INDUSTRY REPORT

SAN DIEGO LABOR MARKET ANALYSIS

Aerospace

A Subsector of Advanced Manufacturing

April 2015

UC San Diego Extension

SAN DIEGO WORKFORCE PARTNERSHIP®

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San Diego East County Economic Development Council

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Executive Summary

As part of the broader Advanced Manufacturing sector[1] of San Diego's economy, the aerospace industry spans a variety of activities, from general aviation to space exploration, commercial logistics to government transportation, and private security to national defense. The aerospace supply chain includes manufacturers and suppliers of parts, equipment, tooling and software. Correspondingly, aerospace relies heavily on national infrastructure, research and development (R&D) and human capital. Despite the budget sequestration of 2013 and the Great Recession (December 2007–June 2009), government spending in defense and aerospace-related contracts grew 38 percent in the past five years, increasing employment throughout the nation. As this industry continues to grow, San Diego's workforce development system will need to develop industry-specific strategies to meet the needs of aerospace employers.

The goal of this report is to document the emerging opportunities for San Diego County's aerospace industry and to identify the specific actions that employers and educators need to take to ensure that the workforce has the knowledge, skills and abilities required to maintain and grow the industry.

This study analyzes four major subsectors of the aerospace industry: 1) R&D and testing laboratories,[2] 2) aerospace products and parts,[3] 3) instruments and components,[4] and 4) support activities.[5] To understand the specific employment needs of aerospace businesses, key occupations in the industry were grouped into five occupational clusters: 1) business operations, 2) computer/software, 3) drafter and technician, 4) engineering and 5) production.[6] In addition to the 252 establishments in the aerospace industry, as defined by this report, the research team identified 575 businesses that were connected to the aerospace industry. Surveys were sent to 827 aerospace and aerospace-related employers, assessing their needs and challenges in hiring for specific occupations and skill sets. This study documents the results of the survey distribution as well as data from executive interviews, employment statistics and more than 10,000 online job postings.

A key finding of the report is that while education and training institutions in San Diego have the capability to train for high-skilled labor to meet the industry's needs, the majority of employers reported having difficulty in hiring qualified workers for each of the occupational clusters studied.

To remain globally competitive, the San Diego region must adopt policies to increase the talent base in science, technology, engineering and math (STEM), and it must educate, retain and attract STEM professionals to the aerospace industry. Investments must be made to update the aerospace research infrastructure and increase R&D funding. San Diego is well positioned to play a vital role in the emerging aerospace market. The region needs the economic and national security benefits that can come from the local aerospace industry.

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[1] The San Diego Workforce Partnership released five Priority Sector reports in October 2014, listing Advanced Manufacturing as one Priority Sector for workforce development. Aerospace is a subsector of the broader Advanced Manufacturing sector. For the Priority Sector reports, view workforce.org/reports.

[2] Industries and subsectors listed in this study are defined by the North American Industry Classification System (NAICS) codes. NAICS is a coding standard used by federal agencies to collect and disseminate data related to the economy and employment. NAICS for R&D and testing laboratories are 541380 & 541712, respectively.

[3] NAICS 33641

[4] NAICS 334416 & 334511

[5] NAICS 48811

[6] Occupations within each cluster, defined by Standard Occupational Classification (SOC) codes, are listed in Appendix B.

Introduction

The United States has been a global leader in aviation and space exploration since the first powered flight by Wilbur and Orville Wright in 1903, followed by innovations in jet aircraft, Global Positioning Systems (GPS) and the Internet. San Diego, specifically, has a long history with the aerospace industry since the mid-1920s when Ryan Airlines was founded. Ryan Airlines built the Spirit of St. Louis plane that Charles Lindbergh flew on his famous flight from New York to Paris—the first solo flight across the Atlantic.[7] Since then, the aerospace industry has permeated the San Diego economy. This industry covers the development and production of military and commercial aircraft, space vehicles and guided missiles, sensors, navigation and imaging devices, to name a few. Aerospace in San Diego encompasses research, development, manufacturing and other services that impact businesses related to aviation or space flight.

In order to better understand the labor market landscape and workforce needs of San Diego's aerospace employers, this study was commissioned by the San Diego Workforce Partnership and developed as a collaborative effort between the San Diego East County Economic Development Council and the University of California, San Diego. Data were collected from online job postings, employment statistics, employer surveys and executive interviews. This study will be used for industry-specific strategies in the development of San Diego's workforce as it pertains to the aerospace industry.

Employment Impact

San Diego County is one of the most concentrated regions for aerospace-related employment in the nation. One method to quantify the concentration of a region's share of employment in an industry compared to the nation is the Location Quotient (LQ). An LQ greater than 1 indicates that the region is more specialized in an industry than the nation as a whole, and an LQ of 1 indicates that the region has an employment concentration that's equal to the nation as a whole. Aerospace has an LQ of 1.42 for San Diego, making it 1.42 times (or 42 percent) more concentrated in employment than the rest of the nation.

Understanding the Location Quotient

If a local industry has an:

- LQ **>** 1, the region is **more** specialized than the nation
- LQ **=** 1, the region has the **same** employment concentration as the nation
- LQ **<** 1, the region is **less** specialized than the nation

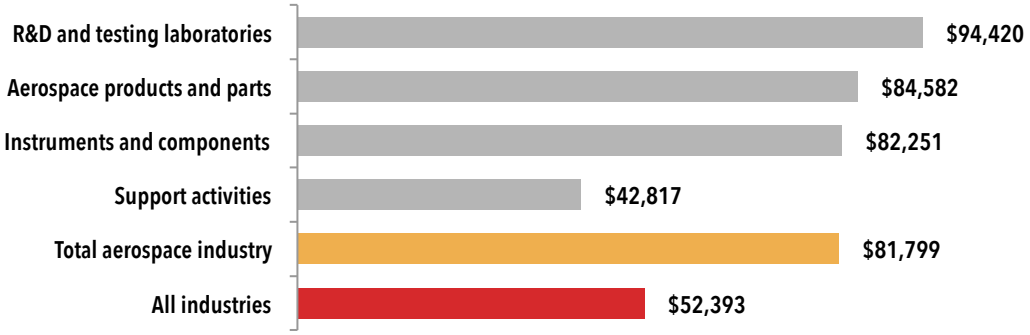
The military's strong presence in the region fosters the growth of not only aerospace-related goods and services, but also laboratories and test facilities that create innovative products. Unsurprisingly, testing laboratories[8] have an LQ of 4.95, and R&D testing laboratories[9] have an LQ of 4.80, which indicates that San Diego has, on average, 400 percent more employment concentration than the rest of the country.

Not only is aerospace highly concentrated in the region, but it is also one of the higher-paying industries with an average payroll of over $81,799, well above the average salary of $52.393 for all industries (Figure 1).[10] A

[7] san.org/sdcraa/airport_initiatives/environmental/ryan.aspx
[8] NAICS 541380
[9] NAICS 541712
[10] Economic Modeling Specialists International. November 2014.

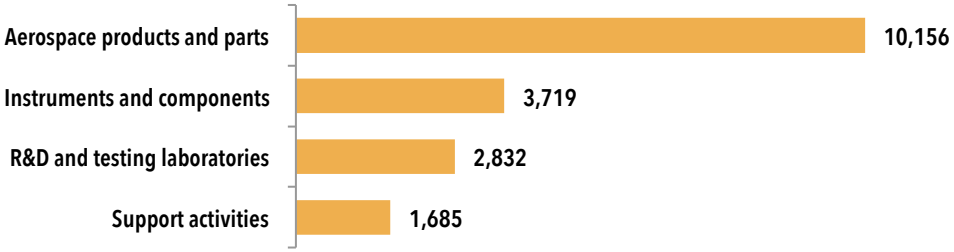
highly-educated workforce dominates the aerospace industry, with over 56 percent of the workers holding a bachelor's degree or above, and only 9 percent holding an associate degree.[11]

Figure 1: Average Payroll in Aerospace-Related Industries in San Diego County



Of the four subsectors, aerospace products and parts has the highest level of employment (Figure 2).[12] With the large cohort of workers in this subsector, aerospace parts is a good area to focus on for education and training programs due to the sheer number of available jobs. All other aerospace-related subsectors have fewer workers but are just as important to the aerospace industry's success in San Diego County.

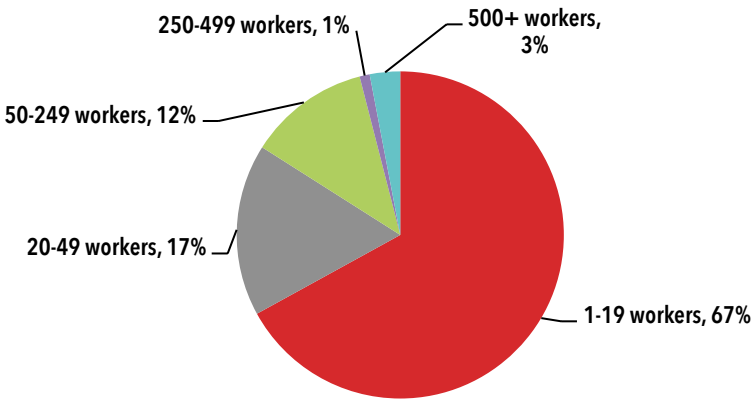
Figure 2: Employment in Aerospace Subsectors in San Diego



The majority of establishments in San Diego County are small businesses, with 87 percent of establishments employing fewer than 20 employees, while approximately 5 percent have 250 or more employees.[13] Similarly, the majority of companies in the aerospace industry have fewer than 20 employees (Figure 3). [14]

[11] Economic Modeling Specialists, International. Staffing Patterns. April 2015.
[12] U.S. Census Bureau. County Business Patterns. San Diego County, 2012. Most recent data available as of November 2014.
[13] U.S. Census Bureau. County Business Patterns. San Diego County, 2012. Most recent data available as of November 2014.
[14] U.S. Census Bureau. County Business Patterns. San Diego County, 2012. Most recent data available as of November 2014.

