation.[2] Between 2011 and 2016, the building has been incrementally repurposed by Hemminger Architects and Heath from a single-tenant industrial facility into a mixed industrial and retail building. In fact, Heath occupies just the 52% of the entire compound, made of one main high-bay single story volume sided by two multi-story buildings (2 stories). The rest of the space has been subdivided into smaller, more manageable units subleased to artists, craftworkers, commercial activities. Along with Heath's showroom and the Boiler Room art gallery, these more open activities act as a buffer between the factory space and the city. Manufacturing opens to the public city through these buffer spaces that, in turn, ensure a certain degree of privacy and safety.

The business model based on direct selling, small-batch on-site production, high-value high-quality products has allowed for rather slow but stable growth. Since 2003, the company has gone from 24 employees and $1 million in sales to more than 170 employees overall and $18 million in sales - today they account for over 200 jobs.[3] There are no available data on the socio-economic impact of the entire Heath SF Campus comprehensive also of the other businesses located inside the facility. Regardless, a direct observation shows a positive impact of the project. By bringing together different forms of entrepreneurship and uses, it fosters economic diversity as well as contributing to the livability and vibrancy of the neighborhood. Besides acting as a place-maker, Heath SF offers jobs ranging from entry-level to high-skilled as well as from manufacturing to creative and retail jobs.[4]

[1] Bailey and Petravic, "Introduction," 14–15.
[2] Duxbury, "Heath Ceramics."
[3] Jao, "How This Ceramics."
[4] Some of the materials and information on Heath Ceramics were part of the case study analysis realized by the author for the paper "Reuse for Production. How New Forms of Production Are Reshaping North-American Cities," presented at 2018 Urban Affairs Association Annual Conference held in Toronto on April 4-7, 2018 (unpublished paper). Paper co-authored with Maicol Negrello.

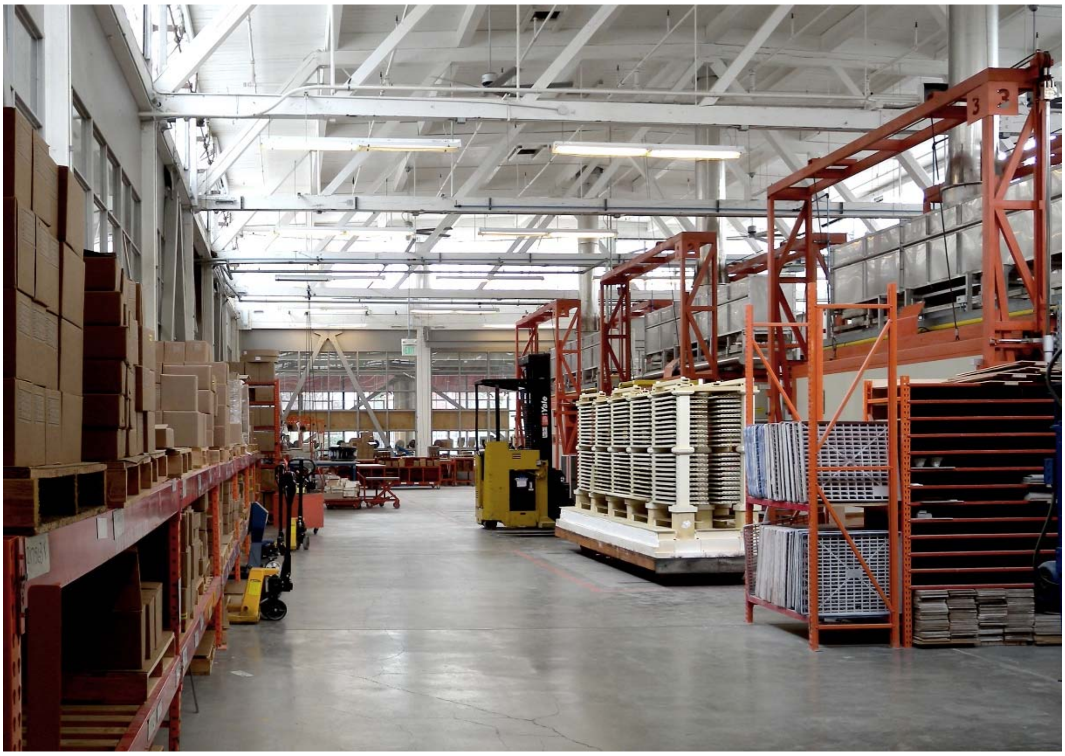


Figure 4.1. Heath SF, production space. Photo by the author.

Figure 4.2. Heath SF, view from the production space on the showroom. Photo by the author.

Figure 4.3. Heath SF, main public access to the building. Photo by the author.

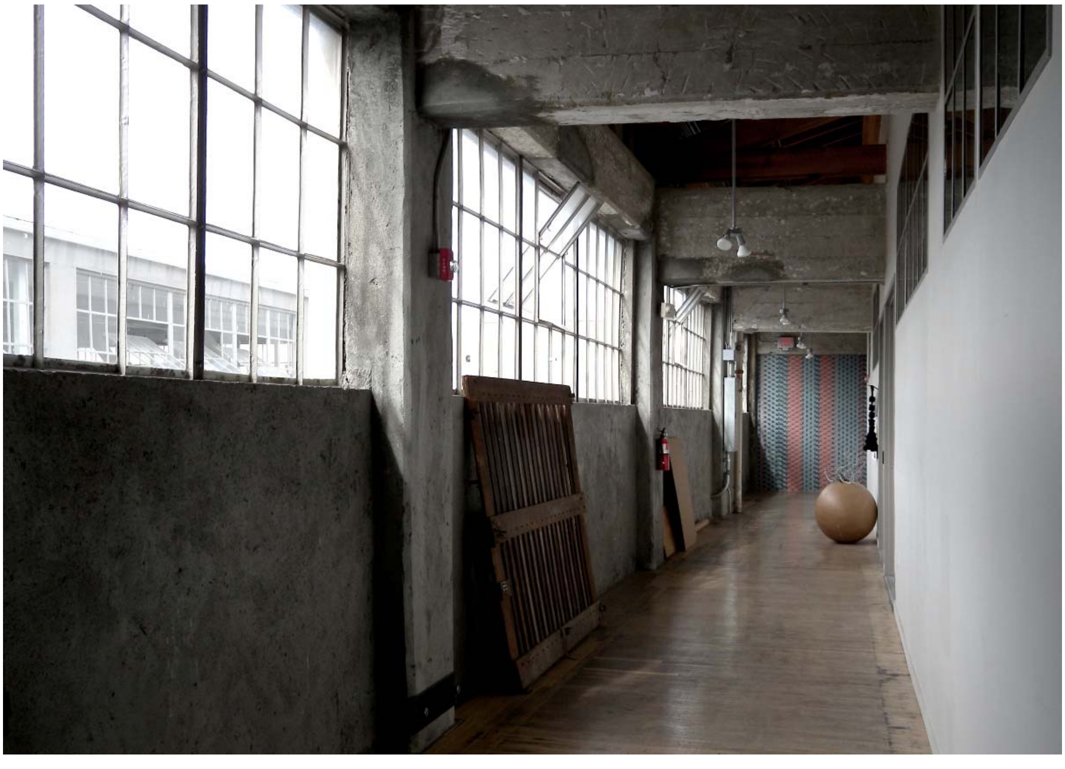


Figure 4.4. Heath SF, distribution to the studio spaces in the first floor. Photo by the author.

Figure 4.5. Heath SF from 18th St. Photo by the author.

Figure 4.6. Heath SF, view of the main entrance from the street. Photo by the author.

Eastern Neighborhoods and the citywide context

The facility sits in the Mission District, part of the Eastern Neighborhoods together with Central Waterfront, East South of Market and Showplace Square/Potrero Hill. Historically, these neighborhoods as well as the neighbor South Bayshore, and Visitacion Valley housed most of the industrial activities of San Francisco, due also to their strategic location along the bay close to the former Port of San Francisco. The property has been leased to Heath back in 2011 (supposedly at an average market rate) that manages the campus and subleases the rest of the spaces to other businesses. In the proximity, the average rent for industrial/flex spaces is around \$430/sqm/Yr (\$40/SF/Yr). Citywide leases for industrial and flex (suitable for both light industrial, office, and commercial use) range between \$215/sqm/Yr (\$20/SF/Yr) to around \$646/sqm/Yr (\$60/SF/Yr) – almost all the industrial properties are located in the Eastern Neighborhoods, where Heath locates, because of the zoning code.[5] In 2013, SFMade a nonprofit organization supporting the local manufacturing sector in SF, reported an average of \$260/sqm/Yr (\$2/SF/Mo).[6]

Heath's parcel is currently zoned as Production Distribution and Repair (PDR), a designation the city adopted for the industrial land (M zones) included in the Eastern Neighborhoods to adjust codes and regulations to the rapidly changing economic and social ecosystem in the early 2000s. The term PDR referred to the variety of industrial activities still occurring in these San Francisco's neighborhoods without conveying the idea that the City was trying to retain old noisy and polluted manufacturing while the city was facing the rapid ascent of the dot com and tech industry.[7] An extensive study conducted by the Planning Department in 2002 showed a still vibrant urban industrial sector that was renovated in its forms and vital to the other leading economic sectors of the city. "While employment in manufacturing in San Francisco dropped from 69,000 in 1953 to 36,550 in 1997, not every business and every job in the manufacturing sector left the City. While some of these jobs are really office jobs (workers in corporate headquarters, for instance), many are in small-scale production. The continued presence of production and even small-scale manufacturing activities in San Francisco is largely explained by the following: new technology, new flexible methods of organization, and the increasing importance of information and knowledge in the production process. These improvements have resulted in radically different production techniques. The recently favored distinction between new economy/old economy is to a large degree a misleading dichotomy,

[5] Source: LoopNet (https://www.loopnet.com/). Industrial and flex properties for lease in San Francisco and in the Mission District. Accessed March 28, 2019.

[6] Urban manufacturing firms in SF reported to SFMade rents ranging "from \$1–\$2 per square foot in the Bayview and \$2–\$3 per square foot in the Mission and SoMa, up from just under an average \$2.00 in 2013." SFMade, *2014 State of Local Manufacturing Report*, 5.

[7] SF Planning Department, "About the Eastern Neighborhoods."

since there is a blurring and overlap between the two."[8] At the time of the survey, PDR activities provided about 68,000 jobs citywide (12% of SF total employment), 47,000 of which were in the Eastern Neighborhoods.[9] The 2002 Citywide Action Plan recognized the need to reassess zoning regulations in the Eastern Neighborhoods to adapt to a completely transformed industrial scenario and an often small-grain mixed-use urban environment of industrial, commercial, and residential uses. The Plan launched a community planning process that brought in 2008 to the adoption of the Eastern Neighborhood Area Plans as part of the City's General Plan.

Like other cities where the industrial land is embedded in hot real estate market areas (e.g., New York), these neighborhoods have seen growing land use conflicts on industrial land where residential, commercial, and office developments constantly compete with industrial uses with far less acquiring power and less economic appeal for developers. At the beginning of the community planning process, 14% of San Francisco's total land area was industrial, mostly concentrated in the Eastern Neighborhoods. By 2008 the industrial land had already decreased to 7% due to the redevelopment authorized before the beginning of the process – percentage destined to decrease even more in the following years. PDR businesses are allowed not only in PDR land but also in other Mixed Use (MU) Districts: Mixed Use-General (MUG), Western SoMa Mixed Use-General (WMUG), Mixed Use-Office (MUO), Service/Arts/Light Industrial (SALI), and Urban Mixed Use (UMU).[10] Due to the small availability of land and to the constant housing shortage (especially affordable housing) characterizing San Francisco, the MU districts – especially those planned in areas already largely comprised of low-scale PDR activities – encourages the development of housing over commercial or PDR ground floors, hence encouraging mixed-use buildings. On the other hand, the 2008 Plan did not include replacement requirements for PDR land loss which, despite zoning recommendations, inevitably led to additional business displacements and land conversions. In 2013, as part of a 17-Point Jobs Plan, the Mayor introduced legislation to support the city's manufacturing sector and the development of new industrial spaces.[11] The following year, the resulting amended zoning controls intended to: "(1) Make it easier to establish PDR as a principally permitted use; (2) Allow PDR uses to share accessory retail space; (3) Entice the development of PDR on underdeveloped 6 parcels in PDR Districts; (4) Support creation of new PDR space in re-built non-conforming self-storage uses; (5) Make 'Small Enterprise Workspace' (SEW) to be more attractive to build; and (6) Clean up the definition of PDR".[12] According to SFMade, between 2011 and 2015 the local manufacturing sector has experienced constant job growth: +12.5% in 2012,

[8] SF Planning Department, *Industrial Land in San Francisco*, 19.
[9] SF Planning Department, *Industrial Land in the Eastern Neighborhoods*.
[10] See: San Francisco Planning Code, Article 8: Mixed Use Districts.
[11] Office of the Mayor, "Mayor Lee Introduces Legislation."
[12] City and County of San Francisco, ORDINANCE NO. 71–14, 2.

+13% in 2013, +15% in 2014,[13] and +10% in 2015.[14] In 2017, aware of the increasing demand for industrial and flex spaces and the adoption of Proposition X, the City introduced the replacement requirements for PDR loss in Urban Mixed Use Zones in the Mission District and some areas of South of Market (SoMa).[15] As of today, the zoning's main strategies to retain and enhance PDR activities also in MU areas are: (1) limiting authorizations for live/work units; (2) for each industrial building that is not unsound (rehabilitation would cost 50% or more to build a comparable one) and is proposed for demolition must be replaced by a new building that provides for the same (over 0.4 FAR) or the double (lower or equal to 0.4 FAR) amount of industrial square footage provided by the demolished building; (3) limiting conversion of production, distribution, and repair use, institutional community use, and arts activities use (for former PDR uses of at least 5,000 square feet - circa 460 sqm).[16]

The 2017 legislation also launched the Mission Action Plan 2020 that, among other strategies, insists on hybrid buildings mixing PDR on the ground floor and affordable housing in the upper floors as an opportunity to contextually tackle shortages of industrial space and affordable housing. "Consider allowing affordable housing on a limited number of underutilized Production, Distribution, and Repair (PDR) parcels with a ground floor requirement for PDR. […] PDR and residential uses have traditionally been separated because of conflicts arising from noise, chemical exposure, and differing design needs (e.g., loading docks), but light industrial and residential, like in the Mosaica project, can be compatible with good design."[17]

To complement the City's planning strategies, investments in education and workforce development, incentives and financial support to small businesses, initiatives at the regional level (Bay Area) have been supporting the urban industrial development of San Francisco.

[13] Data retrieved from: SFMade, *2015 State of Local Manufacturing Report*.
[14] Data retrieved from: SFMade, *Bay Area State of Local Manufacturing Report*, 3.
[15] See: SF Office of Economic and Workforce Development, "City Introduces Legislation."
[16] See: San Francisco Planning Code, Article 2: Use Districts – Sections 202.6-202.7-202.8.
[17] SF Planning Department and MEDA, *Mission Action Plan 2020*, 52.

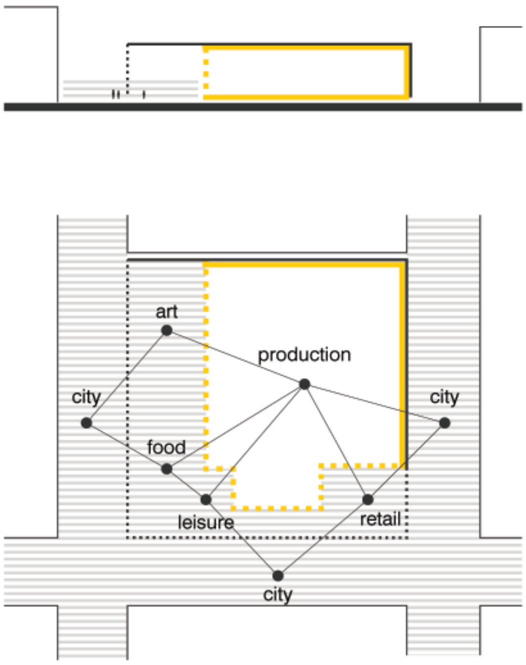
a. Industrial San Francisco

b. Mission District. Accessibility and footprints

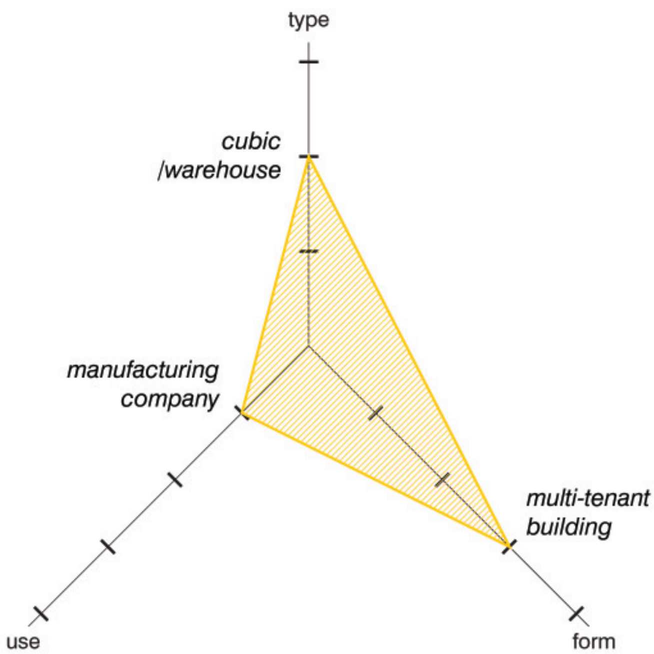

0
50
100
250
500 m

c. Heath. Spatial strategy

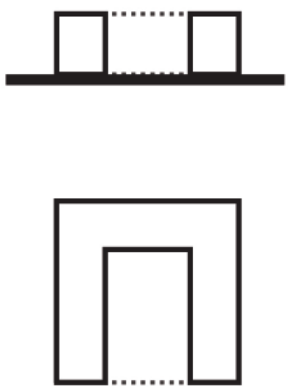
c.1. City-Production



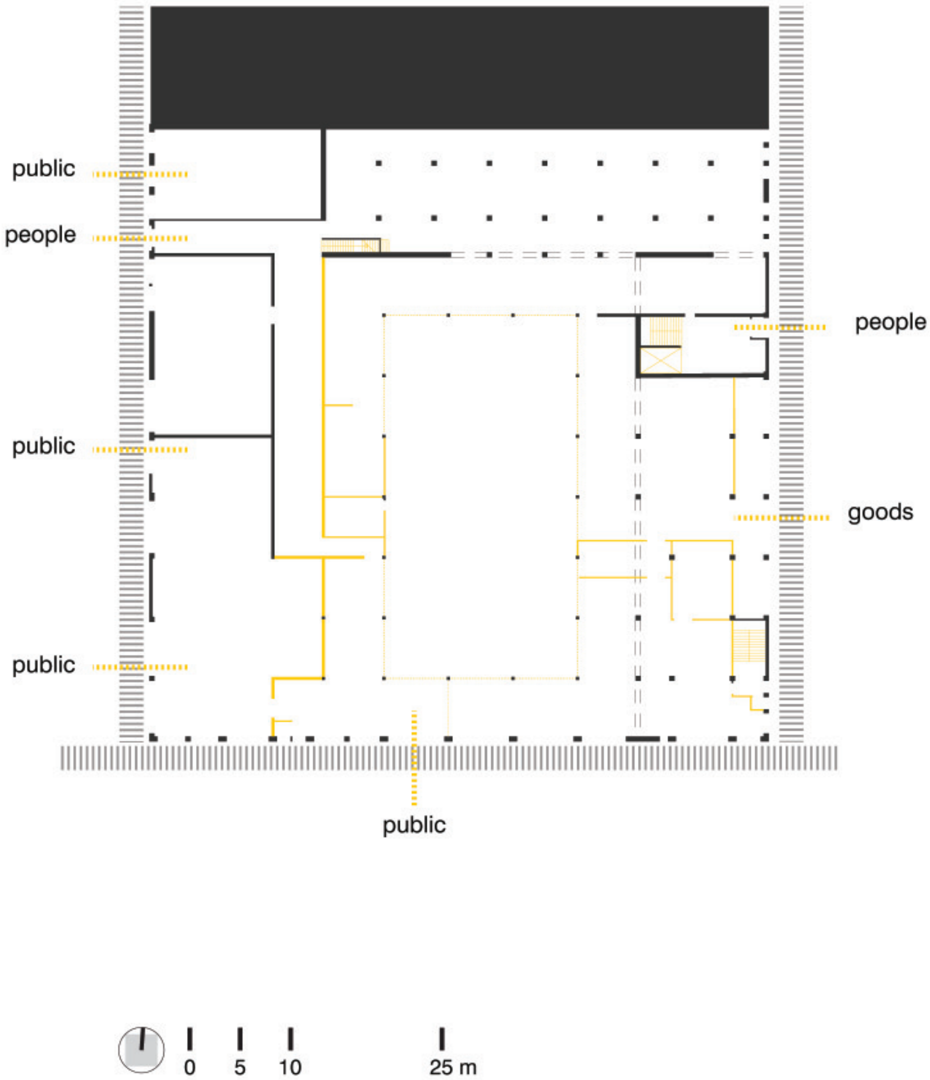
c.2. 3-axis form-type-use



c.3. Diagram

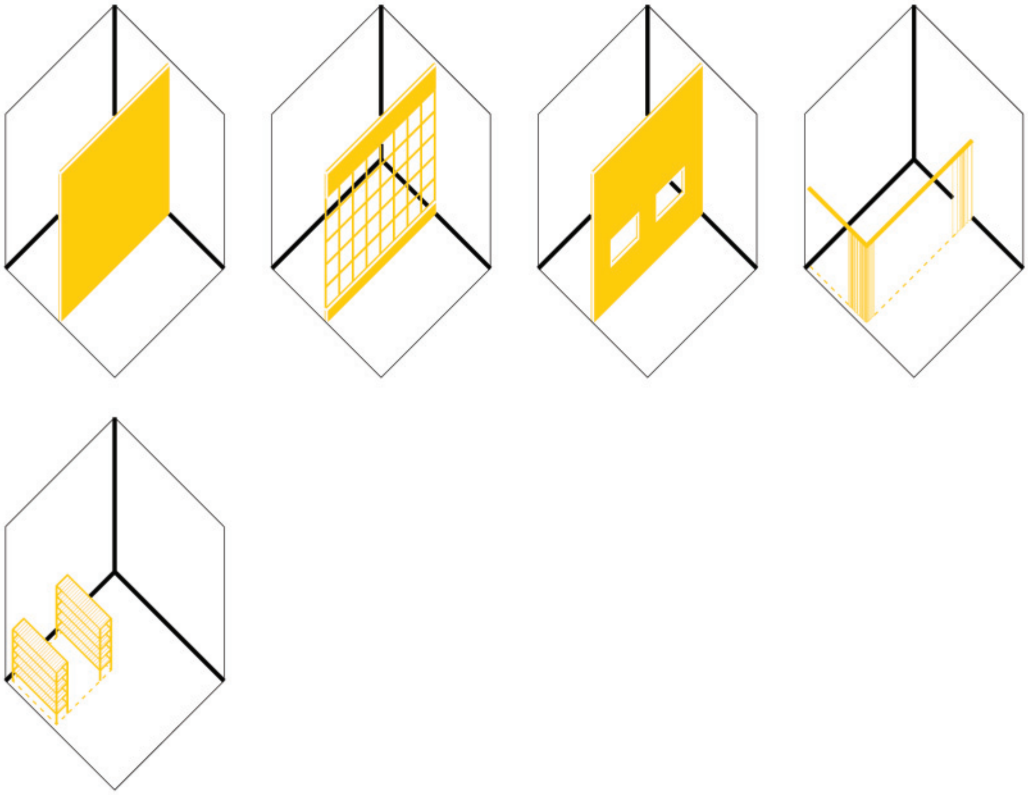


c.4. Plan

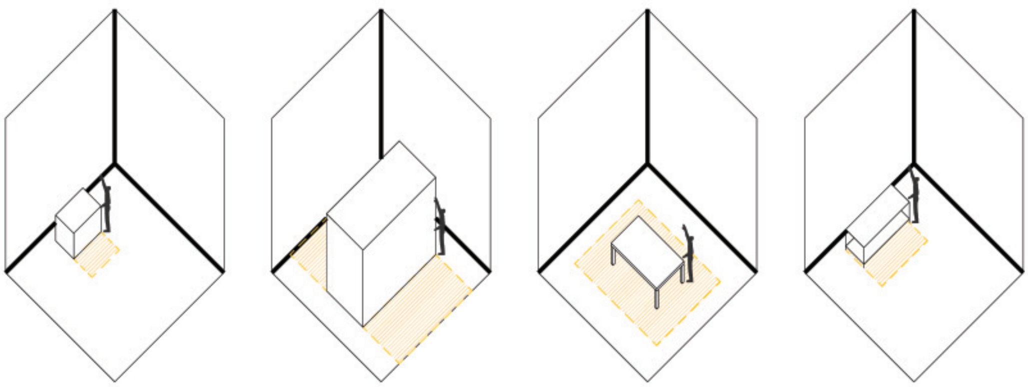


d. Heath. Axonometric view of the workshop

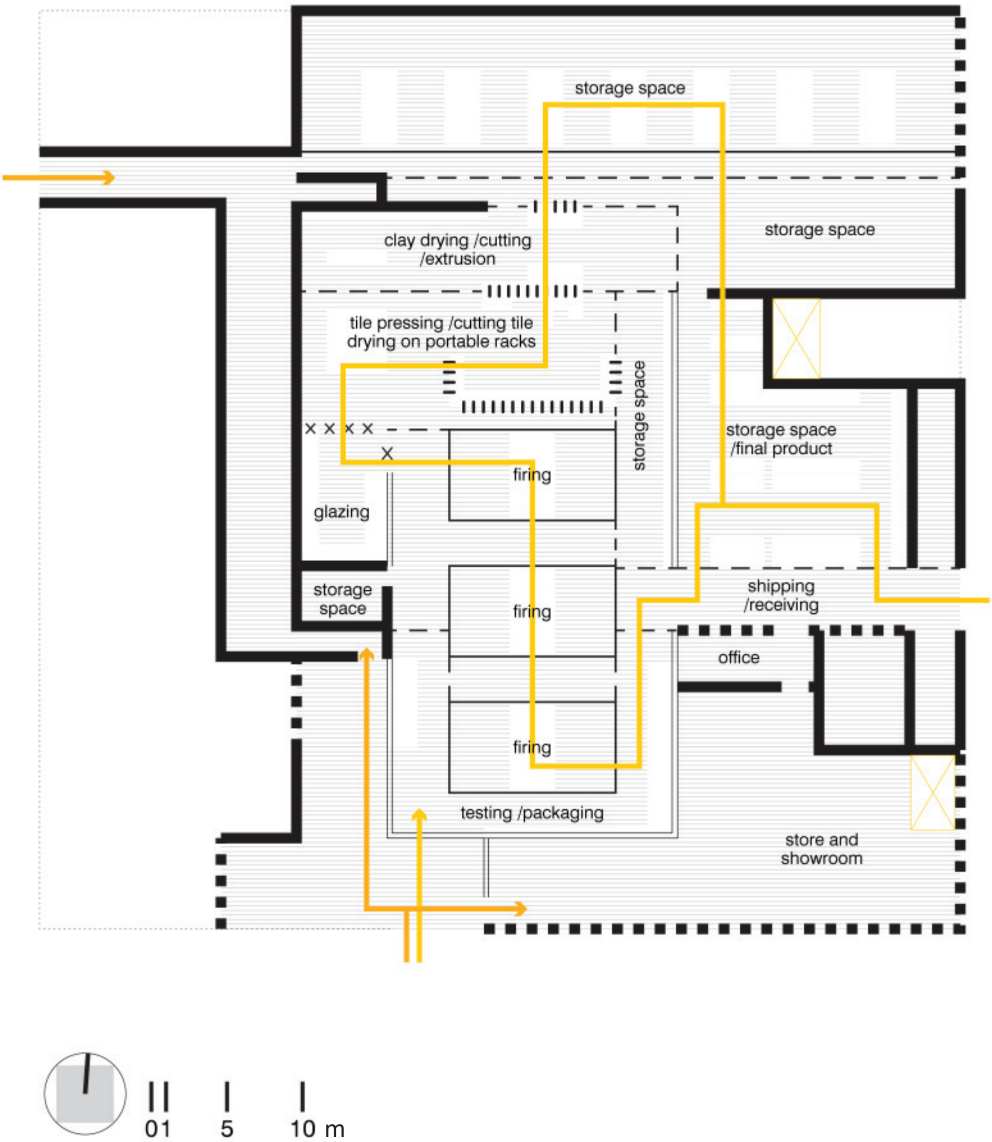
d.1. Organizers



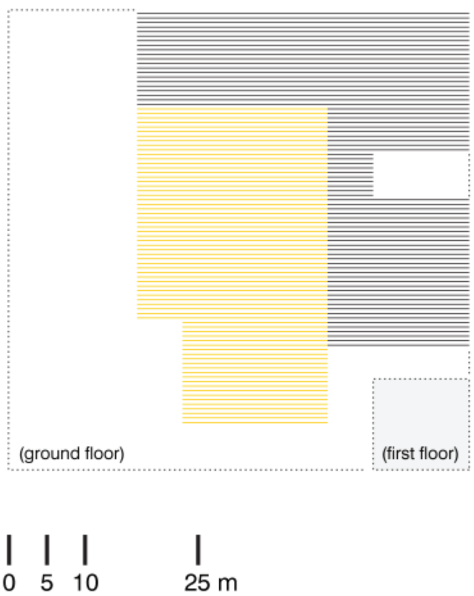
d.2. Operation units



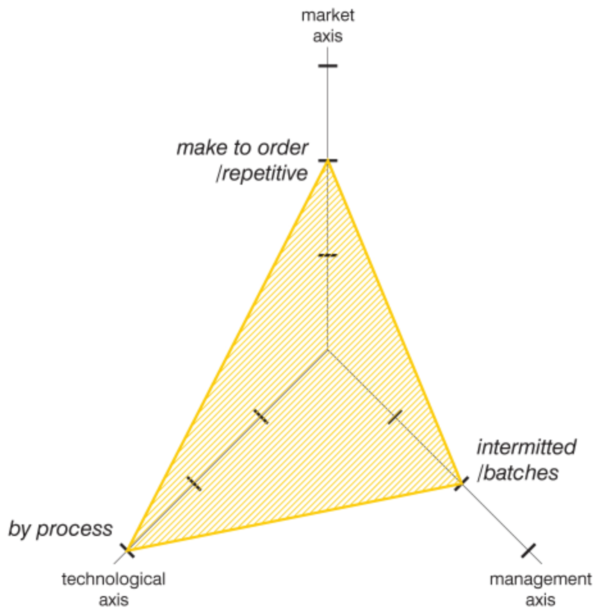
e. Heath. Workshop layout



f. Heath. Diagram of uses



g. Heath. 3-axix classification of production



h. Heath. Data table

Heath Campus San Francisco						
n. tenants: +4	**Tot.**	**Industrial**			**Other**	
					Other uses	**Distribution**
	5000 sqm	3400 sqm			1000 sqm	600 sqm
Heath Ceramics /tile factory	2600 sqm \\\ 52%	**Design**	**Production**	**Storage**	**Showroom and store**	
		150 sqm	970 sqm	1100 sqm	380	
		6%	37%	42%	15%	

4.2 Ferra Designs and Situ at the Brooklyn Navy Yard, New York

Ferra Designs

Ferra Designs is a precision architectural metal fabricator working from design development to high-tech fabrication and site-specific installation. The company was founded in 1989 by Robert Ferraroni in New York and in 2000 Jeff Kahn entered as co-owner. In 2002, Ferra Designs was priced out of its studio in the Williamsburg neighborhood, space where the company had established in 1995.[18] The company then moved to the Brooklyn Navy Yard where it has expanded from a 900 sqm space with 4 employees to a dedicated building (building 10) of 2300 sqm with 24 employees.[19]

Ferra Designs' facility was built between 1894-1852 as a 4-story engine house, then remodeled in 1936 into a 2-story building. The building has been later used for different uses, from machine shop to construction and repair office and storage.[20] Due to the presence of a horizontal crane, it is likely that the building was later transformed into a single-story high-bay shed, as it presents today. Ferra has kept the floor entirely open. Few light architectural elements have been added to define the change of use from manufacturing to design or from more heavy and large format operations to lighter and smaller ones.

Figure 4.7. Ferra Designs at the Brooklyn Navy Yard, view of the factory from the mezzanine. Photo by the author.

[18] Goff, "Designer creates."
[19] Brooklyn Navy Yard, "Ferra Designs."
[20] *NYNS Buildings-Historical Review*, Card 025, BNYDC Archives.

Figure 4.8. Ferra Designs at the Brooklyn Navy Yard, view of the interior. Photo by the author.

Figure 4.9. Ferra Designs at the Brooklyn Navy Yard, view of the mezzanine with the office space underneath. Photo by the author.

Situ/Fabrication

Situ is an architectural practice founded in 2005 in Brooklyn (New York) by Basar Girit, Aleksey Lukyanov-Cherny, Wes Rozen, and Bradley Samuels. The business is structured into three collaborative divisions: Studio, Research, and Fabrication. By operating between a workshop (Situ/Fabrication) and a creative studio (Situ/Studio; Situ/Research), the practice provides services ranging from design and consulting to research and development, prototyping, fabrication, and installation.[21] At the time of the observation (September 2016), Situ was split between two locations. The creative studio, located in an office building in the Dumbo neighborhood, on the west side of the Brooklyn Navy Yard, and the workshop, located since 2013 inside building 132 at the BNY. In 2017, Situ also moved its creative studio to the Yard, inside the newly repurposed building 77 (about the BNY and BLDG 77 see Ferra Designs case studies and chapter 5.2).

The division Situ/Fabrication employs over 45 people and occupies the entire building. It was originally built in 1905 as a single-story high-bay steam engine repair shop.[22] Since the installing of the Brooklyn Navy Yard Development Corporation as manager of the Yard, the building has been used by different tenants. In 2013, Situ entered into a space covered in layers of insulation left by the previous tenant, a local grocery store that used the building as cold storage. Situ has gradually cleared the space and improved its use creating different type of spaces: an enclosed volume for offices, protected spaces for dusty operations, an open high-bay space for assembly, and smaller spaces for finishing and small formats operations. Situ reopened some windows and the large front gate once used to let steam engines and trains inside. They also improved the energy supply and added two mezzanines for additional storage and office space – adding over 200 sqm to the original 930 sqm of the existing building. The workshop is well equipped for woodworking and plastic, while for more complex or advanced metal works it relies on other metal shops inside the Yard.[23]

[21] See: Situ, "About SITU;" Situ, "About Situ/Fabrication."
[22] *NYNS Buildings-Historical Review*, Card 099, BNYDC Archives.
[23] Wes Rozen (founder and partner of Situ), in discussion with the author, September 2016.

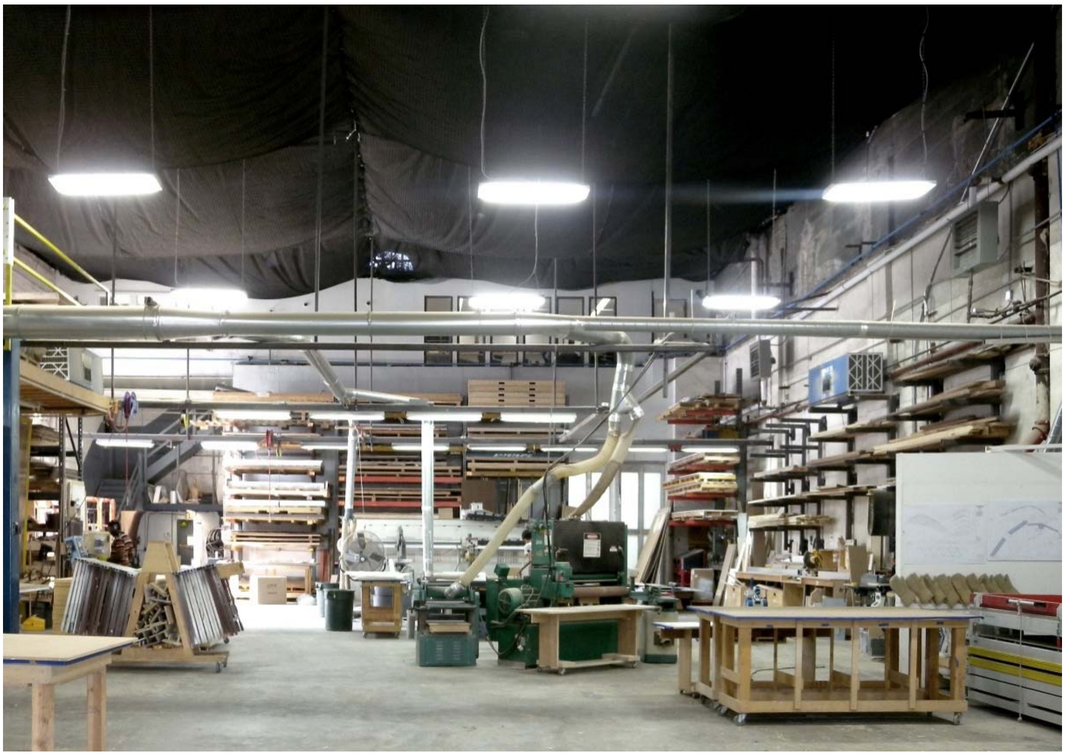


Figure 4.10. Situ Fabrication at the Brooklyn Navy Yard, view of the high-bay production space. Photo by the author.

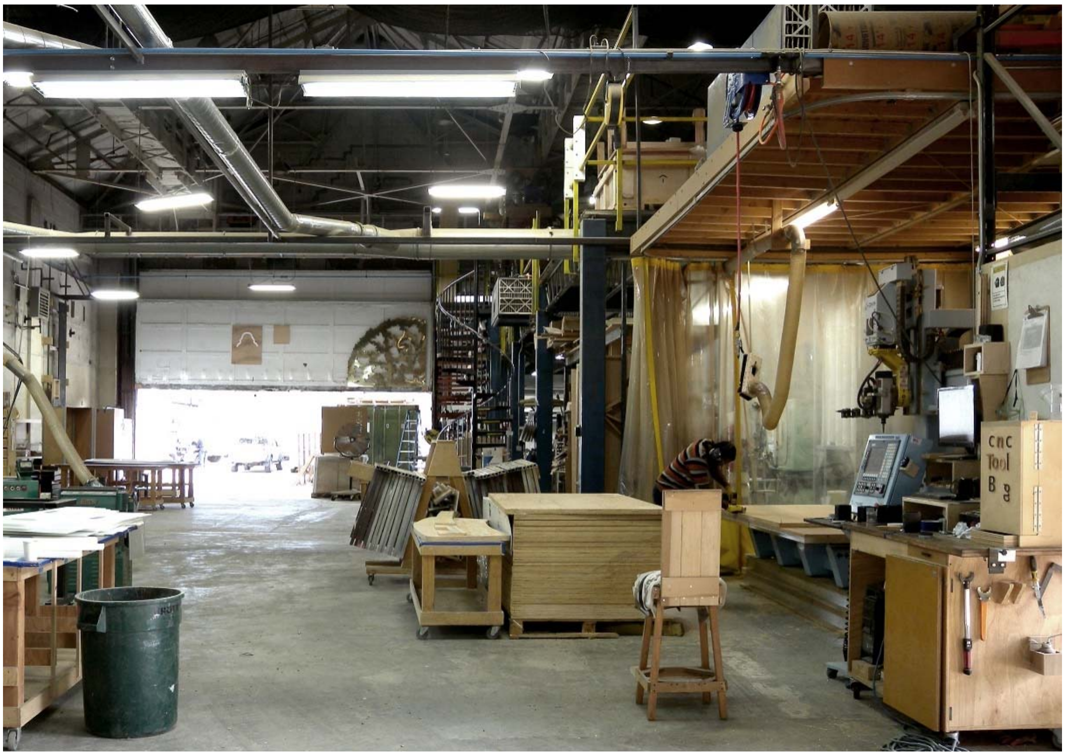


Figure 4.11. Situ Fabrication at the Brooklyn Navy Yard, view of the production space under the mezzanine (right) and of the large gate (left). Photo by the author.

Figure 4.12. Situ Fabrication at the Brooklyn Navy Yard, view of the mezzanine with workshop and storage space underneath. Photo by the author.

The Brooklyn Navy Yard and the citywide context

Ferra Designs and Situ locates into two different buildings inside the Brooklyn Navy Yard (BNY) a city-owned arsenal dismissed in 1966 then repurposed into a multi-tenant industrial park starting from the 1980s (see chapter 5.1 for more information on the Brooklyn Navy Yard and its socio-economic impact). Both companies have signed a long-term lease with the Brooklyn Navy Yard Development Corporation (BNYDC), a nonprofit organization responsible for the leasing, management, maintenance and development of the Yard. "The mission of BNYDC is to fuel The City's economic vitality by creating and preserving quality jobs, growing The City's modem industrial sector and its businesses, and connecting the local community with the economic opportunity and resources of the Brooklyn Navy Yard (the Navy Yard). It serves as a real estate developer and property manager of the Navy Yard on behalf of The City and strives to provide an environment in which businesses and careers can take root and grow."[24] The BNYDC operates under a lease with the City whose investments, together with revenues from leases, loans and other contributions, cover for operating costs and maintenance of buildings as well as they are invested in new developments and leasehold improvements. In 2017, the BNYDC had lease commitments from over 300 tenants for periods ranging from 1 to over 50 years.[25] Ferra's and Situ Fabbrication's leasing terms are likely to be rather long-term leases at a below-market rate even though they remained undisclosed.[26] Due to the high variety of companies and industrial sectors, the BNYDC is able to diversify leasing terms depending on the type of business and its needs – varying between average market rents as well as below market rents, also by cross-subsidizing rents between different companies.[27] In 2011, in a study conducted on the BNY by the Pratt Center for Community Development, the authors reported how the "BNYDC maintains rents roughly in line with market prices based on the particulars of the space (e.g., size, floor number, quality of elevator access, light, etc.). It documents its leasing policy in regular submissions to the board and updates asking rents to reflect market conditions. In many ways, BNYDC has turned the traditional leasing model on its head, often getting higher rents for upper-floor space, for example, from artisans and small, light-industrial businesses who value the natural light over ground-floor access. Tenants priced out of the rest of New York City's industrial market, however, can also be priced

[24] Deans Archer & Co., *Brooklyn Navy Yard Development Corporation*, 12.

[25] Deans Archer & Co., *Brooklyn Navy Yard Development Corporation*, 39.

[26] In September 2016, the author separately interviewed Shani Leibowitz (manager of the planning and transportation departments, Brooklyn Navy Yard Development Corporation), Wes Rozen (founder and partner of Situ), and Robert Ferraroni (founders and partners of Ferra Designs). Even if of none of them disclosed precise leasing terms, the two property owners convey the idea of having very favourable terms for their company, while Shani Leibowitz talked about the cross-subsidization of rents between different type of companies inside the Yard.

[27] Shani Leibowitz (manager of the planning and transportation departments, Brooklyn Navy Yard Development Corporation), in discussion with the author, September 2016.

out of the Navy Yard. Indeed, in 2011, the Yard declined to accept a below-market rent from a large (>100,000 sq.ft.) tenant, fully aware that this tenant would leave the Yard as a result."[28] In the immediate context (area comprised between Dumbo, Williamsburg, and the Broadway Triangle) the average rent is around $223/sqm/Yr ($30 /SF/Yr). Between Brooklyn and Queens, rents for industrial properties range between circa $160–430/sqm/Yr ($15–40 /SF/Yr).[29]

Inside the Yard, businesses can occupy either an entire building, like Ferra Designs and Situ/Fabrication, or one unit inside a multi-tenant building (generally former multi-story warehouses) like Situ/Studio. Over the years, the BNYDC has been repurposing and preparing ready-to-use spaces by installing utilities and sprinkler systems, securing and cleaning spaces. Tenants share all the spaces and facilities dedicated to logistics and distribution, such as streets, elevators, loading docks, corridors as well as leisure spaces. A perimetric wall encloses the entire Yard allowing companies to operate without the concern of crossing path with other daily urban flows while still being physically embedded into the urban ecosystem. Besides housing events and public tours, the BNY opens up to the city mainly through two publicly accessible buildings: the BLDG 92, an exhibition, employment, and visitor center, and the food hall at the ground floor of newly open BLDG 77.[30]

The Navy Yard has a strategic location, enclosed between the Manhattan and Williamsburg Bridges, connected by freight routes as well as public transportation lines to the city and outside. Because of its former use, the entire Yard is zoned as M3-1. M3 districts, historically located along waterfronts, are designated for heavy industrial uses that generate noise, traffic or pollutants. Other manufacturing districts are M1 and M2 districts that allows almost all the light and medium industrial uses under the respect of more (M1) or less (M2) strict performance standards.[31] M Districts were established by the 1961 Zoning Resolution and they have changed very little since then. Regulations and boundaries were based on the already existing industrial areas developed way before the 1960s under far more permissive regulations (or no regulation at all). More significantly, they based on an already declining industrial scenario, without taking into consideration the changing needs of industrial businesses.[32] For instance, Manhattan's industrial lofts were about to turn into the set of a cultural revolution with artists occupying inexpensive vacant lofts into their working and living spaces. In 1955, NYC industrial sector provided 1.8 million jobs, 971,000

[28] Pratt Center for Community Development, *Brooklyn Navy Yard*, 34.

[29] Source: LoopNet (https://www.loopnet.com/). Industrial properties for lease in New York (Brooklyn and Queens). Accessed March 31, 2019.

[30] Shani Leibowitz (manager of the planning and transportation departments, Brooklyn Navy Yard Development Corporation), in discussion with the author, September 2016. For more information of current and future development of the Brooklyn Navy Yard, see: Rosenberg, "At the Brooklyn Navy Yard;" Budds, "Exclusive: The Brooklyn Navy Yard."

[31] See: The City of New York Zoning Resolution, Article IV: Manufacturing District Regulations.

[32] New York City Department of City Planning, "Manufacturing Districts."

of which in manufacturing. By 2001, the sector would have shrunk consistently, leaving the city with just 20% of its 1950s industrial sector (around 1/3 of the company remained in NYC).[33] After the establishment of M districts, the 1971 Planning for Jobs report and the 1993 Citywide Industry Study realized by New York City Department of City Planning (DCP) pointed out the mismatch between M regulations and the contemporary needs of both the manufacturing sector (seeking properties at lower costs and easy access to trade infrastructures) and the new scenario of non-industrial uses and businesses expanding to M areas. Despite their agreement on zoning inadequacy, the two reports laid out different strategies; the first one proposed the strengthening of land use restrictions to non-industrial uses to preserve industrial jobs, while the latter proposed the relaxation of such restrictions to pursue the creation of jobs from new industries.[34] In 1997, the City established the Mixed Use Districts (MX) in some former M zones (especially M1) increasingly characterized by a mix of different non-industrial uses. This new zoning designation was fostered also by the 1982 New York State Loft Law that legalized prior occupations for living and non-industrial uses of industrial loft buildings.[35] Of course, due to the high pressure for conversion converging on industrial land, these areas soon turned into mixed-use neigborhoods with little or no manufacturing. With innovations and changes in the industrial sector and the broadening of the urban manufacturing scope (see chapter 3.2), MX could be a very attractive location for small businesses (makers, artisans, small shops and factories, light or high-tech production processes that produces in small-batches and do not require heavy trucks access etc.). Between 2001 and 2011, the manufacturing rezonings reduced of 5.2% NYC's industrial land, leaving the city with around 8,000 hectares.[36] In 2006, the City established the Industrial Business Zone, a non-zoning designation superposes to part of M districts, including the Brooklyn Navy Yard. "Industrial and manufacturing businesses in IBZs are served by City-selected non-profit organizations and may be eligible for tax incentives, financing tools and workforce development programs."[37] IBZs express the City's intent not to support additional residential rezonings and, more recently, to restrict self-storages (in 2017) and hotels (still under review, up to now allowed in most industrial areas) – of course, since 2006 these resolutions have been often

[33] New York City Department of City Planning, "Manufacturing Districts."

[34] New York City Department of City Planning, *The North Brooklyn Industry*. 1–5.

[35] The Loft Law, then implemented in 2010, was designed "to protect tenants in NYC who are illegally living in commercial or factory buildings. It has two goals: to bring those buildings up to residential safety and fire codes, and to give rights and rent protection to the tenants who live there." See: NYC Loft Tenants, "Loft Law 101. What is the Loft Law?." http://nyclofttenants.org/loft-law-101/; Multiple Dwelling Law 7-C http://www.nyc.gov/html/loft/downloads/pdf/loft_law.pdf.

[36] New York City Department of City Planning, "Manufacturing Districts." This source also offer maps and additional data on rezonings specific for each NYC borough.

[37] New York City Department of City Planning, *Employment in New York City*, 1.

disappointed.[38] "From 2000 to 2014, employment in M districts increased significantly. In 2014, there were 16,675 firms and 313,603 jobs in M districts (IBZs and other M districts), representing a net gain of 4,402 firms (+35.9 percent) and 46,484 jobs (+17.4 percent) since the year 2000. Non-industrial employment steadily grew in M districts between 2000 and 2014, while industrial employment declined between 2000 and 2008 and rebounded after 2010. In 2014, industrial employment had not yet bounced back to the year 2000 levels of employment, but was following an upward trend […] expected to endure."[39]

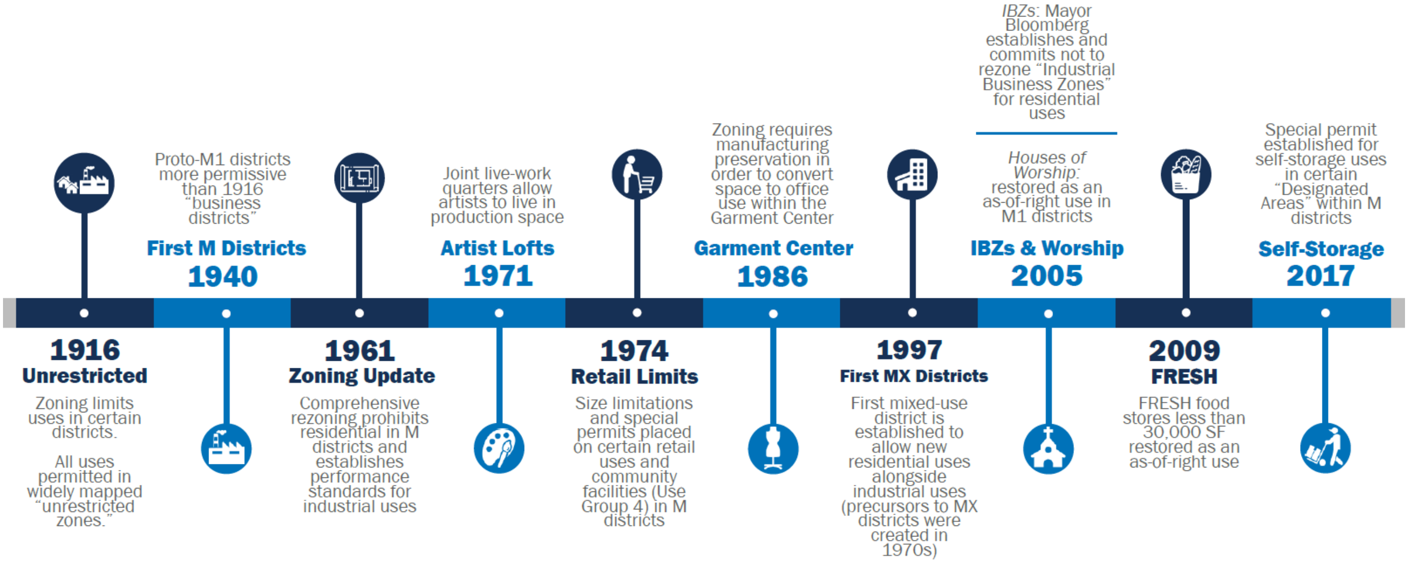


Figure 4.13. Evolution of Zoning in M Districts. Retrieved from: NYC Department of City Planning, *The North Brooklyn Industry and Innovation Planning*, 3.

Proceeding from the 2014 Engines of Opportunities report that provided suggestions on how to support economic diversity and industrial businesses, in 2015 the City released the 10-point Industrial Action Plan. Among the 10 points, the plan intends to: (1) invest in city-owned industrial properties (the Brooklyn Navy Yard being one of them) to provide affordable space and supporting services to industrial businesses; (2) limit new hotels and personal storage in core industrial areas to reduce use conflicts and support diverse economic growth; (3) create new models for flexible workspace and innovation districts; (4) strengthen core industrial areas. Other points include investments in workforce development programs, employment centers, the creation of New Advanced Manufacturing Center, strengthening existing initiatives and organizations supporting the creation

[38] For more information on IBZs, see: New York City Economic Development Corporation, "NYC Industrial Business Zones," https://www.nycedc.com/industry/industrial/nyc-industrial-business-zones.

[39] New York City Department of City Planning, *Employment in New York City*, 4.

of jobs and business development.[40] This plan has been implemented by the 2017 New York Works plan that lays out three main objective: (1) invest in the creation of middle-class jobs (20,000 jobs over the 100,000 foreseen being in manufacturing); (2) ensure those jobs are accessible to New Yorkers; (3) prepare for the jobs of the future.[41] Both initiatives recognize in land use and zoning major tools to increase and develop space for jobs. These tools should adapt to changes in the urban industrial sector as well as emerging patterns of employment (for instance, more office-based businesses moving from Manhattan to more affordable areas in Brooklyn and Queens also close to their workforce).[42] The purpose of creating jobs brought also to new initiatives in transportation and infrastructure systems both for goods, like Freight NYC that aims to strengthen the logistics and distribution system, as well as for people,[43] like the new Ferry public route (the BNY stop will open in the summer of 2019).

With the publication of the North Brooklyn Industry and Innovation Planning in November 2018, the City has finally expressed a stronger commitment to strengthen core industrial areas by limiting non-industrial uses, while also review those zoning regulations limiting the expansion of businesses (both industrial and non-industrial). Nevertheless, the report still distinguishes between on one side industrial businesses requiring truck access and large floorplates, and on the other side office-based businesses. This classification should be accompanied by a more in-depth understanding of the type of businesses that constitutes the industrial scenario. For instance, there might be companies that do not need to locate in truck-intensive areas or massive floorplate but do need dense mixed-use neighborhoods, but also the possibility to eventually grow in-place and affordable space without the threat of being displaced. Like San Francisco, New York has been characterized by a fierce competition for land accompanied by the constant lack of policies addressing land costs to maintain industrial spaces economically accessible by businesses – a problem already expressed in 1971 by the DCP report Planning for Jobs.[44] The New York Works initiatives plans for +20,000 job growth in the industrial and manufacturing sector and +30,000 jobs in tech and innovation industries – which in some cases can entail production as well. "Today, the industrial ecosystem, which spans manufacturing and goods distribution, employs over 530,000 New Yorkers and provides many access points into good-paying jobs. Median wages are just over $50,000 per year and over 60 percent of jobs within the sector do not require a college degree."[45]

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[40] City of New York, "Mayor de Blasio."

[41] The City of New York and Mayor Bill de Blasio, *New York Works*, 8.

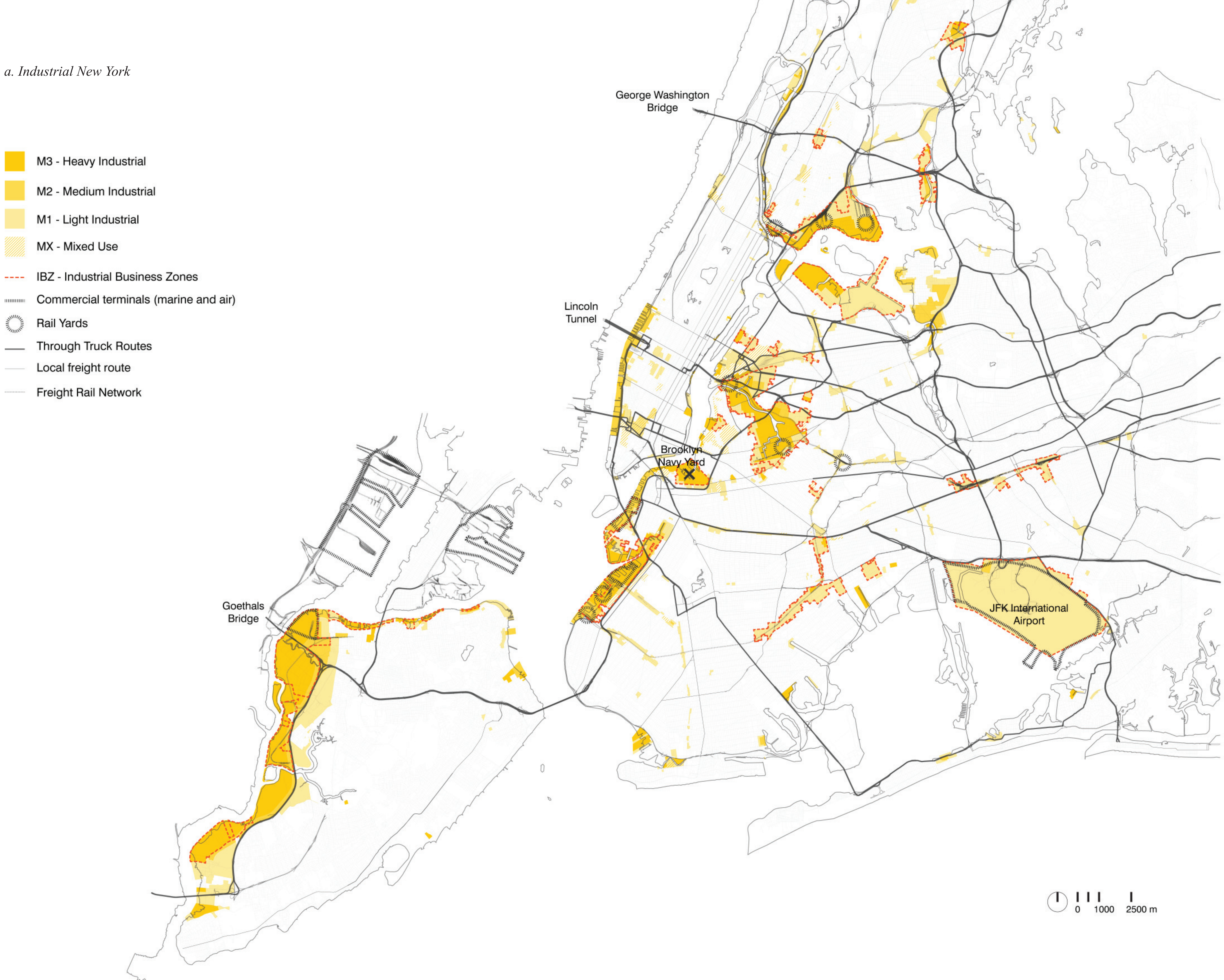
[42] New York City Department of City Planning, *The North Brooklyn Industry*. ii.

[43] For more on Freight NYC and other freight initiatives from the City, see: New York City Economic Development Corporation, *Freight NYC. Goods for the Good of the City* , 2018, https://www.nycedc.com/sites/default/files/filemanager/Programs/FreightNYC_book__DIGITAL.pdf; New York City Economic Development Corporation, "PortNYC," https://www.nycedc.com/service/ports-transportation.

[44] New York City Department of City Planning, *The North Brooklyn Industry*. 3.

