



Make to Manufacture

ADVANCED MANUFACTURING PLAYBOOK



STRENGTHENING THE
ADVANCED MANUFACTURING
SECTOR IN SAN FRANCISCO

ACKNOWLEDGEMENTS

This playbook is a collaborative project of **The San Francisco Mayor's Office of Civic Innovation**, **The San Francisco Office of Economic and Workforce Development** and **SFMade**.



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We would also like to thank the over 70 advanced manufacturers and other service providers throughout the country who spoke with us about their businesses, best practices and greatest challenges (for a complete list see [Appendix XVI](#)).

Cover photos provided by Advanced Prototype Engineering, Flex San Francisco, PCH Lime Lab and SFMade.

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Executive Summary

San Francisco has a deep history of manufacturing, a wealth of hardware incubators, excellent regional training capacity, a strong regional supply chain and substantial engineering and design capabilities in the advanced industries, including manufacturing. These strengths provide a powerful platform for the city to strengthen its advanced manufacturing ecosystem. San Francisco should stake its claim on the advanced manufacturing space in order to support the City's goals of economic equity, an inclusive workforce and a diverse base for economic development generally.

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Urban manufacturing is flourishing nationally and manufacturing in the Bay Area is outpacing both the nation and California as a whole. San Francisco itself is a leader in the urban manufacturing movement with year over year growth since 2010. In 2015, there were over 600 manufacturers with production facilities located in the city. These manufacturers employ over 4000 people, 70% of whom come from low-income households.¹ Urban manufacturing has a unique ability to bring together diverse neighborhoods, socio-economic groups and disciplines by locating jobs and companies in the neighborhoods that need them most.

Manufacturing is an engine for equity, generating and sustaining jobs for a larger variety of skill levels and backgrounds than most industries. In San Francisco specifically, the manufacturing community reports that their production jobs can accommodate individuals with limited experience, as many skills are taught on the job. In addition, manufacturing has a high employment multiplier; each manufacturing job on average supports 2.5 jobs in all other industries.² The fastest growing manufacturing sector in San Francisco is advanced manufacturing, which doubled in size from 2014 to 2015.³ It is expected to continue this growth, joining the two other dominant sectors: apparel and food and beverage.

Advanced manufacturing is a broad term that can encompass every modernizing section of the manufacturing industry. Generally, it is defined as manufacturing that uses automation, sensing and other digital technologies to increase efficiency and precision. Advanced manufacturing is not a new sector or industry but rather a set of digital tools and conceptual frameworks that can be woven into any manufacturing process. There is not yet a global center for advanced manufacturing in high value industries, such as consumer electronics and medical devices, and because new skills are needed in these fields, training can make a significant impact on the employment base. Through training and judicious use of its design and engineering talent, San Francisco can cultivate a new workforce opportunity in this sector.

San Francisco is also home to the Maker Movement and can harness the movement's energy to brand manufacturing careers in a newly attractive way. Makers give cultural value to a traditionally overlooked set of skills, making craft "cool" again. By connecting the manufacturing professions to the Maker Movement, with its do-it-yourself (DIY) values and use of high-tech processes, youth can be inspired to pursue careers in engineering and production, including in advanced manufacturing.

In 2015, the City of San Francisco (the Mayor's Office of Civic Innovation and the Office of Economic and Workforce Development) and SFMade engaged in a one year public-private partnership to define the advanced manufacturing ecosystem in the city and to develop strategies to support it. A 24 person task force—the Advanced Manufacturing Action Team—made up of industry leaders and experts from the public sector, guided the project. The *Make to Manufacture Advanced Manufacturing Playbook: Strengthening the Advanced Manufacturing Sector in San Francisco* represents the culmination of this project and presents a set of concrete strategies and tools to expand and support the local advanced manufacturing ecosystem.

PART 1 ADVANCED MANUFACTURING LANDSCAPE REVIEW describes both the national and regional advanced manufacturing landscapes and details initiatives at both levels to strengthen and expand the sector.

PART 2 THE SAN FRANCISCO ADVANCED MANUFACTURING ECOSYSTEM investigates the advanced manufacturing sector in San Francisco, analyzing its strengths and weakness, identifying opportunities and mapping out the companies located in the city.

PART 3 RECOMMENDATIONS TO STRENGTHEN ADVANCED MANUFACTURING IN SAN FRANCISCO brings together the research from Parts 1 and 2 with the expert guidance of the Advanced Manufacturing Action Team to present implementable recommendations designed to support the advanced manufacturing sector in the city.

The strategies to encourage and expand the advanced manufacturing ecosystem in San Francisco have three primary focus areas.

- ▶ **Strengthen the regional advanced manufacturing sector and rebuild San Francisco’s connection to the ecosystem.** These recommendations support and expand the existing advanced manufacturing supply chain while allowing San Francisco to become a leader in the planning processes for future manufacturing policy.
- ▶ **Address San Francisco’s specific infrastructure weaknesses to grow the low-volume advanced manufacturing sector.** The weaknesses addressed are those inhibiting the growth of low-volume manufacturing in the city and include: supply chain, real estate and preconceptions about manufacturing in San Francisco.
- ▶ **Increase awareness of advanced manufacturing as a career and address the shortage of technical training for advanced manufacturing within the city.** These recommendations address the expansion of technical education for both youth and adults, as well as the promotion of manufacturing as a viable career choice.

The six core recommendations are:		
Strengthen the regional advanced manufacturing sector and rebuild San Francisco’s connection to the ecosystem	1 Regional Advanced Manufacturing Strategy	▶ Create a collaborative initiative across manufacturing cities within in the Bay Area to create a regional advanced manufacturing strategy.
Address San Francisco’s specific infrastructure weaknesses to grow the low-volume advanced manufacturing sector	2 Cultivate Contract Manufacturing	▶ Attract a comprehensive advanced manufacturing services provider to San Francisco.
	3 Small Business Assistance for Manufacturers	▶ Increase advanced manufacturer awareness of local permitting and financing options and make it easier for them to comply.
	4 Manufacturing Real Estate Matchmaking	▶ Create a matchmaking service for small manufacturing businesses that are interested in sharing space.
Increase awareness of advanced manufacturing as a career path and address the shortage of technical training in the city	5 Advanced Manufacturing Awareness	▶ Increase awareness of advanced manufacturing careers by expanding YouthMade.
	6 Manufacturing Specific Work Readiness Program	▶ Create a manufacturing oriented, contextualized soft-skills training program.

Overall, the core recommendations build on San Francisco’s history of manufacturing, abundant engineering and design capacity, existing regional training facilities and strong regional supply chain. These strategies will enable San Francisco to strengthen and participate more fully in the entire advanced manufacturing process from design to manufacture—increasing economic equity, creating a more inclusive workforce and building a more robust and diverse foundation for economic development.

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THE OPPORTUNITY OF ADVANCED MANUFACTURING

What is Advanced Manufacturing?

Advanced manufacturing is a broad term that can encompass every modernizing section of the manufacturing industry. For the purposes of this playbook, it is defined in line with the [President's Council of Advisors on Science and Technology \(PCAST\)](#) 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, for example nanotechnology, chemistry, and biology."⁴ This definition covers technologies ranging from machine tools with Computer Numeric Control (CNC) to robotic material handling to new composite materials (see [Appendix I](#) for a partial list of technologies).

Some of these technologies have been in use for decades and are well integrated into the existing manufacturing sector, while others are brand new. What ties all of the technologies in "Industry 4.0" together is their reliance on digital control, embedded sensing and the constant evolution enabled by information technology. Advanced manufacturing is not a new sector or industry but rather a set of digital tools and conceptual frameworks that can be woven into any manufacturing process.

Why Advanced Manufacturing?

Manufacturing is evolving rapidly as digital control, sensing and automation are worked into every process. Innovations currently called advanced manufacturing will soon be commonplace, as companies adopt these new and more efficient methods. Advanced manufacturing facilitates the larger trend within manufacturing towards customization, agility and responsiveness and may well help American manufacturing regain its strength and return manufacturing jobs to the country.

The United States has long been a global leader in manufacturing. From 1895 to 2009, the U.S. was the world's leading producer of manufactured goods, only surpassed by China in 2010.⁵ In 2014, manufacturing contributed \$2.1 trillion to the national GDP.⁶

In a historical context U.S. manufacturing was in decline for several decades, most recently the sector shed 6 million jobs from 1998 to 2010. This contraction cut across every aspect of manufacturing, from low-wage jobs in low-tech industries to high-tech products, including those resulting from U.S. innovation and inventions.⁷ A complex array of factors contributed to this downturn: the increased productivity of computerized manufacturing and the offshoring of labor costs, but also the larger economic slump from two major recessions in the 2000s.

Over the past five years the manufacturing sector has started to recover. Manufacturing's contribution to the GDP has increased steadily since its low of \$1.73 trillion in 2009 and has stabilized at just above 12%.⁸ Output has surpassed its previous peak in 2007, making a full recovery from the recession.⁹ The employment outlook for manufacturing has also improved, though it is not as rosy a picture. The sector has leveled out and is now a source of moderate employment growth.¹⁰ This is especially encouraging as manufacturing has a high employment multiplier; each manufacturing job on average supports 2.5 jobs in other industries.¹¹

There is also evidence that new trends in the industry are causing companies to reshore some of their manufacturing. This shift includes increased demand for small batch custom goods, on-demand production and short delivery lead times. All of which favor agile, adaptable facilities with the high productivity enabled by advanced manufacturing and a flexible staff located near the end consumer.

Advanced manufacturing is not a new sector or industry but rather a set of digital tools and conceptual frameworks that can be woven into any manufacturing process.

Additionally, there is now a greater appreciation for the hidden costs of offshoring, including decreased productivity, increased communication error, long and expensive supply chains and the cost, time and risk of shipping. Combined with the convergence of wages between the U.S. and China the calculus has changed.¹² While unlikely to return jobs lost in the low-tech industries, modern advanced manufacturing may still have a significant effect on complex, high technology goods (for details on which industries are reshoring see [Appendix II](#)).

As manufacturing begins to incorporate these more efficient methods—starting with high-value sectors such as consumer electronics, petroleum refining and medical devices—a significant employment opportunity will open up. The shift toward automation means that the quality of labor is more important than the price of labor. Advanced manufacturing relies on a highly skilled workforce at all levels, from engineering to production.

By looking at employment numbers, the pivot towards advanced manufacturing in the United States is apparent. Between 2010 and 2013 “... advanced manufacturing industries outperformed other manufacturing industries on both annual employment growth (1.8 versus 1.0% per year) and output growth (1.8 versus 0.4% per year), hinting at something potentially more durable than the standard bounce-back following a recession.”^{13, 14}

Advanced manufacturing creates a new workforce opportunity for San Francisco. There is not yet a global center for advanced manufacturing in high value industries, and because new skills are needed in these fields, training can make a significant impact on the employment base. **Through training and judicious use of its design and engineering talent, San Francisco can stake a claim for leadership in advanced manufacturing.** However, the window is closing as many nations and U.S. cities look to lead in these same industries.

Why Makers?

Make to Manufacture is a new workforce paradigm because the Maker Movement gives cultural value to a traditionally overlooked set of skills. The movement encourages personal growth by educating oneself in the “trades.” At the same time, it helps manufacturing advance because of the excitement it creates around advanced technologies.

Starting with the introduction of *Make Magazine* in 2005, a loose group of technology enthusiasts coalesced into the Maker Movement. “Broadly, a maker is someone who derives identity and meaning from the act of creation. What distinguishes contemporary makers from the inventors and do-it-yourselfers (DIY-ers) of other eras is the incredible power afforded them by modern technologies and a globalized economy, both to connect and learn and as a means of production and distribution.”¹⁵ Making is a DIY, tinkering ethos with a particular focus on electronics, engineering and experimenting with new technologies. Makers have been empowered by the advent of inexpensive CNC tools and 3D printers to build their designs, greatly expanding their abilities and training them in modern manufacturing techniques.

With the steep decline in manufacturing workforce from 1998 to 2010, manufacturing itself began to look less attractive as a profession. The image of manufacturing continues to be one of old fashioned assembly lines, rather than of modern computer controlled equipment and electronics clean rooms. **By connecting the manufacturing professions to the Maker Movement with its DIY values and use of high-tech processes, youth can be inspired to pursue careers in engineering and production, including advanced manufacturing.**

The San Francisco Bay Area is the worldwide center for the Maker Movement. [TechShop](#), the maker “gym,” was founded in the South Bay and there are three in the Bay Area, more than in any other region. Maker Media, the publisher of *Make*, is headquartered in San Francisco, as is [Instructables](#), the premier DIY website. San Francisco can use its unique maker access to help promote engineering and manufacturing careers and to help its existing maker community turn professional.

NATIONAL AND STATE LANDSCAPE

The Federal Landscape

At the federal level there is a strong commitment to capitalize on the growth of the manufacturing sector and to regain the United States' prior leadership position. As explained in the first report from the Advanced Manufacturing Partnership Steering Committee (AMP) in 2011, "there are three compelling reasons why we should strive to revitalize our leadership in manufacturing:

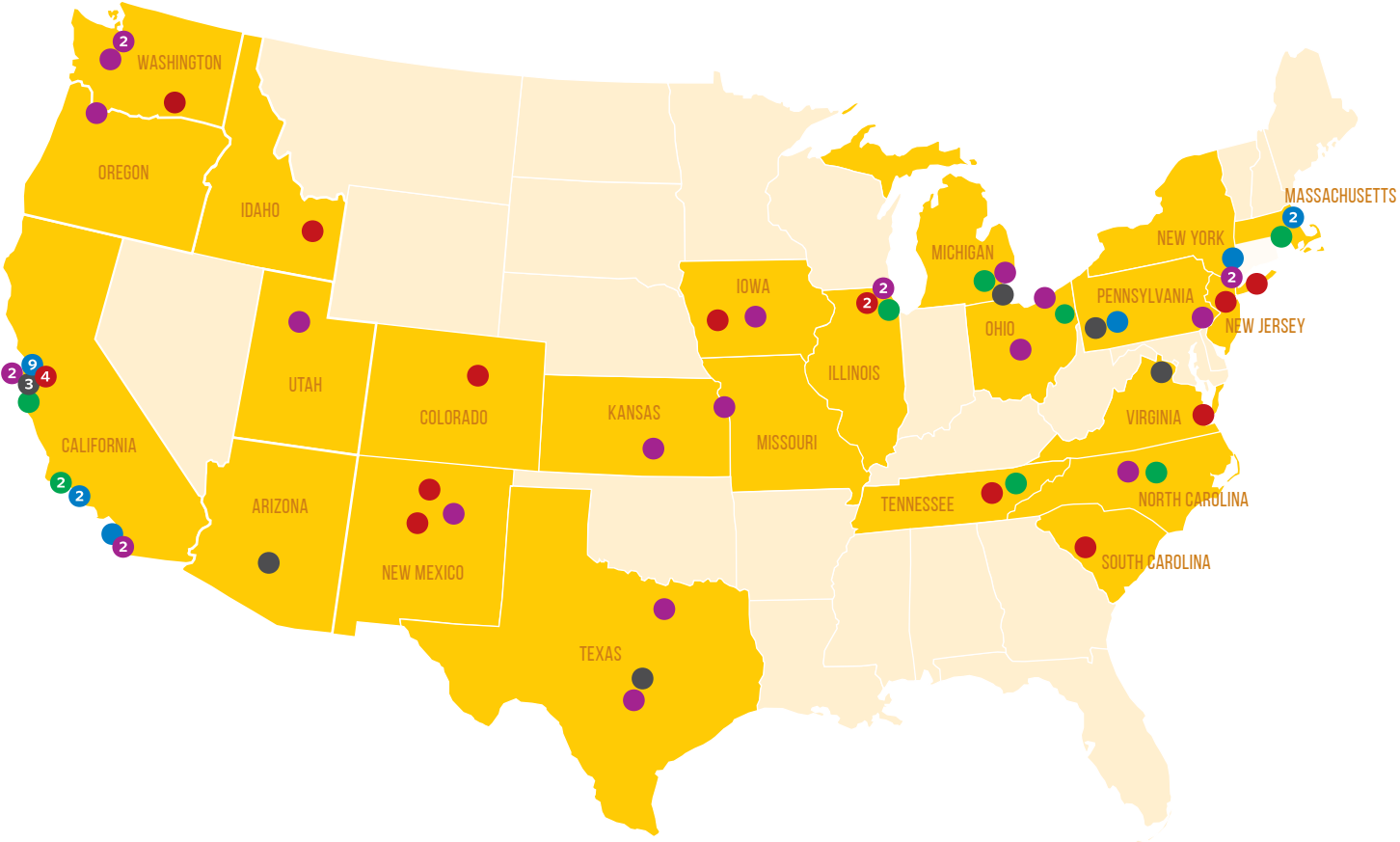
- 1) Manufacturing, based on new technologies including high-precision tools and advanced materials, provides the opportunity for high-quality, good-paying jobs for American workers;
- 2) A strong manufacturing sector that adapts to and develops new technologies is vital to ensure ongoing U.S. leadership in innovation, because of the synergies created by locating production processes and design processes near to each other; and
- 3) Domestic manufacturing capabilities using advanced technologies and techniques are vital to national security."¹⁶

As the federal focus on manufacturing has intensified over the past five years, particularly at the National Institute of Standards and Technology (NIST) and at the National Science and Technology Council (NSTC) in the Office of the President, a national strategy has developed. The National Advanced Manufacturing Strategic Plan, released in 2012, lays out the basic framework of a policy that "...would address the full lifecycle of technology in order to 1. provide a fertile innovation environment for advanced manufacturing, 2. enable vigorous domestic development of transformative manufacturing technologies, 3. promote coordinated public and private investment in precompetitive advanced manufacturing technology infrastructure, and 4. facilitate rapid scale-up and market penetration of advanced manufacturing technologies."¹⁷

A constellation of policies and programs aimed at revitalizing the manufacturing sector are being developed (see Appendix III).¹⁸ AMP, a group of manufacturing experts convened in 2011 and 2013 by PCAST, shaped the overall effort.¹⁹ The centerpiece of their strategy is Manufacturing USA. Manufacturing USA is an interagency program meant to catalyze research and workforce training in high value manufacturing technologies and the products enabled by those technologies.²⁰ The program also aims to help technologies bridge the so-called "valley of death," the funding gap between R&D and commercialization. Individual institutes focus on specific manufacturing processes or products, such as additive manufacturing, high-tech textiles or lightweight metals manufacture.²¹ By incentivizing the creation of dense regional supply chains around each institute, more of the manufacturing itself should remain local (for a list of institutes see Appendix IV).

To complement the increased focus on technology advancement, the Federal Government is working to rehabilitate the image of manufacturing through the Nation of Makers Initiative. The Nation of Makers Initiative supports efforts in both the public and private sectors to teach making, increase access to makerspaces and display work at local and national Maker Faires. The initiative piggybacks off of the popularity and excitement surrounding the Maker Movement to demonstrate the value and desirability of the manufacturing and engineering fields.

NATIONAL MANUFACTURING LANDSCAPE



- Department of Energy National Labs
- Accelerators
- Hacker/Makerspaces/Coworking
- TechShop
- Manufacturing USA: National Network of Manufacturing Institutes

The California Landscape

The most populous state in the nation at an estimated 38,802,500 residents in 2014, California also has the largest number of manufacturing jobs, 1,254,300.^{22,23} Unsurprisingly, California is also the largest state contributor to the total U.S. manufacturing GDP at 11.4%, valued at \$239 billion in 2013.^{24,25} While manufacturing is an important economic base for the state, California lost 842,180 manufacturing jobs between 1990 and 2012, mirroring the national decline.²⁶ However, in the past five years the sector has started to turn around, though at a slower rate than in the United States as a whole.²⁷ “Between 2010 and 2014, total manufacturing employment expanded by 3.1% in the state. (Total state employment grew by 9.2%.) Employment gains were seen in 14 of 18 manufacturing sectors.”²⁸

CALIFORNIA MANUFACTURING	
Total Output (\$ billions, 2013):	\$239.01
% of State GDP (2013):	10.85%
Number of Firms (2012):	36,331
Manufacturing Jobs (2014):	1,254,300
Man. Goods Exports (\$ billions, 2014):	\$149.79
% of Total Goods Exports (2014):	86.02%
Man. Goods Export Growth (2009-14):	42.73%
Source: National Association of Manufacturers. <i>California Manufacturing Facts</i> . 2015.	

Manufacturing in California runs the gamut from traditional labor-intensive steel forging to modern, high-tech aerospace engineering. Almost two-thirds of the manufacturing in California takes place in Southern California with its emphasis on aerospace, apparel, and food and beverage manufacturing. The Los Angeles metro area alone accounts for 524,000 manufacturing jobs and has the highest manufacturing employment of any region in the country.²⁹ However, the largest individual industry in terms of employment is semiconductor and electronic components manufacturing, which is concentrated in the Bay Area. With almost 90,000 jobs across California, the industry accounted for more than 7% of all manufacturing jobs in the state in 2012.³⁰ In Northern California, manufacturing centers on computers, communications equipment, pharmaceuticals and petroleum. More than 55% of all manufacturing employment in the region is in high or medium-high technology industries.³¹

State Efforts

Due to its strength in applicable high-technology industries and renowned research and development ecosystem, California could build a global leadership position in advanced manufacturing. The state capitalizes on these rich resources of knowledge and training to lead the world in other highly technical fields such as software development, robotics and biomedical engineering, and is starting to do the same in manufacturing.

In 2012, the California State Legislature identified manufacturing, and advanced manufacturing specifically, as an important driver of the state’s innovation economy.³² At the same time, advanced manufacturing was added as one of ten priority industry sectors in the California Community College Chancellor’s Office’s *Doing What Matters for Jobs & the Economy Report*, making the sector eligible for state grant funding. While this designation has not led to a targeted manufacturing strategy like the *National Advanced Manufacturing Strategic Plan*, it has led to an increase in grant funding and broad initiatives such as the Advanced Manufacturing Workforce Development Council (see [Appendix V](#) for a more complete list). In addition, several organizations, the most prominent of which is the *California Network for Manufacturing Innovation* (CNMI), are working to craft a state strategy to take advantage of California’s strengths and promote advanced manufacturing.³³

THE BAY AREA

The Regional Landscape

The San Francisco Bay Area, with its wealth of research facilities, educational institutions and history of intellectual cross-pollination, has long been a leader in innovation in many fields.³⁴ In manufacturing specifically, the Bay Area region (which encompasses nine counties: Alameda, Contra Costa, Marin, Napa, San Francisco, San Mateo, Santa Clara, Solano and Sonoma) leads the rapidly evolving computer and

electronics manufacturing sector. The Bay Area stands out front due to its high density of technology and software development companies, access to capital and highly skilled engineering workforce. The Bay Area's 293,847 manufacturing jobs accounted for 8.4% of the Bay Area's total employment and 23.6% of California's manufacturing employment in 2014.³⁵

The Bay Area's manufacturing sector is enhanced by the region's history as a center for goods movement. As the third most important trade gateway on the West Coast, it houses four seaports including the Port of Oakland (the fifth largest in the U.S.), three international airports, two Class I rail main lines and six major truck routes.³⁶

Though California was hard hit by the manufacturing contraction of the past 15 years, the sector is in recovery, particularly in the Bay Area. While manufacturing employment is two-thirds what it was in 2000—a 25-year peak during the Dotcom Bubble—the decline has reversed since 2010, both for the region as a whole and for all nine of its counties.^{37, 38} More generally, "...with a 9.8% increase in employment and 10.7% increase in gross regional product between 2010 and 2013, **the Bay Area has outpaced both California and the U.S. in job recovery and expanding output.**"^{39, 40}

The region is often used as an example of clustering in the "advanced industries" including advanced manufacturing.⁴¹ Of the ten largest manufacturers in the U.S., seven (all of whom are in the advanced industries) have a significant presence in the Bay Area. This presence varies, be it corporate headquarters (Apple, Hewlett-Packard), manufacturing facilities (Chevron, Phillips 66) or innovation/research centers (Ford, General Electric).⁴² San Jose leads the nation in the advanced industries with 30% workforce participation, balanced between manufacturing and computer services. San Francisco comes fifth with 14% participation, primarily in design, research and computer services.⁴³

However, there is still room for growth. The role of manufacturing in major cities generally is expected to grow as manufacturing moves closer to population centers due to new trends, including the Maker Movement, on-demand production and increased productivity due to advanced technologies.