Figure 3: Establishment Size of Aerospace Industry Firms by Number of Employees



Economic Impact

United States

According to the U.S. Bureau of Labor Statistics (BLS) County Business Patterns, there were 1,751 establishments in the aerospace products and parts manufacturing industry, employing almost 388,000 workers in the United States in 2012. There were an additional 220,000 workers in the instrumentation manufacturing industries in approximately 2,500 establishments.

The aerospace industry has been an important part of the U.S. economy. In 2012, aerospace exports amounted to $118.5 billion, with a trade surplus of $70.5 billion—the largest of any manufacturing industry. Aerospace exports support more jobs than the export of any other commodity.[15]

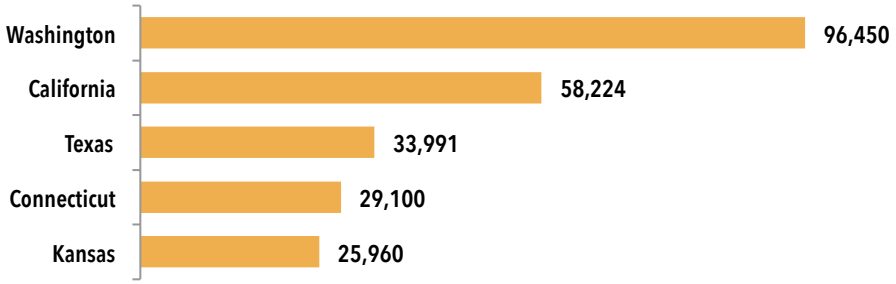
California

In 2011, California's aerospace industry produced $31 billion worth of goods—17 percent of the national total of $183 billion. It is estimated that for every dollar spent in the aerospace industry, more than two dollars are generated in household earnings.[16] One job created in the aerospace industry creates more than three additional jobs in the economy.[17]

California's military presence and its large pool of skilled workers helped establish and grow the industry in the state. The aerospace concentration in California is modest (LQ of 1.23) compared to Washington State (LQ of 8.92), which is home to Boeing's headquarters and has more aerospace workers than California. However, in terms of absolute numbers of aerospace workers, California comes in a close second, indicating the strength of California's aerospace industry (Figure 4).[18]

[15] selectusa.commerce.gov/industry-snapshots/aerospace-industry-united-states
[16] California Research Bureau, Aerospace Manufacturing in California's Economy. www.library.ca.gov/crb/14/B-14-001.pdf
[17] California Research Bureau, Aerospace Manufacturing in California's Economy. www.library.ca.gov/crb/14/B-14-001.pdf
[18] County Business Patterns, 2012. Data for Washington from "Aerospace Manufacturing Skills: Supply, Demand, and Outcomes from Washington's Aerospace Training Programs," Annual Report. 2013. Data for Connecticut from Connecticut Department of Labor.

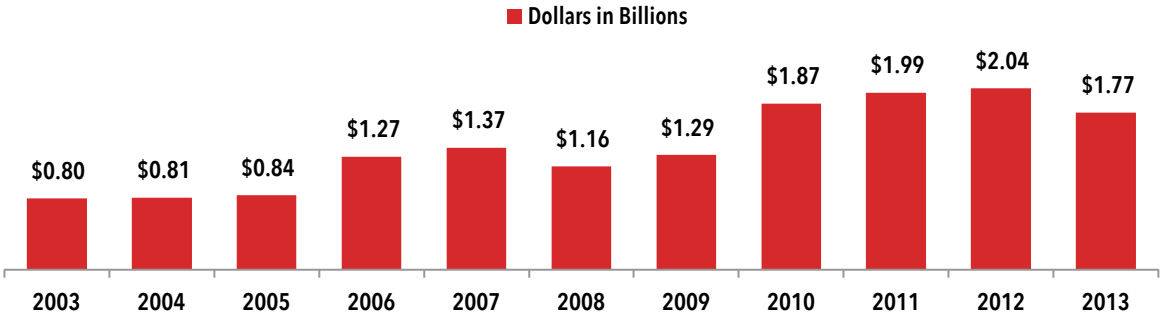
Figure 4: Aerospace Products and Parts Employment by State



San Diego

The strong military presence in San Diego County has a significant effect on the region's economy. One in five jobs in the region is tied to the military sector or defense spending in the county, which includes the aerospace industry.[19] Despite sequestration decreasing the amount of government spending in aerospace by $2.8 billion nationally and $26 million locally in 2013, overall government spending in aerospace increased 38 percent in the past five years and 121 percent in the past 10 years (Figure 5).

Figure 5: Government Contracts and Grants Spending for San Diego's Aerospace Industry 2003-2013



Naturally, many industries supporting the defense sector thrived in the region as a result of increased military spending, including three major customer segments: national security (defense and intelligence), civil (other government) and commercial.

[19] San Diego Military Advisory Council. Military Economic Impact Study. 2013.

Industry Trends

Advancements in the aerospace industry are a result of emerging technologies and developments in areas such as national security and defense, civil usage, commercial airlines and unmanned aerial vehicles.

National Security and Defense

National security and defense have been an integral part of San Diego's economy. Twenty percent of the region's jobs are a direct result of military or defense spending. This includes employment by prime contractors[20] and subcontractors.

San Diego's aerospace industry has benefitted from high levels of federal government investment to keep the military strong and to ensure the highest levels of national security. In San Diego alone, there are two naval bases and a marine base that all rely on aerospace technologies to ensure successful strategies and tactics in combat.

Civil

On the civil side, aerospace has been utilized in many ways by the local government and public services. For example, aircraft pilots help combat wildfires by dropping water and fire retardant. As technology evolves, universities, utility providers and cities are actively exploring ways to leverage aerospace technologies to aid research and activities, which could include policing, more effective firefighting, or other civil government activities.

Commercial

According to a recent report by PricewaterhouseCoopers, new equipment output for commercial aerospace firms in the United States increased by nearly 30 percent in 2011.

UAVs in San Diego County

After coming into public consciousness during the early days of the war in Afghanistan, UAVs (or "drones") and their potential opportunities in military, civilian and commercial operations are becoming increasingly visible.[1] The increase will likely be accompanied by a decrease in qualified aircraft operators. Of the 110 UAV-based locations that the Department of Defense (DoD) lists, two are in San Diego County: Camp Pendleton and the Silver Strand Training Center.

While the use of drones in operations from agricultural farming to search and rescue missions is being discussed, the Federal Aviation Administration's (FAA) rules for UAV operation have not yet been finalized. It is expected that the integration of UAVs into the nation's airspace will be finalized by 2015, which could impact the market for UAVs.

San Diego is currently the national center for the UAV market, which is likely to continue its regional growth considering that two of the nation's largest UAV manufacturers are located in San Diego County.[2] Twelve percent of DoD contracting activity in San Diego County is related to the production of UAVs.[3] National UAV production and R&D totaled approximately $6.6 billion in 2013, with San Diego County accounting for $547 million.[4]

San Diego's universities also drive UAV R&D. Academic research includes work on propulsion systems, structural integrity, and multiple systems coordination. As a result, the local universities supply ample talent as evidenced by university alumni currently working and hiring in this field:

> *We don't have a problem finding qualified employees, whether they be recent graduates from local universities to seasoned engineers from the larger companies excited to be part of groundbreaking work.*

The emerging UAV market also comes with challenges. The primary challenge for the UAV market is limitations by the FAA, which oversees all aspects of aviation use. However, UAV market growth would benefit the region economically and generate additional jobs in the region.

1. www.gizmag.com/uav-future-of-unmanned-flight/2747
2. Northrup Grumman and General Atomics
3. sandiegobusiness.org/sites/default/files/Industry_Aerospace.pdf
4. USASpending.gov data analysis of drones and unmanned aircraft

[20] A prime contractor is a company with a contract for a defense project or job. The firm has full responsibility for completing a project or job, which may include managing one or more subcontractors to complete specific milestones of the contract.

The same report conveys that it is unlikely that customer orders for aerospace and related parts will maintain the accelerated growth they did in 2011; however, there is still an expectation that the commercial segment is expected to have modest growth in 2014 and 2015.[21]

San Diego County companies also reported increased operations. Businesses with commercial consumers are prospering while firms primarily serving defense customers are feeling the impact of sequestration and the reduction of military involvement overseas. Annual production of commercial aircraft is expected to increase 25 percent by 2023. This demand growth will have a ripple effect on aircraft products and parts manufacturers in San Diego County.