[45] The City of New York and Mayor Bill de Blasio, *New York Works*, 55.

a. Industrial New York

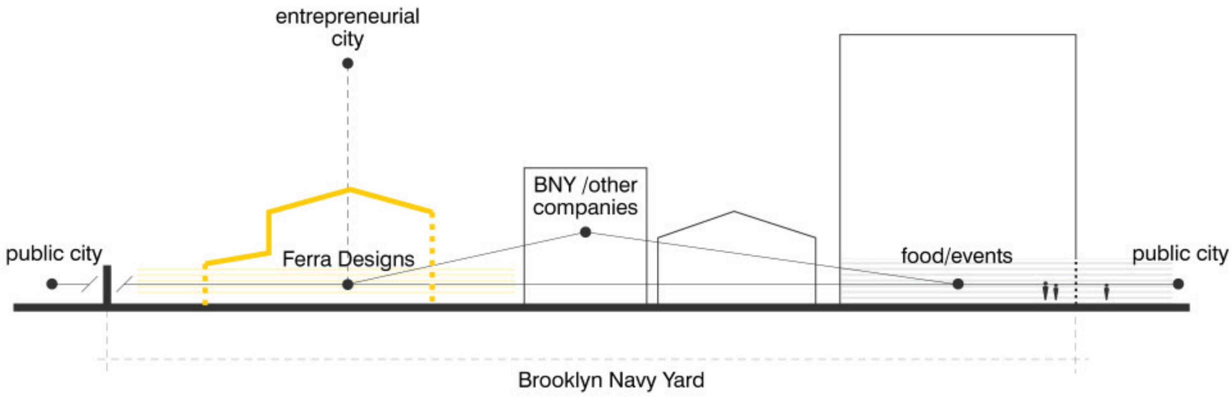


b. Brooklyn Navy Yard. Accessibility and footprints

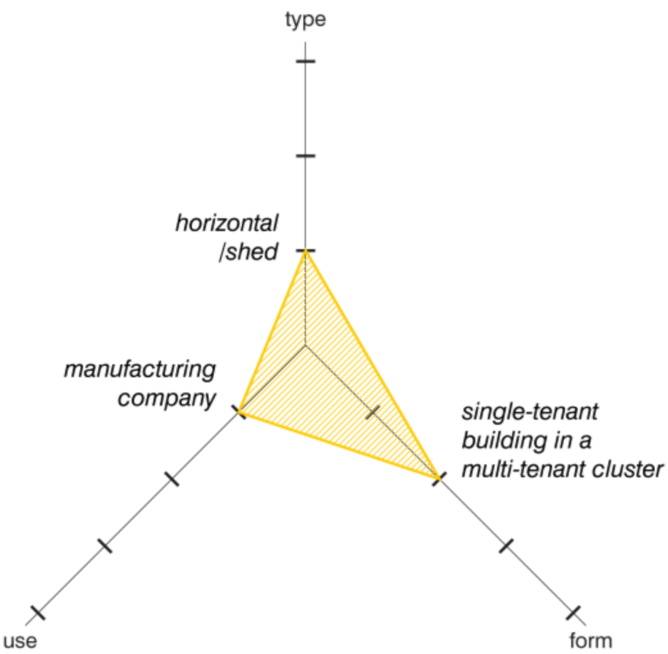

BNY enclosing wall
Public access
Workers and vehicles access
0 50 100 250 500 m

c. Ferra. Spatial strategy

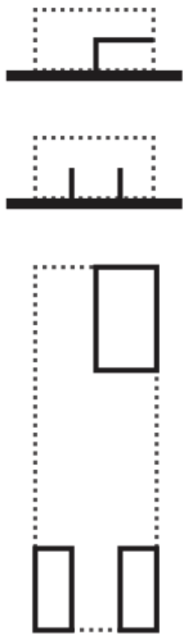
c.1. City-Production



c.2. 3-axis form-type-use

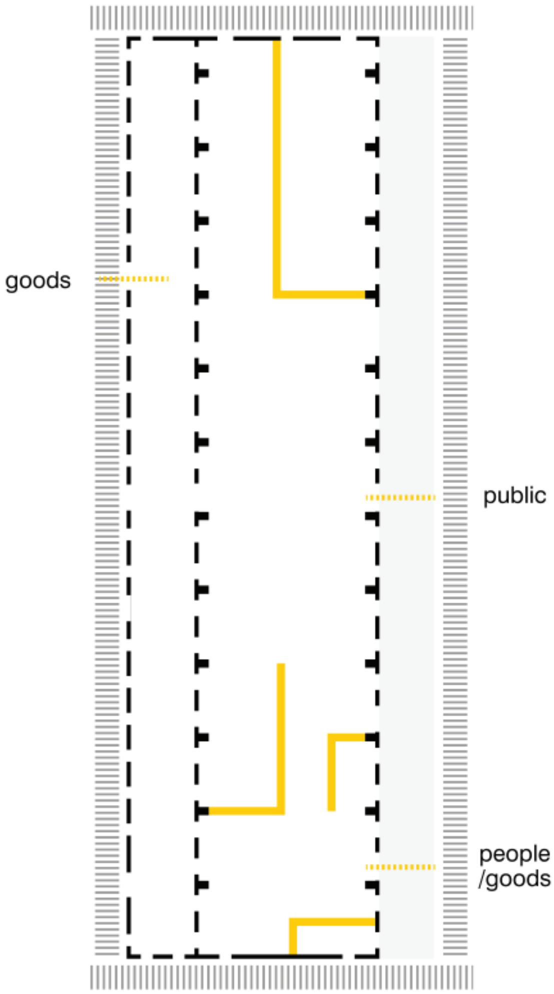


c.3. Diagram

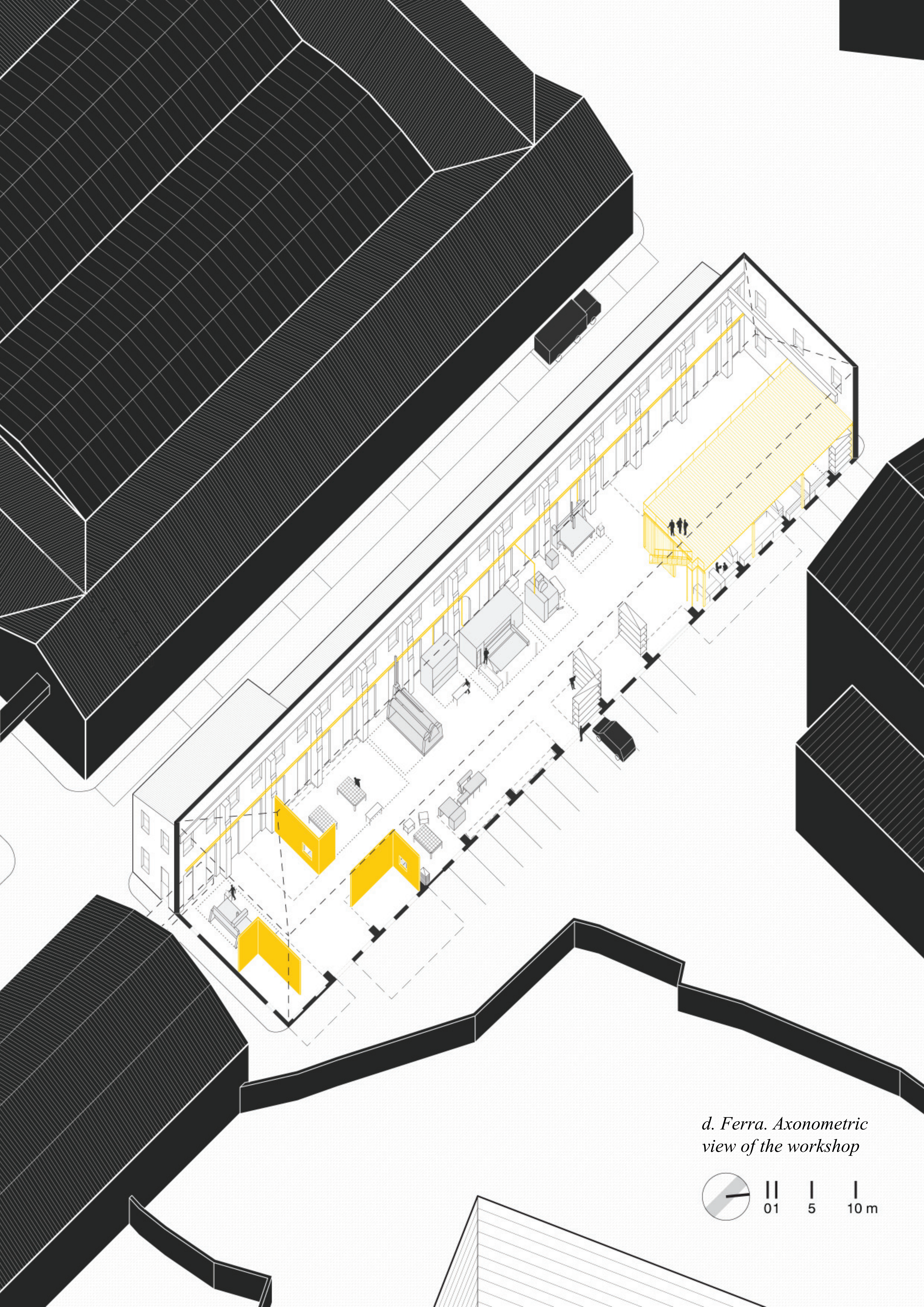


c.4. Plan and section

Section

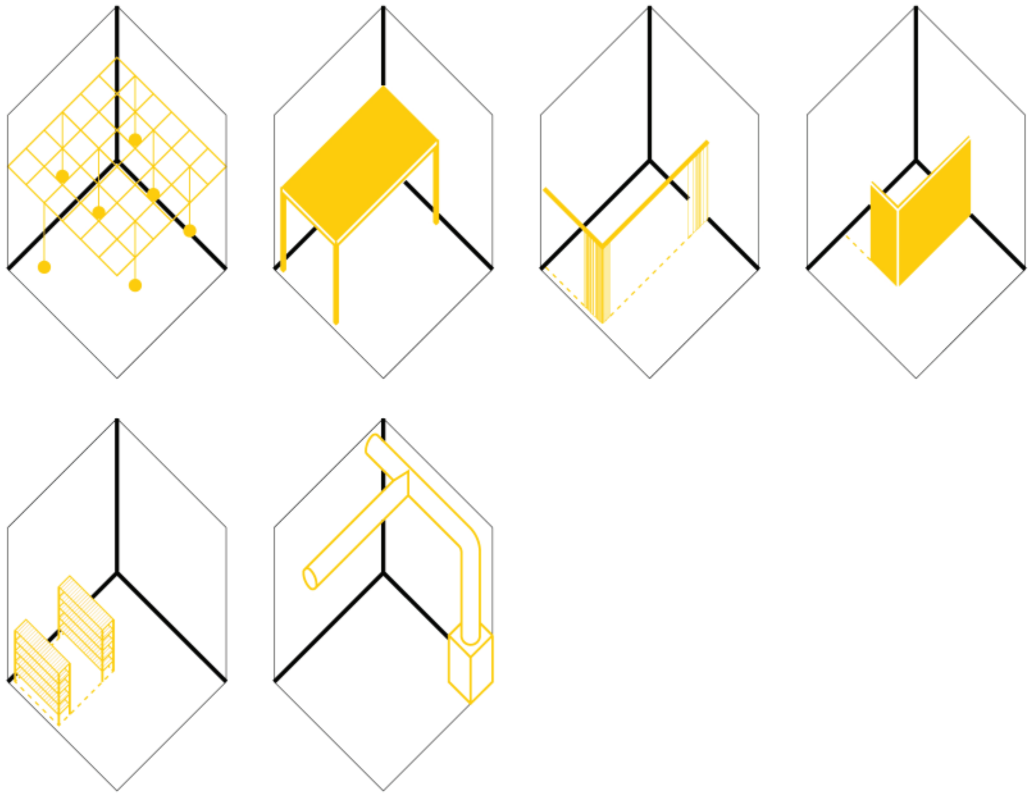


Plan

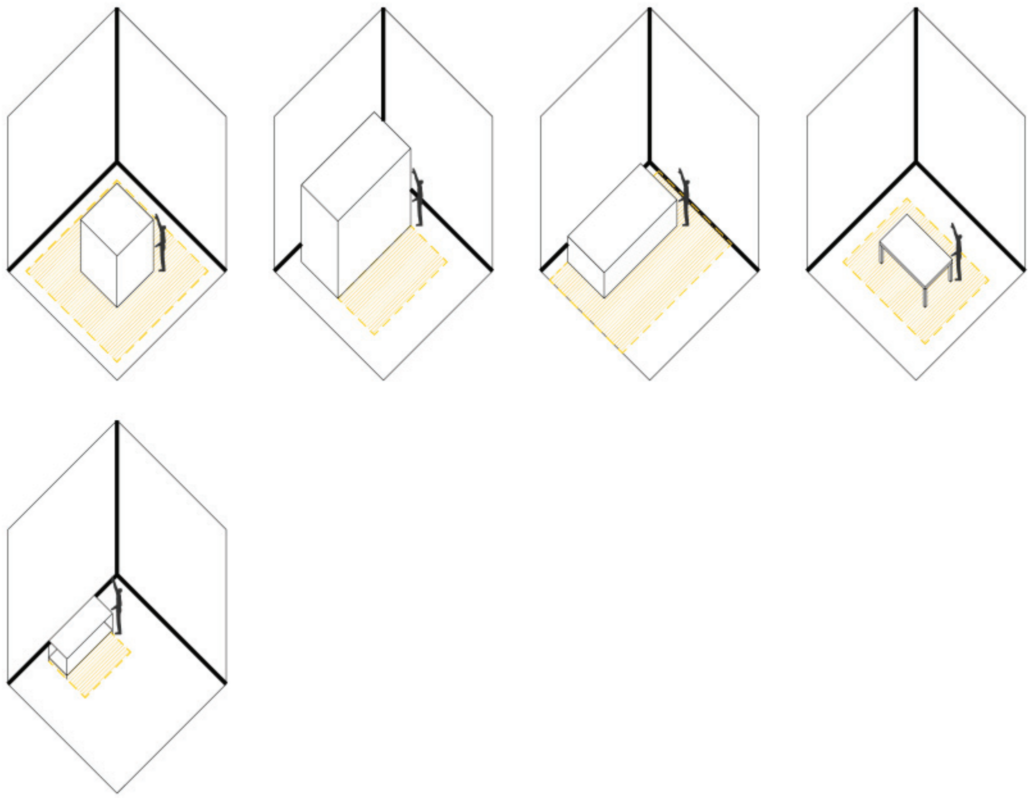


d. Ferra. Axonometric view of the workshop

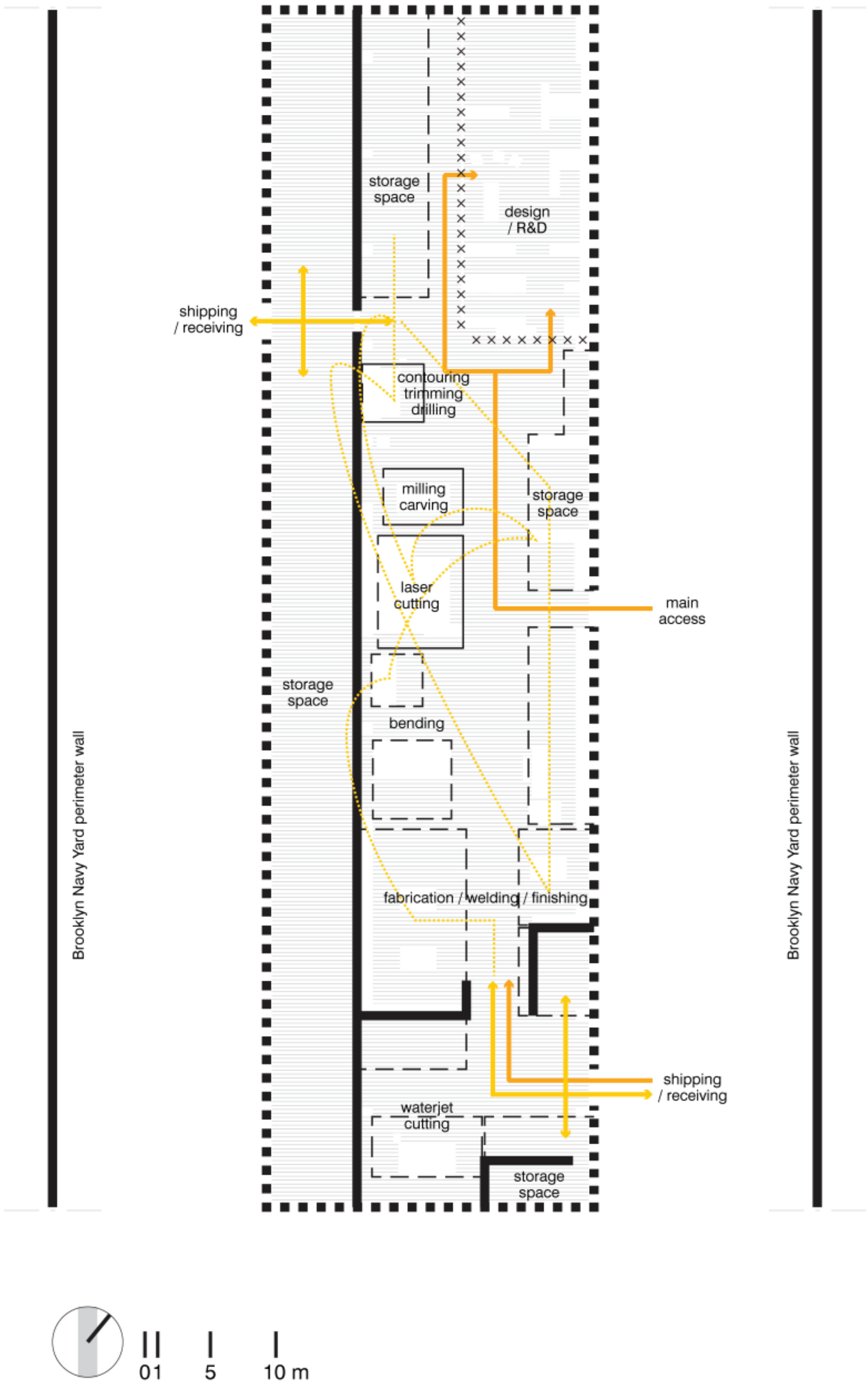
d.1. Organizers



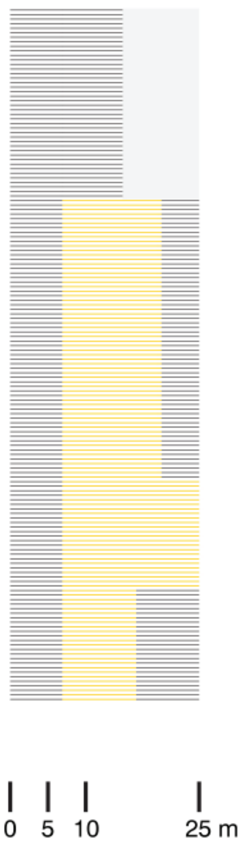
d.2. Operation units



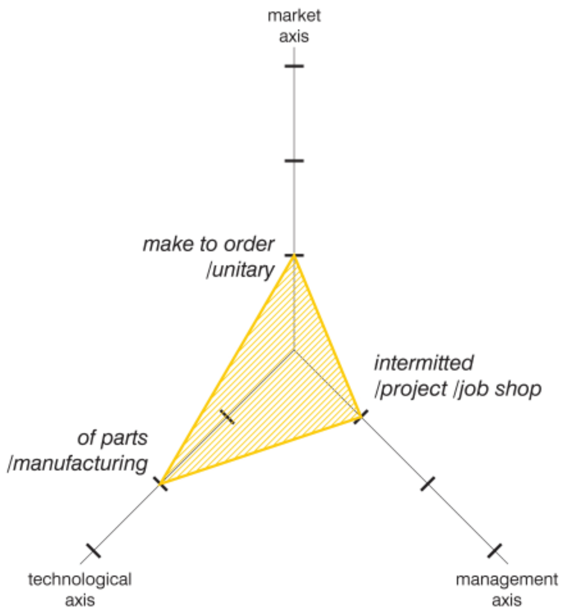
e. Ferra. Workshop layout



f. Ferra. Diagram of uses



g. Ferra. 3-axix classification of production

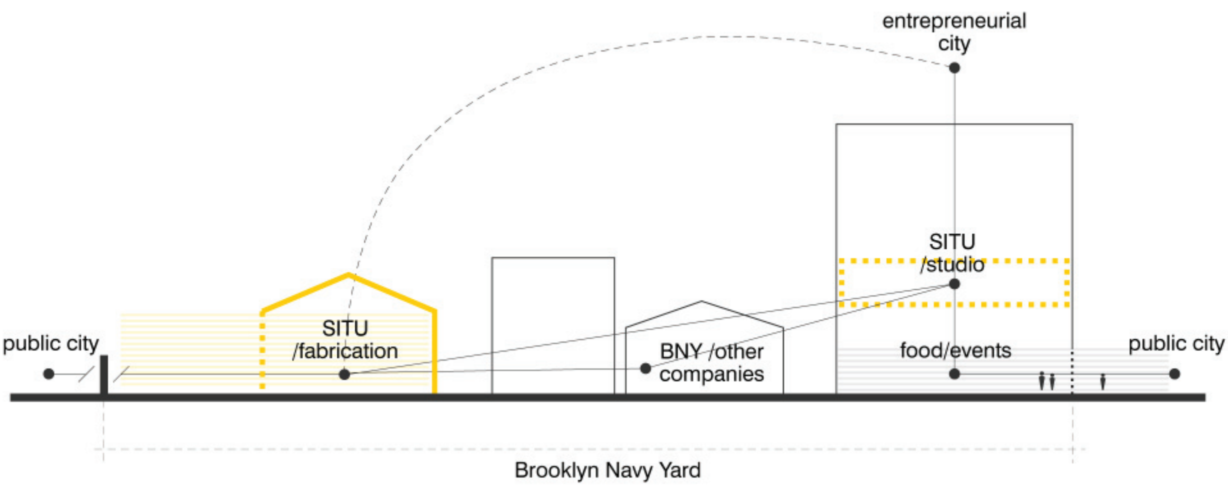


h. Ferra. Data table

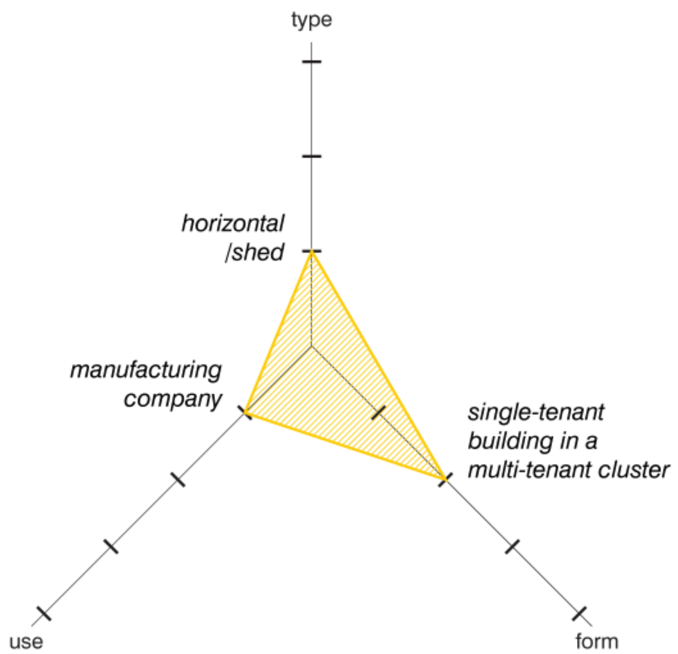
Brooklyn Navy Yard					
Ferra Designs	2300 sqm \\\ 100%	**Design**	**Production**	**Storage**	**Other**
		260 sqm	900 sqm	1140 sqm	/
		10%	40%	50%	/

c. Situ/Fabrication. Spatial strategy

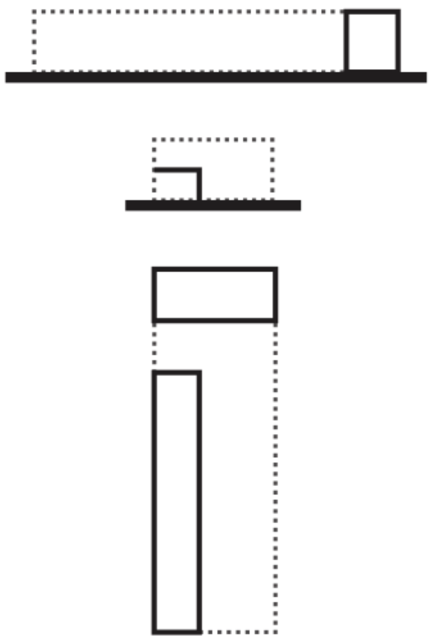
c.1. City-Production



c.2. 3-axis form-type-use

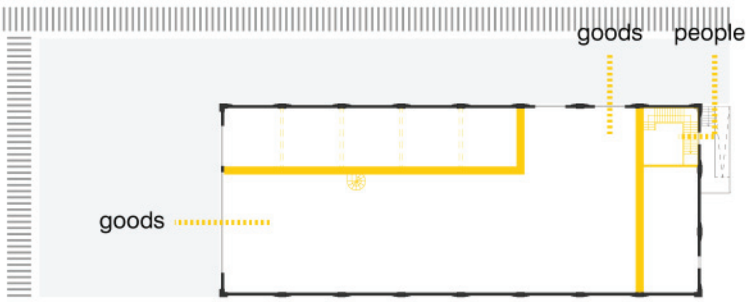


c.3. Diagram



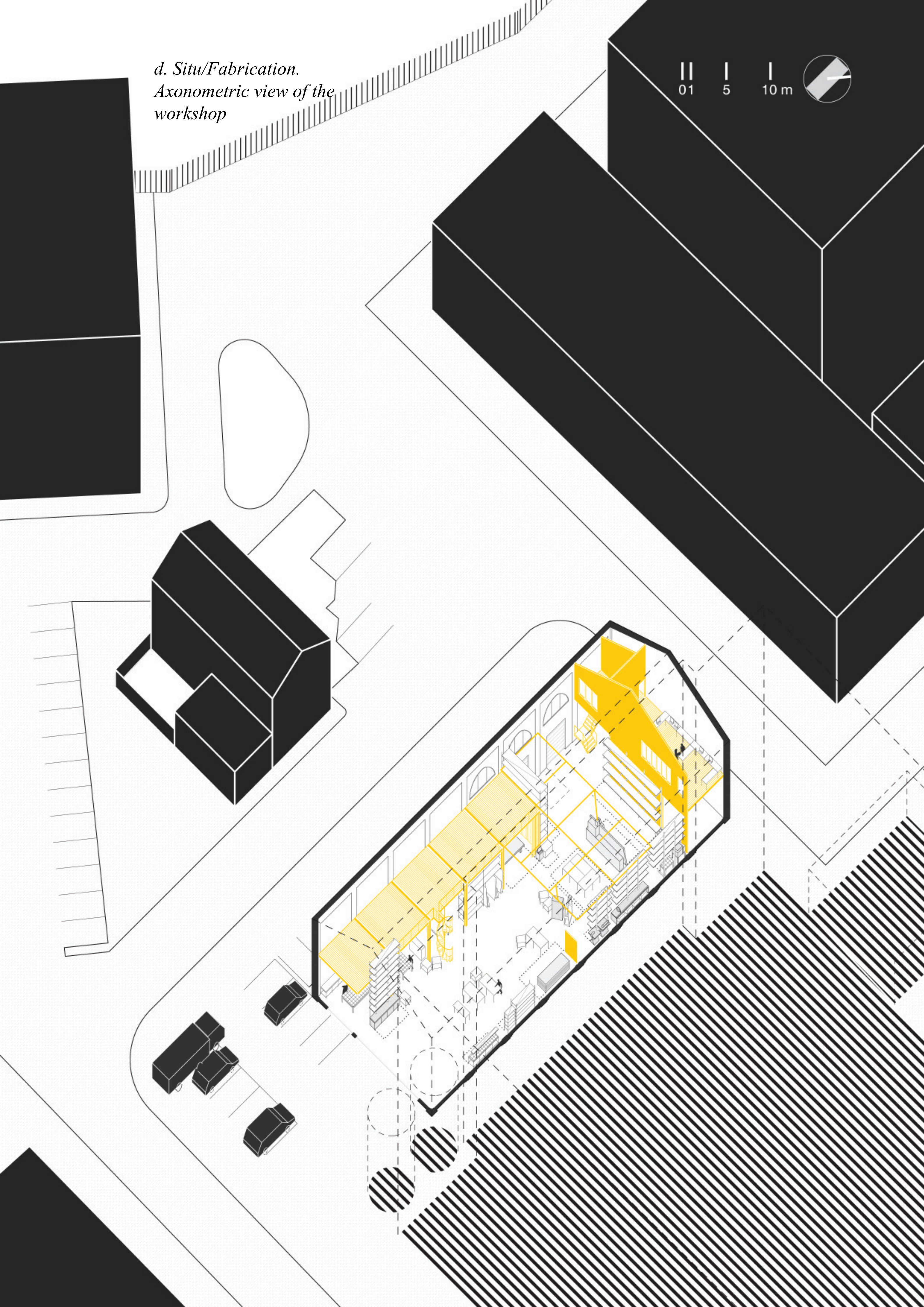
c.4. Plan and section

Section

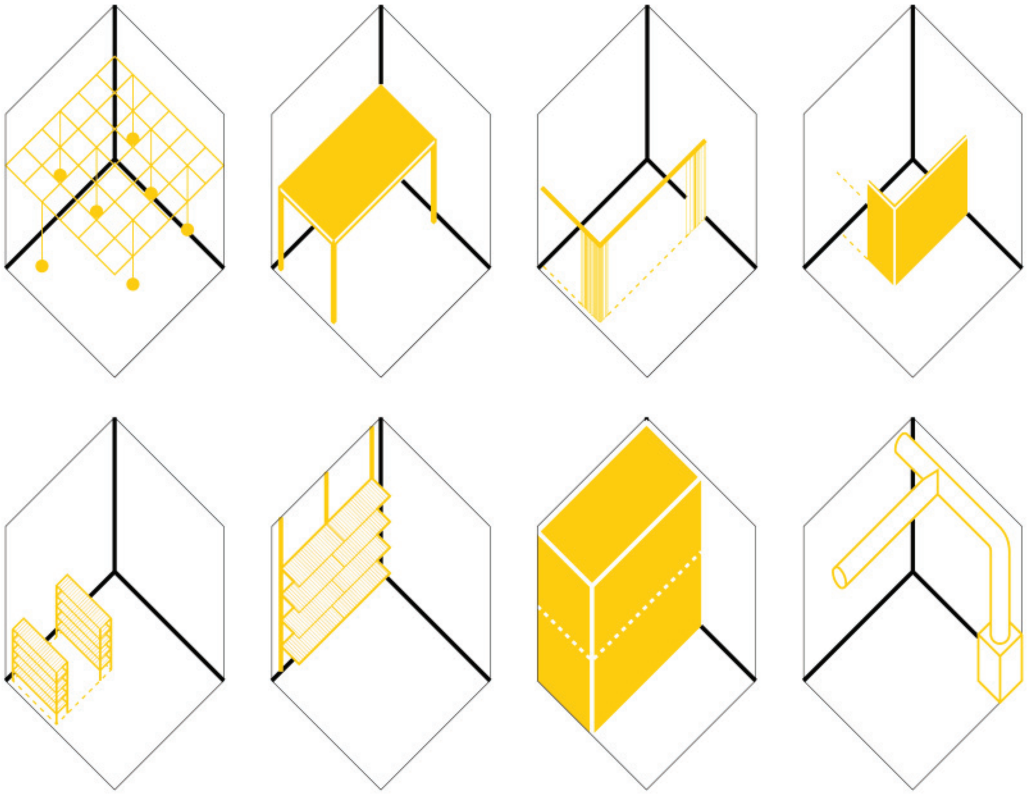


Plan

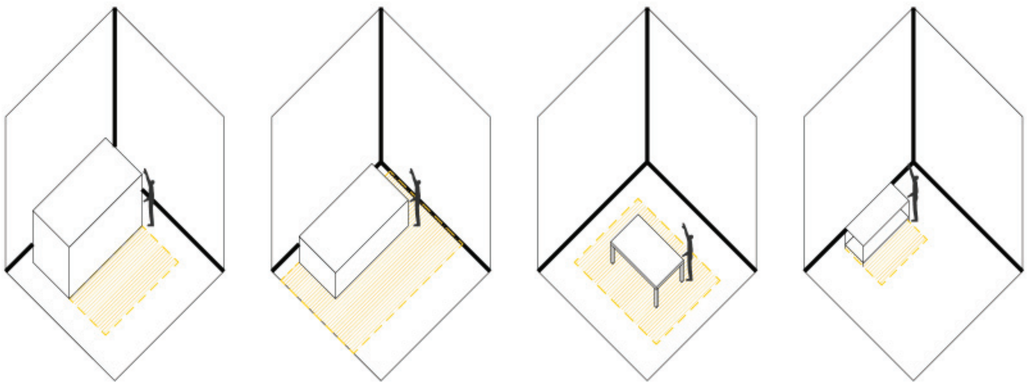
d. Situ/Fabrication. Axonometric view of the workshop



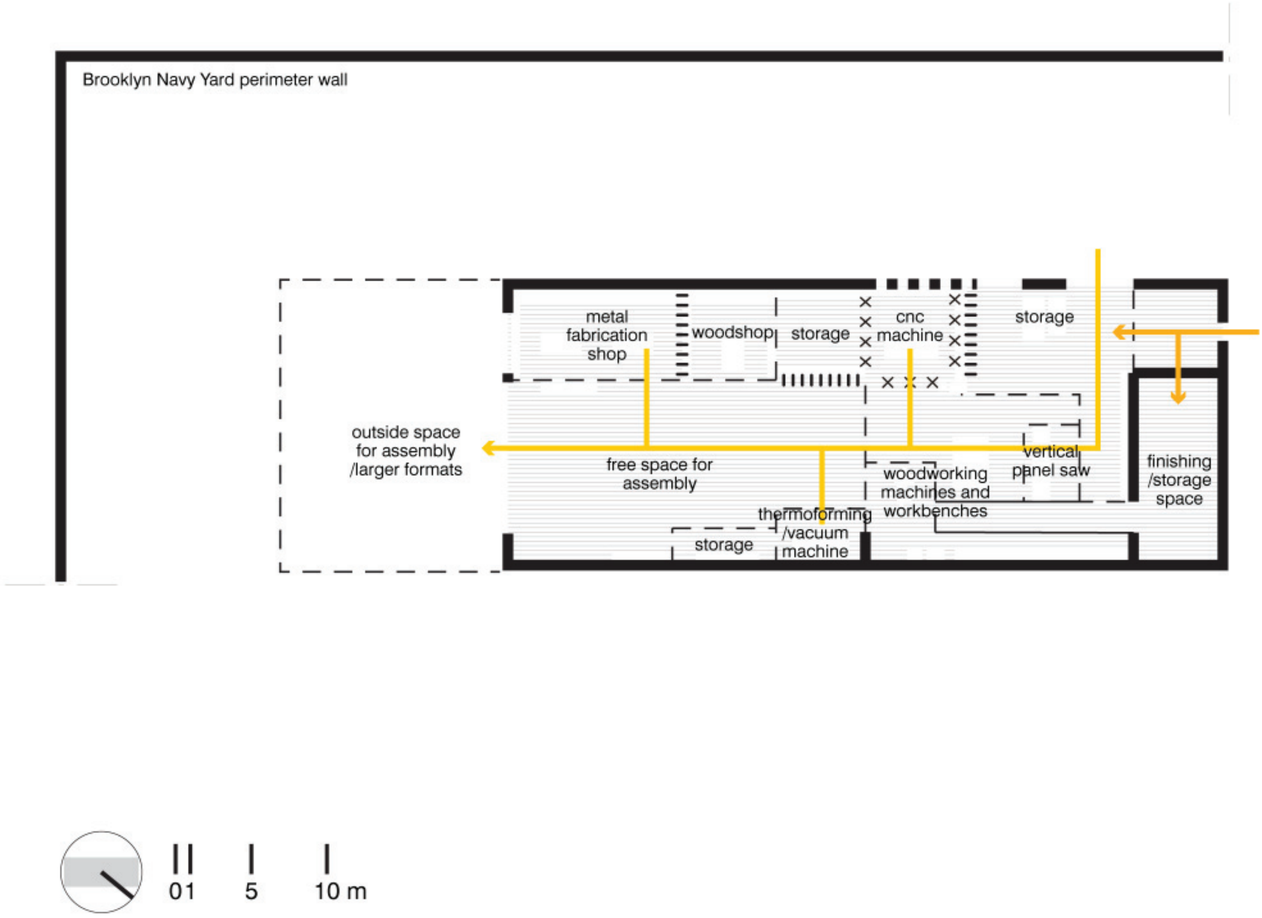
d.1. Organizers



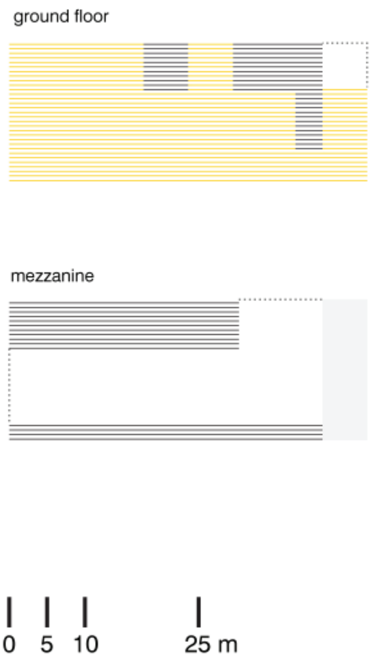
d.2. Operation units



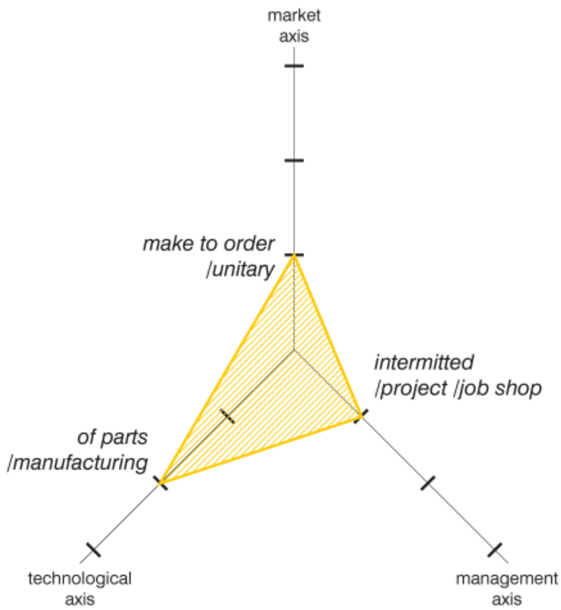
e. Situ/Fabrication. Workshop layout



f. Situ/Fabrication. Diagram of uses



g. Situ/Fabrication. 3-axix classification of production



h. Situ/Fabrication. Data table

Brooklyn Navy Yard					
Situ Fabrication	1155 sqm \\\ 100%	**Design**	**Production**	**Storage**	**Other**
		100 sqm	690 sqm	365 sqm	/
		9%	60%	31%	/

4.3 Ponyride, Detroit

The Empowerment Plan, Lazlo and Détroit Is the New Black[46]

The Empowerment Plan, Lazlo and Détroit Is the New Black are three small businesses located (at the time of the observation, October 2016) inside Ponyride's facility. Ponyride is a nonprofit organization that manages a collaborative space of socially-conscious entrepreneurs, triple bottom ground companies, nonprofits, makers, and artists in Coktown, Detroit. The three companies occupy two units on the first floor: one unit houses The Empowerment Plan and a small common kitchen, whereas Lazlo and Détroit Is the New Black share the second unit. The Empowerment Plan is a nonprofit organization that employs homeless individuals to manufacture a coat convertible into a sleeping bag that is then donated to homeless people and everyone in need. The business is mainly supported by direct donations ($125 per coat[47]). The founder Veronika Scott was involved in Ponyride's first renovation works. The company started inside the building in 2011 where it has grown until employing over 34 people.[48] At the beginning of 2018, from its 325 sqm space at Ponyride the company moved to a 1900 sqm facility in Detroit (West Village) where it has space to grow even more.

Lazlo established its cut-and-sew studio in Ponyride in 2015. It is dedicated to manufacturing sustainable tees using just organic cotton and fibers (the cotton industry one of the most polluting industry). Détroit Is the New Black is a fashion brand, located in Ponyride since 2016. It is dedicated to producing quality products by working with a short supply chain of local manufacturers. Beside its workshop in Ponyride, the company has its flagship store in downtown Detroit, where it offers retail space also to other Ponyride's residents and Detroit-based brands. Both Lazlo and Détroit Is the New Black are very small enterprises; besides the founders, they employ just 1-5 people at their Ponyride's workshop.

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[46] Some of the materials and information on Poniryde were part of the case study analysis realized by the author for the paper "Reuse for Production. How New Forms of Production Are Reshaping North-American Cities," presented at 2018 Urban Affairs Association Annual Conference held in Toronto on April 4-7, 2018 (unpublished paper). Paper co-authored with Maicol Negrello.

[47] The Empowerment Plan, "The EMPWR Coat."

[48] Ponyride, *5 Years Book*, 56.

Figure 4.14. Ponyride, Détroit Is The New Black and Lazlo space. Photo by the author.

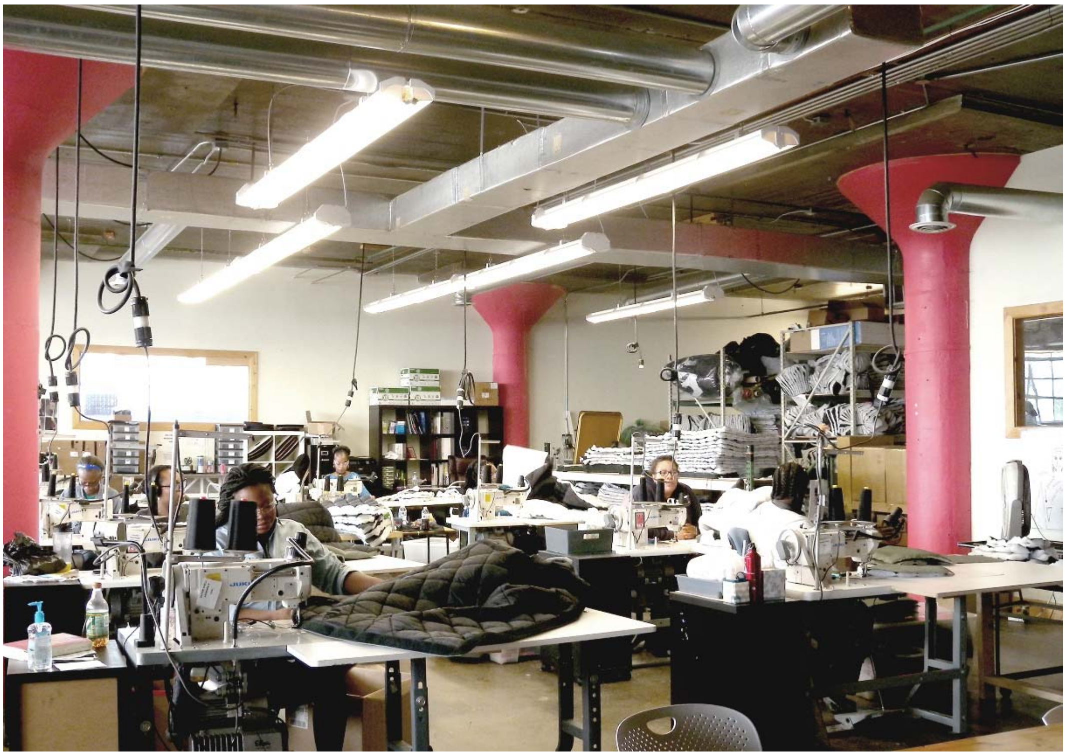

Figure 4.15. Ponyride, The Empowerment Plan space. Photo by the author.

Figure 4.16. Ponyride, public space and Anthology Coffee's entrance. Photo by the author.

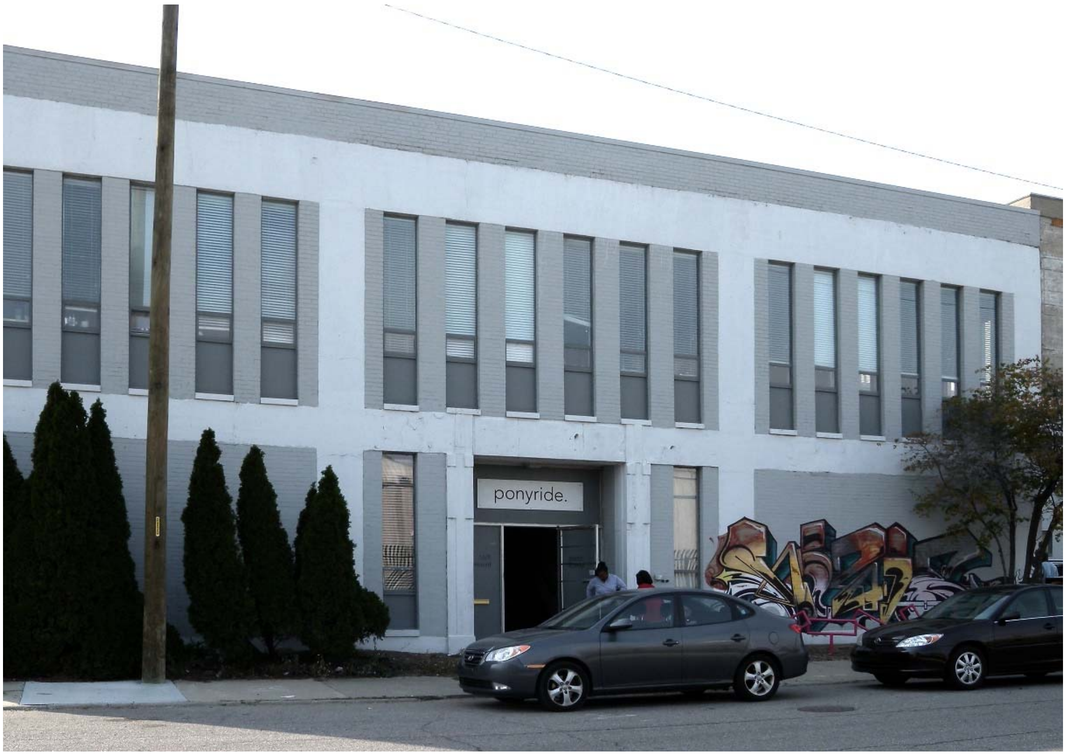

Figure 4.17. Ponyride, main entrance. Photo by the author.

Ponyride and the citywide context

Ponyride started in 2011 when Phillip Cooley bought a foreclosure property by a bank for $100,000. The former printing facility was designed in 1935 by Smith, Hinchman and Grylls for a letter graphic company working in the automotive industry. The building underwent an addition in 1955 and a renovation in 1985 to then shutting down in 2008.[49] Since the beginning, the Ponyride's mission has been for the building to become an asset to the local community. The owner opened the building to people interested in the space and let them free to it build-out. Consequently, most of the renovations have been realized by volunteer works with the support of the architectural design practice Laavu. Since 2011, the renovation work realized through hours of volunteer work and the employment of reclaimed material has accounted for roughly $200,000.[50] The renovation has mostly consisted of uncovering windows, floors, and structural bones as well as reconnecting utilities with the city grids.

The building has evolved from a former single-tenant industrial facility to a multi-tenant multi-purpose building. Around 70% of the space is dedicated to light-industrial activities with a shared woodshop and multiple rentable units, sometimes shared by two or three companies. The building also houses a coworking, artists' studios, and a dance studio. In 2016, over 60 tenants were renting a desk or space inside the facility: 44 on a month-to-month lease, 15 in studio spaces, 15 coworking memberships, 10 regular dance studio members.[51] Through the years, Ponyride has been taking shape more as a concept/business model and a community rather than a building. Its development has led to the awareness that the real story lies in the community rather than the building itself. Openness, diversity, and the mission of leveraging human and social capital potentials through collaboration and support are at the base of Ponyride's model. These concepts reflect in different choices made by the nonprofit as well as in the way space has been reoccupied. For instance, in the coexistence of a highly diversified mix of people, skills, and activities that often do not only operate inside Ponyride but also in other places or communities. Also, each tenant is required to provide at least six hours of free class and education programs per month, as a way for the resident to give back to the community.[52] Especially for industrial units, rents have been kept as below market as possible to allow enterprises to dedicate more resources to increase their employability and growth potential. Economic constraints, uncertainty on future developments, and an ever-expanding community of tenants have often led companies to share space units and amenities (like the three companies analyzed) without building new physical boundaries (unless noise and dust force it) – that would have also compromised the logistics and distribution inside the building. Spatial constraints and the

[49] Ponyride, *5 Years Book*, 13.
[50] Ponyride. "Our focus."
[51] Ponyride, 5 Years Book, 14.
[52] Ponyride. "Our focus."

stabilizing of the Corktown neighborhood after years of increasing attraction of people, capital, and businesses[53] had already led Ponyride to consider moving to a bigger space in a more distressed area.[54] In early 2018, after Ford announced the acquisition of the Michigan Central Station to be redeveloped as a mobility-focused campus, the owner of Ponyride's building Phillip Cooley finally decided to sell the building – a deal closed early this year (2019). Cooley foresaw an economically unsustainable future where he would have started asking for much higher rents as well as realized around $450,000 of major renovations to stay in compliance.[55] Until now, Ponyride has been offering rents starting from $86 sqm/Yr ($8 /SF/Yr) – the rent also includes utilities and other services. With the new redevelopment, within the next two years rents are expected to grow up to $194-$215 sqm/Yr ($18-20 /SF/Yr), which reflects the average market rent in the neighborhood. A rate that is expected to grow even higher moving towards the completion of Ford's new campus and other redevelopment projects that will be accompanied by a soon-to-be-developed new strategic plan for Greater Corktown by the city.[56] Across the entire city, leases for industrial and flex spaces range between $32-130 sqm/Yr ($3-20 /SF/Yr).[57]

Ponyride's parcel is zoned as Intensive Industrial District (M4), part of the Industrial Zoning Districts established by the Ch 61 Zoning Ordinance. This ordinance, approved in October 2018, updates Chapter 61 of the 1984 Detroit City Code, commonly known as the Detroit Zoning Ordinance. The ordinance recognizes five different Industrial Zoning Districts: M1-Limited Industrial District; M2- Restricted Industrial District; M3- M3-General Industrial District; M4-Intensive Industrial District; M5-Special Industrial District. Overall, these designations allow for different kind of industrial uses, from light-industrial in M1 to heavy-industrial (M4) and hazardous (M5) activities. While being manufacturing the ultimate desirable use, different types of businesses and commercial activities are encouraged while residential developments are not allowed except for loft conversions of existing buildings and housing combined in structures with permitted commercial activities.[58] This tool allows for light-manufacturing, and some industrial freight activities related to service and

[53] For instance, besides the residential and commercial redevelopments, Quicken Loans Data Center, Lightweight Innovations for Tomorrow (LIFT), and Institute for Advanced Composites Manufacturing Innovation (IACMI) Vehicles Scale-Up Facility have opened in recent years just right in front of Ponyride.

[54] Noah Elliott Morrison (Director, Ponyride), in discussion with the author, October 2016.

[55] Frank and Pinho, "Ponyride to move."

[56] See: Frank and Pinho, "Ponyride to move." For more information on the Ford's new campus see: Ford, "Michigan Central Station, Centerpiece of Ford's Corktown Campus," accessed April 18, 2019, https://corporate.ford.com/campuses/corktown-campus.html. For the Greater Corktown Strategic Plan see: City of Detroit Planning and Development Department, "Greater Corktown," Accessed April 17, 2019, https://detroitmi.gov/departments/planning-and-development-department/central-design-region/greater-corktown.

[57] Source: LoopNet (https://www.loopnet.com/). Industrial properties for lease in Detroit. Accessed April 16, 2019.

[58] See: The City of Detroit Ch 61 Zoning Ordinance, Article X: Industrial Zoning Districts. https://detroitmi.gov/document/ch-61-zoning-ordinance-october-14-2018.

commercial businesses also in some of the Business Zoning Districts[59] and Special Purpose Districts.[60] Here, the purpose is to create vibrant and diversified business and innovation clusters (hence job-generating clusters) mixing with or juxtaposing to residential areas.

Industrial Districts and part of the Business and Special Purpose Districts represent the legacy of Detroit's industrial heydays as well as the next attempts of the administration to retain and attract large car manufacturing companies during the second half of the XX Century. Detroit's industrial land proceeds mainly from its industrial development during and after WWII. When in 1940 President Roosevelt called the US to 'arm and support' the Allied powers during WWII, Detroit was soon recognized as the 'arsenal of democracy' to produce weapons and vehicles of war due to its strong automobile industrial sector.[61] Existing industrial plants were rapidly adapted to the new production, and many new ones were built in alternative to those factories inadequate to comply with new industrial needs. By the end of WWII, the city of Detroit had already assembled most of its current industrial legacy (both land and buildings), located along major transportation corridors, in proximity to residential neighborhoods, connecting the city with the industrial plants located in rural areas. After WWII, industrial plants shifted back to car manufacturing, and the city soon turned back to its mono-sector industrial economy. Due to wartime policies and the advanced in industrial production requiring ever-larger and ever-advanced plants, outward trends were already in motion, threatening Detroit's prosperity. In 1947 the Detroit City Plan Commission adopted the Generalized Plan of Land Use that aimed to retain industry in the city, close to where people were living, and to prevent job and population loss. The plan almost doubled the amount of industrial land in the city, as an attempt of assembling larger lots that would have attracted at least a share of the industrial production. "While many leaders were focused on the operations of urban renewal, Detroit's economy became more dominated by the automotive industry, just as the industry itself seemed to be moving out. According to June Manning-Thomas, 'Between 1947 and 1955, Chrysler, Ford, and GM built twenty new plants in the Detroit region, employing a total of 72,000 workers. Not a single one of these plants was located within Detroit …' […] While many firms

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[59] Among the Business Zoning Districts: B2-Local Business and Residential District; B4-General Business District; B5-Major Business District; B6-General Services District. See: The City of Detroit Ch 61 Zoning Ordinance, Article IX: Industrial Zoning Districts. https://detroitmi.gov/document/ch-61-zoning-ordinance-october-14-2018.

[60] Among the Special Purpose Zoning Districts: TM-Transitional-Industrial District; W1-Waterfront Industrial District; SD2-Special Development District, Mixed-Use; SD3-Special Development District, Technology and Research; SD4-Special Development District, Riverfront Mixed Use. See: The City of Detroit Ch 61 Zoning Ordinance, Article XI: Industrial Zoning Districts. https://detroitmi.gov/document/ch-61-zoning-ordinance-october-14-2018.

[61] Between 1900 and 1926 the city expanded through annexation from 7,250 hectares (28 square miles) to around 36,000 hectares (138,75 square miles). The expansion led to the inclusion of the industrial plants developed along major transportation lines and adjacent residential communities of workers. See: Kinkead, "Detroit Case Study," 1448; Detroit Historical Society, "Encyclopedia of Detroit. Arsenal of Democracy," accessed April 17, 2019, https://detroithistorical.org/learn/encyclopedia-of-detroit/arsenal-democracy.

would cite city taxes, codes, and requirements for their reasons to invest elsewhere, the reality was a shifting model of auto-production that valued large expansive sites for modern assembly production. Here, Detroit's previously abundant land area had become entirely built out, in many cases with low-density single-family homes, and without additional annexation (which would not happen) Detroit's ability to attract and maintain such auto-production facilities was slipping away. Moreover, the residents in the single-family homes, many of whom were also employed in the factories that were relocating to the suburbs, would soon find their way out too."[62]

The following decades were characterized by different variations of the same declining and outward trends. The City continued struggling between urban renewal and revitalization programs trying to confine increasing social discriminations and disparities, and trying to retain the automotive industry inside the city by assembling larges sites of industrial land (sometimes at the cost of residential communities). For instance, the 1992 Master Plan and the controversial Mayor Coleman Young's Auto Recovery Program that supported General Motors (1981, GM Detroit-Hamtramck Assembly Plant) and Chrysler Corporation (1991, expansion to east of Jefferson Ave) with the expansion and replacement of obsolete assembly plants with new efficient facilities – both realized as urban renewal programs (slum clearance).[63] Meanwhile, regional growth was attracting businesses and populations at a very high rate, directly proportionate to Detroit's decline. From its peak of 1.8 million in 1950 (29% of Michigan' population), Detroit's population dropped to 677,116 in 2016 accounting for just 7% of the state population.[64] The employment percentage held by Detroit compared to the region declines from 38% in 1970 to 13% in 2000.[65] "From 1969 to 2013, Detroit would have fits and starts of new development, but with its inability to attract or retain residents and businesses, less than 30,000 new building permits would be pulled in that forty-four-year span. Over the same time frame, nearly 190,000 demolition permits would be released in the city, and a staggering 828,000 new construction permits would be released across southeast Michigan."[66] In 2015, over around 37,000 hectares, 6,060 (23.4 square miles – 16.4%) were of vacant land and 2,512 (9.7 square miles – 6.8%) were of vacant and often blighted structures.[67]

For decades, the administration's initiatives remained attached to the mono-sectoral industrial model and were not able to offer alternative visions for the city's economy. Between the 1980s and 1990s, "the most dramatic shift in Detroit's economy has been in the area of producer service. Detroit has simply not been competitive in planning, management, financing, marketing, legal, or

[62] Kinkead, "Detroit Case Study," 1482–1491.
[63] Martelle, *Detroit. A Biography*. 225–236.
[64] MacDonald, "Detroit population rank."
[65] Kinkead, "Detroit Case Study," 1563.
[66] Kinkead, "Detroit Case Study," 1499–1508.
[67] Kinkead, "Detroit Case Study," 1629.

accounting services, in part because the city's economic elite have refused to recognize Detroit's potential as a center for such activities, and this has not backed any moves toward more producer services for the city."[68] A first attempt to envision alternative future land uses and development strategies came with the Land Use Task Force between 1994 and 1997 that resulted in the Detroit Community Reinvestment Strategy (CRS) whose recommendations were adopted by the 2001 Master Plan of Policies. These plans, together with the following 2006 Next Detroit Neighborhood Initiative (NDNI), started recognizing Detroit as a post-industrial city, consistently shrunk, and made of an ensemble of local communities that consistently differ in their struggles and potential. Even though the city continued its decline, important steps were made toward the strengthening of the educational, cultural, and service sector as well as towards the first industrial land conversions.[69] Regardless, the 2009 update of the Master Plan of Policies partly failed to continue this path while it simply mirrored the past of the city in its land use definition.[70] One of the most significant experiences for Detroit was the 2-year initiative launched in 2010 as Detroit Works, that worked closely with local communities, stakeholders, and teams of professionals to develop the Detroit Future City Strategic Framework, released in 2012. The plan did much more than a mere land use revision; it was finally able to convey a new comprehensive perspective on the city and its future (50-year vision) by aligning assets with opportunities and mapping a framework that coordinates investment with opportunities.[71] Detroit Future City Strategic Framework built up from the identification of five main assets: economic growth, land use, city systems, neighborhoods, land and building assets. "The Economic Growth Element proposes five strategies to grow Detroit's economy in a way that is equitable for all Detroiters, support Detroit's economic sectors, and can attract new residents and businesses. […] The Land Use Element offers land use strategies that are situated between the city's existing conditions and a range of preferred futures. […] The City Systems Element describes the imperative of moving toward a more affordable, efficient, and environmentally sustainable city through reforms to the service delivery throughout the city, and through the transformation of the systems and networks that carry the city's water, waste, energy, and transportation. […] The Neighbourhood Element proposes six specific strategies to create a diverse range of neighborhood styles and choices that will appeal to a wide variety of people, while strengthening all neighborhoods across the city. […] To transform the Vacant land of Detroit into a potential asset for the city's future, the Land and Building Assets Element calls for all different public agencies that

[68] Rich, *Coleman Young*, 133.

[69] Conversely to New York and San Francisco where land conversion represents a threaten for industrial businesses, in the context of Detroit it can be considered a positive sign. It shows the existence of interest on that land that can lead to redevelopment project.

[70] See: Planning and Development Department Strategic Planning, "Master Planning. Master Plan of Policies," accessed April 17, 2019, https://detroitmi.gov/departments/planning-and-development-department/strategic-planning/master-planning.

[71] Detroit Future City, *2012 Detroit Strategic Framework Plan*, 3.

hold land to align their missions around a single, shared vision. This collaborative effort must reflect the aspirations for the city as a whole, as expressed in its land use and environmental plans, economic growth strategies, and neighborhood revitalization efforts. Such a transformative strategy must provide an integrated approach to land and buildings across the entire city, whether publicly or privately owned."[72] For each asset, the plan proposes some transformative ideas and the implementation strategies and actions that would enhance such transformations as well as few 'must do' addressing more urgent challenges. Within the Economic Growth asset, the plan establishes the Employment Districts, going beyond the traditional Euclidean zoning. For each district, the plan identifies the predominant economic sector and the potential businesses that would thrive due to the neighborhood's characteristics, to then laying down strategies to leverage the districts' employability potential.[73] Despite never turning into an official regulatory tool (right after its release, the City of Detroit filed for bankruptcy in 2013), Detroit Future City became first a program of the Detroit Economic Growth Corporation (2013) and then an independent nonprofit (2015) that keeps working and promoting the strategic vision in partnership with residents and public and private stakeholders. More importantly, the Detroit Future City's vision became the starting point for the new director of Planning and Development Department (PDD), Maurice Cox (appointed by the Mayor in 2015).

Among the actions already taken by the PDD, two non-zoning designations that superpose to the master plan are expected to contribute to the urban economy and attract new businesses – including urban manufacturing, considered as a form of social and economic innovation. Launched in 2016, the initiative "Pink Zoning Detroit" (now called Mix Tape Zone) aims to transform the city's complex land use rules and ease the permitting process to certain small-scale business developments in order to speed new development in its commercial corridors.[74] Also, they continued and improved the 2014 Detroit Innovation District, an outgrowth of the Detroit Future City's Economic Growth Plan. The Innovation District identifies a strategic area already occupied by leading research and innovation institutions (e.g., Wayne State University, Detroit Medical Center, Detroit Institute of Art, College for Creative Studies, Henry Ford Health System, Tech Town, etc.) and where supporting the expansion of this innovation and tech

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[72] Detroit Future City, *2012 Detroit Strategic Framework Plan*, 18–19.

[73] Detroit Future City, *2012 Detroit Strategic Framework Plan*, 59–77.

[74] For more information about the Pink Zoning, see: Planning and Development Department, "Mix Tape Zoning.Transforming Detroit's complex land use regulations into a positive force for neighborhood revitalization," accessed April 17, 2019, https://detroitmi.gov/departments/planning-and-development-department/zoning-innovation-and-historic-preservation/mix-tape-zoning; SmithGroup, "Mixtape Detroit," accessed April 17, 2019, https://www.smithgroup.com/projects/mixtape-detroit.

economy and improve the industrial infrastructures – the area accounts for 55% of Detroit's jobs in just 1140 hectares (4.4 square miles).[75]

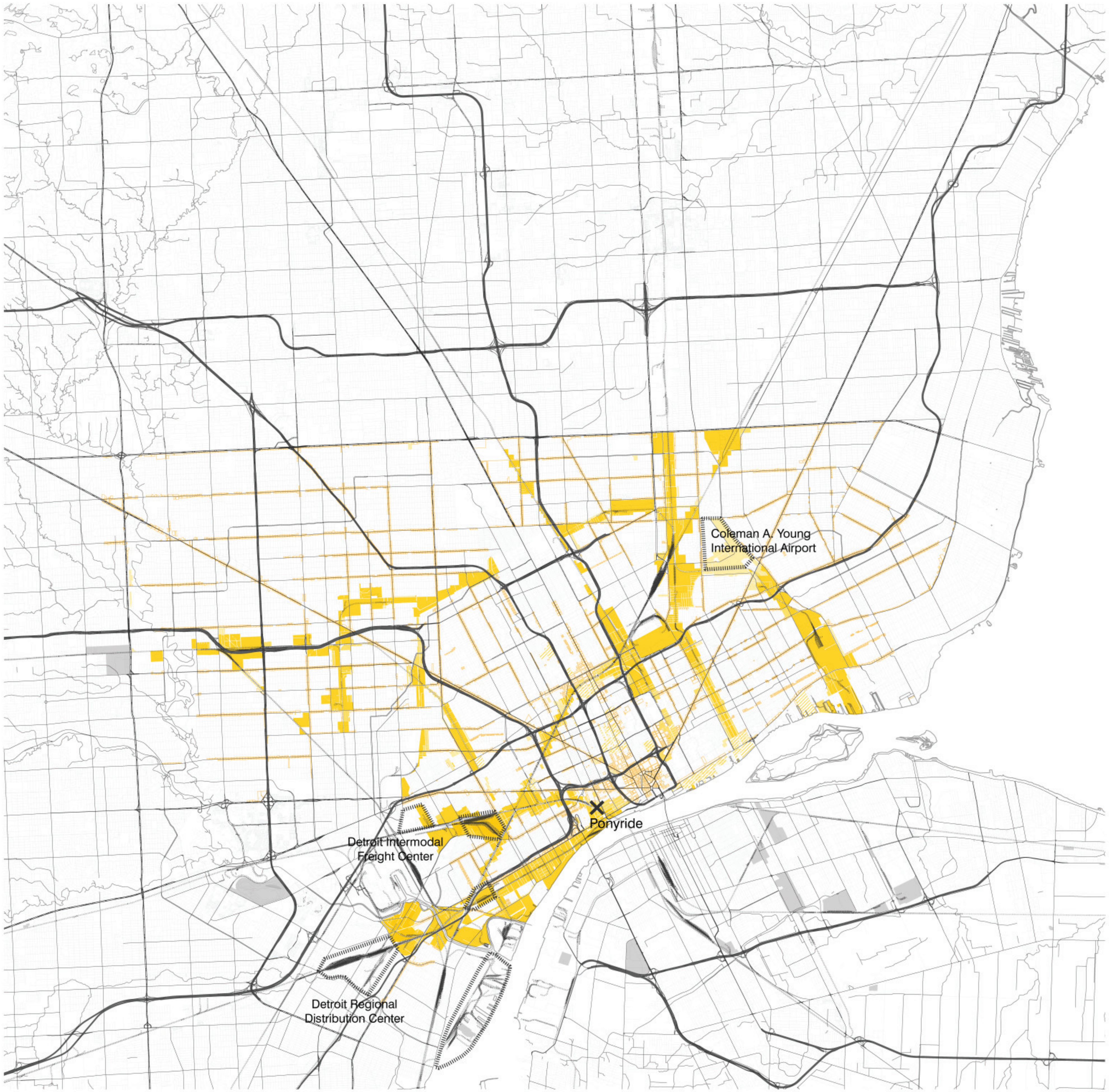
Regardless of the positive visions expressed by these initiatives (a positivity that often match with the reality), the city is still dealing with unemployment, uneven development throughout different neighborhoods, social disparities, and blight. On the other side, in times of deep crisis, people have been reinventing entrepreneurship and the way of doing businesses (e.g., Ponyride, Shinola, Floyd, The Empowerment Plan, Detroit Soup, etc.) by leverage available spatial, capital, and human resources. For instance, vacant land, buildings (e.g., Eastern Market and its network of producers[76]), and the city's research and innovation design legacy from the industrialization period (e.g., in 2015, Detroit received the UNESCO City of Design designation, establishment of the Design Core and the College for Creative Studies, the launch of the 2018 Detroit City of Design Action Plan[77]).

[75] For more information about the Innovation District, see: Interface Studio, "Detroit Innovation District," accessed April 17, 2019, http://interface-studio.com/projects/detroit-innovation-district.

[76] See Eastern Market website https://www.easternmarket.org/.