In addition, several of the largest manufactures in the world are based in the Bay Area, including Apple and HP, but they outsource the bulk of their manufacturing. As the benefits received from offshoring labor costs start to be outweighed by opportunities, (discussed in "Why Advanced Manufacturing?" on page 6) some of these manufacturing jobs will be returned to the U.S. The Bay Area is especially well placed for this potential return as the design and engineering workforce is already in place.

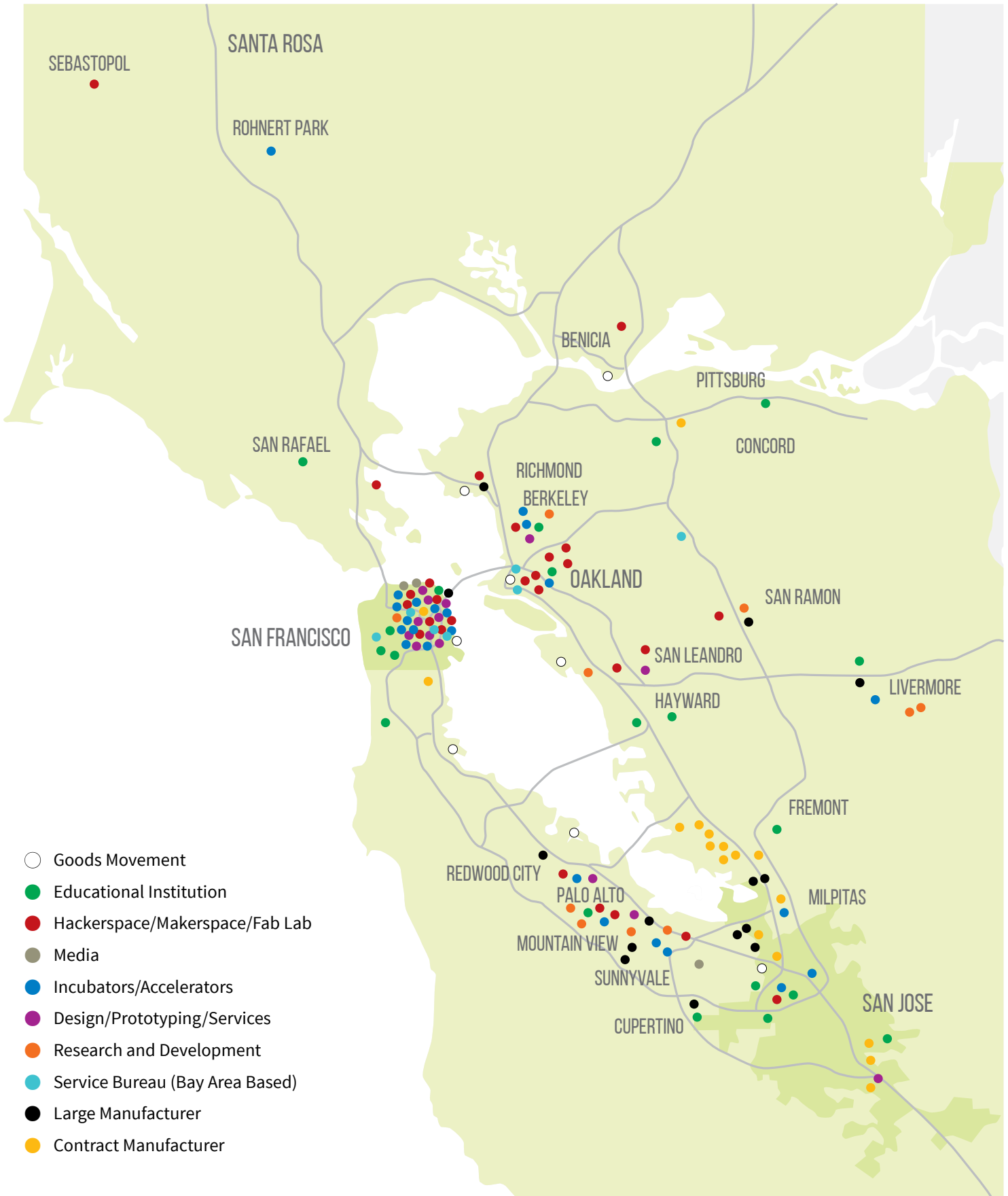
San Francisco Bay Area Industries

Most of the manufacturing industries in the Bay Area are classified as high to medium-high technology, including computer and electronics manufacturing, some types of metal fabrication and petroleum refining.⁴⁴ Manufacturing jobs in the Bay Area are concentrated in the computer and electronic products manufacturing sector, which constituted 47.4% of the Bay Area's manufacturing employment with 139,271 jobs in 2014.⁴⁵ However, advanced manufacturing is not spread evenly throughout the Bay Area as different subregions have different manufacturing specialties. For instance, of the top ten global Electronic Manufacturing Service (EMS) providers, nine have manufacturing facilities in the Bay Area, all of which are located in southern Alameda and Santa Clara counties.⁴⁶

Much of the new large-scale, high-tech manufacturing and distribution space is being built outside the older industrial hubs of northern Alameda County and San Francisco, in greenfield sites farther east.⁴⁷ On the other hand, smaller manufacturing and prototyping firms are spread throughout the East and South Bay. These locations offer the advantages of proximity to research institutions and to the design and engineering firms that cluster in the metropolitan centers of San Jose, San Francisco and Oakland.

To help retain industrial jobs near city centers, the Association of Bay Area Governments (ABAG) is evaluating the creation of Priority Production Areas to complement the existing Priority Development Areas and Priority Conservation Areas. Draft guidelines are expected before the end of 2016.^{48, 49}

BAY AREA MANUFACTURING LANDSCAPE



East Bay (Alameda and Contra Costa Counties)

The inner East Bay (along the shore of the bay) made early investments in goods movement infrastructure such as the railroad system and the Port of Oakland. Northern Alameda County was the core industrial area in the mid-20th century, so it is where most of the legacy industrial building stock is located. As highway construction increased, the outer East Bay (inland) opened up to industrial uses.⁵⁰ Since the 1960s, new manufacturing space has primarily been built in southern Alameda County and the Tri-Valley area. This area offers land and proximity to both major research centers and Silicon Valley. The growing advanced manufacturing sectors are predominantly located in these areas, which have a high share of employment in semiconductor, biomedical and industrial machinery manufacturing activities.⁵¹ The major manufacturing subsector in Contra Costa County is petroleum refining, which has become highly automated.⁵²

Overall, the concentration of manufacturing jobs in the East Bay has increased relative to the U.S., California and the rest of the Bay Area since 1995, particularly the specialized and advanced manufacturing activities that support the high-tech sectors.⁵³ Half of all East Bay manufacturing employment is in the advanced industries. The strong growth in advanced manufacturing in the region is closely linked to the area's research and development prowess.⁵⁴

The East Bay is making the most concerted effort of any Bay Area subregion to capture the advanced manufacturing sector. These efforts include the East Bay Advanced Manufacturing Partnership; Design it, Build it, Ship it; the establishment of the Gate (an advanced manufacturing hub in San Leandro), the Warm Springs Innovation District in Fremont and updated zoning plans to take advantage of existing industrial neighborhoods in Oakland and Berkeley (for regional efforts see Appendices V and VI).

South Bay (San Mateo and Santa Clara Counties)

The San Jose, Sunnyvale, Santa Clara Metro Region dominates manufacturing in the South Bay. The region is one of the national centers for high technology manufacturing with deep expertise in semiconductor, computer and electronics manufacturing. Santa Clara County has the second most manufacturing specialized employment sector of the 100 largest metropolitan areas in the U.S. In 2012, 17.5% of all jobs were in manufacturing.⁵⁵

The San Jose, Sunnyvale, Santa Clara Metro Region is the top ranked location in the country for very high-tech manufacturing, with 74.6% of the manufacturing done in the region qualifying. The computer and electronics industry claims 68.2% of all the manufacturing employment in the region. Fabricated metals and aerospace come in a distant second and third with about 5% of the manufacturing job market each.⁵⁶ The South Bay also has the largest contract manufacturing ecosystem in the Bay Area, feeding the electronics product market and the hardware startup community.^{57,58} Of the 100 largest metropolitan areas in the U.S., the region also has the highest average annual earnings in the manufacturing sector at \$144,899 in 2010.⁵⁹

The City of San Jose is jobs-poor in relation to other area cities with only 87 jobs per 100 employed residents. However, San Jose is conscious of its place as a leader in high technology manufacturing and is looking at ways to increase the density of industrial property, particularly for advanced manufacturing and Internet of Things (IoT).⁶⁰

North Bay (Marin, Napa, Solano and Sonoma Counties)

The primary manufacturing industry in the North Bay is food and beverage processing related to the wine, beer and cider industries. The lion's share of the advanced manufacturing in the region is located in Santa Rosa and Petaluma, both in Sonoma County.⁶¹ These two cities have strong technology sectors and manufacture medical equipment, computers and other electronic products.

San Francisco (San Francisco County)

San Francisco is the only consolidated city and county in California. As such it is both the smallest region in the Bay Area with a population of 852,469 and the second largest city, behind San Jose.⁶² “In 2015 there were approximately 11,000 manufacturing industry jobs in San Francisco County. The city’s manufacturing businesses are small: those 11,000 jobs are spread across over 700 establishments, with an average of just 15 jobs per establishment.”⁶³ Not all of these companies have production facilities in San Francisco. SFMade counted 605 of these 700 manufacturers as members in 2015, meaning their products undergo an “essential transformation” in San Francisco. In 2015, employment at these manufacturers increased 12% from the previous year and manufacturing as a whole “drove \$614M in direct sales into the regional economy.”^{64, 65}

San Francisco excels at consumer oriented, low-volume, boutique manufacturing. Consumer brands can take advantage of the benefits provided by having flexible low-volume production near their end customer. This includes product beta testing, customized products, short production runs, limited editions, New Product Introduction (NPI) and an urban brand. The three dominant manufacturing sectors in the city are computer and electronic products (2,600 jobs), food and beverage (2,300 jobs) and apparel (1,300 jobs), however only food and beverage and apparel have significant numbers of production positions.⁶⁶

In the advanced manufacturing sector the number of companies who actually manufacture in San Francisco is small but growing. Of the more than 600 SFMade members, over 50 qualify as advanced manufacturers and in 2015 the “advanced manufacturing sector was the fastest growing of all sectors, more than doubling the number of jobs...”⁶⁷ These businesses range from jewelers using 3D printers to make innovative designs to furniture makers who use CNC machines to increase efficiency to contract manufacturers with waterjet cutters.

For a more detailed description of the San Francisco advanced manufacturing landscape see Part 2 of this report.

The San Francisco Advanced Manufacturing Ecosystem

ADVANCED MANUFACTURING IN SAN FRANCISCO

In San Francisco, the advanced manufacturing industries collectively employed 3,479 people in 2015, a 72% increase from 2010. About two-thirds of that increase in employment came from the computer and peripheral equipment manufacturing sector alone. Continued growth is expected in these industries leading to an estimated 4,537 jobs in 2020.⁶⁸ While these numbers include companies that only have design and administrative offices in San Francisco, SFMade has also found an increase in employment at companies with production facilities in the city. **According to SFMade’s 2015 State of Local Manufacturing report, the number of advanced manufacturing jobs at companies with manufacturing facilities in San Francisco doubled from 2014 to 2015 alone.** While 30% of these jobs were in production or distribution, 38% were in design and engineering positions, demonstrating that these companies are attracted to San Francisco for many of the same reasons as technology and software companies.⁶⁹ (See [Appendix XII](#) for a breakdown of employment numbers by sector.)

- EXAMPLE ADVANCED MANUFACTURERS:**
- ▶ **Blackbird Guitars** Travel Guitars
 - ▶ **Bird of Virtue** Wood Jewelry
 - ▶ **Nomiku** Connected Kitchen Appliances
 - ▶ **OHIO Design** Furniture
 - ▶ **Standard Metal Products** Machine Shop

Over the past five years electronics manufacturing has become even more concentrated in San Francisco. While many of these companies only locate engineering, design and business services in San Francisco, the industry’s Location Quotient (LQ) shows the overall strength of the local electronics manufacturing sector. LQ indicates the density of a sector in a certain area and both communications equipment manufacturing and computer and peripheral equipment manufacturing have shown large increases in LQ over the past five years and are expected to grow those gains. Other manufacturing sectors with comparatively high location quotients include cut and sew apparel manufacturing and other leather and allied product manufacturing.

NAICS	Description	2010 LQ	2015 LQ	2020 LQ
3341	Computer and Peripheral Equipment Manufacturing	0.48	1.77	2.47
3342	Communications Equipment Manufacturing	0.94	1.78	3.45
3152	Cut and Sew Apparel Manufacturing	1.99	1.99	0.79
3169	Other Leather and Allied Product Manufacturing	1.79	1.53	1.36

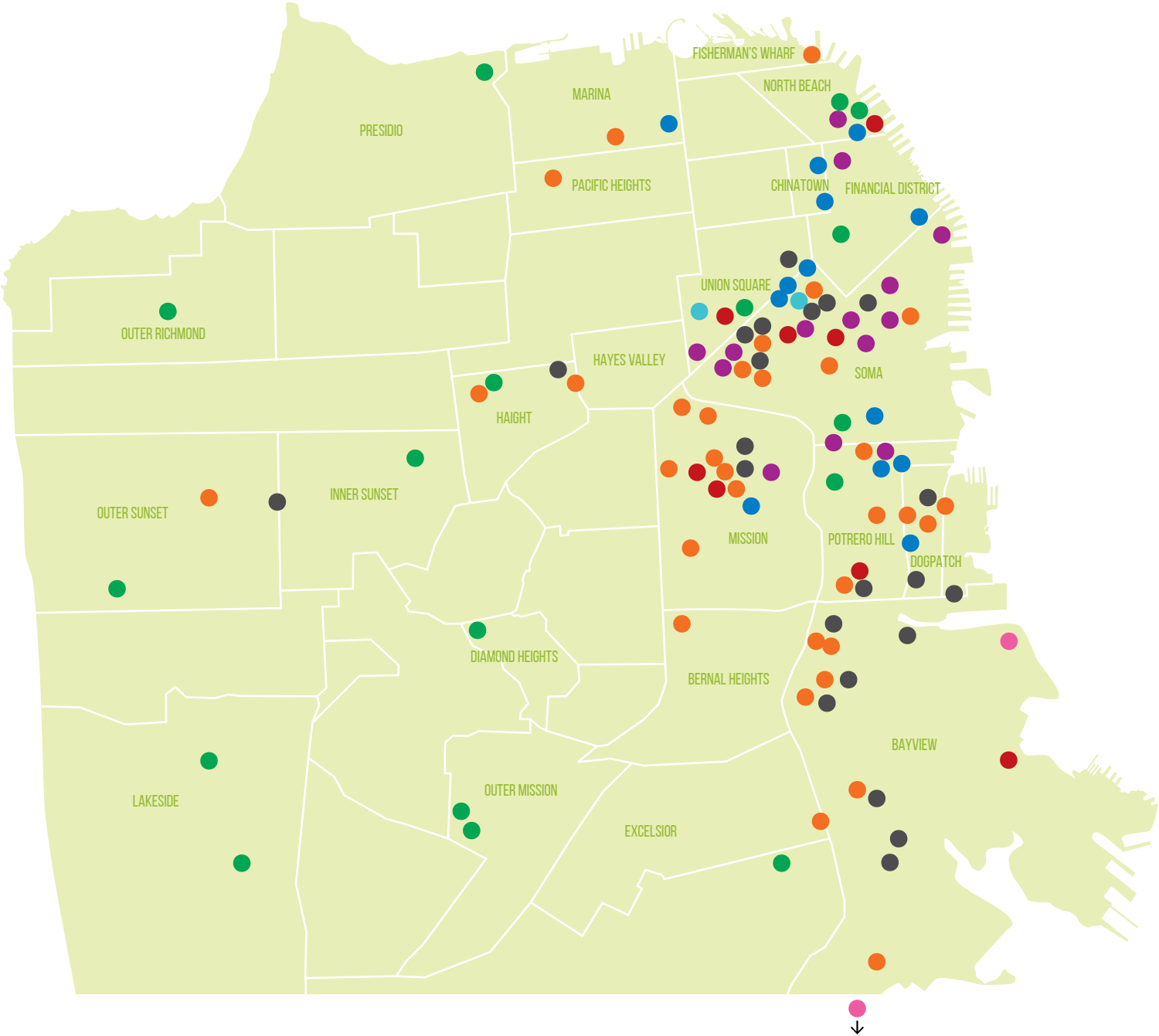
TABLE 1. The average density of a certain sector is noted as a Location Quotient (LQ) of 1. Computer and peripheral equipment manufacturing is expected to have over twice the average density of companies by 2020.⁷⁰

The Manufacturers

In the advanced manufacturing sector, a small but growing number of companies manufacture in San Francisco. Of the more than 600 SFMade members, 53 qualify as advanced manufacturers. In their 2015 *State of Local Manufacturing* (SOLM) report, SFMade found that this was the fastest growing sector in the city. These businesses range from jewelers using 3D printers to machinists using CNC machines to businesses building CubeSats (miniature satellites).

Of SFMade’s 53 advanced manufacturers, 60% completed the 2015 SOLM survey, providing a remarkably accurate picture of the companies working in San Francisco. Of the 32 companies who completed the survey, 23 have fewer than five full-time employees, though half of these bring in contract employees as needed. Three companies have five to ten full-time employees, five have 10-50 full-time employees and only one has over 100 full-time employees. There are two other “large” advanced manufacturing businesses

SAN FRANCISCO MANUFACTURING LANDSCAPE



- In-House Manufacturing
- Hacker/Makerspaces
- Contract Manufacturers
- Goods Movement
- Incubators/Accelerators/R&D
- Service Providers
- Design/Engineering Firms
- Educational Institutions

**Total San Francisco
Advanced Manufacturers: 64+**

Total In-house Manufacturing: 42

Total Contract Manufacturers: 22

**Total SFMade
Advanced Manufacturers: 53**

Total In-house Manufacturing: 35

Total Contract Manufacturers: 18

Total SFMade Companies: 600+

Total SFMade Jobs: 4,400+

**Total SFMade Advanced
Manufacturing Jobs: 400+**

in San Francisco who either did not participate in the SOLM or are not SFMade members. Every advanced manufacturer in San Francisco (excepting Flextronics, see below) qualifies as an SME (small and medium-sized enterprise) and many are owner-operated.

Overall, there are four types of advanced manufacturers who do their production in San Francisco.⁷¹

CONTRACT MANUFACTURERS (Job Shops): Contract manufacturers are third-party companies that manufacture parts to customer specifications. San Francisco contract manufacturers tend to specialize in one type of production—machining, routing, laser cutting, 3D printing, injection molding, etc.—though they often have the ability to diversify. Almost all of the contract manufacturers in San Francisco (outside of apparel) use at least one advanced manufacturing technology for two reasons:

- 1) Advanced manufacturing technologies like CNC machining and 3D printing are high skill and therefore higher value.
- 2) Advanced manufacturing equipment such as waterjets or laser cutters are capital intensive and generally out of reach for San Francisco's small product manufacturers.

Contract manufacturing is often how product manufacturers add advanced manufacturing to their capabilities.

These small manufacturing facilities have up to ten full-time employees (with the exception of Flex Invention Lab, an outpost of a large tier 1 contract manufacturer, Flextronics⁷²). None have taken venture capital and all have variable revenue depending on the size of projects they bring in and the health of the local industry.

CONSUMER PRODUCT MANUFACTURERS: Most San Francisco companies that have added advanced capabilities to more traditional methods have done so to increase efficiency. This means that like the rest of manufacturing in San Francisco, advanced manufacturing primarily consists of consumer goods. These companies vary widely and most do not self identify as advanced manufacturers.

There are two types of advanced consumer product manufacturers in San Francisco: early stage or “start” businesses and growth-stage businesses.

START: Often only a single person but can have up to five full-time employees. Most produce one or two products and their primary production is in-house (or at shared workshops such as TechShop). All have under \$750,000 in revenue and over two-thirds have less than \$250,000 in revenue. Of SFMade's 53 advanced manufacturers, 19 fall into this category.

GROW: As product companies grow they often add advanced manufacturing techniques alongside more traditional manufacturing processes. These companies are slightly larger than those in the start category and have between 5-30 employees. All have between \$2-7M in revenue.

HARDWARE PRODUCT MANUFACTURERS: While also consumer product companies, hardware product manufacturers are distinguished by the fact that their products require advanced technologies for their production. These companies produce consumer electronics and all have taken venture capital (VC).⁷³ The manufacturers vary in size but all have between 5-20 employees. Each of these companies has taken less than \$8M in VC funding, is in the early stages of development and plans to take more VC in the future. Venture capital is important because it means these companies have far more working capital than the consumer product manufacturers and also have to show growth within a specific time frame.

Hardware companies that have taken more significant funding—like the smart lock company, August, which has taken \$48M in three rounds—do not manufacture in San Francisco.⁷⁴ The companies in the hardware product manufacturers category are all at risk for leaving San Francisco as they grow because they cannot access the scaled manufacturing they will need as their market increases. As industrial real estate of the correct size and with proximity to transit can be difficult to find, even companies with in-house manufacturing are at risk.

HARDWARE AS A SERVICE: Hardware as a service companies sell a service that uses proprietary hardware rather than selling the hardware itself. There are three companies in San Francisco that focus on hardware as a service and do their manufacturing locally. Plethora and Tempo Automation both want to create a new type of job shop, one that feels virtual rather than physical. The entire interface

is on the web and production is as automated as possible (much of their intellectual property is in the automation). Planet Labs builds CubeSats, which they use to take photographs of Earth. It is these photographs that they sell, not the hardware.

