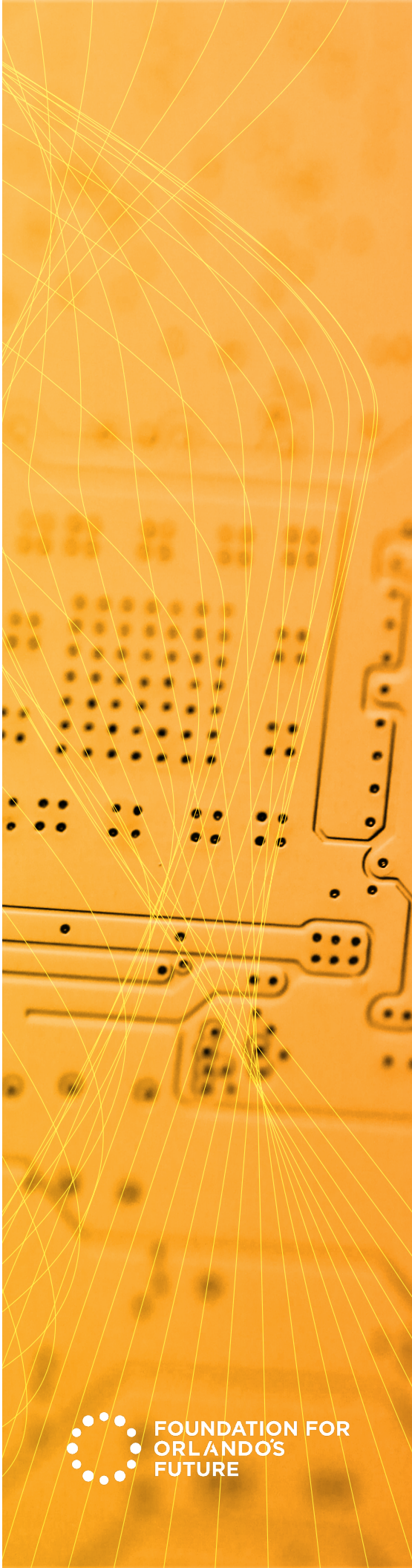
ORLANDO ECONOMIC PARTNERSHIP

Semiconductor Manufacturing in Orlando:

Part II – A Skills-based Approach to Workforce Development



FOUNDATION FOR ORLANDO'S FUTURE

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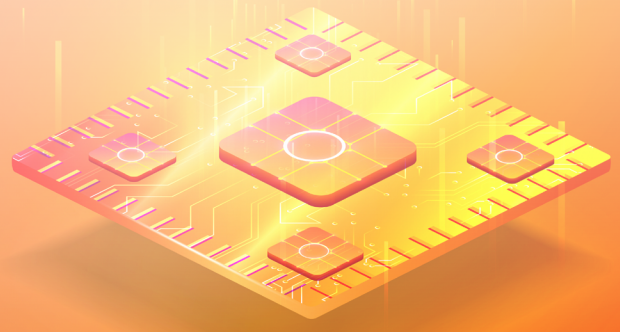
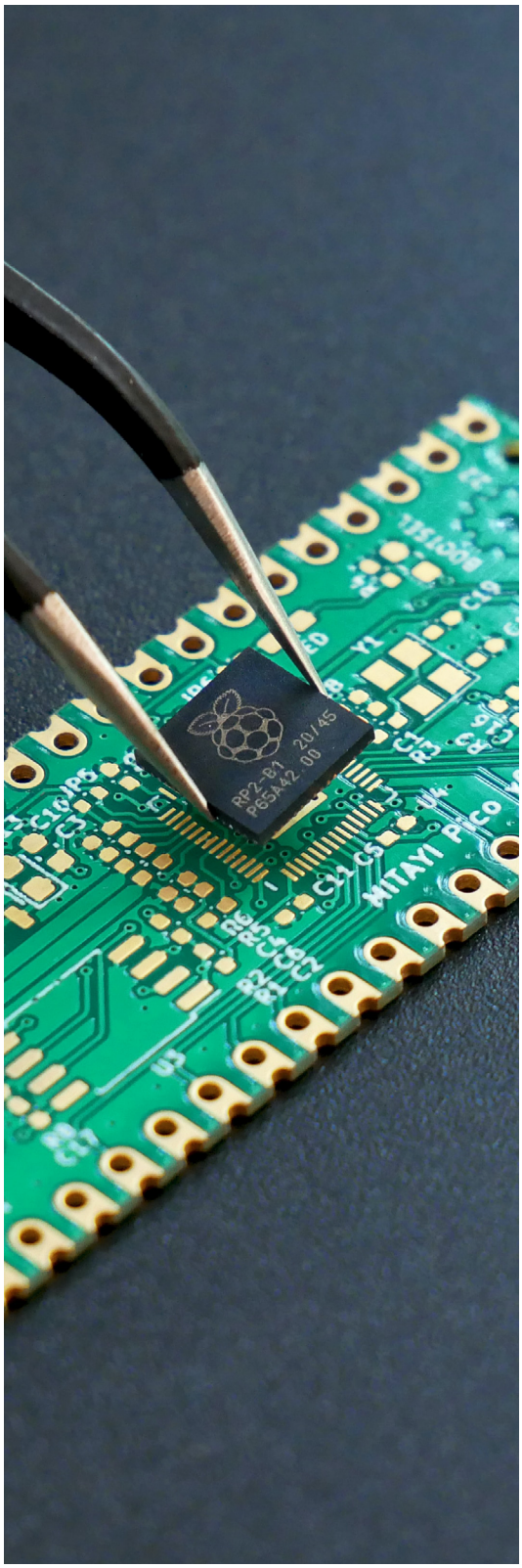


FOUNDATION FOR ORLANDO'S FUTURE

The Purpose of This Series

This report series is meant to serve a specific audience, targeted to Orlando, including companies in need of semiconductor manufacturing talent or related talent, higher education providers looking to support the development of this industry with programming and training, and workforce development institutions in search of new upward mobility pathways for the individuals they serve.

Readers who are unfamiliar with the semiconductor manufacturing industry and the Orlando ecosystem are encouraged to read part I of this series. Part I can be found by visiting **Orlando.org/upskill-semiconductor**. Part II, is focused on understanding the semiconductor manufacturing workforce and identifying skills-based approaches for solving talent pipeline constraints.



The Hopes for a Skills-Based Approach

Skills-based hiring and upskilling are possible solutions to the challenges outlined in the beginning half of this report. Before diving into the research and analysis, it is important to outline exactly what this report hopes to accomplish.

There is a difference between skills-based hiring and upskilling – both of which are touched upon in this report. Skills-based hiring is the process of writing clearer job posts that remove unnecessary barriers to employment. Sometimes this means removing inflated degree requirements. It always means evaluating new hires on the knowledge, skills, and abilities they possess rather than purely on the attainment of a degree. Upskilling, on the other hand, is the process of identifying an individual's existing skills and finding or creating training programs that will take him/her to the next level in their career. It can be used to help individuals pivot into another career entirely and help meet employer demand for talent.

The aim of this analysis is not to suggest that by switching to skills-based hiring, semiconductor manufacturers will magically find the talent they have been searching for. The lack of awareness about the industry and number of foreign-born workers means the existing talent pipeline in America is small. The surge in investment generated by the CHIPS Act and the reshoring of

manufacturing capabilities in America means that, in the immediate term, the competition for talent will likely increase.

Instead, this report recognizes the long game. Workforce development takes time. It takes time to build new programs, to recruit potential workers, and to inspire a new generation of engineers and specialists. The hope is that by highlighting lists of occupations that have a high level of skills overlap with the semiconductor manufacturing workforce a few things will happen.