[77] See: Design Core Detroit, "Detroit City Of Design: Background," accessed April 18, 2019, https://designcore.org/detroit-city-of-design/overview/; Design Core Detroit, *2018 Detroit City of Design ACTION PLAN. Leveraging Detroit's UNESCO City of Design designation to drive inclusive growth*, https://designcore.org/wp-content/uploads/2018/06/OG-Detroit_ActionPlan_Exo_180410_final_web.pdf.

a. Industrial Detroit



- M5 - Special Industrial District
- M4 - Intensive Industrial District
- M3 - General Industrial District
- M2 - Restricted Industrial District
- M1 - Limited Industrial District
- Business Zoning Districts: B2-Local Business and Residential +B4-General Business + M5-Major Business + B6-General Service
- Special Purpose Zoning Districts: TM-Transitional-Industrial + W1-Waterfront-Industrial + SD2-Special Development District, Mixed-Use + SD4pecial Development District, Riverfront Mixed Use
- Industrial Land (outside Detroit)
- Commercial terminals (marine, air, intermodal yards)
- Through Truck Routes
- Freight Rail Network
- Local freight routes

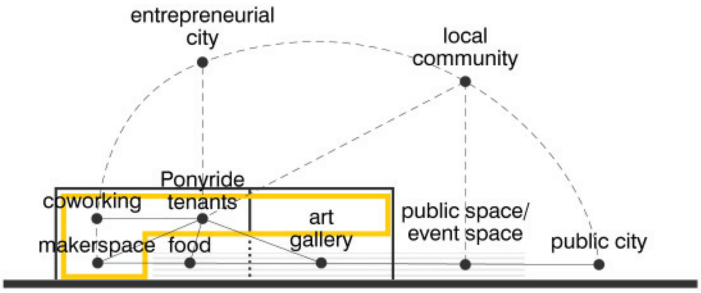
0 1000 2500 m

b. Corktown. Accessibility and footprints


0 50 100 250 500 m

c. The Empowerment Plan, Lazlo, Détroit Is the New Black. Spatial strategy

c.1. City-Production



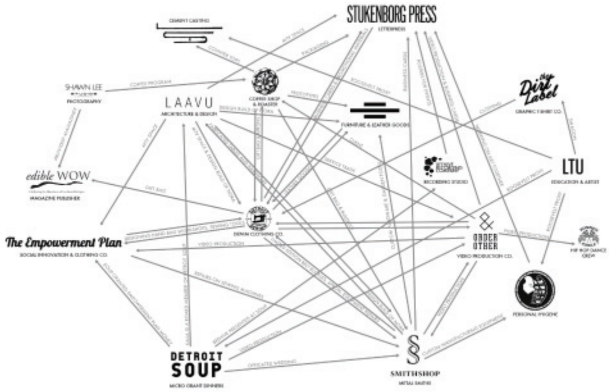
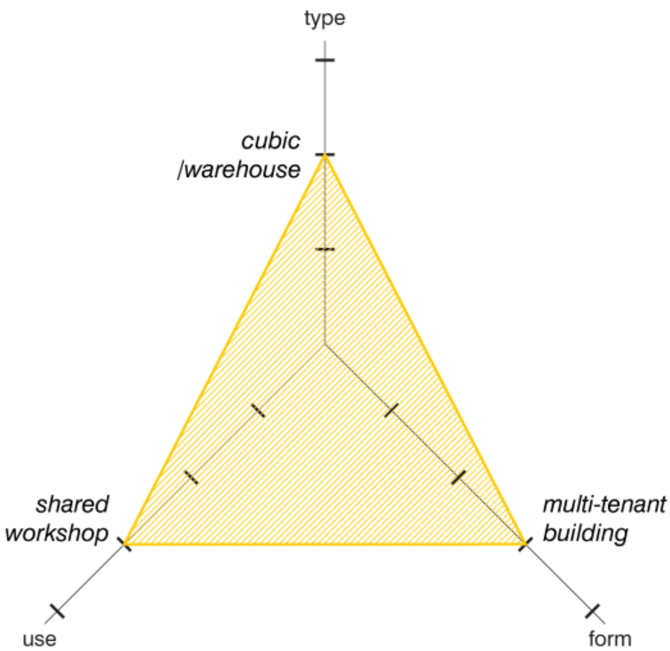
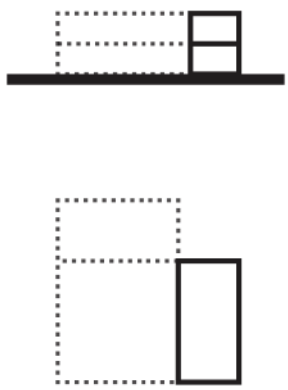


Figure retrieved from: Ponyride, *5 Years Book*, 84-85.

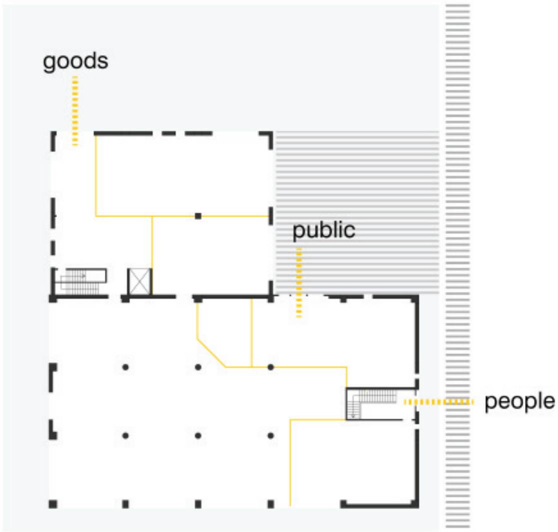
c.2. 3-axis form-type-use



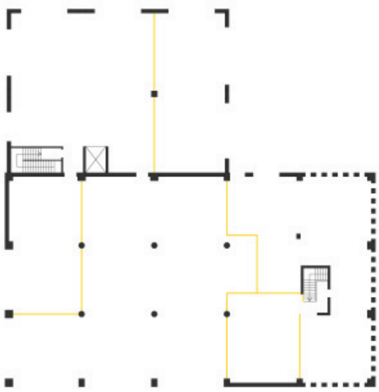
c.3. Diagram



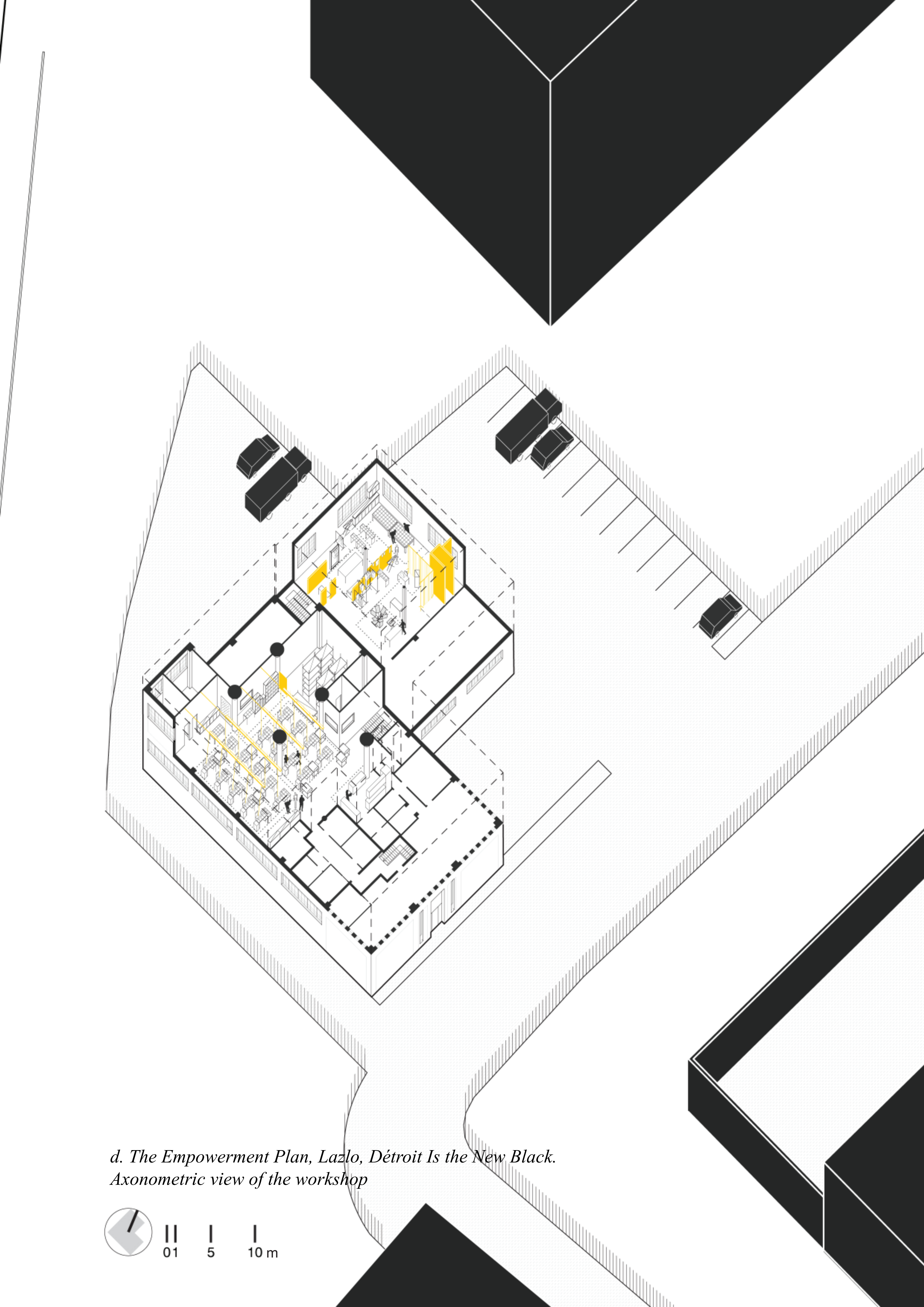
c.4. Plan and section



Ground floor

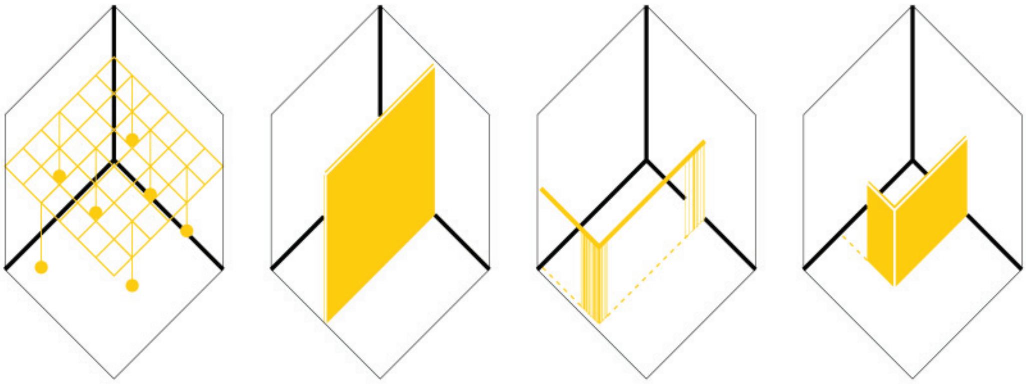


First floor

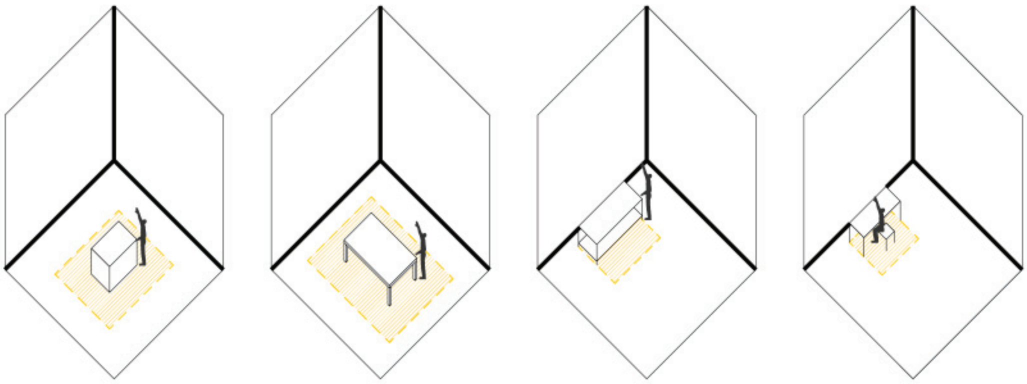


d. The Empowerment Plan, Lazlo, Détroit Is the New Black.
Axonometric view of the workshop

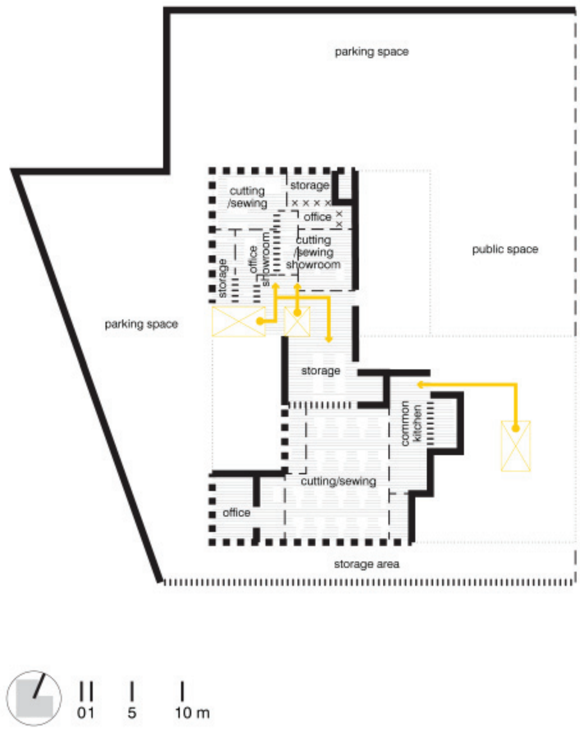
d.1. Organizers



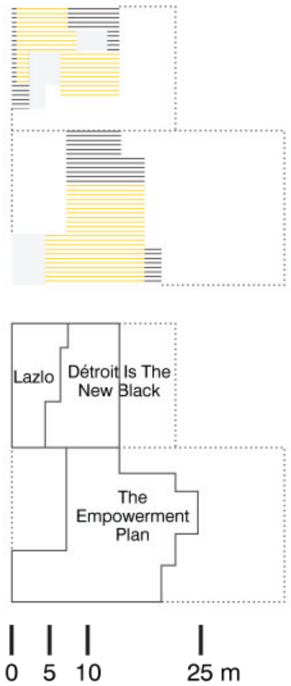
d.2. Operation units



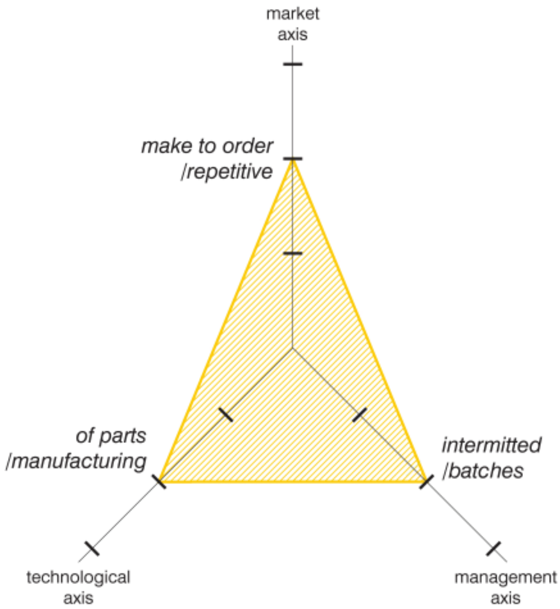
e. The Empowerment Plan, Lazlo, Détroit Is the New Black. Workshop layout



f. The Empowerment Plan, Lazlo, Détroit Is the New Black. Diagram of uses



g. The Empowerment Plan, Lazlo, Détroit Is the New Black. 3-axix classification of production



h. The Empowerment Plan, Lazlo, Détroit Is the New Black. Data table

<table>
<tr><th colspan="7">Ponyride</th></tr>
<tr><td rowspan="2">n. tenants: 18 + 4 multi-tenant spaces: woodshop, dance studio, coworking, artist residency</td><th>Tot.</th><th colspan="3">Industrial</th><th>Other</th><th>Distribution</th></tr>
<tr><td>2400 sqm</td><td colspan="3">1630 sqm</td><td>710 sqm</td><td>60 sqm</td></tr>
<tr><th rowspan="3">Détroit Is The New Black</th><td rowspan="3">90 sqm \\\ 3%</td><th>Design</th><th>Production</th><th>Storage</th><th colspan="2">Other</th></tr>
<tr><td>10 sqm</td><td>55 sqm</td><td>25 sqm</td><td colspan="2">/</td></tr>
<tr><td>11%</td><td>61%</td><td>28%</td><td colspan="2">/</td></tr>
<tr><th rowspan="3">Lazlo</th><td rowspan="3">90 sqm \\\ 3%</td><th>Design</th><th>Production</th><th>Storage</th><th colspan="2">Other</th></tr>
<tr><td>30 sqm</td><td>45 sqm</td><td>15 sqm</td><td colspan="2">/</td></tr>
<tr><td>33%</td><td>50%</td><td>17%</td><td colspan="2">/</td></tr>
<tr><th rowspan="3">The Empowerment Plan</th><td rowspan="3">325 sqm \\\ 13,5%</td><th>Design</th><th>Production</th><th>Storage</th><th colspan="2">Other /common space</th></tr>
<tr><td>30 sqm</td><td>160 sqm</td><td>70 sqm</td><td colspan="2">65 sqm</td></tr>
<tr><td>9%</td><td>50%</td><td>21%</td><td colspan="2">20%</td></tr>
</table>

4.4 Lawrenceville Technology Center and 7800 Susquehanna Street, Pittsburgh

Carnegie Robotics and the Lawrenceville Technology Center[78]

Carnegie Robotics is a spin-off enterprise of Carnegie Mellon University's National Robotics and Engineering Center (NREC). Founded in 2010, it is dedicated to design and manufacture robotics systems, technologies, and components for defense, commercial and industrial application.

In 2013, the company signed a long-term lease with the Regional Industrial Development Corporation (RIDC) for the occupation of the former foundry, part of the abandoned Happenstall Steel Company. The site is adjacent to the NREC building; a former foundry renovated in 1996. The RIDC is an industrial nonprofit developer that acquired the Happenstall site in 2002 and completed its preparation (demolitions) and remediations in 2012. The renovation was carried out in collaboration with the RIDC and the Pittsburgh-based architectural practice Desmone Architects. From its establishment in this space, the company has grown up to over 60 employees, "about 35 of whom are engineers. Over the next two to three years, the firm expects to grow to about 100 employees, with most of the growth on the production side."[79]

The project maintains the structural frame of the building, which internally defined two longitudinal sections. On one side, the integrity of the space initially designed as a single-story high-bay industrial shed is maintained. This section is dedicated to projects dealing with larger robotic pieces and equipment. The company often carries out individual projects commissioned by government agencies as well as private companies that require privacy protection. Hence, a series of portable panels define enclosed spaces (*corrales*) for each project. Size and distribution of the corrals change according to the nature of the commissioned project. For privacy reason, the drawings do not show machinery or specific information regarding the activities carried out inside the *corrales*. In the second section of the building, a new 2-floor structure provides space to smaller, quieter or cleaner operation, with clean room assembly labs, offices, and common spaces.

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[78] Some of the materials and information on the Lawrenceville technology Center were part of the case study analysis realized by the author for the paper "Reindustrializzazione e no-profit: Pittsburgh e il caso della Regional Industrial Development Corporation," presented at the XX Italian Society of Urbanists (SIU) Conference (XX Conferenza SIU Società Italiana degli Urbanisti) held in Rome on June 12-14, 2017. Paper co-authored with Roberta Ingaramo, with whom were conducted the site visits to the Lawrenceville Technology Center and Keystone Commons on September 2016. See: Roberta Ingaramo and Caterina Montipò. ""Reindustrializzazione e no-profit: Pittsburgh e il caso della Regional Industrial Development Corporation," in *Atti della XX Conferenza nazionale SIU, Urbanistica e/è azione pubblica. La responsabilita' della proposta, Roma 12-14 giugno 2017* (Roma-Milano: Planum Publisher, 2017) 1916–1926.

[79] Schmitz, "Transforming an Industrial Building."

Carnegie Robotics is part of the Lawrenceville Technology Center (LTC), an area of 5.6 he redeveloped and managed by RIDC located along the Allegheny River in the Lawrenceville neighborhood. In addition to the Carnegie Robotics facility, the LTC includes other two buildings: the Chocolate Factory, acquired by the RIDC in 1996, and the newly constructed Tech Forge, completed in 2017 over part of the Happenstall's reclaimed brownfield. Overall, the three buildings offer over 15,600 sqm to over 15 fast-growing companies operating in the robotics, biotech, engineering, and high-tech sectors.[80] Types of tenure across the facilities of the LTC vary consistently (terms undisclosed) according to businesses' needs and potentials. They range between long-term leases, like Carnegie Robotics and Caterpillar at Tech Forge, to shorter leases or monthly-based rents, like the Chocolate Factory's 'turnover unit' that over the years became the temporary workspace for manufacturing and robotics companies looking for a space in Pittsburgh.[81] Lawrenceville Technology Center has consistently fostered the redevelopment of the industrial strip (Strip District-Lawrenceville) developing along the Allegheny River. Robotic and high-tech companies are repurposing vacant warehouses and sites in an area that until a few years ago was largely abandoned. Along with this positive trend, the area is also facing socio-economic pressure, especially in the real estate market, for the convergence of commercial, residential, and industrial interests.[82]

Figure 4.18. Carnegie Robotics, exterior. Photo by the author.

[80] Regional Industrial Development Corporation. *2016 Year in Review*; Regional Industrial Development Corporation. *Annual Report 2017*; Timothy White (Senior Vice President, Development of RIDC), in discussion with the author, April 2017.

[81] Timothy White (Senior Vice President of Development, Regional Industrial Development Corporation) in discussion with the author, April 2017.

[82] For a more comprehensive understanding of the 'renaissance' of Pittsburgh as a post-industrial economy focused on innovation, education, and industry see: Carter, "Pittsburgh case Study," 2935–3539; Andes et al., *Capturing the next economy*.

BoXZY and 7800 Susquehanna Street

BoXZY is a small enterprise (range of 5-15 employees) based in Pittsburgh that produces a desktop all-in-one 3D printer/CNC mill/laser engraver. Founded in 2014 by Joel and Justin Johnson, the business started at Pittsburgh Tech Shop[83] and soon expanded into a dedicated production space at 7800 Susquehanna Street in 2015, still maintaining a small office and its membership at Tech Shop (until it shut down).

7800 Susquehanna Street is a former Westinghouse Electric plant in the Homewood neighborhood in Pittsburgh. After its dismission, the building has been underutilized by a CNC components producer until 2013, when Bridgeway Capital[84] acquired the building with the intent of repurposing it as a multi-tenant industrial and economic hub.[85] With the last floor still vacant, in 2017 the building housed 20 businesses between manufacturing companies, artists' studios, job training organizations.[86] The reuse has consisted of cleaning and securing spaces at each floor, installing the utilities, and adding a passenger elevator and a new volume on the ground floor. Each floor has been subdivided into smaller units whose size changes based on companies' needs – units range between 80 and 1000 sqm. Tenants share distribution and logistics elements, like freight elevators and loading docks as well as a shared space. BoXZY occupies a 450 sqm units on the second floor. Space has been left entirely open, except a small space dedicated to carrying out occasional more dusty operations.

Inspired by projects like the Brooklyn Navy Yard and the Greenpoint Manufacturing and Design Center in New York (see chapter 5.2), 7800 Susquehanna aims to offer relatively affordable space (10-20% below market[87]) and resources to different income-generating activities. Bridgeway Capital has been attracting to the building local enterprises deeply networked with other local businesses as well as with the leading actors in the innovation, education, and economic assets ecosystem in Pittsburgh.[88]

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[83] In November 2017 the chain of makerspaces Tech Shop filed bankruptcy, consequently shutting down all its location (10 throughout the US). Since its opening in 2013, Pittsburgh's Tech Shop (closed in September 2017) has been an asset for the entire city. Besides the collaboration with schools and universities, the makerspace has seen emerging many startups and small businesses, some of which have been able to grow outside of it - some example are BoXZY, Kerf Case, Puzzle Pax, Frost Finery, Conturo Prototyping. Due to its key role in Pittsburgh's industrial ecosystem, Tech Shop's members and staff have founded a new nonprofit called Protohaven that recently opened a new 300 sqm makerspace in the Wilkinsburg community (right across the street from 7800 Susquehanna Street). See also: https://www.protohaven.org/.

[84] Bridgeway Capital is a Community Development Financial Institution (CDFI).

[85] Matthew Madia (Chief Strategy and Development Officer), in discussion with the author, July 2017. See also: Montipò, "Stati Uniti, così si sono riciclate le fabbriche/2."

[86] See: Bridgeway Capital, "7800 Susquehanna Street."

[87] Matthew Madia (Chief Strategy and Development Officer), in discussion with the author, July 2017.

[88] Unfortunately, no specific data has been provided to the author by the interviewees.

Figure 4.19. 7800 Susquehanna Street. Photo by the author.

Innovation rows and the citywide context

BoXZY and Carnegie Robotics embody two poles of the same developing innovation economy in Pittsburgh.[89] On one side, BoXZY emerged from the maker economy, fueled by local communities of craftsmen, artists, and DIY enthusiast (also connected with universities). These types of economic and cultural activities tend to occupy abandoned warehouses, industrial and commercial facilities in a strip comprised between Bakery Square and Wilkinsburg and between three important transportation lines: Penn Ave, the railway track (legacy of the industrial era) and the dedicated busway. On the other side, Carnegie Robotics belongs to the highest levels of research and education, the same network from which it has emerged. It is part of the 'robotics row' taking shape inside old warehouses and industrial facilities from the former steel plants in the Lawrenceville neighborhood toward the entire Strip District (one of the major commercial terminals of the city during the industrialization). In both areas, for industrial and flex spaces leases range between $65-108 /sqm/Yr ($6-10 /SF/Yr).[90]

7800 Susquehanna Street is located at the fringe of an industrial area in Point Breeze North, where more and more industrial activities have reoccupied vacant buildings in the last decade, and south of Homewood, a low-income neighborhood on its way of recovery from decades of abandonment since the 1970s-1980s. The industrial area that includes 7800 Susquehanna is zoned as Urban Industrial District (UI). Besides UI, the current Zoning Code establishes other two industrial designations: General Industrial District (GI), and

[89] See: Andes et al., *Capturing the next economy*.

[90] Source: LoopNet (https://www.loopnet.com/). Industrial properties for lease in Pittsburgh. Accessed April 20, 2019.

Neighborhood Industrial District (NDI). Inherited from the 1923 Zoning Ordinance and Zone Map, these industrial districts partly reflect the industrial geography of the early XX Century. Originally, this fist zoning ordinance distinguished only between heavy-industrial areas (mainly dedicated to industrial plants located along the rives), light-industrial areas (along the rivers and railways), commercial, and residential.[91] While the spatial definition of zoning districts has been kept almost the same, the characteristics of many industrial and working-class neighborhoods have consistently changed throughout the almost 100 years from the 1923 ordinance[92] – leading to variations in permitted uses and the detailing of designations and subdistricts.

Despite the designation, today UI, NDI, GI are all considered mixed-use – the same is true for Highway Commercial District (HC) that share similar characteristics. They allow manufacturing, warehousing activities, laboratory and research services to different extents, being NDI the most restrictive (manufacturing subject to performance standards) and GI the most permissive (allowing by right also manufacturing spaces of over 1,800 sqm). Contextually, different mixed-use patterns of housing, employment, and shopping opportunities are allowed as well (by right or under permit). In GI and UI districts, the code explicitly encourages the adaptive reuse of older industrial buildings for high-density multi-unit residential development.[93] Supposedly, These districts are the ones dedicated to retaining industrial land and include most of the city's legacy of warehouses and multi-story industrial buildings that today represent the physical backbone supporting the development of Pittsburgh's innovation economy. Most of the start-ups and companies operating in anchor sectors of innovation like robotics, advanced manufacturing, and life and science, seek these existing industrial spaces because of their characteristics (high-bay, good loadbearing capacity, flexibility, etc.), strategic location (in proximity to universities and talents), and affordability (they usually can't afford to build new ones).

Most of the heavy-industrial land and brownfields located along the riversides have been reclaimed and rezoned first as Specially Planned Districts (SP) and then as Riverfront Districts (RIV). SP areas leave reclaimed brownfields open to the development of site-specific master plans. Some examples are the Almono/Hazelwood Green, Smallman Street improvement plan (Strip District), and the Pittsburgh Technology Center.[94] Riverbanks have been the setting of

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[91] See: City of Pittsburgh Zoning Ordinance and Zone Map, 1923, https://archive.org/details/zoningordinancez1923pitt.

[92] Raymond W. Gastil (AICP, Director of Pittsburgh City Planning), in discussion with the author, September 2016.

[93] See: The Pittsburgh Code, Title Nine, Zoning Code, Article II, Chapter 904-Mixed Use Zoning Districts.

[94] See: Hazelwood Green, "The Plan. SP-10 District Preliminary Land Development Plan & Zoning," accessed April 21, 2019, https://www.hazelwoodgreen.com/plan; Bill O'Toole, "City unveils preliminary designs for Smallman Street bike lanes, walking and transit," *Next Pittsburgh*, February 7, 2019, https://www.nextpittsburgh.com/city-design/city-unveils-preliminary-designs-for-smallman-street-bike-lanes/; Regional Industrial Development Corporation, "Pittsburgh

Pittsburgh's industrial development between the early XIX Century and the post-war period. Steel plants, factories, and warehouses concentrated on the flatlands along the rivers (and later along railroads too) while residential neighborhoods developed up on the hills adjacent to industrial plants. By the end of the Civil War, the Pittsburgh region was producing 50% of iron and glass (and much of the oil) in the US. Industry-related sectors like banking, retail, housing, and entrepreneurship saw a rapid development too. Between 1870 and 1910, the population grew from 86,076 to 533,905 and by 1950[95] it had reached its peak at 677,000.[96] Industrial development came with as much pollution as economic prosperity. In 1943, Pittsburgh saw a first step toward tackling pollution problems with the 'Renaissance I,' established by the collaboration between the Democratic Mayor David L. Lawrence and the Republican businessman Richard King Mellon. This first attempt was followed by the 'Renaissance II' launched in 1977 by Mayor Richard Caliguiri.[97] These initiatives opened a period of environmental measures, consistent investments in redevelopment projects (framed of course in the US debate on urban renewals) as well as cultural and philanthropic initiatives. Within this framework, two agencies that became key players during the following decades emerged. First, in 1946, the Urban Redevelopment Authority (URA),[98] an economic development agency of the City of Pittsburgh dedicated to a wide range of planning, economic, and community redevelopment projects – often becoming more influential (or even the predominant decision maker) than City Planning in strategic planning processes. Second, in 1945, CEOs of Pittsburgh's corporations, banks, private foundations, and universities created the Allegheny Conference on Community Redevelopment (ACCD) to lead Pittsburgh's renaissance. In 1955, the ACCD founded the Regional Industrial Development Corporation, a private nonprofit committed to tackle the undiversified economy of Pittsburgh through strategic industrial real estate operations at the regional level dedicated to light manufacturing and small and medium enterprises.[99]

In the 1980s, industrial decline reached its bottom with 75% of the steelmaking capacity vanished, 130,000 manufacturing jobs lost, and unemployment at 18%.[100] During ths period, the URA and RIDC collaborated and contributed to most of the brownfield remediations and redevelopment projects, most of which occurred on the former industrial hotbeds along the riversides. Since its establishment, the RIDC has dedicated to the diversification of the region's economic sector. Until the 1970s, its activity had mostly focused on the

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Technology Center," accesses April 21, 2019, https://ridc.org/properties/browse-portfolio/pittsburgh-technology-center/.

[95] Carter, "Pittsburgh case Study," 2987.

[96] Glaeser, "Revenge of the Rust Belt."

[97] Carter, "Pittsburgh case Study," 3000.

[98] See: Urban Redevelopment Authority of Pittsburgh, "Here is URA;" Carter, "Pittsburgh case Study."

[99] Carter, "Pittsburgh case Study," 3142–3149.

[100] Andes et al., *Capturing the next economy*, 10.

construction of flexible industrial parks for light manufacturing along major transportation roads outside Pittsburgh (the 1963 RIDC Park is one of the first industrial parks realized in the US). At the time, light-industrial spaces were rather scarce due to the century-long dominance of the heavy industry in the area. After the decline of the steel industry due to global economic forces, RIDC's attention turned to the physical industrial legacy as a lever for strategic economic development and innovation.[101] From the 1980s on, the nonprofit has focused on the construction of university research centers (e.g., the Pittsburgh Technology Center built on a reclaimed brownfield and the Carnegie Mellon University's Collaborative Innovation Center) as well as in the redevelopment and conversion of abandoned industrial facilities, from single-company plants to multi-tenants multi-sectorial clusters (both outside and inside Pittsburgh, e.g., Keystone Commons, RIDC Westmoreland, and Bakery Square).[102] The Lawrenceville Technology Center belongs to this story.

In July 2018, the City Council approved the establishment of the Riverfront District (RIV), which includes 57.25% of former GI, UI, and NDI Districts and 16.8% of Specially Planned Districts, leaving to the city very low percentages of industrial land established by previous regulations.[103] The RIV District regulation establishes different subdistricts, some of which recall the industrial designation while trying to capture also the current identity of each area. The "pattern of zoning illustrates that the riverfront has a variety of characters and cannot be simply zoned a single district with one set of allowed uses and one set of dimensional standards. Previous plans have all acknowledged that the riverfront area gets its strength from its combination of a variety of uses and urban forms. The plans suggest, and outreach has confirmed, that future zoning should continue to accommodate a variety of uses including residential, industrial (both light and heavy), office, R&D/urban flex, retail and open space both passive and active."[104] The Lawrenceville Technology Center is part of a Riverfront's Industrial Mixed-Use Subdistrict (RIV-IMU). Overall, manufacturing, assembly, and freight activities are allowed in RIV-IMU, in the General Industrial Subdistrict (RIV-GI) as well as in the Mixed-Use Subdistrict (RIV-MU) under performance standards. These subdistricts also allow R&D and lab facilities (allowed in almost all the subdistricts and could include production), warehouses, welding and machine shops. In addition, they try to limit self-storage and residential storage uses. On the other side, they echo their counterparts outside the RIV District by allowing some denser residential typologies as well as office-based businesses, entertainment, services, retail, and cultural activities.[105]

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[101] Timothy White (Senior Vice President of Development, Regional Industrial Development Corporation) in discussion with the author, September 2016.

[102] Regional Industrial Development Corporation, "Our Properties."

[103] Camiros and City of Pittsburgh, *Pittsburgh Riverfront Zoning*, 1.

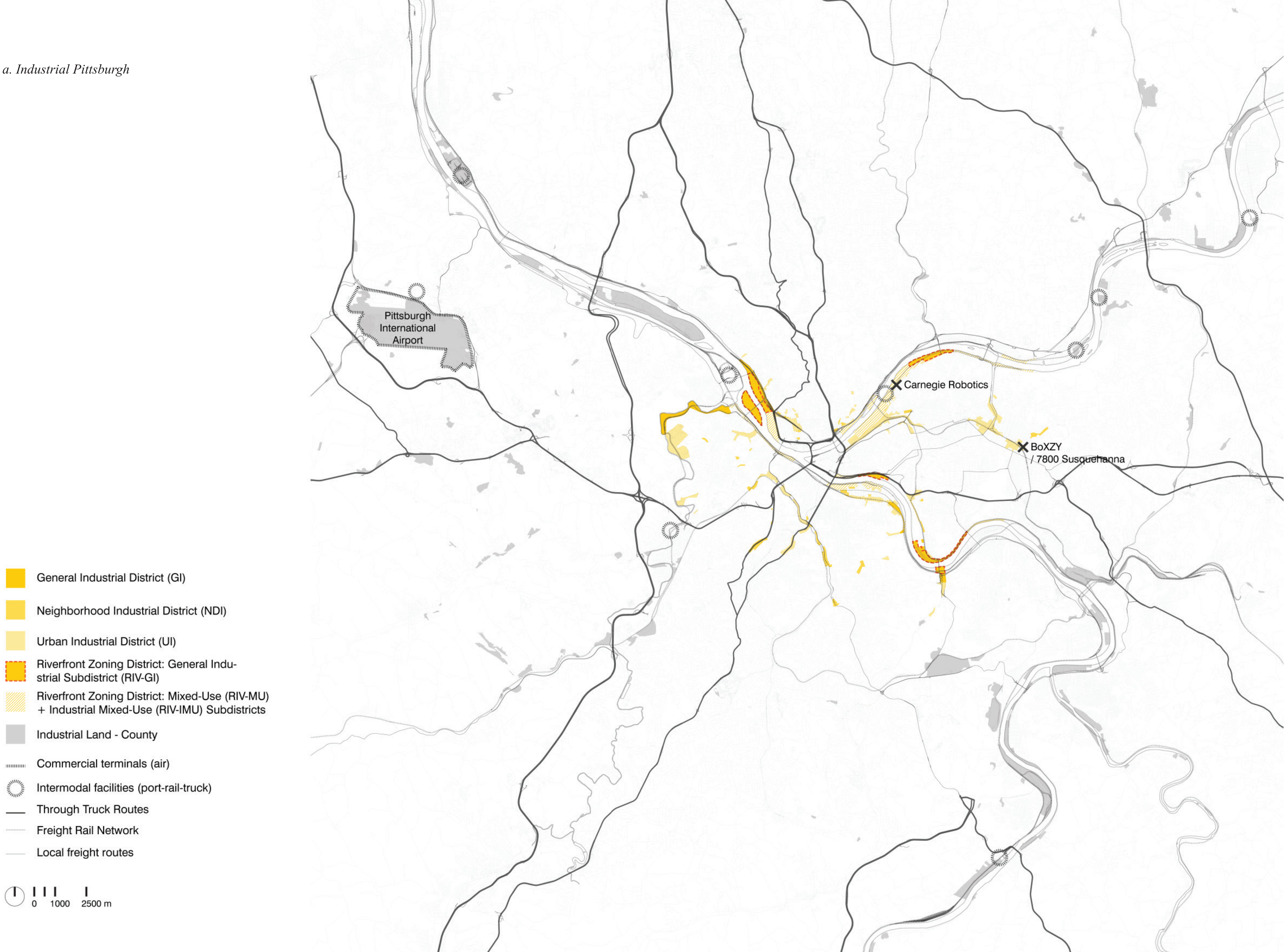
[104] Camiros and City of Pittsburgh, *Pittsburgh Riverfront Zoning*, 1.

[105] See: The Pittsburgh Code, Title Nine, Zoning Code, Article II, Chapter 905-Special Purpose Districts, 905.04 RIV, Riverfront. https://pghriverfrontzoning.files.wordpress.com/2018/08/sections-905-04-and-915.pdf.

Overall, incentivizing such mix of uses is not harmful per se, especially in formerly distressed areas like these Pittsburgh's neighborhoods (Strip District, Lawrenceville, East Liberty, and Point Breeze) that needed to attract people, capitals, and urban life in general. On the contrary, it reflects a definite attempt to pursuing diverse livable and sustainable neighborhoods. However, these areas are now experiencing real estate pressures due to the convergence of interests over affordable industrial land. Like in San Francisco and New York, non-industrial activities, for instance commercial, residential, and office-based uses (considered 'higher' uses), potentially turn into a threat for manufacturing when the incentivized mix of uses is not sided by policies that retain and secure space for industrial uses, at least to a certain extent. Especially in these central neighborhoods, the physical industrial legacy has played a key role in fostering the growth of Pittsburgh's innovation sector, made of startups, R&D labs, and established companies of all sizes operating especially in the advanced manufacturing, engineering, robotics, tech, and life science sectors. In 2017, the Brookings Institution while praising the scientific and technical strengths of Pittsburgh it also observed how these competitive advantages had not fully translated into a broad-based inclusive economy. The report depicts two possible scenarios for Pittsburgh 2030. "In one, the city's economy is aptly described as two Pittsburghs. Here, a minority of jobs are driven by university research, small high-tech firms, and a handful of corporate research centers, while the broader economy (which makes up the majority of workers and families) consists of local services and traditional low- and mid-level manufacturing jobs that, like in much of the Rust Belt, are increasingly automated or outsourced. In this scenario, income and unemployment will vary significantly depending upon the neighborhood. But in a more dynamic scenario, Pittsburgh's broader economy flourishes. The lines between academic research and industry innovation are indistinguishable as major employers in health care, finance, corporate services, and manufacturing collaborate, adopt, and nimbly deploy technology to stay ahead of global competitors. As such, high-value exports of both goods and services expand, creating a reliable tax base and pool of high-wage jobs. Well-resourced and coordinated education and workforce programs identify and attack unemployment in high poverty neighborhoods. Getting a lifelong job in a factory with a high school education is as unrealistic in the future as it is today—but unlike today, everyone has options. In this scenario, the innovation economy is Pittsburgh's economy and all benefit."[106] As the two case studies show, affordable flex industrial spaces have been the backbone of the development of advanced industries. How Pittsburgh will manage this asset could play a significant role in determining which one of Brookings' future visions the city will tend to.

[106] Andes et al., *Capturing the next economy*, 9.

a. Industrial Pittsburgh

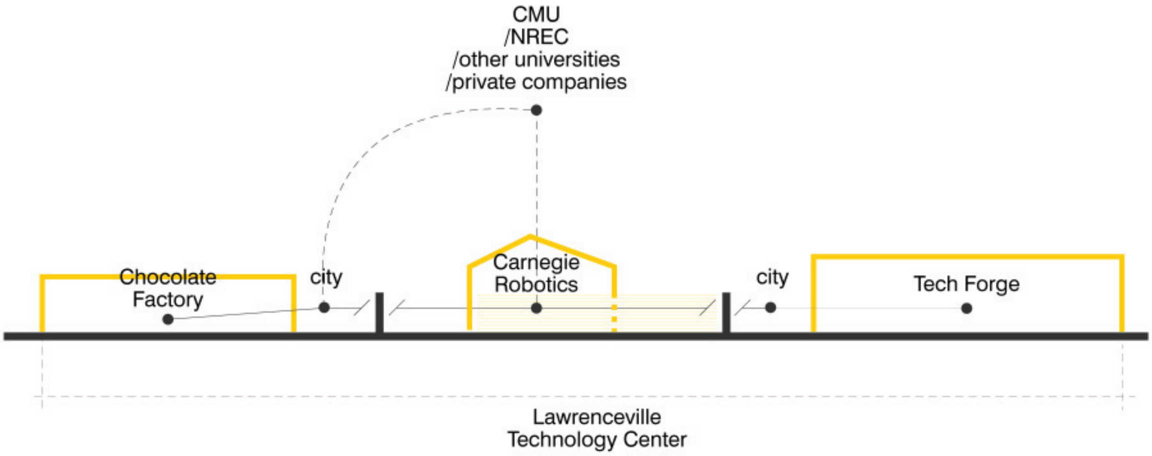


b. Lawrenceville Technology Center. Accessibility and footprints

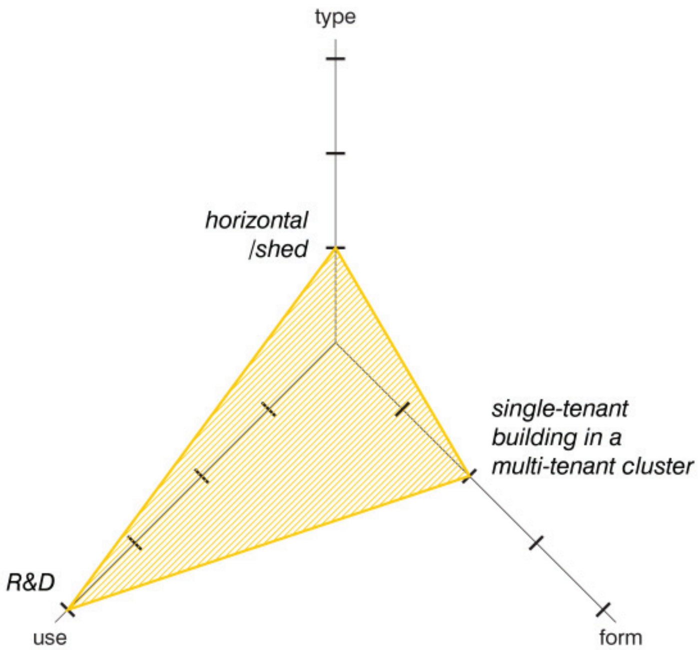
LTC enclosing wall
Workers and vehicles access
0 50 100 250 500 m

c. Carnegie Robotics. Spatial strategy

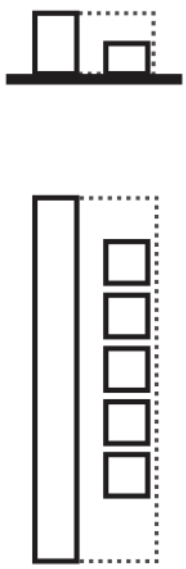
c.1. City-Production



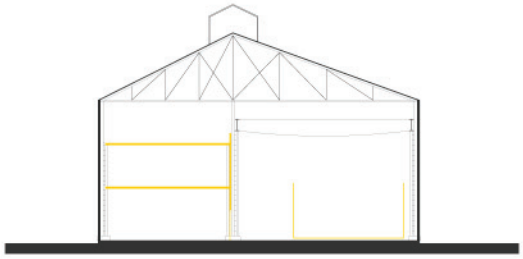
c.2. 3-axis form-type-use



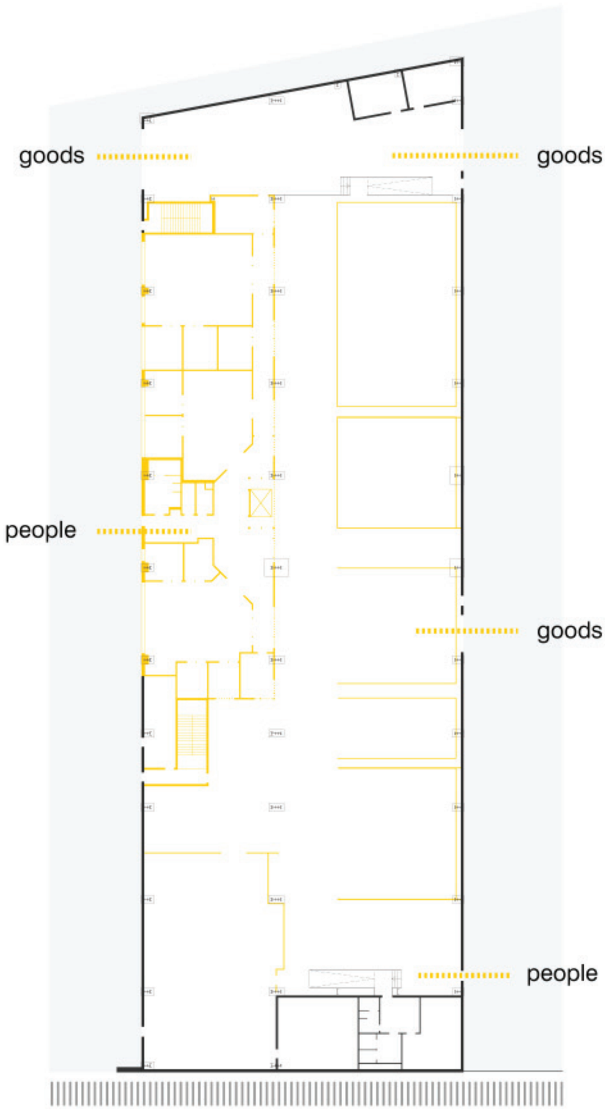
c.3. Diagram



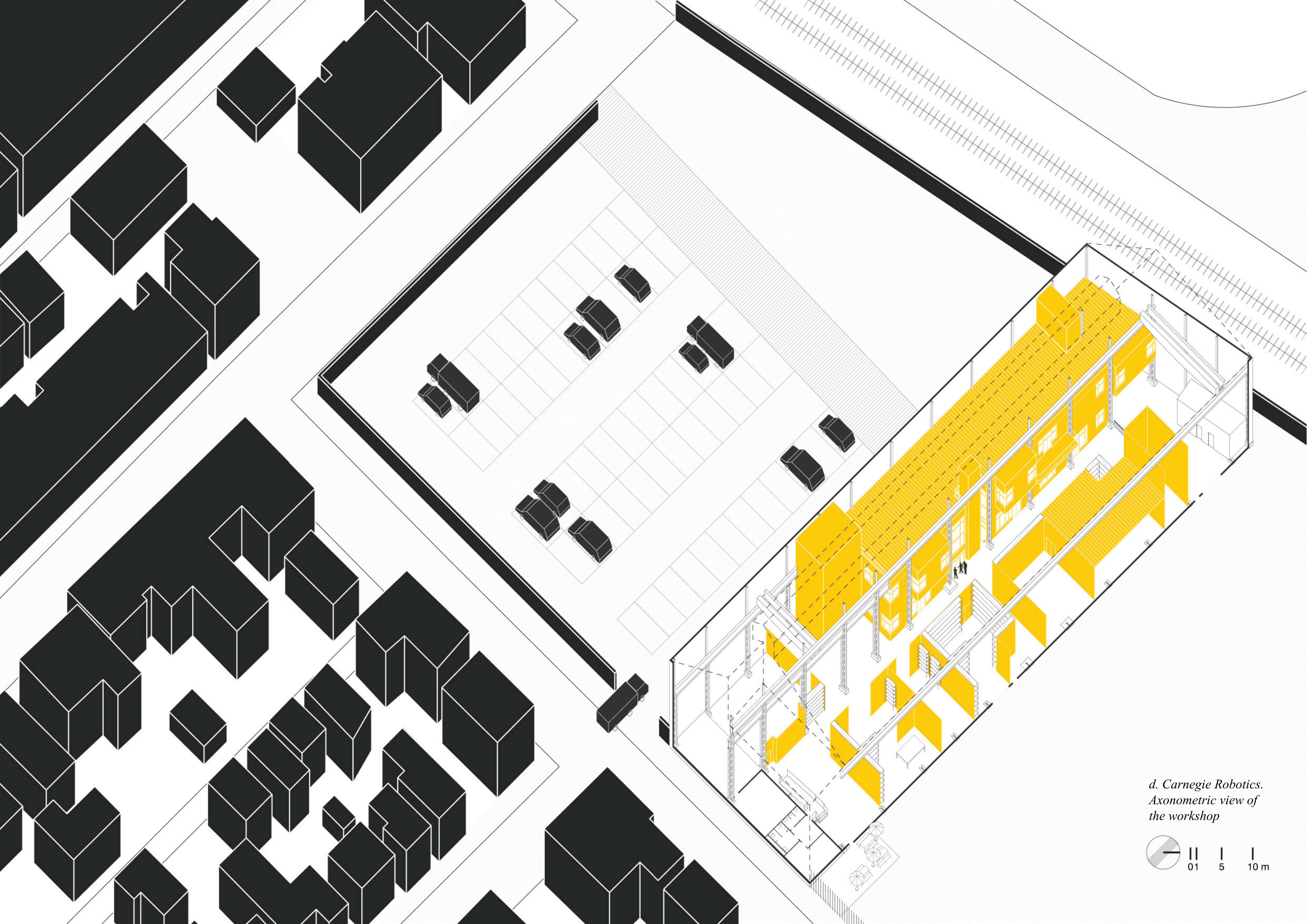
c.4. Plan and section



Elevation

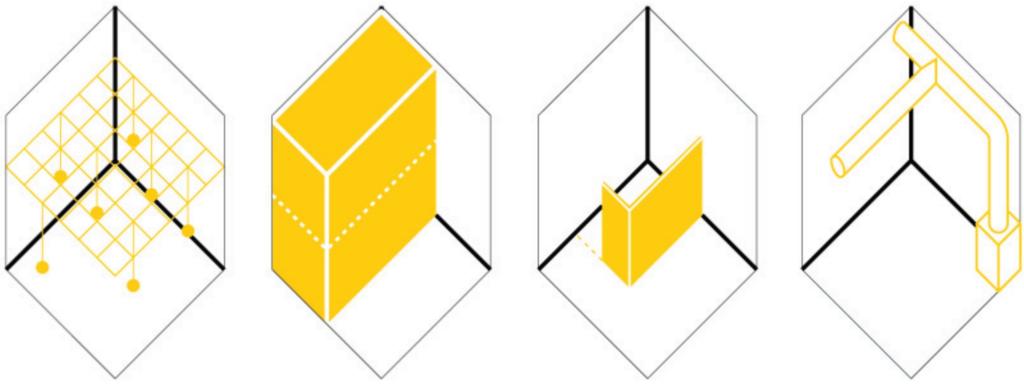


Plan

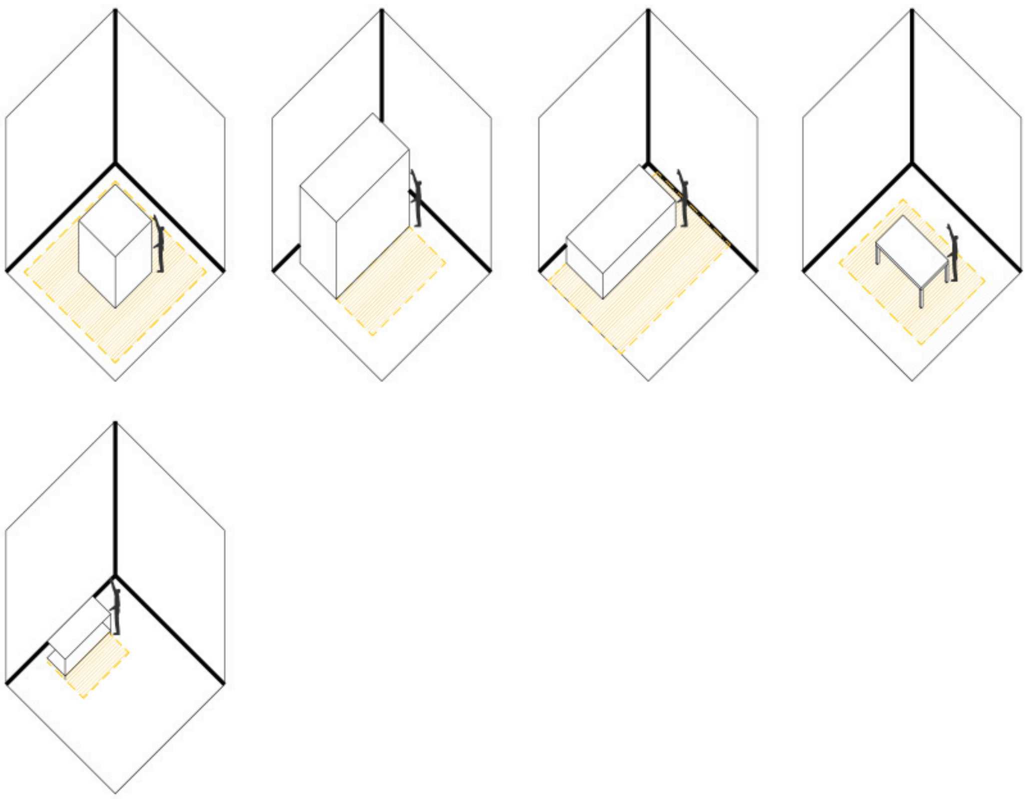


d. Carnegie Robotics. Axonometric view of the workshop

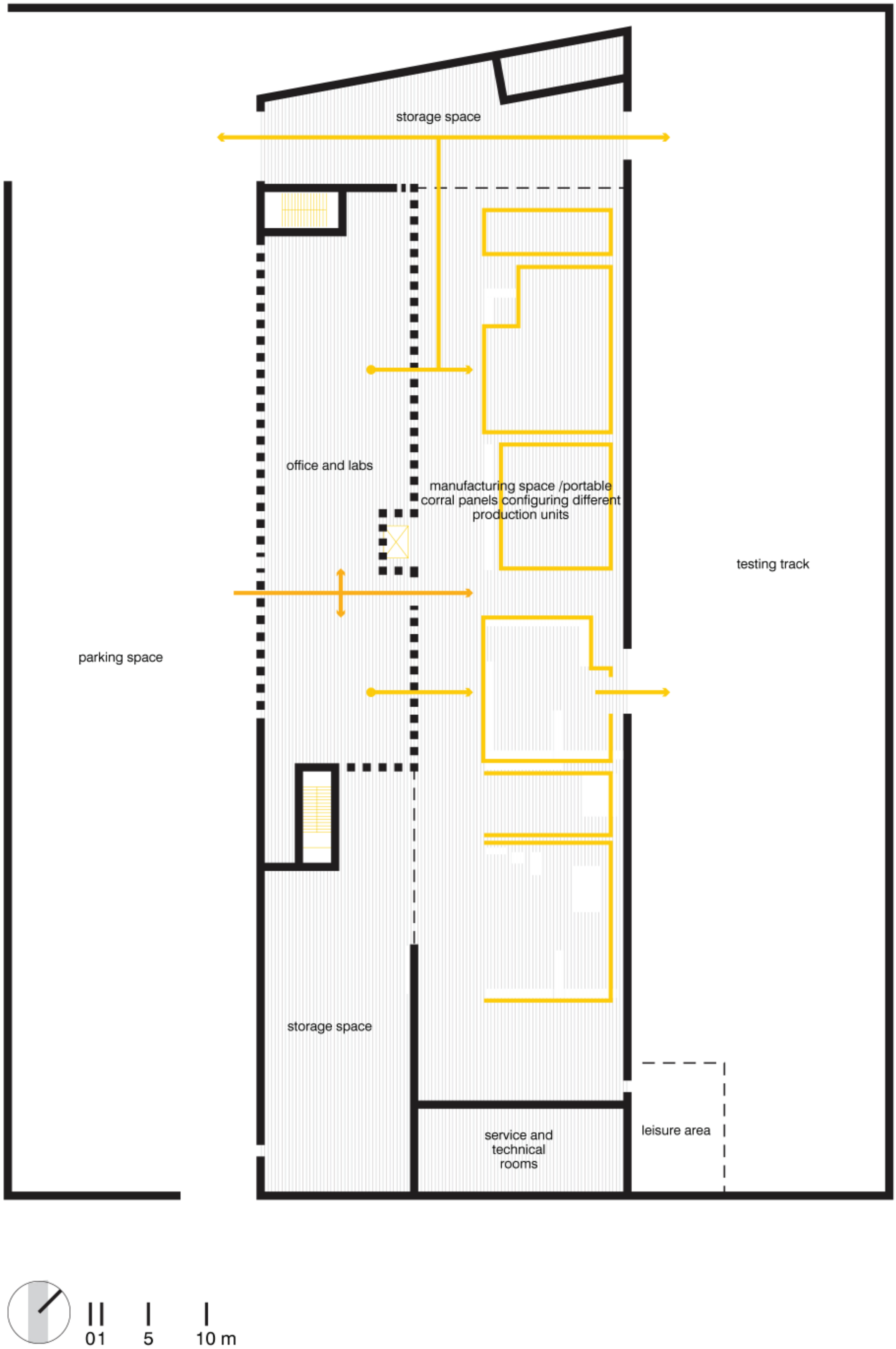
d.1. Organizers



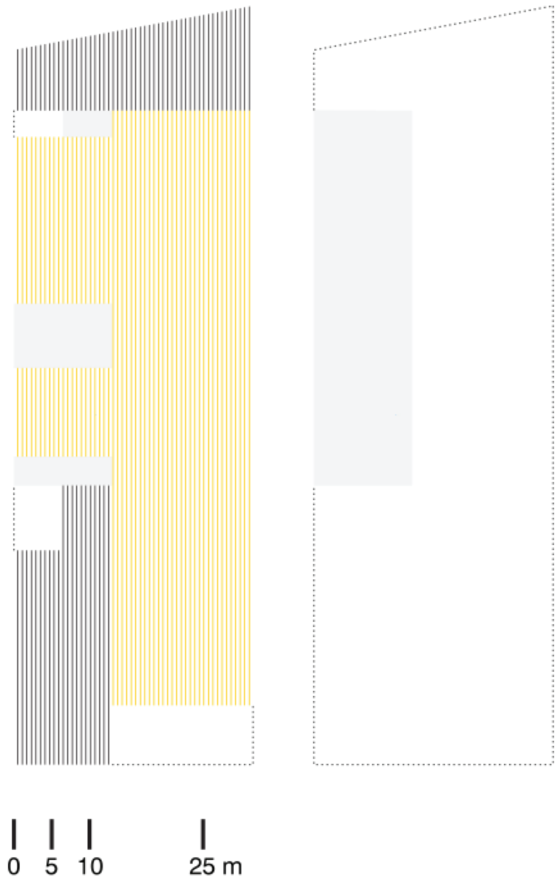
d.2. Operation units



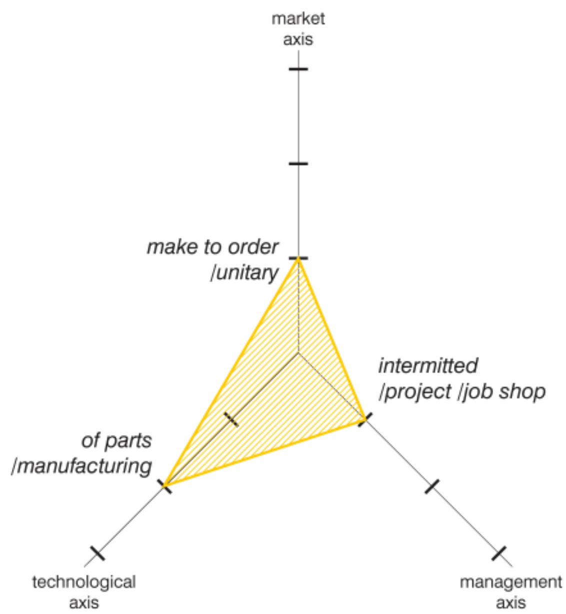
e. Carnegie Robotics. Workshop layout



f. Carnegie Robotics.
Diagram of uses



g. Carnegie Robotics. 3-axix classification of production



h. Carnegie Robotics. Data table

Lawrenceville Technology Center					
Carnegie Robotics	3960 sqm \\\ 100%	**Design**	**Production**	**Storage**	**Other**
		865 sqm	1720 sqm	915 sqm	460
		22%	43%	23%	12%

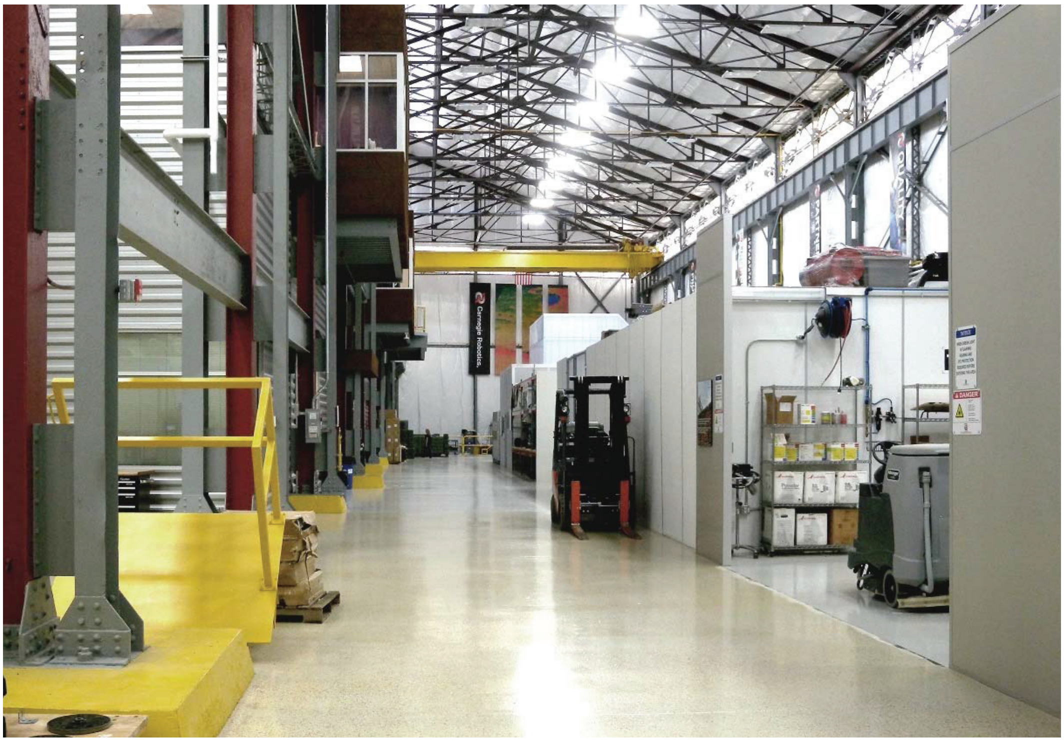


Figure 4.20. Carnegie Robotics, view of the interior with the *corrales* on the right. Photo by the author.