All three of these companies have raised or plan to raise between \$50-200M in 2016/17 (the two smaller companies have raised \$15.6M and \$9.26M respectively). All three of these companies sell a service rather than a product and therefore their sales are not constrained by their manufacturing.

As a center for hardware businesses, San Francisco has an opportunity to greatly expand its advanced manufacturing sector by creating a local pathway to volume production, demystifying the local manufacturing supply chain and expanding that supply chain.

Company	Last Round	Year	Total Raise ▼	Type
Oru Kayak	Angel	2014	\$500k	Consumer Product
BistroBot	Seed	2015	\$170k	Consumer Product
Open ROV*	Seed	2013	\$1.3M	Consumer Product
Nomiku	Seed	2015	\$1.47M	Consumer Product
LIM Innovations	Angel	2015	\$3.05M	Consumer Product
Crave	Undisclosed	2015	\$5.22M	Consumer Product
Alta Motors*	Series A	2014	\$6.3M	Consumer Product
Other Machine Co.*	Series A	2015	\$7.15M	Consumer Product
Tempo Automation	Series A	2016	\$9.26M	Service
Plethora	Series A	2015	\$15.6M	Service
Planet Labs	Series C	2015	\$196.1M	Service
ODG	Undisclosed	n/a	Undisclosed	Military/Consumer Product

*Moved some or all operations out of the city in 2016.

TABLE 2. Venture capital raises for advanced manufacturers with production facilities located in San Francisco, based on publicly available data (see Appendix XI for a list of hardware companies with headquarters in San Francisco but no manufacturing facilities).⁷⁵

San Francisco has become a hub for hardware companies of all types. Many of these companies use contract manufacturing outside of San Francisco (either local or foreign) because they are:

- 1) producing at volumes that require specialized contract manufacturing or,
- 2) manufacturing a simple product whose primary requirements are a sensor and an injection molded housing (two weak points in the San Francisco manufacturing supply chain).

As a center for hardware businesses, San Francisco has an opportunity to greatly expand its advanced manufacturing sector by creating a local pathway to volume production, demystifying the local manufacturing supply chain and expanding that supply chain.

Support Services

An array of business support services and service providers surrounds advanced manufacturers in San Francisco. This ecosystem is robust because these services are used by companies manufacturing all over the world but headquartered in the Bay Area. These services fall into several categories:

LOCAL BUSINESS SERVICES: These businesses, primarily non-profits, assist small businesses and entrepreneurs with everything from business planning classes to sourcing assistance and financial planning as the businesses grow. Providers include the [Office of Economic and Workforce Development](#), the [Renaissance Entrepreneurship Center](#), the [San Francisco Small Business Development Center](#) and [SFMade](#).

INCUBATION SERVICES: These businesses, all for profits, help hardware and product companies build their early prototypes and may also provide business services such as marketing assistance, New Product Introduction (NPI) planning, investor introductions and capital investment. Providers include [Highway1](#), [Lemnos Labs](#), [RockIT Co-Labs](#) and [TechShop](#).

DESIGN AND ENGINEERING SERVICES: These businesses provide design and engineering services, some also build prototypes and do low-volume production. Few assist companies in finding scale production. Providers include [Advanced Prototype Engineering](#), [Astro Studios](#), [IDEO](#), [PCH Lime Lab](#), [Matter](#) and [Radicand](#).

OPERATIONS ASSISTANCE: These businesses help companies, primarily in hardware and electronics, find manufacturing partners. Almost all specialize in overseas production. Providers include [Ops on Tap](#) and [Blue Clover Devices](#).

VIRTUAL MANUFACTURING PORTALS: These businesses help companies find manufacturing partners through online portals. Some focus on a specific types of manufacturing such as 3D printing, others are intended to locate many types of manufacturers. Providers based in the Bay Area include [Britehub](#) and [Fictiv](#); others include [Makers Row](#), [MFG.com](#), [SyncFab](#) and [Thomasnet](#).

SAN FRANCISCO STRENGTHS

San Francisco is internationally known as a place to start technology companies, both in hardware and in software. This reputation has led to the creation of a strong entrepreneurial ecosystem encompassing everything from advising services to incubators to design consultancies to venture capital.

San Francisco has many strengths in the realms of hardware design, development and manufacture specifically. These include an abundant and highly trained engineering and design workforce combined with an ecosystem of informal training and tinkering spaces supported by the maker community. In addition, hardware companies can gain access to a dense regional supply chain for manufacturing prototypes and moving into low/medium volume production. Access to engineering staff and an easy onramp from prototype to production makes San Francisco attractive to a variety of hardware companies, from those manufacturing 100% in-house to those manufacturing 100% overseas.

Entrepreneurial Ecosystem

San Francisco has a strong entrepreneurial ecosystem due to the area's long history of company creation and growth. While much of the entrepreneurial ecosystem is informal and therefore difficult to classify, a few definable indicators of strength can be identified. These include the prevalence of meetups in the region, the number and size of incubators and the amount of venture capital available. San Francisco leads the nation in all three areas.

One indicator of a vibrant ecosystem is the number of meetups in a given sector. Meetups are used as a way to network and gain advice from like-minded people in a variety of fields. San Francisco boasts the most hardware meetups per capita with 29 that have over 100 members or 3.46 per 100,000 residents,

while Boston has 12 or 2.01 per 100,000 residents and New York has 21 or 0.26 per 100,000 residents.⁷⁶ (For a list of San Francisco based meetups see [Appendix VII](#)).⁷⁷

The second indicator is the number of incubator and accelerator programs in the city. San Francisco has more hardware incubators than any other city in the world (for a list of hardware focused incubators see [Appendix VII](#)). Incubators are a new category of entrepreneurial support that has developed over the past decade. In exchange for equity, these programs assist companies in a variety of ways, from seed funding to business planning to marketing assistance to investor introductions. In the hardware sector, incubators often use manufacturing expertise as one of their primary selling points. By tracking the number of incubators and the services they offer, the strength of the entrepreneurial sector in general and of hardware in particular can be seen.

Over the spring of 2016 SFMade undertook a survey and interviews of the five primary hardware incubators in San Francisco (for a list of those included see [Appendix VII](#)). Two companies that self-identify as micro-VCs were also included as they both provide formal incubator like services. Of the seven, three focus exclusively on hardware, one works in the intersection between hardware and software and three work with both hardware and software companies. Of those doing both, the percentage of hardware companies varies widely from 10%-70% depending on the incubator.

Incubators have two primary functions. They are both a source of seed funding and a business services provider. In terms of funding, the incubators give each company selected between \$20,000-\$250,000. Several of the incubators give standard amounts of money in exchange for standard amounts of equity. Highway1 for instance, advertises that they give at two levels, \$50,000 for 5% or \$100,000 for 8% of their companies.⁷⁸ While most incubators take an equity stake, it is not mandatory and at least one only gives convertible notes. The two micro-VCs: [Bolt](#) and Lemnos Labs, invest larger amounts of money but still under \$1M.

One of the differences between an incubator and a traditional business services provider is that incubators are organized into onsite classes who work alongside one another. Of those surveyed, 80% have two classes per year with an average of 10 companies per class and length of 3-6 months. The maximum number of companies per class is 30 and the most intensive program is over a year long.

Incubators generally provide three types of services: business development services, engineering/manufacturing assistance and investor introductions or a formal demo day. When asked to self report their three primary services, half reported that assistance finding capital and investment was their most valuable service while the other half listed it in either second or third place. Incubators are both a gatekeeper and a pipeline to venture capital. Accessing investors without being part of the culture and gaining introductions from reputable sources is notoriously difficult, so the focus on introductions and funding is not a surprise.

Other primary services listed included: user validation, key hire assistance, business strategy, aligning financing strategy with product development, design for manufacturability and formalizing the development process. Half of all of the local incubators advertise assistance with scaling manufacturing and helping companies through design for manufacturability. The through-line with all of these services is that incubators help people working on products become companies with standard operating procedures and formal business practices.

The incubator ecosystem has the potential to be a strong driver for local manufacturing. Many companies in incubator programs are just starting out and are not yet producing at volumes that necessitate overseas production. In addition, while companies come from all over the world to participate in these programs (45% of participants were located in San Francisco before the program) after graduation 76% of companies stay in San Francisco and 85% stay in the greater Bay Area. Reasons for staying include access to capital and to the network they created by participating in the incubator. **By educating incubator participants about the benefits of local manufacturing and the resources available, more manufacturing could be kept in the Bay Area if not in San Francisco.**

The third indicator of a strong entrepreneurial ecosystem is the amount of venture capital available and how easy it is to access. Venture capital for hardware is discussed in more detail in the next section.

Access to Capital

The Bay Area leads the country in access to early stage capital for hardware such as venture capital and crowdfunding.

VENTURE CAPITAL

Over the past five years investment in hardware has skyrocketed nationally. The entrepreneurialism of San Francisco combined with the regional strength in technical R&D, deep local electronics supply chain and the move towards integrating software and hardware has made the city the center of that hardware focused funding.⁷⁹

Traditionally, it was much more difficult to find funding as a hardware company than as a software company. This was due to the comparative expense of starting a company selling a physical rather than digital product. Hardware companies need larger founding teams, have a longer road to a minimum viable product and have more significant secondary expenses, all leading to larger asks at the beginning.

Despite these challenges investment in hardware startups began to pick up steam in 2010. The increase in investment was likely due to a number of very successful exits in the hardware sphere, many of them local, notably [Fitbit](#), [Oculus](#), [GoPro](#) and [Nest](#).

In 2010 Boston led in investment numbers but the Bay Area quickly came to dominate, bringing in almost \$500M in 2011. This trend continued with almost \$1.1B of hardware investment in the Bay Area in 2014, roughly 5 times what Boston raised and over 10 times what either New York or Boulder raised. As found by Bolt, in 2014 there were 110 hardware startups in the Bay Area that had each publicly raised over \$1M.⁸⁰ Both Boston and New York, the Bay Area's closest competitors, have about a third of that number of startups. San Francisco has such a reputation as the capital of investment that accelerators located in other cities (most notably [Hax](#), based in Shenzhen, China) have their demo days in San Francisco.

CROWDFUNDING

San Francisco excels not only in investment in hardware but also in the crowdfunding of hardware. Many hardware companies use crowdfunding as a way to both validate their market and to take pre-sales before they have finished their product. Because it is primarily product presales, crowdfunding should be thought of as debt with an accelerated repayment schedule.⁸¹

It is possible to see San Francisco's lead in crowdfunding by looking at data provided by [Kickstarter](#), the largest crowdfunding website. The average Design and Technology raise from Kickstarter is \$61,192 and three times over the stated goal.⁸² While San Francisco only has 4% of the total successful Design and Technology Kickstarter projects, that 4% is of much higher value. San Francisco based companies have taken in over 25% of the total amount of the Design and Technology funding raised on the site or \$79,133,264, almost \$20M more than Seattle, Boston, Los Angeles and New York combined.⁸³

TRADITIONAL CAPITAL

For young cutting edge companies, the type which are often headquartered in San Francisco, traditional capital such as bank loans or inventory financing is difficult to acquire. SFMade has found that only 5.69% of their companies used bank loans in their first 12 months of operation as compared to 80.43% who used personal resources or loans from family.⁸⁴ For most companies the inaccessibility of bank loans is due to business age; half of all the manufacturers in San Francisco were established less than five years ago.⁸⁵

Hardware companies also come from a culture of venture capital financing where founders do not have to use personal assets to secure loans. Additionally, they are often working on relatively risky products that may not have a clear customer base, market entry point or even product/market fit.

Design and Engineering Ecosystem

When advising hardware or other high tech manufacturers, SFMade hears that the reason companies are based in San Francisco is to gain access to the design and engineering workforce in the city. For those that also manufacture in the city, the primary benefit of co-location is that their engineers can closely oversee the manufacturing process to increase efficiency and quality.

Due to a combination of the high quality educational resources available in the Bay Area and its history as a center for computer and hardware engineering, San Francisco has the second highest number of computer hardware engineers in the country (San Jose is number one).⁸⁶ In addition, San Francisco pays the second highest wages in the industry, indicating the demand for these skills.

San Francisco is also a center for industrial design. According to the National Endowment for the Arts' 2013 report *Valuing the Art of Industrial Design*, excluding Greensboro-High Point, NC the “furniture capital of the world,” the San Francisco metro area has the highest per capita number of design firms, with 6.9 firms per 500,000 residents.⁸⁷

San Francisco is home to three of the largest international industrial design firms: Frog Design, IDEO (also in Palo Alto) and Lunar Design.⁸⁸ (For a partial list of the design and engineering consultancies based in San Francisco, see Appendix VIII).

Maker/Artist Ecosystem

The community of makers, hackers and artists in San Francisco forms the backbone of two important components of the advanced manufacturing landscape. It creates the environment of creativity and intellectual risk taking that is so important to innovation in all spheres, be it cultural, technological or otherwise. More easily understood is the network of informal educational sites these communities created, where much of the advanced manufacturing training in San Francisco occurs.

TECHSHOP

TechShop is the most formal of the informal educational resources in San Francisco. It is a gym for makers. Anyone can walk in off the street and purchase a membership to access equipment. However, before using any machine, they must be trained on it, whether or not they have prior experience. In addition, TechShop teaches classes in Computer Aided Design (CAD), Computer Aided Manufacturing (CAM) and electronics.

THE EXPLORATORIUM

The Exploratorium is an important site for informal advanced manufacturing education because it brings together its educational mission and its need for technical staff. The Exploratorium is a hands-on science museum that builds and maintains science exhibits both for their own use and to sell to other institutions. To do this they operate two machine shops and work with numerous outside contractors.

As part of their educational work, the museum runs a program called the High School Explainers. They bring in 40 students—who can be in the program for up to three years—to interact with visitors, explain the science and to run the more complex exhibits. Ten of the Explainers work as Exhibit Maintenance Explainers (EME) and receive on the job training in the Exploratorium's machine shops. Each student is paired with a staff member and they work together to keep the exhibits in good working order. EMEs learn to use the machinery, how to weld and more generally how to be comfortable in a prototyping machine shop.⁸⁹

SFMADE

SFMade runs a manufacturing awareness and training program called YouthMade. The only program of its kind in San Francisco, YouthMade is made up of two parts. The YouthMade Internship Program, provides low-income youth with paid internships at SFMade manufacturers. Over 100 youth have been placed in internships since 2013. The Inside Manufacturing Program exposes high school students in Career and Technical Education (CTE) and engineering classes to the different kinds of manufacturing

done in San Francisco, through field trips to manufacturers and hands-on workshops. Together both YouthMade programs now reach 100 high school students a year.

HACKERSPACES

There are several prominent hackerspaces in San Francisco including [Noisebridge](#) and [Double Union](#).⁹⁰ The two primary functions of these spaces are to give the community a place to come together and collaborate on projects, and to create a safe space for people to learn new skills (an explicit goal of Double Union). A makerspace designed especially for youth is located at [the Mix](#) in the main branch of the San Francisco Public Library and is only open to teens.

Regional Supply Chain

San Francisco sits at the center of a healthy regional supply chain. As discussed in Part 1 of this report, the Bay Area is especially strong in high technology manufacturing such as computer and electronic device manufacturing and biotech manufacturing (including both pharmaceuticals and medical devices). The apparel and food and beverage sectors are also well represented.

This strong regional supply chain, coupled with the Bay Area's dominance in electronics design and engineering means that in addition to having access to manufacturers, San Francisco companies have access to components suppliers who are located here to take advantage of proximity to very large manufacturers such as Apple and HP. SFMade has found that their advanced manufacturers source 72% of their parts and materials from somewhere in the Bay Area.⁹¹ However, they also take advantage of the Bay Area's strength as a transit hub and the increasing interconnectedness of supply chains worldwide. Of those surveyed, 41% source parts internationally.

The strength of the local supply chain means that companies with a variety of product lines may have completely different suppliers and supply chains for each one. For instance, Crave Innovations has at least 10 SKUs, which are manufactured in a variety of ways. Manufacturing location depends on the price of the parts and the difficulty of assembly. Manufacturing in San Francisco allows these companies to produce technically complex or luxury goods.

SAN FRANCISCO WEAKNESSES

Weaknesses in San Francisco's advanced manufacturing ecosystem include the city's high cost of living, expensive real estate, public transit infrastructure and low investment in training programs for advanced manufacturing. These difficulties combined with the availability of industrial real estate and training programs in other parts of the Bay Area have enticed advanced manufacturing companies to leave San Francisco. This exit from San Francisco has weakened the local supply chain, making it ever harder for local advanced manufacturers to source parts from within the city.

Industrial Real Estate

Within the Bay Area, San Francisco has a comparatively high concentration of industrial real estate. The percentage of land used for industrial operations in the Bay Area ranges from 0.02% in Sonoma County (1,876 acres) to 4.2% in Contra Costa County (20,193 acres). While 4.2% of real estate in San Francisco is used for industry, because of the city's size the actual amount of industrial real estate is just 1,265 acres.⁹²

The City is conscious of the limited amount of industrial real estate available and has protected industrial land by instituting zoning controls to preserve Production, Distribution and Repair (PDR) areas. Examples include the upcoming Central SoMa plan, the Eastern Neighborhoods planning process, which included East SoMa, Mission, Showplace Square/Potrero Hill and Central Waterfront and the renaming of existing industrially zoned parcels in the Bayview, so that they also have a PDR designation. In addition, the City is

INDUSTRIAL RENTS (avg. \$ sq ft/year):

Regional: \$7.22	South Bay: \$9.96
San Francisco: \$26.26	North Bay: \$8.48
Peninsula: \$12.02	East Bay: \$6.01

Source: Chapple, K. *Overview of Industrial Activities in the Bay Area: Industrial Land Supply and Demand, Draft technical Memo #1*: November 1, 2015: 26-27.

PROTECTED INDUSTRIAL LAND:

1,274 total acres in San Francisco

SLI and SALI **90 acres**

PDR in Mission/Showplace **140 acres**

Industrial Port Land **406 acres**

PDR in Central Waterfront/Bayview **638 acres**

Source: Wertheim S. *Production, Distribution, and Repair in San Francisco*, San Francisco Planning Department: 2014.

piloting new techniques for encouraging affordable industrial real estate such as an inclusionary industrial zoning provision passed in 2014. For more details on how the city government is responding to these issues, see the reports listed at the end of this section.

While industrial rents have risen in all neighborhoods, they have risen faster in neighborhoods close to the city center and the regional transport hubs of BART and Caltrain, where there is increased demand for commercial and office space. Industrial rents in SoMa for instance average \$41.52 a sq ft/year.⁹³ As rents increase, manufacturing has been pushed to the perimeter of the city.

Based on conversations with manufacturers looking for space in spring 2016, SFMade reported an asking rent spread for PDR space of \$24-60 sq ft/year in Northeast Mission, Potrero Hill and Central Waterfront (PDR 1D/G) and of \$8.40-30 sq ft/year, with an average closer to \$12 in the Bayview (PDR 2).⁹⁴

In the Bayview, the neighborhood with the most affordable industrial acreage, one of the difficulties is finding space that is appropriately sized.⁹⁵ Much of the available space in that neighborhood is over 7,000 sq ft. San Francisco advanced manufacturers tend to need smaller spaces, generally between 1,000-2,000 sq ft. Encouraging shared space or creating shared manufacturing facilities would help smaller businesses take advantage of this affordable space.

Though these larger spaces are available in San Francisco, SFMade has noticed a pattern of advanced manufacturers starting in San Francisco and then moving out of the city when they reach an expansion stage and need more space to house a larger team. According to exit interviews conducted with manufacturers, they are leaving the city because of a combination of the high cost of real estate and employee transportation concerns.

The San Francisco industrial real estate market has been covered extensively elsewhere. For more information see the following reports:

- *The Central SOMA Plan and Implementation Strategy*. San Francisco Planning Department: August 2016.
- Chapple, Karen. *Overview of Industrial Activities in the Bay Area: Industrial Land Supply and Demand, Draft technical Memo #1*: November 1, 2015.
- *Eastern Neighborhoods Area Plans: Central Waterfront, East SOMA, Mission and Showplace Square/Potrero Hill*. San Francisco Planning Department: December 2008.
- *Supply/Demand Study for Production, Distribution, and Repair (PDR) in San Francisco's Eastern Neighborhoods*. Prepared by Economic and Planning Systems for the City and County of San Francisco: April 15, 2005.
- *Industrial Land in San Francisco: Understanding Production, Distribution, and Repair*. San Francisco Planning Department: July 2002.

Public Transit

San Francisco is a destination for workers in all industries; only 50% of people who work in San Francisco live within 10 miles of their job.⁹⁶ Complementing San Francisco's strength as a net jobs importer is the city's connection to regional public transit, both the BART and Caltrain systems. This has become increasingly important as commuting by car has declined throughout the Bay Area, while BART and Caltrain ridership is at an all time high.⁹⁷

The dispersal of production employees throughout the region as the cost of living increases, means that access to regional transit is a key business need at this time. In SFMade's *Industrial Jobs of the Future* report, transit accessibility and commute times were listed as two of the primary business concerns of companies.⁹⁸ One business owner said their biggest difficulty was "finding individuals that can handle the commute to Bayview... generally these workers live in the East Bay or [the] Sunset and the commute via public transportation is really terrible. I wish SF had a better

The dispersal of production employees throughout the region as the cost of living increases, means that access to regional transit is a key business need at this time.

and more efficient transit system, because some employees can take up to an hour to get to work, from within SF, taking public transit.”⁹⁹

Most of the affordable industrial real estate is in the Bayview, an area with a history of inadequate public infrastructure including being underserved by transit. Prior research has found that the neighborhood has especially poor connections to regional transit.¹⁰⁰ For instance, while Caltrain runs through the neighborhood, there are no station stops. However, improvements to the Bayview’s public transit infrastructure are in progress. Improvements include: increasing the frequency of the 29 Sunset, 44 O’Shaughnessy, 24 Divisadero and T Third during the day to address crowding issues and creating a new 44 O’Shaughnessy Owl route between Glen Park BART and the Bayview, allowing easier access to the neighborhood for those working non-traditional hours.¹⁰¹

Transit concerns and the SFMTA’s plans for improvement in the Eastern Neighborhoods and the Bayview have been covered in several recent reports. For more information see:

- San Francisco Municipal Transit Agency. *Muni Service Equity Strategy Report: Fiscal Year 2016-17*: April 2016.
- San Francisco Municipal Transit Agency. *Eastern Neighborhoods Transportation Implementation Planning Study*: December 2011.
- San Francisco County Transportation Authority. *Bayview Hunters Point Neighborhood Transportation Plan*: Presented to the Authority Board, June 2010.

Production Workforce

There has been an increase in the number of advanced manufacturing companies based in San Francisco and a corresponding increase in the number of advanced manufacturing jobs located in the city. However, in comparison to other manufacturing fields in San Francisco, fewer of these jobs are production positions. The lack of production positions comes from two facts about advanced manufacturing in San Francisco:

- 1) Most companies are very young, concentrating on design and engineering and not yet manufacturing at volume.
- 2) Advanced manufacturers and companies making hardware are more likely to manufacture using a contract manufacturer, of which there are a limited number in San Francisco.