1. **Existing and new manufacturers** in the region will be encouraged to beef up their skills-based hiring practices, especially when it comes to recruiting operators and technicians.
2. **Workforce development professionals** gain a better sense of the semiconductor ecosystem and see semiconductor manufacturing as an attractive and attainable road to employment for their clients.
3. **Higher education providers** build strong pipelines of students into their semiconductor manufacturing training programs by targeting nontraditional students (working adults over age 25) who already have some of the required knowledge, skills, and abilities. The same goes for employers who do have the capacity to train their own workforce.

If these things happen, the timeline to creating a robust talent ecosystem for the domestic semiconductor manufacturing workforce will shrink drastically. This is critical to long-term success of the industry.

Executive Summary of the Analysis

This is a brief summary of the analysis contained in the full body of this report. For data, charts, sources, and graphics supporting these ideas continue past the executive summary.

Compared to other industries, semiconductor manufacturing offers a more balanced mix of job types with various skill and education levels needed to enter the industry. This means there are more opportunities for individuals with all types of educational backgrounds to enter the industry.

The largest groups of jobs in semiconductor manufacturing are production jobs and engineering jobs. Production and engineering roles can be broken down into three major job categories based on responsibilities and skill level: operators, technicians, and subject matter experts (SMEs).

To find talent, employers typically use degree requirements on job posts to signal the level of expertise they are looking for in new hires. This is especially true when manufacturers are looking for highly skilled engineers (SMEs) to bring new fabs online. Unfortunately, the lack of investment in semiconductor manufacturing in the recent past has shrunk the domestic talent pipeline for SMEs as entry-level engineers and technicians have not realized semiconductor manufacturing is a possible career path and foreign-born talent look elsewhere for work.

The analysis looks deeply at an example occupation from each of the three major categories to understand where there may be opportunities for individuals to transfer into the industry from other occupations or upskill with minimal training costs.

Category One: Operators

Category one jobs in semiconductor manufacturing, typically titled Cleanroom Operator or something similar, are like many types of production and warehouse jobs. They require employees to have the physical ability, dexterity, and wherewithal to work in a manufacturing setting.

The result of a skills analysis showed that there are roughly 24 dif-

“Compared to other industries, ***semiconductor manufacturing offers a more balanced mix of job types*** with various skill and education levels needed to enter the industry.”

ferent occupation titles, representing more than 95,500 workers in Orlando, that have high compatibility with operators. Not only that, these 24 jobs make median wages lower than operators. Meaning an individual's move into the semiconductor manufacturing industry from one of these positions would likely yield improved wages (a proxy for a higher quality of life).

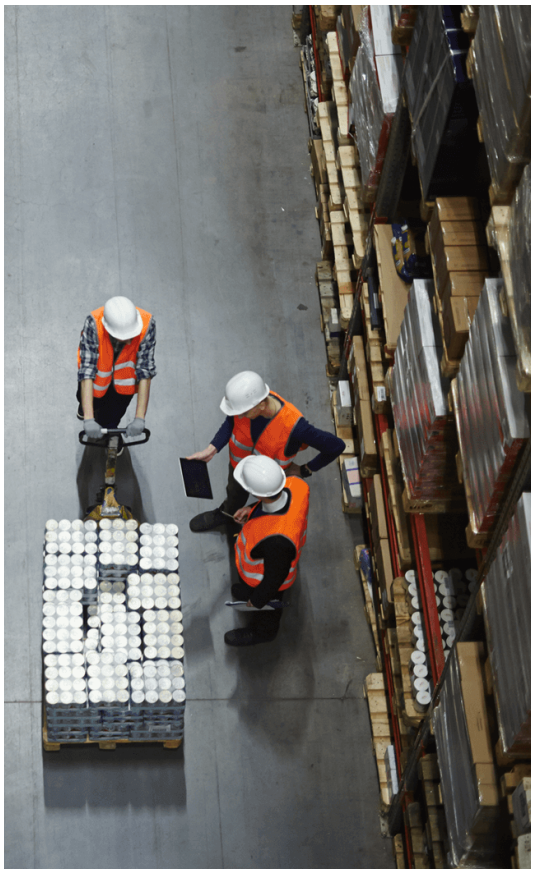
To highlight the skills transferability even more, this report compared the knowledge, skills, and abilities (KSAs) needed for operators to laborers and material movers. Many of the physical abilities required of laborers and material movers are also important to operators, such as multilimb coordination and control precision (which is the ability to quickly and repeatedly adjust the controls of a machine or a vehicle to exact positions).