Unmanned Aerial Vehicles (UAVs)

Advancements in new technologies have brought diversification opportunities to the aerospace industry. The manufacture of UAVs, or "drones," is one opportunity that has emerged as a leading market in San Diego's aerospace industry. Although defense spending has decreased in recent years due to sequestration, UAV funding and activity continue to increase in the region.

How Demand and Supply are Calculated

A demand and supply analysis is the initial step in identifying training gaps in the region. Demand is determined by the number of job openings available for an occupation for a particular year. Job openings are a result of job growth, retirement and other replacement needs. Demand data come from the U.S. Bureau of Labor Statistics and Economic Modeling Specialists, International (EMSI). Supply is determined by the number of people completing an education or training program that meets the basic qualifications for an occupation. Supply data include the Integrated Postsecondary Education Data System (IPEDS) from the U.S. Department of Education National Center for Education Statistics (NCES) for four-year credentials and the California Community Colleges Chancellor's Office (CCCCO) Data Mart for two-year credentials. 2012 is the most recent year in which data are available for program completions.

Comparing supply and demand is only the initial indicator of training gaps. For demand or number of job openings, the projection model from EMSI is based on historical employment data trends and does not account for recent legislative policies and other factors that may stimulate job growth in these areas. The supply or number of completers is not specific to one industry and as a result, the supply listed is the number of available workers for *all* industries. Competition with other industries for these positions suggests that there may be more of an undersupply than what the numbers indicate.

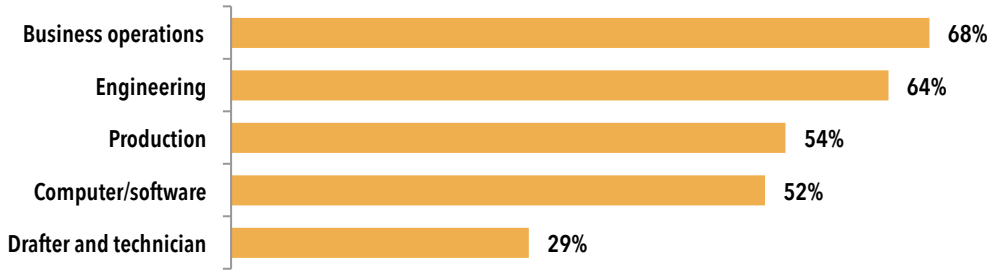
To compensate for limitations in the data, employer survey responses provide additional insight in training gaps. If a significant number of employers have difficulty hiring for a particular occupation, the supply of workers may need to increase to match the actual demand in the labor market.

Occupational Overview

To better understand the workforce needs of businesses, surveys were sent to 827 aerospace and aerospace-related employers in San Diego County; 91 firms participated in this study. Interviews were also conducted with 21 companies. Aerospace occupations analyzed for this study were grouped into five occupational clusters: business operations, computer/software, drafter and technician, engineering, and production. Over 50 percent of employers surveyed reported employing four out of the five occupational clusters studied (Figure 6).

[21] pwc.com/en_US/us/industrial-products/assets/pwc-aerospace-defense-2013-year-in-review-and-2014-forecast.pdf

Figure 6: Percentage of Employers Employing Occupations Studied

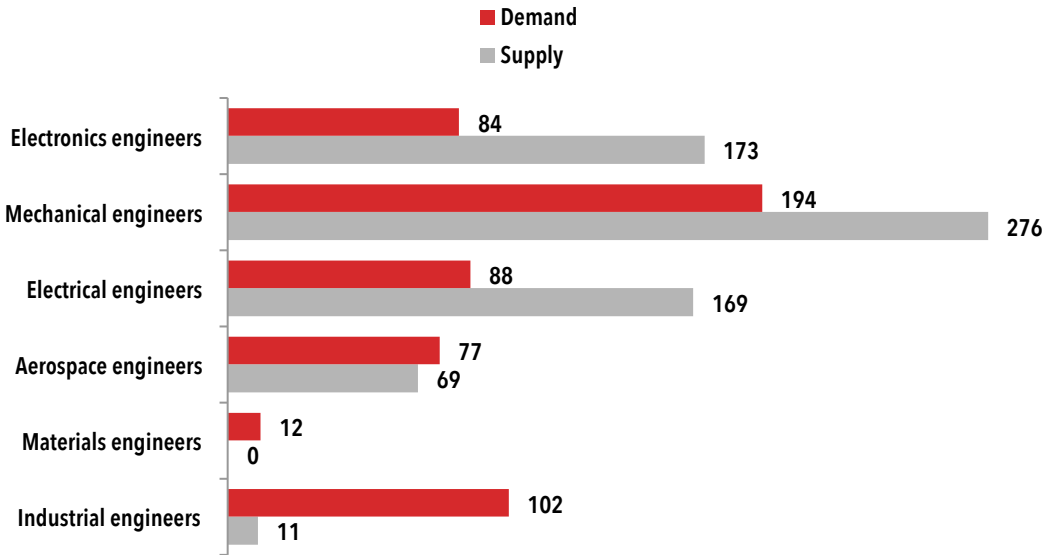


To better understand aerospace employers' workforce needs, this study focuses on specific occupations in each cluster that are essential for the operations and product development of the industry. The analysis includes a comparison between supply and demand for each occupation, identification of difficulties employers have in filling positions, and a list of top skill sets requested by employers for each occupation. This assessment helps determine which occupations can be addressed by workforce development.

Engineering Occupations

In an industry that builds technology-heavy products, such as aircraft, spacecraft and guided-missile systems, engineering is a crucial occupational group. Engineers are needed to design, test, build products, and conduct R&D activities. Figure 7 shows the supply and demand of engineers for San Diego County. Industrial engineers had the greatest supply gap, with the University of San Diego (USD) offering the only industrial engineering program in the county.[22] Although not as sizable, there was also an undersupply of materials and aerospace engineering occupations.

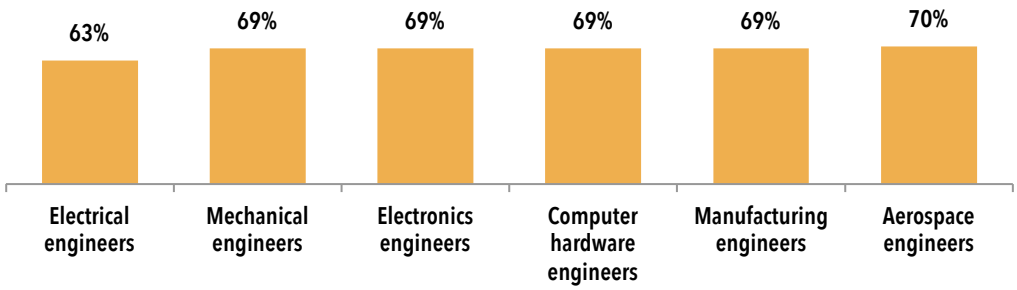
Figure 7: Demand and Supply for Engineering Occupations



[22] California Community Colleges Chancellors Office (CCCCO), Integrated Postsecondary Education Data System (IPEDS) and Economic Modeling Specialists, International (EMSI) data. 2012 is the most recent year in which data are available for most programs.

Even with an adequate supply of engineering graduates in many disciplines, almost 70 percent of aerospace companies reported experiencing some or significant challenges recruiting qualified individuals for engineering positions. This could be due to aerospace companies competing with other industries to hire these graduates, or to insufficiently trained graduates who lack the desired skills. As indicated in Figure 8, over 60 percent of employers indicated difficulty in hiring qualified engineers in specific disciplines. This indicates that supply does not necessarily meet demand. However, to know the true cause, further research must be conducted.

Figure 8: Percentage of Employers with Difficulty Hiring Engineers



n=49

Employers reported a struggle in finding mechanical engineers with computer-aided design/computer-aided manufacturing (CAD/CAM) machining experience. As engineering companies become increasingly reliant on technology, students are focusing more on technology-assisted design and development. While there are opportunities in multiple industries for engineers with design knowledge, the aerospace industry needs engineers who have practical, hands-on experience working with different materials and machines in various environments and altitudes. Employers believe that this type of experience produces better engineers. As one aerospace employer explains:

> *"We have difficulty in recruiting mechanical engineers with practical experience. Mechanical engineers need to have fabrication experience . . . they need to understand machine capacities, metal characteristics and tolerances."*

Engineers with program management skills are highly sought-after. Companies need engineers who are able to coordinate projects effectively and manage different production schedules for the products they are creating. This type of experience is valuable to employers because it makes processes more efficient. Interviews with employers expressed the need for project management:

> *"Mechanical engineers need to have program management knowledge. They need to be able to see the whole picture and keep all the pieces."*

Electrical engineers are also in high demand, with over 63 percent of employers having some to significant challenges hiring for these positions. Companies reported that the challenges come from the amount of time it takes to find a qualified employee. On average, there is a three-month turnaround from posting the position to making an offer, compared to an average position with approximately 25 days to make an offer.[23]

Specific skill sets needed for engineering occupations vary depending on the type of engineer. There are some common trends across the majority of engineering positions, such as validation, repair and simulation.