By looking at local job postings, advanced manufacturers’ current emphasis on engineering and software development can be seen. Burning Glass data shows that San Francisco’s advanced manufacturers are often looking for software developers and engineers (see Table 3).¹⁰² In addition, when posting production positions these companies posted jobs with significant technical skills, such as CAD, CNC, Python and Linux (see Appendix XIV for a complete list). However, Burning Glass data privileges those occupations that are filled through English language online listings.

Occupation	Job Postings
Software Developers, Applications (15-1132.00)	43
Mechanical Engineers (17-2141.00)	26
Electrical Engineers (17-2071.00)	23
Electronics Engineers, Except Computer (17-2072.00)	14
Retail Salespersons (41-2031.00)	14
Architectural and Engineering Managers (11-9041.00)	13
Manufacturing Engineers (17-2199.04)	10

TABLE 3. Number of job postings by occupation for advanced manufacturing in San Francisco. Software development is the most sought after position, even in manufacturing.¹⁰³

Entry-level technician and fabrication positions are often filled through a combination of word of mouth, community publications and staffing agencies, and therefore do not show up on Burning Glass.^{104, 105} Planet Labs, San Francisco's largest advanced manufacturing employer with in-house production (by an order of magnitude), may also be distorting the data. As a Hardware as a Service company Planet Labs has a roughly 20:1, software/engineering/admin to production job ratio in their San Francisco office.

On a more positive note, 70% of the advanced manufacturers surveyed for the Industrial Jobs of the Future Initiative stated that they have entry-level assembly positions in their companies. These positions do not require significant technical skill and staff can be trained on the job. In fact, most of these employers report training their employees this way, even those that are not entry level.¹⁰⁶

Training was another of the primary concerns raised by the Industrial Jobs of the Future Initiative, which found that the two principal hiring issues seen by manufacturers were competition for a limited supply of skilled labor and a need for specific skills.¹⁰⁷ In advanced manufacturing, the skills mentioned as difficult to find included machining, 3D printing, general fabrication, quality assurance, lean manufacturing, woodworking and software such as CAD, CAM and the Adobe Creative Suite. These concerns are at their core training issues. Production and fabrication skills are usually taught through Career Technical Education (CTE). San Francisco still has CTE training, including in advanced manufacturing, at both the secondary and post-secondary levels.

Education and Workforce Preparation

Production jobs in advanced manufacturing often require more training and experience with computers than production jobs in other manufacturing fields. Access to the training needed is available in San Francisco through a combination of secondary level CTE classes, post-secondary education in engineering and industrial design and informal training locations such as TechShop.

SECONDARY EDUCATION

At the secondary education level there are seven public high schools with programs relevant to advanced manufacturing, mostly in CTE classrooms, though almost all of these point students towards continued engineering training rather than towards production jobs. This corresponds with the national trend towards post-secondary education.

There are currently 2,395 students enrolled in CTE coursework across the San Francisco Public School District (SFUSD) in 11 industries ranging from agriculture to marketing to engineering.^{108, 109} Many CTE courses in SFUSD are legacy and have been taught for over ten years. While the Mayor's Office has designated IT, public service and manufacturing as the focus of CTE education generally, the focus of the CTE coursework at an individual school depends on the principal/school's vision and the presence of existing credentialed teachers.¹¹⁰ The programs relevant to advanced manufacturing range from automotive technology to architecture to engineering and most teach some CAD or applied computer science (see [Appendix IX](#) for a list of schools and programs).

Though many of San Francisco's shop facilities have been closed, makerspaces are being added to schools throughout SFUSD. The spaces are being developed in response to community desires, primarily as clubs, so there is no district-wide plan or resource allocation. Each school is independently finding funding, teachers and space. The growth of these spaces shows an increasing interest in making and engineering that could be formalized in the future and integrated into the existing CTE curriculum (see [Appendix X](#) for a list of makerspaces in the SFUSD system).¹¹¹

In addition to hand skills, advanced manufacturing requires computer skills and SFUSD is moving towards a pre-K to grade 12 comprehensive computer science curriculum.¹¹² The curriculum focuses on programming and related subjects such as algorithms, networking and design thinking rather than working with particular types of programs or general computer literacy. The programming focus means that CAD, which is one of the most important components of advanced manufacturing, will not be integrated into the curriculum.¹¹³ However, more familiarity with computer science generally is a benefit to students interested in advanced manufacturing. Additionally, the existing engineering and architecture programs teach CAD (see [Appendix IX](#) for more details).

POST-SECONDARY EDUCATION

Advanced manufacturing has three workforce training tracks at the post-secondary level. The first is a production track, which requires technical skill but not necessarily formal education. The second and third are engineering and design tracks, both require at least a four year degree and in many cases graduate coursework. Though fabrication and production skills can be taught informally, SFMade has observed that some companies prefer to hire people with four-year degrees even if it is not necessary for the position in the hopes of finding a better employee. Companies with engineering capacity, as with many advanced manufacturers, often require a bachelor's degree even for low skill, entry-level positions.¹¹⁴

While San Francisco has a highly trained workforce, principally in engineering and design, advanced manufacturers rely on educational institutions outside of the city for much of that training. This has not been an issue because San Francisco is a destination city for engineers and designers from all over the world. However, fabricators and production talent are less likely to move for work. This means that local advanced manufacturing CTE training is important.

Career Technical Education

City College of San Francisco (CCSF) is the community college based in San Francisco. It is the largest community college in California with 38,000 degrees and certificates awarded and an enrollment of over 100,000 in 2014.¹¹⁵ City College offers both associate's degrees and CTE certificates. All of the relevant advanced manufacturing coursework on both tracks sits in the engineering department.

City College's engineering program offers associates degrees in biotechnology, engineering, electronic engineering technology and mechanical engineering technology, and focuses on transferring students to the four-year engineering programs in both the University of California (UC) and the California State University (CSU) systems. In 2013/14, 1,711 students transferred from CCSF to UC and CSU. Sixty-five percent of those students enrolled at San Francisco State.¹¹⁶

On the CTE track, the department focuses on biotechnology, construction adjacent fields (CAD and HVAC) and electronics. The department offers certificates in CAD (general and architectural), electronics (basic and intermediate) and manufacturing and fabrication.¹¹⁷ The electronics series is specifically meant as training for manufacturing technicians. The two certificates and A.S. degree offered in electronics are not aligned with transfer to other educational institutions.¹¹⁸ Though there is a certificate offered in manufacturing and fabrication, there is no CNC training offered. At this time City College does not have the faculty, machinery or space to teach CNC machining or modern quality control (coordinate measuring machines, optical metrology, 3D scanning, etc.).¹¹⁹

Manufacturing is not one of the curricular or strategic emphases at City College. The California Community College system is a statewide system and is organized at a regional level. This means that outside of general education requirements every school need not offer every subject. City College has not needed to focus on manufacturing careers as there are good programs at Laney College (14 miles from San Francisco) and De Anza College (45 miles from San Francisco) (see [Appendix IX](#) for a list of local community colleges with relevant coursework).

Engineering Programs

Engineering education is one of the primary ways to get experience and training on both the tools and design software needed for advanced manufacturing. There are two college level engineering programs in San Francisco, one at San Francisco State University (SFSU) and the other at the University of San Francisco (USF). Of the two, only San Francisco State has a School of Engineering, offering both undergraduate and graduate engineering degrees. At the undergraduate level SFSU students can concentrate in civil, computer, mechanical or electrical engineering. Engineering is the third most popular major at the school. The graduate level degree is more focused with only three concentrations: embedded electrical and computer systems, energy systems and structural/earthquake engineering.

In addition to the engineering coursework provided, San Francisco State has a full complement of labs including a machine shop, a microprocessors laboratory and a robotics and autonomous systems laboratory, among many others. A makerspace located in the library opened in December 2015. The

space can be used by all students and includes a 3D printer, 3D scanner, electronics prototyping materials and CAD software such as Rhino and Solidworks.

While USF does not have an engineering school, it does offer a dual degree with University of Southern California (USC). The engineering degree consists of three years of study in physics at USF and then another two years of study in the engineering program at USC. When the degree is completed students hold two B.S. degrees, one from each institution. All of the engineering coursework, including design and mechanics, is taught at USC.

USF also has a STEM education program, at both the undergraduate and graduate levels. As part of this program USF runs a small makerspace in the Center for Instruction and Technology (CIT). While software and basic graphic design skills are focus of CIT trainings, they now run biweekly 3D printing trainings with a focus on encouraging design thinking.

Industrial Design Programs

The third location for post-secondary education in CNC machining and CAD is in industrial design programs. There are three industrial design programs in San Francisco at San Francisco State, [California College of the Arts \(CCA\)](#) and [Academy of Art University](#).

San Francisco State offers a major in industrial design, with two concentrations: product design and development, and industrial technologies.¹²⁰ The primary difference is that the industrial technologies concentration includes some business and finance classes. Both concentrations teach CAD, digital design, rapid prototyping and modern manufacturing methods. SF State also offers a graduate degree in industrial design that primarily consists of thesis work on a topic of the student's choice.

Two private art colleges in San Francisco teach both CAD and the use of CNC tools, laser cutters and 3D printers. The first is CCA, which has campuses in both San Francisco and Oakland. CCA has undergraduate and graduate degrees in industrial design and teaches CAD, model making, materials and modern manufacturing methods. The school has studios with a full suite of CNC machines, laser cutters and 3D printers for student use.

The other private institution with industrial design training is the Academy of Art University. The Academy of Art has a focus on transportation design and automotive restoration, and offers CAD, machining, manufacturing processes and modeling coursework. The Academy of Art differs from the other schools mentioned in that it is a for-profit institution and has a lower 6-year graduation rate of only 31%.

NON-TRADITIONAL

As discussed in "Maker/Artist Ecosystem" on page 22, advanced manufacturing's connection to the maker movement has supported a strong ecosystem of non-traditional educational sources. These include, but are not limited to educational initiatives such as the Exploratorium Explainers program and YouthMade, workspaces such as TechShop, and makerspaces like Noisebridge, the Mix and Double Union. (For a more complete list, see [Appendix IX](#)).

Public Infrastructure

In interviews and roundtable discussions with San Francisco manufactures, one issue that comes up repeatedly is the belief that San Francisco is more difficult to do business in than other jurisdictions. Advanced manufacturers often do not understand how to get permits for more complex or potentially toxic/dangerous manufacturing procedures and feel like they cannot talk to the city government about their questions. Some of this comes from the relative youth and inexperience of the advanced manufacturing companies in San Francisco and some of it comes from a lack of clarity around permitting, zoning and manufacturing regulation. In addition, California is a maze of regulatory jurisdictions. Interestingly, SFMade often hears companies say that they just assume it is hard, so they do not even try to get permits, especially for VOC restricted items like paint booths.

The Office of Economic and Workforce Development (OEWD) has started to address this issue head on with their online [Business Portal](#) and [Starter Kits](#). These valuable resources could be expanded to cover more types of manufacturing, including electronics and metals fabrication. The current “hire employees” section of this tool could be expanded to cover important manufacturing employment concerns such as OSHA compliance that would serve the advanced manufacturing sector directly. Expanding both of these offerings would help small advanced manufacturing businesses navigate the complexities of opening for business.

Local Supply Chain

HOLES IN THE SAN FRANCISCO SUPPLY CHAIN

- Box-build/assembly
- Wire bending
- Metal extrusions
- Glass fabrication
- Non-PCB electronics fabrication
- Blow molding/rotomolding plastic

While the regional supply chain is remarkably robust, the supply chain for advanced manufacturing within the city itself is shallow. The existing contract manufacturers and vendors specialize in low-volumes, custom work and one or two manufacturing methods each.¹²¹ This leads many advanced manufacturers to do their primary production either completely in-house or completely out of house and out of San Francisco.

The loss of a single contract manufacturer, such as [LeeMAH Electronics](#), can hit SFMade companies especially hard. LeeMAH was one of the last full service electronics manufacturers (EMS) in San Francisco and was an important part of the city’s supply chain. While LeeMAH is still located in the Bay Area, several SFMade companies have struggled to stay members now that their contract manufacturer has left the city.

San Francisco’s current limited supply chain is a consequence of the weaknesses discussed in the prior sections: expensive industrial real estate, lack of training, limited production workforce, etc. However, San Francisco’s wealth of hardware incubators, excellent regional training capacity, strong regional supply chain and preeminence in engineering and design in the advanced industries, including manufacturing, gives the City an advantage in strengthening the advanced manufacturing ecosystem. **By focusing on advanced manufacturing and strengthening the whole ecosystem, San Francisco can support the City’s goals of economic equity, growing an inclusive workforce and creating a more diverse base for economic development generally.**

Recommendations to Strengthen Advanced Manufacturing in San Francisco

OVERVIEW

The recommendations developed to support the advanced manufacturing ecosystem in San Francisco have three primary focus areas.

- ▶ **Strengthen the regional advanced manufacturing sector and rebuild San Francisco's connection to the ecosystem.** These recommendations are intended to support and expand the existing advanced manufacturing supply chain while allowing San Francisco to become a leader in the planning processes for future manufacturing policy.
- ▶ **Address San Francisco's specific infrastructure weaknesses to grow the low-volume advanced manufacturing sector.** The weaknesses addressed are those inhibiting the growth of low-volume manufacturing in the city and include: supply chain, real estate and preconceptions about manufacturing in San Francisco.
- ▶ **Increase awareness of advanced manufacturing as a career and address the shortage of technical training for advanced manufacturing within the city.** These recommendations address the expansion of technical education for both youth and adults, as well as the promotion of manufacturing as a viable career choice.

The core recommendations, as identified by the Advanced Manufacturing Action Team, SFMade and the Make to Manufacture Fellowship Steering Committee are described below, for a complete list of recommendations see page 42.

Develop a Manufacturing-Specific Work Readiness Program¹²²

OPPORTUNITY / NEED

While many businesses would be happy to hire someone with prior manufacturing experience or demonstrated mechanical aptitude, those skills and experiences are not the most important for entry-level employees. The 2016 SFMade *Jobs of the Future* report instead found that businesses are looking for employees who possess a variety of skills and characteristics that will make them good employees. These skills are often referred to as work readiness skills. They are skills and behaviors that are necessary for any kind of job, rather than tailored to a specific occupation. Work readiness training is an essential part of many workforce training programs. Particularly for those training programs that are attempting to increase the labor force attachment of lower-skilled/low-income workers and people who have not previously been attached to the labor market, including youth.

Most businesses look for evidence of these skills during the interview process. Did the interviewee show up on time? Had they researched the company in advance? Were they dressed professionally? Did they communicate articulately? In the absence of a mechanism to assess employability skills, some employers use education as a proxy, such as preferentially hiring those with a Bachelor's degree even for jobs that do not require one. This increases the barriers to employment faced by lower-skilled workers who may still be qualified for a given job.

While general work readiness training programs can be very effective, research shows that programs are even more successful when they are contextualized to a particular industry, occupation or work environment, rather than generic. While most people have some idea of what working in a restaurant or retail service environment would be like, fewer have experience with the environment and norms of a manufacturing business. For example, manufacturing work is hands-on and fast paced, and safety

and cleanliness are of paramount importance. When programs are contextualized, participants gain the specific skills needed to perform well within the manufacturing environment and are more likely to stay in the job because they know what to expect before they are hired.

RECOMMENDATION

Develop a contextualized work readiness program that includes generalized manufacturing specific technical skills like soldering techniques, precision measurement and safety, but also teaches people how to adapt, improvise and look for ways to increase efficiency and solve problems, all qualities that companies value highly in an entry-level employee. Key elements to investigate to determine if such an approach is feasible or appropriate include:

- 1) Hiring demand by employers in San Francisco to justify setting up a training program.
- 2) Commitment by employers to champion the program's creation, inform its development and hire its graduates.
- 3) Capacity of local providers to create and sustain such a program, including a funding/investment strategy to do so.

One concern raised by some of SFMade's workforce partners and potential training partners is that of scale. The overall size of the manufacturing industry in San Francisco is relatively small. To access as many potential positions as possible the program will need to be broadly applicable to all types of manufacturing. In addition, in order to have enough job openings to meet trainee demand, the program might need to look outside the city of San Francisco for placement opportunities.

For a program to be launched here, it would be necessary to engage local businesses in identifying the specific skills, both technical and soft skills, that they are looking for and which could be included in such a program. Examples soft skills include:

- Showing interest in the product
- Evidence that they researched the position and the company
- Time management
- Strong work ethic
- Personal characteristics: energetic, positive attitude and pride in one's work
- Ability to persevere and achieve a goal
- Able to hustle, has a "need for speed"
- Detail-oriented while doing consistent work

Significant business outreach would be conducted in order to identify the specific skill needs that would drive the development or adaptation of a training curriculum. On an ongoing basis, businesses would also provide:

- Curriculum development assistance, including asking the management or human resources staff about required skills.
- Participation in training program delivery, such as preforming mock interviews and opening up their facility for site visits for trainees.
- Commitment to interview and/or give preference to applicants who completed the training program.

Another important element in proceeding would be to engage a training provider. There are a variety of training providers in San Francisco who offer work readiness programs, either on their own or through Office of Economic and Workforce Development sector initiatives.

PROGRAM EXAMPLES

Manufacturing Pre-Employment Program, Everett Community College, Everett, WA

The Manufacturing Pre-Employment program is an introduction to manufacturing with an emphasis on aerospace. Graduates receive a manufacturing pre-employment certificate and the national career readiness certificate. The program is a one-quarter, 12-credit optional pathway within an associate degree program, but is also offered as a stand-alone credential for people seeking to enter the manufacturing field.¹²³

Manufacturing Work Readiness Program, Grand Rapids Community College, Grand Rapids, MI

This short term accelerated program prepares participants for entry-level work in area manufacturers. Local manufacturing human resource managers selected topics for the class, and students that successfully complete the course are guaranteed at least two job interviews with local manufacturers.¹²⁴

Manufacturing Readiness Program, Oh-Penn Manufacturing Collaborative

This program is a product of a manufacturing collaborative that spans 5 counties across two states (Columbiana, Mahoning and Trumbull Counties in Ohio and Lawrence and Mercer Counties in Pennsylvania). The program combines two weeks of soft skills training with four weeks of technical skill training, which includes OSHA-10 and Certified Production Technician critical production functions. Each participant also earns a WorkKeys credential.¹²⁵

POTENTIAL PARTNERS

Potential partners could include: FACES SF (offers airport hospitality soft skills training), Goodwill, Jewish Vocational Services, Mission Hiring Hall (offers a work readiness for hospitality program), SFMade (offers manufacturing awareness programs), Young Community Developers.

NEXT STEPS

- Conduct outreach to employers to gauge their willingness to participate in the program and in what capacities.
- Conduct outreach to potential training providers to understand existing offerings and to determine what scale of demand is needed to justify program delivery.
- Identify potential population targets for such a training program.
- Investigate funding sources for developing and delivering the training.

Enable a Regional Manufacturing Strategy

OPPORTUNITY/NEED

Manufacturing is evolving rapidly as digital control, sensing and automation are integrated into every process. The San Francisco Bay Area is rich in industrial commons and well placed to take advantage of this evolution due to its history as a center for high technology manufacturing and manufacturing innovation. However, the highest potential to create more entry-level and middle-class manufacturing jobs across the region will be realized only if a well defined and interconnected regional manufacturing ecosystem is developed. To achieve the maximum benefit, the region must connect city economic development organizations, regional intermediaries, product incubators and established manufacturers to solve market failures within the manufacturing sector: small business support, workforce development and industrial land use.

San Francisco's advanced manufacturing sector has much to gain from connecting to the larger regional manufacturing ecosystem. San Francisco has a long history of incubating advanced manufacturing companies and while the number of companies manufacturing their products within the city limits is growing, it is still rare. Advanced manufacturers operating in the city are already connected to a wide range of subcontractors and suppliers regionally, nationally and internationally. Integrating the intermediary and support organizations such as government, advising services and education within the region will strengthen the support systems for advanced manufacturers thus keeping more of this kind of manufacturing within the Bay Area.

RECOMMENDATION

To strengthen connections between manufacturers, suppliers, governments and intermediaries throughout the region, **San Francisco should create a collaborative initiative across manufacturing rich cities in the Bay Area to identify a regional manufacturing strategy and to communicate why manufacturing is important to the region.**

This work has already begun. In May 2016, SFMade and OEWD began work on the Bay Area Urban Manufacturing Initiative. The Initiative grew out of the insights of Advanced Manufacturing Action Team and the work done for this playbook. A three-year collaboration between economic development departments, educational institutions and manufacturing support services to develop a regional manufacturing strategy, the Initiative will set shared goals that are critical to the continued health of the manufacturing sector in the Bay Area. The purpose of the Initiative is to remedy those issues that have not been, or cannot be, solved by industry. It will bring together a coalition of city governments and regional stakeholders from the manufacturing, education and non-profit communities to meet specific, concrete goals.

The objective of the Bay Area Urban Manufacturing Initiative is to galvanize existing organizations across cities and manufacturing subsectors to accomplish four key objectives:

- 1) Increase the number of maker businesses that become local manufacturers.
- 2) Grow the number of manufacturing jobs held by those with less than a four-year degree.
- 3) Preserve and grow affordable industrial real estate throughout the region.
- 4) Promote the Bay Area as a center for manufacturing innovation.

Phase one of the Initiative started with the four largest cities in the Bay Area—San Francisco, San Jose, Oakland and Fremont—and focused on developing the *Bay Area Survey on Urban Manufacturing*. In September of 2016, SFMade collected replicable data on connections between manufacturers throughout the region. At the same time they identified existing regional studies such as the Association of Bay Area Government's (ABAG) *Industrial Land and Jobs Study*. Using this information SFMade and their partners will prepare the first *Bay Area State of Urban Manufacturing* report.

The report will be released in November 2016, at the inaugural Bay Area Summit on Urban Manufacturing. After the summit, stakeholders from industry, government, education, and economic and workforce development will gather to direct the objectives of the Initiative. The updated survey will act both as a launchpad and grounding device for the Initiative. Using the data collected by the survey, the working group will establish specific deliverables, a workplan and interim milestones.

Funding for the first year of the Initiative has been secured, as have commitments from the Mayors of San Francisco, San Jose, Oakland and Fremont.

PROGRAM EXAMPLES

Urban Manufacturing Alliance, New York, NY

The Urban Manufacturing Alliance (UMA) is a coalition of city economic development departments, manufacturing support organizations, intermediaries and educational institutions that work together to unite individual urban manufacturing practitioners as partners in the movement to bring manufacturing jobs back to cities. The UMA develops best practices, promotes living wage manufacturing jobs and shares stories between cities. In doing so, the UMA helps urban areas expand and support their manufacturing ecosystems.¹²⁶

Philadelphia Manufacturing Growth Strategy, Philadelphia, PA

The Philadelphia Manufacturing Growth Strategy launched in January of 2013 with the mission to evaluate the region's competitiveness and to develop recommendations for the growth of Industry. While this project was limited to a single city, it looked at the issues within the sector that could not be addressed by industry alone.