There are more than 20,000 laborers and material movers employed in Orlando. If employers and education and training providers were to focus on building out this career path and create a pipeline of laborers and material movers to become operators, then some KSAs would require more training and upskilling than others. These include knowledge of: chemistry, education and training, computers and electronics, the English language, and production and processing. Individuals may also need upskilling in the ability to express themselves in written formats and skills with quality control analysis.

There are more than ***20,000 laborers*** and material movers employed ***in Orlando***

Category Two: Technicians

Category two jobs in semiconductor manufacturing are those technician or specialist roles where employees are performing experiments, documenting findings, and working from schematics and diagrams to find solutions to engineering or production challenges. Meaning these roles require more background knowledge on semiconductor devices and electronic principles than a category one job, but they do not require knowledge at the level of a senior engineer or subject matter expert. Category two jobs require a wide array of knowledge and skill types; combining background knowledge, communication skills, and the physical abilities required to work in a manufacturing setting.



It is important to note that as the jobs in semiconductor manufacturing become more advanced, not only is more advanced background knowledge required but also more advanced interpersonal and communication skills.

Identifying occupations that have high skill compatibility with Semi-

conductor Technicians and that make lower wages in Orlando yielded a list of four standard occupation codes. These four job titles are Broadcast Technicians, Camera Equipment Repairers, Computer and Office Machine Repairers, and Surveying and Mapping Technicians. Roughly 1,700 people are employed in these four jobs in the region, the recognition of which broadens the potential talent pool for category two jobs substantially.

Comparing the required KSAs of a Semiconductor Technician with a Surveying and Mapping Technician reveals that there is a high degree of skill overlap. Six of the 10 most important KSAs for Semiconductor Technicians are also in the top 10 most important KSAs for Surveying and Mapping Technicians. Think of Surveying Technicians as another job that requires strong physical capabilities combined with needing specific knowledge about a technical subject (in this case, geography and mathematics).

Of course, no job is 100 percent compatible to the next. There are gaps in knowledge that can either be made up through workforce training programs, higher education offerings, or on-the-job training. Comparing Semiconductor Technicians with Surveying and Mapping Technicians shows six (out of 47) KSAs where the mastery levels are large enough to suggest additional training is needed. Those KSAs are mainly areas of knowledge, including knowledge of specific machines and tools, some engineering techniques, production and processing, physics, and telecommunications.

Category Three: Subject Matter Experts

Category three jobs are the most advanced, subject matter experts in semiconductor manufacturing. They are the electrical, industrial, and manufacturing engineers who are responsible for developing processes, integrating solutions, and partnering with customers and other internal teams. They need high levels of technical knowledge about their field but also very high communication and reasoning capabilities.

A skill compatibility analysis between SMEs and all other occupation codes revealed a list of 35 jobs that had a large amount of knowledge, skill, and ability overlap. Those compatible jobs were not only engineers. The high amount of communicative soft skills required of Industrial Engineers means that managers in technical fields, analysts, and other types of specialists also had high compatibility. Shortening the list to those jobs that make wages lower than Industrial Engineers resulted in a final list of 12 jobs, represent-

ing 19,300 employed people in Orlando.

To highlight skills transferability, the required KSAs of SMEs were compared to Sustainability Specialists. These two jobs have a high amount of overlap especially when it comes to interpersonal skills and the ability to communicate with others. All of the most important interpersonal skills related to communication and reasoning for SMEs are also important for Sustainability Specialists.

However, the two jobs have some gaps in technical knowledge areas. While Sustainability Specialists are required to understand law and governance or building construction, they are not required to know production processes or mechanics or engineering principles. This is not surprising. At this more advanced level, it is going to be difficult to identify other occupations from outside of the industry that share the same technical knowledge requirements.