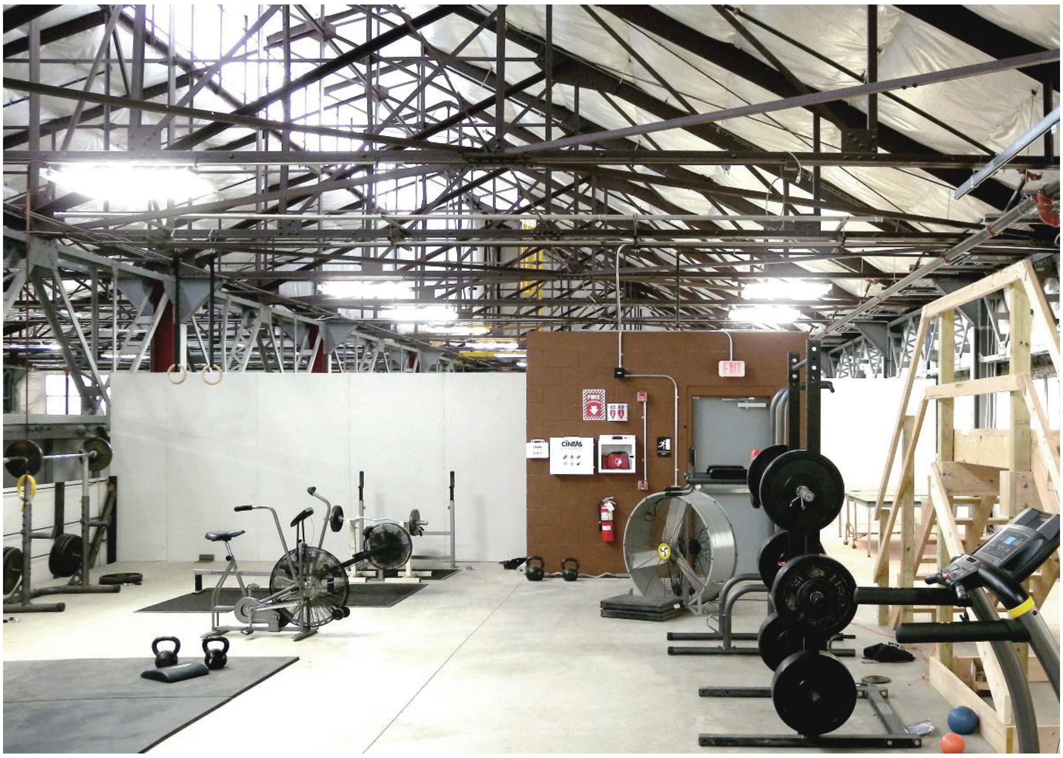
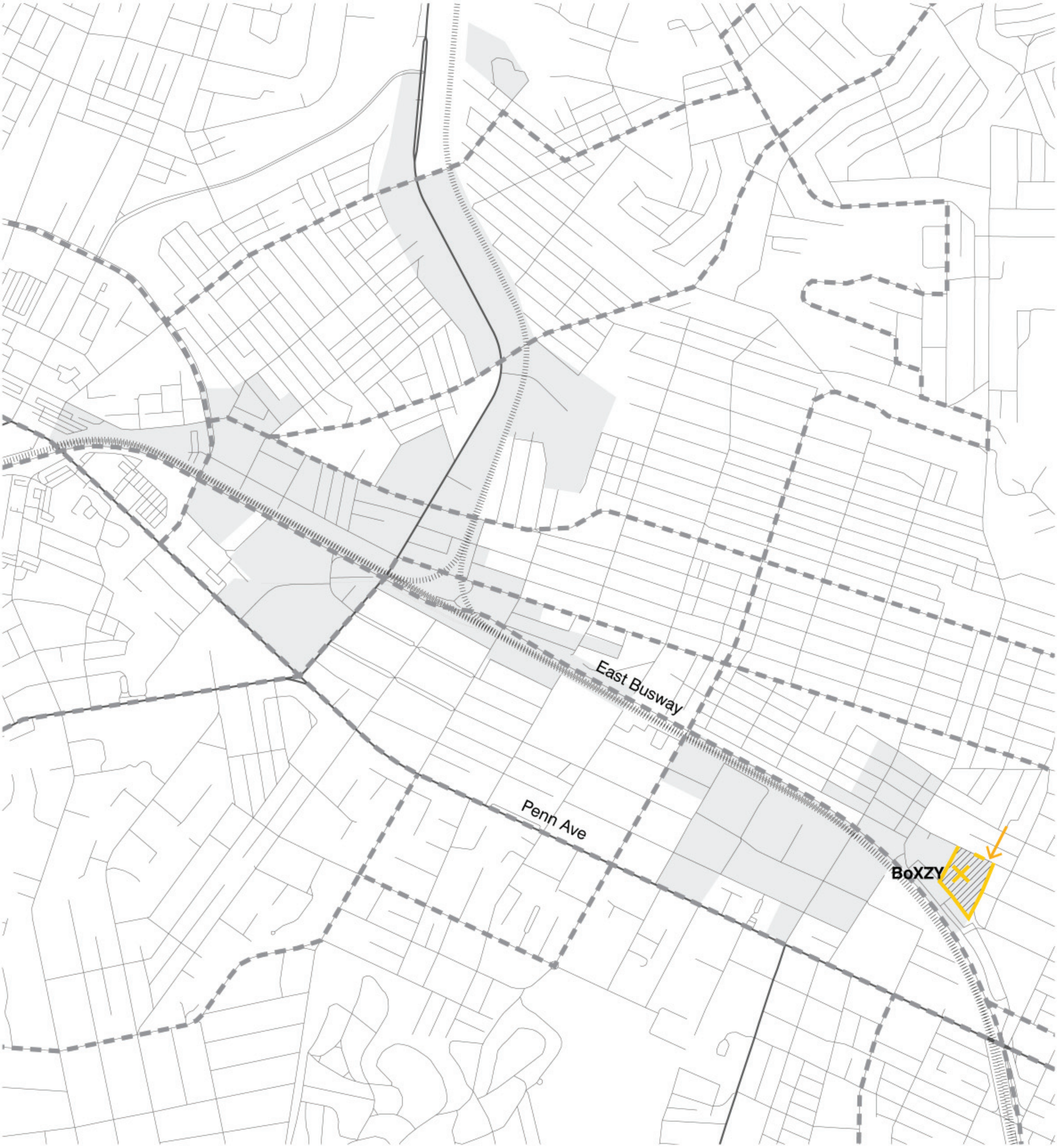


Figure 4.21. Carnegie Robotics, view of a workers’ space on the roof of the new volume. Photo by the author.

b. 7800 Susquehanna Street. Accessibility and footprints



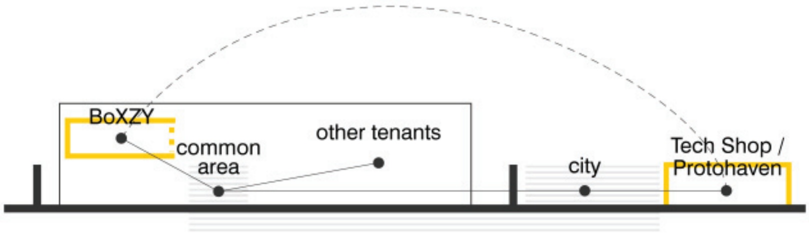
7800 Susquehanna Street enclosing fence

Workers and vehicles access

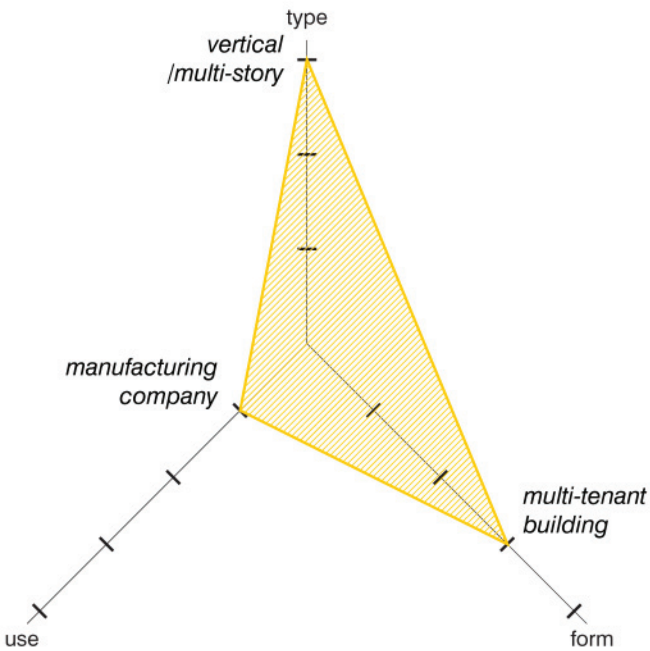
0 50 100 250 500 m

c. BoXZY, 7800 Susquehanna. Spatial strategy

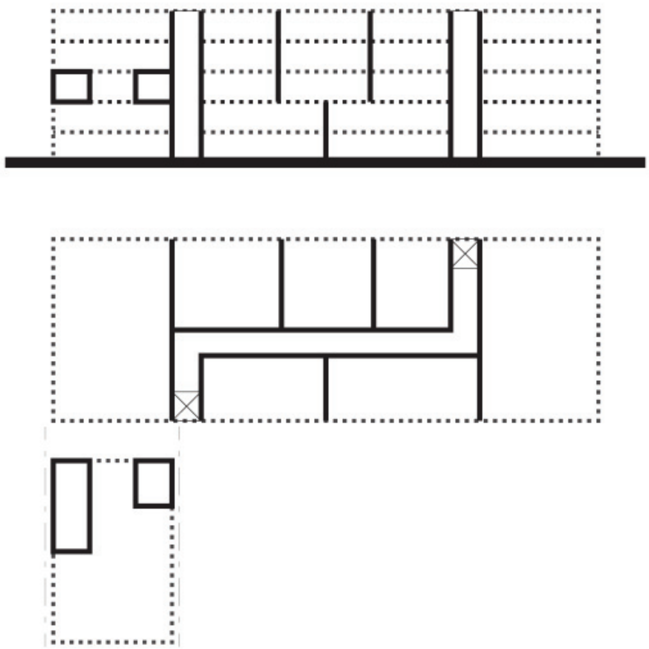
c.1. City-Production



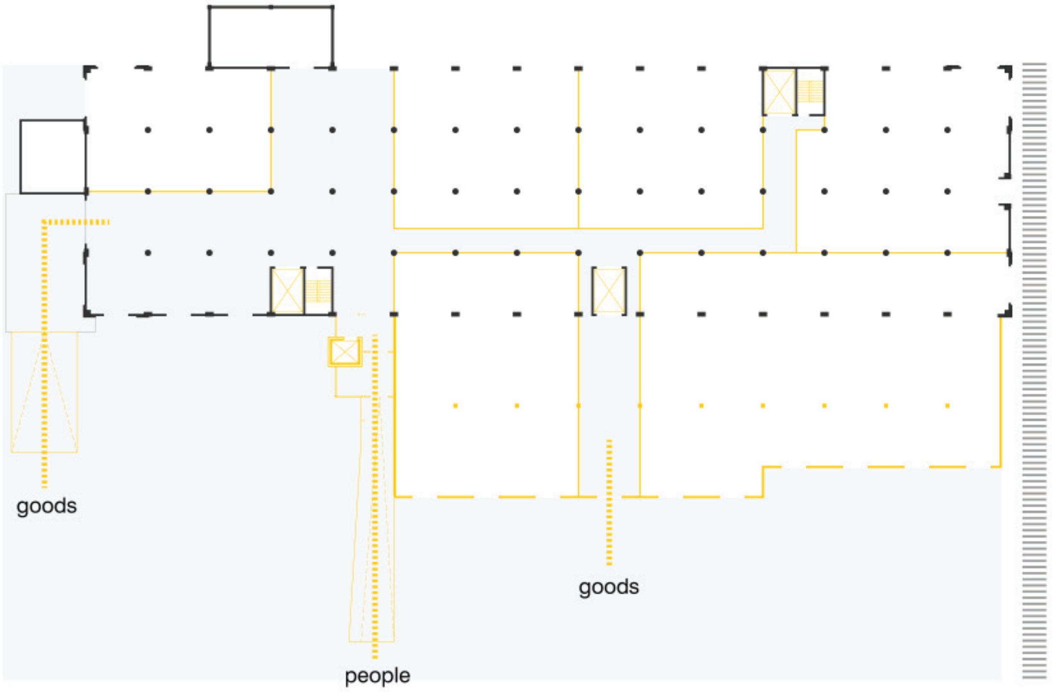
c.2. 3-axis form-type-use



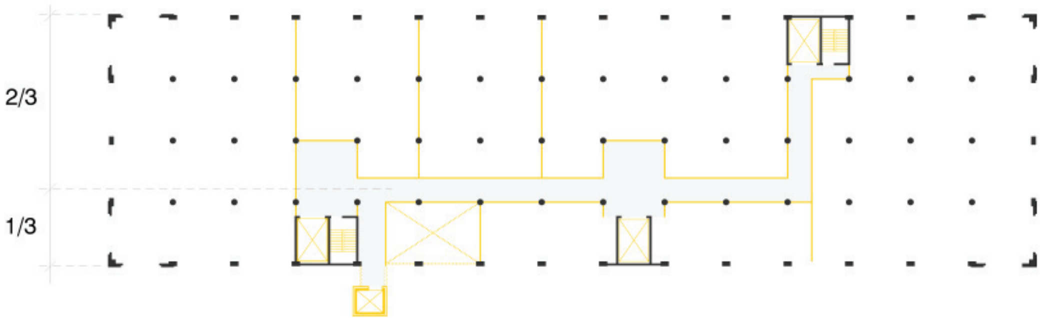
c.3. Diagram



c.4. Plan and section

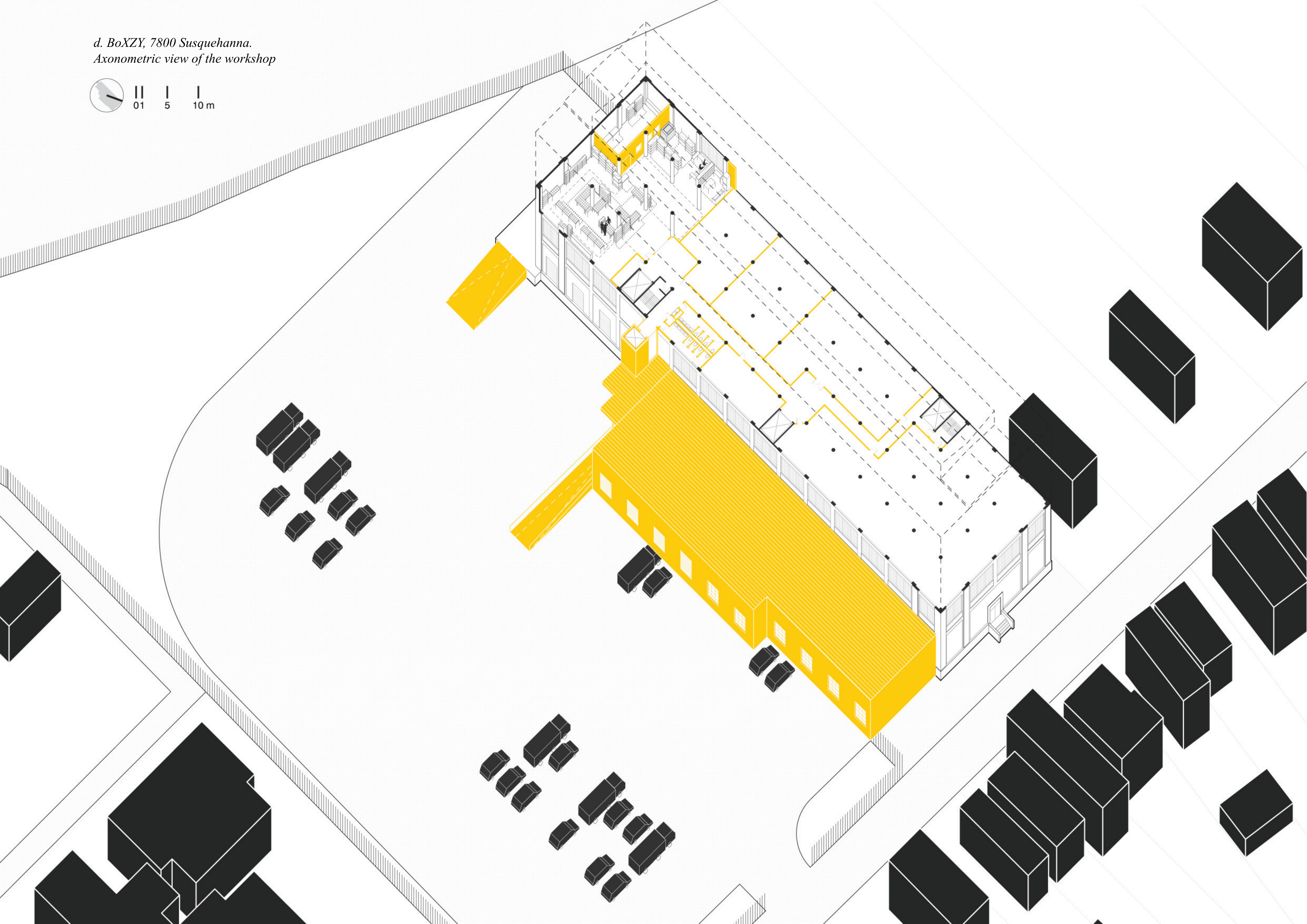


Ground floor

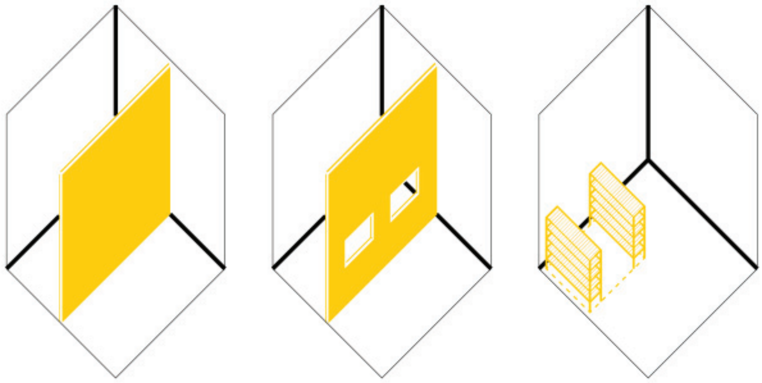


Upper floors

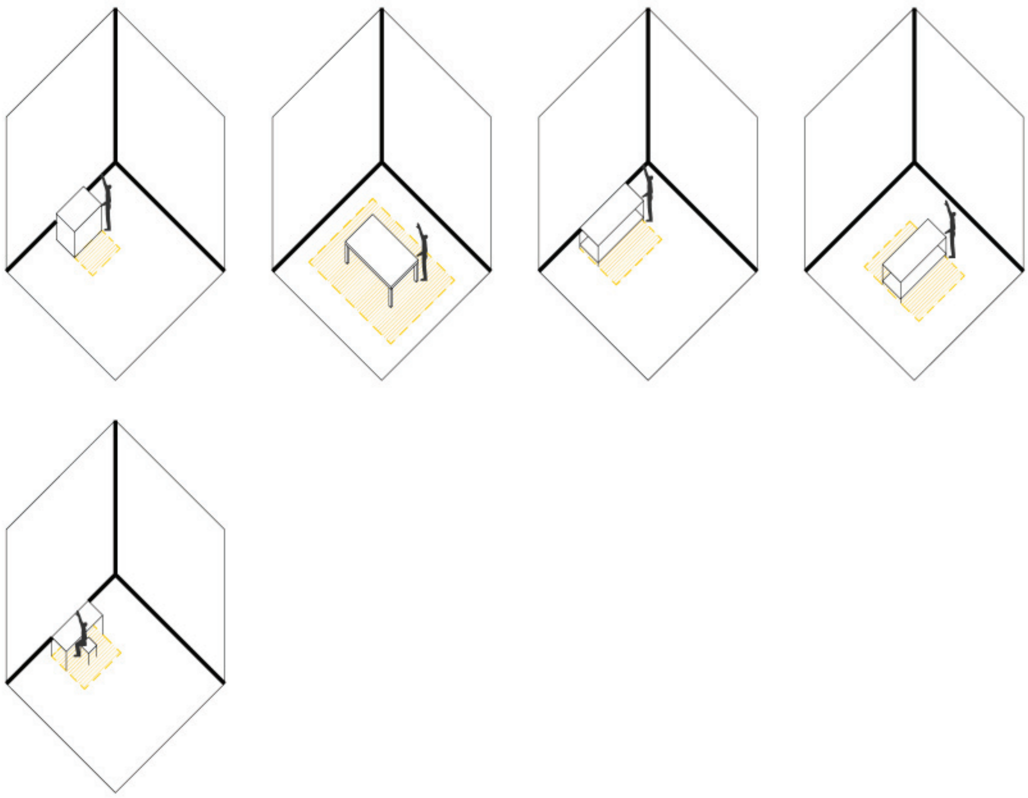
d. BoXZY, 7800 Susquehanna.
Axonometric view of the workshop



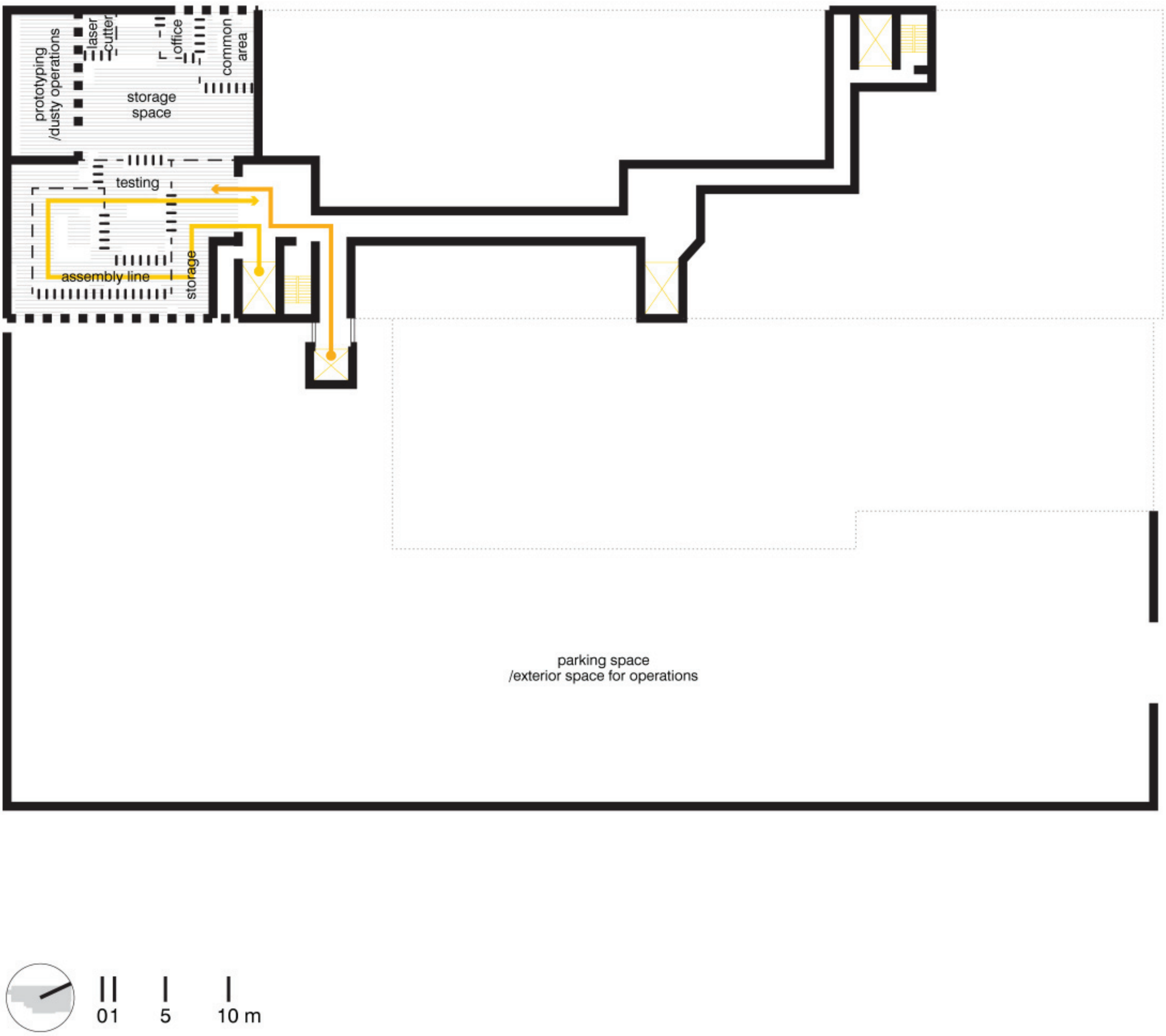
d.1. Organizers



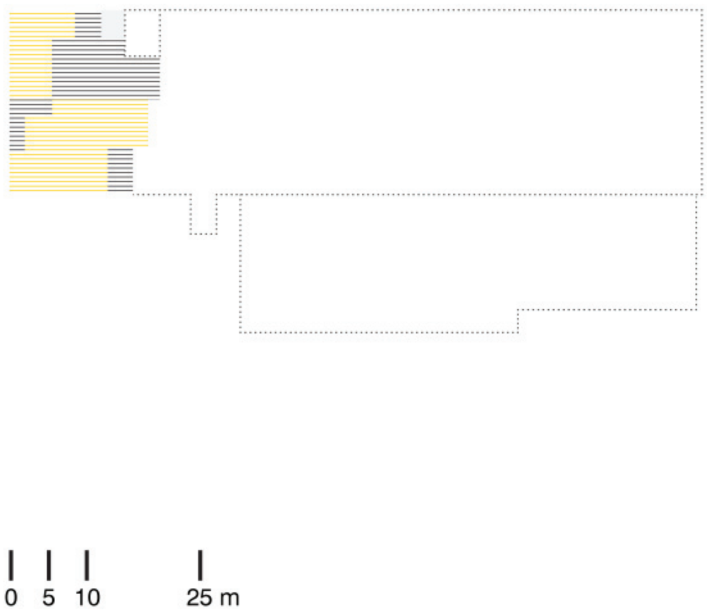
d.2. Operation units



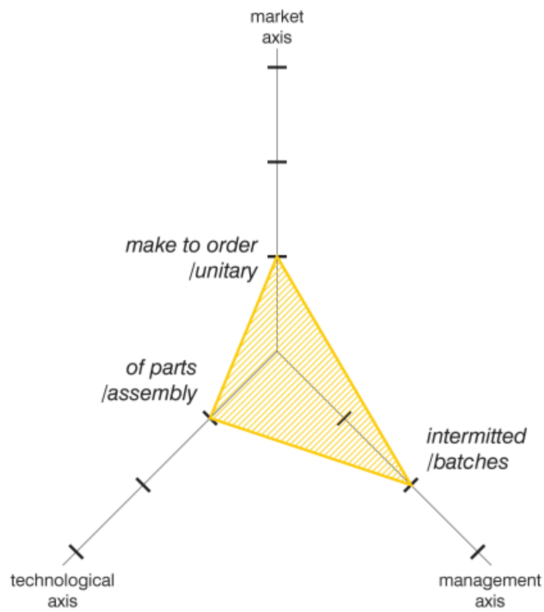
e. BoXZY, 7800 Susquehanna. Workshop layout



f. BoXZY, 7800 Susquehanna. Diagram of uses



g. BoXZY, 7800 Susquehanna. 3-axix classification of production



h. BoXZY, 7800 Susquehanna. Data table

<table>
<tr><th colspan="7">7800 Susquehanna Street</th></tr>
<tr><td rowspan="3">n. tenants: 20 + 1 multi-tenant spaces: artist residency</td><th rowspan="2">Tot.</th><th rowspan="2" colspan="3">Industrial</th><th colspan="2">Other</th></tr>
<tr><th>Interior</th><th>Exterior</th></tr>
<tr><td>12200 sqm</td><td colspan="3">10170 sqm</td><td>2030 sqm</td><td>9650 sqm</td></tr>
<tr><th rowspan="3">BoXZY</th><td rowspan="3">450 sqm \\\ 3,7%</td><th>Design</th><th>Production</th><th>Storage</th><th colspan="2">Other /common space</th></tr>
<tr><td>12 sqm</td><td>250 sqm</td><td>160 sqm</td><td colspan="2">28 sqm</td></tr>
<tr><td>3%</td><td>55%</td><td>36%</td><td colspan="2">6%</td></tr>
</table>

Figure 4.22. BoXZY’s industrial space at 7800 Susquehanna Street. Photo by the author.

Figure 4.23. BoXZY’s industrial space at 7800 Susquehanna Street. Photo by the author.

4.5 Southwick, Haverhill

Southwick

Southwick[107] is a clothing manufacturer founded in 1929 by Nicholas and Vito Grieco in Lawrence – Haverhill's neighbor city along the Merrimack Valley.[108] After years of working as a contractor for Brooks Brothers, in 2008 the company acquired Southwick that continued designing and manufacturing high-quality man suits and garment (around 80% of production is for Brooks Brothers).[109] Southwick also produces its line of suits as well as made-to-measure garments for different stores and firms. In 2009, right after being purchased by Brooks Brothers, Southwick relocated into an 8300 sqm plant in Haverhill's Broadway Business Park. Southwick has soon benefitted from Brooks Brothers' reshoring policies by taking over almost the entire man suit production of the acquiring company – previously realized in part by different contractors overseas.[110] Southwick has consistently grown during the following years.

In 2015, Brooks Brothers' owner (Claudio Del Vecchio, whose family also owns Luxottica) acquired a larger facility for the expanding Southwick's production line. From a 30-40 years old industrial building, the company moved right across the street into a recently build and soon abandoned retail 'big box.' The building was built in 2007-2008 for Lowe's Retail Store, but the store quickly went out of business two years later.[111] With the support of the local administration, Southwick and the developer Dacon Corporation converted the building from a wholesale commercial facility into a smart production plant. Among the many advantages of this relocation – like adding around 5000 sqm and moving to a newer building – the company was able to integrate advanced digital technologies to the production process. Technological improvements have been made in the production line as well as in the indoor environmental control system to improve productivity and the sustainability of the factory plant. Some examples are the temperature and humidity control, a computerized energy management system, the installation of LED lighting and an advanced steam and inhaling system. The production space has been kept entirely open. At the halfway of the bay height, the company located a utility grid that provides to the entire floor light, plugs, wiring, and electrical feed ways – machines are never more than 6 meters away from a utility hook. Instead of forcing production to adjust to the

[107] Southwick is one of the few companies among those visited during field trips that mass-produced customized products.

[108] For more information about the history of the company see: Southwick, "History."

[109] Chesto, "Brooks Brothers."

[110] Chesto, "Brooks Brothers."

[111] Along with another building build for Target, the project was part of the local administration's attempt to attract retail stores in the area. Haverhill is really close to the no-sales tax state of New Hampshire where people find more convenient prices. Despite that, Target is surprisingly enduring in this location. Curt Clark (Director of Manufacturing at Southwick) and Nate Robertson (Assistant Director of Economic Development at City of Haverhill), in discussion with the author, April 2018.

utility network, this suspended grid allows utilities to follow the production layout and provide energy wherever it is needed. The distance of this utility grid from the production floor corresponds to the more efficient solution for illumination with no shadowing, energy consumption, and employment of electrical wiring.[112] The front side of the building has been subdivided into two floors to house administrative and design offices, workers' common spaces, a retail store, and other service spaces.

Since its establishment in Haverhill, the company has added over 230 jobs (+76%).[113] Today, Southwich employs around 540 people (union jobs), many of whom are immigrants or refugees trying to establish in the US.[114]

Figure 4.24. Southwick, view of the production space from the offices on the first floor. Photo by the author.

[112] Curt Clark (Director of Manufacturing at Southwick) and Nate Robertson (Assistant Director of Economic Development at City of Haverhill), in discussion with the author, April 2018.

[113] Dineen, "Why Brooks Brothers."

[114] For more information on the socio-economic impact of Southwick on the Haverhill see: City of Haverhill Massachusetts Business Portal, "Southwick Does More."

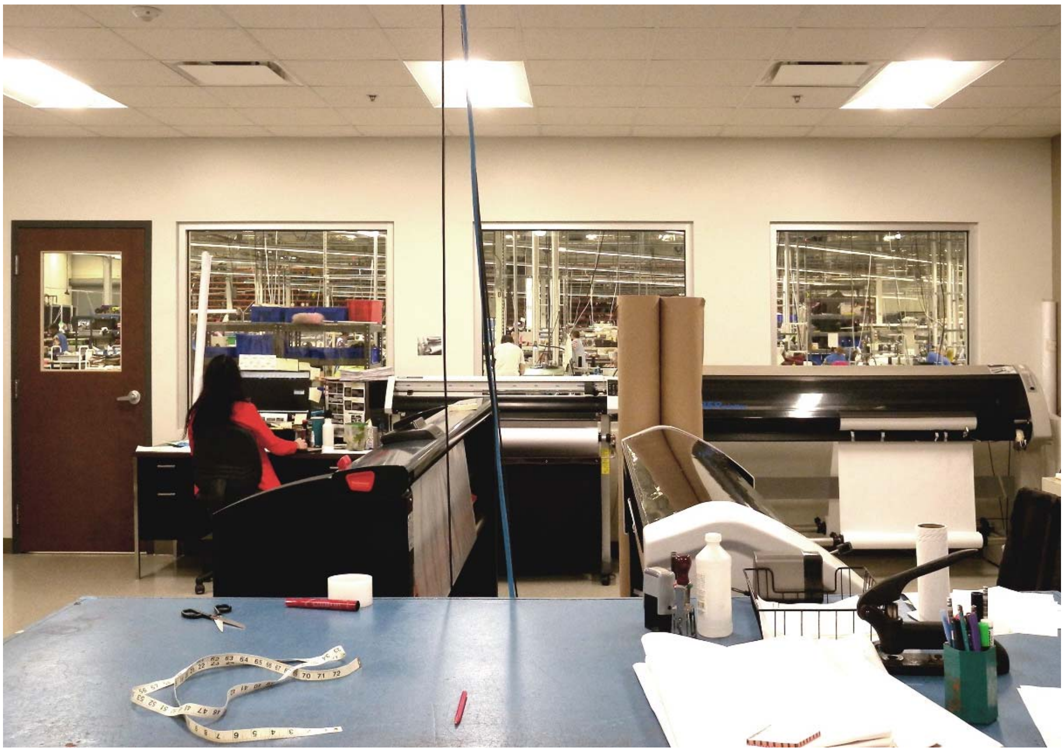


Figure 4.25. Southwick, view on the production space from the design office. Photo by the author.

Figure 4.26. Southwick, view of the former greenhouse, now dining hall. Photo by the author.

Figure 4.27. Southwick, view of the main entrance. Photo by the author.

Haverhill's business megaparks and the citywide context

Southwick locates inside a facility initially built as a wholesale commercial building located right outside the city at the crossroad of major transportation and commercial roads. Because of its original purpose (see also Footnote 111), the site is zoned as Highway Commercial (HC). Overall, this designation is dedicated to services, retail, wholesale, commercial and recreational activities. It does not allow industrial uses, except for few light-industrial and trade activities connected with services. The table of uses makes exception specifically for Southwick's parcel where also manufacturing and assembly have been allowed to make possible the establishment of the company and not losing an essential economic and social asset for the city.[115] The current zoning was approved in 1971 and then amended in some of its parts in the following decades, for instance, the Downtown Smart Growth Overlay District (2005) and the Special Waterfront Interim Planning Overlay District. Industrial uses are allowed in three main zoning designations: Business Park (BP), Industrial Office Park (OP), and to a less extent and under special permit in Industrial General (IG).

Over 8,900 hectares of total land, 9% (798 hectares) is dedicated to commercial, industrial, R&D, and wholesale activities.[116] According to the 2017 PitchBook realized by the City, the 2016 average lease cost for industrial spaces

[115] See: City of Haverhill (MA) Code, Part II, Chapter 255, Attachment 1 - Table 1: Table of Use and Parking Regulations. https://ecode360.com/6262973.

[116] City Of Haverhill Massachusetts, *Open space and recreational plan*, 19.

in Haverhill was \$70 /sqm/Yr (\$6.51 /SF/Yr).[117] As of 2019, leases in the area range between \$80-107 sqm/Yr (\$7.5-10 SF/Yr).[118] The percentage might appear low, but this location usually attracts medium-sized business with over 100 employees. These businesses range from a large multinational corporations, medium-sized established companies, to rather new enterprises that just scaled up production and wanted to do that locally (perhaps forced to move out from central Boston due to the smaller sized and more expensive spaces). Here, the city offers appropriate floorplates, logistics spaces, workforce (nearly 35,000 person workforce in Haverhill and a pool of 340,000 workers within the easy commuting distance[119]), and proximity to Boston's service and innovation economy. "Haverhill features a more diversified economy than it has traditionally, with unemployment figures near historical lows. Manufacturing is still prevalent, but health care, social services, education, retail and business services all have strong and nearly equal presence in the city. Given the city's geography, plentiful water and wastewater, and ideal highway access, food manufacturing in particular is a unique and notable industry in Haverhill, for example. There is still a very talented precision manufacturing workforce, with some veterans from the former Western Electric/Lucent Technologies manufacturing days"[120] Haverhill is at its peak of population with over 63,000 people (53,884 in 1920 during industrialization) and at one of its lowest rate of unemployment (at 3.4% in 2017) since the Great Recession.[121]

Southwick's property adjoins other commercial and industrial facilities, a compound of around 160 hectares identified by the city as Broadway Business Park (other key companies besides Southwick are Magellan Aerospace, Adamson Industries Corp., and Hans Kissle).[122] The city has identified other three Business Megasites (non-zoning designation) where incentivizing economic development through different strategies that depend on the characteristics of the areas. For instance, three of these megasites (Ward Hill Business Park, Broadway Business Park, Hilldale Ave./Newark St. Business Park) develops along an important freight route (route 495) that allows easy access to the closest commercial ports, the city of Boston, and the nearby towns of the Lower Merrimack Valley. These areas include BP, OP, and HC zones and they reflect the legacy of industrial and

[117] City of Haverhill Massachusetts. *Haverhill*, 3.

[118] Source: LoopNet (https://www.loopnet.com/). Industrial properties for lease in Haverhill. Accessed April 24, 2019.

[119] City of Haverhill Massachusetts. *Haverhill*, 2. ""Haverhill's location has been a key factor in maintaining its reputation and use as a major employment center. The proximity of the Merrimack River historically attracted factory industries to this area. Currently, the City's placement between Interstates 93 and 95 and on Route 495 has attracted the growing technology industries. The City is also only 33 miles from Boston; and, Lowell, Lawrence, Cambridge, Nashua, NH, Manchester, NH and Portsmouth, NH are all within a 30-mile radius. Therefore, Haverhill also acts as a bedroom community for workers in those areas." City Of Haverhill Massachusetts, *Open space and recreational plan*, 12.

[120] City Of Haverhill Massachusetts, *Open space and recreational plan*, 16.

[121] City Of Haverhill Massachusetts, *Open space and recreational plan*, 15–16.

[122] City of Haverhill Massachusetts, *Haverhill*, 5.

commercial trends of the late XX Century. They are characterized mostly by low-rise and dispersed 'big-box' buildings that house medium-size companies whose shipping operations often employ heavy trucks.

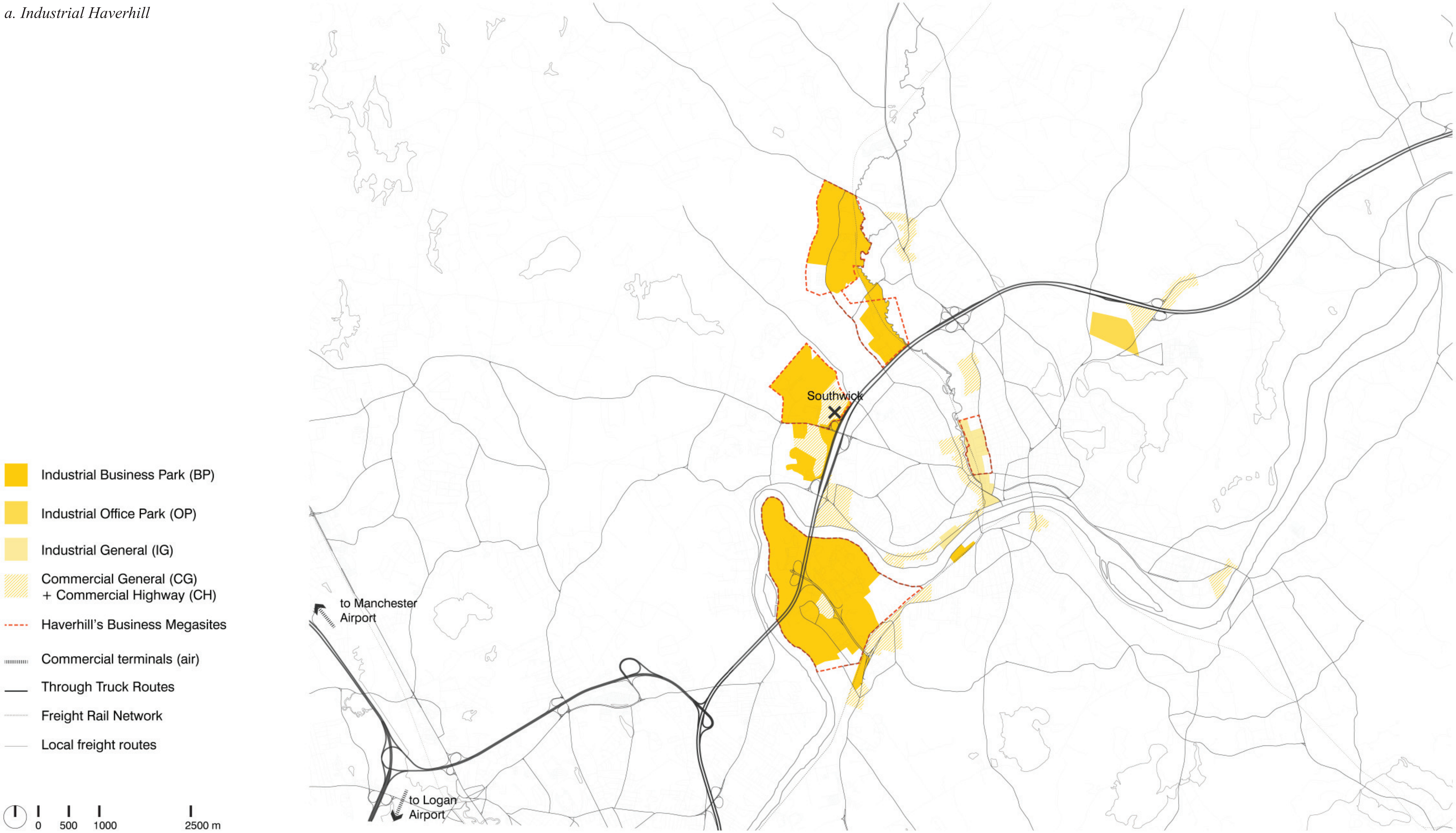
On the contrary, the fourth business megasite (Downtown Business Zones) locates in the downtown area along older commercial routes (waterways and railways). Its dense fabric of multi-story loft buildings and small warehouses proceeds from Haverhill's industrial heyday of the late XIX-early XX Century. Here economic development strategies focus on attracting small-sized manufacturers, startups, artists, makers, and local entrepreneurs that could take advantage of the proximity and good connection with Boston, the closeness to downtown and the cultural legacy of the city, the local colleges, institutions, and other established companies.[123] This area is the extension of the Washington Street Shoe District, an area where most of the shoe factories located starting from the 1880s then left in despair and largely abandoned after the 1950s. Today, the area represents the historic part of Downtown Haverhill. In the last years, the main strategies for the area have been focusing on converting old mills into mixed-use buildings to provide for alternative living solutions, affordable housing,[124] as well as spaces to non-chain retail stores and small businesses.[125]

[123] For instance, see the initiatives: WeAreMV Merrimak Valley Here for the Making (https://wearemv.com/) , and the City of Haverhill's Business Portal and the Support Programs (https://www.haverhillbusinessportal.com/).

[124] In this central district, the City of Haverhill employed the 2004 Massachusetts law Smart Growth Zoning and Housing Production Act ("Chapter 40R"). "Chapter 40R encourages cities and towns to zone for compact residential and mixed-use development in "smart growth" locations by offering financial incentives and control over design. Proponents see it as a way to increase housing production and ultimately bring down housing costs in Massachusetts by creating zones pre-approved for higher density development that will attract developers." Ann Verrilli and Jennifer Raitt, *The Use of Chapter 40R in Massachusettsas. A Tool for Smart Growth and Affordable Housing Production* (October 2009), 5; 76–78, http://www.mapc.org/wp-content/uploads/2017/09/Chapter_40R_Report.pdf.

[125] Nate Robertson (Assistant Director of Economic Development at City of Haverhill), in discussion with the author, April 2018.

a. Industrial Haverhill



b. Southwick. Accessibility and footprints

Southwick site

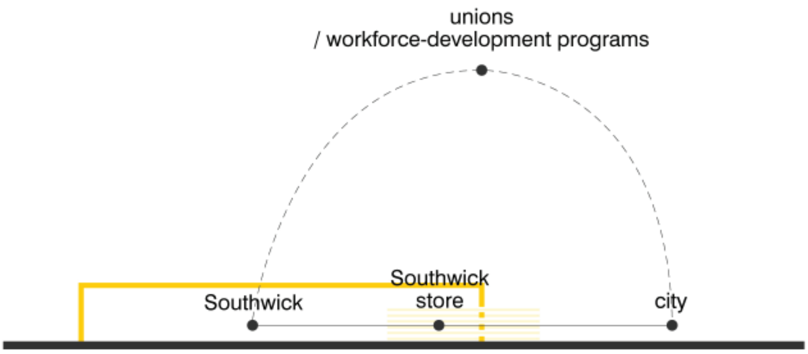
Public access

Workers access

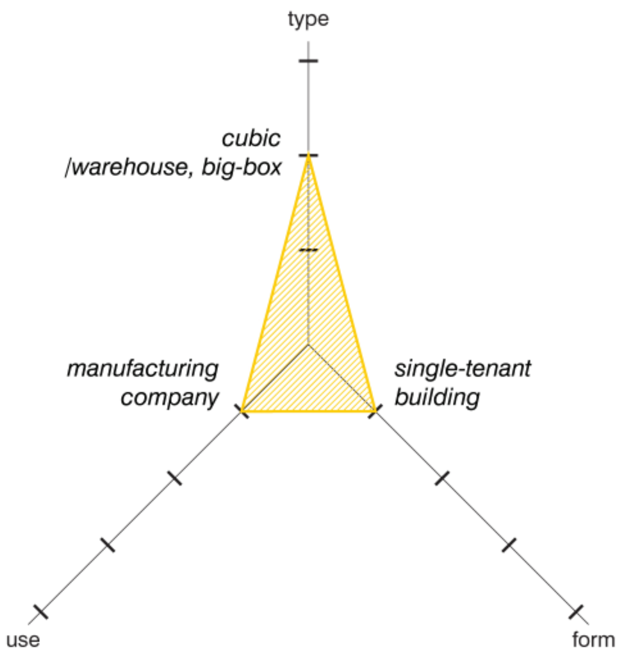
0 50 100 250 500 m

c. Southwick. Spatial strategy

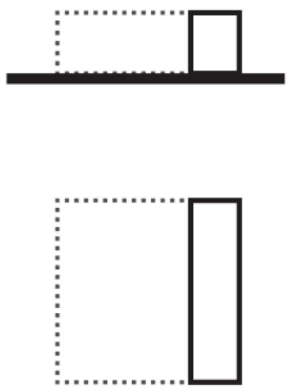
c.1. City-Production



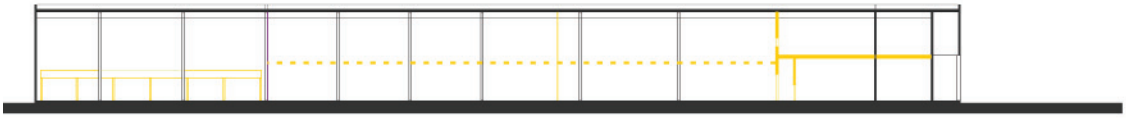
c.2. 3-axis form-type-use



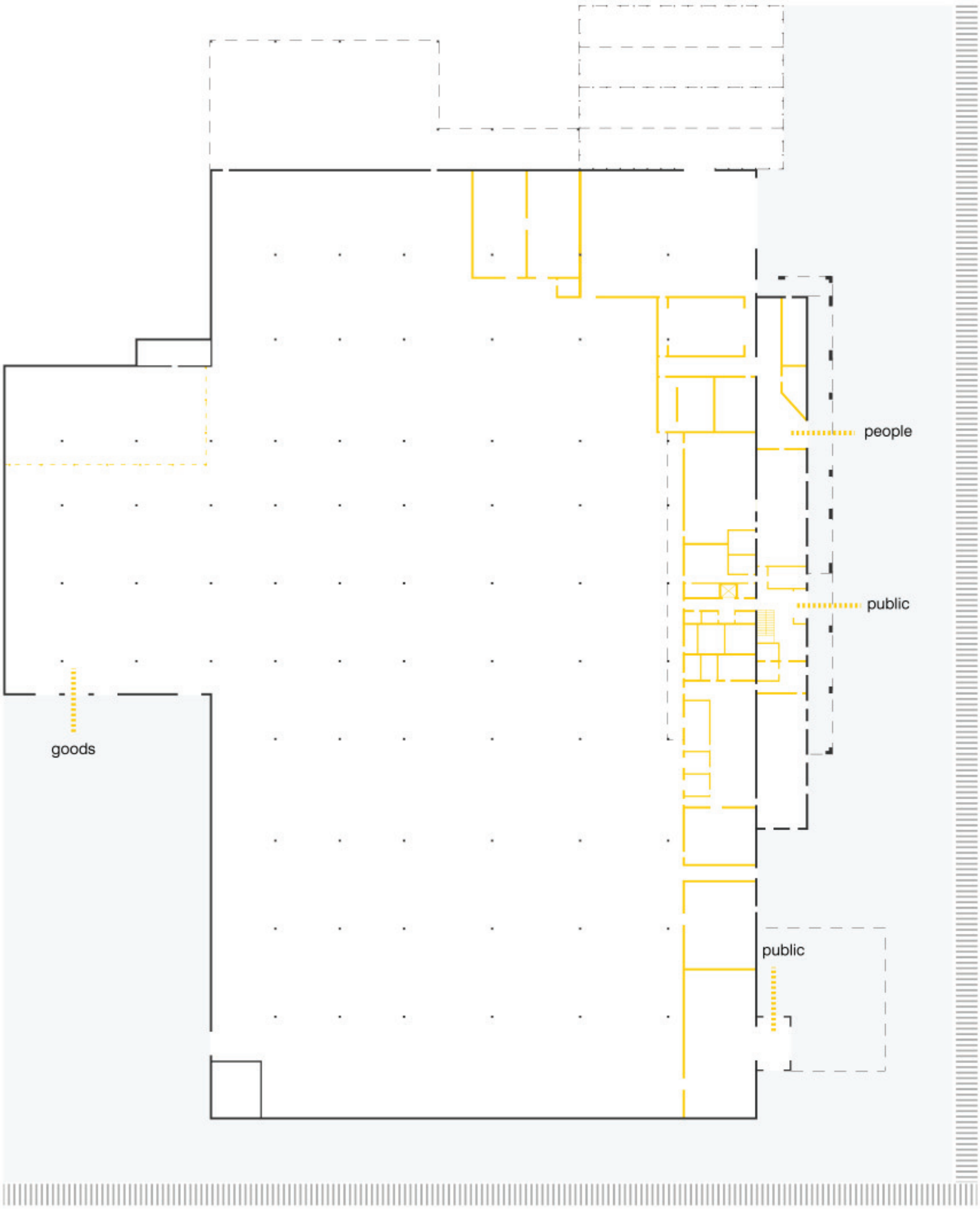
c.3. Diagram



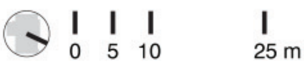
c.4. Plan and section



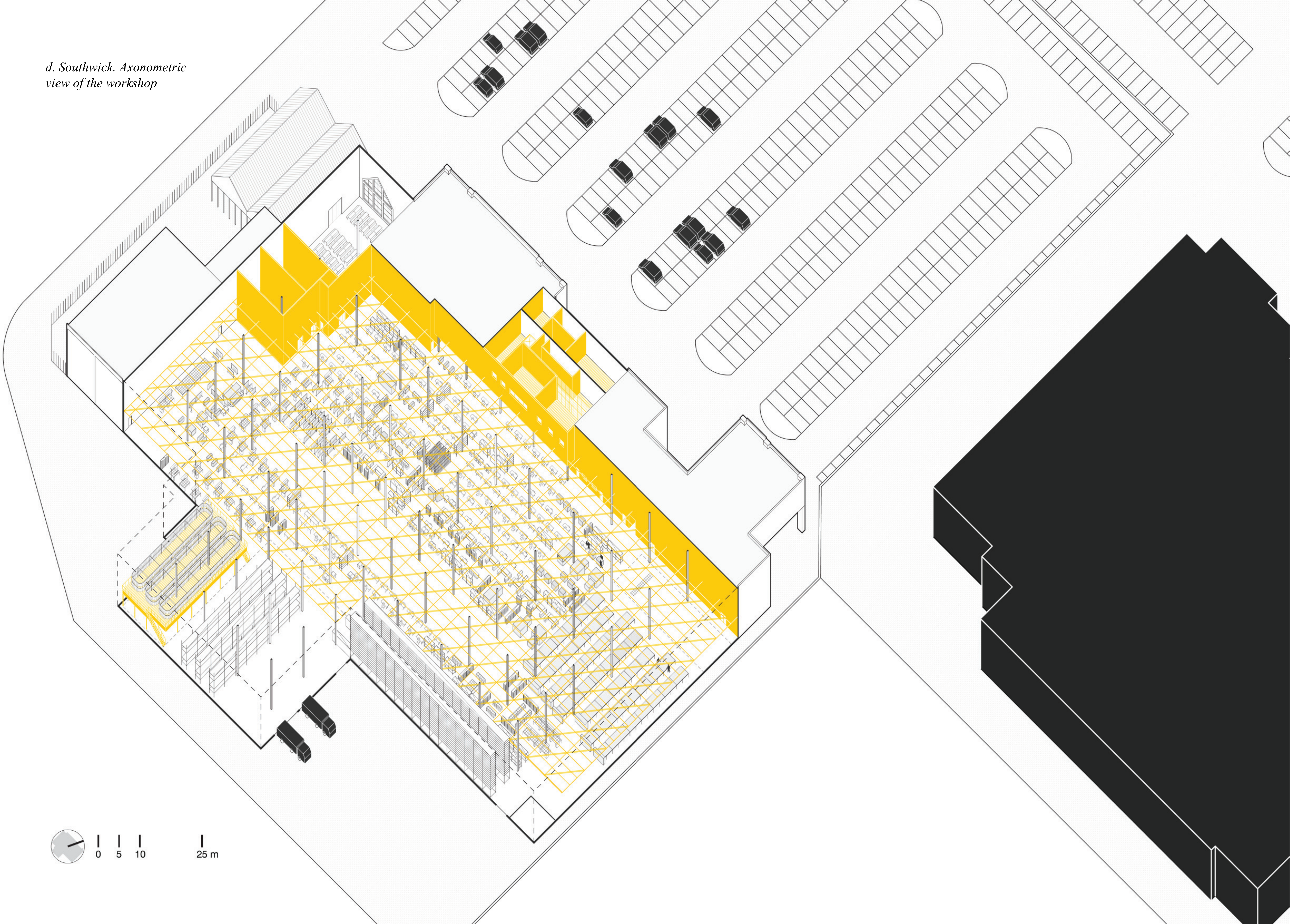
Section



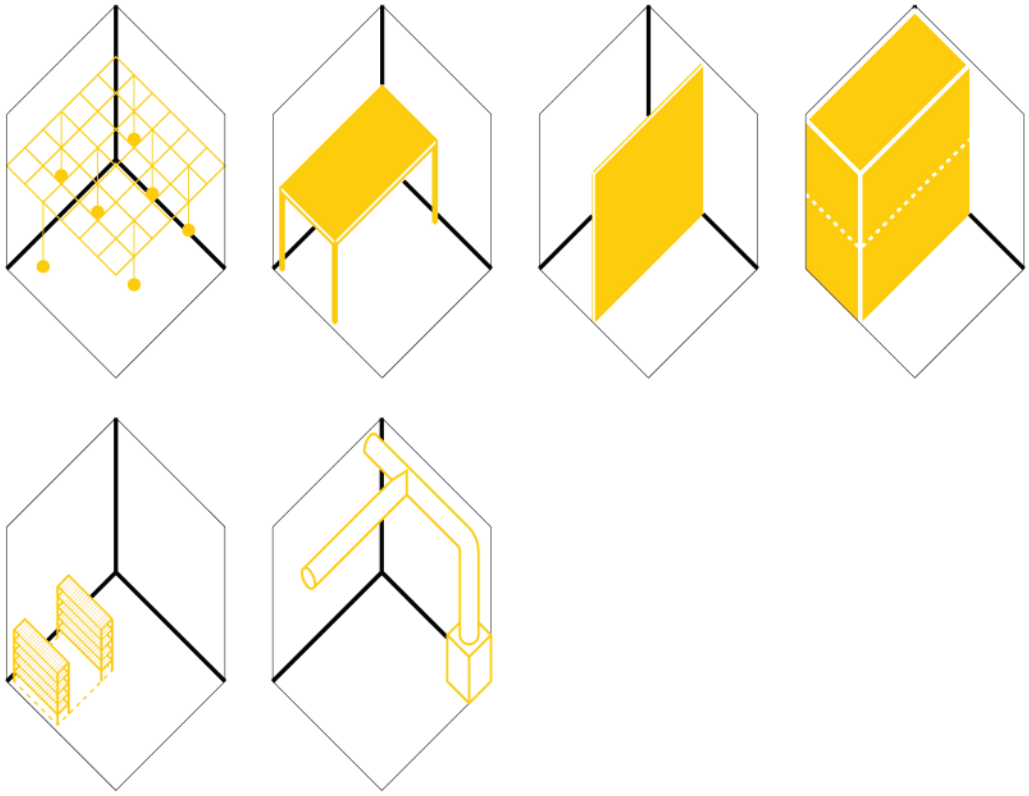
Plan



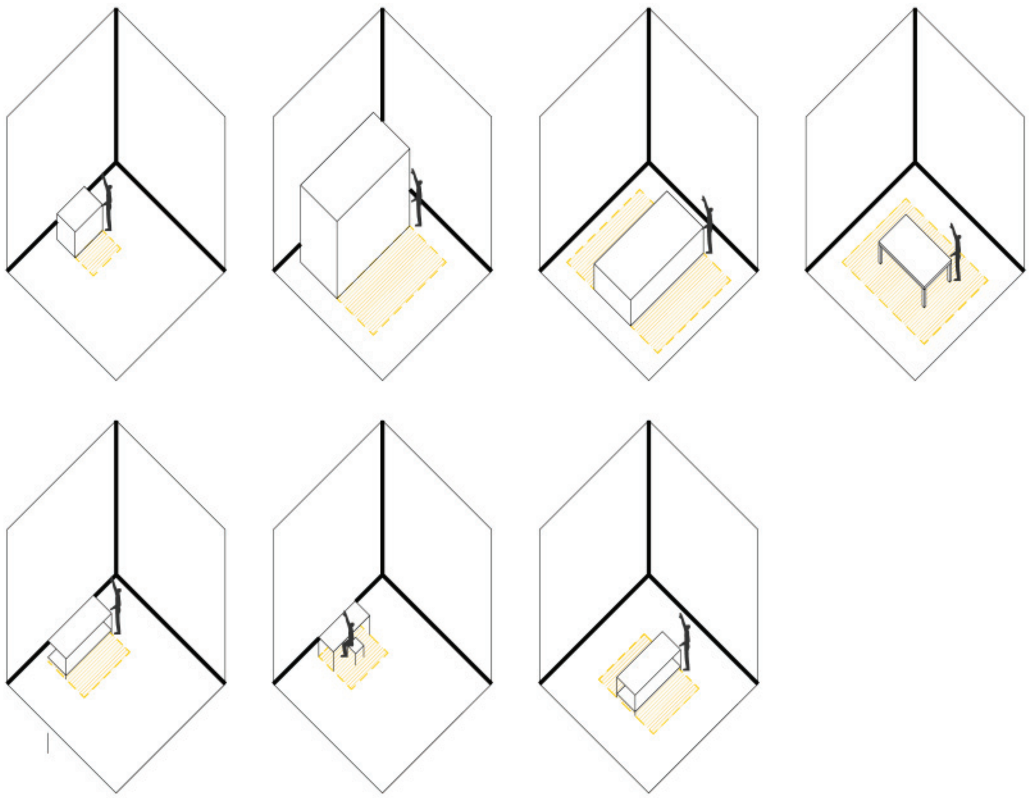
d. Southwick. Axonometric view of the workshop



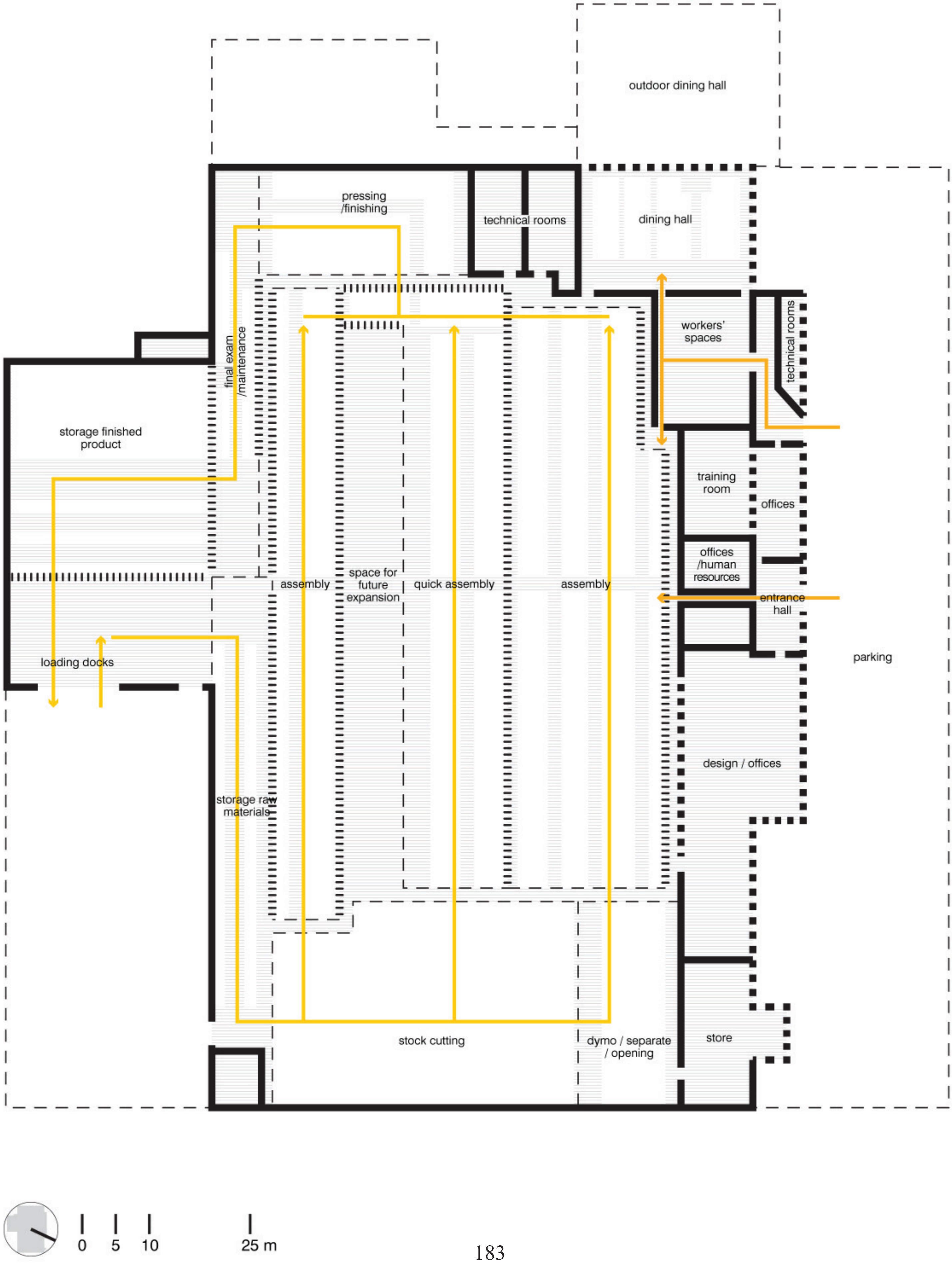
d.1. Organizers



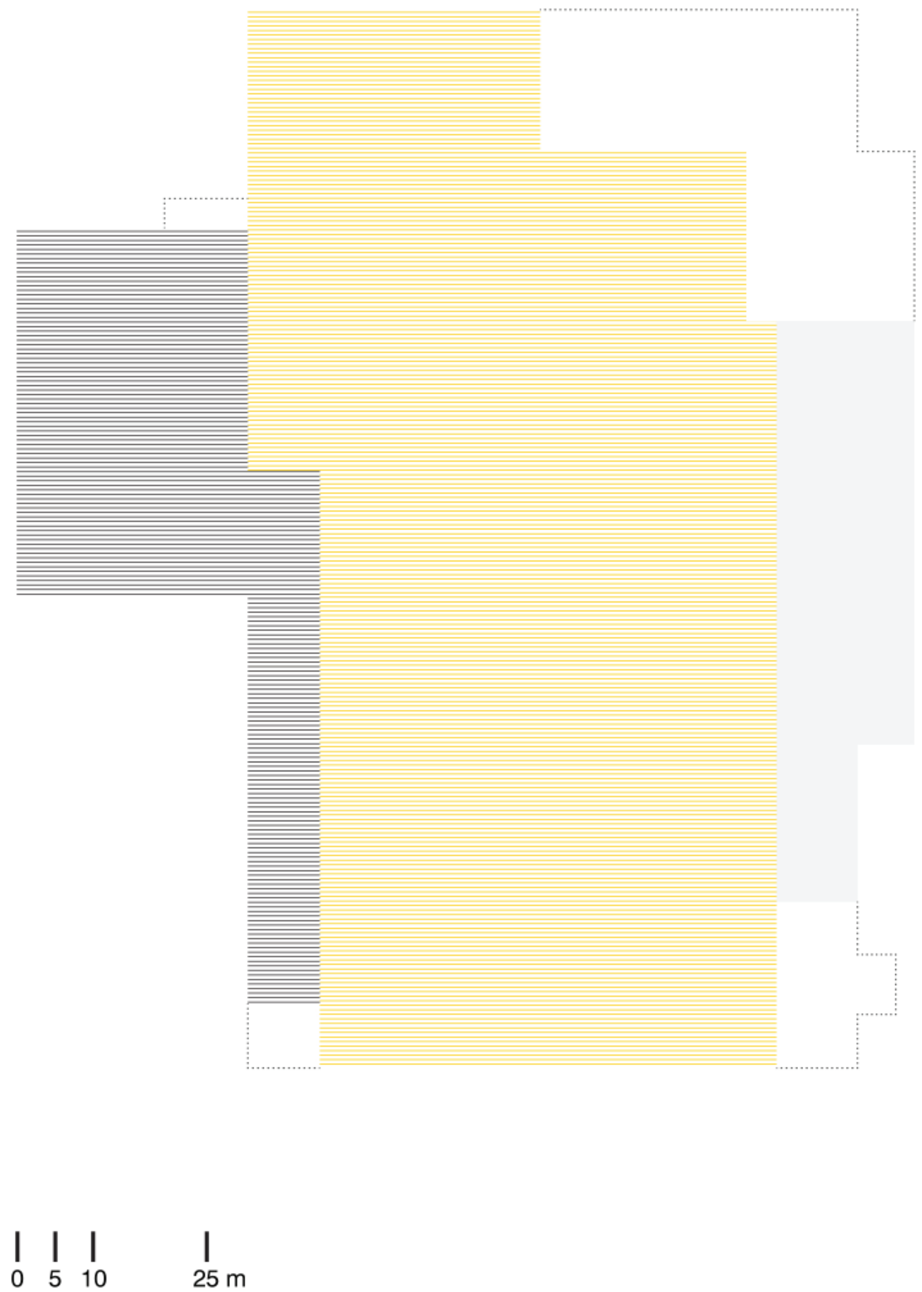
d.2. Operation units



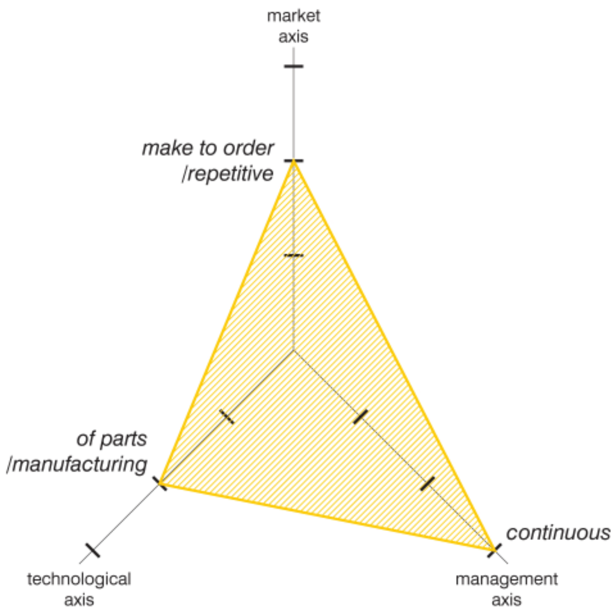
e. Southwick. Workshop layout



f. Southwick. Diagram of uses



g. Southwick. 3-axix classification of production



h. Southwick. Data table

Southwick	14420 sqm \\\ 100%	Design	Production	Storage	Other	
					common space	store
		1700 sqm	8390 sqm	2565 sqm	1120 sqm	275 sqm
		12%	58%	18%	12%	

Chapter 5

Loft working in the city

The nine companies analyzed in Chapter 4 and in general all the case studies reported in Appendix A are representative of a common trend: different forms of production increasingly attracted to urban contexts that occupy affordable disposable spaces to set their workspace/factory. These spaces are part of the physical legacy left behind by XIX- and XX-Century industrial and economic trends. Despite the variety of contexts, forms of production, and type of businesses, what bonds these experiences together is the way all parts involved in the process conceive and use spaces and infrastructure.