The Growth Strategy started by creating a detailed picture of manufacturing as it currently stands within Philadelphia and then moved on to create a series of specific, concrete strategies to grow the sector. The final report set strategies such as:

- Expand technical training opportunities provided by community colleges that are aligned to the needs of the manufacturing sector.
- Create new loan and/or equity funds targeted specifically to small and mid-sized manufacturers investing in product development and innovation.
- Continue to preserve by-right zoning in industrial corridors and upgrade existing industrial districts and facilities to support modern manufacturing.¹²⁷

POTENTIAL PARTNERS

SFMade has committed to lead the three-year Bay Area Urban Manufacturing Initiative. In 2016, four cities committed to collaborating on the survey, report and event. Each year more cities will be added to the Initiative.

Committed city partners for Phase I: • San Francisco • Oakland
• San Jose • Fremont

Other Potential Partners:

Intermediaries	Education	Workforce
Association of Bay Area Governments	Bay Area Community College Consortium	Alameda County Workforce Development Board
Bay Area Council	California Community College Navigators	Contra Costa Workforce Sector Development Board
East Bay Manufacturing Group	De Anza College	NoVA Workforce Board
Manex	Diablo Valley College	Sonoma County Workforce Investment Board
Silicon Valley Manufacturing Roundtable	Laney College	Work2Future
SPUR	Napa Valley College	Workforce Investment San Francisco

NEXT STEPS

- Complete initial *Bay Area State of Urban Manufacturing* survey and report. Pilot the survey in partnership with the metropolitan centers of San Francisco, San Jose, Oakland and Fremont.
- Present the Bay Area Summit on Urban Manufacturing, a high-level convening, where the participating cities will reveal the major findings of the report to a room of manufacturers, policy makers and strategic partners.
- Bring together manufacturing sector stakeholders to establish specific Initiative deliverables, a workplan and interim milestones.

Cultivate Contract Manufacturing

OPPORTUNITY/NEED

Due to its central location between multiple world-class research centers, history of product design and the regional strength in semiconductor and electronic device manufacturing, San Francisco has become a center for the design and engineering of hardware and electronics products of all kinds from consumer goods to robots to medical devices.

San Francisco has one of the most substantial entrepreneurial ecosystems in the United States, with more incubators, design firms and meetups per capita than any other metropolitan area. However, currently it has a limited advanced manufacturing and electronics supply chain with only one electronics contract manufacturer.

The physical proximity of design to manufacturing increases a company's capacity for complexity. If fabrication and design are close together, the small runs, quality control and ability to make engineering changes needed for intricate products, product development, customization and boutique production become much easier. In addition, high-value/high-intellectual property items cannot be safely made in every country (and in the case of aerospace and medical devices cannot be legally made in many).

The products that San Francisco companies specialize in see a strong benefit from the co-location of design and production: innovative hardware and electronics products, medical devices, aerospace components and highly customizable or boutique consumer goods. Most companies that manufacture electronics and other "advanced" goods in San Francisco do a large part of it, if not all of it, in-house, closing the loop between design and production. However, this limits the number of products produced in San Francisco, as not all companies have or want to acquire the manufacturing expertise needed.

The manufacturing companies that thrive in San Francisco need contract manufacturers that are flexible, have a diverse set of skills and are interested in working with small companies. Contract manufacturers specialize in manufacturing a product, rather than in the design and sale of that product. Depending on the manufacturer they can do everything from creating boards to molding housings to machining mechanical parts to assembling the final product. Some even print the packaging and ship in-house. Access to such a contract manufacturer would allow more hardware companies to stay in the city.

RECOMMENDATION

Attract an existing comprehensive manufacturing services provider to San Francisco and help them locate in the city. Companies in San Francisco need access to small batch production with quick turn around times, so called low-volume/high-mix manufacturing. San Francisco should look for a mid-size manufacturing firm that has both the inclination to work with newer companies and the desire to provide a diversity of services. This could be because they are looking to build a sales pipeline of companies that could grow into their volume services, because they want to learn about the pioneering products being created in San Francisco or because they specialize in low-volume/high-mix.

When looking for a contract manufacturer, San Francisco should target an established firm without a footprint in the Bay Area that wants to take advantage of the business opportunities afforded by the city. This could include a foreign contract manufacturer that wants a presence in the United States or a firm from another region that wants to gain a toehold in the Bay Area's hardware innovation ecosystem.

There are several types of contract manufacturing facilities that would be beneficial to the advanced manufacturing ecosystem in San Francisco.

- *Electronics Manufacturing Services Provider (EMS):* Though for some this term has come to simply mean a board house, EMS providers can deliver services ranging from manufacturing PCB boards to creating wiring harnesses to assembly. An EMS facility would fill one of the primary gaps in San Francisco's supply chain, a lack of electronics assembly and box build.

- *Comprehensive Manufacturing Services Provider:* A contract manufacturer that provides a wide range of services from electronics and subassembly construction to molding housings and machining mechanical parts. To make this type of manufacturing affordable at low-volumes, the factory would likely need to be both highly automated and flexible. A manufacturing services provider of this type would be able to serve a wide range of industries throughout San Francisco, from consumer electronics to medical device and could fill many of the holes currently found in the supply chain.
- *Emergent Manufacturing Technology Hub:* San Francisco is home to several companies that are working to improve contract manufacturing itself through the creation of new technologies. San Francisco could collaborate with the existing companies and attract others located throughout the United States to create a “factory of the future” showcasing the optimal mix of technology, process and labor to achieve maximum efficiency and profitability in small batch production. These technologies could be used to pilot a replicable urban factory model.
- *Final Assembly and Test Facility:* One of the primary reasons hardware and electronics companies manufacture in San Francisco is to be able to oversee Final Assembly, Test and Packing (FATP) and therefore control their quality and testing regimen. FATP is particularly important with new categories of product, like those designed in San Francisco. Many companies would like to do FATP close to home but do not have the trained staff or space to do so. A specialized FATP facility designed to work with small companies and on small runs (flexible and reconfigurable with a trainable workforce) would be extremely valuable.

Any manufacturer invited to San Francisco will also need to provide product development and design for manufacturability services. Due to recent technological advancements that have made prototyping easier and more accessible, companies with little manufacturing experience are creating hardware products. Though this is causing the market to expand and diversify in amazing ways, it also means that there are more inexperienced manufacturers in the sector than ever before. Unfortunately, manufacturing itself has not become more user-friendly. For new inexperienced companies manufacturing support and design services are as important as manufacturing.

The cost of industrial real estate in the city will have to be a consideration as this project moves forward. As a city we will have to create the capacity for a competitive contract manufacturer to locate in San Francisco, whether through public/private financing, new markets tax credits or other opportunities.

PROGRAM EXAMPLES

LeeMAH Electronics, Brisbane, CA

LeeMAH Electronics was an electronics manufacturing services provider in San Francisco, specializing in low-volume/high-mix production. In business since 1971, LeeMAH left San Francisco to consolidate their business at their Brisbane facility. When they closed, the city lost not only one of its last contract manufacturers doing component assembly but also the last providing box build and final assembly and test services. LeeMAH also has facilities in Texas and China allowing companies to keep the same manufacturer as they grow.

City Garage/Under Armour Lighthouse, Baltimore, MD

The Under Armour Lighthouse at City Garage is an advanced manufacturing facility for textiles, apparel and footwear. It is based at City Garage, a co-working, maker and incubator space for hardware and physical product companies. The Lighthouse is run in partnership with Under Armour and is located next to their design facility. It is intended to support and expand Under Armour’s local manufacturing presence and to increase their access to advanced manufacturing equipment.

Factorli, Las Vegas, NV

Factorli was a “factory of the future” project based in Las Vegas that was a pillar of Tony Hsieh’s ambitious Downtown Project. The factory was meant to be both highly automated and reconfigurable, decreasing costs and allowing for short-run production. While the project was canceled in 2014, it was due to factors other than the viability of the factory itself.¹²⁸ Factorli’s engineering and design team is based in San Francisco and they could participate in a project to create a similar facility here.

TextielLab, Tilburg, NL

Located at the TextielMuseum in Tilburg, Netherlands, the TextielLab combines a specialized workshop for textiles manufacturing with an open studio and access to the museum’s archive. The TextielLab focuses on R&D and new product development, working with artists, independent designers and large fashion houses to create new products and develop processes to manufacture them at scale.

POTENTIAL PARTNERS

Local Electronics Manufacturing Partners	Corporate Partners	Emerging Technology Partners
LeeMah	Autodesk*	Plethora*
Bestronics	Seimens	Tempo Automation*
Jabil	DMG/Mori	Carbon3D
Flex	Haas	3DEO
Sanmina	Kuka	Electroloom*
Essai	Festo	Rethink Robotic

*San Francisco Based

NEXT STEPS

- Gather a group of stakeholders in the field to assist in business model development and contract manufacturer relationship building.
- Consider alternative business models such as partnering with incubators or corporations to stabilize the sales pipeline and allow for a diversity of client companies.
- Research foreign and American contract manufacturers to find those that would benefit from a location in the Bay Area.
- Develop a real estate strategy to help offset the cost of locating inside of San Francisco.

Increase Advanced Manufacturing Awareness

OPPORTUNITY/NEED

The manufacturing sector continues to be a viable career choice in the Bay Area with many jobs becoming cleaner and safer over the last 20 years. However, there is a lack of visibility around the continuing opportunity provided by manufacturing locally. While there are good regional educational opportunities for those interested in manufacturing, high school students have little exposure to these careers and are often not aware that they provide a stable and potentially lucrative career path.

To address this issue, SFMade has created YouthMade, two linked programs that build awareness and interest in manufacturing careers in San Francisco: a paid summer internship program in collaboration with Jewish Vocational Services and a career exposure program for CTE classrooms called Inside Manufacturing. Currently, YouthMade as a whole serves 100 high school students a year.

The Bay Area has other STEM and Maker focused youth programs, but the only other manufacturing specific program for high school students is in the East Bay at Laney College, the Introduction to Manufacturing programs are funded by a combination of the Alameda County Workforce Investment Board, the Deputy Sector Navigator grant and corporate funders.

RECOMMENDATION

Increase awareness of modern manufacturing careers in young people by expanding SFMade's YouthMade programs. These two programs expose public high school students to manufacturing facilities and place them in paid summer internships in those manufacturers.

These programs are both well established and already in the process of expanding. To continue their expansion, YouthMade needs funding for program development, outreach and coordination with more schools and manufacturers. The program is currently funded by a combination of the Office of Economic and Workforce Development and the Department of Children, Youth and Their Families.

PROGRAM EXAMPLES

YouthMade Inside Manufacturing, San Francisco, CA

Launched in 2013, Inside Manufacturing exposes high school students to the manufacturing sector in San Francisco through both educational and experiential elements. High school students in CTE classes at Washington High School, Burton High School and John O'Connell High School tour multiple businesses during the academic year, hear directly from business owners about what it takes to run their operations, and participate in hands-on workshops. This year, SFMade is introducing the first ever Inside Manufacturing curriculum, which will give context for the field trips by exploring the manufacturing process.¹²⁹

YouthMade Paid Summer Internships, San Francisco, CA

YouthMade gives low-income youth direct work experience inside small, urban manufacturing businesses. During their internship, youth get to know local entrepreneurs, build their professional skills and experience and have the opportunity to see themselves in a manufacturing career. Since 2013, 110 high school students have been placed in paid internships through the program.¹³⁰

POTENTIAL PARTNERS

Potential partners include, Enterprise for High School Students, Jewish Vocational Services, the Office of Economic and Workforce Development, the Department of Children, Youth, and Their Families and United Way of the Bay Area. The expansion of YouthMade itself will be lead by SFMade, as this is an existing SFMade program.

NEXT STEPS

- Identify sources for increased funding for program development and expansion.
- Hire an additional staff member to manage the expansion.
- Identify additional CTE classrooms/teachers who want to participate.
- Increase outreach to potential YouthMade participants and manufacturers.

Improve Small Business Assistance For Advanced Manufacturers

OPPORTUNITY/NEED

Small hardware and advanced manufacturers report that they have trouble finding information about legal operation within the city. In particular, information on permitting and compliance is cited as a barrier to operating within San Francisco.

The City of San Francisco already has a robust system for disseminating operations information to small businesses, including information on permitting, inspections, ADA compliance and more. [The San Francisco Business Portal](#) houses information for businesses ranging from catering to salons to doctor's offices and could be expanded to include even more manufacturing subsectors.

RECOMMENDATION

Promote new advanced manufacturing business growth by increasing manufacturer awareness of permitting and financing options and making it easier for them to comply with regulations by:

- Expanding the San Francisco Business Portal to include permits for hardware, electronics, machining and assembly.
- Creating a starter kit for hardware/electronics manufacturing.
- Creating a growth handbook for small businesses covering regulatory changes as revenue and employee numbers increase.
- Adding a tax incentives (local, state and national) category to the “Finance Your Business” section of the San Francisco Business Portal.
- Adding and updating a current grants category to the “Finance Your Business” section of the San Francisco Business Portal.
- Increasing clarity around VOC and air quality regulation by adding VOC regulations to the to the San Francisco Business Portal and by creating a list of commonly used chemicals, whether they are allowed in San Francisco and how to mitigate their use.
- Increasing the visibility of, and outreach around, the Business Portal among potential hardware and advanced manufacturers.

The Office of Economic and Workforce Development has indicated that the addition of more information on hardware, electronics and advanced manufacturing would be beneficial and is interested in posting this information on the Business Portal.

PROGRAM EXAMPLES

SF Business Portal, San Francisco, CA

The San Francisco Business Portal is a one stop shop for small business needs, including information permitting, fundraising and paying taxes. The Business Portal is the City’s primary online business resource. With comprehensive information about starting a business in San Francisco, the Portal helps companies navigate the steps to start, manage, and grow a business, and learn what it takes to be compliant. Manufacturing industries such as breweries and cut and sew are already represented on the Business Portal.¹³¹

Food and Beverage Manufacturing Sector Starter Kit, San Francisco, CA

Starter Kits on the San Francisco Business Portal provide all the relevant permits, resources and guides available to help foster the creation of a new business. Kits have been created for a variety of sectors including bars, salons, retail stores and food and beverage manufacturers. They include as much relevant information for a specific sector as possible in a single location.

POTENTIAL PARTNERS

The Office of Economic and Workforce Development would lead the effort with the assistance from partners such as Pacific Community Ventures, the Renaissance Entrepreneurship Center, SFMade and other government and regulatory partners such as the Bay Area Air Quality Management District.

NEXT STEPS

- City agencies to work on resources listed above.

Formalize Manufacturing Real Estate Matchmaking

OPPORTUNITY/NEED

In San Francisco, where most of the manufacturing businesses are small—companies with 1-4 employees make up over 80% of SFMade’s membership—spaces between 1-2,000 sq ft are the most sought after. Much of the affordable real estate in the city are spaces over 7,000 sq ft and making it easier for small businesses to share these spaces would allow San Francisco’s smaller manufacturers to take advantage of their affordable prices. In addition, PlaceMade has found that there are unused spaces in existing manufacturing facilities throughout the city that could house one or more small companies.

Places to Make, SFMade’s industrial real estate service, already serves as a link between available industrial spaces and SFMade member companies. The service also lists spaces for sublet and makes introductions between companies to encourage the sharing of space. Currently, Places to Make only works with SFMade members or “pre-members” (those who would qualify as members if they found space in San Francisco). Therefore, only a specific subset of the PDR population is eligible to use their services.

RECOMMENDATION

Formalize the work that Places to Make does to introduce small manufacturers and encourage the sharing of larger spaces. Under the auspices of PlaceMade create an online matchmaking service for small industrial businesses that are interested in sharing space or subletting space they have already secured. To reach the widest possible audience the matchmaking service should be open to anyone who qualifies as PDR: manufacturers, artists, custom builders, repair companies, etc.

Create a web-portal that provides the following services:

- A location where people/companies can meet each other.
- A searchable database of people/companies who are looking for space.
- A way for people/companies to ensure they are compatible: an intake form with automated matching and filtering.
- The infrastructure for people/companies to work together: a standard agreement between renters and a list of clarifying questions such as who holds the lease, how are utilities split, times of use, noise, noxious chemicals, etc.
- The infrastructure for people/companies to work with landlords: a standard agreement for multi-tenant rentals, subletting agreements, etc.
- Services for finding a space: Places to Make, public listings, etc.

To test the viability of the matchmaking service, run a pilot program that includes:

- Creating an intake form (process manually).
- Making real estate listings available on Places to Make website (automate listing).
- Campaigning to publicize service.

PROGRAM EXAMPLES

SFMade Job Board, San Francisco, CA

The SFMade job board acts as an intermediary between manufacturing companies and potential employees. It lists jobs at SFMade companies and promotes those jobs to both the SFMade network of workforce partners and to SFMade’s followers. SFMade’s staff then assists companies with pre-screening, scheduling interviews and hiring incentives. They also do significant outreach on behalf of populations with barriers to employment. The job board is an example of a low-filter, high-touch online listing portal.

Sublease.com

Sublease.com is an online listing platform for commercial subleases. However, it does not specialize in industrial real estate and has become a traditional classified. Sublease.com was developed for non-traditional commercial spaces: those with smaller sizes or shorter lease term lengths. They provide no matching services. It is an example of a low-touch online listing portal for a specific community.¹³²

POTENTIAL PARTNERS

The effort would be coordinated by PlaceMade. Potential partners could include American Industrial Center, ActivSpace, Eclectic Cookery, Hunt Projects, SFMade, Urban Solutions, Working Solutions.

NEXT STEPS

- Determine how to track and show success.
- Investigate funding opportunities for a pilot program.
- Work with a database architect and UI developer to create a mock up of the portal and database.
- Conduct outreach to existing PDR businesses about the benefits subletting.
- Conduct outreach to commercial landlords about benefits of shared space.

SUMMARY LIST OF PROPOSED RECOMMENDATIONS FOR THE ADVANCED MANUFACTURING SECTOR

1. Strengthen the regional advanced manufacturing sector and rebuild San Francisco’s connection to the ecosystem

Strategy: Recommendations focus on San Francisco’s disconnection from the regional advanced manufacturing ecosystem. They are intended to support and expand the existing advanced manufacturing supply chain while allowing San Francisco to become a leader in the planning processes for future manufacturing policy.

Recommendation	Description	Difficulty	Impact	Time
		1 = LEAST	4 = MOST	
Regional Advanced Manufacturing Strategy	Create a collaborative initiative across manufacturing cities in the Bay Area to create a regional advanced manufacturing strategy.	3	4	2-5 years
State Advanced Manufacturing Strategy	Engage with the existing efforts to create a cohesive statewide advanced manufacturing strategy.	3	2	1-2 years
Local Supply Chain Strategy	Formulate a strategy to increase transparency and access to the local advanced manufacturing supply chain.	2	3	1-2 years
Priority Industrial Real Estate Strategy	Facilitate the advancement of a regional land use strategy using the upcoming ABAG <i>Industrial Land and Jobs Study</i> .	2	4	2-5 years
Manufacturing Operations Advising Strategy	Create a manufacturing operations advising strategy to deliver more services and to promote existing services.	2	2	< 1 year
Modernize Manufacturers	Generate a plan to modernize existing manufacturers and to improve outreach about existing programs.	4	4	> 5 years

2. Address San Francisco’s specific infrastructure weaknesses to grow the low-volume advanced manufacturing sector

Strategy: Recommendations are intended to address specific weaknesses in the city’s advanced manufacturing landscape, allowing the low-volume manufacturing sector to grow. Increasing both the amount of manufacturing and the types of manufacturing will encourage existing hardware, electronics, medical device and other product companies to keep their short-run manufacturing and prototyping local. Weaknesses addressed include: supply chain, real estate and preconceptions about manufacturing in San Francisco, among others.

Recommendation	Description	Difficulty	Impact	Time
		1= LEAST	4= MOST	
National Advanced Manufacturing Policy	Engage with existing efforts to encourage and expand advanced manufacturing in the United States.	3	2	1-2 years
Local Advanced Manufacturing Promotion	Publicize opportunities provided by San Francisco and the benefits of co-locating design and manufacturing.	2	2	2-5 years
Cultivate Contract Manufacturing	Attract a comprehensive advanced manufacturing services provider to San Francisco.	4	4	> 5 years
Expanding Access to Tools	Increase access to advanced manufacturing tools through subsidized TechShop memberships and classes.	2	2	2-5 years
Incubator Education	Educate incubators/makerspaces about local manufacturing and connect their members/alumni to existing resources.	2	3	2-5 years
Local Growth	Create a strategy to fund early-stage hardware companies that commit to local manufacturing.	4	3	> 5 years
Small Business Assistance for Manufacturers	Increase advanced manufacturer awareness of local permitting and financing options and make it easier for them to comply.	1	4	< 1 year
Appropriate Real Estate for Small Manufacturing	To keep small manufacturing businesses in San Francisco create suitably sized, affordable real estate.	4	4	> 5 years
Manufacturing Real Estate Matchmaking	Create a real estate matchmaking service for small manufacturing businesses that are interested in sharing space.	1	3	< 1 year
Affordable Industrial Real Estate	Expand PlaceMade or a similar non-profit industrial developer to build/secure affordable industrial real estate.	4	4	> 5 years
Increase Shared Transit Options	To increase access, continue improving transit access to the Bayview.	3	3	2-5 years

3. Increase awareness of advanced manufacturing as a career path and address the shortage of technical training within the city

Strategy: These recommendations address the expansion of technical education for both youth and adults, as well as the promotion of manufacturing as a viable career choice.