[23] wsj.com/articles/companies-are-taking-longer-to-hire-1409612937

Mechanical and manufacturing engineers are both expected to have CAD knowledge. Other commonalities depend on the specific position but survey respondents expressed challenges recruiting engineers with CAD, simulation, validation, and stress analysis knowledge. Table 1 below lists the top five specialized skills collected from online job postings.[24]

Table 1: Top In-Demand Skills for Engineering Occupations

Occupation	Top Specialized Skills
Aerospace engineer	Stress analysis NASTRAN Technical writing/editing Repair Finite element analysis
Computer hardware engineer	Electrical engineering Simulation VHSIC hardware description language (VHDL) Hardware experience Verilog
Electrical engineer	Test equipment Repair Physics Mathematics Simulation
Electronics engineers	Simulation Test equipment Validation MATLAB Mathematics
Industrial engineer	Inspection Six sigma Machining Industrial engineering Nondestructive testing (NDT)
Manufacturing engineer	Manufacturing processes Lean manufacturing CAD Mechanical engineering

[24] Burning Glass. Job postings listed by San Diego employers between Jan. 2013 and Dec. 2013.

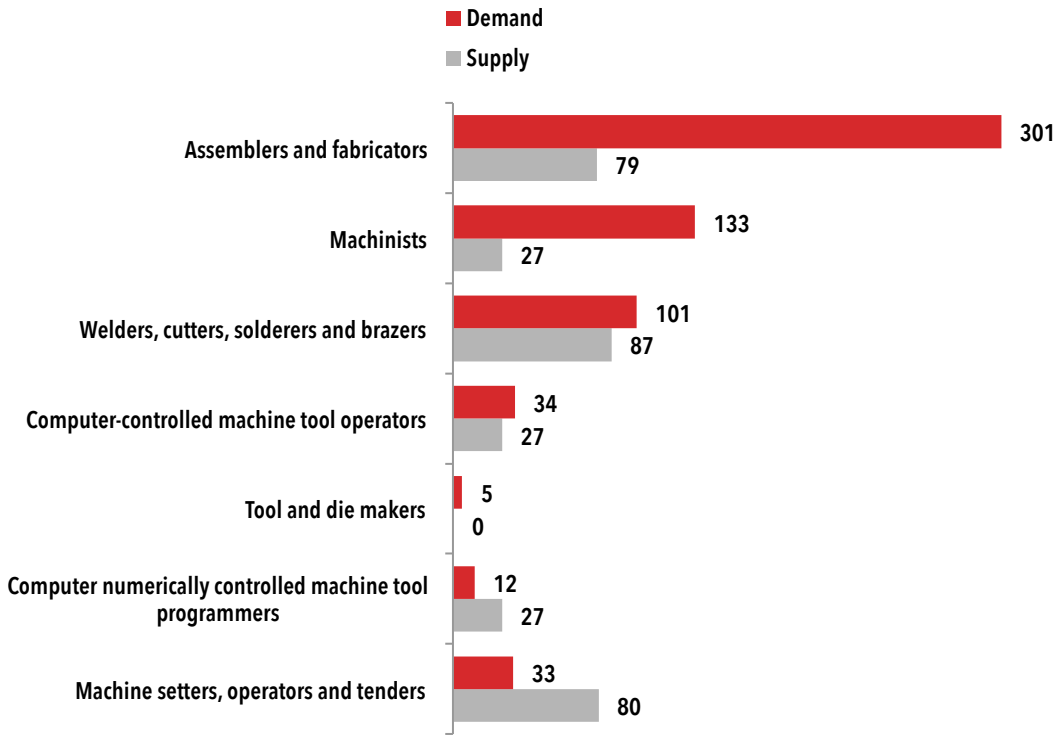
	Process improvement
Mechanical engineer	CAD Mechanical design Product development Validation Repair

Production Occupations

Aerospace production workers assemble and build aviation and space-related products. These occupations are in high demand, with the greatest number of occupations being assemblers and fabricators, machinists, and welders, cutters, solderers and brazers. Fifty-four percent of aerospace firms reported employing production occupations. Within this group, the majority hire assemblers, fabricators and machinists.

Figure 9 illustrates the demand for and supply of workers in production occupations in San Diego County.[25] Despite an undersupply of assemblers and fabricators in the county, only 43 percent of firms reported some challenges in hiring assemblers and fabricators. Because these positions are entry-level, firms do not require a specific training program, with most requiring only a high school diploma and minimal work experience.

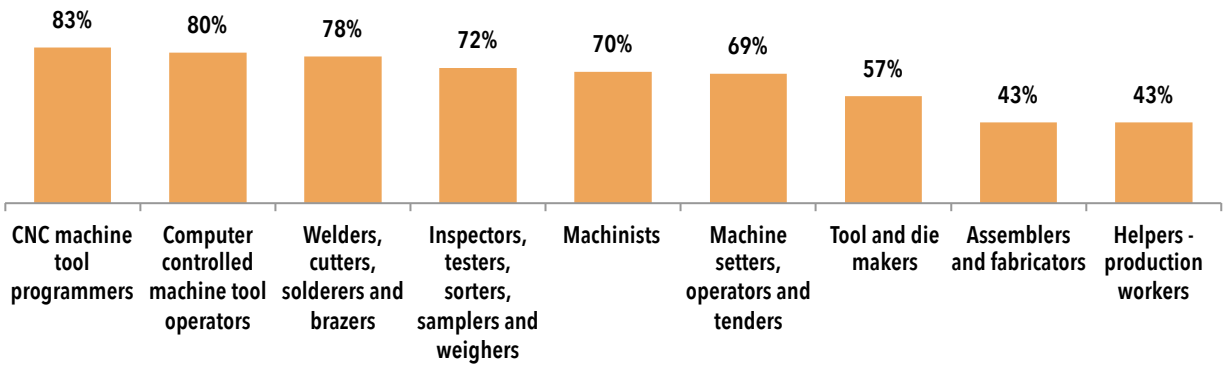
Figure 9: Demand and Supply for Production Workers



[25] CCCCO, IPEDS and EMSI. 2012.

Seventy percent of aerospace firms reported some to significant challenges in hiring machinists, which is unsurprising due to the undersupply of that occupation. Of the educational programs in the county reported by California Community Colleges Chancellors Office and the Integrated Postsecondary Education Data System, San Diego City College was the only accredited institution that provided machinist training in 2012. Other machinist programs exist within the county; however, they are not counted in the CCCCO and IPEDS data because these programs are not at accredited institutions. Even taking these programs into account, companies are still reporting challenges hiring qualified individuals. This could be due to inadequate training or to other manufacturing industries also competing for machinists.

Figure 10: Percentage of Employers with Difficulty Hiring Production Workers



n=52

Aerospace companies reported that the top missing skills for machinists are related to repair, machining and knowledge of lathes. Employers also indicated that on-the-job experience is crucial, as it provides irreplaceable training regarding machine capabilities and metallurgy. Table 2 lists the top five skills for jobs within production occupations. [26]

Table 2: Top In-Demand Skills for Production Occupations

Production Occupations	Top Specialized Skills
Assemblers and fabricators	Hand and power tools SAP Oracle Six Sigma Environmental compliance
Computer numerically controlled (CNC) machine tool programmers	Computer Numerical Control (CNC) Machining 5-axis machining

[26] Burning Glass. Job postings listed by San Diego employers between Jan. 2013 and Dec. 2013.

	Lathes Inspection
Computer-controlled machine tool operators	CNC Micrometers Dimensions CNC lathes Machinery
Helpers-production workers	Mathematics Physical demand Inspection Machine operation Environmental compliance
Inspectors, testers, sorters, samplers and weighers	Inspection Validation Medical device Calibration Chemistry
Machine setters, operators and tenders	Inspection Machine tools Grinders Machine operation Blueprints
Machinists	Machining Lathes CNC Machine tools Mathematics
Tool and die makers	Repair Lathes Machining Blueprints Grinders

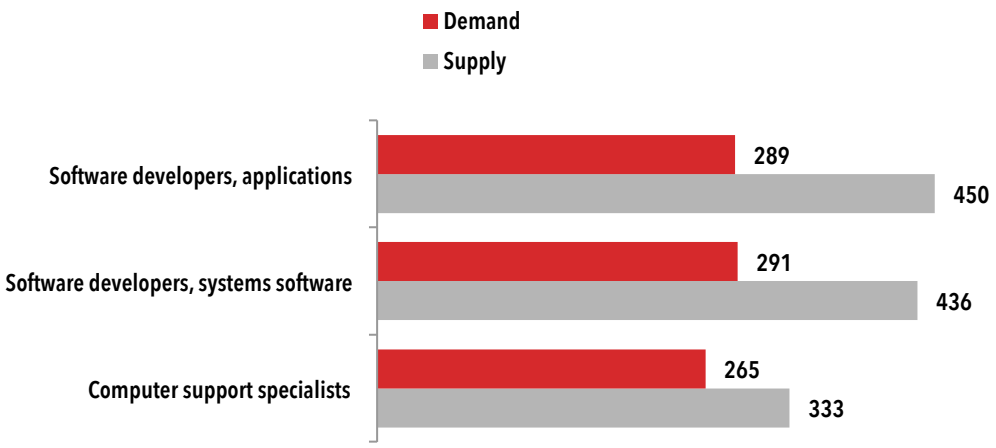
Welders, cutters, solderers and brazers	Soldering Repair Schematic diagrams Inspection Screw drivers

Although aerospace employers value experience more than education for production occupations, their customers are interested in the education, training and certifications possessed by their workforce. Customers frequently ask aerospace manufacturers to complete annual or biannual surveys regarding their workforce's educational attainment.