5.1 New old spaces of production

The presence of local manufacturing activities in cities has never completely disappeared. However, since offshoring and outsourcing trends became the predominant choice among the leading companies, and cities started focusing on other economic sectors, urban manufacturing was definitively out of the big picture. During the last decades, urban manufacturing has reshaped its presence in cities. It has been gaining attention especially after the Great Recession; but this time, due to socio-economic and technological changes, it looks completely transformed in its characteristics and forms of production compared to 19th- and 20th-century urban manufacturing.

The initial disregard has made of urban manufacturing an unplanned use in planning practices, pushing existing firms as well as new enterprises to reoccupy existing spaces and infrastructures, hence leading to adaptive reuse practices. In the transitional period when cities saw the emergence of the factory system, but the factory as a building typology was still under development (with the exception of the textile industry), manufacturing started taking shape inside the available building stock; old warehouses, houses, and even schools (see chapter 2.1 and footnote 11). These examples can be considered first cases of adaptive reuse for industrial purposes, even if they belong to a too different socio-economic context to be recognized as the roots of what reuse for production means today. Rather, these roots can be recognized in some experiences started during the late 1970s-1980s, when cities definitively acknowledged the need to shift to post-industrial economies and urban manufacturing was increasingly pushed on the side of informal and unplanned urban economies.[1] This period represents the first of the two main waves of reuse for production practices. Existing urban manufacturing firms were given a hard time in their attempt to endure in urban locations, often ending up displaced or shut down. The same was true for artists, craft workers, and other creative industries needing 'low road' spaces. These activities were constantly endangered by rising rents, conversions to more profitable uses, or even demolition. Significant experiences of this first period are the already cited American Industrial Center (AIC) in San Francisco, the Industrial Corridor of Nearwest Chicago (ICNC) in Chicago, the Brooklyn Navy Yard (BNY) and the Greenpoint Manufacturing and Design Center in New York (GMDC) in New York.

In 1975, Angelo Markoulis bought the former American Can Company in San Francisco – now American Industrial Center. The building, dismissed by the company six years earlier, was initially used just in part by the owner for its manufacturing business. Throughout the years the rest of the building (over 70,000 square meters) has been rented to other companies: in 1985, it housed around 35-40 small and medium traditional manufacturers, but more recently also creatives, tech companies, associations, and other commercial businesses started occupying the building. Today, the AIC is a family-owned, multi-tenant facility housing over 285 firms occupying units between 25 and 3,200 square meters.

In Chicago during the 1960s, a group of businessmen called Industrial Corridor of Nearwest Chicago was already active to prevent their industrial area to fall into complete disrepair. In 1980, the group decided to form a nonprofit with the purpose of acquiring and redevelop an old industrial building into a multi-tenant facility for small and medium manufacturers. Today, the building houses over 120 companies. Also, through the acquisition of other abandoned industrial spaces, and the establishment of a business incubator and advocacy program, ICNC offers space and support to industrial businesses throughout the entire Kinzie Industrial Corridor.

[1] In her contribution "The Informal Economy: Between New Development and Old Regulation" in *Urban Catalyst: The Power of Temporary Use*, Saskia Sassen analyses the different patterns of informalization of urban material economies as a consequence of the economic restructuring of cities from manufacturing- to service-dominant economic complexes. "The specific mediating process that promote informalization of work are: on one hand, increased earnings inequality, and the concomitant restructuring of consumption in high-income, and very-low-income strata; and on the other hand, the inability of providers of many of the goods and services that are part of the new consumption to compete for necessary resources in urban contexts, where leading sectors have sharply bid up the prices of commercial space, labor, auxiliary services, and other factors of production. The growing inequality in earnings among consumers, and the growing inequality in profit-making capabilities among firms in different sectors in the urban economy, have promoted the informalization of a growing array of economic activities." Sassen, "The Informal Economy," 97.

In 1981, the New York administration formed the nonprofit Brooklyn Navy Yard Development Corporation (BNYDC) to take over the Brooklyn Navy Yard, an arsenal of 122 hectares dismissed in 1966. The project has evolved as a slow incremental process of regeneration, reorganization, and new construction still underway. At the base of the project has always been the purpose of offering affordable space to production or manufacturing-related activities able to create local and stable industrial jobs. The mission has also been supported with workforce and business development programs as well as by the effort to incentivize collaborations and service exchange between firms. Today, the BNY houses over 400 businesses in 60 buildings and over 455,000 square meters. The Yard currently offers over 7,000 jobs, a number expected to jump to 17,000 by 2020 after the completion of new renovations and expansions started in 2017.

Always in New York, the nonprofit Greenpoint Manufacturing and Desing Center was formed in 1992 to save an industrial building from demolition or conversion. The future of the building was uncertain since the 1980s leaving it in a state of neglect, but it was rented to artists and small manufacturers anyway. With their support, GMDC acquired it and started repurposing the rest of the space as affordable industrial units for other artists, artisans, and manufacturers. The successful model was later applied to other seven buildings throughout Brooklyn and Queens (New York), with a new project underway. Among the five buildings currently managed, GMDC provides space (+56,000 square meters) for over 111 businesses generating over 620 jobs.[2]

These experiences have become the main references for the second wave that emerged during the Great Recession, along with the growing attention on small/medium manufacturers and local economies in general. Behind the increasing support in favor of these activities is the belief that a highly diversified economy could benefit cities in coping with inequalities and unaffordability as well as in competing globally. During this second wave, the reshaping of affordable disposable spaces for production purposes has been consolidating not only as a practice for leftovers (spaces, businesses, economies, neighborhoods, and people) but also for those innovation economies that ordinary planning tools could not foresee. There are three main actors in these practices: urban manufacturing enterprises, owners and/or managers of properties, and finally cities with their industrial legacy. While the first two actors have an active role of

[2] Informations on these projects have been retreived from websites, journal articles and personal interviews. Following the project listing, see: American Industrial Center, “About Us;” Gina Falsetto (Manager of Real Estate at SFMade) in discussion with the author, November 4, 2016; Industrial Council of Nearwest Chicago, “About Us. Overview;” Steve DeBretto (executive director Industrial Council of Nearwest Chicago), in discussion with the author, October 25, 2016; Brooklyn Navy Yard, “About Us;” Brooklyn Navy Yard, “History of the Yard;” Shani Leibowitz (manager of the planning and transportation departments, Brooklyn Navy Yard Development Corporation), in discussion with the author, September 27, 2016; Greenpoint Manufacturing and Design Center. “About Us;” Greenpoint Manufacturing and Design Center. “Buildings;” Brian T. Coleman (Chief Executive Officer, Greenpoint Manufacturing and Design Center), in discussion with the author, October 4, 2016. See also: Montipò, “Stati Uniti, così si sono riciclate le fabbriche/1.”

place maker, the city represents the backbone of these practices where it plays a decisive but sometimes controversial role.

From the owners' standpoint, these experiences have started as a necessity to rent unused spaces to top-up incomes or to temporarily earn something from an otherwise latent property while waiting to have the resources to convert it for more profitable uses. Alternatively, they were the result of a planned for-profit real estate operation. In other cases, owners have been driven by the mission of offering affordable spaces to local manufacturers to retaining industrial land and activities in cities. Regardless of the purpose behind the project, sometimes properties are owned and managed by the same agency, while other times the owner demands the management to a third party.[3] Owners/managers range from for-profit real estate companies (sometimes managing the property from elsewhere) to mission-driven locally-rooted nonprofit associations, or individuals operating for the benefit of the local community. Variations in the type of ownership/management can lead to very different developments throughout time. Also, these variations determine the ecosystem of tenants and program of uses will that take shape inside the property. Development and planning strategies depend on the purpose of the owners, the state of the property, the interest shown by potential tenants, and on financial capitals availability (of both tenants and developers). The redevelopment project can be carried out all at once or in phases, while spaces are almost always filled incrementally over time. All the case studies analyzed resulted from long-lasting redevelopment projects, some of which are still ongoing (e.g., the Brooklyn Navy Yard and 7800 Susquehanna St). Incremental processes allow property owners/managers to: redeveloping buildings piece by piece due to often limited capital resources; keeping space available for prospective expansions of businesses; and maintaining a flexible building program and ecosystem of tenants able to adjust over time to possible changes in the economy or the urban context.

From the firms' standpoint, the action of re-occupying existing buildings has proceeded from a series of concurrent circumstances. Urban manufacturing firms generally carry out production processes that do not need controlled industrial environments; they can adjust to almost any lofty space. Moreover, technological innovations and advanced manufacturing systems make more production processes independent from the characteristics and performances of the physical space (the factory) as well as cleaner and compatible with urban contexts. As seen in chapter 2.1, due to the transition to a factory conceived as a digital entity, space and infrastructures have been losing weight in economic terms as well as co-operators in the production process. On the other hand, space and location have become increasingly determinant for the existence and success of a business. As seen in chapter 3.2, due to the nature of urban manufacturing firms, the urban

[3] Most of the times, owners constitute parallel organizations that appear as manager (often if they are a for-profit they establish a nonprofit spinoff) to have access to more tax incentives, funds and grants.

location is key to ensure firms proximity to the services sector (for which they usually produce), customers, suppliers, and other manufacturers, as well as to innovation, knowledge, workers, and talent. However, cities have been often found unprepared for urban manufacturing, not only because it may result being an unplanned use or forced to informal patterns, but also because it moves and transforms at a much faster pace than the physical city. Together with the production paradigm employed (customized, small-batch, advanced manufacturing), all these reasons have led urban manufacturing firms to invest more in talent and innovation than in infrastructure. For these activities, leftover industrial and commercial buildings in urban areas represent the contextual opportunity for a good location (embedded in a dense and networked industrial ecosystem), having access to affordable and disposable spaces, and the possibility to renting space rather than buying or building a new facility which ensure them a more flexible commitment in case of changing needs.

These new spaces of production superpose and reshape the physical legacy left behind by the course of different economic trends and industrial paradigms. The buildings where today's urban manufacturing firms locate have been often designed to house one large company, a single operation, or one step of the entire industrial process. Also, they have been designed to respond strictly to that purpose as if it would last forever. Today, urban manufacturing is characterized by small- and medium-size firms whose flexible and adaptable production needs equal flexibility and adaptability in the use of space – at the scale of their workspace as well as at the urban and metro level. These shifts result in a programmatic and distributional reconfiguration of spaces into working lofts.

Loft working dynamics reshape urban contexts in two steps. First, from a former 'something' to a generic and undetermined left-as-loft space. Left-as-loft spaces result from reducing different typologies of former industrial/commercial buildings into open, generic, rough spaces able to house a wide variety of economic and human activities. This status allows spaces to express their potential better and to act as platforms of emancipation for often-unplanned uses. This first reconfiguration is usually carried out by developers on behalf of property's owners/managers. Urban manufacturing firms are usually neither the owner nor the managers of the facility; they just lease space. They are responsible for the second step, that transforms space from an open and generic loft to an urban manufacturing workspace through the projection into the real space of the production process as efficiently as possible, given the capacity and characteristic of the loft.

Reconfiguring buildings (or portions of them) into working lofts means not only reorganizing the internal distribution and logistics of a building, but also re-programming it with different combination of private, shared/semi-private, and public spaces (both indoor and outdoor and of different sizes) that develop either on multiple levels or over a single floor. Also, it means reshaping the relationship of that place with urban dynamics. Space reconfigurations have to be able to evolve and adapt over time according to the changing ecosystem of activities and tenants, manufacturing needs, owners/managers purposes, and contextual contingencies. Reconfigurations are solved through light and flexible architectural devices and design choices that can be easily removed or modified (software) – e.g., walls, glass walls, movable partitions, curtains, mezzanines, furniture, no partition at all, etc. Both developers and firms employ these architectural devices: in the first case, to better reorganize the facility and subdividing different tenants or functions; in the second case, to make their production layout fit into a given space. Loft working in the city heads towards multiple resolutions. First, it reactivates latent structures by turning them into a flexible and adaptable spaces and empowering tool (the loft). Then, it gives space to income- and job-generating economies (urban manufacturing). Lastly, it reconnects lost pieces of the urban fabric with the city' and metro's socio-economic dynamics (placemaking).

The contingencies of forms, types, and uses

Urban manufacturing shapes in cities through very different combinations of different types of businesses, buildings, and settlements (in Chapter 4, case studies analysis, see drawing *c.2. 3-axis form-type-use*; see also the same analysis in Appendix A). In these processes, urban manufacturing enterprises represent the new content reusing and reshaping a given context. Contextually, buildings and settlements that define such given context determine not only how and where urban manufacturing occur but also influence the shaping of workspaces. Different types of production enterprises can be found in single- or multi-tenant buildings that are either part of an industrial compound or isolated cases in a mixed-use context.

The research has identified four types of enterprises: manufacturing firms,[4] MaaS companies,[5] shared workshops and hardware-oriented incubators,[6] R&D activities[7] (fig. 5.1). Also, during the field trips, the research has detected a fifth production-related enterprise: enhancing platforms. This type of business is a service that does not directly include any form of making a physical product, (hence it has not been included in the analysis). Regardless, companies like Fictiv (San Francisco) and Makers' Row (New York) are essential to expanding the access to means of production to designers and small businesses while also strengthening regional supply chains (see Chapter 2.2). These enterprises take shape inside existing facilities whose spatial characteristics and form of settlement

[4] Amond the case studies reported in Appendix A: Ferra Designs, Situ/Fabrication, Southwick, BoXZY, Détroit Is The New Black, Lazlo, The Empowerment Plan, Heath Ceramics, Taza Chocolate, Bien Hecho, Parallel Development, Riva Precision, Taktl, Urban Tree, Kerf Case, Optimus Technologies, Puzzle Pax, Smith Shop, Detroit Denim, Shinola, Rickshaw Bagworks, American Apparel.

[5] Amond the case studies reported in Appendix A: Conturo Prototyping, PCB:NG, Linda Tool.

[6] Amond the case studies reported in Appendix A: Artisan's Asylum, Autodesk BUILT Space (Boston and San Francisco), New Lab, Supersmith, Protohaven, mHUB, Lost Arts, PS:1, Tech Shop SF, Manylabs, La Kretz Innovation Campus, Toolbox LA.

[7] Amond the case studies reported in Appendix A: Carnegie Robotics, Protoinnovation, NREC, Astrobotic Technology, Plethora, Flex Invention Lab, Hyperloop Innovation Campus.

proceed from their original purpose. For this research, buildings have been roughly subdivided between three typologies that recall their development in space; vertical, horizontal, and squared. Figures 5.1, 5.2, and 5.3 analyze the different combinations found in the fifty case studies presented in Appendix A.[8]

The most recurrent combination is manufacturing firms occupying a dedicated unit inside a multi-tenant building (over 30% of the case studies). Due to their often large size, this scenario takes shape predominantly inside vertical multi-story buildings or extended 'cubic' warehouses (either single- or multi-story). That is the case of BoXZY, The Empowerment Plan, Détroit Is The New Black, and Lazlo at Ponyride. All these companies rent their spaces in facilities owned and managed by two nonprofits. BoXZY occupies a private unit at 7800 Susquehanna Street. The workspace is separated by a wall from the rest of the facility, where each company has its private space and share with the others distribution and logistics spaces (freight and people elevators, corridors, main access, loading docs, outside space). The other three companies are distributed between two contiguous units at Ponyride. None of them has its private enclosed space. The Empowerment Plan's production space houses a shared kitchen used by all tenants, while Lazlo and Détroit Is The New Black share one room where they use the furniture arrangement to distinguish between the two dedicated areas. Also, both units are often crossed by other tenants to move inside the facility (Ponyride has almost no dedicated spaces for distribution, like corridors). Heath is another example of a multi-tenant facility, with the difference that the company manages the facility. Multi-tenant facilities are characterized by the combination of private (dedicated production spaces), shared, and public spaces. Shared spaces might include distribution, logistics, and warehouse spaces (e.g., loading docks, freight elevators), as well as leisure areas, shared shops or machinery (e.g., a shared spray room at one GMDC facility). Public spaces can include the street, parking, and open spaces, as well as publicly accessible food courts and indoor leisure spaces (e.g., Industry City, building 77 BNY, Heath Ceramics).

The second most recurrent combination (around 20%) are collaborative workshops/incubators located in single-tenant buildings. This scenario takes shape more frequently in rather small warehouses and other 'box-syle' buildings (cubic typology). The single-tenancy refers to the enterprise that runs the facility; in some cases, this enterprise is not the owner of the building but it is running it out of a long-term lease. Here, many firms and individuals pay a membership (usually monthly-based) that gives them access to shared shops, desk space, and tools. Ponyride's makerspace and woodshop at the ground floor correspond to this model. Also, BoXZY started at one of these types of facilities (Tech Shop) and after moving its dedicated factory kept using the makerspace for office and R&D activities. In this model, all spaces are shared between members. As part of the business model, some of these enterprise houses public courses or events (like

[8] This analysis has considered the average tenant for those case studies where a tenant hasn't been reported in Appendix A (hence there is no 3-axix form-type-use diagram).

Supersmith that rents its makerspace for social dinners, weddings, and other events), others collaborate with schools for STEM courses, while other times they provide for financial and business development support to members (e.g., Autodesk BUILD). Some collaborative workshop offers the possibility to rent small dedicated production or storage spaces (e.g., Supersmith, Factory Unlocked, Tech Shop SF).

Carnegie Robotics, Ferra Designs, and Situ Fabrication are representative of a third model: manufacturing firms occupying an entire building (single-tenant) that is part on a multi-tenant industrial compound (in this case, the Lawrenceville Technology Center and the Brooklyn Navy Yard). All three companies occupy horizontal single-story sheds, where they have reconfigured parts of the open space to obtain smaller units dedicated to specific operations. Like in multi-tenant buildings, this model sees the combination of private, shared, and public spaces; with the difference that the private space corresponds to the entire building, while shared and public spaces are just open spaces or separated buildings (e.g., the food court inside BLDG 77 at the Brooklyn Navy Yard). Again, all these companies do not own their spaces, but they have signed a long-term commitment with the property owner/manager. On the contrary, due to the size of the company and type of production system, Southwick owns (as part of the Brooks Brothers corporation) and occupies an entire building, part of an industrial park made mostly of single-tenant buildings.

Urban manufacturing enterprises may occur entirely in one place or being distributed among different spaces of production within the same context. For instance, one firm can occupy an entire building and carrying out all the operations inside it (e.g., Southwick). Alternatively, the firm can be part of a multi-tenant facility where it still carries out all the operations inside its unit, but it shares loading docks, storage areas, or other logistic areas with other tenants (e.g. Ferra Designs, Situ/Fabrications, BoXZY). Other times, the firm has its dedicated production space but it maintains part of the design and innovation process in a dislocated but strategic location, still in proximity to the factory (e.g., BoXZY, who kept its office inside Tech Shop until its closure; and Situ, that had the research unit and prototyping lab in multi-tenant facility housing mostly creative and tech offices). In some other cases, the firm relies on dislocated production facilities like makerspaces, incubators, or MaaS companies to carry out some of the operations; then its main space is mostly dedicated to non-manufacturing operations such as design, storage, shipping, etc. Other times instead, all the operations are carried out inside a makerspace or incubator temporarily using shared tools and machinery.

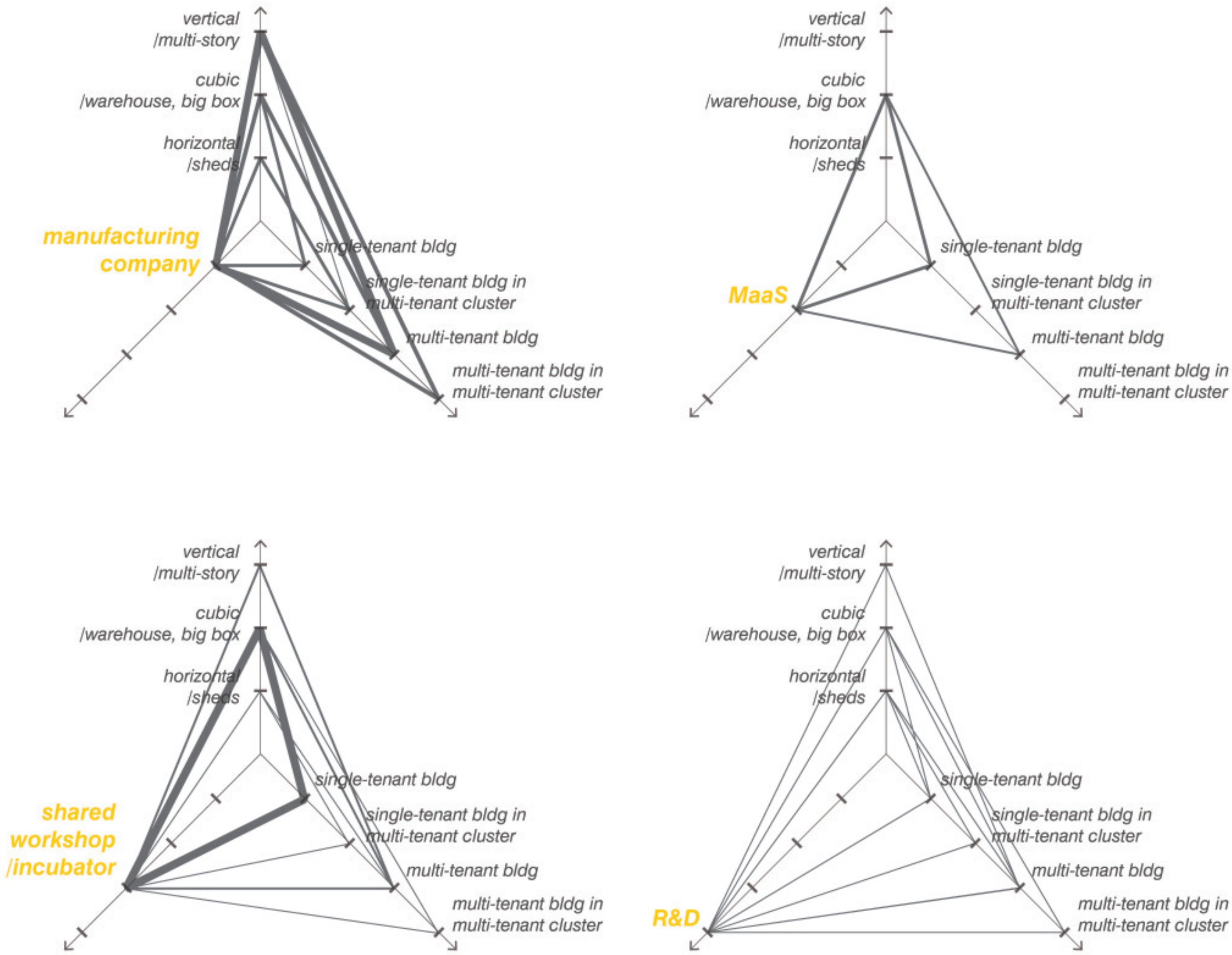


Figure 5.1. Type of production enterprises. Comparison based on the 50 case studies reported in Appendix A.

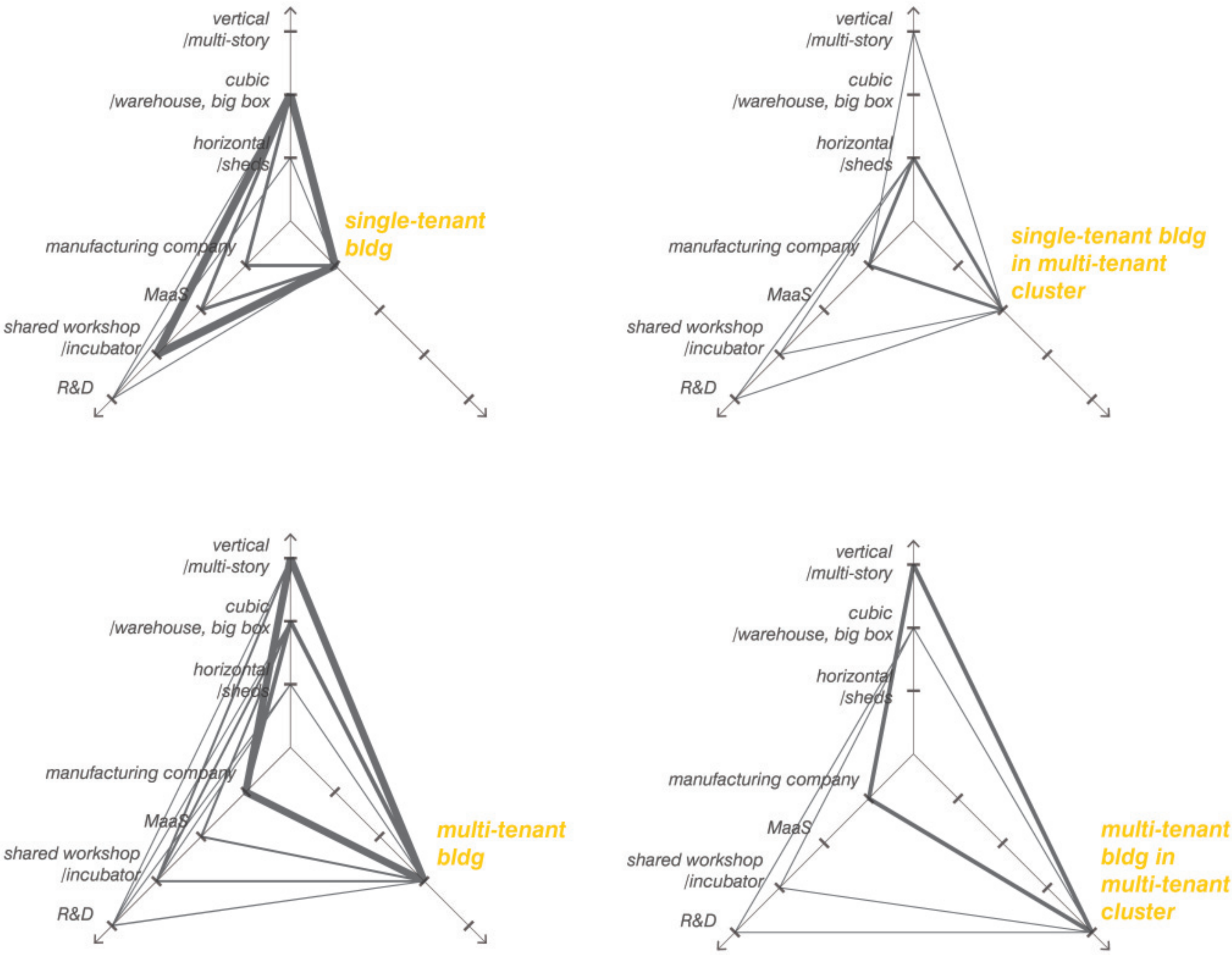


Figure 5.2. Forms of settlement that include urban manufacturing. Comparison based on the 50 case studies reported in Appendix A.

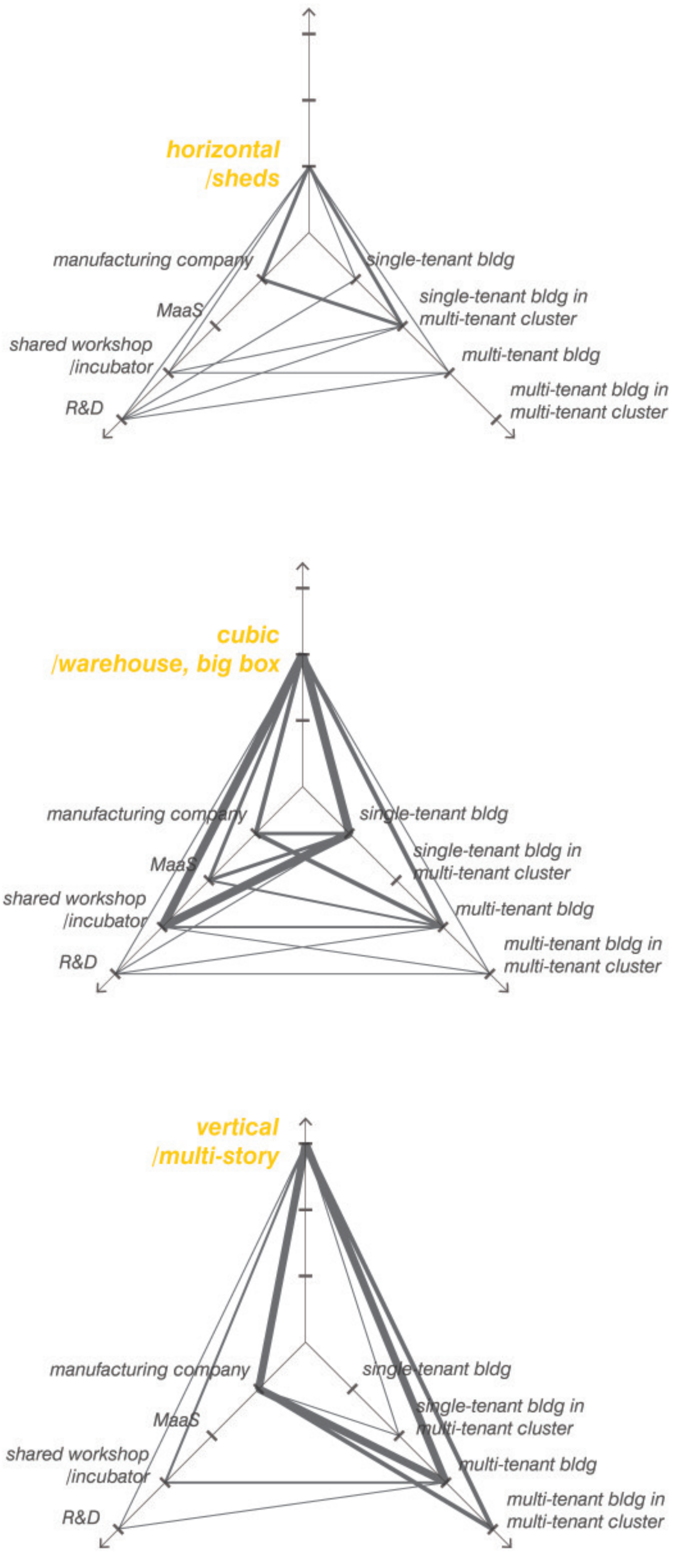


Figure 5.3. Types of building that house urban manufacturing. Comparison based on the 50 case studies reported in Appendix A.

Leaving space as loft: reconfiguring space for general purposes

Loft working processes start with reducing space to its essential infrastructures (the hardware), leaving it as open and rough as possible, ready to be reinterpreted by users. This way, space better expresses its intrinsic potential to adjust to every upcoming purpose. Warehouses, daylight factories, wholesale stores, commercial malls, storages, industrial sheds, multi-story industrial lofts, big boxes; once reduced to their generic, rough, open status they all act as suitable spaces for a wide variety of businesses and plant layout.

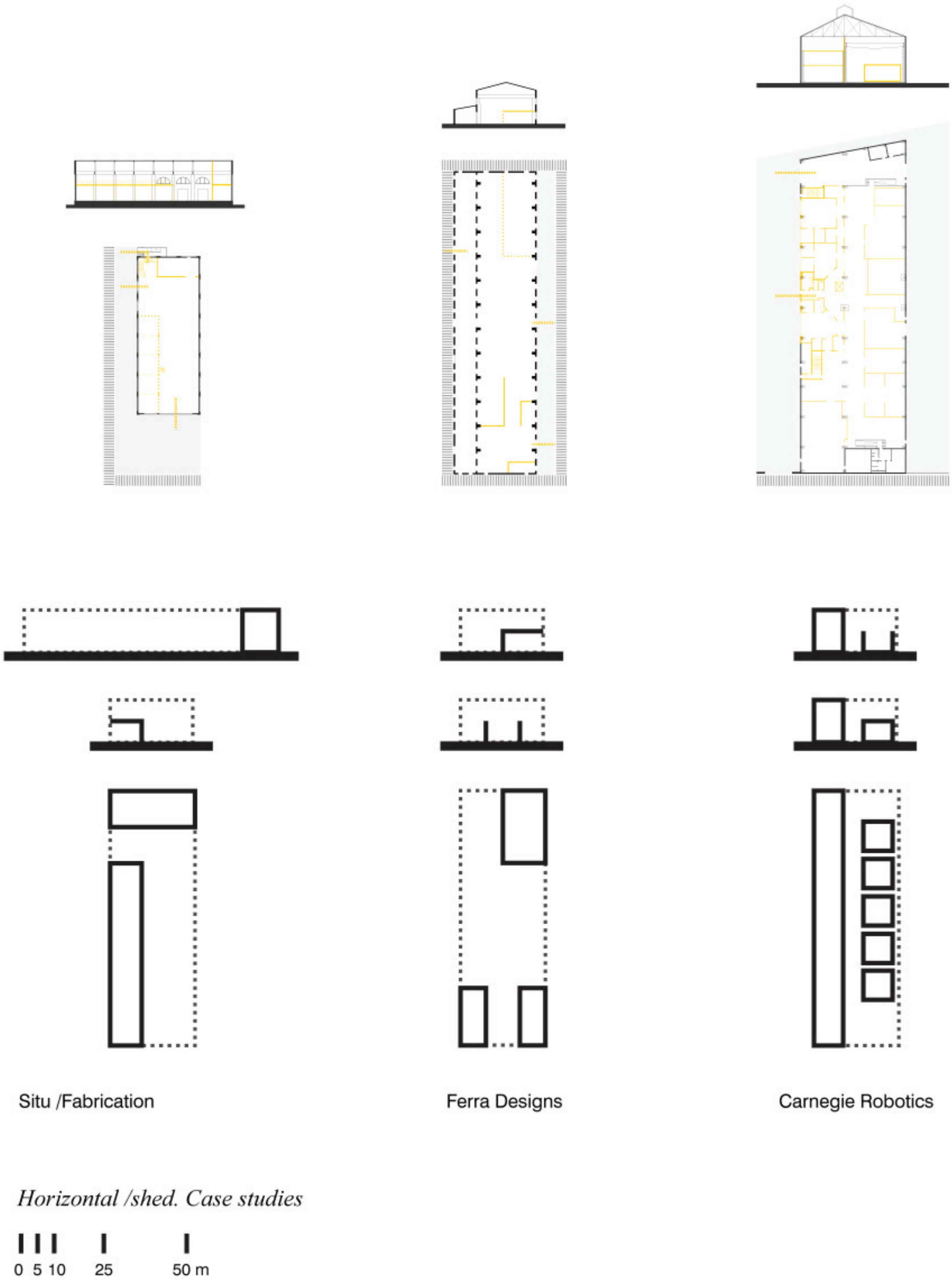
Owners and managers are those who provide for this first reinterpretation of space. Most of the times they do not know what businesses will occupy the space, while other times they collaborate with future tenants. In some cases, the project seems to be almost non-existent. Facilities are set to respond to general industrial needs and adapt over time to possible variations in type and size of uses that will be carried out inside them. The spatial strategy diagrams in Chapter 4 (Chapter 4, case studies analysis, see drawings *c.3. Diagram*) stress the attention on the change in firms' size between older industrial paradigms and urban manufacturing's one. There is a recurrent mismatch between the space needed by contemporary firms and the massive floorplates of former industrial buildings. Buildings owners/managers subdivide properties into minimum space units that can eventually be assembled. Figure 5.4 shows some recurrent ways to reconfigured space for each type of building. The dashed line indicates the existing open floorplate, while the continuous line shows how the new occupation reshapes it to obtain smaller-sized, protected, or additional spaces. Depending on the type of economic activity and company, the production part can be either placed in the space left open and wide or confined into the reconfigured part of the building. Reconfigurations can consist of transforming a building from a single-tenant to a multi-tenant facility, as well as of obtaining smaller-sized or protected spaces (needed for some operations) either in a single-tenant building or in the unit occupied by one business. In this sense, spatial reconfigurations work like a Russian Doll. If we consider a multi-tenant multi-story building, the first spatial reconfiguration will obtain small units (generally based on a market survey of business' size in the area) and a new distribution network starting from the structural grid and the vertical elements like elevators and stairs. Then, each unit would be again reconfigured by the user as if it were a single-floor open generic loft connected first to the building' freight distribution system then to the city's one. The spatial solutions would then recall those adopted in the squared or horizontal type of spaces. The same could happen for the other type of buildings.

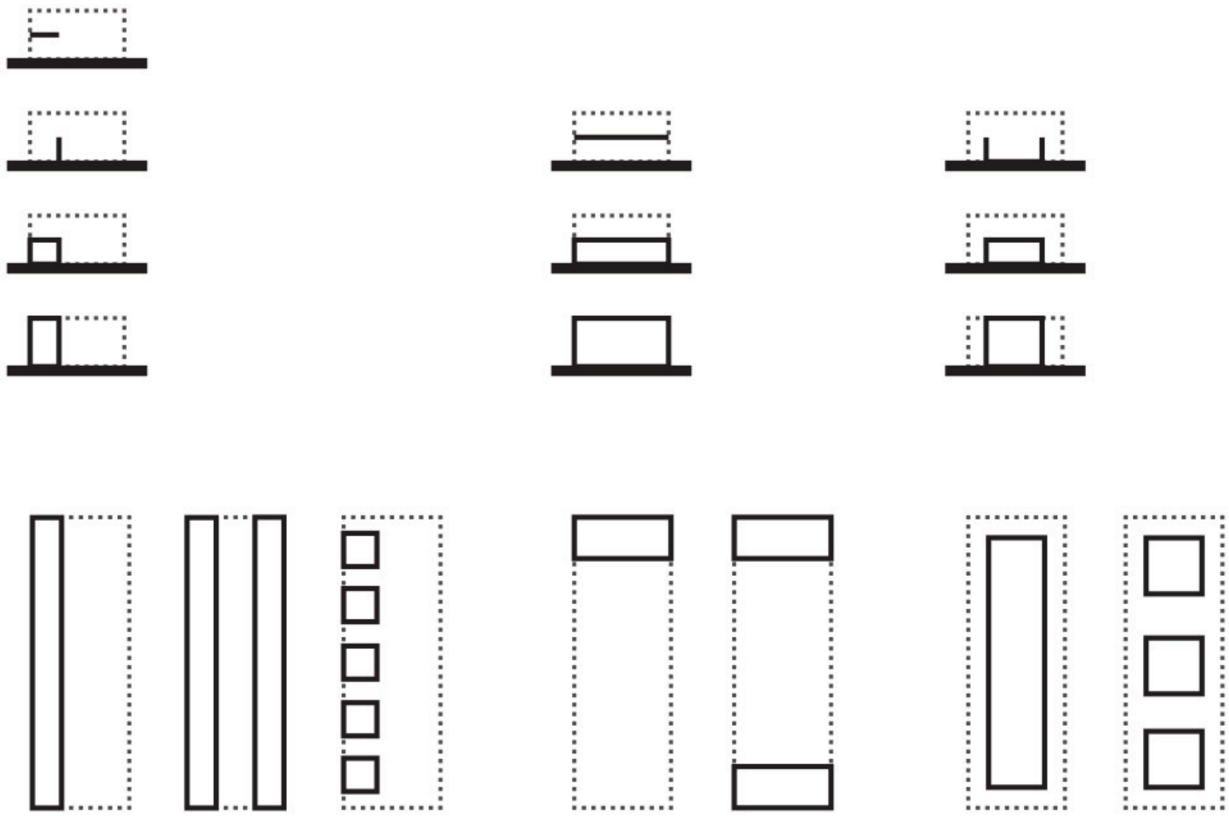
The practice of reconfiguring spaces for general purposes – i.e., leaving spaces as lofts – consists of:

- Reducing spaces to their essential structural and infrastructural elements by: cleaning up and securing spaces and structural elements; uncover or rethinking natural air and ventilation systems; updating or installing utilities, sprinkler systems, artificial lighting/ventilation, and in general all supply networks.

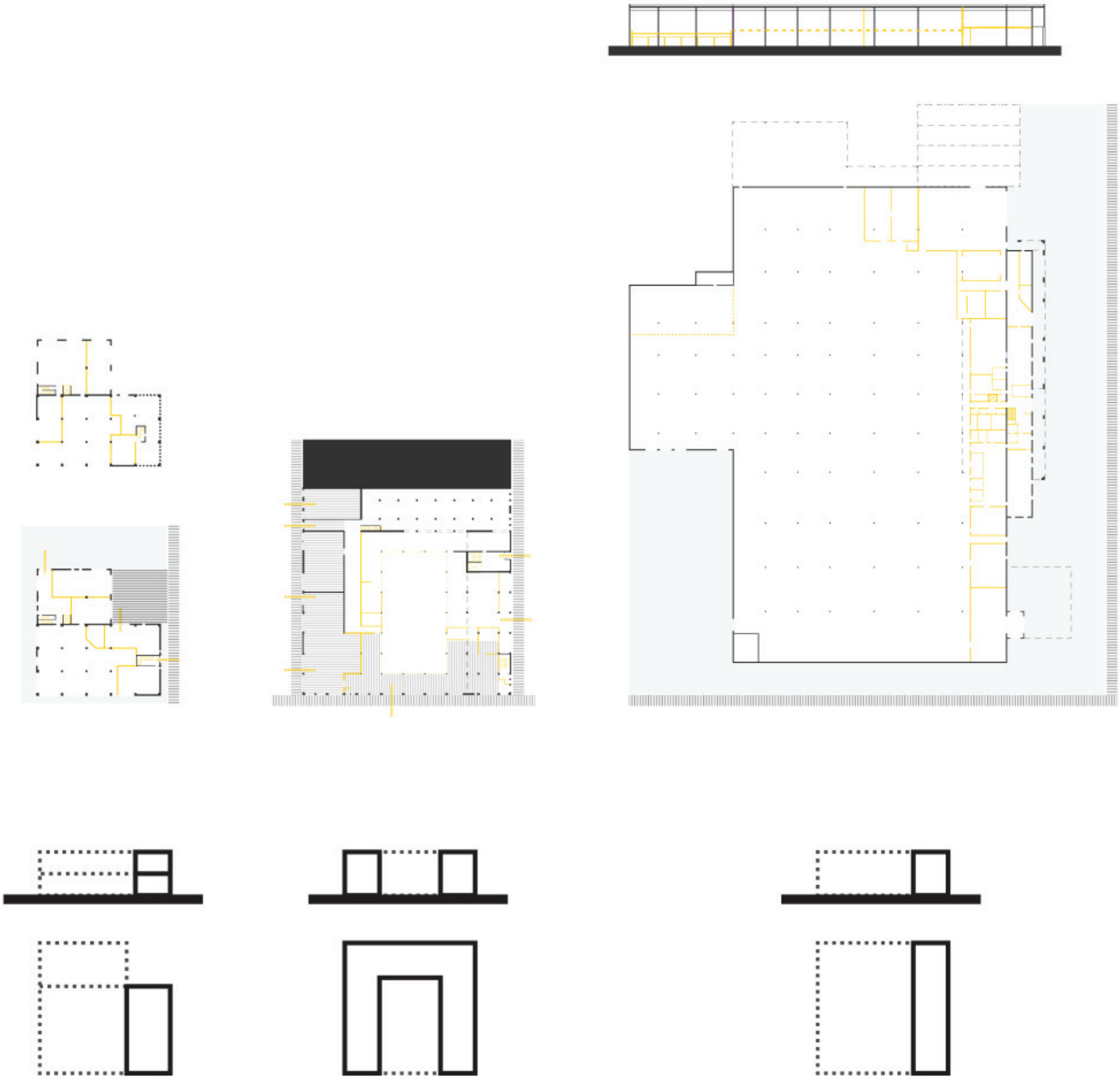
- Rethinking size and distribution of spaces to make properties more suitable to firms' needs but also adaptable and flexible to be able to absorb changing needs and variations in the building program. These issues depend on the typology of the building as well as on potential tenants (urban manufacturing enterprises) and economic trends in the area.
- Managing flows of people and materials with design solution and architectural devices – do they interfere with each other? Do they have to be separated or forced to cross? Do they have to see each other but not cross? etc.;
- Rethinking logistics and service spaces inside and outside the building as well as around it – how can people/materials access the building? Who can access it? etc.;
- Planning for a balanced subdivision between private, shared, and public spaces based on the characteristics of the building as well as of the urban context (if needed).

Figure 5.4. Spatial reconfigurations subdivided per building typology.





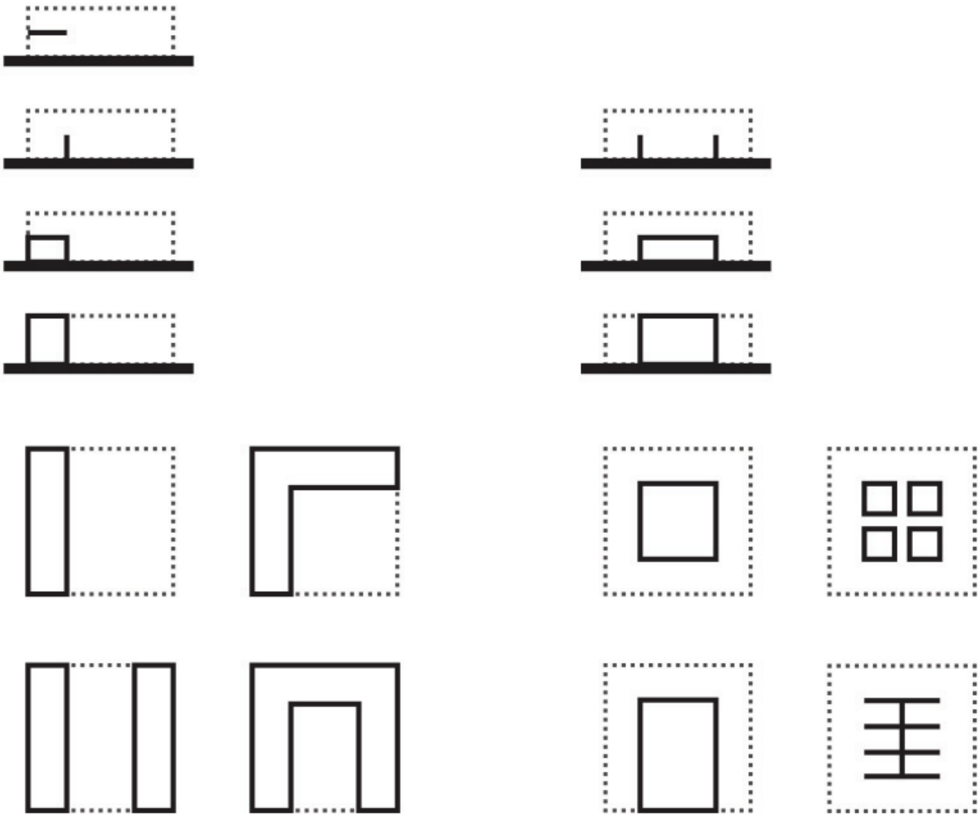
Horizontal /shed. Recurrent spatial strategies



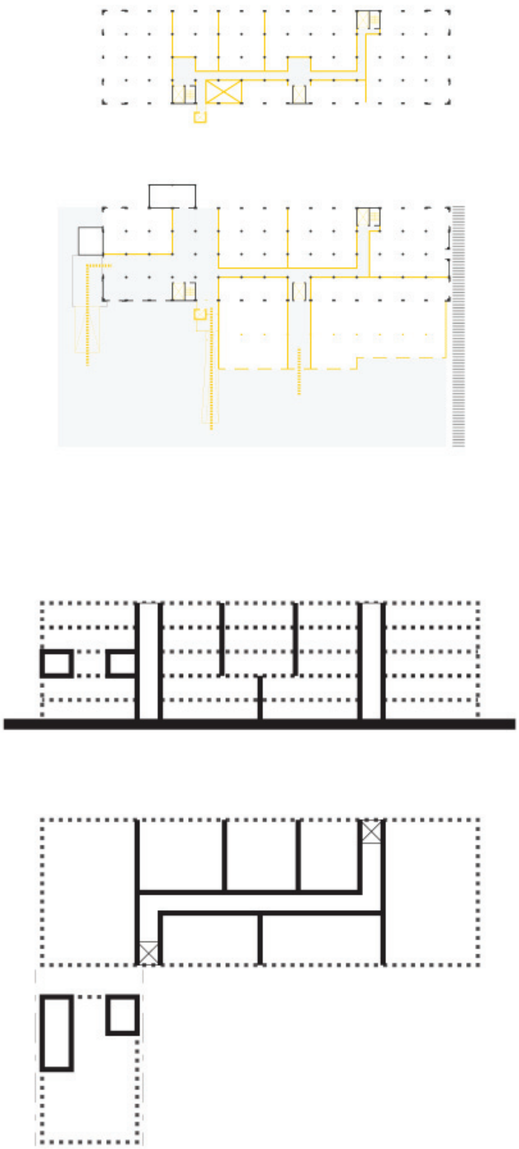
Ponyride   Heath Ceramics   Southwick

Cubic /warehouse. Case studies

0 5 10   25   50 m



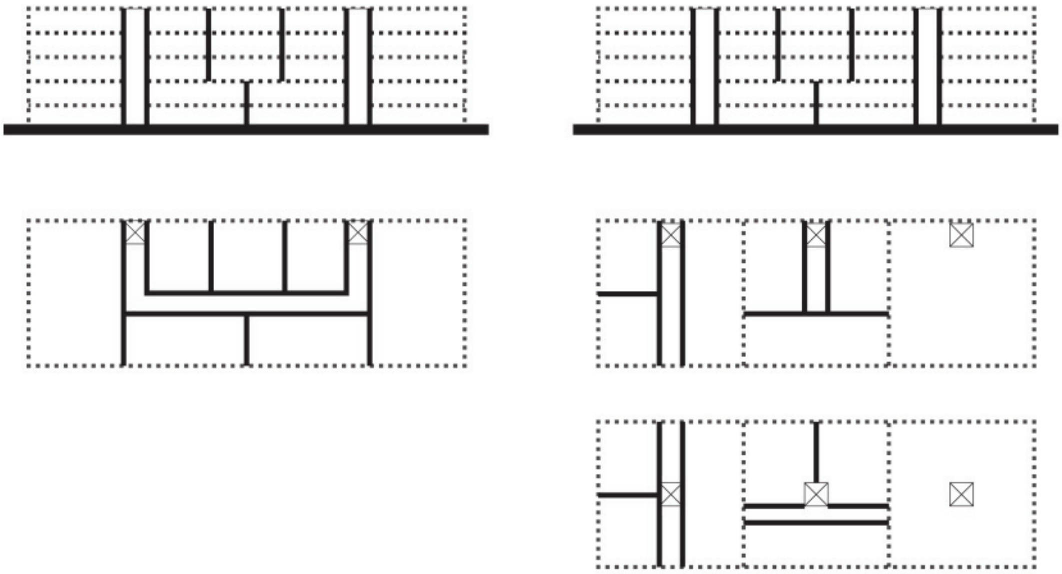
Cubic /warehouse. Recurrent spatial strategies



BoXZY

Vertical /multi-story. Case studies

0 5 10 25 50 m



Vertical /multi-story. Recurrent spatial strategies

Working in lofts: reconfiguring space for production purposes

How spaces of production organize in space depend on some variables connected to the nature of the production activity: for instance, the type of enterprise, the production system and plant layout,[9] as well as the size of the company and its business development model.

Overall, firms organize production over one floor but not necessarily at the street level, which entails the possibility for some forms of production to locate in upper floors and be vertically stocked. At the same time, storage and design spaces are sometimes developed vertically on multiple levels. Comparing the diagram of uses in Chapter 4 (tab 5.5, fig. 5.6), approximatively half of the space is usually for production, around 10% for design, and the rest for storage. Percentages slightly vary depending on the type of business. For instance, BoXZY dedicates only 3% of its space to design, partly because at the time of the site visit the company used the nearby Tech Shop (where the business started) as its office space. On the contrary, Carnegie Robotics has a higher percentage of design space (22%), probably due to the R&D nature of the company. Among the manufacturing firms, Lazlo dedicates 33% of its space to design, a very high percentage compared to the average of the other manufacturers. This high percentage can be partly explained by the fact that the company produces very small batches of few items of clothing sold at a high price (they are supposed to last a lifetime thanks to the high quality of the cotton fiber). In this case, material sourcing, prototyping, and marketing operation are likely to take much more space than manufacture the product. These variations in the amount of space for design find their final explanation in the fact that in urban manufacturing firms – that tend toward advanced manufacturing paradigms – design and fabrication often merge. During field trips, it has sometimes been hard to distinguish between the two activities clearly; design operations have been often found spread throughout the production space (in fact, the diagram of uses reported in figure 5.6 represent an abstraction of the organization of the different functions).

All companies except for Southwick employ intermitted production systems that vary between job shop, batch production, and project production. Southwick, which is also the largest and more established company, mass produces customized products. Southwick's production space is based on product layout. The same happens in Heath Ceramics and BoXZY, even if their production processes differ from Southwick. With each *corral* dedicated to a single project, Carnegie Robotics resembles a fixed position layout where all the resources are taken to the project site for 'on the spot' performances. Situ Fabrication's shop follows a process layout where machines performing similar operations are grouped in clusters. Conversely, Ferra Designs has organized its shop following a group layout (or cellular manufacturing) where operations are clustered by

[9] For the definition and description of the different production systems and plant layouts cited in the following paragraph, see: Cuomo et al., *Dalla strategia al piano*, 189–228.

technology or process. The size of these companies can be determined by both the amount of space occupied and the number of employees (tab. 5.5). Southwick is the largest company with over 14,400 sqm and 540 employees. On the contrary, Lazlo and Détroit Is The New Black occupy very small units and employ between 1 to 5 people. These differences reflect in the fact that the first company is the one producing in largest batches (mass customization and daily shipping), while the latter two manufacture to order very few items. Carnegie Robotics, Ferra Designs, and Heath Ceramics occupy rather large spaces (especially compared to the number of employees) of over 2,300 sqm (25,000 sf). This number is often considered by developer and city planners the limit to determine if a production space is rather small or large (hence more likely to house heavy-manufacturing or needing of larger spaces for freight operations).[10] Besides the indoor space, firms occasionally outflow their factories' boundaries with their operations. For instance, Situ Fabrication often occupies the open space in front of its building for the assembly of large pieces. Likewise, Carnegie Robotics often uses the space behind the factory as a test track.

[10] Timothy White (Senior Vice President of Development, Regional Industrial Development Corporation), in discussion with the author, September 2016; April 2017.

Company	Amount of space [sqm] [% of the total space]	Amount of Design/Production /Storage space [%]	Number of jobs	Square meters per employee
Heath Ceramics	2600 (52%)	6% Design 37% Production 42% Storage	+34 (just SF factory)	76.5
Ferra Designs	2300 (100%)	10% Design 40% Production 50% Storage	24	95.8
Situ /Fabrications	1115 (100%)	9% Design 60% Production 31% Storage	+45 (just the fabrication division)	24.8
Lazlo	90 (3%)	33% Design 50% Production 21% Storage	3 (average) (1-5 jobs besides the founders)	30
Détroit Is The New Black	90 (3%)	11% Design 61% Production 28% Storage	3 (average) (1-5 jobs besides the founders)	30
The Empowerment Plan	325 (13,5%)	9% Design 50% Production 21% Storage	+34	9.5
Carnegie Robotics	3960 (100%)	22% Design 43% Production 23% Storage	+60	66
BoXZY	450 (3,7%)	3% Design 55% Production 36% Storage	10 (average) (5-15 jobs based on orders)	45
Southwick	14420 (100%)	12% Design 58% Production 18% Storage	540	26.7

Table 5.5. A comparison between the total amount of space, the amount of space dedicated to design, production, and storage, number of jobs, and average square meters per employee.

Figure 5.6.
A same-scale comparison of diagrams of uses

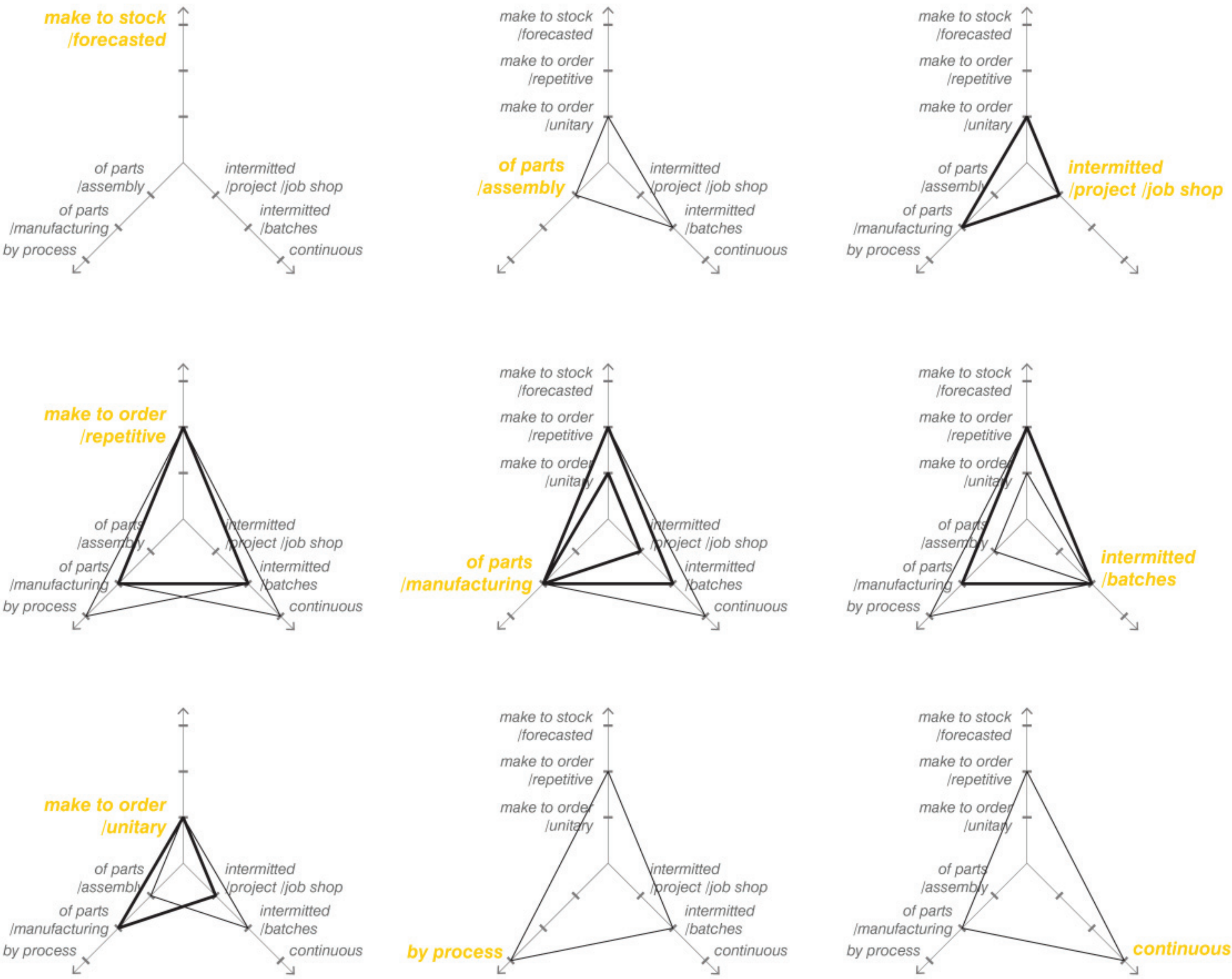


Figure 5.7. A comparison between 3-axis classification of production of companies analyzed in Chapter 4.