	Recommendation	Description	Difficulty	Impact	Time
			1 = LEAST	4 = MOST	
YOUTH ORIENTED	Advanced Manufacturing Awareness	Increase awareness of advanced manufacturing careers by expanding Inside Manufacturing and the YouthMade Internship Program	1	3	1-2 years
	Youth Access to Makerspaces	Build, program, and support a robust ecosystem of makerspaces intended for youth.	2	3	1-2 years
	Advanced Manufacturing Education Integration	Integrate advanced manufacturing into secondary education to build knowledge and related competencies.	4	4	> 5 years
	Advanced Manufacturing Pathway	Create an advanced manufacturing educational pathway, integrating secondary and post-secondary education.	4	2	> 5 years
	Marketing Advanced Manufacturing	Support the regional Dream it, Do it campaign and an upcoming online marketing campaign.	2	3	1-2 years
ADULT ORIENTED	Increase Access to Post-Secondary Manufacturing Training	Increase access to manufacturing training through partnerships with Laney and De Anza Community Colleges.	2	4	1-2 years
	Manufacturing Specific Work Readiness Program	Create a manufacturing oriented, contextualized soft-skills training program.	4	3	> 5 years
	Regional Job Board	Create a regional online job board for manufacturing and technical positions.	2	4	2-5 years

APPENDIX I

Advanced Manufacturing Technologies

Advanced manufacturing technologies include but are not limited to:

- Additive Manufacturing (3D Printing)
- Automated Material Handling Systems
- Advanced Material Processing/Manufacturing
- Computer-Aided Design (CAD)
- Computer-Aided Manufacturing (CAM)
- Computer-Integrated Manufacturing (CIM)
- Computer-Numerically Controlled (CNC) Machines
- Digital Thread (DT)
- Embedded Sensing, Industrial Internet of Things Integration (IIoT)
- Flexible Manufacturing Systems (FMS)
- Manufacturing Resource Planning (MRP II)
- Optimized Production Technology (OPT)
- Industrial Robotics

APPENDIX II

Reshoring¹³³

Top Reshoring Industries

	Percent Cases
Electrical Equipment, Appliance, & Component Manufacturing	15%
Transportation Equipment Manufacturing	15%
Apparel Manufacturing	12%
Computer & Electronics Product Manufacturing	10%
Miscellaneous Manufacturing	7%
Plastics & Rubber Products Manufacturing	7%
Machinery Manufacturing	5%
Fabricated Metal Product Manufacturing	5%
Primary Metal Manufacturing	3%
Furniture & Related Product Manufacturing	3%
Chemical Manufacturing	2%
Other Manufacturing	8%
Other Non-Manufacturing	8%

Top 10 Reasons for Reshoring

	Percent Mentions
Delivery Time Improvement	30%
Quality Improvement	29%
Image/Brand (prefer US)	20%
Freight Cost Improvement	20%
Wage Cost Improvement	20%
Total Cost Ownership	17%
Energy Cost Improvement	14%
Government Incentives	14%
Innovation/Product Differentiation Improvement	13%
Higher Productivity	13%

Federal Initiatives to Support Advanced Manufacturing

Program	Launched	Description
EERE Advanced Manufacturing Office (AMO)	1976	The AMO “partners with industry, small business, universities, and other stakeholders to identify and invest in emerging technologies with the potential to create high-quality domestic manufacturing jobs and enhance the global competitiveness of the United States.” ¹³⁴
Skills for America’s Future	2010	Partnership with National Association of Manufacturers to give industry recognized credentials to 500,000 workers over five years.
Advanced Manufacturing National Program Office (AMNPO)	2011	Interagency office charged with: <ul style="list-style-type: none"> • Convening and enabling industry-led, private-public partnerships focused on manufacturing innovation and engaging U.S. universities, and • Designing and implementing an integrated whole of government advanced manufacturing initiative to facilitate collaboration and information sharing across federal agencies.¹³⁵
Advanced Manufacturing Partnership Steering Committee	2011	Launched by the White House in 2011, released two reports, “Report To The President On Capturing Domestic Competitive Advantage In Advanced Manufacturing,” July 2012 and “Report To The President Accelerating U.S. Advanced Manufacturing,” October 2014. These reports recommended many programs that have since been implemented, such as AMNPO and manufacturing.gov.
Material Genome Initiative	2011	“A multi-agency initiative designed to create a new era of policy, resources, and infrastructure that support U.S. institutions in the effort to discover, manufacture, and deploy advanced materials.” ¹³⁶
National Strategic Plan for Advanced Manufacturing	2012	A national innovation policy designed to reduce the gap between R&D and deployment of advanced manufacturing innovation.
Right Skills Now	2012	Partnership with the National Manufacturing Institute to create fast track certification programs at the community college level.
Advanced Manufacturing Technology Consortia (AmTech)	2013	AmTech is “a competitive grants program intended to establish new or strengthen existing industry-driven consortia that address high-priority research challenges impeding the growth of advanced manufacturing in the United States. As of July 2015, thirty-five AMTech Planning Awards have been awarded.” ¹³⁷ It is a program of AMNPO.
American Energy & Manufacturing Competitiveness (AEMC) Summit	2013	Co-hosted by the Department of Energy, the AEMC Summit is a gathering of industry leaders to discuss “critical national imperatives in manufacturing and energy.” ¹³⁸
Investing in Manufacturing Communities Partnership (IMCP)	2013	A program of the Economic Development Association (EDA). In 2014 and 2015, the partnership designated 12 communities each year as “manufacturing communities.” Funds are meant to build a stronger local ecosystem, including research, workforce training and retraining, supply chain development, etc.
Manufacturing USA (National Network for Manufacturing Innovation)	2013	An interagency initiative to provide “a manufacturing research infrastructure where U.S. industry and academia collaborate to solve industry-relevant problems. Manufacturing USA is a network of Institutes for Manufacturing Innovation that each has a unique focus, but a common goal to create, showcase, and deploy new capabilities and new manufacturing processes.” ¹³⁹
Manufacturing.gov	2014	A central clearinghouse for National Advanced Manufacturing Initiatives as required by the 2014 the Revitalize American Manufacturing and Innovation Act.
Department of Energy Small Business Vouchers Pilot	2015	Vouchers for small renewable energy companies to access the advanced manufacturing facilities of the National Lab system.
MForesight	2015	MForesight housed at the University of Michigan, “serves as the voice of the national advanced manufacturing community to the public and provides the federal government with intelligence about emerging technologies to shape priorities for future federal and private sector investment and set the trajectory of U.S. advanced manufacturing.” ¹⁴⁰
Oak Ridge Manufacturing Demonstration Facility (MDF)	ongoing	The MDF exists to “provide industry with affordable and convenient access to facilities, tools and expertise to facilitate rapid deployment of advanced manufacturing technologies to enhance the competitiveness of U.S. manufacturing.” ¹⁴¹

Federal Initiatives to Support “Making”

Program	Launched	Description
Annual White House Maker Faire	2014	A science fair/carnival for Makers.
Congressional Maker Caucus	2014	Bipartisan caucus co-chaired by U.S. Representatives Mark Takano (D-CA), Steve Stivers (R-OH), Tim Ryan (D-OH), Mick Mulvaney (R-SC).
Mayor’s Maker Challenge	2014	White House call to action before first White House Maker Faire. Over 100 mayors participating, including Mayor Ed Lee of San Francisco.
Nation of Makers Initiative	2015	White House initiative to get the public excited about STEM through the Maker Movement. Dozens of programs highlighted throughout the nation.
National Week of Making	2015	Coinciding with the 2015 White House Maker Faire, the National Week of Making involved several hundred events organized by dozens of governmental organizations.

APPENDIX IV Manufacturing USA (National Network for Manufacturing Innovation)

Name	Location	Concentration
Advanced Functional Fabrics of America	Boston, MA	Textiles and Composites
AIM Photonics	Santa Barbara, CA	Integrated Photonics
America Makes	Youngstown, OH	3D Printing and additive manufacturing
DMDII	Chicago, IL	Digital Manufacturing and Design
IACMI	Knoxville, TN	Composites Manufacturing
LIFT	Detroit, MI	Lightweight Metal Manufacturing
NextFlex	San Jose, CA	Flexible Hybrid Electronics
Power America	Raleigh, NC	Wide Bandgap Semiconductors
Smart Manufacturing Leadership Coalition	Los Angeles, CA	Clean Energy Smart Manufacturing

Program	Description	Location
Advanced Manufacturing Workforce Development Council	Founded in 2013 to develop a strategy to prepare a globally competitive, highly skilled workforce.	CA
California Alternative Energy and Advanced Transportation Financing Authority Sales and Use Tax Exclusion (STE)	SB 71 and SB 1128: STE on property purchased for advanced manufacturing project, eligible until June 30, 2016	CA
California Career Pathways Trust	Established in 2013 to provide funding to motivate the development of sustained kindergarten through grade fourteen (K–14) career pathways programs that connect businesses, schools, and community colleges together in order to better prepare students for the 21st century workplace.	CA
California Centers for Excellence	Workforce development and needs assessment for community colleges.	CA
California Community Colleges Economic and Workforce Development Program	Workforce services coordinated by regional Deputy Sector Navigators. Goals include identifying and filling gaps in community college curricula with the help of industry partners and attract-ing more students to career paths in manufacturing and other technical areas.	CA
California Network for Manufacturing Innovation	Collaboration between, CMTC, LBNL, LLBL, Manex, USC, UCI and others to support and advance the manufacturing ecosystem in California. Special attention given to smart manufacturing and additive manufacturing.	CA
Centers for Applied Competitive Technologies (CACT)	“The San Francisco CACT offers a wide range of technical assistance, consulting services, and customized workforce development training to companies located in San Francisco, North and East Bay areas. Our technology-related trainings focus on digital design tools for industrial and product designers, as well as the sewn products industry.” ¹⁴²	CA
iHub	Go Biz network of 16 state centers, including one in San Francisco, to promote innovation and partnership in healthcare, manufacturing and aerospace.	CA, San Francisco
Advanced Manufacturing Partnership of Southern California Manufacturing Community	Founded in 2014 to create a regional strategy to promote advanced manufacturing through workforce training, supplier development, infrastructure development, and access to capital.	Southern CA
Bay Area Community College Consortium	Developing 28 programs to increase alignment between training and industry needs.	Bay Area
Bay Area Machinist Apprenticeship	Apprenticeship program at Chabot College, De Anza College, and Laney College. Partnership with the California Tooling & Machining Association and the International Association of Machinists.	Oakland, Cupertino, Hayward
The Advanced Manufacturing Jobs and Innovation Accelerator Challenge	East Bay regional partnership (Manex and Laney College) to accelerate innovation in biomedical manufacturing.	Oakland
East Bay Advanced Manufacturing Partnership	Founded in 2014 to be a vehicle for East Bay manufacturers to set priorities and work with a range of partner organizations at a single table to strengthen manufacturing, build awareness of jobs and salaries throughout the East Bay	Oakland

Bay Area Advanced Manufacturing Resources**East Bay:**

- Bay Area Machinist Apprenticeship: a joint program with Laney College in Oakland, Chabot College in Hayward and De Anza College in Cupertino.
- Design it, Build it, Ship it: “a 4-year, \$14.9 million U.S. Department of Labor-funded initiative in the East Bay under the Obama Administration’s Trade Adjustment Assistance Community College Career Training program (TAACCCT). The goal of DBS is to build an integrated, regional, industry-driven workforce development system in the East Bay.”¹⁴³
- East Bay Advanced Manufacturing Partnership: industry cluster working group
- i-GATE: co-working space and incubator with a small makerspace supported by of the City of Livermore, Sandia National Laboratory and Lawrence Livermore National Laboratory.
- Warm Springs Innovation District: a plan to “facilitate the creation of a vibrant, urban, mixed-use district in the vicinity of the Warm Springs/South Fremont BART station. The goal of the plan is to provide a thriving employment center focused on innovation and advanced manufacturing...”¹⁴⁴

South Bay:

- Bay Area Machinist Apprenticeship: joint program with Laney College in Oakland, Chabot College in Hayward and De Anza College in Cupertino.
- NextFlex: The Flexible Hybrid Electronics Manufacturing Institute founded with assistance from the federal government as part of the Manufacturing USA network. NextFlex will fund the development of products and manufacturing techniques to help commercialize hybrid electronics products.

North Bay:

- California Tooling and Machining Apprenticeship: NIMS accredited machining apprenticeship program at Petaluma High School and Santa Rosa Junior College
- Soco Nexus: a mentoring and business development non-profit in Rohnert Park. Focus on startups working on sustainable resources, medical technology, cloud-based technology and manufacturing.
- 101MFG: a supply chain and manufacturing engineering consultancy based in Santa Rosa.

San Francisco:

- See Part 2 of this report for a detailed breakdown of the resources available in San Francisco.

San Francisco Hardware Meetups:
within 5 miles of San Francisco and over 100 members¹⁴⁵

Name	Members
San Francisco Hardware Startup Meetup	5,502
San Francisco Internet of Things Meetup	4,329
Mobile Monday Silicon Valley	4,148
SF Wearables	1,639
Bay Area Pebble Meetup	1,519
Bay Area Factory Tours	1,498
San Francisco Bay Area Robotics Group	1,350
Wearable Technology Startup	1,231
Hardware Developers Didactic Galactic	699
Hardware Club	579
Hackster Hardware Meetup Bay Area	564
3D Hubs San Francisco	552
Bluetooth Low Energy Meetup	513
SF Internet of Things Stack Meetup	511
IDSF San Francisco	481
San Francisco Fusion 360 Meetup	435
Wearable Wednesday SF	412
Bay Area Modular Electronics Meetup	410
Hardware Startup Lab Silicon Valley	378
Home Automation San Francisco	342
ManyLabs Meetup	188
SF Digital Fabrication Meetup	174
Onshape Users-San Francisco	144
Raspberry Pi Users Group	140
Women in Hardware*	137
Talking Robots	135
IoT/Wearable Founders Connect	131
Women in IoT	129
Machine Learning for Hardware	111

*Facebook rather than Meetup.com group,
also based in Boston and New York.

Leading Hardware Incubators/Accelerators

Name	Type	Detail	Location	Surveyed
Revvx	Incubator	Hardware	Bangalore, India	
Cyclotron Road	Incubator	Energy	Berkeley, CA	
Hardware.co	Incubator	Hardware	Berlin, Germany	
Greentown Labs	Incubator	Hardware	Boston, MA	
Tandem	Incubator	Hardware	Burlingame, CA	
CIID Nest	Incubator	Hardware	Copenhagen, Denmark	
Next VC/InfinitiLab	Incubator	Transportation	Hong Kong	
Brinc	Incubator	Hardware/IoT	Hong Kong	
Makers Bootcamp	Incubator	Hardware	Kyoto, Japan	
LA Dodgers Sports and Entertainment Accelerator with R/GA	Incubator	Sports Hardware	Los Angeles, CA	
Los Angeles Clean Tech Incubator	Incubator	Clean-Tech	Los Angeles, CA	
Make it in LA	Incubator	Hardware	Los Angeles, CA	
Flex Lab IX	Incubator	Hardware	Milpitas, CA	
Techfounders	Incubator	Hardware	Munich, Germany	
New Lab	Co-working	Hardware	New York, NY	
R/GA IOT Accelerator	Incubator	IoT	New York, NY	
Zahn Innovation Center	Incubator	Hardware/Software	New York, NY	
Next Top Makers	Incubator	Hardware	New York, NY	
Shenzhen Valley Ventures	Incubator	Hardware	Palo Alto, CA	
Start X	Incubator	Hardware/Software	Palo Alto, CA	
AlphaLab Gear	Incubator	Hardware	Pittsburgh, PA	
Qualcomm Robotics Accelerator	Incubator	Robotics	San Diego, CA	
Autodesk Pier 9	Artist Residency	Technology enabled art	San Francisco, CA	
Hax Boost	Incubator	Hardware-Logistics/Distribution	San Francisco, CA	
Highway1	Incubator	Hardware	San Francisco, CA	✓
Lemnos Labs	Micro-VC	Hardware	San Francisco, CA	✓
Orange Fab	Incubator	IOT only	San Francisco, CA	✓
PCH Access	Incubator	Hardware	San Francisco, CA	
R/GA Connected Commerce Accelerator	Incubator	Commerce Hardware	San Francisco, CA	
Rocket Labs	Co-working	Hardware	San Francisco, CA	
UCSF Pediatric Device Consortium	Incubator	Medical Device	San Francisco, CA	
UCSF Surgical Innovations Lab	Incubator	Medical Device	San Francisco, CA	✓
Wearable World Labs	Incubator	Wearables/IoT	San Francisco, CA	✓
QB3	Incubator	Medical Device	San Francisco and Berkeley, CA	
Bolt	Micro-VC	Hardware	San Francisco, CA and Boston, MA	✓
500 startups	Incubator	Hardware/Software	San Francisco, CA, Mountain View, CA and Mexico City, Mexico	
Y Combinator	Incubator	Hardware/Software	San Francisco and Mountain View, CA	✓
Prospect Silicon Valley	Incubator	Energy/Transportation	San Jose, CA	
InnoSpace	Incubator	Hardware	Shanghai, China	
Hax	Incubator	Hardware	Shenzhen, China	
Enchant	Incubator	Hardware	Singapore	
Buildit	Incubator	Hardware	Tartu, Estonia	
Industrio	Incubator	Hardware	Trento, Italy	
Techstars	Incubator	Hardware/Software	Various Locations	

Name	Category	Detail
219 Design	Product Design	Mechanical and Electrical Engineering
Advanced Prototype Engineering	Product Design	Mechanical Engineering
Astro Studio	Product Design	Industrial Design
Character	Product Design	Branding
Cooper Perkins	Product Design	Mechanical and Electrical Engineering
Flex Invention Lab	Product Design	Mechanical and Electrical Engineering
Frog Design	Product Design	Industrial Design
fuseproject	Product Design	Industrial Design
IDEO	Product Design	Industrial Design
PCH Lime Lab	Product Design	Mechanical and Electrical Engineering
Lunar	Product Design	Industrial Design and Mechanical Engineering
Matter	Product Design	Industrial Design
Place Droid	Product Design	Electrical Engineering
Radicand	Product Design	Mechanical and Electrical Engineering
Synapse	Product Design	Mechanical and Electrical Engineering
Think2Build	Product Design	Mechanical Engineering
New Deal Design	Product Design	Industrial Design
Blue Clover Devices	Operations	Supply Chain Management
Ops on Tap	Operations	Supply Chain Management
VSC Consulting	Operations	Business Strategy and Marketing

Advanced Manufacturing Education

Local Universities and Colleges with Advanced Manufacturing Relevant Curriculum

School	Location	Focus
University of California	Berkeley	Engineering, Research focus
De Anza College	Cupertino	Drafting, Machining, Electronics
Ohlone College	Fremont	Engineering, Electronics
Cal State East Bay	Hayward	Engineering
Chabot College	Hayward	Engineering, Machining, Electronics
College of Marin	Kentfield	Machining, Electronics
Las Positas College	Livermore	Machining, Electronics
Laney College	Oakland	Drafting, Machining, Engineering, Electronics
Sanford	Palo Alto	Engineering, Design, Research focus
Los Medanos	Pittsburgh	Machining, Electronics
Diablo Valley College	Pleasant Hill	Engineering, Machining, Electronics
Skyline College	San Bruno	Engineering, Electronics
Academy of Art University	San Francisco	Industrial Design
California College of Art	San Francisco	Industrial Design
City College of San Francisco	San Francisco	Engineering, Electronics
San Francisco State University	San Francisco	Engineering, Industrial Design
University of San Francisco	San Francisco	Engineering, STEM education
Evergreen Valley College	San Jose	Drafting, Engineering, Design
San Jose City College	San Jose	Machining
San Jose State	San Jose	Engineering, Industrial Design
College of San Mateo	San Mateo	Drafting, Engineering, Electronics
Sonoma State	Sonoma	Engineering

San Francisco High Schools with Advanced Manufacturing Relevant Curriculum

School	Public	Program	Length	Hands on?	CAD?
Abraham Lincoln High School	Yes	ACE: Art, Architecture and Construction Engineering	8 sem.	Y	Y
Asawa School of the Arts	Yes	Architecture	8 sem.	Y	Y
George Washington High School	Yes	Automotive Technologies	2 sem.	Y	N
John O'Connell High School*	Yes	Building and Construction Trades, Environmental Technology	2 sem.	Y	N
June Jordan High School	Yes	Makerspace	1 sem.	Y	Y
Lick-Wilmerding High School	No	Technical Arts	a la carte	Y	Y
Lowell High School	Yes	Computer Science	6 sem.	Y	N
Phillip and Sala Burton High School	Yes	Engineering	6 sem.	Y	Y
St. Ignatius College Preparatory School	No	Robotics	3 sem.	Y	Y
The Urban School	No	Makerspace	Club	Y	Y

Informal Education Locations in San Francisco

Name	Category	Detail
Autodesk Pier 9 Artist in Residence	Artist Residency	Artists
Double Union	Makerspace/Hackerspace	Women
Exploratorium Explainers	Educational Institution	Apprenticeship/Internship
Exploratorium Tinkering Studio	Makerspace/Hackerspace	Youth
Inside Manufacturing	Educational Institution	Apprenticeship/Internship
Instructables	Media	Makers/How To
Maker Media	Media	Makers/How To
Mission Science Workshop	Makerspace/Hackerspace	Youth
NoiseBridge	Makerspace/Hackerspace	Electronics/Hardware
Rokit Colabs	Makerspace/Hackerspace	Hardware/IoT
Shared	Makerspace/Hackerspace	General
TechShop	Makerspace/Hackerspace	General
The Mix @ San Francisco Public Library	Makerspace/Hackerspace	Youth
The BoxShop	Makerspace/Hackerspace	Artists
Workshop SF	Makerspace/Hackerspace	Craft
YouthMade	Educational Program	Apprenticeship/Internship

APPENDIX X

Makerspaces in San Francisco Public Schools*

School Level	School Name
Elementary	Alamo
Elementary	Chinese Immersion School at de Avila
Elementary	Francis Scott Key
Elementary	John Muir
Middle	A.P. Giannini
Middle	Aptos
Middle	Hoover
Middle	Paul revere
Middle	Roosevelt
Middle	Willie Brown
High	Balboa
High	Hilltop
High	Mission

*Incomplete. Updated September, 2016.

San Francisco Based Hardware Companies*

Company name	Website	Product
Aetho	http://aetho.co/	Stabilizer
Anki	https://anki.com/en-us	Robotic Toys
August	http://august.com/	Smart Lock
Autodesk, Ember	https://ember.autodesk.com/	3D Printer
BACtrack	http://www.bactrack.com/	Smart Breathalyzer
Bellabeat	https://www.bellabeat.com/	Fitness Tracker
birdi	http://getbirdi.com/	Smoke Detector
boombotix	https://boombotix.com/	Speakers
Carbon Robotics	http://www.carbon.ai/	Automation
CellScope	https://www.cellscope.com/oto	Smart Thermometer
Compology	http://compology.com/	Tracking
emberlight	http://www.emberlight.co	Smart Bulb
FitBit	https://www.fitbit.com/	Fitness Tracker
Helium	https://www.helium.com/	Sensing
Hello	https://hello.is/3	Smart Alarm
Here One	https://hereplus.me/	Headphones
Jawbone	https://jawbone.com/	Fitness Tracker
June	https://juneoven.com/	Smart Oven
Kinsa	https://kinsahealth.com	Smart Thermometer
Lattis	http://www.lattis.io	Smart Lock
Leap Motion	https://www.leapmotion.com/	Motion Controller
Lily	https://www.lily.camera/	Camera
Lively	http://www.mylively.com	Senior Tracking
Lumio	http://www.hellolumio.com/	Lamp
Momentum Machines	http://momentummachines.com/	Automated Food Service
Moxxly	http://www.moxxly.com/	Breast Pump
Navdy	https://www.navdy.com/	Heads Up Display
OpenBike	https://openbike.com/	Bicycle
Orion Labs	http://www.orionlabs.co	Communication
Pantry	http://www.pantryretail.com	Vending Machine
Particle	https://www.particle.io/	DevKit
Podob	http://www.podolabs.com	Camera
Ractiv	http://www.ractiv.com/	Touchscreen
Revolve Robotics	https://www.revolverobotics.com	Telepresence
SeeSpace	http://seespace.co/company.html	Smart TV
SkyCatch	https://www.skycatch.com/	Drones
Spire	https://spire.com/	Weather Tracking
Sproutling	http://www.sproutling.com/	Tracking
Square	https://squareup.com	Mobile Payment
Sutro	http://www.mysutro.com/	Pool Monitor
Thermodo	http://thermodo.com/	Smart Thermometer
Vibease	https://www.vibease.com/	Smart Vibrator
Vigo	http://www.wearvigo.com/	Bluetooth Headset
Whistle	http://www.whistle.com/	Tracking

*Incomplete. Updated September, 2016.