Computer and Software Occupations

Computers are used in many roles in the industry, from inventory control to design and manufacturing planning. Just over half of the respondents employ computer and software positions. Of these firms, almost all of them employ systems and applications software developers. In San Diego County, the supply of software workers exceeds the demand.[27]

Figure 11: Demand and Supply for Computer and Software Occupations



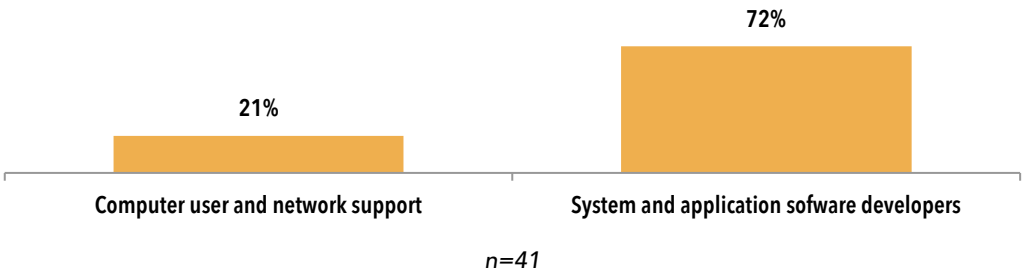
Despite producing a surplus of graduates in this field, aerospace firms reported some difficulty filling software and application developer positions. Part of the difficulty finding computer software workers can be attributed to other industries seeking similarly qualified workers, meaning employers in aerospace must compete with employers in other industries for the best and the brightest. As one employer explains it:

> *"System programmers with software experience are difficult to find. Because our company has government contracts, we have the added complication of needing to find individuals who have security clearances, understand the politics of the nature of our business, and have good verbal and written skills."*

[27] CCCCO, IPEDS and EMSI. 2012.

Finding qualified individuals with the ability to obtain a security clearance is critical for employers, especially those supplying the defense industry or those with government contracts.

Figure 12: Percentage of Employers with Difficulty Hiring Computer/Software Occupations



n=41

Additionally, employers also reported some or significant challenges in recruiting workers with the desired skills, contributing to their hiring difficulties. The technology used in and skills required by the aerospace industry vary significantly and is often contingent on the employer's customer base.[28] For example, a UAV manufacturer may want their software developer to develop an application that can control unmanned vehicles from a tablet device. On the other hand, defense customers tend to use older technologies, which require knowledge of legacy systems and an understanding of how to integrate newer technologies into older equipment/technologies.

Table 3: Top In-Demand Skills for Computer/Software Occupations

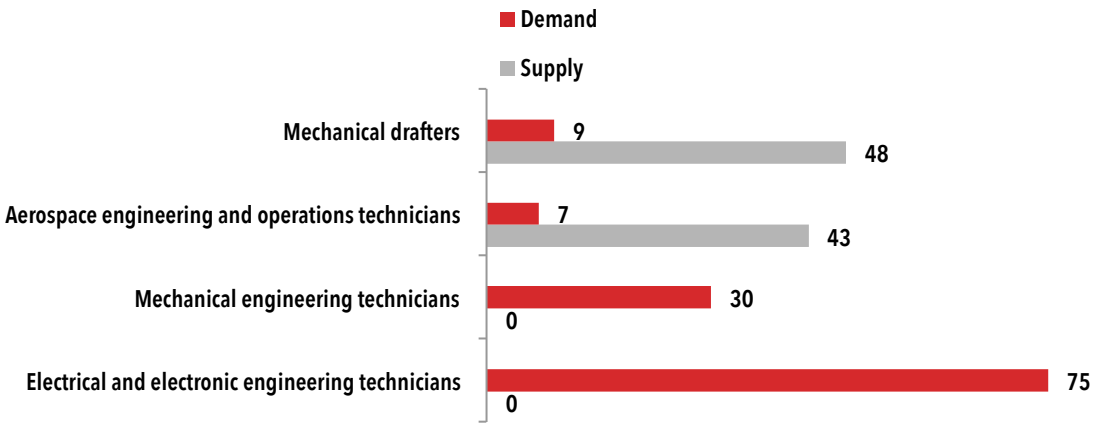
Computer/Software Occupations	Top Specialized Skills
Computer user and network support	Hardware and software configuration Business process Technical support Help desk support
Software developers, applications	Software engineering C++ JAVA Microsoft C# Software development
Software developers, systems	Systems engineering Systems integration Validation System architecture C++

[28] Burning Glass. Job postings listed by San Diego employers between Jan. 2013 and Dec. 2013.

Drafter and Technician Occupations

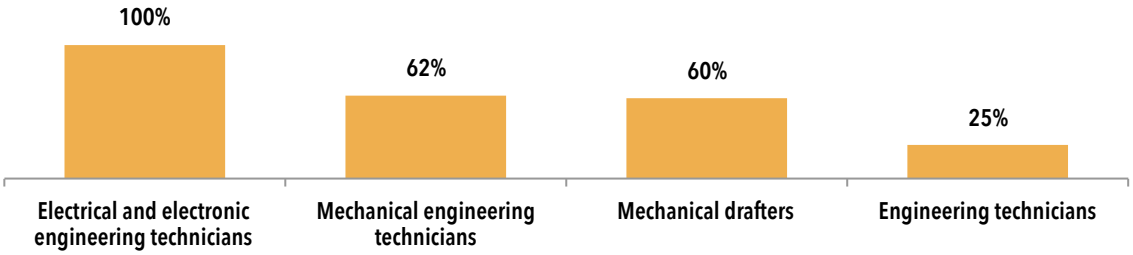
Technicians and drafters assist engineers in building prototypes and testing. In an industry that is constantly innovating, drafters and technicians play a significant role. Educational institutions throughout the county train for technician and drafter positions; however, according to demand and supply, the biggest shortfall of labor supply is for electrical and electronics engineering technicians (Figure 13).[29] Other drafter and technician training programs exist in San Diego County; however, they are not included in the CCCCO and IPEDS data because the programs are not run through accredited institutions.

Figure 13: Demand and Supply for Drafter and Technician Occupations



Twenty-nine percent of aerospace firms reported hiring drafters and/or technicians. Of these firms, employers had difficulty hiring mechanical engineering technicians, mechanical drafters, and electrical and electronic engineering technicians. Although respondents expressed challenges recruiting for drafter and technician positions, nearly all reported only having *some* difficulty hiring rather than *significant* difficulty hiring (Figure 14). Despite some challenges recruiting for these positions, the majority of employers are able to find the workers they need.

Figure 14: Percentage of Employers with Difficulty Hiring Drafter and Technician Occupations



n=25

[29] CCCCO, IPEDS and EMSI. 2012.

Part of the difficulty employers have finding qualified workers is due to job candidates not possessing the skills employers require. Table 4 lists the top skills needed for drafter and technician occupations.[30]

Table 4: Top In-Demand Skills for Drafter and Technician Occupations

Occupations	Top Specialized Skills
Aerospace engineering and operations technicians	Inspection Nondestructive Testing (NDT) Network Attached Storage (NAS) Government regulations
Electrical and electronic engineering technicians	Repair Test equipment Calibration Hand tools Technical writing/editing
Engineering technicians, except drafters, all other	Inspection Calibration Cell culturing Cleaning Good Manufacturing Practices (GMP)
Mechanical drafters	AutoCAD Computer Aided Drafting (CAD) 3D modeling CAD design Revit
Mechanical engineering technicians	Calipers Blueprints Inspection Screwdrivers Micrometers

Business Operations Occupations

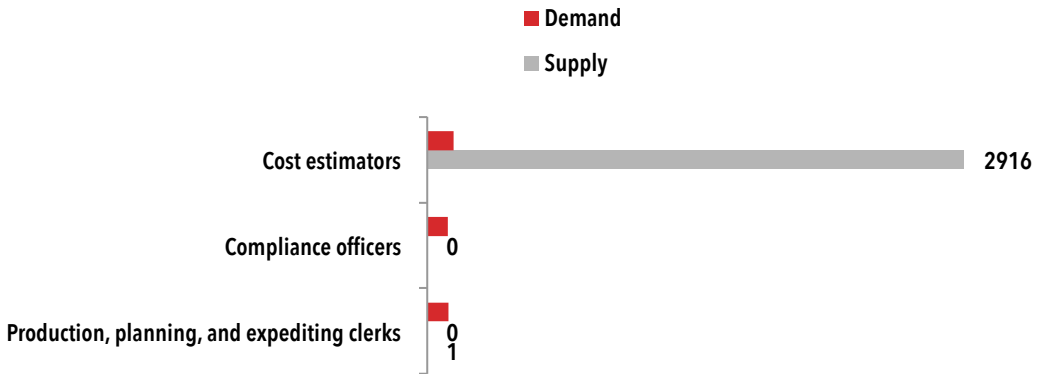
Business operations occupations encompass workers who ensure that the business runs smoothly, keeping production on schedule and within the bounds of the laws and regulations of the industry or contracts. Sixty-

[30] Burning Glass. Job postings listed by San Diego employers between Jan. 2013 and Dec. 2013.

eight percent of survey respondents employ business operations occupations within their firms. In order to identify occupations that are going unfilled due to a lack of skilled workers, this study examines the gap between demand and supply of workers.