These variables in the production process and business model determine a virtual model of the factory that allows urban manufacturing enterprise to determine how production and information flows should run through operations and which relationship should be established between different part of the process. Companies find their soon-to-be-occupied spaces already reduced to their rough generic status; cleared, cleaned, and left with the essential structural elements and basic supply systems. This status is considered the 'ground zero' starting from which planning how to set the workspace. The 'fitting' process consists of projecting the virtual model into the real space. Production processes adjust and organize as efficiently as possible to the characteristics of the given space with the minimum amount of investment and actions.

As said at the beginning of the chapter, urban manufacturing firms carry out production processes that can adjust to almost any lofty space. They take advantage of the openness and wideness – owed to the original purpose of their buildings – to let production run with as few boundaries and interfering elements as possible. In Chapter 4, the layouts of these spaces of production have been analyzed by breaking them down into typical elements; operation units and space organizers (fig. 5.8). Operation units include technology-based operations carried out by a machine supported by human expertise (machinery), and hand/tools operations (workbenches). Organizers are different architectural elements employed to organize or define the use of space; these elements reflect the light architectural devices employed by developers to reconfigure spaces and distribution when they repurpose a facility for industrial uses (cfr., in the previous paragraph the discourse about spatial reconfigurations that work as a Russian Doll). The analysis has then observed what type of relationship exists between contiguous 'typical elements' throughout the entire plant layout. All firms have organized production processes without physical boundaries between operations. The area dedicated to each operation is usually outlined by a drawn line on the floor or simply by considering the amount of space occupied by a machine/workbench and the elbow room needed to access and use it (Chapter 4, case studies analysis, see drawings *e. Workshop layout*). Carnegie Robotics is the only exception where, for privacy reasons, production is carried out inside enclosed cells (fig. 5.9).

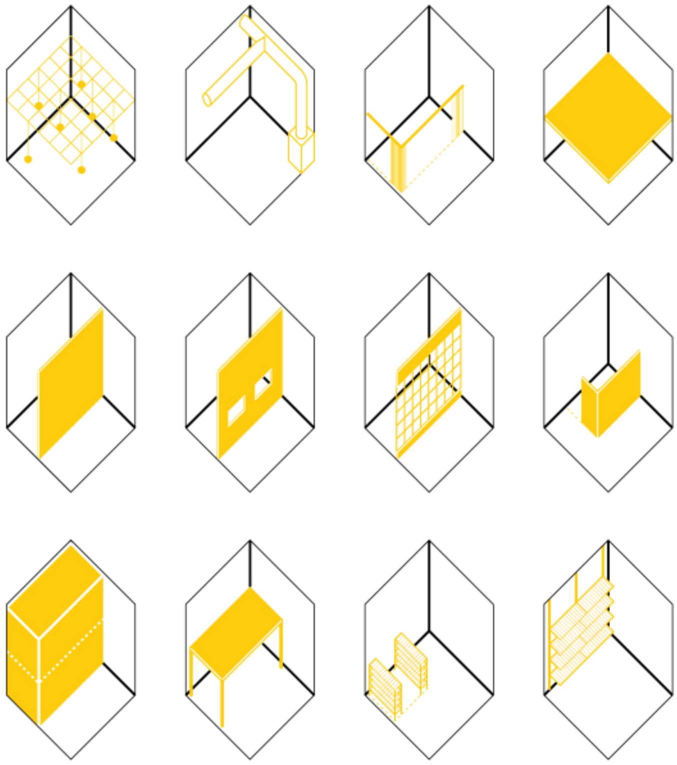
All companies have added few light architectural devices dedicated to increase the amount of space or create dedicated spaces. These elements generally have three purposes:

- creating additional space for storage;
- creating smaller-sized units for offices, finishing, workshops for small formats, etc.;
- isolating operations that either need a controlled environment or generate too much noise and dust.

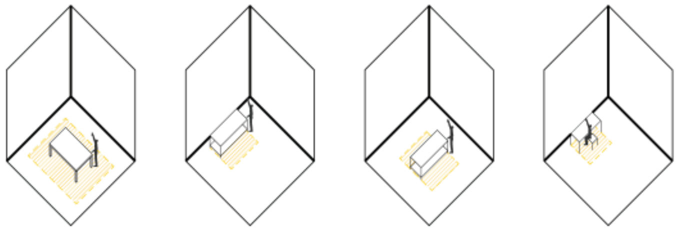
For instance, by adding two walls in one corner of its space, BoXZY has obtained a small room for dusty operations that would otherwise negatively affect the assembly line and the integrity of their product. Situ Fabrication has added a mezzanine and a vertical storage system to gain additional storage space. Under the mezzanine floor, the company placed a CNC machine isolated by plastic curtains and has organized a metal/wood shop for finishing and small formats that do not require a high bay. Carnegie Robotics added the steel structure on one side of the Happenstall building. Based on the original drawings of the reuse project, this light structure was supposed to be closed by walls just at the ground floor to create controlled labs. At the time of the site visit (three years later the renovation works) the company had already occupied the second floor with additional office space and was due to occupy the third floor too with a gym and other leisure areas for workers. In general, office and design operations are often set into an additional multi-story volume obtained on one side of the facility to guarantee properly sized spaces and a better working environment protected by the eventual nuisance of production – e.g., Carnegie Robotics, Southwick, and Situ Fabrication. In addition to these architectural elements, almost every company has added electrical feed ways or install suspended grids for additional lighting, plugs, and wiring. During the site visits, electricity and internet have been often reported as the most essential utilities, and more problematic as well, to set well-functioning and efficient urban manufacturing spaces.

Figure 5.8. Typical elements in urban manufacturing spaces.

Organizers



Operation units /workbenches



Operation units /machinery

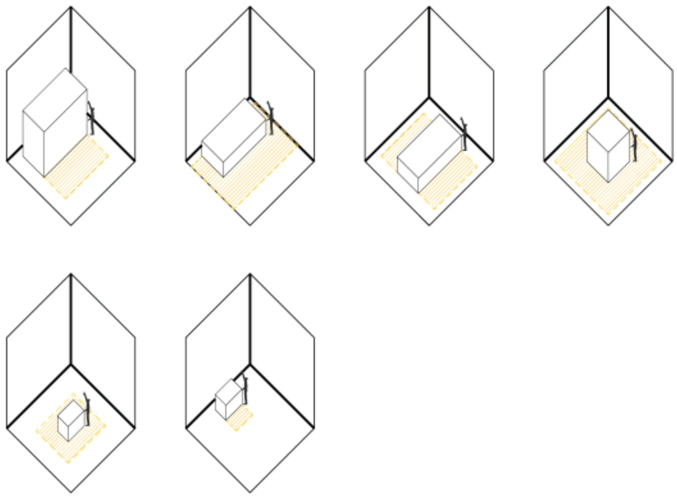
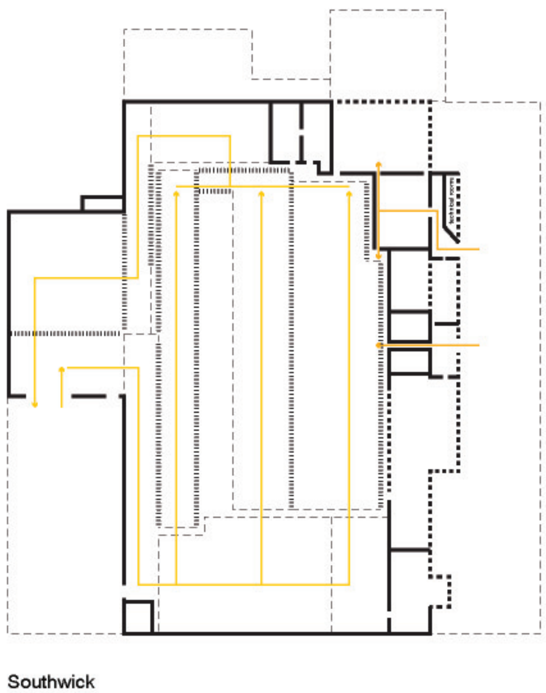


Figure 5.9.
A same-scale
comparison of
workshop layouts

0 5 10 25 50 m
1:2000



Space, time, and contextual variables

Depending on their nature, stage of development, and future projections of development, manufacturing activities may pursue a temporary or permanent location in cities. Firms are highly subjected to rapid or frequent variations in productivity, size of the operation, and consequently in their needs of space and location. Cities not always represent the best locational choice throughout the entire life of one business. However, when firms locate in cities, even if just temporary, they rely on the context both virtually and physically, and at different scales. While at the urban and metro level they benefit from the urban ecosystem of customers, workers, infrastructures, and other resources, at the local scale, they take advantage of the characteristics of the immediate context as well as of the presence of services and amenities. At the same time, cities are not always able to respond to these changes and needs promptly. Planning tools and economic development policies rarely offer proper support to industrial activities businesses, neither they are able to keep up with its constant innovation and rapid transformation. Almost none of the zoning analyzed in Chapter 4 has been able to deeply and fully understand the nature, organization, and dynamics of the different forms of production that cities could house and really benefit from them – hence resulting in lacking citywide policies. On the contrary, urban manufacturing has developed in cities punctually, one project at a time, thanks to the convergence of interests and resources from all the parts involved in these processes: firms, property owners/managers (or the developers operating in their behalf), and the city. In the cities observed by this research, as well as in many others, these individually developed projects have started growing more and more into a distributed network of places of production/working lofts.

Variations in the type of ownership/management can lead to very different outcomes. Lease terms and rates are highly influential in determining what ecosystem of tenants and program of uses will take shape inside the property. The lease terms vary based on owners/managers' mission and type of agency (for-profit or nonprofit); from monthly-based rents that usually include costs of operation, utilities, and shared facilities, to long-term leases from one year up depending on both the owner's and company's needs. The rising cost of space and the instability of leases are among the main reasons why urban manufacturing activities often end up displaced to make space for 'higher' uses or because they can afford rent anymore. These pressures are a risk that many firms take into account when planning for their location and business development, especially in hot real estate markets like San Francisco and New York.[11] For instance, Ferra Designs ended up at the Brooklyn Navy Yard because it got displaced from its original production space in Dumbo (Brooklyn, New York). Also in New York, the collaborative workshop Supersmith (see Appendix A) was founded by two

[11] Mohammad Hosein Asgari (Electrical Engineering Lead/technologist, Parallel Development), in discussion with the author, July 2017.

designers and makers who got evicted by their previous workshop in Dumbo as well, and they needed a place and tools to work.[12] Most of the nonprofit organizations that manage industrial properties commit to retaining industrial businesses in cities. In some exceptional cases so do for-profit organizations (e.g., Bridgeway Capital for 7800 Susquehanna St). Buildings' owners/managers commit to offering below-market rates (e.g., Ponyride) or at least rather stable rent rates that do not rise on a regular base following fluctuations in the real estate market. Other times, the cross-subsidization of rents allow them to offer affordable and convenient lease terms (e.g., Brooklyn Navy Yard). To do so, especially in large multi-tenant facilities, it is increasingly frequent to have one anchor tenant[13] or a diversified mix of commercial and office-based activities (together with industrial businesses) that can afford higher rents. Other organizations (especially for-profit ones) do not commit to retaining manufacturing businesses in specific but more in general economic activities. Therefore, they base their leases to the real estate value and let them fluctuates with the market. These facilities are likely to house increasingly more office-based and commercial businesses that most times cannot afford anymore traditional office districts (or do not like those environments) but could definitely afford these industrial spaces. These economic activities are at the same time a threat and an asset: they are potentially displacing a manufacturing firm, but they might provide those services and amenities needed by workers and manufacturing companies. What makes the difference is how owners/managers balance these different economies.

San Francisco	**New York** (Brooklyn-Queens)	**Detroit**	**Pittsburgh** (Central city)	**Haverhill**
\$215–646 /sqm/Yr (\$20–60/SF/Yr)	\$160–430/sqm/Yr (\$15–40 /SF/Yr)	\$32–130 sqm/Yr (\$3–20 /SF/Yr)	\$65–108 /sqm/Yr (\$6–10 /SF/Yr)	\$80–107 sqm/Yr (\$7.5–10 SF/Yr)

Table 5.10. Lease rates by city.

In this regard, sometimes firms locate in areas that for different reasons lack of commercial activities, public spaces and other services in their immediate context (e.g., Southwick and 7800 Susquehanna St). Southwick locates inside a facility initially built as a wholesale commercial building right outside the city at the crossroad of major transportation infrastructures, consequently lacking the benefits that a denser urban fabric would offer. The company has therefore converted the old greenhouse into a cafeteria and dining hall for its workers. 7800

[12] Natalie Shook (Co-owner and Founder, Supersmith) and Zach Blaue (Founder, Supersmith), in discussion with the author, October 2016.

[13] Timothy White (Senior Vice President of Development, Regional Industrial Development Corporation), in discussion with the author, September 2016; April 2017; Shani Leibowitz (Manager of the Planning and Transportation Departments, Brooklyn Navy Yard Development Corporation), in discussion with the author, September 27, 2016.

Susquehanna St locates in a residential area affected by abandonment and decay during the last decades. Also, a railroad and dedicated busway isolate the property (especially from a pedestrian perspective) from a nearby neighborhood where many industrial and commercial activities locate. The owners and tenants of the building then established a mobile food and cafeteria stand that temporarily occupy the main access of the building for a certain number of hours per day.[14] Except for dense and consolidated central areas (for instance like in San Francisco and New York), these situations of isolations or depletion are not so uncommon among industrial districts (as seen for instance in Haverhill, Detroit, and Pittsburgh). In many urban industrial areas, it is not uncommon to walk on long streets sided just by windowless walls. From the perspective of a pedestrian, this can only worsen an already negative perception of manufacturing in cities. At the same time, due also to privacy and safety issues, the space of production rarely open directly to the street or interface with the public city.

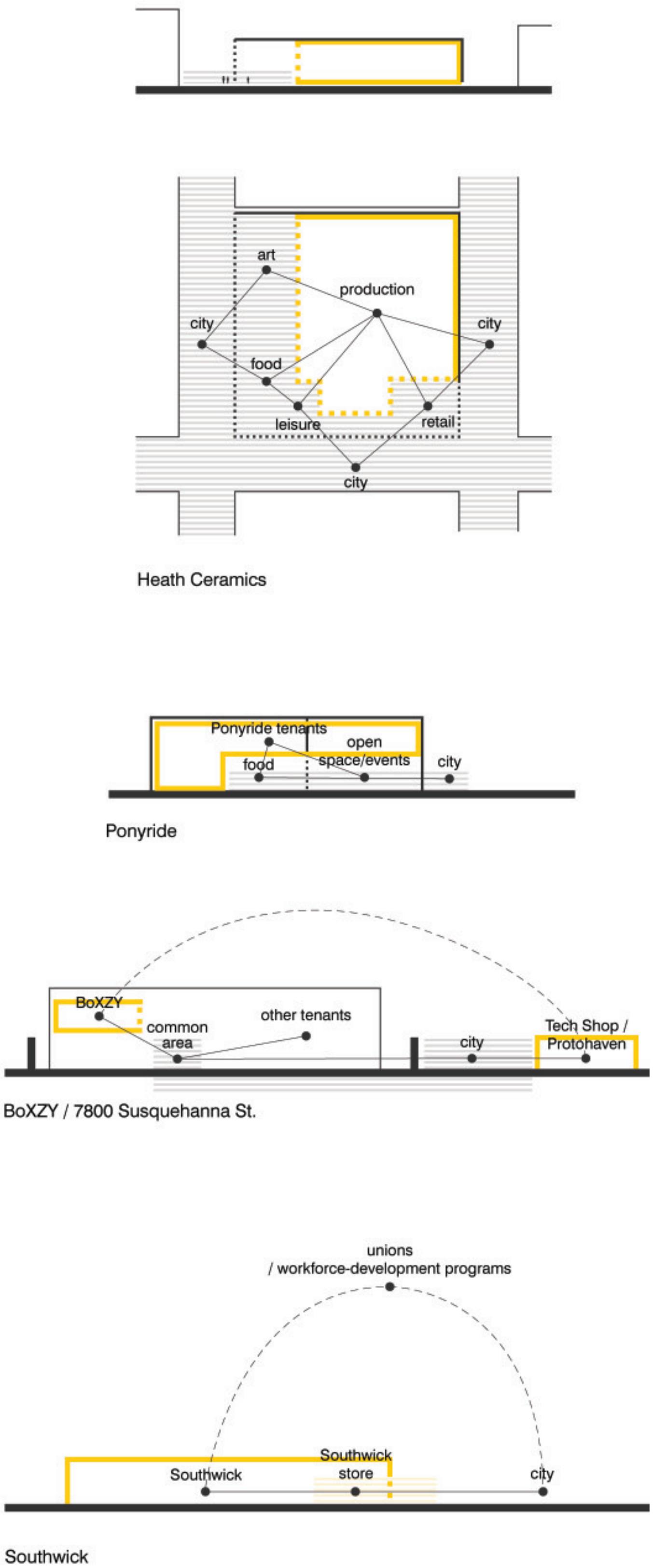
The observed companies have found different strategies of integration and placemaking to validate their presence in that specific location. In general, all of them have expressed the necessity to open up to the city in some way; not only to be better perceived but also to benefit more from the same context they rely on. Strategies vary from the integration of production with retail spaces to the participation to initiatives like factory tours, art fairs, or other events, or also providing educational and workforce development service. Heath Ceramics opens to the public city through a buffer of more openly accessible functions - like a restaurant, an art gallery, and retail spaces – that in turn ensure a certain degree of privacy and protection to the manufacturing space. This buffer acts as a porous threshold where city and production interact. At Ponyride, each tenant has to provide six hours of free classes to the community as well as share their work with the other tenants. Also, some spaces inside and outside the building are dedicated to events and activities open to the public: for instance, a public square, a cafeteria, a dance studio, and a loading dock that occasionally turns into an art gallery. These small initiatives have generated virtuous mechanisms of integration of production into the city where the industrial activity contributes to the improvement of the quality of life of the neighborhood. In Pittsburgh, BoXZY and Carnegie Robotics are apparently disconnected with the public city: Carnegie Robotics' building has very few openings while BoXZY space is part of a multi-tenant facility that acts as a wall between the company and the public. Their deep integration with the city results from their active role in supporting education, innovation, and other enterprises. After Tech Shop shut down, BoXZY got involved in the development of the makerspace Protohaven as well as in educational programs for kids but also for makers, and aspiring entrepreneurs. Carnegie Robotics is involved in university as well as STEM educational programs. By becoming assets not just in quantitative terms (jobs, revenue, etc.)

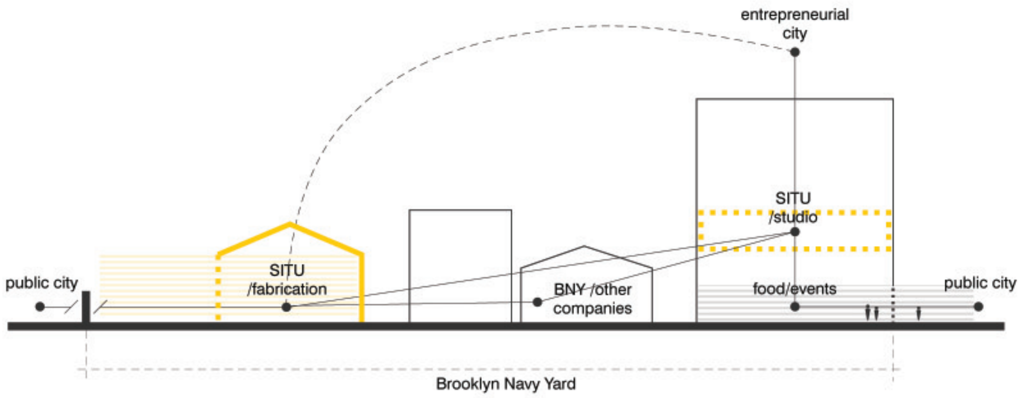
[14] Charles R. Broff (Member of the Board of Directors, Bridgeway Capital), in discussion with the author, June 2017.

but also as active contributors to the quality of life of the neighborhood and socio-economic growth of the city (educational services, involvement in innovation streams, etc.), these companies have ensured themselves a more stable and strong presence in their location (fig. 5.11).

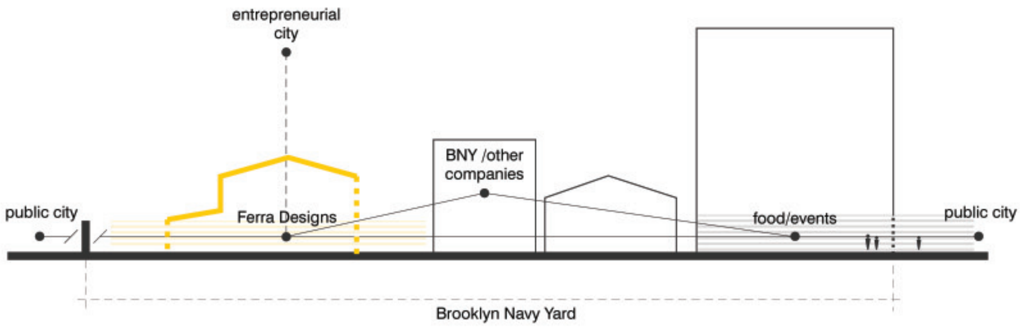
The urban location can be temporary or permanent. Temporary, if building's owners are not committed to retaining industrial activities but are renting space to industrial businesses while waiting to have the resources to convert it to more profitable uses. Also, it can be temporary when they need larger floorplates that can be found just outside the urban core, or else, when they 'use' the city just as a temporary business incubator during the startup stage, ready to move as soon as it graduates to the next step. Permanent, when owners rent space to industrial businesses with the mission to retain income- and job-generating activities to the city. Also, it can be permanent when firms decide to expand and eventually scale up production in place to be able to maintain the same supply chain and industrial ecosystem.

Figure 5.11. A comparison of the city-industry diagrams.

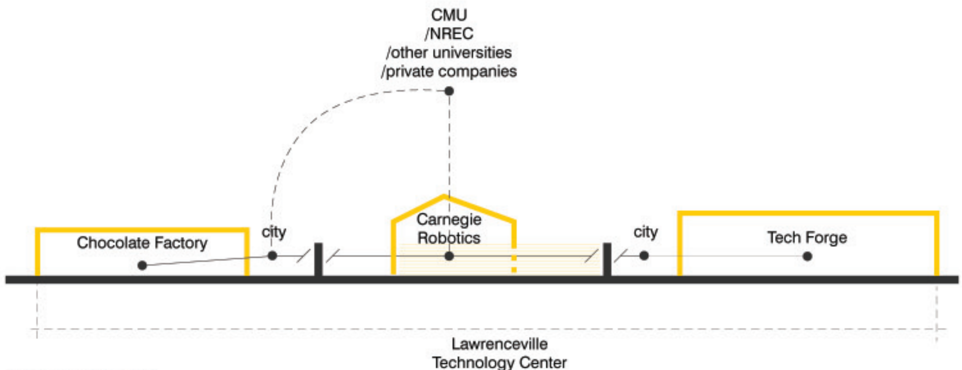




Situ Fabrication



Ferra Designs



Carnegie Robotics

5.3 It has to do with freedom:[15] the loft

A typology for the unplanned: evolution of the loft concept.

The case studies show a diversified selection of spaces and type of businesses. What bonds these experiences together is the concept at the bases of the reuse and interpretation of space. Regardless of typology or previous use, the building is reduced to its essential infrastructure. Space is turned into its 'loft' status: generic, open, and rough. This interpretative key proceeds from the industrialization period when the term was employed to refer to a specific building typology; industrial lofts. "The term loft came into use during this time to describe crudely, finished, unpartitioned, and often unheated upper-story spaces devoted to such work as canvas stitching in a sail loft. The term loft was revived during the late nineteenth century to refer to multistory manufacturing buildings erected in urban areas to house several commercial or industrial tenants. The term industrial loft, rather than mill, best denotes a general building type, the multistory industrial building."[16] After that, the ability to interpret space as loft became the *fil rouge* connecting those experiences where unplanned or informal human activities have leveraged underused spaces as platforms of emancipation.

The evolution of industrial spaces shows a recurrent search for roughness, adaptability, and affordability by some forms of production in what would be its 'container.' The practice of arranging the plant or workshop layout inside spaces build for other or non-special purposes proceeds from the artisanal workshop in the merchant city[17] and then continues with the industrial loft typology characteristic of American industrial cities. Craftmanship was associated with no specific type of building – as it still is not today. 'Artisanal workshop' refers to the activity carried out inside a space (the content) rather than to the building itself (the container).[18] With the emergence of industrial building typologies, multi-story industrial lofts were purposely designed as 'general type' of buildings able to address almost any industrial requirements – regardless of sector and process. Industrial lofts played a key role in the flourishing of the industrial sector in cities.

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[15] The expression "it has to do with freedom" quotes the title and the opening of Brand's chapter on Low Road buildings. Brand, *How Buildings Learn*, 48.

[16] Bradley, *The Works*, 30.

[17] For instance, Wright depicts an early-19th century mercantile city where "in almost every urban neighborhood – except the most fashionable and (more problematically) the extremely poor – patterns of mixed residential, commercial, and light industrial use dominated the early 'walking cities.' The first floor of many small houses functioned as a workshop or storage. Large multiple-pane windows let in more light and encouraged passersby to enter a shop. Master craftsmen housed apprentices in the top floors of their buildings, maintaining their shops on the first floor or next door to their own living quarters. […] after the 1820s, many apprentices and journeymen began to rent single rooms in lodging houses or dormitories near their work." Wright, *Building a Dream*, loc. 776.

[18] In his book *The Craftsman*, Richard Sennett describes workshops as a place shaped by materials, machines, tools, human relationship, rules, hand gestures, cultural practices, and social history. "The workshop is the craftsman's home. […] the workshop is: a productive space in which people deal face-to-face with issues of authority." Sennett, *The Craftsman*, 53–54.

They provided affordable space to a wide variety of industrial activities, from established ones to those businesses starting with uncertain possibilities to succeed or small investment capitals. Space was intentionally left rough, generic, and adaptable: a 'universal space' that firms would have characterized and adjust to their needs. Along with their spatial characteristics, industrial lofts offered the basic infrastructures and features needed to carry out production like freight elevators and loading docks. Besides the hardware part of the building, the rest of the space was left open to being occupied in different forms: as multi-tenant facilities occupied by several small businesses, as partially vacant buildings, or as single-tenant factories when taken by a single operation.

The continuous tenant's turnover in lofts cannot be properly considered an adaptive reuse practice.[19] Despite that, they have passed on the concept of lofts as a generic, rough, open spaces adaptable to endless possibilities. In industrial lofts, the concept of 'left-as-loft' spaces acting as platforms of emancipation was already implied: if lofts were built, manufacturing would have come and flourish. Of course, parallel to industrial lofts, there were businesses locating in specific industrial spaces like sheds and factories, establishing an ever-stronger interdependence between the production process and architecture. With the daylight factory, this relationship went consolidating with the factory becoming the master-machine. The following evolution of factories – especially after the definitive push of WWII to build generic, horizontally spread industrial sheds – increasingly leaned toward flexible, modular, multi-purpose systems until dematerializing (in theory) in the digital factory. Nevertheless, contrary to industrial lofts, these buildings have still been conceived for a specific company and use – even if they might have been ready to be adapted to future changes in use and needs. Plus, the 'urban' determinant had gone lost.

The 'loft' concept is peculiarly urban. Adaptive reuse practices in the 1960s New York analyzed by Sharon Zukin[20] finally disclosed the empowering potential of lofts. Abandoned industrial lofts became the rough, identity-deprived, open spaces where art and creativity could find breeding ground (see chapter 3.1). Loft spaces became empowering platforms for artists, cultural economies, and in general for unplanned uses in the city. Like in industrial lofts, space was already there, and the use eventually came. These practices imply the ability of the user to reinterpret an existing space still highly identified by its former use as if it was again a generic open space, a sort of 'ground zero' situation upon which shaping new needs.

The concept of reading a leftover space as a loft is captured again in Stewart Brand's observation of Low Road buildings.[21] "Low Road buildings are low-visibility, low-rent, no-style, high-turnover. Most of the world's work is done in

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[19] The research refers to Robiglio's definition of adaptive reuse "as the process of reusing an existing site, building, or infrastructure that has lost the function it was designed for, by adapting it to new requirements and uses with minimal yet transformative means." Robiglio, *RE–USA*, 173.

[20] Zukin, *Loft Living.*

[21] Brand, *How Buildings Learn*, 48–67.

Low Road buildings, and even in rich society the most inventive creativity, especially youthful creativity, will be found in Low Road buildings taking full advantage of the license to try things."[22] The author describes a 1980s-1990s economic sector in full transformation under the technological revolution in the information and communication sector. Here, new economies and any idea that needs to break out of planned rigid boundaries find full expression in general-purpose or leftover buildings where 'nobody cares what you do in there.'[23] Garages, flex spaces, storages, warehouses, factories, shacks, containers, mobile homes, etc., are seen as open and disposable spaces to be reinterpreted by new uses: "economic activity follows Low Road activity."[24] Low Road buildings may be far from resembling, physically and typologically, the initial industrial loft but they behave as such.

In more recent years, in their investigation on adaptive reuse practices, Baum and Christiaanse[25] take the definition of loft a step further by extending the concept beyond the artist's studio to the entire city – from buildings to public spaces. The loft explicitly becomes a way to read urban spaces and the entire city. The loft is any space 'full of potential,' 'replete with meaning,' and 'open to programmatic and semantic changes;' characteristics described as dynamic-stable.[26] The term loft "sums up these urban qualities. […] It is used to describe adaptable, flexible, and at the same time powerful spaces with identity in which people can live and work."[27] The contextual openness and strong urban identity are the characteristics that define lofts' urban quality and ability to allow for new and unexpected networks, patterns of usage, and lifestyles.

This research captures a further step into the interpretation of the loft (see Chapter 1, fig. 1.1). Left-as-loft spaces are the way through which a set of unexpected and unplanned human activities – in this case, urban manufacturing – is shaping within cities. In this definition, any space left or reduced to its open and generic status, accidentally or intentionally, temporary or permanently, is a loft. This allows space to express its intrinsic potential to act as an empowering platform to every upcoming use. The loft is any space in its suspended status of open generic system. 'Generic' because it is in-between the "liberation from the straitjacket of identity" and "either being completely solved or totally left to chance."[28] 'Open' because it acts as an open non-linear system in space and time: in time, it ranges "from path-dependency to the patterns of chance studied by Giorgy Markov. In space, an open system resembles a chemical colloid rather than a compound."[29]

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[22] Brand, *How Buildings Learn*, 48.
[23] Brand, *How Buildings Learn*, 48.
[24] Brand, *How Buildings Learn*, 56.
[25] See: Baum and Christiaanse, *City as Loft*;
[26] Baum, "City as Loft," 8–9.
[27] Baum, "City as Loft," 9.
[28] Koolhaas, "The Generic City," 1253.
[29] Sennett, "The Open City," 6.

In contemporary cities, if all the residual, vacant, unplanned, or underused urban spaces would be read-as-loft or accidentally left-as-loft, the ensemble could be interpreted as that Generic or Open City[30] that silently superposes to the planned city. Like the Generic City, the loft city "is the post-city being prepared on the site of the ex-city."[31] Like the Open City, the loft city is made of ambiguous edges, incomplete forms, and unsolved narratives.[32] Finally, it allows the urban complexity and all the "experiences which stick out because they are contestatory or disorienting"[33] to exist and reveal.

Form left-as-loft to working loft

Loft working refers to the scenario of urban manufacturing's workspaces taking shape inside open generic lofts within the urban fabric. It reshapes urban contexts in two steps. First, from a former 'something' to a left-as-loft space defined by its capacity. Then, from an open and generic loft to an urban manufacturing workspace that reshapes not only the use of space but also the relationship of that place with urban dynamics.

Left-as-loft spaces result from reducing different types of former industrial or commercial building to their essential structures and infrastructures, then leaving spaces as open and rough as possible ready to be reinterpreted by a wide variety of economic and human activities. Warehouses, daylight factories, wholesale stores, commercial malls, storages, industrial sheds, multi-story industrial lofts, big boxes; once left-as-lofts, they all turn into the same type of space – open, generic, rough, disposable, and (hopefully) affordable. Lofts are characterized not by a specific shape or typology but by a basic degree of adaptability/suitability determined by its capacity in terms of space, location, and supply infrastructure. For instance, the dimension of openings, freight elevators, and the load-bearing capacity; they all restrict what machinery or materials could fit in the space. The same is true for supply infrastructures like electricity and telecommunication infrastructure, extremely important especially in advanced forms of production. Other contextual features like having proper space for logistics and materials handling or access to urban freight systems, or if and what type of trucks can reach one facility are equally determinant. Finally, rents and leasing terms are key variables to take into account by firms' development plans. For instance, a 5- or 10-year lease at a rather stable rent gives much more stability than a month-to-

[30] The choice of using the terms 'generic' and 'open' when describing loft spaces intentionally evoke to two influencial urban theories: Rem Koolhaas's Generic City, described in a text originally written in 1994, and Richard Sennett's Open City, presented in many conferences and theorized in an undated essay. This parallelism continue here in the attempt to understand how this concept of loft spaces can look like if applied not just to single sporadic contexts but to the city system as a whole. See: Koolhaas, "The Generic City;" Sennett, "The Open City."

[31] Koolhaas, "The Generic City," 1252.

[32] Sennett, "The Open City," 8–14.

[33] Sennett, "The Open City," 4.

month lease where rent fluctuates following variations of properties' value in that area.

Determining loft's capacity is key for understanding what activities could be compatible with that location and eventually identifying what it is to do if the project aims to attract a specific type of users. Workspaces take shape starting from this open and generic situation offered by left-as-loft spaces that contextually offer potential and constraints. Urban manufacturing firms then project into the real space their factory layout. This 'fitting' process passes through a series of architectural design choices that solve practical necessities like adding energy supply grids, vertical storage systems or isolating a dusty operation and establish how production and information flows will run throughout space passing through different kinds of thresholds/degrees of separation. These actions expand lofts' capacity in terms of performance and quantity. They allow production processes to configure in their most efficient layout given the capacity of the loft and through the employment of less resources and modification as possible (see fig. 5.12).

Loft's capacity also affects how urban manufacturing economies develop and distribute in space at the urban and metro level. Urban manufacturing economies are subject to frequent and rapid variation in size and location needs, depending on the stage of development of one business as well as on potential collaborations or variations in the production process. Besides global or local supply chains, each activity may occur entirely in one location, contextually occupy different spaces of production within the same urban context, or conveniently changing the location at need. By being affordable, disposable, occasional, distributed throughout metro areas, and diversified in their capacity and potentials, left-as-loft spaces have been the supporting system of urban manufacturing dynamics. These spaces have allowed unplanned and fast-changing socio-economic trends to express and evolve; a process that is still under development, from which cities would be able to capture and take advantage from only through undetermined and unfinished strategies.

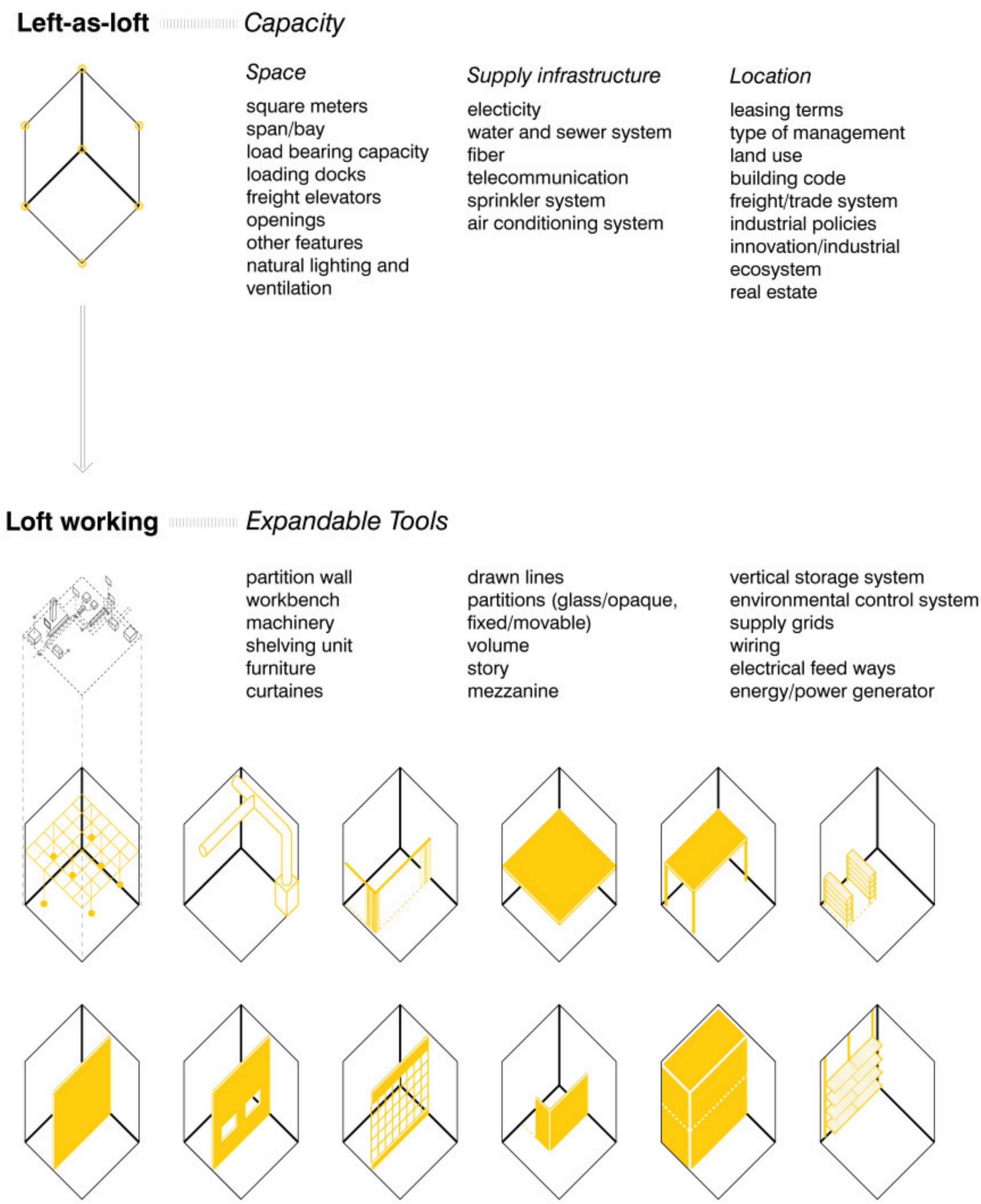

Figure 5.12. Loft/Loft working scenario.

Chapter 6

Final remarks

This research focuses on the most recent reconfiguration of the city-production relationship. Despite coming a long way since the first industrial revolution and even before, technological innovations and other socio-economic transformation in production-consumption dynamics make the observed phenomena a trend still in its early stage of development with a very uncertain future. Architectural and planning issues represent just part of the matter, but too often they become just the passive background as a result of economic and political choices. During the last years, professionals, administrators, and scholars from urban studies have rediscovered industry as an urban and architectural concern where space and planning tools could play an active role in the shaping of city-industry dynamics. In the US, the works of research groups, associations, and individual advocates[1] have been addressing the reintegration and retention of industrial activities within the urban fabric as a complex socio-spatial challenge. What emerges from these studies is the urgent need to place living-wage jobs and income-generating activities where people live; in cities. A need that merges with the calling for deeper integration and hybridization at the neighborhood and building scale. Likewise, this research starts from the idea that rethinking production in cities represents a unique opportunity to tackle urban issues starting from the idea that people come to cities for jobs, economic opportunities, education, and culture[2] rather than commercial strips, alternative lifestyles and

[1] Among many others promptly reported throughout the thesis: Urban Manufacturing Alliance; Pratt Center for Community Development; MIT Industrial Urbanism; Nina Rappaport; SFMade; IABR2016/Marteen Hajer; Greenpoint Manufacturing and Design Center; Distl; *Maker City* book.

[2] This perspective seems to have been often forgotten by mainstream urban policies and plans. One example is the paper "Smart Growth's Blind Side" by Nancey Green Leigh and Nathanael Z. Hoelzel, already cited in the thesis. Here, the authors report how smart growth policies fails to recognize the urban industrial sector a key agent of economic growth. "Smart growth policies, in turn, offer little guidance to cities that are losing productive industrial land essential to supporting industrial firms and jobs and preventing industrial sprawl. Likewise, by not

living solutions – these are important but subsequent issues. Putting jobs at the center of spatial strategies means contextually approaching urban development and the future of cities from a social and economic perspective.

The thesis has observed urban manufacturing activities taking shape in urban contexts through adaptive reuse practices. Today, the action of reoccupying existing buildings proceeds from the convergence of a set of conditions. Among many others: the fact of often resulting as an unplanned use in cities; not requiring specific controlled environment for production; the opportunity to co-locating with other competitors and complementary businesses with which potentially establish positive collaborations; and more importantly, the possibility to access affordable spaces thus consistently reducing the resources invested in space and infrastructure. As seen through the thesis, with the transition to a factory intended as a digital object (see chapter 2.1), the physical infrastructure and space have consistently lost weight in economic terms as well as importance in the production process. For urban manufacturing firms, these elements are determinant for their existence and success but still have to weigh on the investment plan as little as possible, in favor of innovation, knowledge, and location. As of today, urban manufacturing is a metropolitan matter: it has been reshaping as an advanced sector, with the advanced part lying in the production process, the final product, the business model, or the economic paradigm.

Urban manufacturing:

(1) it is a dense network of lean, small, specialized firms operating in contracting and subcontracting chains, so they need an urban location;
(2) firms produce customized products in unitary or small-batches through just-in-time/just-in-place systems, so they need proximity to customers, complementary businesses, and other manufacturers;
(3) it serves service industries;
(4) it has a consistent multiplier effect given to the network effect;
(5) firms are sites of innovation and enable the scaling up to commercialization of flow of innovations from the R&D sector, so they need proximity to talent, knowledge, and innovation;
(6) firms carry out production processes that are compatible with urban contexts and can adjust to almost any lofty space;
(7) firms invest in talent, innovation, and location (they rely on the urban context) rather than infrastructure;

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encouraging industrial revitalization in mixed-use, transit- oriented, and infill redevelopment projects, smart growth policies overlook a significant economic sector that con- tributes to diverse, innovative, and more resilient local economies. The resulting narrowing of cities' economic bases may inadvertently place them in vulnerable positions during economic recessions and slow economic recovery." Green Leigh and Hoelzel. "Smart Growth's Blind Side," 88.

(8) firms occupy leftover buildings that represent the contextual opportunity for a good location, access to affordable and disposable spaces, and the possibility to renting space rather than buying or building a new facility (more flexible commitment).

This thesis has identified the spatial practice of setting urban manufacturing workspaces inside reconfigured leftover spaces as loft working. New spaces of production superpose and reshape the physical legacy left behind by the course of different economic trends and industrial paradigms. The recurrent mismatch in size and needs between contemporary small/medium firms and former industrial buildings often designed as rigid, mono-functional facilities for one large company lead to the reconfiguration of these spaces into flexible and adaptable loft spaces.

Loft working:

(9) results from different combinations of forms of settlements, types of buildings, and urban manufacturing enterprises.
(10) Different building typologies are reinterpreted as lofts (entirely or partially, temporary or permanently, incrementally or all at once). Spaces are reduced to their essential infrastructures (the hardware), leaving it as open, rough, and generic as possible.
(11) Left-as-lofts spaces are characterized by their basic capacity in terms of location, space, and infrastructure (rather than a form or specific typology) that determine their potential adaptability/suitability.
(12) Lofts are reconfigured into urban manufacturing workspaces through a series of expandable tools that amplify lofts' capacity (quantitatively and qualitatively).
(13) Firms project their virtual factory into the real space (the loft). The 'fitting' process consists of organizing production as efficiently as possible inside of a given space through the minimum amount of investment and adjustments.
(14) Spaces are reconfigured into two steps through flexible architectural devices (software) and design choices that solve how flows run and how different parts interface (thresholds). These elements resized spaces and allow programmatic and distributional reconfigurations of spaces into working lofts.
(15) Space reconfigurations have to be able to evolve and adapt over time according to the changing ecosystem of activities and tenants, manufacturing needs, owners/managers purposes, and contextual contingencies.
(16) The urban location can be temporary or permanent.
It is temporary when: (a) building's owners are not committed to retaining industrial spaces but are renting space to industrial businesses while waiting to have the resources to convert it to more profitable uses; (b)

companies need larger floorplates or facilities that can be found just outside the urban core; (c) when firms ‘use’ the one space or the city just as a temporary business incubator during the startup stage, ready to move as soon as they graduate to the next step.

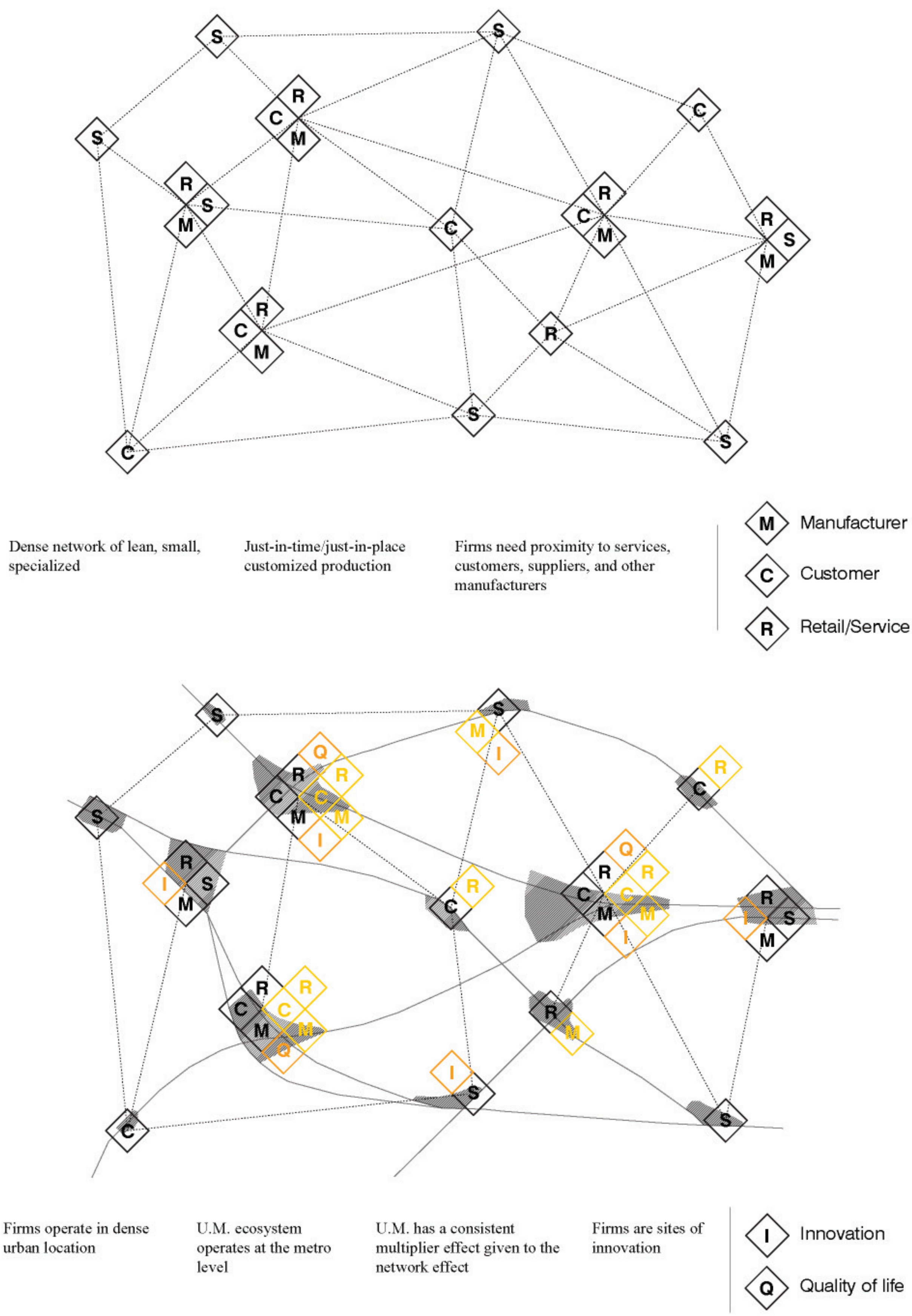
It is permanent when: (a) owners rent space to industrial businesses with the mission to retain income- and job-generating activities to the city; (b) when firms decide to expand and eventually scale up production in place to be able to maintain the same supply chain and industrial ecosystem.

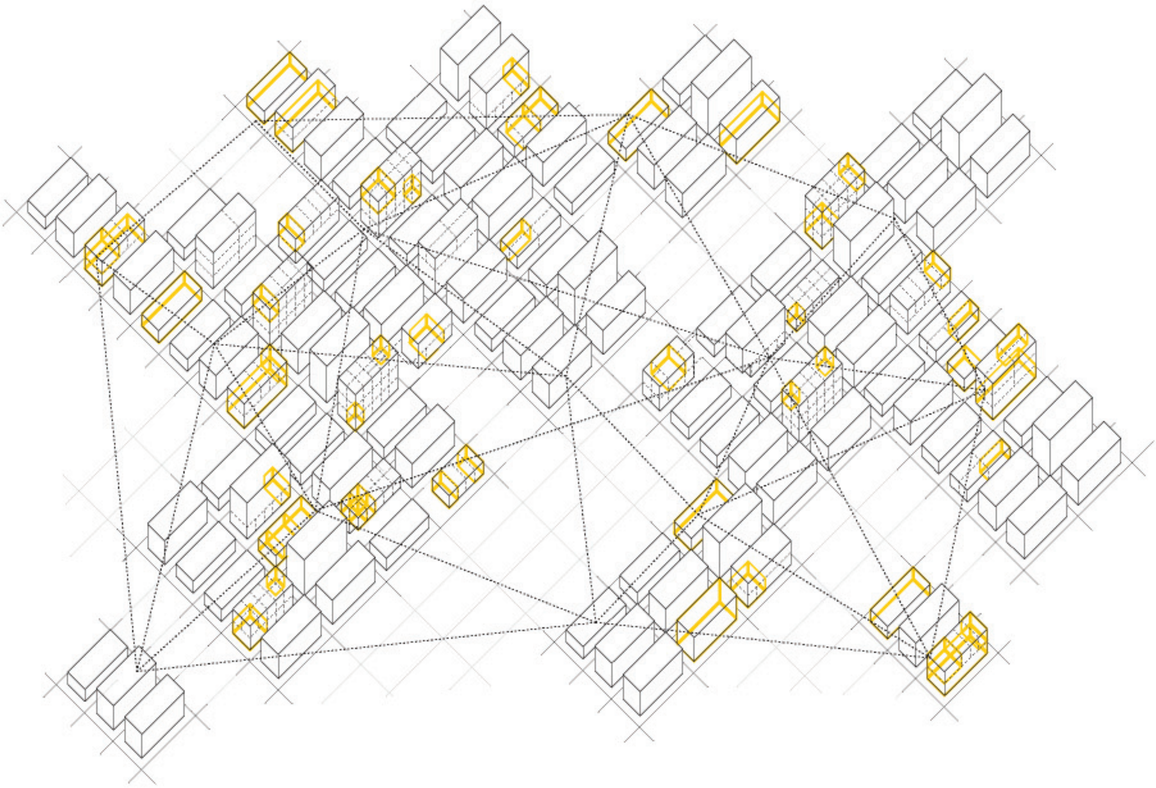
Loft working in the city heads towards multiple resolutions. First, it reactivates latent structures by turning them into flexible and adaptable spaces and empowering tools (the loft). Then, it gives space to income- and job-generating economies (urban manufacturing). Lastly, it reconnects lost pieces of the urban fabric with the city’ and metro’s socio-economic dynamics (placemaking).

Until now, citywide initiatives and planning tools have often struggle, especially in front of overcoming real estate interests, to offer proper support to fast-changing industrial trends and to keep jobs as the constant driver of urban development. Loft working has developed in cities punctually, through the occasional convergence of interests and resources in favor of production in one specific spot at a time. Here, the ability (not always intentional or planned) of ‘bringing back’ different types of spaces to their loft status, generic and open, has enabled the shaping of spaces of production. Increasingly, this ensemble of single places is growing into a distributed and dynamic network.

The loft is at the base of these processes; it is not defined by a function or shape but by its capacity to absorb change. The loft works as an empowering social and economic tool for the unforeseen and unplanned. Loft working processes develop at the middle point between public/private, global/local, formal/informal, temporary/permanent, non-profit/for-profit. These intrinsic compelling dualities represent an opportunity for cities to take a step forward in their effort to address increasing complexity, diversity, inequalities, and rapid transformations.

Figure 6.1. Urban manufacturing's performance within a virtual and physical ecosystem





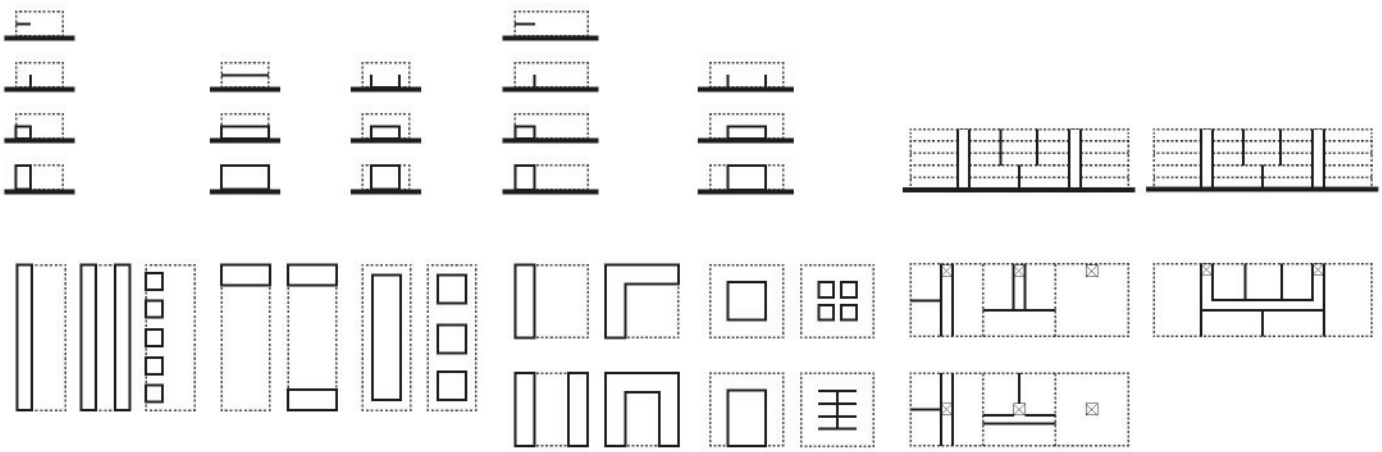
Firms invest in talent, innovation, and location rather than infrastructure

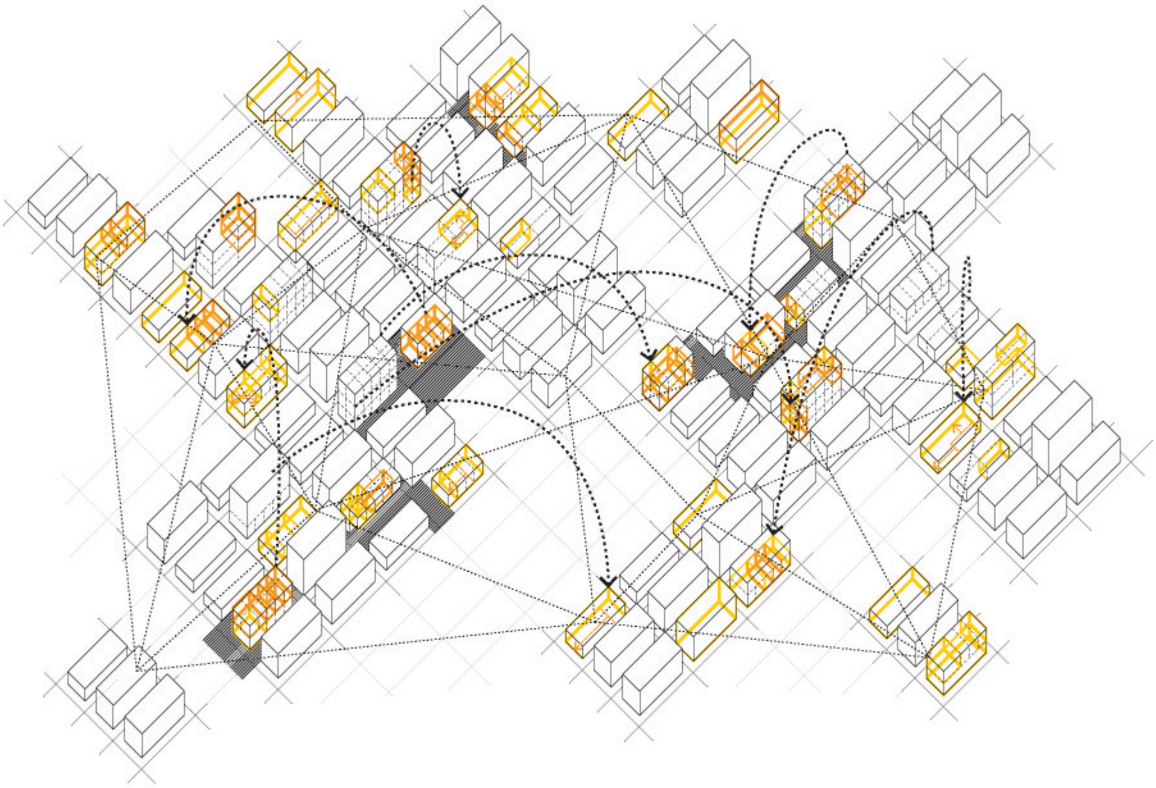
Different building typologies are reinterpreted as open generic lofts

Space are reconfigured to be able to evolve and adapt over time to changing needs

Properties are incrementally redeveloped and occupied

The ensemble of single projects gradually develops into a distributed and dynamic network





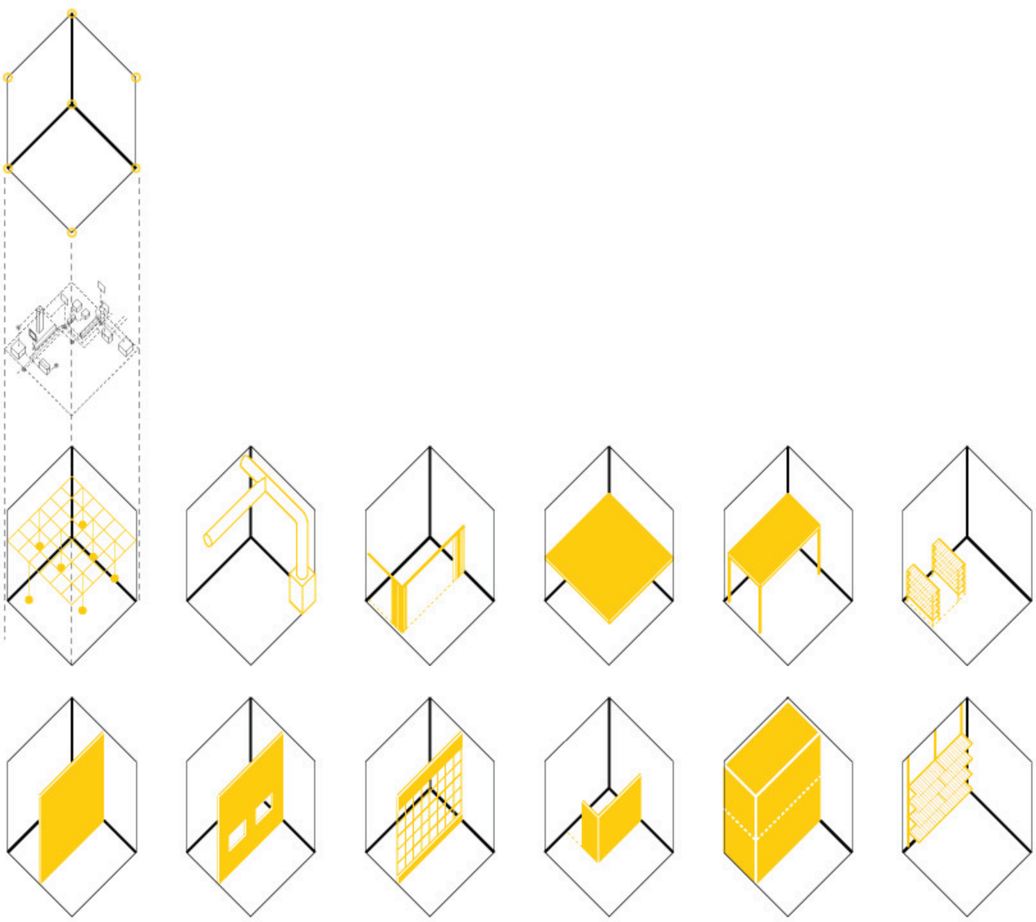
Firms project their virtual factory into the real space (working loft).

Businesses occasionally occupying other spaces of production within or outside their workspace

Co-location and proximity foster collaboration, trust, and growth

Firms pursue a deep integration with the context: they contribute to the improvement of the quality of life.

Expansion or shrinkage in place or elsewhere / temporary or permanent location.



Besides the urgent need for adequate industrial, financial, and educational policies and programs, cities should start improving their support for productive economies through more effective planning strategies. For instance, by easing and incentivizing the accessibility to vacant properties to non-profit associations or directly to industrial businesses. Contextually to reuse projects, architects should also be called to rethink factories again as an urban typology that could reflect the needs of digital factories – smart, clean, small, and mobile (see chapter 2.1). Urban factories could be temporary buildings connecting to the urban infrastructural systems just for the time needed and then move to another location for another firm, or perhaps recycle its construction materials in other constructions, hence leaving no footprint. Alternatively, they could be multi-purpose buildings designed to adapt to different spatial configuration and type of users – including industrial businesses – that could vary throughout time as well as coexist at the same time inside the same structure. That is the idea behind today's flex spaces, built either as entire buildings like the RIDC Tech Forge in Pittsburgh or as ground floors of residential or commercial buildings like in the SFMade's 100 Hooper project in San Francisco.

These buildings are first examples of new urban spaces of production that contextually foster the hybridization between production and commercial/residential spaces for long advocated by many researchers and practitioners.[3] However, flex spaces could not necessarily be the only response to the problem neither the best one. While on one side new flex buildings could mean adaptable urbanities, on the other side they could also drive to the flattening of urban forms and stratifications as well as to the banalization of its complexity. Contextually, leveraging the concept of loft working could not be the solution either since it implies potential risks too. Lofts, intended as a spatial typology for the germination of the new, the rough, and the uncertain, might work very well as long as it moves within fuzzy boundaries of formal and informal. But what happens once this concept turns into formal and codified practice? If we think of the commercialization of loft apartments or loft-style new residential buildings shaped after artists' practice to reuse industrial lofts as affordable live-work spaces, a similar path could easily unfold for 'reuse for production' spaces or working lofts. The case studies visited during the field trips already present some worrying tendencies in this sense. Developers and owners often claim to provide space for light-industrial firms and creating new jobs, instead at the same time they offer unbearable leasing terms for most manufacturers – sometimes because they are too pressured by real estate dynamics, other times because they are

[3] For more information on flex spaces and the cited projects see: Love, "A New Model of Hybrid Building," 44–57; Rappaport, "Hybrid Factory," 72–86. See also: Franjo Construction, "Tech Forge at 47th," https://www.franjoconstruction.com/tech-forge-on-47th/; Regional Industrial Development Corporation, "Demand Rises for Emerging Tech-Flex Sector," https://ridc.org/demand-rises-for-emerging-tech-flex-sector/; Marin Camille, "Demand Rises for Emerging Tech-Flex Sector," uploades February 16, 2017, SFMade blog, https://sfmade.org/blog/the-manufacturing-foundry-at-150-hooper/.