APPENDIX XII Job and Location Quotient in San Francisco Advanced Manufacturing Industries¹⁴⁶

NAICS Code	Description	2010 Jobs	2015 Jobs Δ	2010-2015 % Δ	2010-2015	2020 Jobs Δ	2015-2020 % Δ	2015-2020	2010 Location Quotient	2015 Location Quotient	2020 Location Quotient
3254	Pharmaceutical and Medicine Manufacturing	157	358	201	128%	566	208	58%	0.13	0.26	0.38
3272	Glass and Glass Product Manufacturing	11	46	35	318%	52	6	13%	0.03	0.11	0.14
3325	Hardware Manufacturing	13	28	15	115%	32	4	14%	0.13	0.24	0.33
3329	Other Fabricated Metal Product Manufacturing	13	31	18	138%	42	11	35%	0.01	0.02	0.03
3341	Computer and Peripheral Equipment Manufacturing	326	1,380	1,054	323%	1,778	398	29%	0.48	1.77	2.47
3342	Communications Equipment Manufacturing	469	757	288	61%	1,281	524	69%	0.94	1.78	3.45
3345	Navigational, Measuring, Electromedical, and Control Instruments Manufacturing	83	180	97	117%	233	53	29%	0.05	0.10	0.12
3359	Other Electrical Equipment and Component Manufacturing	13	42	29	223%	42	0	0%	0.03	0.07	0.07
TOTAL		2024	3479	1455	72%	4537	1058	30%			

APPENDIX XIII Contract Manufacturers in San Francisco Using Advanced Technologies

Name	Category	SFMade
3D Grounds	3D Printing	No
Advanced Prototype Engineering	Injection Molding	Yes
Bayshore Metals	Metalwork	No
Conceptual Art Technologies	Metalwork	Yes
Ego Engravers	Laser Cutting	No
Fictiv*	3D Printing	No
Flex Invention Lab	Full Service/EMS	Yes
Lightsmith Laser	Laser Cutting	Yes
Lucid Machine Art	Routing	Yes
Moddler LLC	3D Printing	Yes
Padoga Arts	Laser Cutting	Yes
Plethora*	CNC Machining	Yes
Ralph King Cabinetry	Routing	Yes
San Francisco Machine Works	Metalwork	Yes
SF Metalworks	Metalwork	Yes
ShopFloor Design	Metalwork	Yes
Standard Metal Products	Metalwork	Yes
Tempo Automation*	Electronics	Yes
You3Dit	3D Printing	No
Zomadic	CNC Machining	Yes

* Virtual manufacturing portal based in San Francisco.

APPENDIX XIV Job Postings from SFMade Advanced Manufacturers

By Company

Company	# of Postings
Planet Labs	223
Flextronics International	91
Alta Motors**	12
Rickshaw Bagworks	2
Blackbird	1
Dodocase	1
Galanter & Jones	1
Plethora*	1
Tempo Automation*	1

By Industry

NAICS Code	Industry	Job Postings
5416	Management, Scientific, and Technical Consulting Services	91
6117	Educational Support Services	8
5239	Other Financial Investment Activities	4
5419	Other Professional, Scientific, and Technical Services	4
5191	Other Information Services (5191)	2
2211	Electric Power Generation, Transmission and Distribution	1
9271	Space Research and Technology	1
5414	Specialized Design Services	1

*SFMade has worked with these companies extensively and know them to be hiring in multiple positions.

** Moved production operations out of San Francisco in 2016.

Specialized Skills Listed

Skills	Job Postings
Python	95
Computer Aided Drafting/Design (CAD)	62
Product Development	50
LINUX	38
Electrical Engineering	36
Software Engineering	36
Optimization	34
Manufacturing Processes	31
Concept Development	29
Prototyping	29
JavaScript	28
Validation	28
Product Design	26
Product Management	26
Consumer Electronics	23
Hardware Experience	22
Collaboration	21
Injection Molding	21
Simulation	21
Calibration	20
C++	18
Computer Numerical Control (CNC)	18
Configuration Management	18
Repair	18
Mechanical Engineering	17
System Design	17

Skills	Job Postings
PCB Layout and Design	16
Machining	15
PostgreSQL	14
Adobe Photoshop	13
Business Development	13
Computer Aided Manufacturing (CAM)	13
Design for Manufacture/ Design for Assembly (DFM/DFA)	13
Mechanical Design	13
Network Hardware/Software Maintenance	13
Equipment Maintenance	12
Physics	12
Web Site Development	12
Description and Demonstration of Products	11
Mentoring	11
Procurement	11
Scheduling	11
Test Equipment	11
Accounting	10
GPS	10
Invoicing	10
Nagios	10
Systems Engineering	10
Telemetry	10
Test Development	10
Web Site Design	10

1. Strengthen the regional advanced manufacturing sector and rebuild San Francisco's connection to the ecosystem

Recommendations focus on San Francisco's disconnection from the regional manufacturing ecosystem. They are intended to support and expand the existing advanced manufacturing supply chain while allowing San Francisco to become a leader in the planning processes for future manufacturing policy.

Enable A Regional Manufacturing Strategy

See description in Part 3 of this report.

State Manufacturing Strategy

Engage with existing efforts to create a cohesive statewide manufacturing strategy and to adopt statewide training certifications for advanced manufacturing. Make sure the city is represented in the final document. Potential statewide efforts to participate in include:

- The institution a system of "stackable" transferable certifications for manufacturing such as the NIMS metalworking certifications.
- Collaborating with the Bay Area Council to push for a special tax credit for venture capital investments in enterprises that manufacture products locally.

Existing Models: [Iowa Advanced Manufacturing Strategy](#)

Possible Resources: The Mayor's Office of Economic and Workforce Development, Bay Area Urban Manufacturing Initiative, SFMade, 101 MFG, Silicon Valley Manufacturing Roundtable, East Bay Manufacturing Group, East Bay Advanced Manufacturing Partnership, Association of Bay Area Governments, California Network for Manufacturing Innovation

Local Supply Chain Strategy

To streamline manufacturing scaling throughout the region formulate a strategy to increase transparency and access to the local supply chain. This may include creating a network of certified vendors leading from prototyping firms through low to mid-volume production so that hardware companies can scale locally.

Existing Models: Made in Northern California

Possible Resources: Britehub, SyncFab, MANEX, CMTC

Priority Industrial Real Estate Strategy

Facilitate the advancement of a regional land use strategy using the upcoming ABAG *Industrial Land and Jobs Study*. Support the effort led by ABAG to create and promote Priority Production Areas.

Existing Models: [ABAG Priority Conservation Areas](#)

Possible Resources: The San Francisco Mayor's Office, San Jose Mayor's Office, Oakland Mayor's Office, Fremont Mayor's Office, other regional governments, Bay Area Council, Association for Bay Area Governments

Manufacturing Operations Advising Strategy

Improve the regional manufacturing operations advising strategy to deliver more robust advising services and to promote existing services. Services may include assistance with regional sourcing, contract manufacturer identification and vetting, audits, final document creation and regulatory concerns such as OSHA compliance.

Existing Models: MEP, [Dragon Innovation](#), [SyncFab](#), [the Connecticut Center for Advanced Technology](#)

Possible Resources: CMTC, MANEX, PCV Advising, Inner City Advisors, SFMade

Modernize Manufacturers

Generate a plan to modernize existing manufacturers and improve outreach about existing programs. Prioritize developing novel financing solutions to assist small manufacturers with the capital expense of

new equipment and retraining their employees (\$50-250K). Participate in existing efforts to restructure the federal Industrial Revenue Bond program to better serve small manufacturers.

Existing Models: [Connecticut Manufacturing Innovation Fund Voucher Program](#), [California partial sales tax exemption for equipment](#), [California sales and use tax exemption for advanced transportation](#), [IRB program brief](#)

Possible Resources: CMTC, MANEX, NIST, EDA, Pratt Center for Community Development, Urban Manufacturing Alliance

2. **Address San Francisco's specific infrastructure weaknesses to grow the low-volume advanced manufacturing sector**

Recommendations are intended to address specific weaknesses in the city's advanced manufacturing landscape, allowing the low-volume manufacturing sector to grow. Increasing both the amount of advanced manufacturing and the types of manufacturing will encourage existing hardware, electronics, medical device and other product companies to keep their short-run manufacturing and prototyping local. Weaknesses addressed include: supply chain, real estate and preconceptions about manufacturing in San Francisco, among others.

National Manufacturing Policy

Engage with existing efforts to encourage and expand advanced manufacturing in the United States to raise the profile of San Francisco as a manufacturing center. Potential efforts include:

- [H.R.4505 - Make It In America Manufacturing Communities Act](#), an effort to make the Manufacturing Communities designation permanent.
- [Manufacturing USA](#), an effort to create linked manufacturing institutes to accelerate the commercialization of the newest and most promising manufacturing technologies.

Existing Models: n/a

Possible Resources: Bay Area Council, Association for Bay Area Governments

Local Advanced Manufacturing Promotion

To increase interest in locating in San Francisco, publicize the opportunities provided by the city and the benefits of co-locating design and manufacturing. Teach manufacturers how to take advantage of those opportunities and showcase viable business models.

Awareness and interest can be built through a series of marketing campaigns. These campaigns should:

- Highlight existing San Francisco manufacturers
- Communicate to manufacturers that they are wanted and appreciated
- Claim space in the regional manufacturing sector
- Showcase women in modern manufacturing

All of this promotion leads to the San Francisco Business Portal, SF Chamber of Commerce and SFMade websites as appropriate.

Existing Models: [Bolt](#) and [Dragon Innovation](#) manufacturing blogs, [SF Business Portal](#), [SFMade Job Board](#)

Possible Resources: SFMade, local incubators, Bay Area Urban Manufacturing Initiative, HardwareCon, San Francisco Chamber of Commerce

Cultivate Contract Manufacturing

See description in Part 3 of this report.

Expanding Access to Tools

To increase access to advanced manufacturing tools and to increase diversity in the advanced manufacturing field, encourage subsidized TechShop memberships and classes for underserved and low-income populations. Potential models include:

- Expanding Inside Manufacturing to include TechShop memberships
- Creating a pool of funding for memberships that could be accessed by qualified applicants
- Partnering with a corporate sponsor to subsidize memberships for either of the above methods

Existing Models: [LA agreement with TechShop](#), [FirstBuild](#), [Pier 9 AIR](#)

Possible Resources: TechShop, Pier 9, industry partners

Incubator Education

Fund an organization to work directly with incubators, accelerators, and makerspaces to increase interest in local manufacturing in the pipeline of hardware companies. Increase education around local manufacturing and connect their members/alumni to existing city services and resources.

Existing Models: Jabil/Radius incubator advising

Possible Resources: SFMade, Lemnos Labs, Wearable World Labs, Highway1, Y Combinator

Local Growth

Create a strategy for funding early stage companies that commit to local manufacturing to incentivize local manufacturing growth. Apply for a Regional Innovation Strategy grant from the EDA to develop program.

Existing Models: [Futureworks NYC Growth Initiative](#), [Regional Innovation Strategy](#)

Possible Resources: Mayor's Office of Civic Innovation, EDA: Office of Innovation and Entrepreneurship, Bay Area Urban Manufacturing Initiative

Improve Small Business Assistance For Advanced Manufacturers

See description in Part 3 of this report.

Appropriate Real Estate for Small Manufacturing

To keep small manufacturing businesses in San Francisco create suitably sized, affordable spaces by:

- Developing shared manufacturing spaces for small companies that grow out of TechShop/makerspaces. Allows for shared capital expenses and operational budget.
- Incentivizing a large industrial landowner to split their building into smaller units.
- Creating an industrial real estate model based on American Industrial Center (AIC) where companies can move from shared workspaces to larger spaces within the same campus.

Existing Models: [AIC](#), [New York's Next Top Makers](#), [Los Angeles Clean Tech Incubator](#), [New Lab](#), [Industry City](#)

Possible Resources: TechShop, PlaceMade, AIC

Formalize Manufacturing Real Estate Matchmaking

See description in Part 3 of this report.

Affordable Industrial Real Estate

To maintain and expand the stock of available affordable industrial real estate for companies of all sizes:

- Expand PlaceMade or another similar non-profit industrial real estate developer to build/secure affordable industrial real estate throughout the region.
- Create an affordable industrial trust, similar to that for housing.
- Dedicate land for particular industrial uses/projects.
- Advocate for state funding for a regional effort to create affordable industrial real estate.

Existing Models: [PlaceMade](#), [Affordable Housing Trust Fund](#), [Boston Innovation District](#), [Warm Springs Innovation District](#), [Brooklyn Navy Yard](#), [Greenpoint Manufacturing and Design Center \(GMDC\)](#)

Possible Resources: PlaceMade

Increase Shared Transit Options

To increase employee access to the remaining affordable industrial real estate without cars, improve transit options throughout the city. Progress on this issue includes dedicated owl service from Glen Park BART to Bayview starting summer 2016 with the 44 O'Shaughnessy Owl.

Existing Models: Corporate shuttles, [Muni Equity Strategy](#)

Possible Resources: SFMTA, industry partners

3. Increase awareness of advanced manufacturing as a career path and address the shortage of technical training within the city

These recommendations address the expansion of technical education for both youth and adults, as well as the promotion of manufacturing as a viable career choice.

Youth Oriented Recommendations:

Increase Advanced Manufacturing Awareness

See description in Part 3 of this report.

Youth Access to Makerspaces

To increase youth interest in making, promote existing makerspaces throughout the city. Explore opportunities to increase programming in these spaces and to create additional makerspaces with youth access in mind.

Existing Models: [FabLab](#), [Lighthouse Creativity Lab](#), [TechShop STEAM](#), [Maker Vista Initiative](#), [the Mix at the San Francisco Public Library](#)

Possible Resources: Mayor's Office of Education, San Francisco Public Library, SFUSD, MakerEd, Fab Foundation, Department of Children, Youth, and Their Families, TechShop STEAM, Engineering for Kids

Advanced Manufacturing Education Integration

Investigate methods to increase manufacturing knowledge and related competencies in engineering, math and design at the secondary level. Potential methods may include:

- Incorporating advanced manufacturing skills into existing STEM curricula, including machining, CAD, 3D printing and electronics.
- Creating manufacturing and electronics courses leading towards existing two-year certificate programs with public and/or private educational entities.
- Creating articulation agreements between secondary institutions and the local community colleges for machine technologies and electronics classes.
- Work with existing engineering and design classes at Burton, O'Connell, SOTA and Lincoln High Schools to add CAD, CNC and 3D printing to CTE curriculum

Existing Models: [PRIME](#), [Commonwealth Engineering Design Academies](#), San Leandro High School, Benjamin Franklin High School, Philadelphia

Possible Resources: Mayor's Office of Education, SFUSD, Laney College, City College, Bay Area Community College Consortium

Advanced Manufacturing Pathway

Explore the possible integration of an advanced manufacturing educational pathway consisting of one/two years of coursework at a CTE Academy (contingent on alignment/compatibility with an existing CCPT grant), two years at the community college level, paid internships and intensive job placement assistance.

Existing Models: [Biotech Partners](#),

Possible Resources: SFUSD, Laney College, City College, Bay Area Community College Consortium

Marketing Manufacturing

To increase awareness of the opportunities in, and advantages of, manufacturing careers create a series of marketing campaigns. Engage in the existing plan to increase awareness about manufacturing through a regional Dream it, Do it campaign and an upcoming online marketing campaign. These marketing campaigns should highlight:

- General interest in manufacturing and the local opportunity in advanced manufacturing
- The changes in manufacturing that make it cleaner, safer, etc.
- Women and advantages of advanced manufacturing

Existing Models: ["Dream it, Do it,"](#) the Manufacturing Institute

Possible Resources: Laney College, East Bay Advanced Manufacturing Partnership, the Manufacturing Institute

Adult Oriented Recommendations:

Increased access to Post-Secondary Manufacturing Training

Investigate methods to increase access to advanced manufacturing training through partnerships with existing regional community colleges.

Existing Models: [Cal Biotech Careers](#)

Possible Resources: Laney College, City College, De Anza College, Bay Area Community College Consortium

Develop A Manufacturing-Specific Work Readiness Program

See description in Part 3 of this report.

Regional Job Board

To increase the ease of access to manufacturing jobs throughout the Bay Area create an online regional job board for manufacturing and technical positions.

Existing Models: [SFMade Manufacturing Job Board](#), [Bay Area Manufacturing Careers](#)

Possible Resources: Workhands, Laney College, De Anza College, WIBs

APPENDIX XVI Complete List of Interviews and Other Assistance

Cara Allamano, Planet Labs
Kevin Binkert, Standard Metal Products
Ben Bateman, Indiegogo
Patricia Blakely, Merchants Fund
Valerie Sathe Brugeman, Center for Automotive Research
Karen Burns, East Bay Manufacturing Group
Andrew Calvo, TechShop
Nicola Clifford, Mayor's Office of Education
Gene Chien, Orange
Jeremy Conrad, Lemnos Labs
Catherine Cormier, San Francisco Public Library
Rebecca Corteza, OEWD Workforce Development Division
Tammy Coxen, Skilled Work
Andrew Dahlgren, Community Centered Industry
Craig Dalton, DODOcase
Carrie Davis, Advanced Prototype Engineering
Eric Dimond, Exploratorium
Craig Dudenhoeffer, Wearable IoT World
Emily Van Dyke, San Francisco Unified School District
Rob Ehret, Lucid Machine Arts
Lisa Ellsworth, Workshop Residence
Dave Evans, Fictiv
Nathan Evans, Fictiv
Lisa Fetterman, Nomiku
Elena Ginebreda-Frendel, Indiegogo
Jeremy Goldberg, Mayor's Office
Elizabeth Gress, University of California San Francisco
Gerry Harris, IDEO
Myisha Hervey, Office of Economic and Workforce Development
Diem Ho, IDEO
Luke Iseman, Y Combinator
Eva Jennings, Contra Costa Community College District
Miranda Jones, Galanter and Jones
Pamela Kan, Bishop-Wisecarver
Jon Kaplan, IDEO
Greg Kress, Radicand
Tanu Kumar, Pratt Center for Community Development
Jon Lau, Office of Economic and Workforce Development
Amelise Javier Lane, Autodesk
Brian Lee, Highway 1
David Liu, SOMA Precision
Joe Luttwak, Blackbird Guitars
Lauren Marinaro, Wearable IoT World
Elizabeth Mattiuzzi, University of California
Tushyati Maudgalya, Plethora
Jeff McAlvay, Tempo Automation
Kate McAndrew, Bolt
Jen McCabe, Flextronics
Holger Michaelis, Burton High School
Zane Murray, California College of Art
Erin Nelson, Seattle Good Business Network
Laate Olukotun, NextFab
Jon Oxford, Helimec
David Pierce, OHIO Design
Clarissa Redwine, Kickstarter
Andrew Rutter, Type A Machines
Shashank Samala, Tempo Automation
Peter Sands, Many Labs
Heidi Sheppard, NIST MEP
Espen Sivertsen, Type A Machines
Hitesh Soneji, City College of San Francisco
Katy Stanton, Urban Manufacturing Alliance
Brett Swope, Swope Design Solutions
Alex Thompson, Pagoda Arts
Michael Topolovac, Crave Innovations
Matt Trocker, Bay Area Community Colleges
Bryan Twarek, San Francisco Unified School District
Ryan Vineyard, Highway 1
Noah Weinstein, Autodesk
Christina Aguiar Whippen, ShopFloor
Jason Wilkins, IDEO
Amanda Williams, Jabil
Emily Woods, TechShop