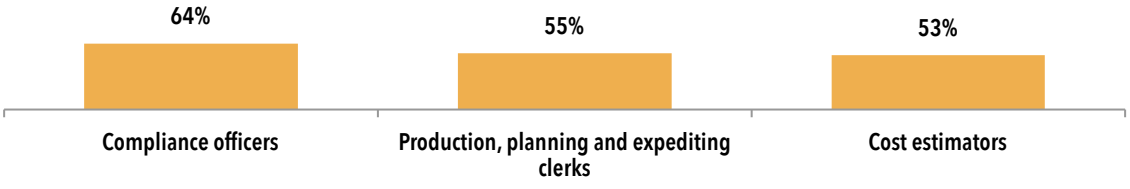
According to the gap analysis of the business operations occupations, there are multiple shortages within this group (Figure 15).[31] Neither compliance officers nor production, planning and expediting clerks have accredited training programs that produce graduates in the region. On the other hand, a worker with a Business Administration degree is counted in the supply pool for the cost estimator profession; however, this overestimates the supply due to the large number of institutions throughout the region.

Figure 15: Demand and Supply for Business Operations Occupations



Although there is a surplus of cost estimators, half of survey respondents expressed challenges hiring for these positions (Figure 16). The disconnect between the over-supply of cost estimators and the difficulty in hiring them may be due to undergraduate business administration programs not training aerospace-specific skills, which makes graduates unqualified for available positions. Or, other industries compete and recruit graduates from these programs, which reduces the pool of available workers for the aerospace industry. This is an area for further research. Aerospace companies also reported challenges in recruiting production, planning and expediting clerks with scheduling, logistics and Manufacturing Resource Planning (MRP) experience, which is unsurprising considering the severe undersupply of trained workers for that position.

Figure 16: Percentage of Employers with Difficulty Hiring Business Operations Occupations



n=45

[31] CCCCO, IPEDS and EMSI. 2012.

There are likely several factors leading to the difficulty in hiring qualified business operations workers, including a lack of specialized skills. Common skills employers seek from these workers are listed in Table 5.[32]

Table 5: Top In-Demand Skills for Business Operations Occupations

Business Operations Occupations	Top Specialized Skills
Cost estimators	SAP Mathematics Procurement Cost analysis Scheduling
Compliance officers, construction, health-safety and transportation	Regulatory affairs Medical device SAP Product development Labeling
Production, planning and expediting clerks	Scheduling Enterprise Resource Planning (ERP) SAP Manufacturing Resource Planning (MRP) Logistics

Education and Training

San Diego County has a large number of universities and colleges that train students for the occupations studied. Table 6 lists some of the education credentials that can lead to potential jobs and career pathways in aerospace. Appendix C lists the educational institutions that train for occupations in the aerospace industry.

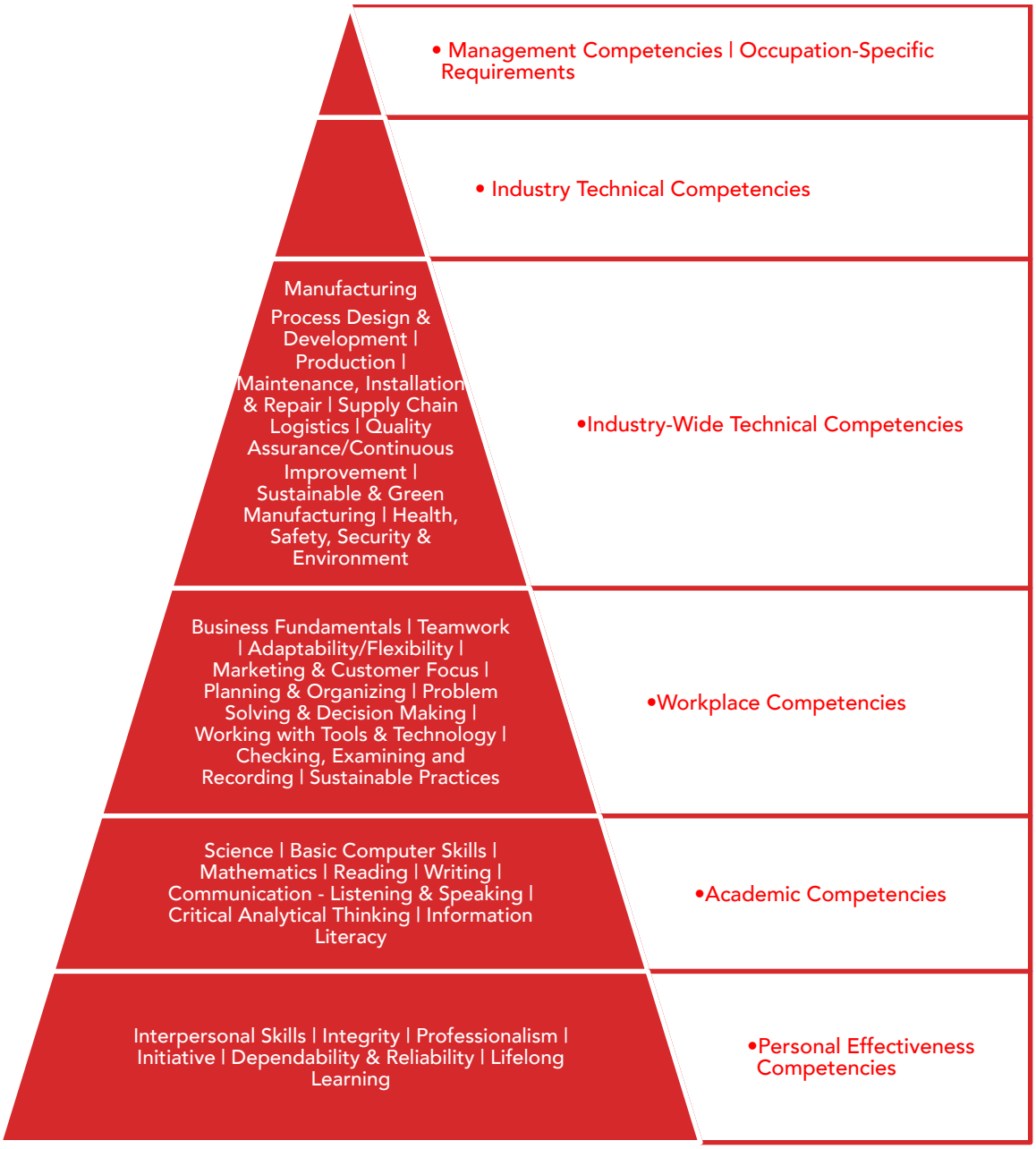
Table 6: San Diego Education Credentials and Related Occupations

Bachelor's degrees	Associate degrees	On-the-Job training
Aerospace Engineering	Computer Networking	Heavy Equipment Maintenance
Mechanical Engineering	Computer Programming	CAD/CADD
Electrical Engineering	Business Management	Aircraft Electronics
Electromechanical Engineering	Aviation Airframe Mechanics	Machining/Machine Tools
Industrial Engineering	Aviation Power Plant Mechanics	Welding Technology
Computer Hardware Engineering	Drafting and Design Technology	Machine Tool Technology
Business Administration	Business Administration	
Business Management	Aeronautical and Aviation Technology	
Software Development		

[32] Burning Glass. Job postings listed by San Diego employers between Jan. 2013 and Dec. 2013.

In addition to academic skills, workers also need to have well-developed soft skills. Workplace competencies in writing, mathematics and communication are a few of the essential skills for aerospace industry workers at all levels. The competency model for the aerospace industry, developed by Career One Stop, is presented in Figure 17.[33] This figure illustrates a bottom-up perspective of the skill sets desired by companies in the aerospace industry. Although personal effectiveness competencies provide the model's foundation, both these and academic competencies need to be developed to create a strong workforce. The competencies are gained through experience and practice, in both academia and workplace settings. The model empowers potential job candidates in understanding the competencies desired (and often required) by employers.