'simply' for-profit companies with no other mission. In any case, these terms turn out to be affordable just by high-revenue businesses, like commercial activities, tech companies, or creative offices. In projects including a certain percentage of light-industrial spaces, it would be useful if some urban agency would ensure that more resourceful economic activities will not be favored over manufacturing businesses eventually interested in that space – at least to a certain extent. Especially in high-value real estate areas, more affordable rents and stable long-term leasing contracts could be ensured through smarter and innovative cross-subsidization strategies,[4] both at the building and neighborhood scale. These could ensure stability to production activities, lowering the risk of displacement, and allowing them to plan for long-term and sustainable growth in that location. Cases like Heath Ceramics, Ponyride, Supersmith, Industry City, and the Brooklyn Navy Yard (see Chapter 4 and Appendix A) show how stability and long-term vision could turn urban manufacturing activities into integrated and active contributors of the quality of life. These places not only have a local socio-economic impact (e.g., jobs, revenues, investment attraction) but they have also become public gathering places that people recognize and identify with. That is because people are attracted not only by social places like stores and restaurants that might have opened but also by the possibility to see and be directly involved in the production process.[5] Finally, urban industrial spatial strategies should not be limited to the administrative limit of the city but re-thought at the metro scale. Urban manufacturing spatial dynamics operate at the metro level. Especially in territories affected by disinvestment and abandonment, vacant industrial and commercial facilities (often located on major transportation networks) could be reused for industrial or complementary uses rather than fall into decay or struggling to attract resources for other mainstream conversions. For instance, these leftover buildings could be turned into data centers, distribution hubs, and spaces set as loft ready house industrial firms outgrowing central cities' floorplates. This could facilitate the straightening and creation of a dense supporting network for innovation and manufacturing in central cities while also contributing to local economic developments.[6]

[4] Concerning the need for smarter and innovative cross-subsidization strategies see also: Rappaport, *Vertical Urban Factory*.

[5] In this regard, see for instance Rappaport's analysis on the consumption of production and the factory as a spectacle. See: Rappaport, *Vertical Urban Factory*, 342–368.

[6] The Regional Industrial Development Corporation in Pittsburgh operates in this sense. Since the 1960s-70s, the non-profit has been investing in redevelopments and new constructions of industrial spaces located both in the central city as well as in the region with the purpose of diversifying the economy of the region (back then increasingly focused on services and education, and later on innovation as well). If projects in central cities have been targeting startups, research labs, tech incubators, and small manufacturers, suburban properties have been prepared to house larger firms but also eventual businesses graduating from their startup stage in cities. See: Roberta Ingaramo and Caterina Montipò, "Reindustrializzazione e no-profit: Pittsburgh e il caso della Regional Industrial Development Corporation," in *Atti della XX Conferenza nazionale SIU, Urbanistica e/è azione pubblica. La responsabilita' della proposta, Roma 12-14 giugno 2017* (Roma-Milano: Planum Publisher, 2017) 1916–1926. Also, other research on the reuse of big box architecture and demalling offer additional insights. See: Gabriele Cavoto, *Demalling. A response*

Future research

Economic and industrial dynamics often evolve faster than urban spaces and plans. Many cities in the US have already started addressing issues like industrial land retention or business attraction. Strategies that may have been more or less successful, but still struggle in keeping up with the rapid transformation and changing needs of urban economies. Comprehensive knowledge of city-production dynamics should benefit from quantitative data and spatial analysis. At the urban level, a deeper understanding of how urban manufacturing moves through urban and metropolitan areas could help to elaborate more effective and responsive plans. These dynamics should be mapped not only as a fixed capture but in their evolution through time. Data on urban manufacturing spatial dynamics should be intersected with other information at different scales. Some of the elements that could be mapped and overlaid are:

- past and current location of firms reporting the amount of space occupied, type of facility (single- or multi-tenant, shared workshop, incubators, etc.), and size of the business (e.g., number of workers);
- vacant spaces including leftovers and abandoned buildings as well as properties temporary unleased, each reported with its capacity as a loft space (see chapter 5.3) and real estate value;
- on the ground freight distribution and trade systems (e.g., streets with freight capacity and classification, distribution centers, railroads, etc.);
- underground technical infrastructures networks – used and dismissed (e.g., energy infrastructure, pipelines, fiber, etc.);
- waste collection and waste recycling systems.

Overlapping these data in a multi-layered map could stress the attention on what spaces and locations are more suited for production and could actually worth applying urban industrial strategies. Also, it could help to elaborate policies able to embrace spatial and timing mismatches between urban economies and urban plans as well as how to include openness and genericness into the mix.

In this sense, urban industrial processes and planning tools should be re-thought within the framework of practices of temporary use, informal use, incremental design, and architectural processes integrating time as a variable.[7] For instance, a strategy to plan for/deal with the left-as-loft city could start from a ruling infrastructure characterized by lofts (with an open generic form) and their expandable capacity. Then, starting from simple common sense and coexistence rules, processes and codes would be left open to restricting, detailing, relaxing,

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to the demise of retail buildings (Santarcangelo di Romagna: Maggioli Editore, 2014); Julia Christensen, *Big Box Reuse* (Cambridge, MA and London: The MIT Press, 2008) Kindle.

[7] For instance, in the book Urban Catalyst, Fezer's contribution offers a comprehensive view on planning processes integrating time and temporary use and concepts like 'vagueness,' 'growing structures,' 'do-it-yourself construction/planning,' and 'open frameworks,' see: Fezer and Urban Catalyst, "Open Planning," 165–189.

transforming, or automatically updating by learning from repetitive situations depending on what ecosystem of users goes shaping inside spaces. It may be integrated into the regular plan or occasionally superposed to it whenever a building/an urban area/a city copes with unplanned urban economies. Starting from the steps identified by this research in the evolution of the concept of the loft, further research should focus on the possible correlation between the identification of one spatial practice and a consequential transformation or innovation in the urban governance (e.g., the Loft Law in New York). These studies would support even more the purpose of this research; to reveal spatial practices and understand logic and processes behind them to support the improvement of planning tools and urban development strategies.

At the building level, the analysis of spaces of production through the observation of thresholds has underlined significant changes in the forms of working in factories that have been already acknowledged by social and engineering studies. For instance, in previous industrial paradigms engineers and unskilled workers operated in separate spaces or even locations (they also dressed differently), whereas in advanced manufacturing workers, technicians, and engineers work closely in the same space and in collaboration with machines. These changes happen transversally at every level and in different sectors, consequently influencing how we work and live. Additional research should address the spatial dynamics of work. For instance, real-time locating systems (RTLS) could provide additional data on workers movements through the workspace as well as on their interaction with machines, tools, and other workers. This data could be implemented with the tracking – through mobile phone tracking systems and applications – of workers movements outside buildings in the urban space. It could become an additional layer to the previous map or it could be used to improve the factory plan layout as well as firms' locational choices. Spatial analysis based on such information could be at the base of research on the future of industrial jobs and the robot-human interaction. Future research should also analyze how emerging forms of working and places of jobs are transforming in relation to living and economic trends, and consequently reshaping cities and how we live them. These studies would contribute to the understanding of the evolution of work in general and of working-living dynamics in cities.

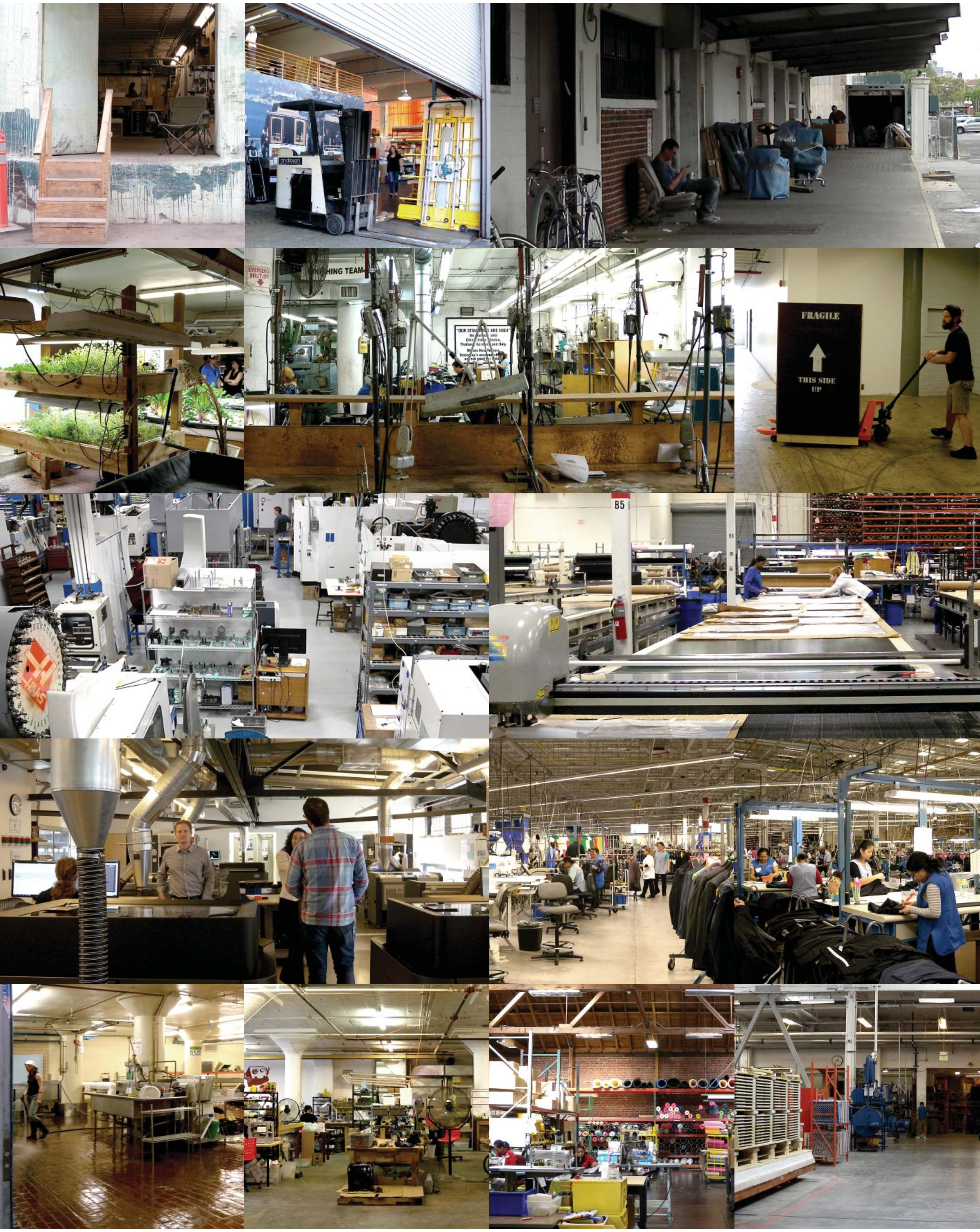

Figure 6.2. Forms of working: urban manufacturing


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Appendix A. 50 working lofts

This section documents the fieldworks conducted between August 2016 and April 2018. First, it lists places surveyed and people interviewed in each city.

The list of places reports the day and type of visit. 'Site visit' means that the site visit was conducted inside and outside with a person involved in the project – either one firm's employee or the building's owner/manager or the developers/architects. In some cases, it was not possible to get inside the spaces so the list states 'just outside.' 'Factory tour' means that the place was visited through public tours or during public events. The list of people reports the day and type of discussion, distinguishing between 'interview,' a more formal and structured information exchange, and 'conversation,' an informal discussion.

Then, it presents a selection of 50 most interesting places of production visited during field trips. Here, for each project, the report outlines basic information on the building and the reuse project, a selection of photos, and the 3-axis description of the company (see description in the graphic method in Chapter 1). Case studies are presented at their stage of development and location at the time they were observed. Few projects (e.g., Factory Unlocked, Protohaven, Lost Arts, etc.) were either at their very early stage or about to start, but they have been included anyway in the report due to their relevance and successful development since the visit.

Fieldworks have happened unevenly among the different cities, depending on the time scheduled for each city (average of 10 days per city, except for Pittsburgh where the author spent 5 months as visiting PhD student at Carnegie Mellon University) and the responses received by the people contacted. Initially, fieldworks in the Boston area (Including Haverhill and Somerville) were not planned. Along the way, the possibility to attend the Urban Manufacturing Alliance 2017 Annual Gathering has led to additional site visits in the area.

Pittsburgh, PA (US)

Places

Cork Factory. Site visit. September 7, 2016.

Carnegie Robotics (Lawrenceville Technology Center). Site visit. September 9, 2016; June 13, 2017.

Chocolate Factory (Lawrenceville Technology Center). Site visit. September 9, 2016.

Keystone Commons. Site visit. September 9, 2016; June 13, 2017.

TAKTL (Keystone Commons). Factory tour organized by Heinz College (CMU) and RIDC. September 9, 2016.

Station Square. Site visit. September 12, 2016.

Bakery Square. Site visit. September 12, 2016.

South Side Works. Site visit (just outside). September 13, 2016.

Tech Shop Pittsburgh (Bakery Square). Site visit. September 15, 2016; June 6, 2017; June 12, 2017.

The Brew House. Grand Opening House. September 16, 2016.

NextManufacturing Center, Carnegie Mellon University. Site Visit. September 16, 2016.

National Robotics Engineering Center. Site visit (just outside). September 9, 2016; June 13, 2017.

Carrie Blast Furnaces. Site visit. September 20, 2016.

Astrobotic Technology. Site visit. September 20, 2016.

Crane Building. Site visit. March 28, 2017.

ANSYS Hall, *Maker Wing*, and *Nanofab lab* (Carnegie Mellon University). Site visit (under construction). June 5, 2017

Artists workspaces at *615 Gross Street* (industrial property redeveloped by Valentina Vavasis). Site visit. June 6, 2016

BoXZY (7800 Susquehanna Street). Site visit. June 12, 2017.

Urban Tree (7800 Susquehanna Street). Site visit. June 12, 2017.

Helomics (Chocolate Factory, Lawrenceville Technology Center). Site visit. June 13, 2017.

Almono/Hazelwood Green. Site visit (under construction). June 13, 2017.

Conturo Prototyping (Lexington Technology Park). Site visit. June 14, 2017.

Kerf Case (Mine Safety Appliance Building). Site visit. June 14, 2017.

Puzzle Pax. Site visit. June 14, 2017.

The X Factory. Site visit. June 22, 2017.

7800 Susquehanna Street. Site visit. June 23, 2017.

MSA Mine Safety Appliance Building. Site visit. July 5, 2017.

Blumcraft. Site visit. July 8, 2017.

ProtoInnovations (Ice House). Site visit. July 12, 2017.

Optimus Technology (The X Factory). Site visit. July 18, 2017.

People

Don K. Carter (David Lewis Director of Urban Design and Regional Engagement, Remaking Cities Institute, Carnegie Mellon University). Conversation. September 6, 2016.

Chip Desmone (Principal, Desmone Architects), *Wolfgang Spengler* (Senior Architectural Designer, Desmone Architects). Interview. September 6, 2016.

John M. Ginocchi (AICP Executive Vice President, TREK Development), *Trey Barbour* (former TREK employee). Interview. September 7, 2016.

Charles Hammel (President PITT OHIO). Interview. September 7, 2016.

Raymond Gastil (Director of Pittsburgh City Planning), *Andrew Dash* (Assistant Director, Pittsburgh City Planning – Strategic Planning Division), *Andrea Lavin Kossis* (Riverfront Planning & Development Coordinator, Pittsburgh City Planning – Strategic Planning Division). Interview. September 8, 2016.

Timothy White (Senior Vice President of Development, Regional Industrial Development Corporation). Interview. September 8, 2016; April 25, 2017.

Sarah Stroney (former Development & Policy Analyst, Regional Industrial Development Corporation). Conversation. September 9, 2016.

Jason Flannery (Design Director and co-founder, TAKTL). Factory Tour. September 9, 2016.

Robert Rubinstein (Executive Director, Urban Redevelopment Authority of Pittsburgh), *Kyra Straussman* (Director of Real Estate at Urban Redevelopment Authority of Pittsburgh). Interview. September 13, 2016.

Todd Reidbord (Principal and President Walnut Capital). Interview. September 12, 2016.

Thomas Despres (former Chief Financial Officer, Soffer Organization). Interview. September 13, 2016.

Bill Gearhart (former General Manager, Tech Shop Pittsburgh). Conversation. September 15, 2016.

Daragh Byrne (Assistant Teaching Professor, School of Architecture and Integrated Innovation Institute, Carnegie Mellon University). Conversation. September 16, 2016.

Sandra DeVincent Wolf (Executive Director Manufacturing Futures Initiative, Executive Director NextManufacturing Center, Director of Research Partnerships, College of Engineering, Carnegie Mellon University). Interview. September 16, 2016; June 5, 2017.

Stephen Quick (Adjunct Professor of Architecture, Carnegie Mellon University). Conversation. September 17, 2016; September 20, 2016; March-July 2017 (multiple meetings).

Jonathan Kline (Associate Studio Professor, School of Architecture, Carnegie Mellon University; principal and founder, Studio for Spatial Practice). Conversation. September 19, 2016.

Martin Aurand (Principal Architecture Librarian and Archivist of the Carnegie Mellon University Architecture Archives, Carnegie Mellon University). Conversation. September 19, 2016; March 15, 2017.

Mandy Fleeger (Public Relations and Customer Care Coordinator). Interview. September 20, 2016.

Caryn B. Rubinoff (President, Rubinoff Company), *Craig Dunham* (former Principal at the Rubinoff Company, current President, Dunham reGroup LLC). September 21, 2016.

Joel Tarr (Richard S. Caliguiri University Professor of History and Policy, Engineering and Public Policy, Heinz College, Carnegie Mellon University). Conversation. March 20, 2017.

William A. Perry (Senior Vice President & Wealth Advisor, The Penn-Atlantic Group - Morgan Stanley; Owner, Crane Building). Interview. March 28, 2017.

Timothy Schooley (Journalist, Pittsburgh Business Times - The Business Journals). Interview. April 21, 2017.

Matthew Sanfilippo (Chief Partnership Officer, College of Engineering, Carnegie Mellon University). Interview. June 5, 2017.

Valentina Vavasis (Adjunct Associate Professor, School of Architecture, Carnegie Mellon University). Conversation. June 6, 2017.

Gadsden Merrill (General Manager Tech Shop Pittsburgh). Interview. June 12, 2017.

Hadley Pratt (former Operations Manager, BoXZY – KinetiGear LLC). Interview. June 12, 2017.

John Conturo (Founder of Conturo Prototyping). Interview. June 14, 2017.

Ben Saks (Founder & Owner, Kerf Case). Interview. June 14, 2017.

Gio Attisano (Founder & Owner, Puzzle Pax). Interview. June 14, 2017.

Stephen R. Lee (Professor & Head, School of Architecture, Carnegie Mellon University). June 21, 2017.

Howard Eisner (Owner, The X Factory). Interview. June 22, 2017.

Charles R. Broff (Member of the Board of Directors, Bridgeway Capital). Conversation. June 23, 2017.

Ani Martinez (Field Director, Remake Learning; Program Associate on the Community Building, The Sprout Fund). June 30, 2017.

Richard Allen (Real estate developer and leasing manager, Cube Creative Space and Mine Safety Appliance Building). Interview. July 5, 2017.

Bernie Lynch (Founder & Chief Vision Officer, Factory Unlocked; Chief Executive Officer, Made Right Here and Made Right Here Alliance; CEO, Strategic Development Solutions). Interview. July 5, 2017.

Donald F. Smith (President, Regional Industrial Development Corporation). Interview. July 12, 2017.

Erica R.H. Fuchs (Professor, Engineering and Public Policy, Carnegie Mellon University). Conversation. July 13, 2017.

Matthew Madia (Chief Strategy and Development Officer, Bridgeway Capital). Interview. July 14, 2017.

Ian Winner (former Business Analyst, Optimus Technologies). Interview. July 18, 2017.

Ihsane Youcef Debbache (former Robotics Engineer, ProtoInnovations). Conversation. July 12, 2017.

New York, NY (US)

Places

Situ/Studio (former location in Dumbo) and *Situ/Fabrication*. Site visit. September 26, 2016.

Brooklyn Navy Yard. Site visit (just outside). September 27, 2016; October 1, 2016 (Turnstile public tour).

Bien Hecho, *Woodside Press*, *Urban Grange* (Brooklyn Navy Yard, Building 3). Site visit. September 28, 2016.

New Lab (Brooklyn Navy Yard). Site visit. September 29, 2016.

1155-1205 Manhattan Avenue, Greenpoint Manufacturing and Design Center. Site visit. October 4, 2016.

630 Flushing. Site visit. October 6, 2016.

Ferra Designs (Brooklyn Navy Yard). Factory tour, organized by Turnstile, held by Robert Ferraroni (Founder and Co-owner, Ferra Designs). October 7, 2016.

Industry City. Site visit. October 7, 2016; May 16, 2017; July 25, 2017.

Supersmith. Site visit. October 10, 2016.

Liberty Warehouses. Site visit (just outside). October 10, 2016.

Linda Tool. Site visit. July 25, 2017.

Brooklyn Army Terminal and *Riva Precision* (Brooklyn Army Terminal, Building B). Site visit. July 25, 2017.

Garment District. District and factory tours organized by the Municipal Art Society of New York with Nina Rappaport. July 25, 2017.

810 Humboldt Street, Greenpoint Manufacturing and Design Center, and *Parallel Development* (810 Humboldt Street, GMDC). Site visit. July 26, 2017.

1102 Atlantic Avenue, Greenpoint Manufacturing and Design Center; *PCB:NG*, *BigHeavy Studios*, *IN.SEK Design* (1102 Atlantic Avenue, GMDC). Site visit. July 28, 2017.

People

Wes Rozen (Co-founder and Partner, Situ). Interview. September 26, 2016.

Shani Leibowitz (Manager of the Planning and Transportation Departments, Brooklyn Navy Yard Development Corporation). Interview. September 27, 2016.

John Randall (Owner, Bien Hecho). Interview. September 28, 2016.

Davin Kuntze (Book maker; Worker, Woodside Press). Interview. September 28, 2016.

Nicko Elliott (former Managing Partner and Creative Director, Macro Sea; Chief Design Officer, New Lab). Interview. September 29, 2016.

Brian T. Coleman (CEO, Greenpoint Manufacturing and Design Center). Interview. October 4, 2016.

Nina Rappaport (Director, Vertical Urban Factory). Conversation. October 5-6, 2016; October 6, 2016; May 17, 2017; July 27, 2017.

Jeffrey Rosenblum (Limited Liability Broker, Acumen Capital Partners – 630 Flushing). Interview. October 6, 2016.

Lee Wellington (Executive Director, Urban Manufacturing Alliance), *Katy Stanton* (Program and Membership Director, Urban Manufacturing Alliance) Conversation. October 2016 and July 2017 (e- mail); May 17, 2017 (at the UMA's 2017 Somerville Gathering "Making, Scaling, and Inclusion"); June 28, 2017 (phone call with L. Wellington).

Natalie Shook (Co-owner and Founder, Supersmith), *Zach Blaue* (Founder, Supersmith). Interview. October 10, 2016.

Bob Bland (CEO and Founder, Manufacture New York). Conversation (e-mail). October 2016.

Justin Collins (Director of Strategic Partnerships & Development, Southwest Brooklyn Industrial Development Corporation). Conversation. May 17, 2017; July 2017 (e- mail).

Michael DiMarino (President, Linda Tool). Interview. July 25, 2017.

Ted Doudak (CEO, Riva Precision Manufacturing Inc.). Interview. July 25, 2017.

Mohammad Hosein Asgari (Electrical Engineering Lead/technologist, Parallel Development). Interview. July 26, 2017.

Jonathan Hirschman (CEO, PCB:NG). Interview. July 28, 2017.

Detroit, MI (US)

Places

Ponyride, including Ponyride's coworking, makerspace, dance studio, and all tenants e.g., *The Empowerment Plan*, *Smith Shop*, *Floyd*, *Lazlo*, *Detroit Is The New Black*, *Line Studio* (Ponyride). Factory tour organized by Ponyride. October 12, 2016.

LIFT Lightweight Innovation Headquarters. Site visit (just outside). October 12, 2016.

Russell Industrial Center. Site visit. October 13, 2016.

Eastern Market and *Dequindre Cut*. Site visit. October 15, 2016.

Detroit Denim. Site visit (just outside). October 15, 2016.

Packard Plant. Site visit (just outside). October 17, 2016; March 26, 2017.

TechTown. Site visit. October 18, 2016.

Argonaut Building. Site visit. October 19, 2016.

Shinola (Argonaut Building). Site visit (just outside). October 19, 2016.

General Motors Tech Center and *Warren Technical Center*. Site visit (just outside). March 26, 2017.

The Heidelberg Project. Site visit. March 26, 2017.

People

Noah Elliott Morrison (Director, Ponyride). Interview. October 12, 2016.

Eric Novack (former Operation Manager, Russell Industrial Center). Interview. October 13, 2016.

Dan Kinkead (former Executive Director, Detroit Future City; Principal, Urban Design Practice Co-Director, SmithGroup). Conversation. October 14, 2016.

Anika Gross-Foster (Executive Director, Detroit Future City). Interview. October 16, 2016.

Deirdre Hennebury (Assistant Professor and Director BS Arch, College of Architecture and Design, Lawrence Technological University). Conversation. October 17, 2016.

Ned Staebler (President and CEO, TechTown; Vice President for Economic Development, Wayne State University). Interview. October 18, 2016.

Maurice D. Cox (Director, City of Detroit Planning and Development Department), *Jacqueline Taylor* (Lead Historian/Cultural Landscape Specialist, City of Detroit Department of Planning and Development). Converzation, meeting organized by Prof. Steve Quick for the Master of Urban Design Studio, Carnegie Mellon University. March 24, 2017.

Chicago, IL (US)

Places

mHUB and *GE Microfactory* (mHUB). Site visit. October 21, 2016.

The Mart. Site visit. October 23, 2016.

Polsky Center for Entrepreneurship and Innovation, University of Chicago. Site visit. October 24, 2016.

Industrial Corridor of Nearwest Chicago and *Make City* (multiple tenants). Site visit. October 25, 2016.

Kinzie Industrial Corridor and *Fulton Market* (multiple manufacturers). Site visit (just outside). October 25, 2016.

Pumping Station: One (PS:1). Site visit. October 28, 2016.

Lost Arts. Site visit (former Goose Island location). October 28, 2016.

UI Labs and *Digital Manufacturing Design Innovation Institute*. Site visit (just outside). October 28, 2016.

The Plant. Factory tour organized by The Plant. May 27, 2017.

People

Haven Allen (CEO and Co-founder, mHUB). Interview. October 21, 2016

Iker Gil (Director, MAS Studio). Interview. October 24, 2016.

Charles Adler (Founder, Lost Arts; Co-founder, Kickstarter). Conversation. October 24, 2016; October 28, 2016.

Steve DeBretto (Executive Director, Industrial Corridor of Nearwest Chicago), *Hannah Jones* (Director of Economic Development, Industrial Corridor of Nearwest Chicago). Interview. October 25, 2016.

Ray Doeksen (Maker and Board Member, Pumping Station: One). Conversation. October 28, 2016.

San Francisco, CA (US)

Places

Wearable IoT World Labs Accelerator. Site visit. November 1, 2016.

Tech Shop SF. Site visit. November 1, 2016.

Bolt (SF office, Pier 9). Site visit. November 3, 2016.

Autodesk Technology Center (Pier 9). Site visit. November 3, 2016.

Fictiv. Site visit. November 3, 2016.

Pinterest Headquarter. Site visit. November 5, 2016.

Heath Campus SF. Factory tour organized by Heath Ceramics. November 6, 2016.

1890 Bryant Street Studios. Open Studios event. November 6, 2016.

Timbuk2, Mission Factory Store. Site visit (just outside). November 7, 2016.

Tempo Automation. Site visit (just outside). November 7, 2016.

American Industrial Center. Site visit. November 8, 2016.

Rickshaw Bagworks. Site visit. November 8, 2016.

Manylabs. Site visit. November 8, 2016.

100 Hooper. Ground breaking and Project presentation with Kate Sofis (CEO, SF Made), John Kilroy (CEO, Kilroy Realty Corporation), Ed Lee (former Mayor of San Francisco). Site visit. November 10, 2016.

Plethora. Site visit. November 10, 2016.

Flex Innovation Lab. Site visit. November 11, 2016.

People

Lauren Marinaro (Director of IoT for Cities, Wearable IoT World Labs Accelerator; Director of Smart Cities, ReadWrite), *Trevor Curwin* (former Editor in Chief, ReadWrite). Interview. November 1, 2016.

John Rahaim (Planning Director, City and County of San Francisco). Conversation (e-mail). September-November 2016.

Renee Shenton (Community Manager, Highway1 PCH). Conversation (e-mail). October-November 2016.

Andrew Calvo (Director of Sales, Tech Shop Inc.). Interview. November 1, 2016.

Kate McAndrew (Principal, Bolt; Founder, Women in Hardware). Interview. November 3, 2016.

Finbarr Watterson (Hardware Community Evangelist, Fictiv). Interview. November 3, 2016.

Gina Falsetto (Manager of Real Estate and Place to Make Program, SFMade). Interview. November 4, 2016.

Peter Sand (Founder, Manylabs), and other Manylabs' members. Conversation. November 8, 2016.

Martine Neider (Manager of Manufacturing Operations, SFMade). Conversation. November 10, 2016.

Alexander Price (former Head of Sales and Business Development, Plethora). Interview. November 10, 2016.

Nora Naranjo (former Mechanical Design Engineer, Flex San Francisco Design Center and Innovation Lab), *Steven Heintz* (former VP Engineering & General Manager, Flex San Francisco Design Center and Innovation Lab). Conversation. November 11, 2016.

Los Angeles, CA (US)

Places

Fashion District. Site visit (just outside). November 15, 2016.

Make in LA, *HexLab Makerspace* (former location), and *Toolbox LA* (under development at the time). Site visit. November 17, 2016.

The Reef and *Maker City LA*. Site visit. November 17, 2016.

La Kretz Innovation Campus (part of Los Angeles Cleantech Incubator LACI) and *The Advanced Prototyping Center* (LKIC). Public walking tour and info session. November 18, 2016.

Row DTLA, and *American Apparel*. Site visit (just outside). November 18, 2016.

Hyperloop One. Site visit (just outside). November 18, 2016.

Ford Factory. Site visit (just outside). November 18, 2016.

People

Krisztina "Z" Holly (Host, The Art of Manufacturing podcast; Founder & Chief Instigator, Make It in LA - Mayor Garcetti Initiative; Advisor, Good Growth Capital). Conversation. November 16, 2016.

Zack Hurley (Founder and CEO, IndieSource). Conversation. November 16, 2016.

Shaun Arora (Managing Director and Co-founder, Make in LA – MiLA Capital). Interview. November 17, 2016.

Teresa Garcia (General Manager, Maker City LA), *Adriana Sintia Ascencio* (Assistant General Manager, Maker City LA). Interview. November 17, 2016.

Ben Stapleton (former VP Facilities and Operations, Los Angeles Cleantech Incubator). Conversation. November 18, 2016.

Patricia Diefenderfer (Senior City Planner, Los Angeles Department of City Planning; part of the Plan re:code DTLA 2040), *Bryan Eck* (Senior City Planner, Los Angeles Department of City Planning; part of the Plan re:code DTLA 2040). Interview. November 21, 2016.

Event: How to "Make It" in L.A. - The MiA Project Store, with Micha Thomas (The MiA project), Adrienne Lindgren (LA Mayor's Office), Zack Hurley (IndieSource), Cheyann Benedict (designer)

Boston, MA (US)

Places

Autodesk BUILD Space (The Innovation and Design Building). Site visit (during the UMA’s 2017 Somerville Gathering “Making, Scaling, and Inclusion”). May 17, 2017.

The Innovation and Design Building. Site visit. April 13, 2018.

Somerville, MA (US)

Places

Aeronaut Brewing Company (Somernova – Somerville Innovation Hub). Site visit (during the UMA’s 2017 Somerville Gathering “Making, Scaling, and Inclusion”). May 18, 2017.

Taza Chocolate (561 Windsor St.), *FormLabs*, *Union Square Donuts*, and *Somerville Brewing Company*. Factory tours organized by the Urban Manufacturing Alliance (UMA). May 19, 2017.

Somernova – Somerville Innovation Hub, and *Artisan's Asylum* (Somernova). Site visit. April 11, 2018.

Greentown Labs – The Global Center for Cleantech Innovation. Site visit. April 11, 2018.

People

Tom Vancor (Facilities Manager, Artisan's Asylum). Interview. April 11, 2018.

Haverhill, MA (US)

Places

Southwick. Site visit. April 10, 2018.

People

Curt Clark (Director of Manufacturing, Southwick). Interview. April 10, 2018.

Nate Robertson (Assistant Director of Economic Development, City of Haverhill). Conversation. April 10, 2018.

James J. Fiorentini (Mayor of Haverhill). Conversation. April 10, 2018.

1

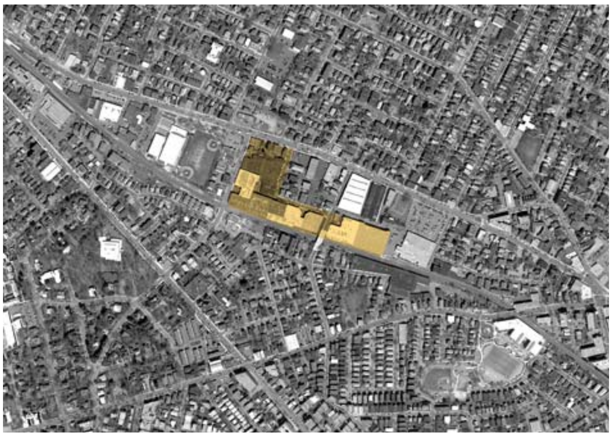
Somernova - Somerville Innovation Hub / Ames Business Park

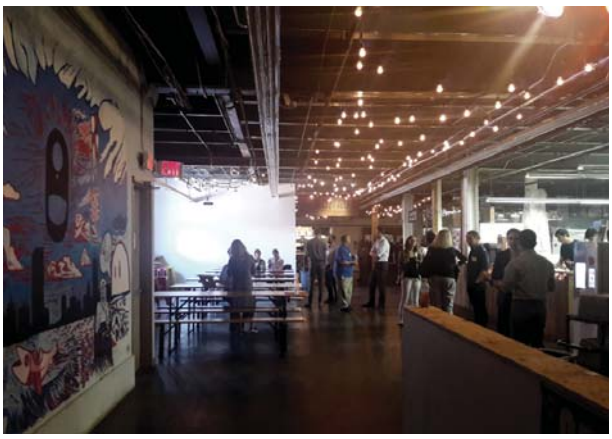
Somerville, MA (Boston area)

square meters: 27,870
n. tenants: 21
ownership: family-owned

year built: 1938
dismissed: 2010
reuse: 2010-present

usage: *former*
Ames Safety Envelope manufacturing facility
current
multi-tenant industrial facility and innovation hub

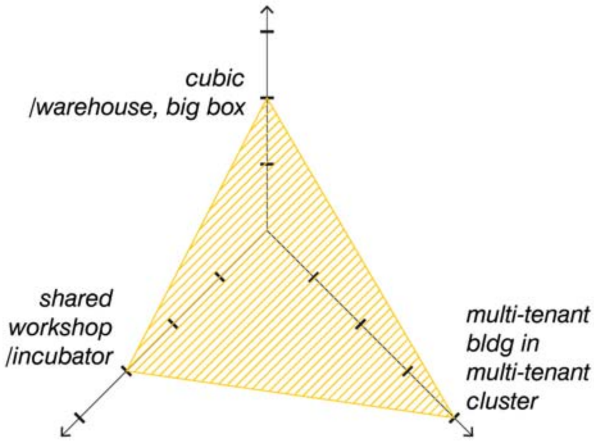




1a

Artisan’s Asylum

square meters: 3,700
established in: 2010
type of business: non-profit community workshop / membership-based makerspace



2

561 Windsor St

Somerville, MA (Boston area)

square meters: 7,000
n. tenants: 15
ownership: private for-profit

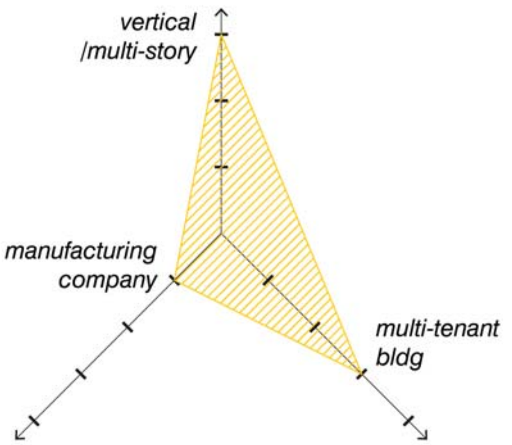
year built: 1927
dismissed: unknown
reuse: 2001-present

usage: *former*
unknown
current
multi-tenant commercial and industrial facility

2a

Taza Chocolate

square meters: 900+
established in: 2006
type of business: stoneground, organic chocolate manufacturer



3

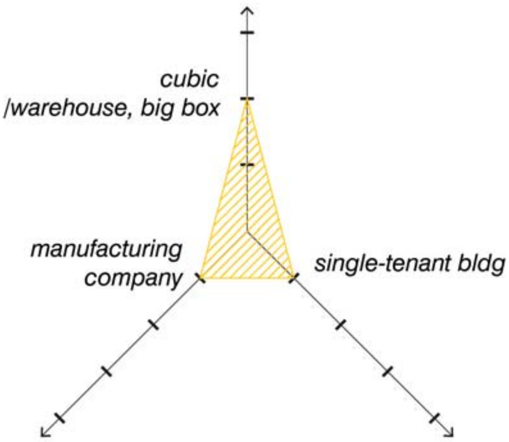
Southwick Clothing / Brooks Brothers

Haverhill, MA (Boston area)

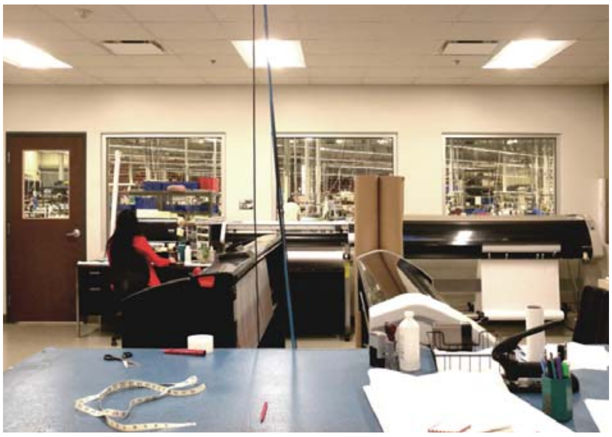
square meters: 14,420
n. tenants: 1
ownership: private company

year built: 2006
dismissed: 2011
reuse: 2014-2015

usage: *former*
Lowe’s Retail Store - wholesale
current
clothing manufacturing facility




F3

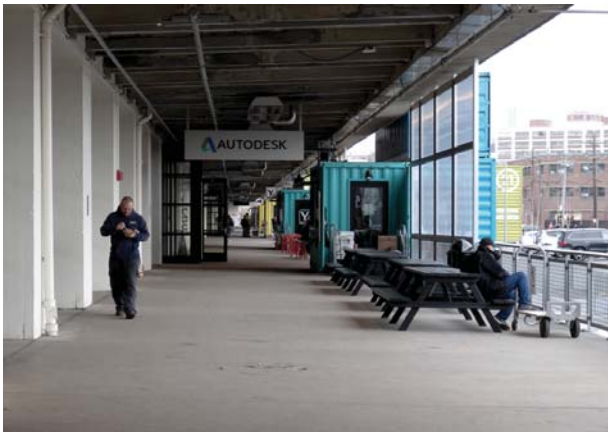
4

Innovation and Design Building (IDB)

Boston, MA

square meters:	130,000
n. tenants:	30+
ownership:	for-profit investment and management company

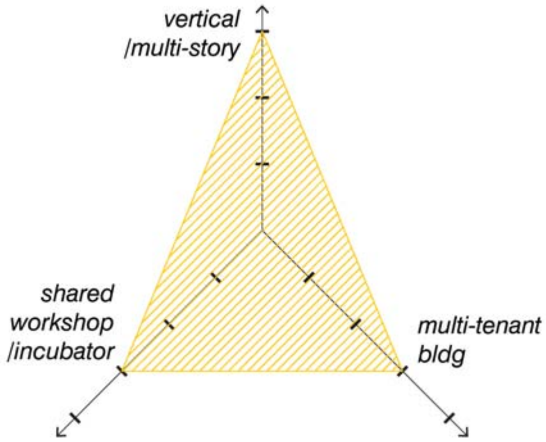
year built:	1918
dismissed:	-
reuse:	1980s / 2013-2016
usage:	*former* storehouse for the South Boston Army Base; then Bronstein Center/ Boston Design Center (Boston Marine Industrial Park). *current* Boston Design Center and Multi-tenant commercial and industrial facility

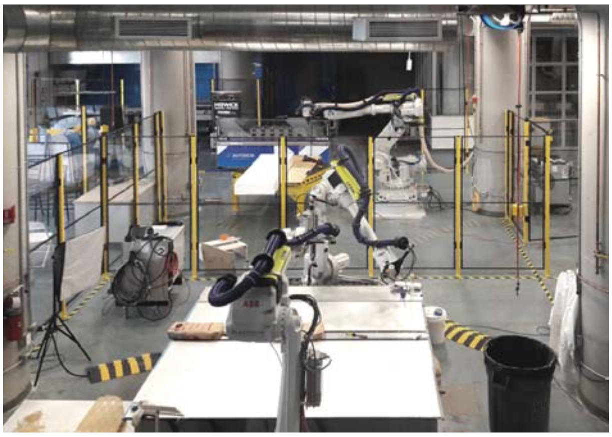


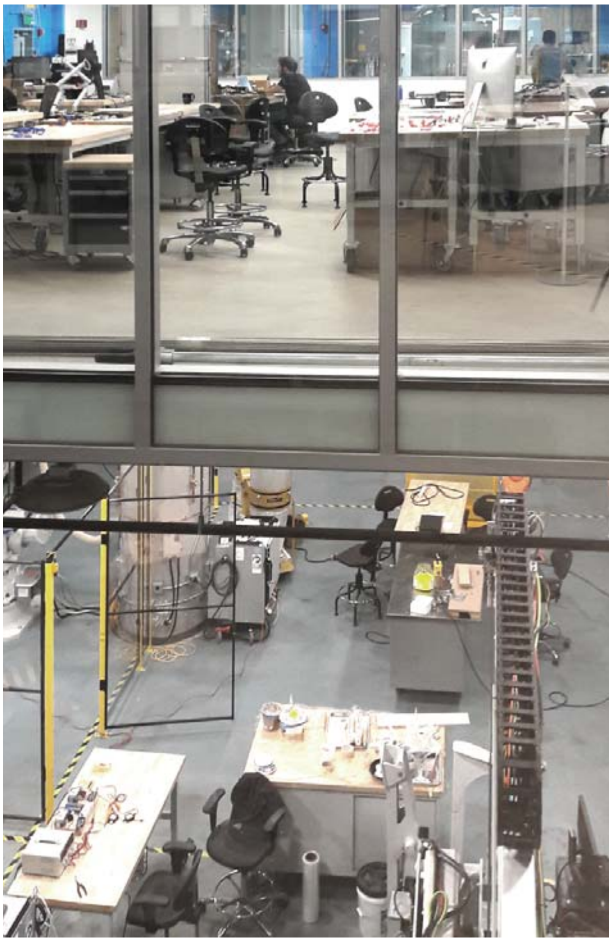
4a

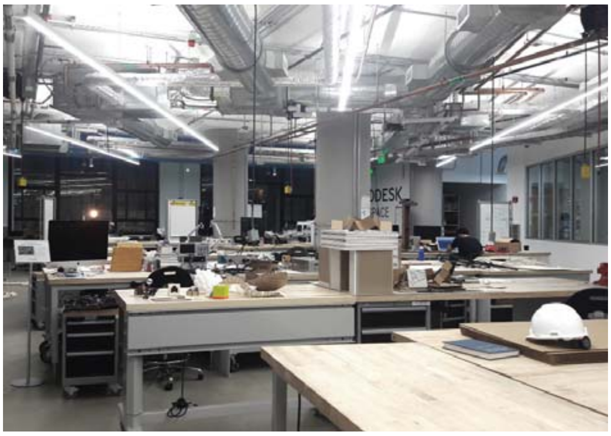
Autodesk BUILT Space

square meters:	3,200
established in:	2016
type of business:	collaborative R&D and prototyping workshop; incubator









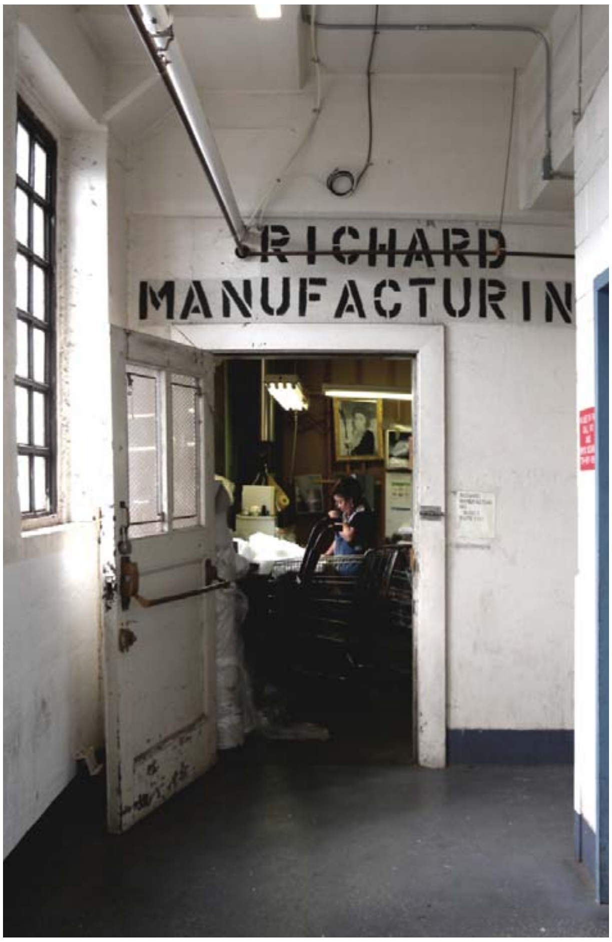
5

Building 3, Brooklyn Navy Yard (BNY)

New York, NY

square meters:	67,000
n. tenants:	40+
ownership:	city-owned; managed by a nonprofit

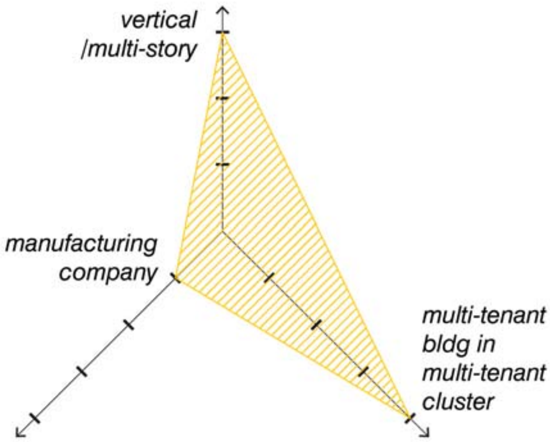
year built:	1918
dismissed:	1960s
reuse:	1980s-present
usage:	*former* General Storehouse, Offices *current* multi-tenant industrial facility



5a

Bien Hecho

square meters:	260
established in:	2009
type of business:	woodshop, custom design and fabrication of furniture




OLIVER

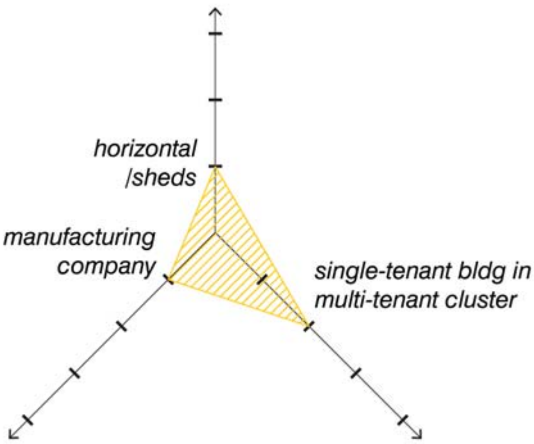
6

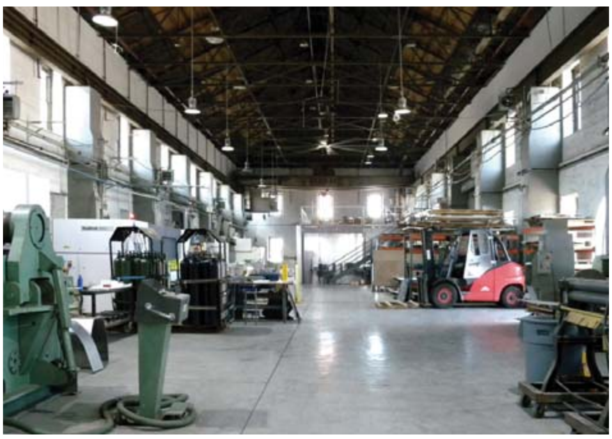
Ferra Design
/ Bldg 10, Brooklyn Navy Yard (BNY)

New York, NY

square meters:	2,300
n. tenants:	1
ownership:	city-owned; managed by a nonprofit

year built:	1849-1851 / remodelled in 1936
dismissed:	1960s
reuse:	1980s-2002 (Ferra's establishment)
usage:	*former* engine house; then power house; then different type of shops; then diesel engine school; then storage. *current* precision architectural metal fabrication firm





7

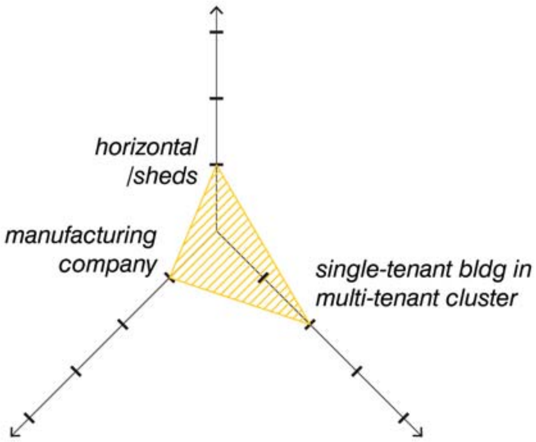
Situ Fabrication
/Bldg 132, Brooklyn Navy Yard (BNY)

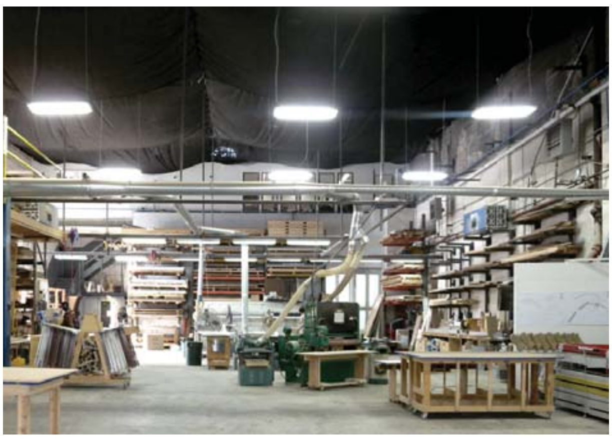
New York, NY

square meters:	1,155
n. tenants:	1
ownership:	city-owned; managed by a nonprofit

year built:	1905
dismissed:	1960s
reuse:	1980s-2013 (Situ's establishment)

usage:	*former* Locomotive Shed; then storage; then Material Handling Equipt.; then Locomotive Repair Shop; then cold storage *current* design, research and fabrication workshop





8

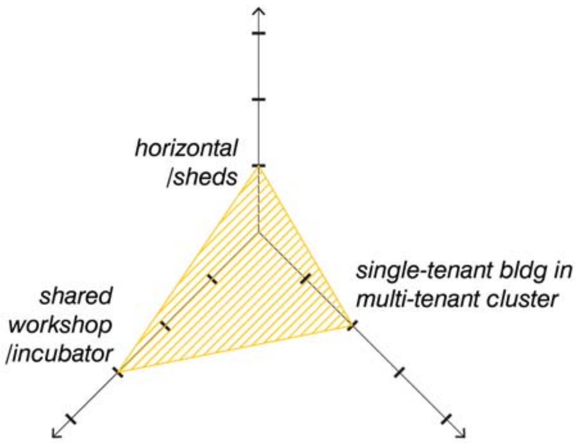
New Lab
/Bldg 128, Brooklyn Navy Yard (BNY)

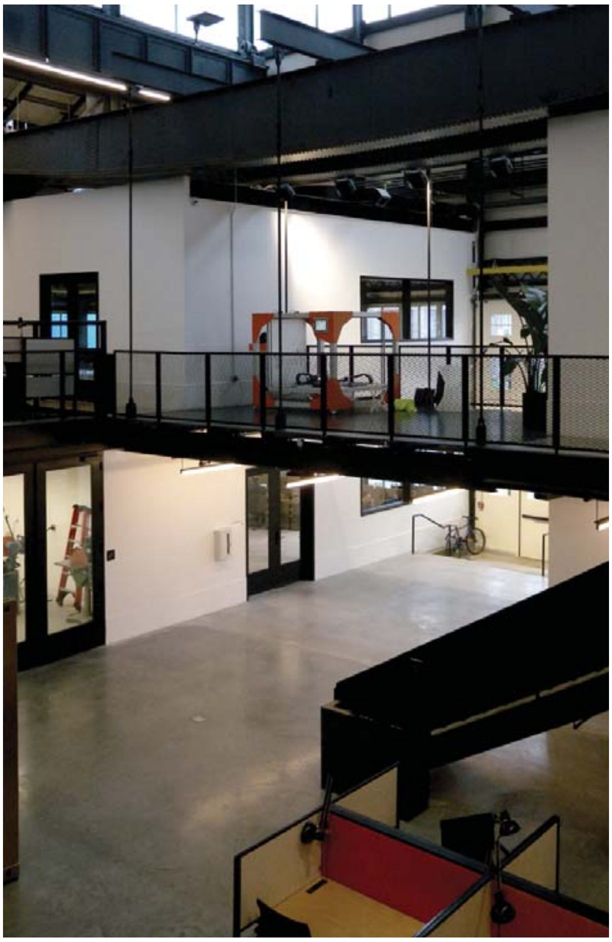
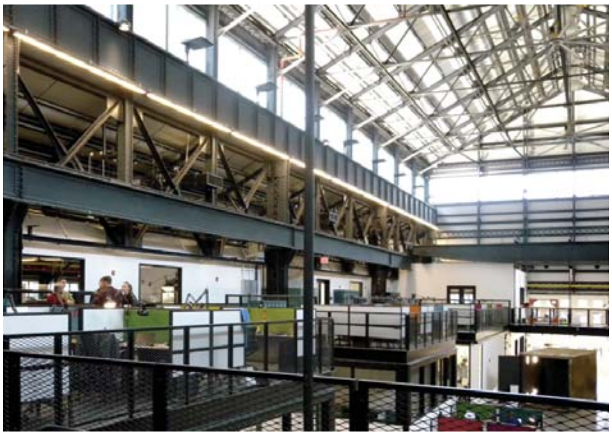
New York, NY

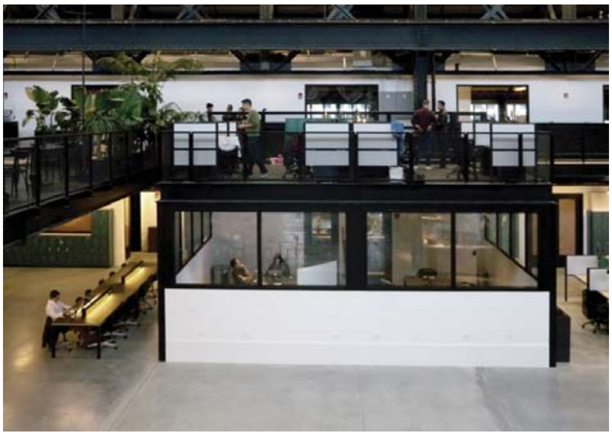
square meters:	7,800
n. tenants:	500+ (members)
ownership:	for-profit, in partnership with the City of New York

year built:	1902
dismissed:	1960s
reuse:	2011-2016

usage:	*former* shipbuilding facility
	current hardware-orinted high-tech coworking space




9

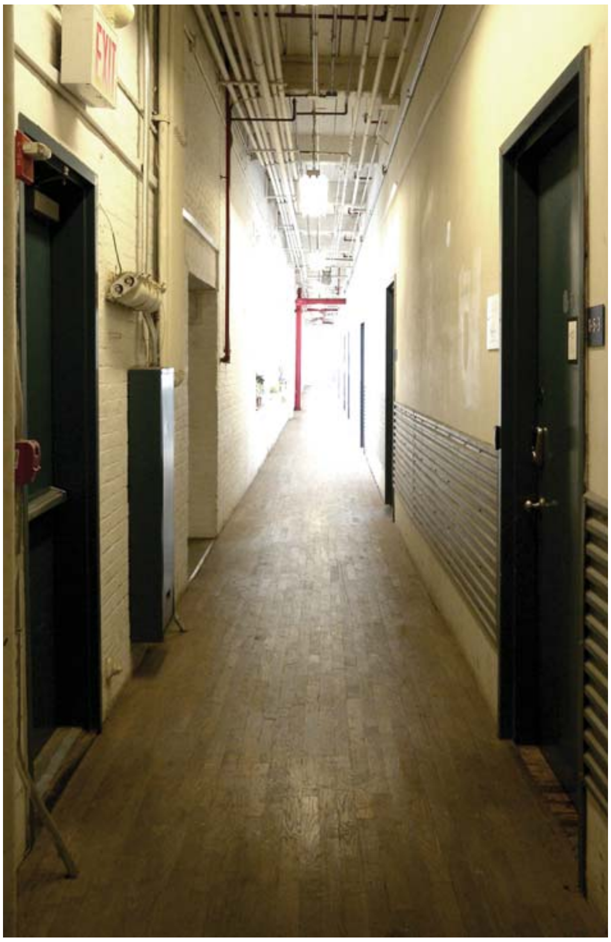
1155-1205 Manhattan St, Greenpoint Manufacturing and Design Center (GMDC)

New York, NY

square meters: 34,000
n. tenants: 76
ownership: nonprofit industrial developer

year built: 1868
dismissed: 1980s
reuse: 1992-Present

usage: *former*
Chelsea Fiber Mills complex
current
multi-tenant industrial facility




1203

10

810 Humboldt St, Greenpoint
Manufacturing and Design Center (GMDC)

New York, NY

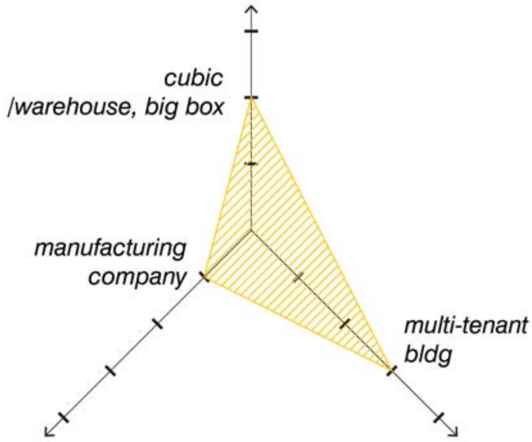
square meters:	8,800
n. tenants:	14
ownership:	nonprofit industrial developer

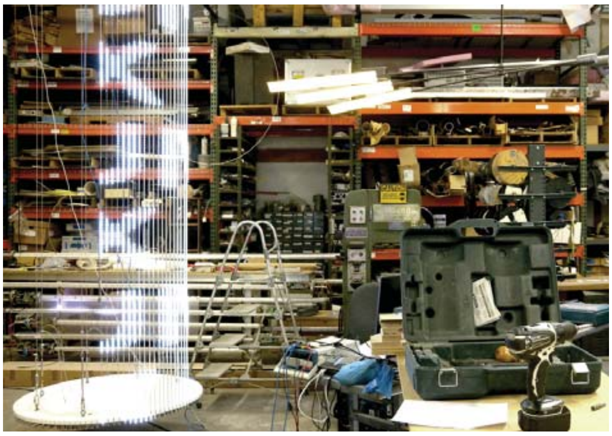
year built:	1868
dismissed:	unknown
reuse:	2000
usage:	*former*
	bowling alley
	current
	multi-tenant industrial facility

10a

Parallel Development

square meters: 300+
established in: 2010
type of business: design and fabrication of electronic media systems and custom LED displays





11

1102 Atlantic Avenue, Greenpoint Manufacturing and Design Center (GMDC)

New York, NY

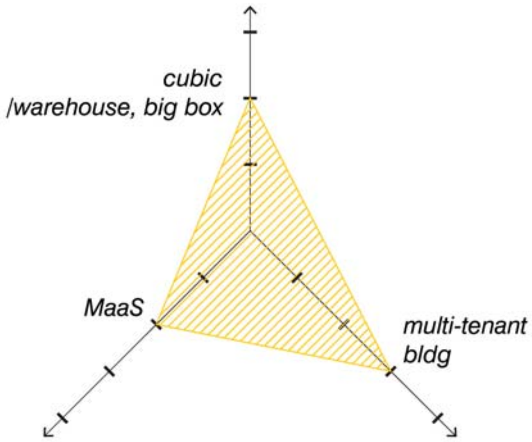
square meters:	4,700
n. tenants:	11
ownership:	nonprofit industrial developer

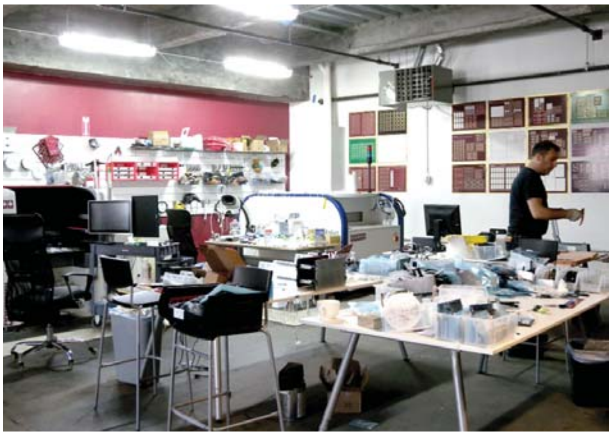
year built:	unknown
dismissed:	unknown
reuse:	2012-2015
usage:	*former*
	auto parts warehouse facility
	current
	multi-tenant industrial facility

11a

PCB:NG

square meters: 120 circa
established in: 2015
type of business: custom manufactured electronics, automated process and SMT assembly line





12

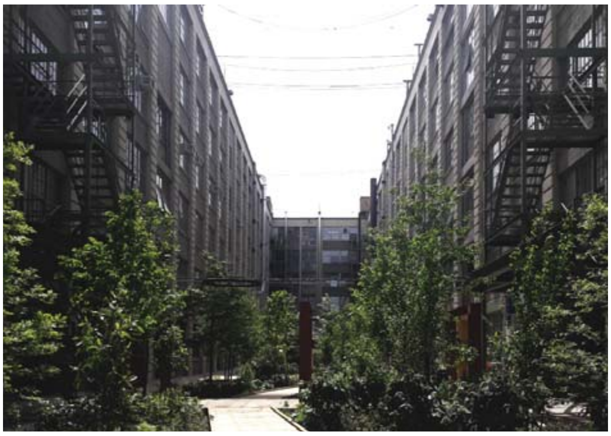
Industry City (IC)

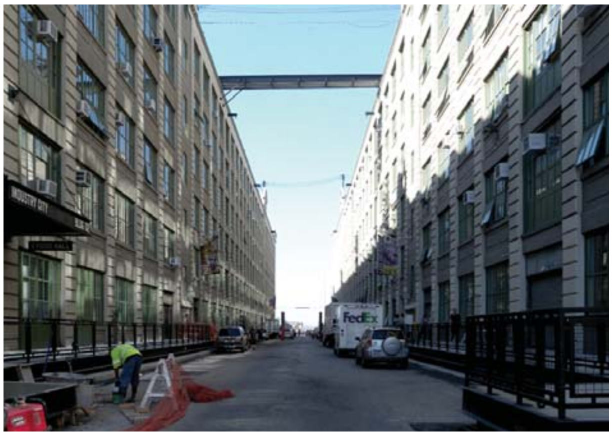
New York, NY

square meters: 600,000+
n. tenants: 370+
ownership: for-profit investment and management company

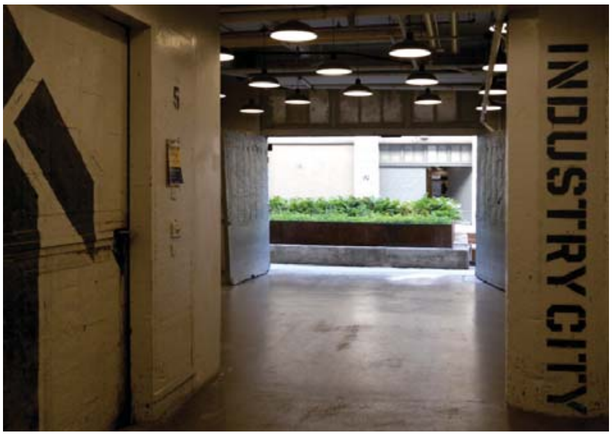
year built: 1890s
dismissed: 1960s
reuse: 2013-Present

usage: *former*
Bush Terminal, intermodal manufacturing, warehousing and distribution center
current
multi-tenant office, commercial and industrial facility