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- ³ SFMade, 2015: 2
- ⁴ President's Council of Advisors on Science and Technology. *Report to the President on Ensuring American Leadership in Advanced Manufacturing*, Washington, D.C.: Executive Office of the President; 2011: ii.
- ⁵ *Ibid.*, 1.
- ⁶ U.S. Bureau of Economic Analysis (BEA). 2015. Available at: <http://www.bea.gov/iTable/iTable.cfm?ReqID=51&step=1 - reqid=51&step=51&isuri=1&5114=a&5102=1>. Accessed December 28, 2015.
- ⁷ President's Council of Advisors on Science and Technology, 2011: iii.
- ⁸ U.S. Bureau of Economic Analysis (BEA), 2015.
- ⁹ Baily M. *U.S. Manufacturing May Depend on Automation to Survive and Prosper*. Washington D.C.: The Brookings Institution; 2015. Available at: <http://www.brookings.edu/research/opinions/2015/12/18-manufacturing-depend-on-automation-baily>. Accessed December 27, 2015.
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- ¹¹ DeVol R, et al. 2009: 7.
- ¹² Helper S, Krueger T, Wial H. *Why Does Manufacturing Matter? Which Manufacturing Matters?*. Washington D.C.: Brookings Institution; 2012: 13.
- ¹³ Muro M, Kulkarni S, Fikri K, Andes S, Rothwell J. *America's Advanced Industries*. Washington, D.C.: The Brookings Institution; 2015: 24-25
- ¹⁴ The advanced industries as a whole employed 5,449,900 people in 2013 (see Muro, M, et al. 2015) and as the *President's Framework for Revitalizing American Manufacturing* notes, "even though wage premiums in manufacturing overall have declined for workers with less formal education, high-technology workers on average earn 50 to 100% more than the average of workers in *all other fields*."ⁱ
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- ¹⁵ Deloitte Center for the Edge. *A Movement In The Making*. Deloitte University Press; 2014: 3. Available at: <http://dupress.com/articles/a-movement-in-the-making/?id=us:2el:3dc:dup689:eng:tmt:dcpromo>. Accessed December 30, 2015.
- ¹⁶ President's Council of Advisors on Science and Technology, 2011: ii.
- ¹⁷ National Science and Technology Council, 2012: 3
- ¹⁸ Several key opportunities where government investment could prevent market failures include investing in the advancement of new technologies with transformative potential, supporting shared infrastructure) and accelerating the manufacturing process through targeted support for new methods and approaches. ⁱⁱ
ⁱⁱ President's Council of Advisors on Science and Technology, 2011: iii
- ¹⁹ AMP was tasked with reviewing the landscape and recommending policies to support and expand the advanced manufacturing sector. They published two reports, in 2012 and 2014, with 11 specific recommendations in three target areas: "Enabling Innovation," "Securing the Talent Pipeline," and "Improving the Business Climate." ⁱⁱⁱ
ⁱⁱⁱ President's Council of Advisors on Science and Technology. *Accelerating U.S. Advanced Manufacturing: AMP 2.0 Steering Committee Report*. Washington, D.C.: Executive Office of the President; 2014: 17 & 18
- ²⁰ NextFlex, a flexible hybrid electronics manufacturing institute based in San Jose was founded as part of the Manufacturing USA system in fall 2016. For more information see [Appendix IV](#).
- ²¹ Nine of fifteen planned institutes have been funded for a current total of over \$500 million federal dollars at a 1:1 cost share with industry.
- ²² 2014 census estimate - Annual Estimates of the Resident Population for the United States, Regions, States, and Puerto Rico: April 1, 2010 to July 1, 2014 (NST-EST2014-01), Source: U.S. Census Bureau, Population Division. Release Date: December 2014
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- ²⁸ Bay Area Council on Science and Innovation Consortium. *Reinventing Manufacturing: How the Transformation of Manufacturing Is Creating New Opportunity for California*. San Francisco: Bay Area Council Economic Institute, April 2016: 2
- ²⁹ Morath E, Van Dam A. “Where Are the Most U.S. Manufacturing Workers? Los Angeles.” *Wall Street Journal*. 2015. Available at: <http://blogs.wsj.com/economics/2015/07/15/where-are-the-most-u-s-manufacturing-workers-los-angeles/>. Accessed December 27, 2015.
- ³⁰ Cooper C, et al., 2014: 13
- ³¹ As advanced manufacturing is a nascent and minimally defined field, the number of employees using these techniques can be difficult to estimate. However, using the Organization for Economic Co-operation and Development (OECD) taxonomy for technology in manufacturing industries, you can see that a third of the manufacturing in California is classified as high-technology, with 432,932 jobs in the sector in 2012. Another 158,569 are medium-high technology. The industries covered by these two classifications include aerospace, communications equipment, medical devices, machinery and electrical devices, all mainstays of the Northern California manufacturing sector. ^{iv}
- ^{iv} Cooper C, et al., 2014: 20 & 30
- ³² California State Assembly. *Importance of Manufacturing within California Economy*. Available at: <http://ajed.assembly.ca.gov/index> Accessed December 23, 2015.
- ³³ CNMI is lead by CMTC, the MEP for Southern California and the board includes members from El Camino/CACT, Lawrence Berkeley National Labs, University of Southern California, Lawrence Livermore National Labs, Manex and University of California Irvine.
- ³⁴ In manufacturing this is known as a region’s industrial commons: their talent pool, shared industry knowledge and R&D capacity. San Francisco is centrally located between the renowned research universities of Berkeley, Stanford, and UCSF in addition to the research institutes of the Lawrence Berkeley National Laboratory, Lawrence Livermore National Laboratory, NASA Ames, SLAC National Accelerator, SRI International and Xerox PARC.
- ³⁵ Bay Area Council on Science and Innovation Consortium, April 2016: 71
- ³⁶ Cambridge Systematics, Inc. *San Francisco Bay Area Freight Mobility Study*. Sacramento: California Department of Transportation; 2014: ES13
- ³⁷ Association of Bay Area Governments. *San Francisco Bay Area’s State Of The Region 2015: Economy, Population, Housing*. Oakland: Association of Bay Area Governments; 2015: 23
- ³⁸ *Vital Signs. Jobs by Industry*. 2015. Available at: <http://www.vitalsigns.mtc.ca.gov/>. Accessed December 24, 2015.
- ³⁹ Association of Bay Area Governments, 2015: 6
- ⁴⁰ “Measured by overall number of jobs, the five largest Bay Area manufacturing sectors all experienced job growth between 2010 and 2014: Computer & Electronic Product Manufacturing grew by 3.6% (adding 4,797 jobs); Food Manufacturing increased by 16.1% (adding 3,292 jobs); Beverage Manufacturing expanded by 17.0% (adding 3,019 jobs); Fabricated Metal Product Manufacturing grew by 7.7% (adding 1,451 jobs); and Machinery Manufacturing increased by 16.9% (adding 2,413 jobs). Beverage Manufacturing is the only one of these five sectors that did not experience employment contraction between 1990 and 2014 and therefore achieved a net gain in jobs over the long term.” ^v
- ^v Bay Area Council on Science and Innovation Consortium, April 2016: 72
- ⁴¹ The 50 advanced industries identified by Brookings include manufacturing such as aerospace, electrical device and petroleum manufacture, services such as engineering, computer systems design and software publishing, and energy. These industries tend to cluster because they depend on proximity to “shared innovation resources such as universities and national laboratories; access to pools of skilled labor; and myriad “ecosystem” benefits including information spillovers, local supply chain density, and available networks of related firms, specialized suppliers, and service providers.” ^{vi}
- ^{vi} Muro M, et al., 2015: 17
- ⁴² Industryweek.com. *The 2015 IndustryWeek US 500*. 2015. Available at: <http://www.industryweek.com/resources/us500/2015>. Accessed December 22, 2015.
- ⁴³ Muro M, et al., 2015: 28
- ⁴⁴ In the Bay Area the food and beverage industry and apparel manufacturing still (mostly) use traditional techniques.
- ⁴⁵ Bay Area Council on Science and Innovation Consortium, April 2016: 71
- ⁴⁶ Ventureoutsource.com. *Top 10 EMS / ODM Rankings, Reviews, Ratings | VentureOutsource.com*. 2015. Available at: <https://www.ventureoutsource.com/contract-manufacturing/top-10-ems-odm-reviews-ratings/>. Accessed December 10, 2015.
- ⁴⁷ The move towards Fremont and Newark is occurring because remediation and reuse of older industrial properties can be prohibitively expensive and most are not appropriate for modern warehousing needs.
- ⁴⁸ Association of Bay Area Governments. *San Francisco Bay Area’s People, Places, And Prosperity*. Oakland: Association of Bay Area Governments; 2015: 30
- ⁴⁹ Chion M, Jaramillo J. *Priority Industrial Area Concept*. Oakland: Association of Bay Area Governments; 2015.
- ⁵⁰ Levy S, Belzer D, Srivastava S, Braun D, Popuch E, Haveman J. *Building On Our Assets: Economic Development & Job Creation In The East Bay*. Oakland: East Bay Economic Development Alliance; 2011: 11
- ⁵¹ *Ibid.*, 66
- ⁵² Craft Consulting Group. *Advancing Manufacturing In Contra Costa County*. Workforce Development Board of Contra Costa County; 2013: 37

- ⁵³ Levy S, et al., 2011: 5
- ⁵⁴ Ibid., 23.
- ⁵⁵ Just behind Wichita, KS. Helper S, Krueger T, Wial H. *Locating American Manufacturing: Trends In The Geography Of Production*. Washington D.C.: Brookings Institution; 2012: 15
- ⁵⁶ Metropolitan Policy Program. *San Jose-Sunnyvale-Santa Clara, CA Metro Area*. Washington D.C.: Brookings Institution; 2011.
- ⁵⁷ BW Research Partnerships. *Contract Manufacturing In Silicon Valley*. work2future; 2012: 3
- ⁵⁸ Two of the world's largest EMS providers are headquartered in the county and five, including the two with headquarters, have manufacturing facilities in San Jose and Milpitas.
- ⁵⁹ Helper S, et al. *Locating American Manufacturing*; 2012: 23
- ⁶⁰ San Jose City Council. *History of Employment Land Conversions in San Jose and the Fiscal Impact of Land Use*. 2015. Available at: <http://www.sanjoseca.gov/DocumentCenter/View/43561>. Accessed December 23, 2015: slides 15, 28 & 29
- ⁶¹ Sonoma County BEST. *Advanced Manufacturing-Sonoma County BEST*. 2015. Available at: <http://sonomacountybest.com/advanced-manufacturing/>. Accessed December 21, 2015.
- ⁶² Annual Estimates of the Resident Population for Incorporated Places of 50,000 or More, Ranked by July 1, 2014 Population: April 1, 2010 to July 1, 2014. Source: U.S. Census Bureau, Population Division, Release Date: May 2015
- ⁶³ Coxen and Gerrie, 2016: 4.
- ⁶⁴ Over 90% of all San Francisco manufacturers are SFMade members. To be a member of SFMade companies must have a business license in San Francisco and manufacture at least one product in the city either in-house or with a contract manufacturer located in the city.
- ⁶⁵ SFMade, 2015: 1
- ⁶⁶ Coxen and Gerrie, 2016: 5.
- ⁶⁷ SFMade, 2015: 2
- ⁶⁸ Corporation for a Skilled Workforce's analysis of data supplied by Economic Modeling Systems Inc. Data accessed 4/1/16
- ⁶⁹ SFMade. *State Of Local Manufacturing 2015*. San Francisco: SFMade; 2015: 2
- ⁷⁰ Corporation for a Skilled Workforce's analysis of data supplied by Economic Modeling Systems Inc. Data accessed 4/1/16
- ⁷¹ Not included in this survey of advanced manufacturers are companies that are currently in incubators/ accelerators. These companies may not ultimately choose to locate in San Francisco and while they usually do some prototyping in-house, they are not yet in production. Also not included are research and development firms. While these firms, such as Otherlab in the Mission, may spin off hardware companies, they themselves are primarily concerned with designing and prototyping new devices.
- ⁷² There are generally said to be three tiers to electronic manufacturing services. Though there are no hard and fast rules, the tiers breakdown roughly by the following: Tier 1: revenue around or above \$1 billion, Tier 2: revenue between \$250,000-\$1 billion, Tier 3: revenue <\$250,000. Flextronics for instance had \$26.15 billion in revenue in 2015. See *Flex 2015 Annual Report: from Sketch to Scale*, available at: http://s2.q4cdn.com/065994059/files/doc_financials/annual_reports/2015/2015_Annual_Reports.pdf
- ⁷³ There are two hardware companies that act more like small consumer products companies, They are staying small, have not taken venture capital and do not plan to. One spun out from a larger company and both make a single high-value, boutique, B2B electronics product, with a small but steady market.
- ⁷⁴ Data from Crunchbase and CB Insights. Accessed 3/15/16.
- ⁷⁵ Ibid.
- ⁷⁶ Source meetups.com, Accessed 4/21/16.
- ⁷⁷ There are also many specialized meetups such as the SF Virtual Reality Meetup (2,215 members) or the SF Crowdfunding Meetup (520 members) that have a hardware component but do not specialize in it.
- ⁷⁸ Highway1. *Highway1 Program for Hardware Entrepreneurs*. 2016. Available at: <http://highway1.io/program/>. Accessed June 3, 2016.
- ⁷⁹ As investment has increased, a number of hardware specific funds have arisen, the most prominent of these also act as incubators and accelerators to help their companies through all the things that make "hardware hard," a refrain heard throughout the industry. Two of the most prominent VC/incubator combos are located in San Francisco, Lemnos Labs (San Francisco only) and Bolt (San Francisco and Boston). Both are so called micro-VCs, meaning they manage under \$100M, and tend to invest in early stage companies.
- ⁸⁰ Quintero C. *Who Invests in Hardware Startups?* Boston, MA: Bolt, September 14, 2015. Available at: <https://blog.bolt.io/who-invests-in-hardware-startups-d1612895a31a#.gpb23m44a>. Accessed March 23, 2015. For an updated view of the numbers see *Who Invests in Hardware Startups 2016*. Available at: <https://blog.bolt.io/who-invests-in-hardware-2016-3b8149769924#.c0yntoieil>
- ⁸¹ Though there are some additional impacts both pro and con such as, acquiring a pool of excited, early adopters who can be a company's greatest fans or biggest detractors. Also, because crowdfunding can be used to show a company's potential market it is often used a springboard to gain more investment and/or a better deal with contract manufacturers.
- ⁸² Data provided by Kickstarter, received 3/26/16

- ⁸³ Take the location with a grain of salt. Companies often say they are based in the nearest large recognizable city and this is particularly true in the Bay Area. Of the 2,815 total successful Kickstarter projects in the Bay Area, 2,639 of them are labeled San Francisco.
- ⁸⁴ Analysis of SFMade State of Local Manufacturing 2015 survey data.
- ⁸⁵ SFMade. *State Of Local Manufacturing 2014*. San Francisco: SFMade; 2014: 1
- ⁸⁶ BLS Occupational Employment and Wages, *May 2015 17-2061 Computer Hardware Engineers* Available at: <http://www.bls.gov/oes/current/oes172061.htm>. Accessed April 14, 2016.
- ⁸⁷ Includes Oakland and Fremont.
- ⁸⁸ As of 2007. Nichols B. *Valuing The Art Of Industrial Design: A Profile Of The Sector And Its Importance To Manufacturing, Technology, And Innovation*. Washington, D.C.: National Endowment for the Arts; 2013: 28.
- ⁸⁹ Data from SFMade interview with Eric Dimond, Project Director/Associate Curator at the Exploratorium, August 28, 2015.
- ⁹⁰ San Francisco has four hackerspaces with significant member engagement (one of these, ManyLabs is temporary). Oakland, which is less than half the size of San Francisco, has the same number.
- ⁹¹ Analysis of SFMade State of Local Manufacturing 2015 survey data
- ⁹² Chapple, K. *Overview of Industrial Activities in the Bay Area: Industrial Land Supply and Demand, Draft technical Memo #1*: November 1, 2015: 12.
- ⁹³ *Ibid.*, 26-27.
- ⁹⁴ As of March 17, 2016
- ⁹⁵ SFMade considers rents of less than \$2.00 a sq ft/month affordable.
- ⁹⁶ The Corporation for a Skilled Workforce and Pathways Consultants. *Industrial Jobs Of The Future Initiative: Preliminary Data Report*. San Francisco: SFMade; February 29, 2016: 21.
- ⁹⁷ *Vital Signs. Commute Mode by Choice and Transit Ridership*. Metropolitan Transportation Commission; 2015 Available at: <http://www.vitalsigns.mtc.ca.gov/>. Accessed June 3, 2016.
- ⁹⁸ Coxen and Gerrie, 2016: 8.
- ⁹⁹ The Corporation for a Skilled Workforce and Pathways Consultants, 2016: 19.
- ¹⁰⁰ Community needs as identified by the 2010 *Bayview Hunters Point Neighborhood Transportation Plan* include: pedestrian safety, infrequent and unreliable Muni service, constrained on-street parking supplies, difficulty accessing regional transit services from the neighborhood, and negative impact of truck traffic on residential streets.
- ¹⁰¹ *Muni Service Equity Strategy Report For Fiscal Year 2016-17*. San Francisco: San Francisco Municipal Transportation Agency; April 2016: 36.
- ¹⁰² Source: Corporation for a Skilled Workforce's analysis of data supplied by Burning Glass Technologies, data accessed 4/1/16.
- ¹⁰³ *Ibid.*
- ¹⁰⁴ The Corporation for a Skilled Workforce and Pathways Consultants, 2016: 9
- ¹⁰⁵ Companies report using staffing agencies because they cannot find people with the specific skills they need, need seasonal employees or want to be able to replace employees without having to worry about lawsuits or downtime on the line.
- ¹⁰⁶ Analysis of SFMade 2016 *Industrial Jobs of the Future* survey data.
- ¹⁰⁷ The Corporation for a Skilled Workforce and Pathways Consultants, 2016: 8.
- ¹⁰⁸ Conversation with Emily Van Dyke, CTE Program Administrator, SFUSD: 3/1/16
- ¹⁰⁹ San Francisco Unified School District, *CTE Academies*. Available at: <http://www.sfusd.edu/en/graduation-college-and-career/preparing-for-a-career/career-academies/academies-and-pathways.html> Accessed: April 29, 2016
- ¹¹⁰ Conversation with Emily Van Dyke, CTE Program Administrator, SFUSD: 3/1/16
- ¹¹¹ Conversation with Brian Twarek, Computer Science Education Coordinator, SFUSD: 6/15/16
- ¹¹² SFUSD: *Board Approves Plans to Expand Computer Science Curriculum to All Grades*. Sfusd.edu: 2016. Available at: <http://www.sfusd.edu/en/assets/sfusd-staff/news-and-calendars/files/archives/6%2010%2015%20SFUSD%20Adopts%20Computer%20Science%20Curriculum.pdf>. Accessed June 3, 2016.
- ¹¹³ Conversation with Brian Twarek, Computer Science Education Coordinator, SFUSD: 6/15/16
- ¹¹⁴ The Corporation for a Skilled Workforce and Pathways Consultants, 2016: 17.
- ¹¹⁵ *California Community Colleges Chancellor's Office: College Details*. California Community Colleges, cccco.edu: 2016. Available at: <http://californiacommunitycolleges.cccco.edu/collegeDetails.aspx?collegeID=361&txt=City%20College%20of%20San%20Francisco>. Accessed June 3, 2016.
- ¹¹⁶ Hom G. *An Introduction to Transfer An Introduction to Transfer Education at City College Education at City College for ENGN 10A*, City College of San Francisco: 2015. Available at: <http://fog.ccsf.edu/~hsoneji/SP2015-TransferCenter/Engn10APPSpring2015rev04232015.pdf> Accessed June 3, 2016
- ¹¹⁷ *Credit Certificates*. City College of San Francisco, [ccsf.edu](http://www.ccsf.edu/en/educational-programs/school-and-departments/school-of-science-and-mathematics/engineering-and-technology/credit-certificates.html): 2016. Available at: <http://www.ccsf.edu/en/educational-programs/school-and-departments/school-of-science-and-mathematics/engineering-and-technology/credit-certificates.html> Accessed June 3, 2016.
- ¹¹⁸ Headcount is an institutional challenge across all CTE programs. To teach hands on skills, class sizes must be kept down. However, this means that CTE programs often do not bring in enough funds to pay for themselves and so must be subsidized in some manner. In addition, this means that if local CTE resources are good, not all colleges will focus on all CTE subjects.

- ¹¹⁹ Though the engineering department has over an average of 351 enrolled students a year (average FTES 2010/11-2014/15), the electronics and CAD subject areas have only 28 and 32 students respectively (average FTES 2010/11-2014/15). The overall enrollment trend at both City College and in the engineering department is down, with general enrollment at 69% of its 2010/11 level. The low enrollment is likely due CCSF's accreditation problems of the last four years.^{vii} This is playing out in advanced industry training as well, with the electronics and CAD subject areas at 81% and 53% of their 2010/11 school year levels.^{viii}
- ^{vii} Smith A. *One Problem Leads to Another?* Inside Higher Ed: January 14, 2016. Available at: <https://www.insidehighered.com/news/2016/01/14/city-college-san-francisco-faces-new-scrutiny-finances-amid-ongoing-accreditation> Accessed July 28, 2016.
- ^{viii} research360. *Instructional Productivity*. San Francisco: City College of San Francisco; 2015. Available at: https://public.tableau.com/profile/research360-!/vizhome/InstructionalProductivity_0/InstructionalProductivity Accessed June 3, 2016.
- ¹²⁰ *Bachelor of Science in Industrial Design - Department of Design and Industry*. San Francisco State University, sfsu.edu: 2016. Available at: <http://design.sfsu.edu/pages/bachelor-science-industrial-design> Accessed June 3, 2016.
- ¹²¹ For a list of contract manufacturers based in San Francisco using advanced technologies see Appendix XIII.
- ¹²² Originally proposed in SFMade's 2016 *Jobs of the Future Initiative* report.
- ¹²³ Everett Community College. *Manufacturing Pre-Employment*. Available at <https://www.everettcc.edu/programs/aamc/pre-employment> Accessed: August 30, 2016
- ¹²⁴ Grand Rapids Community College. *Manufacturing Readiness Program*. Available at: https://learning.grcc.edu/ec2k/CourseListing.asp?master_id=1501&course_area=CEMF&course_number=132&course_subtitle=00 Accessed: August 30, 2016
- ¹²⁵ Industry Needs You. *Home*. Available at: <http://www.industryneedsyou.com/> Accessed: August 30, 2016.
- ¹²⁶ Urban Manufacturing Alliance. *About*. Available at: <http://www.urbanmfg.org/about/> Accessed: August 30, 2016.
- ¹²⁷ Manufacturing Alliance of Philadelphia. *Mayor's Manufacturing Task Force Presents Findings for a Manufacturing Growth Strategy for Philadelphia*. Available at: http://www.manufacturingonline.org/alerts_show.cfm?FORM_recordtempkey=0CDD95B5-D657-1006-EE0F32514A0085A8 Accessed: August 30, 2016
- ¹²⁸ Bowels, N. "Factorli, an Early Casualty of the Las Vegas Downtown Project," *Re/code*. Sep 30, 2014. Available at: <http://www.recode.net/2014/9/30/11631412/factorli-an-early-casualty-of-the-las-vegas-downtown-project> Accessed: August 9, 2016.
- ¹²⁹ SFMade. *Inside Manufacturing*. Available at: <http://www.sfmade.org/blog/inside-manufacturing/> Accessed: August 30, 2016.
- ¹³⁰ SFMade. *Youthmade*. Available at: <http://www.sfmade.org/program/youthmade/> Accessed: August 30, 2016.
- ¹³¹ San Francisco Business Portal. *Home*. Available at: <http://businessportal.sfgov.org/> Accessed: August 30, 2016
- ¹³² Sublease.com. *About us*. Available at: <http://www.sublease.com/list/main/about.php> Accessed: August 30, 2016.
- ¹³³ Bay Area Council on Science and Innovation Consortium, April 2016: 12. A.T. Kearney Reshoring Database
- ¹³⁴ Energy.gov. *Advanced Manufacturing Office*. Available at: <http://energy.gov/eere/amo/advanced-manufacturing-office> Accessed December 20, 2015
- ¹³⁵ Manufacturing.gov. *About*. Available at: http://manufacturing.gov/about_adv_mfg.html Accessed: December 17, 2015
- ¹³⁶ Materials Genome Initiative. *About the Materials Genome Initiative*. Available at: <https://www.mgi.gov/about> Accessed: December 17, 2015
- ¹³⁷ NIST Advanced Manufacturing Office. *Funding Opportunities*. Available at: <http://www.nist.gov/amo/amtech/funding.cfm> Accessed December 21, 2015
- ¹³⁸ Council on Competitiveness. *About the Summit*. Available at: <http://www.aemcsummit.compete.org/about> Accessed December 10, 2015
- ¹³⁹ Manufacturing.gov. *What is Manufacturing USA?* Available at: <http://www.manufacturing.gov/nnmi.html> Accessed: September 19, 2016
- ¹⁴⁰ Manufacturing Foresight. *About MForesight*. Available at: <http://research.umich.edu/mforesight/about-mforesight> Accessed December 21, 2015
- ¹⁴¹ Oakridge National Laboratory, Innovations in Manufacturing. *About us*. Available at: <http://web.ornl.gov/sci/manufacturing/about/> Accessed December 17, 2015
- ¹⁴² CACT @ City College of San Francisco. Centers for Applied Competitive Technologies, California. Available at: http://www.makingitincalifornia.com/centers_san_francisco.php. Accessed: October 4, 2016
- ¹⁴³ Design it Build it Ship it. *About*. Available at: <http://designitbuilditshipit.com/about/> Accessed December 21, 2015
- ¹⁴⁴ *Chapter 18.49 Warm Springs Innovation District*, Fremont Municipal Code. Passed July 12, 2016. available at: <http://www.codepublishing.com/CA/Fremont/html/Fremont18/Fremont1849.html> accessed September 18, 2016
- ¹⁴⁵ Data compiled from meetup.com on April 12, 2016.
- ¹⁴⁶ Source: Economic Modeling Systems Inc. Data accessed 4/1/16