Figure 17: Aerospace Industry Workplace Competency Model

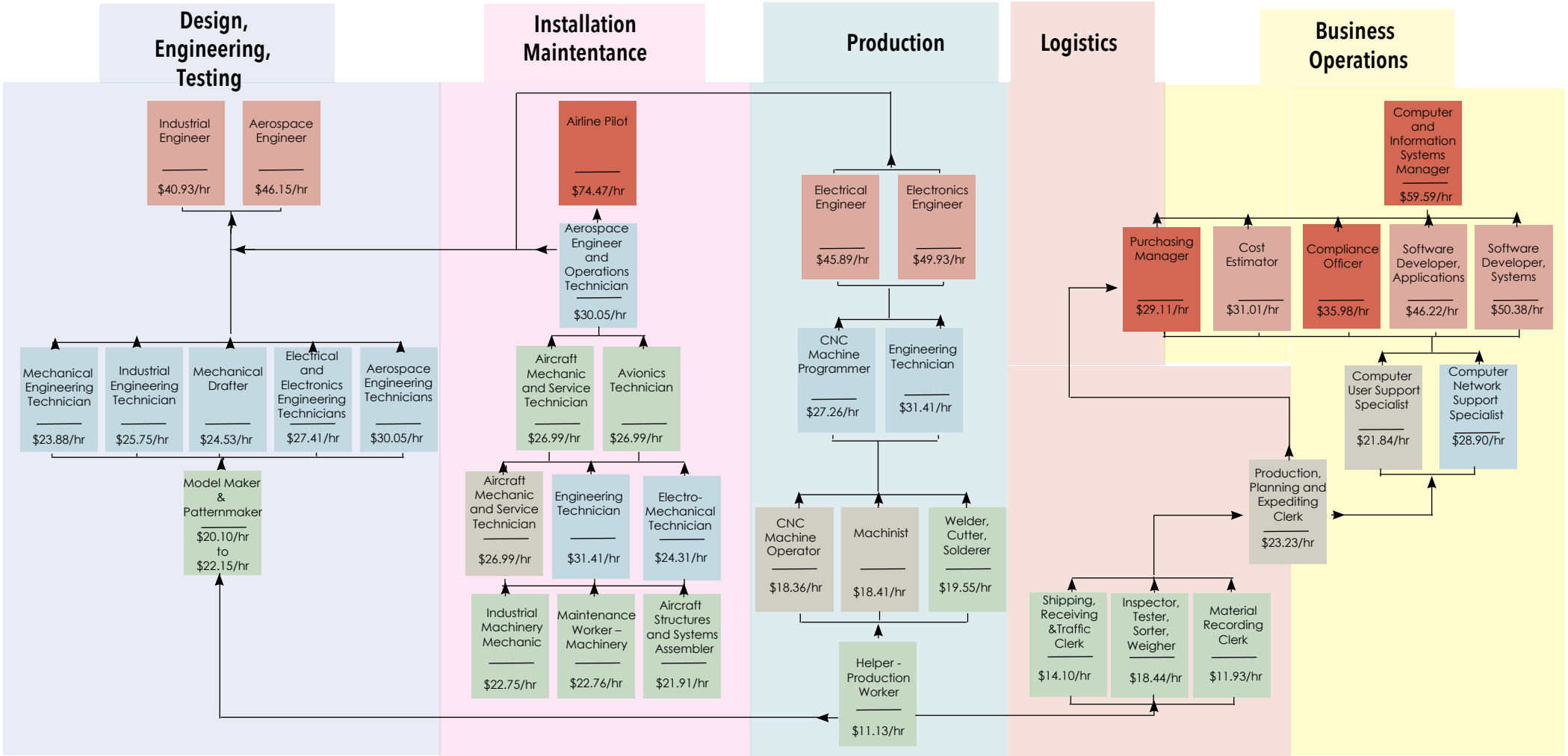


[33] Adapted from Advanced Manufacturing Competency Model. Washington, DC: United States Department of Labor, Employment and Training Administration. careeronestop.org/competencymodel/competency-models/advanced-manufacturing.aspx.

Aerospace Industry Career Pathways

The aerospace industry encompasses a wide range of sectors and occupations from manufacturing to engineering. As a result, the skills required in this sector range from blue-collar, production-related abilities to white-collar, information technology occupations. A job in this sector can begin with a high-school diploma and provide a pathway to management jobs with the acquisition of skills and academic credentials. Potential paths can take a worker up within a line function or across alternate lines as work experience or academic degrees are added to the worker's résumé. The career lattice (Figure 18) is an illustration of possible paths in the aerospace industry, but is not all-inclusive. For example, a worker can begin as a helper production worker after earning a high school diploma, move on to be a machinist after some on-the-job experience, then become a CNC machine programmer after acquiring an associate degree, and finally, an industrial engineer with a bachelor's degree. This is all dependent on training and education; however, the career lattice provides a sample path that job seekers can take in this diverse industry.

Figure 18: Aerospace Careers, Training and Edcuation Lattice



Recommendations

The recommendations offered in this report outline strategies and action steps aimed at increasing the worker pipeline for those aerospace industry sectors with skill gaps. In order to ensure that these workers possess the necessary skills to make San Diego's aerospace companies competitive, recommendations fall into two distinct categories: 1) education and training and 2) industry.

Education and Training

To remain globally competitive, San Diego must adopt policies to increase the talent base in STEM fields across all ages. This includes reevaluating, reeducating, reengaging and retaining STEM professionals in methods consistent with generational changes in technologies and markets.

The K-12 system should incorporate more training for soft skills and workplace competencies (through hands-on training and/or work experience) by better aligning curriculum with community college and university curricula and admissions requirements. An aligned talent pipeline will allow workers to be prepared throughout the educational process to ensure they have mastered all levels of required competencies (from soft skills and basic competencies through technical skills required by employers).

An emphasis should be placed on technical skills, both in the K-12 system and higher educational learning institutions. Strategies can incorporate project-based learning, student-industry collaboration projects or other hands-on training.

The workforce development system should consider training workers with similar skills for other positions. This could include identifying compatible occupations, and the skills that are needed to close the gap in knowledge deficiencies for similar occupations. Education and training programs should develop pathways to help dislocated workers (especially those affected by sequestration in similar industries) develop skill sets needed to transition to new jobs requiring similar skill sets. For example, a worker could transition from a maritime industry production job to an aerospace industry production job with minimal transitional training.

The workforce development system should tailor programs to serve small businesses. The majority of firms in San Diego County have fewer than 20 employees, while training programs tend to be targeted toward larger companies. Many small businesses do not qualify for certain training programs, nor can these businesses invest in new equipment for training as easily as larger companies.

To assist job seekers, the workforce development system should also consider utilizing career lattices (such as the lattice in Figure 18) to help educate workers on future possibilities when starting out their careers in the aerospace industry.

Industry

The aerospace industry in San Diego should seek out investments from local and national governments and private entities to provide incentives for R&D investments that help to attract high-quality workers and academics. R&D dollars provide a return by supporting graduate students, generating knowledge, creating innovation opportunities for small businesses around universities and building the next generation of talented

engineers. Without investment in aerospace workers, San Diego may lose the valuable economic benefits derived from the industry.

One such investment could include R&D in the UAV market, a growing area in the aerospace industry that is used both commercially and by the military. As uses for UAVs expand, so too should the industry that supports it.

Additionally, internship, apprenticeship or other types of hands-on training programs should be utilized further to ensure that job candidates have the work experience required by employers. Employers can assist in this manner by providing such positions within their companies.

Conclusion

The aerospace industry has been one of the key drivers of the economy in San Diego. While Ryan Airlines helped develop the civilian component of the aerospace industry long ago, the military's presence led to the development of the industry's defense component. While the industry is still relatively small compared to mature economic sectors such as Life Sciences,[34] it is a critical component of vital sectors to San Diego such as defense, Advanced Manufacturing[35] and logistics. Like Life Sciences 20 years ago, aerospace is an industry in transition that can grow to become an even greater component of the San Diego economy. The constant innovation required in materials, fuel use and instrumentation consequently led to a growth in R&D establishments, creating a high-tech hub around this industry. Although defense spending is declining, civilian and commercial use of UAVs is on the rise, with San Diego poised to benefit from this increase.

Developing a globally competitive aerospace industry requires a workforce system that is responsive to industry needs and is able to supply a steady stream of talented workers. However, as this report documents, there is a shortfall of qualified workers that is required to grow and develop the industry. While local educational institutions are not meeting demand for some engineering occupations, there is a much larger gap in the production of technicians. A sustained effort is needed from educators, manufacturers and the government to encourage students to pursue STEM fields starting in high school (through Career Technical Education classes), and help them acquire further credentials in two-year institutions. San Diego is well positioned to play a role in the growing aerospace market, but it will need to invest in talent development as well as research infrastructure to continue providing the innovation that drives the region's aerospace industry.

[34] Life Sciences is one of the Priority Sectors identified by the San Diego Workforce Partnership (SDWP) and the San Diego and Imperial Counties Community Colleges (SDICCCA). workforce.org/reports

[35] Advanced Manufacturing is also an SDWP and SDICCCA Priority Sector. workforce.org/reports

Appendix A: Methodology

The research design utilized both qualitative and quantitative approaches appropriate and necessary for identifying and assessing the specific skills and knowledge that employers are looking for in this changing industry, as well as a jobs gap assessment and career pathways analysis. The research study relied on a combination of surveys, semi-structured interviews, focus groups and quantitative analyses to elucidate the four major phases of research identified above.

(1) Defining Jobs and Industries that Meet the Sector Definition

For the purposes of this report, the research team chose two approaches in defining the aerospace industry.

The first approach was selected to obtain a conservative estimate of the impact of the aerospace industry, by analyzing sectors that primarily produce products or services in aviation or the surrounding space. Within this approach, aerospace covers a wide range of activity—from the manufacture of aircraft for both commercial and military use, to space vehicle and guided missile production. There are numerous subsectors that feed the aerospace sector, ranging from supply parts and instruments to the R&D laboratories that provide the technical knowledge. In order to narrow the focus, the research team used SANDAG's cluster report, *Traded Industry Clusters in the San Diego Region*.[36] The table below lists the NAICS codes used in this study. Some codes refer to subsectors belonging exclusively to the aerospace industry such as aerospace products and parts manufacturing (NAICS 3364), while others such as instrumentation manufacturers (NAICS 334513) do not supply solely to the industry. Therefore, NAICS codes were analyzed separately whenever possible. Also included in the analysis are support activities for air transportation, as well as research and design, and testing laboratories for this sector.