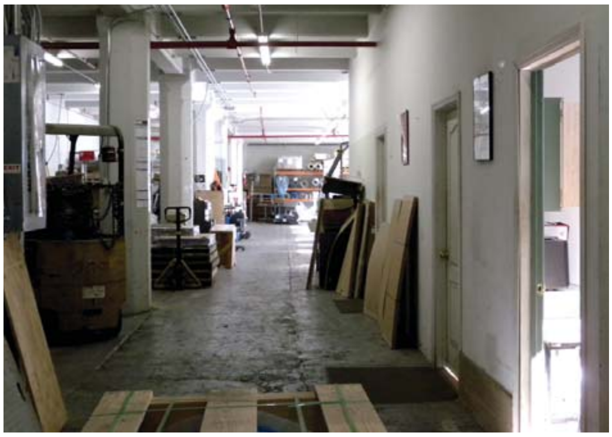


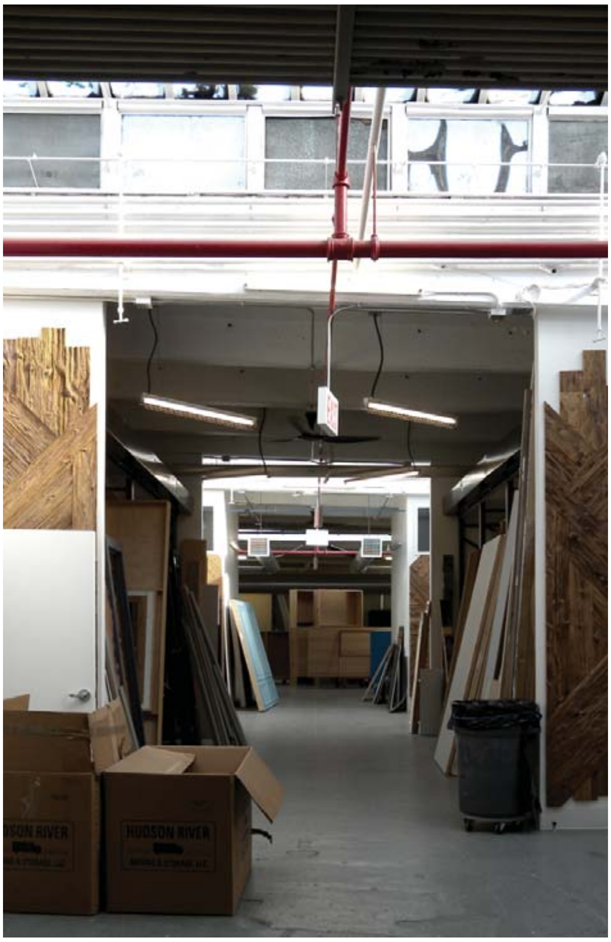

EXIT
INNOVATION ALLEY


INDUSTRY CITY


THE
WORKING
IRON
NEVER
RUSTS


CHOCOLATES SINCE 1923




HUDSON RIVER

13

630 Flushing Ave.

New York, NY

square meters: 53,000+
n. tenants: 29+
ownership: for-profit investment and management company

year built: beginning of 1900
dismissed: 2008
reuse: 2011-Present

usage: *former*
Pfizer pharmaceutical plant, drugs and chemicals
current
multi-tenant office, education, and industrial facility

14

Bldg B, Brooklyn Army Terminal (BAT)

New York, NY

square meters:	177,000+
n. tenants:	60
ownership:	city-owned, managed by New York City Economic Development Corporation (public)

year built:	1918-1919
dismissed:	early 1970s
reuse:	1984-Present

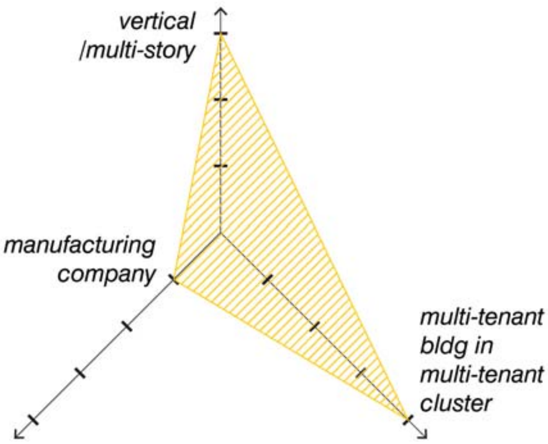
usage:

former
military depot and supply base
current
multi-tenant industrial facility; governative storage space and archives

14a

Riva Precision Manufacturing

square meters: 3,500
established in: 2013
type of business: jewelry design and precision manufacturing



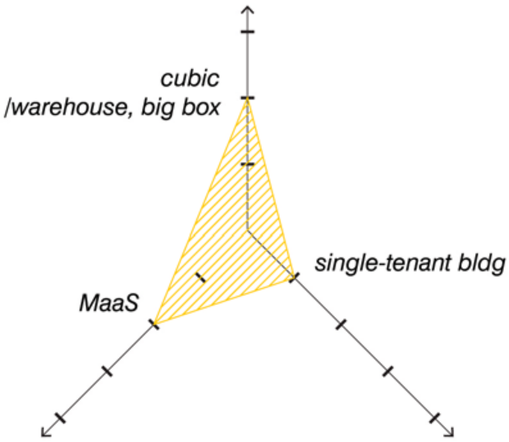
15

Linda Tool

New York, NY

square meters:	1,500
n. tenants:	1
ownership:	private company

year built:	unknown
dismissed:	unknown
reuse:	2003-2004; 2008
usage:	*former* warehouse, industrial facility *current* precision machining, contract manufacturer



16

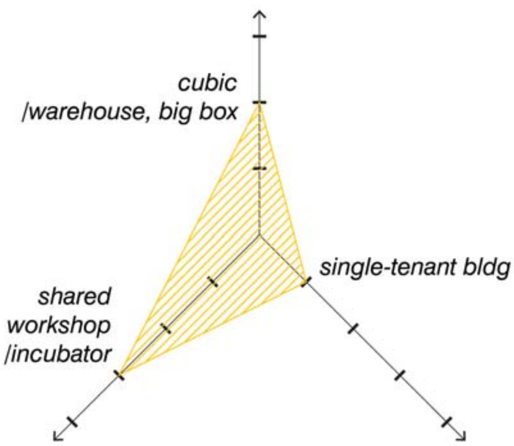
Supersmith

New York, NY

square meters: 800+
n. tenants: 20+ (members)
ownership: space leased, unknown owner

year built: unknown
dismissed: unknown
reuse: 2014-2017

usage: *former*
lumbing supply facility
current
coworking, collaborative workshops (wood, metal, ceramics), retail and event spaces



17

RIDC Keystone Commons

East Pittsburgh/Turtle Creek (Pittsburgh area)

square meters: 210,000
n. tenants: 40+
ownership: nonprofit industrial developer

year built: 1880s
dismissed: 1988
reuse: 1989-Present

usage: *former*
Westinghouse Electric Corporation
current
multi-tenant industrial park; warehouse, office, and manufacturing spaces

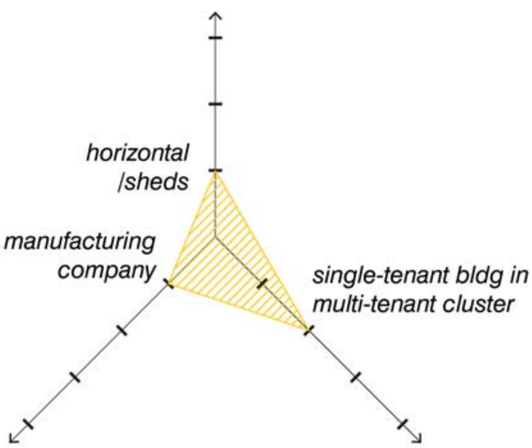
17a

TAKTL

square meters: 13,200

established in: 2015

type of business: Ultra High Performance Concrete design and manufacturing company

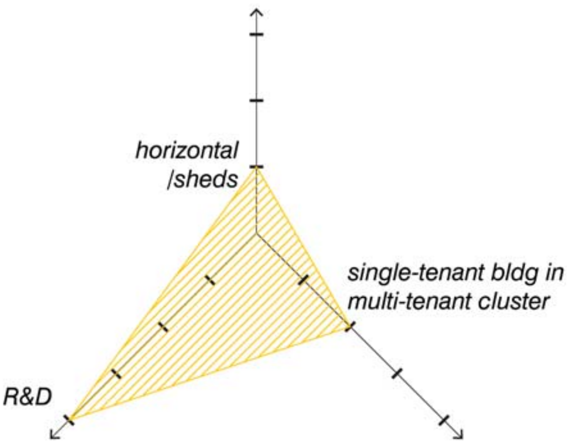


18

Carnegie Robotics, RIDC Lawrenceville Technology Center

Pittsburgh, PA

square meters:	2,960
n. tenants:	1
ownership:	private company, partnership with a nonprofit industrial developer
year built:	late 1880s-early 1990s
dismissed:	1979
reuse:	2013
usage:	*former* Heppenstall Steel Company *current* designer and producer advanced robotics sensors and platforms for real-world applications




Carnegie

19

Chocolate Factory, RIDC Lawrenceville Technology Center

Pittsburgh, PA

square meters: 6,600
n. tenants: 10+
ownership: nonprofit industrial developer

year built: unknowk
dismissed: 1998-99
reuse: 1996 (acquired) - Present

usage: *former*
Geoffrey Boehm Chocolates
current
multi-tenant industrial and office facility

20

Ice House

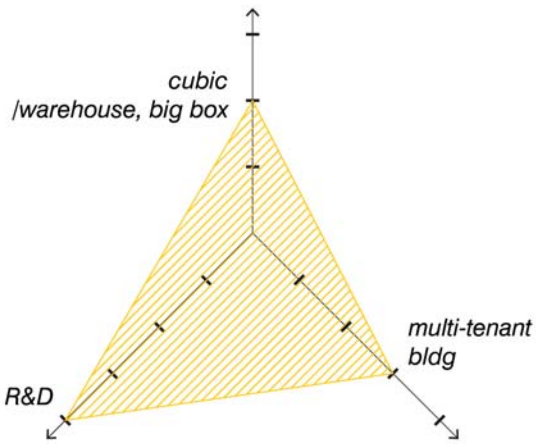
Pittsburgh, PA

square meters:	3,700+
n. tenants:	35+
ownership:	community development corporation
year built:	1907
dismissed:	1951
reuse:	2000-2001
usage:	*former* Consolidated Ice Company Factory No. 2 *current* multi-tenant industrial commercial facility; artist studios

20a

Protoinnovations

square meters:	350 circa
established in:	unknown; company founded in 2005
type of business:	design and engineering of advanced Robotic Prototypes and Automation Technologies



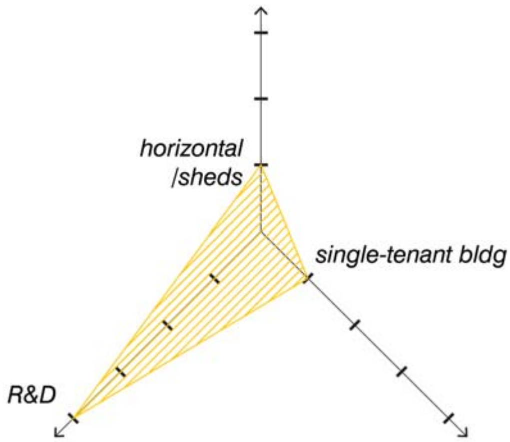
21

National Robotics Engineering Center (NREC)

Pittsburgh, PA

square meters:	9,300+
n. tenants:	1
ownership:	university

year built:	unknown
dismissed:	unknown
reuse:	1996
usage:	*former* foundry *current* R&D of robotic technologies from concept to commercialization; operating unit of Carnegie Mellon University's Robotics Institute (RI)



22

Factory Unlocked

Pittsburgh, PA

square meters: 3,000
n. tenants: still calling up mebmers
ownership: private real estate company

year built: 1970
dismissed: unknown
reuse: 2018-Present

usage: *former*
warehouse, logistics and distribution companies
current
product start-up manufacturing co-working space

23

Mill 19, Almono/Hazelwood Green

Hazelwood - Pittsburgh, PA

square meters: 25,000
n. tenants: 1 (still under development)
ownership: nonprofit industrial developer

year built: 1943
dismissed: 1997
reuse: 2017-Present
usage: *former*
munitions production storage; then steel rolling mill; then warehouse
current
CMU Advanced Robotics for Manufacturing (ARM) Institute; multi-tenant industrial, R&D, and office facility

24

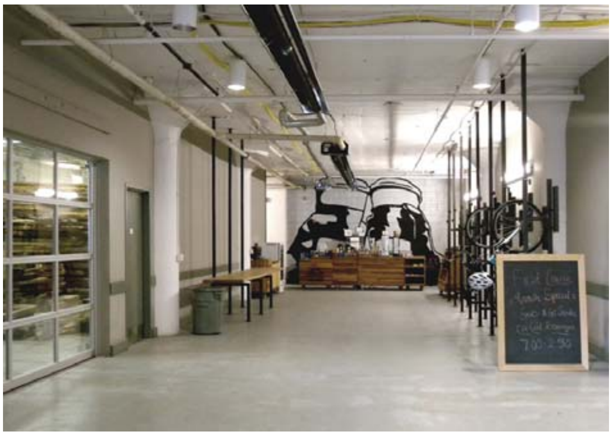
7800 Susquehanna Street

Homewood - Pittsburgh, PA

square meters:	12,200
n. tenants:	20+
ownership:	community development financial institution

year built:	1920s
dismissed:	2013 (latest dismission)
reuse:	2014-Present

usage:	*former* Westinghouse Electric facility; then CNC machine components producer *current* multi-tenant industrial, commercial and office facility



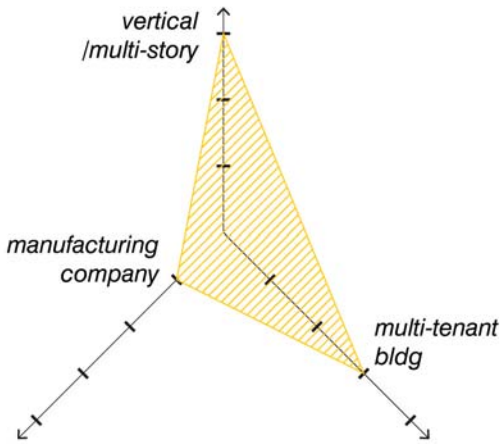
24a

BoXZY

square meters: 450

established in: 2015

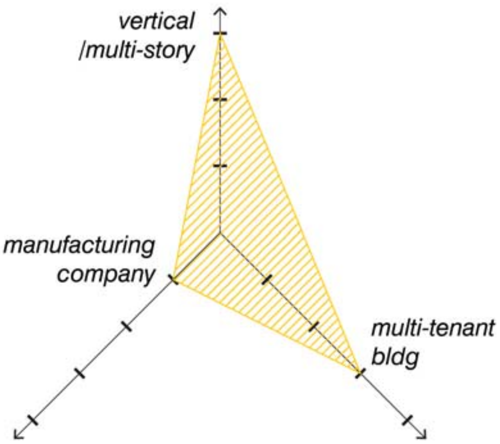
type of business: producer of a three-in-one 3D printer, laser engraver, and CNC mill desktop makerspace

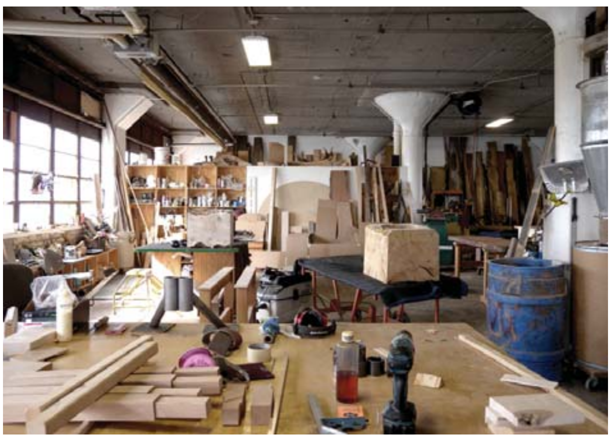


24b

Urban Tree

square meters: 800
established in: 2014
type of business: tree reclaiming and custom woodworking





25

MSA Building / MINE Factory

Pittsburgh, PA

square meters: 18,600
n. tenants: 30+
ownership: for-profit real estate company

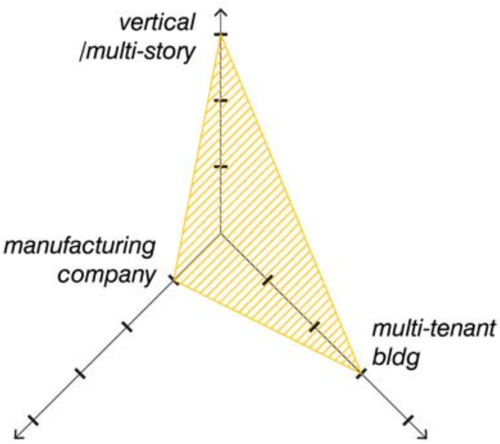
year built: unknown
dismissed: unknown
reuse: 2011-2014 / 2014-Present

usage: *former*
The Mine Safety Appliance Company; then self-storage
current
multi-tenant industrial, commercial and office facility; university workshops; artists studios

25a

Kerf Case

square meters: 250
established in: 2015
type of business: precise manufacturing of wooden accesories




26

Lexington Technology Park

Pittsburgh, PA

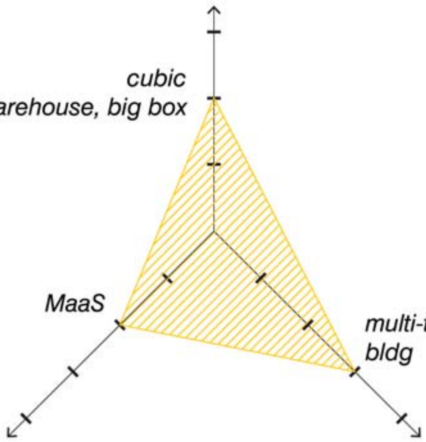
square meters:	30,500+
n. tenants:	10+
ownership:	Urban Redevelopment Authority of Pittsburgh (public)

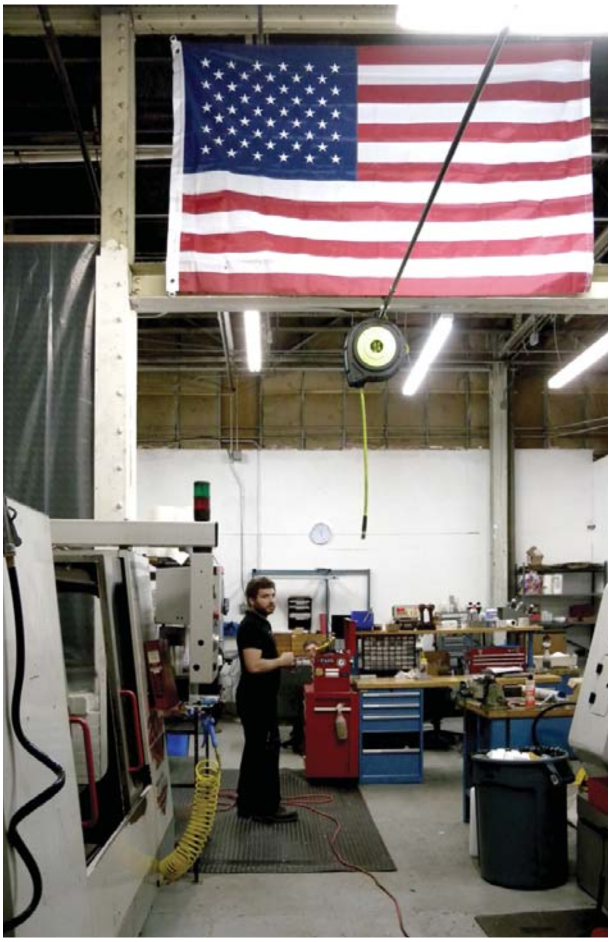
year built:	1914
dismissed:	1995
reuse:	1996-Present

usage:	*former* Model Engine Company; then Rockwell International manufacturing, office, and R&D facility *current* multi-tenant industrial and office facility; government departments


26a Conturo Prototyping

square meters: 300+
established in: 2016
type of business: contract manufacturer for small batches of of high quality, custom metal prototypes and components





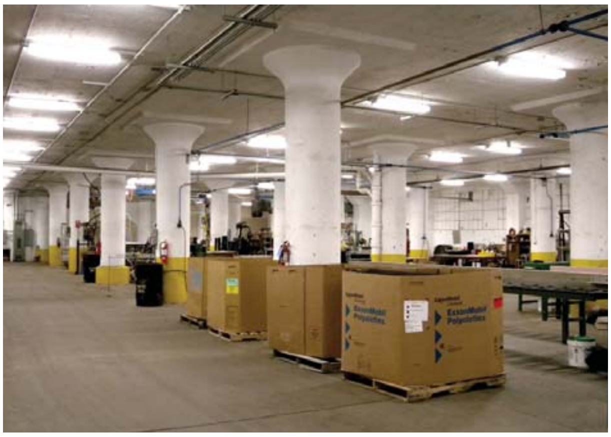
27

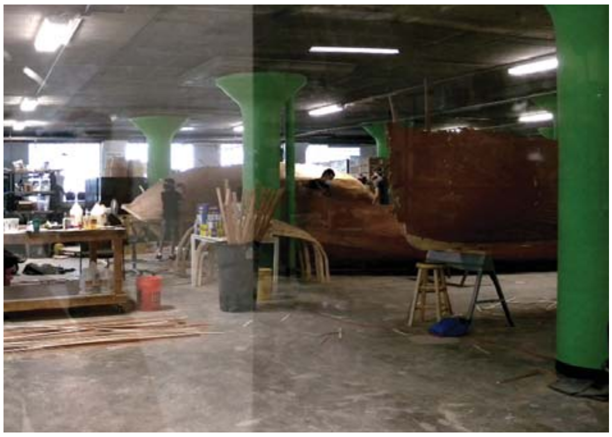
X Factory

Pittsburgh, PA

square meters: 23,200+
n. tenants: 10+
ownership: private company

year built: early 1900s
dismissed: 1970-1980s
reuse: 2013-Present
usage: *former*
Great Atlantic and Pacific Tea Company grocery depot; then fenestration products manufacturer (still active)
current
multi-tenant industrial, commercial and office facility, co-working and artists studios

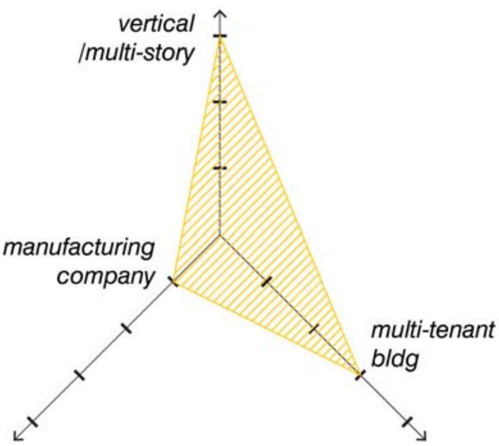


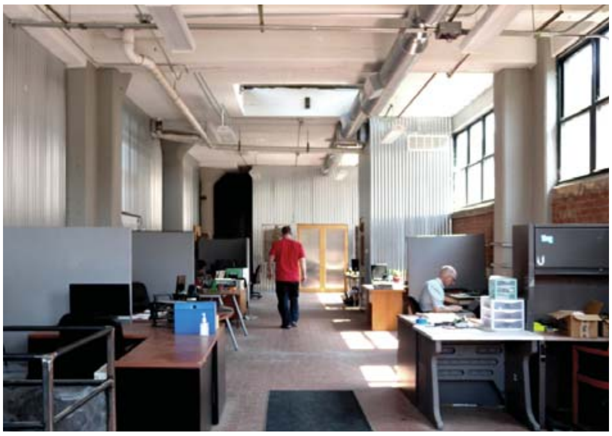


27a

Optimus Technologies

square meters: 1,000 circa
established in: 2014/2015
type of business: producer of high performance biodiesel conversion systems for medium and heavy-duty diesel trucks








28

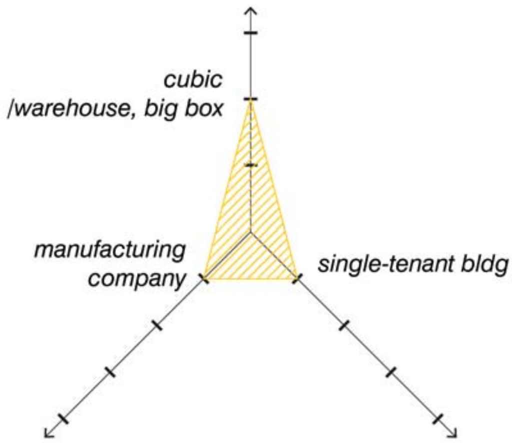
Puzzle Pax

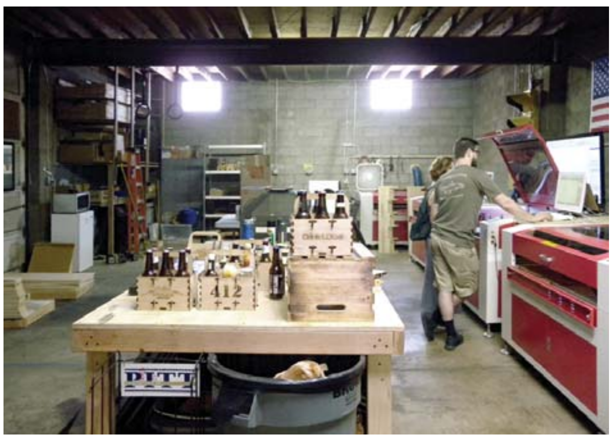
Pittsburgh, PA

square meters: 90
n. tenants: 1
ownership: private owner

year built: unknown
dismissed: -
reuse: 2015-2016

usage: *former*
garage
current
craft beer lifestyle goods company





29

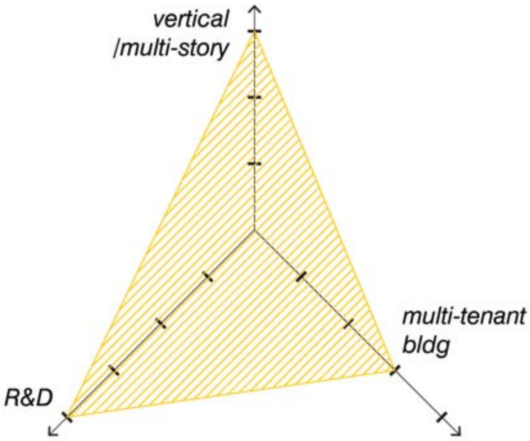
Astrobotic Technology

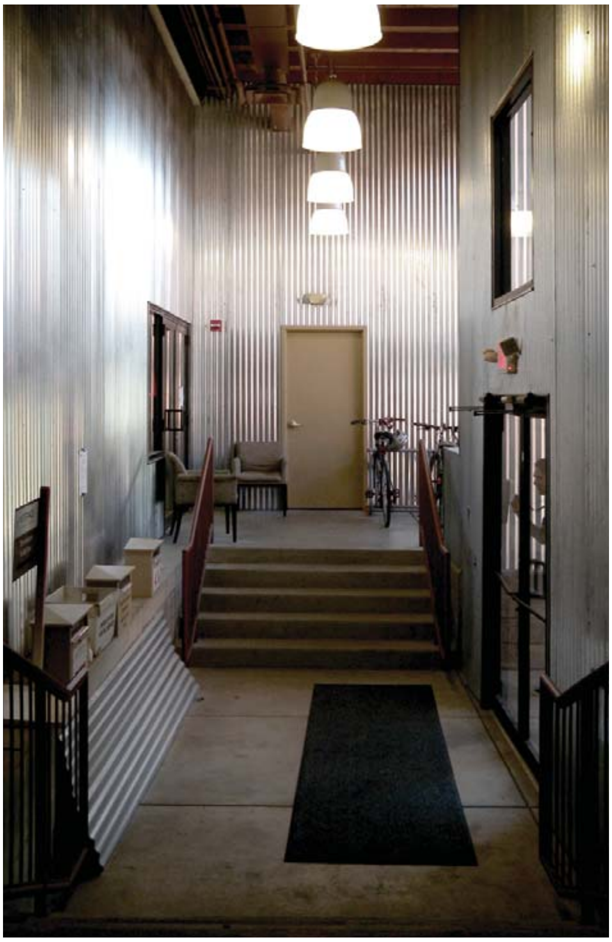
Pittsburgh, PA

square meters: 600+
n. tenants: 1 (space part of a multi-tenant facility)
ownership: private real estate company

year built: unknown
dismissed: unknown
reuse: 2012-2013

usage: *former*
Metal stamping facility
current
developer of space robotics technology for planetary missions





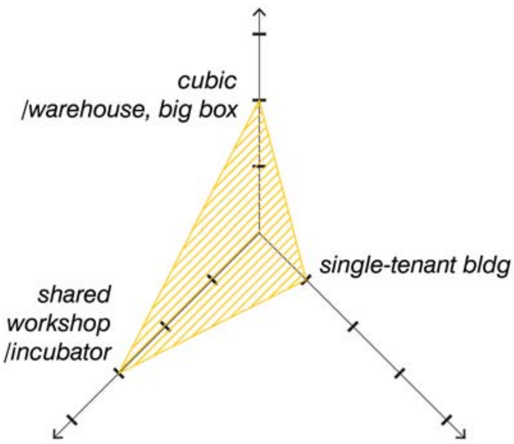
30

Protohaven

Wilkinsburg - Pittsburgh, PA

square meters:	1,000
n. tenants:	100+ (members)
ownership:	private real estate company

year built:	unknown
dismissed:	unknown
reuse:	2017-2018
usage:	*former*
	warehouse
	current
	makerspace



31

Bloomcraft, Blumcraft Building 1

Pittsburgh, PA

square meters: 1,500
n. tenants: 10+
ownership: private real estate company

year built: unknown
dismissed: unknown
reuse: 2015-Present

usage: *former*
warehouse
current
multi-tenant industrial, commercial facility; creative hub; community space

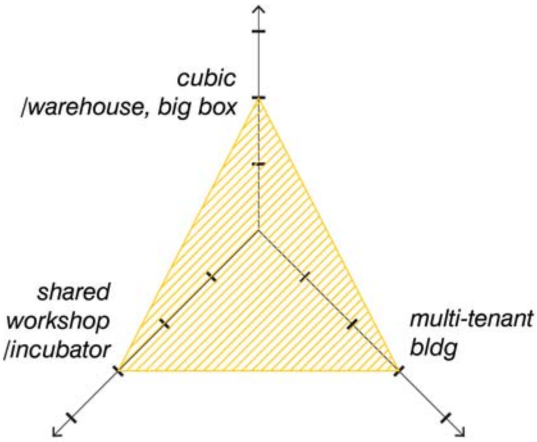
32

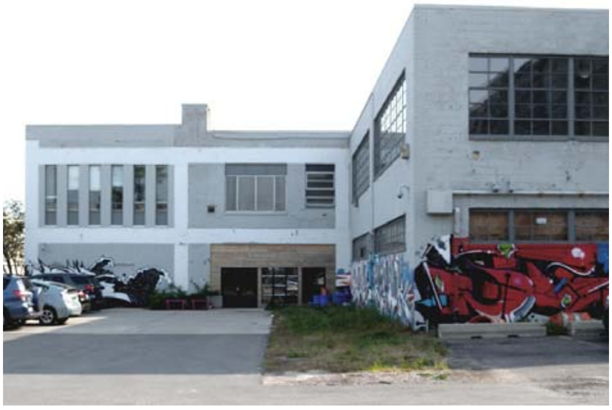
Ponyride

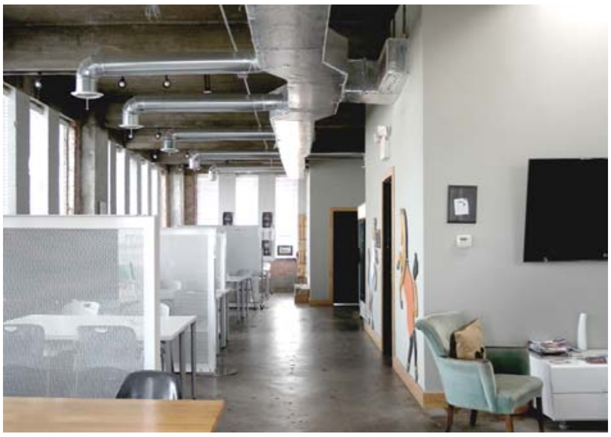
Detroit, MI

square meters:	2,400
n. tenants:	60+
ownership:	private owner; managed by a nonprofit

year built:	1935
dismissed:	2008
reuse:	2011-2014
usage:	*former* printing facility *current* multi-tenant industrial, commercial and office facility; coworking; makerspace



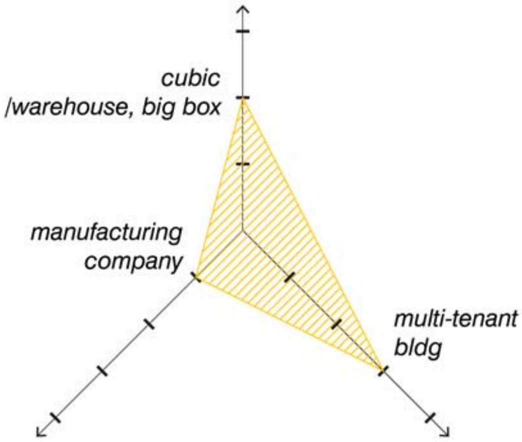




32a

Détroit Is The New Black.

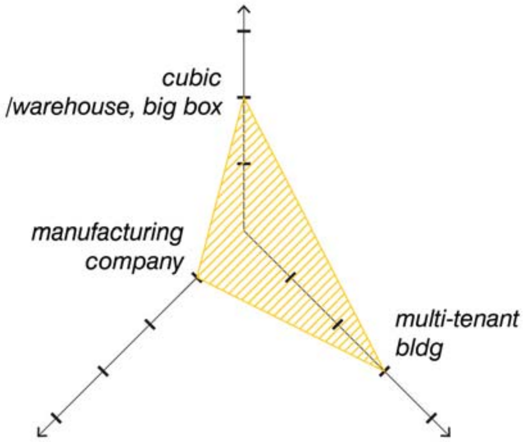
square meters: 90
established in: 2016
type of business: apparel designer and manufacturer



32b

The Empowerment Plan

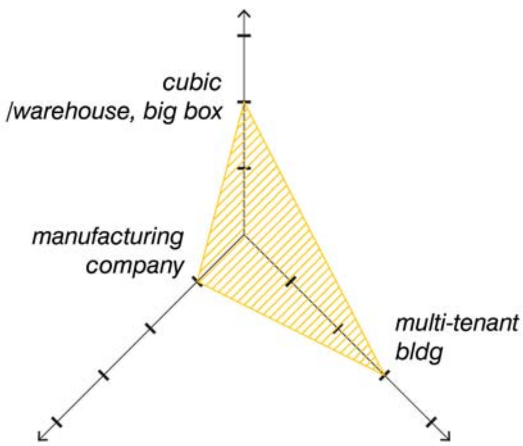
square meters: 325
established in: 2011 (until 2018)
type of business: non-profit organization dedicated to manufacture and distribute coats for homeless



32c

Smith Shop Detroit

square meters: 90
established in: 2012
type of business: craft metalworking company



33

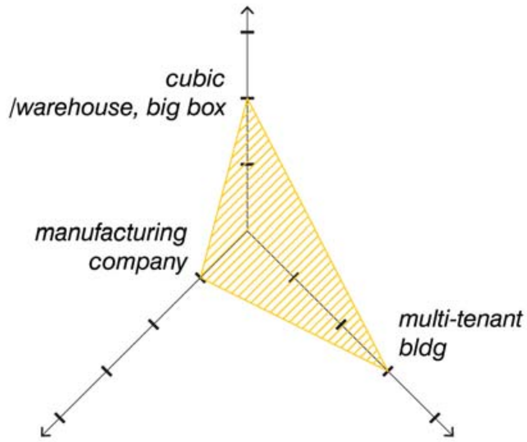
Detroit Denim

Detroit, MI

square meters:	500+
n. tenants:	1 (part of a 1,000+ sqm multi-tenant facility)
ownership:	private real estate company

year built:	1943
dismissed:	unknown
reuse:	2016

usage: *former*
warehouse
current
denim apparel factory and flagship store

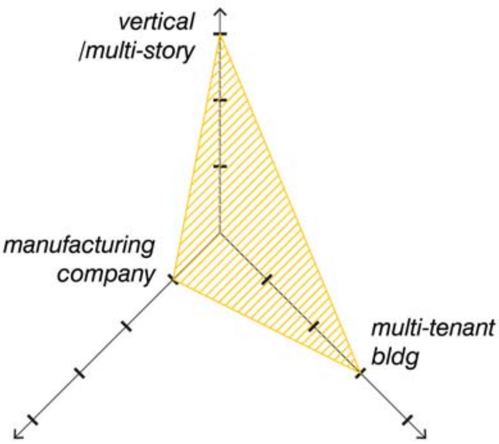


34

Shinola at the Argonaut Building

Detroit, MI

square meters:	4,000+
n. tenants:	1 (space inside a multi-tenant facility)
ownership:	unknown
year built:	1928-1936
dismissed:	early 2000s
reuse:	2009; 2012 (Shinola)
usage:	*former* General Motors Research Laboratory; then Argonaut Realty Corporation *current* watch and other products factory (part of the A. Alfred Taubman Center for Design Education)



35

Industrial Council of Nearwest Chicago (ICNC) / Make City

Chicago, IL

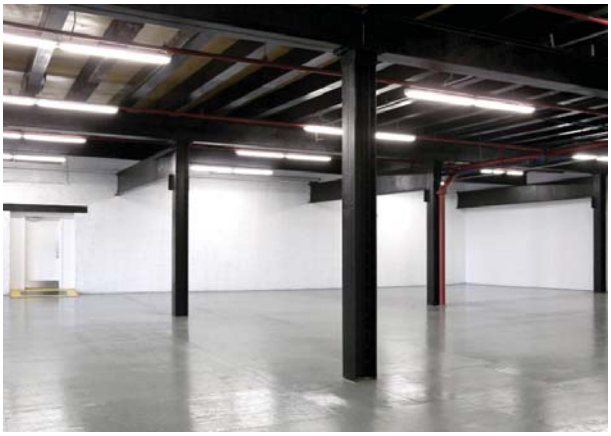
square meters: 38,600+
n. tenants: 110+
ownership: economic development organization

year built: 1890s
dismissed: unknown
reuse: 1980-Present

usage: *former*
industrial
current
multi-tenant industrial facility; incubator; workforce development


APEX


Yale



36

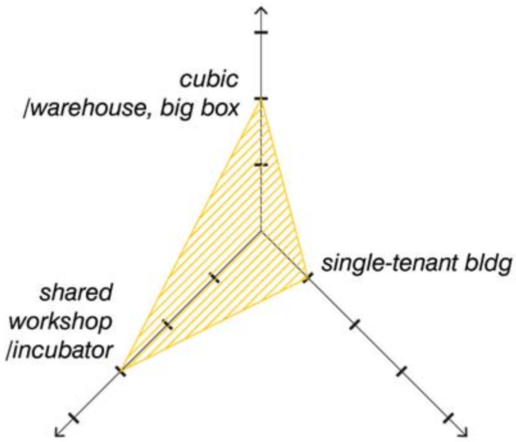
mHUB

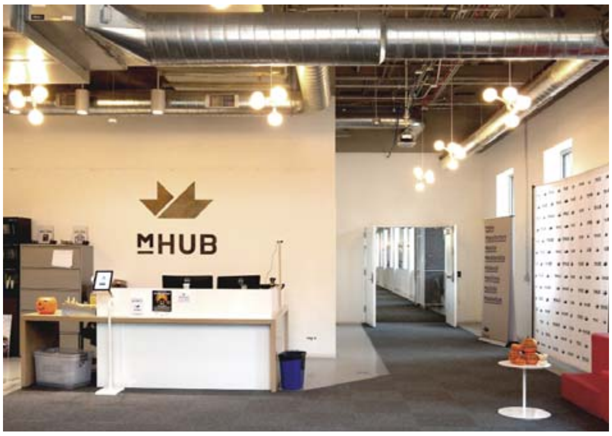
Chicago, IL

square meters: 5,600+
n. tenants: 100+
ownership: unknown

year built: 1957
dismissed: unknown
reuse: 2016

usage: *former*
Motorola Mobility's prototyping lab
current
innovation, prototyping, and manufacturing labs





37

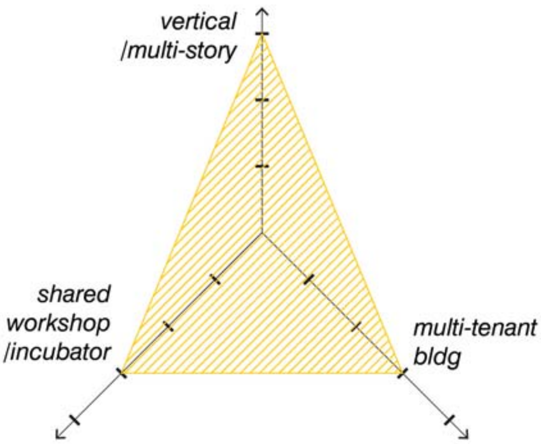
Lost Arts

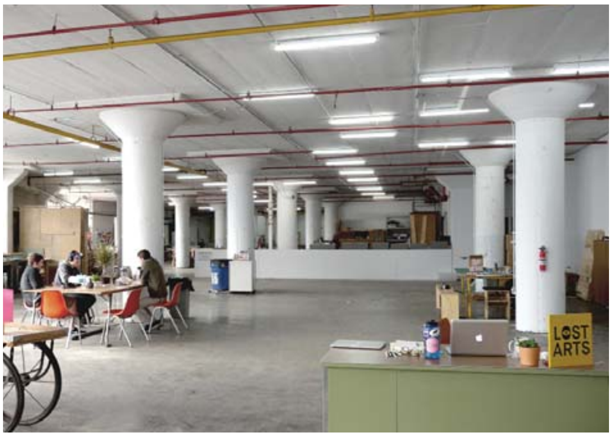
Chicago, IL

square meters: 900+ (part of a 26,500 sqm abandoned facility)
n. tenants: still calling up mebmers
ownership: pivate real estate company

year built: 1870s
dismissed: unknown
reuse: 2015-Present

usage: *former*
Lissner Corporation warehouse; then Pickens-Kane warehouse
current
makerspace and creative hub




LOST
ARTS

38

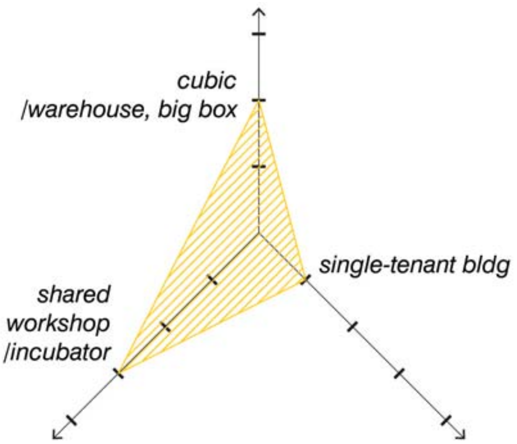
Pumping Station: One (PS:1)

Chicago, IL

square meters: 1,000 circa
n. tenants: 480+ (members)
ownership: unknown

year built: 1950s
dismissed: unknown
reuse: 2009-Present

usage: *former*
warehouse, industrial
current
maker/hackerspace



39

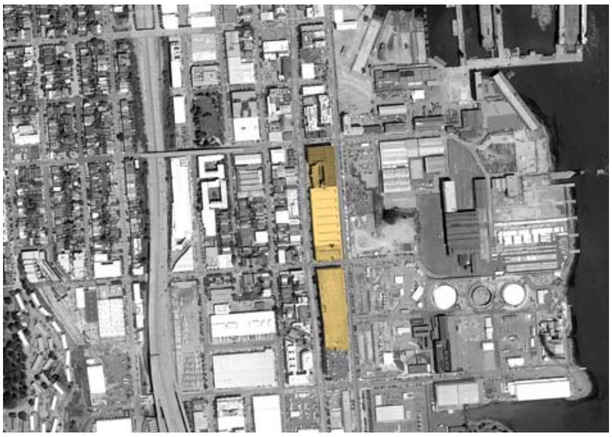
American Industrial Center

San Francisco, CA

square meters: 70,000+
n. tenants: 285+
ownership: family-owned and managed

year built: 1915-1955
dismissed: 1969
reuse: 1975-Present

usage: *former*
American Can Company
current
multi-tenant industrial, commercial and office facility




Rocket

40

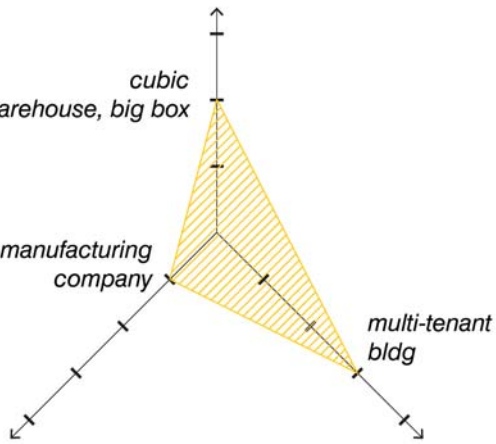
Heath Campus

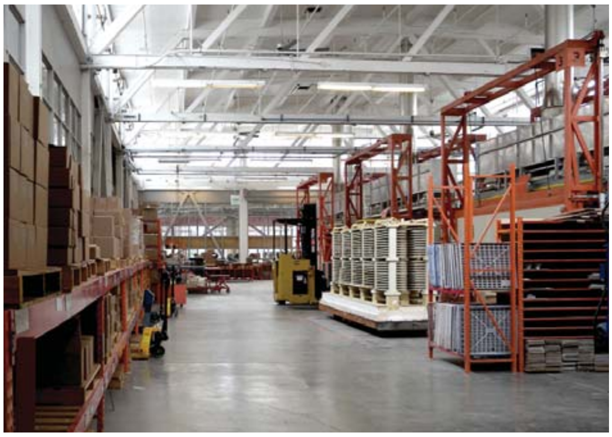
San Francisco, CA

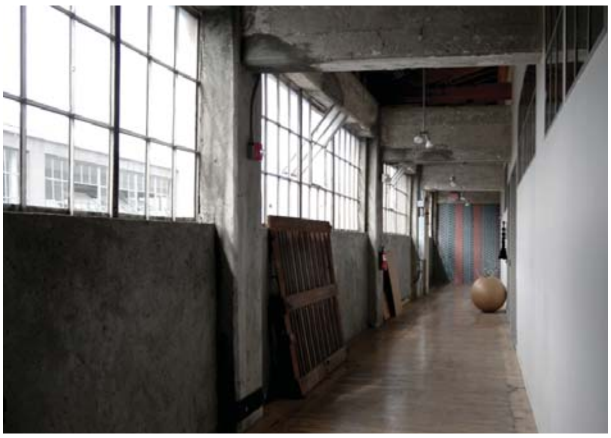
square meters: 5,000
n. tenants: 4+
ownership: private company

year built: 1990s
dismissed: 2000s
reuse: 2011-2016

usage: *former*
Mission Laundry
current
Heath Ceramics tile factory, showroom, and clay studio; commercial and creative studios







41

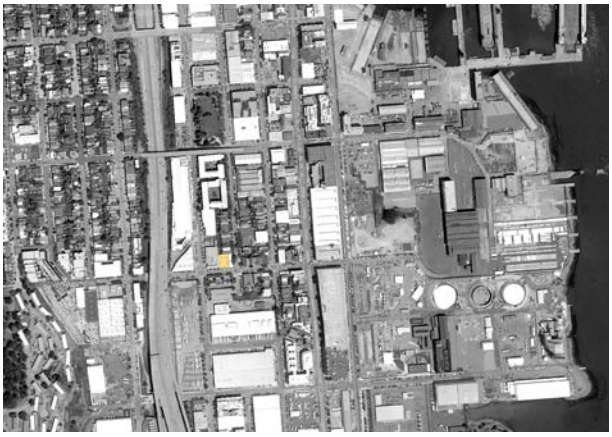
Rickshaw Bagworks

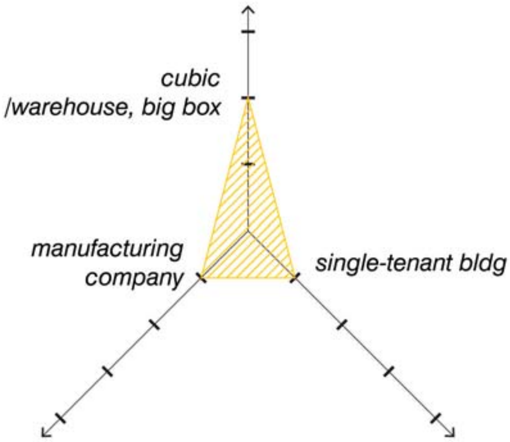
San Francisco, CA

square meters: 700
n. tenants: 1
ownership: private company

year built: unknown
dismissed: unknown
reuse: 2007-2009

usage: *former*
warehouse
current
custom messenger bags and accessories manufacturer



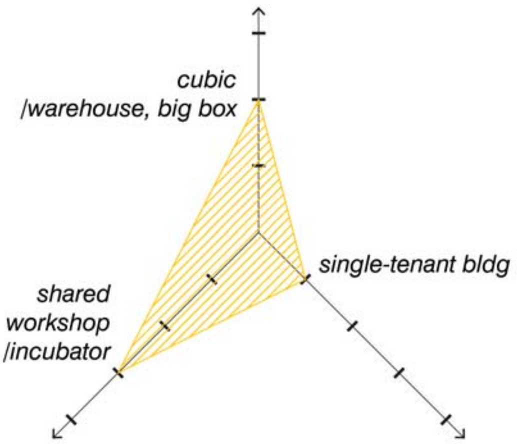


42

Tech Shop

San Francisco, CA

square meters:	1,000+
n. tenants:	1,000+ (members)
ownership:	private real estate company
year built:	unknown
dismissed:	unknown
reuse:	2011
usage:	*former* warehouse *current* makerspace (now reopened as Tech Shop 2.0 after Tech Shop closing in Nov. 2017)



43

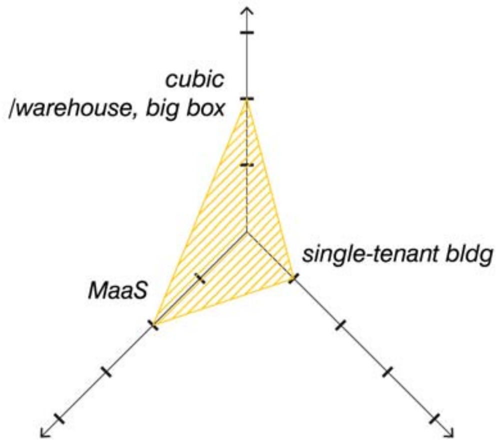
Plethora

San Francisco, CA

square meters: 1,600
n. tenants: 1
ownership: unknown

year built: unknown
dismissed: unknown
reuse: 2015-2017

usage: *former*
warehouse
current
online instant feedback system and automated contract manufacturer



44

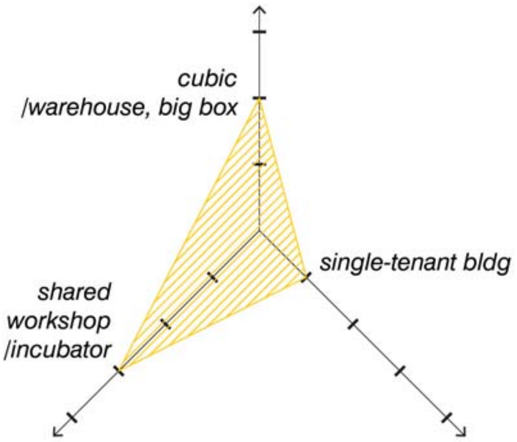
Manylabs

San Francisco, CA

square meters: 510+
n. tenants: unknown
ownership: private real estate company

year built: 1928
dismissed: unknown
reuse: 2015

usage: *former*
mixed-use
current
maker/hackerspace (now closed at this location)



45

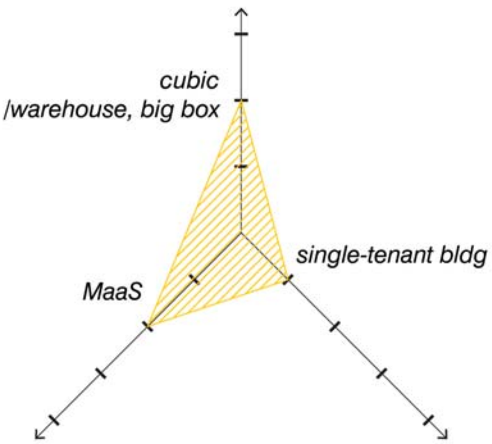
Flex Invention Lab and Micro-Factory

San Francisco, CA

square meters: 1,000+
n. tenants: unknown
ownership: private company

year built: unknown
dismissed: unknown
reuse: 2015

usage: *former*
warehouse
current
"sketch-to-scale" engineering design shop - prototyping, design, and small-batch contract manufacturing facility



46

Pier 9

San Francisco, CA

square meters: 9,300
n. tenants: unknown
ownership: Port of San Francisco and San Francisco Waterfront Partner, LLC

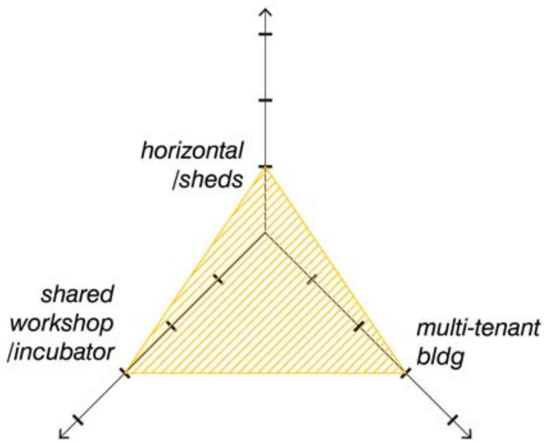
year built: 1917; 1936-1938
dismissed: unknown
reuse: early 2000s-Present

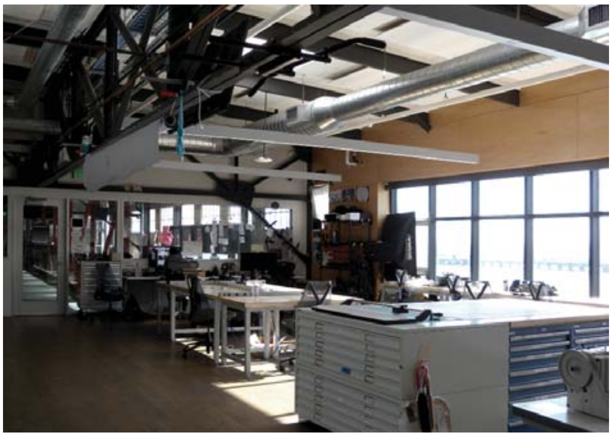
usage:
former
steamship lines and cargo shed
current
multi-tenant industrial, commercial, R&D, and office facility

46a

Autodesk BUILT Space

square meters:	3,000+
established in:	2013
type of business:	collaborative R&D and prototyping workshop; incubator





47

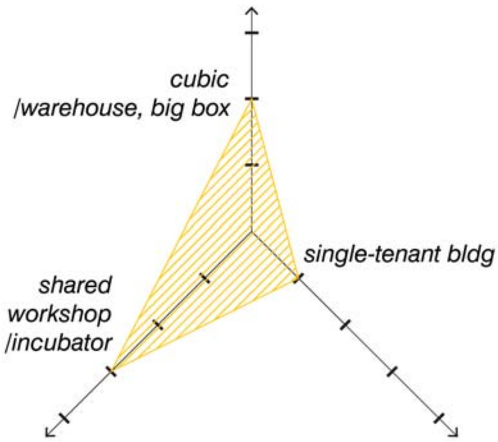
La Kretz Innovation Campus (LKIC) / Los Angeles Cleantech Incubator (LACI)

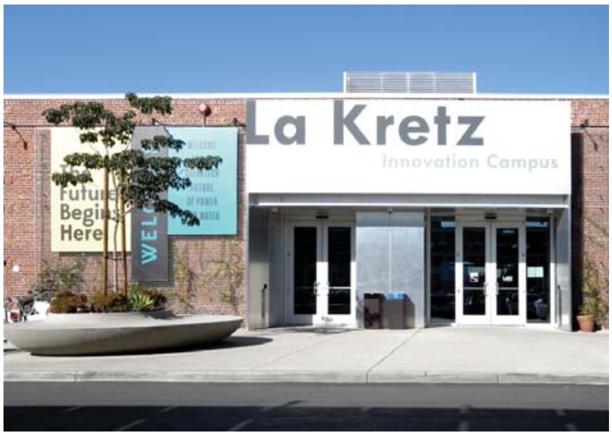
Los Angeles, CA

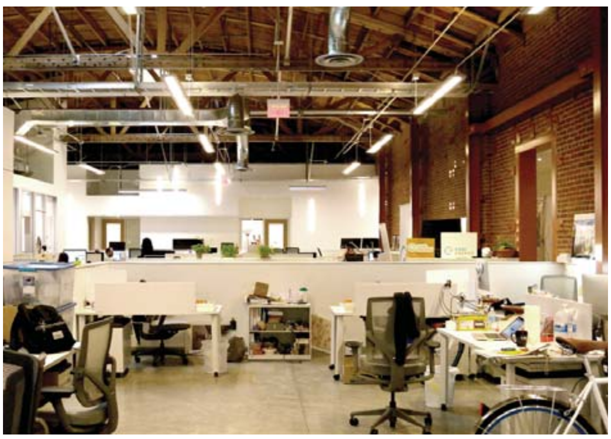
square meters: 5,700
n. tenants: 30+
ownership: Los Angeles Department of Water and Power (public), managed by a nonprofit

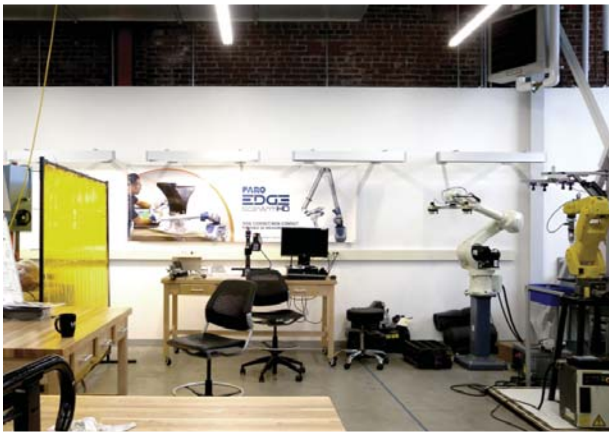
year built: unknown
dismissed: unknown
reuse: 2016

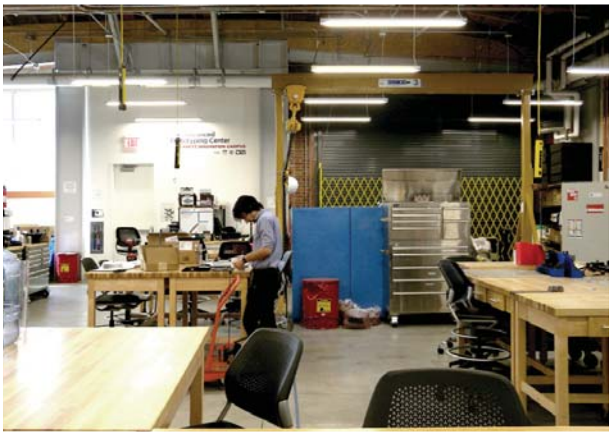
usage:
former
warehouse
current
incubator, collaborative workspace, training center, and Prototype Manufacturing Center & Equipment

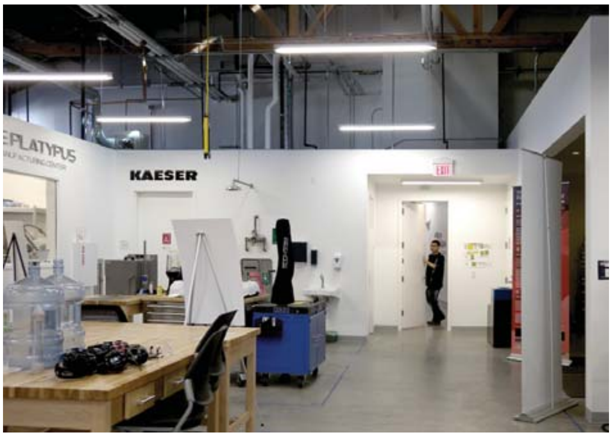











KAESER

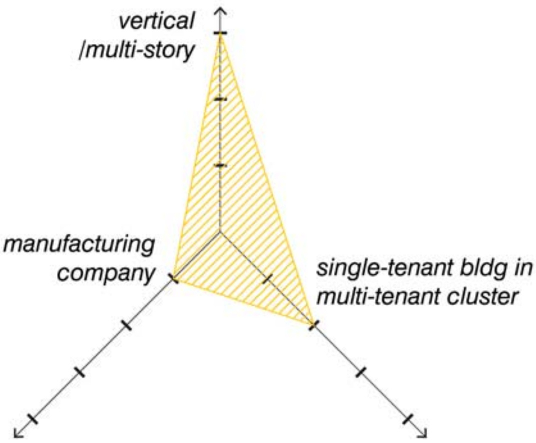
48

American Apparel / ROW DTLA

Los Angeles, CA

square meters:	190,000+
n. tenants:	unknown
ownership:	for-profit investment and managment company

year built:	1917-1923
dismissed:	2017 (latest dismission, just the American Apparel's building)
reuse:	2014-Present
usage:	*former* LA Terminal Market; then American Apparel *current* multi-tenant creative office, commercial and light industrial spaces



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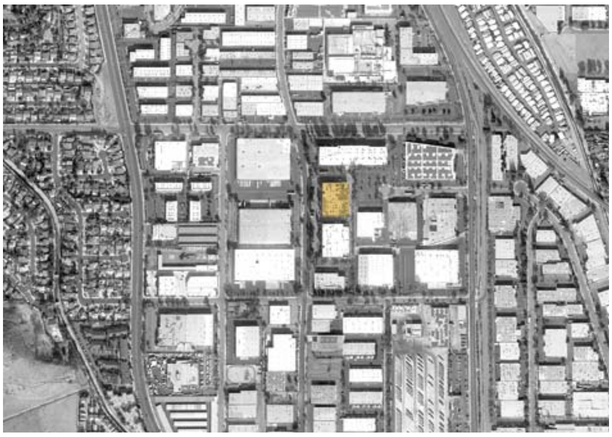
Toolbox LA

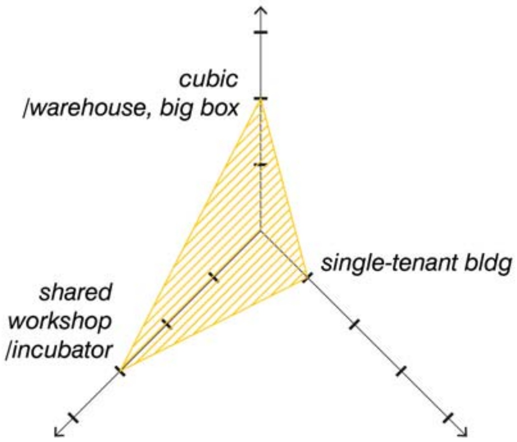
Chatsworth, CA (Los Angeles area)

square meters: 4,500+
n. tenants: 6+
ownership: unknown

year built: unknown
dismissed: unknown
reuse: 2016-2017

usage: *former*
warehouse
current
hardware accelerator, makerspace, biotech lab, and coworking





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Hyperloop Innovation Campus

Los Angeles, CA

square meters: 5,100 (+1 ha of open area)
n. tenants: 1
ownership: private company

year built: unknown
dismissed: unknown
reuse: 2014-2015

usage: *former*
warehouse
current
R&D workshop and testing facility