Aerospace Industry Definition

NAICS Code	Industry Description
334414	Electronic Capacitor Manufacturing
334416	Electronic Coil, Transformer, and Other Inductor Manufacturing
334511	Search, Detection, Navigation, Guidance, Aeronautical, and Nautical System and Instrument Manufacturing
335313	Switchgear and Switchboard Apparatus Manufacturing
335314	Relay and Industrial Control Manufacturing.
336411	Aircraft Manufacturing
336412	Aircraft Engine and Engine Parts Manufacturing
336413	Other Aircraft Parts and Auxiliary Equipment Manufacturing
336414	Guided Missile and Space Vehicle Manufacturing
336419	Other Guided Missile and Space Vehicle Parts and Auxiliary Equipment Manufacturing
488111	Air Traffic Control
488119	Other Airport Operations
488190	Other Support Activities for Air Transportation

[36] www.sandag.org/uploads/publicationid/publicationid_1715_15318.pdf

541380	Testing Laboratories (35%)
541712	Research and Development in the Physical, Engineering and Life Sciences (except Biotech) (20%)

The second approach was to build a broader definition of the aerospace industry because of its supply chain and interconnections with other industries—it is a multi-faceted industry. It covers not only commercial, but also military functions. Companies in this analysis included businesses that have performed work in the aerospace industry but for whom aerospace is not the primary or sole customer base. For example, an advanced precision manufacturer that produces components for aircraft, military land vehicles, submarines and other markets would be included in this method. The research team's workforce survey asked companies to self-identify what percentage of business comes from the aerospace industry. Survey respondents classified their companies as performing work for the aerospace industry. The second approach was used to fully understand workforce demands using the broader definition of the aerospace industry.

Staffing Patterns data were used from the California Labor Market Information Division to identify Standard Occupational Classification (SOC) codes that were prevalent in these industries.

(2) Jobs Gap Assessment

UCSD Extension and the San Diego East County Economic Development Council (East County EDC) analyzed the supply and demand of the occupations meeting the sector definition identified above. The five elements of this research and corresponding methodologies are described below:

2a. Job demand in the short-term (12 months): The data collection for short-term job demand was done with a quantitative analysis of survey responses. UCSD and East County EDC used pre-established relationships with industry to supplement employer outreach and accelerate the outreach and industry collaboration that this grant required.

2b. Job demand in the long run (5 years): The research team used data from Economic Modeling Specialists, International (EMSI) for occupational projections to estimate future trends based on historical data. EMSI bases its estimates on BLS data. For the job gap, we used their estimate of annual job openings for each occupation.

2c. Supply of eligible workers: The research team used data from the Department of Education's IPEDS database to determine the supply of eligible workers for the occupations. The Centers of Excellence, San Diego and Imperial County Region, provided us with education codes that matched the skills required for the occupations under consideration.

2d. Alignment of job demand with labor supply: To ascertain the alignment of job demand with labor supply, the research team used EMSI occupation projections for the demand occupations in our list. The projections account for job growth in each occupation as well as replacement needs. The supply data for occupations used IPEDS data from the U.S. Department of Education's National Center for Education Statistics (NCES) to determine the number of students that were being trained for these occupations. The latest year for which data was available was 2012. Both data sets were analyzed in order to present a full picture of the future job gap (if any). The research team used this analysis as a springboard to pinpoint key drivers and parameters that indicate a mismatch between labor and industry.

2e. Economic size and scope of the aerospace industry: The importance and impact of this sector to the national and regional economy was analyzed using publicly available data from the BLS and U.S. Census Bureau.

(3) Overall assessment of employers' workforce needs

3a. Surveys: To understand the overall environment and changes in the advanced manufacturing space, the research team conducted a representative sample survey of all employers meeting the sector definition.

The research team was able to utilize East County EDC's Connectory, a database of primary industry businesses in the region, which provided a list of establishments in the aerospace sector. The team was uniquely positioned to conduct this work because of the Connectory's close connection with manufacturing and supply companies and the work the East County EDC did for SDWP's San Diego Advanced Manufacturing: Labor Market Analysis. Building off the Connectory's database as well as the personal relationships with employers in the region, the team worked with SDWP to design and distribute the survey to collect pertinent data on the future of aerospace in San Diego.

The survey was sent through *Qualtrics* to all sector employers identified above. Each survey had a common core of items relating to a) identification of occupations in the aerospace sector, b) assessment of occupations with some to significant challenges finding qualified personnel, c) number as well as type of workers to be hired in the next 12 months, d) training programs or certifications for occupational skills that employers value. The survey was constructed to collect pertinent company information for data analysis (i.e., size, occupations, necessary skill sets). Survey questions were collapsed across individual survey items to create a single composite score for each construct, rather than attempting to interpret individual scores from multiple questions. Preliminary data was scored and presented using exploratory data analysis.

3b. Interviews: A sample of employers across the industry sector was interviewed to probe beyond survey answers. Through these interviews, the research team gained employers' insight into their labor forecasts, an assessment of the skills they prioritize in new hires, feedback regarding the current education and training model, and its effectiveness in developing the skill sets employers have highlighted. Each interview was semi-structured, creating a common core of questions, but leaving latitude to explore differences in attitudes, perceptions and challenges.

Collectively, the utility of the interviews and surveys enabled a nuanced and sophisticated understanding of employer perceptions, as well as an illustration of their educational/training requirements.

(4) Career Pathway Diagrams

Using employer feedback and occupations and skills identified in the previous phases, as well as secondary BLS data and job boards such as Burning Glass, the research team created career pathway diagrams that show occupations, educational level needs, and median salary. These diagrams serve as a guidepost for those seeking employment in the advanced manufacturing sector and identify clear channels to specific occupations.

Appendix B: Aerospace Industry Related Occupations

The following table shows the list of occupations studied in this report by Standard Occupational Classification (SOC) code.

SOC	Description
13-1041	Compliance Officers
13-1051	Cost Estimators
15-1132	Software Developers, Applications
15-1133	Software Developers, Systems Software
15-1151	Computer User Support Specialists
15-1152	Computer Network Support Specialists
17-2011	Aerospace Engineers
17-2071	Electrical Engineers
17-2072	Electronics Engineers, Except Computer
17-2112	Industrial Engineers
17-2131	Materials Engineers
17-3013	Mechanical Drafters
17-3021	Aerospace Engineering and Operations Technicians
17-3023	Electrical and Electronics Engineering Technicians
17-3026	Industrial Engineering Technicians
17-3027	Mechanical Engineering Technicians
17-3029	Engineering Technicians, Except Drafters, All Other
19-4099	Life, Physical, and Social Science Technicians, All Other
43-4181	Reservation and Transportation Ticket Agents and Travel Clerks
43-5061	Production, Planning, and Expediting Clerks
49-3011	Aircraft Mechanics and Service Technicians
49-9041	Industrial Machinery Mechanics
49-9043	Maintenance Workers, Machinery
51-2011	Aircraft Structure, Surfaces, Rigging, and Systems Assemblers
51-4011	Computer-Controlled Machine Tool Operators, Metal and Plastic
51-4012	Computer Numerically Controlled Machine Tool Programmers, Metal and Plastic
51-4041	Machinists
51-9061	Inspectors, Testers, Sorters, Samplers, and Weighers
51-9141	Semiconductor Processors
53-2022	Airfield Operations Specialists

Appendix C: Education and Training Programs

Below are education and training programs that directly relate to the occupations studied in this report.

Production occupations	Machine setters, operators and tenders	Tool and die makers	Welders, cutters, solderers and brazers	Assemblers and fabricators	Computer-controlled machine tool operators, metal and plastic	Computer numerically controlled machine tool programmers	Machinists
Palomar College	✔		✔				
SD Adult	✔						
SD City College	✔				✔	✔	✔
SD Mesa College							
SD Miramar College				✔			

Engineering occupations	Aerospace engineers	Electrical engineers	Electronics engineers, except computers	Industrial engineers	Materials engineers	Mechanical engineers
UCSD	✔	✔	✔			✔
SDSU	✔	✔	✔			✔
USD		✔	✔	✔		✔

Computer and software occupations	Software developers, applications	Software developers, systems software	Computer support specialists, all other
UCSD	✔	✔	✔
SDSU	✔	✔	✔
USD	✔	✔	✔
CSUSM	✔	✔	✔
PLNU	✔	✔	✔
MiraCosta College			✔
Palomar College			✔
Southwestern College			✔

Drafter and technician occupations	Aerospace Engineering and operations technicians	Electrical and Electronic engineering technicians	Engineering Technicians, except drafters, all other	Mechanical drafters	Mechanical engineering technicians
Cuyamaca College				✔	
MiraCosta College			✔	✔	
Palomar College				✔	
SD Adult			✔		
SD City College			✔	✔	
SD Miramar College	✔				
Southwestern College			✔	✔	

Business operations occupations	Compliance officers	Cost estimators	Production, planning and expediting clerks
Southwestern College		✔	
MiraCosta College	✔	✔	
National University	✔		
UC San Diego		✔	
Cuyamaca College		✔	
Grossmont College		✔	
San Diego State University		✔	
University of San Diego		✔	
Palomar College		✔	
SD City College		✔	
SD Miramar College		✔	

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