Instead, employers and workforce trainers should think of the occupations identified in this section as those occupations where the pathway to full proficiency is the shortest. Think of these occupations as ones to target for future development. This idea is discussed more in the full body of the analysis.

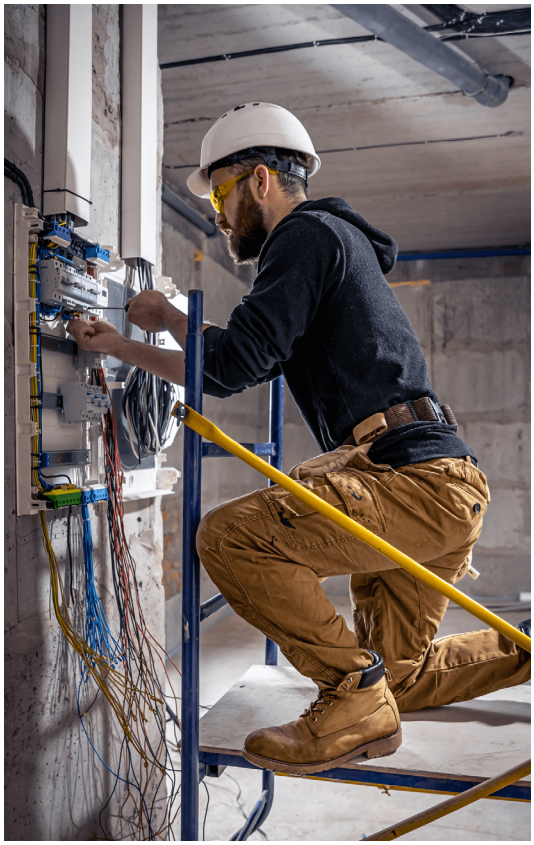
Understanding The Semiconductor Manufacturing Workforce

The Types of Jobs in Semiconductor Manufacturing

Something that makes the semiconductor manufacturing industry unique is the range of job types that are available to workers with different skill and experience levels. According to the Semiconductor Industry Association (SIA), "one in five workers in the industry has not attended college."[1] This means semiconductor manufacturers provide important job prospects in an advanced industry for individuals who have not had the opportunity to pursue higher education.

"one in five workers in the industry *has not attended college"*

Staffing pattern data shows that roughly 40 percent of jobs in the US semiconductor manufacturing industry are production jobs. This includes occupations with descriptions such as: "Electrical, Electronic, and Electromechanical Assemblers" and "Semiconductor Processing Technicians". Production jobs like this have median wages of roughly $19 per hour, the typical entry-level education is a high school diploma, and no previous industry experience is required.



The next largest group of jobs in the semiconductor manufacturing industry is engineering. Almost 22 percent of total industry employment is in engineering jobs, which includes titles such as "Industrial Engineer", "Electrical and Electronic Engineering Technologists and Technicians", and "Electronics Engineers, Except Computer". These jobs offer median wages ranging from $29 to $48 per hour; the typical entry-level education is a two-year or bachelor's degree.

FIGURE 1 visualizes the size of each major occupation group employed in the American semiconductor manufacturing industry. Larger rectangles mean the occupation group represents a larger share of industry employment. Production occupations are by far the largest group followed by engineering roles and then management occupations.

(1) https://www.semiconductors.org/chipping-in-sia-jobs-report/

FIGURE 1: HIGH-LEVEL STAFFING PATTERNS IN THE US SEMICONDUCTOR INDUSTRY, 2022

Industry staffing patterns for NAICS 3344, Semiconductor and Other Electronic Component Manufacturing. Source: Lightcast.

This distribution is generally the same for Orlando, skewed slightly towards production roles. In Orlando, 45 percent of the industry employment is in production roles and 15 percent is in engineering roles. In 2022 there were 1,550 people employed in the semiconductor manufacturing industry in Orlando.[2]

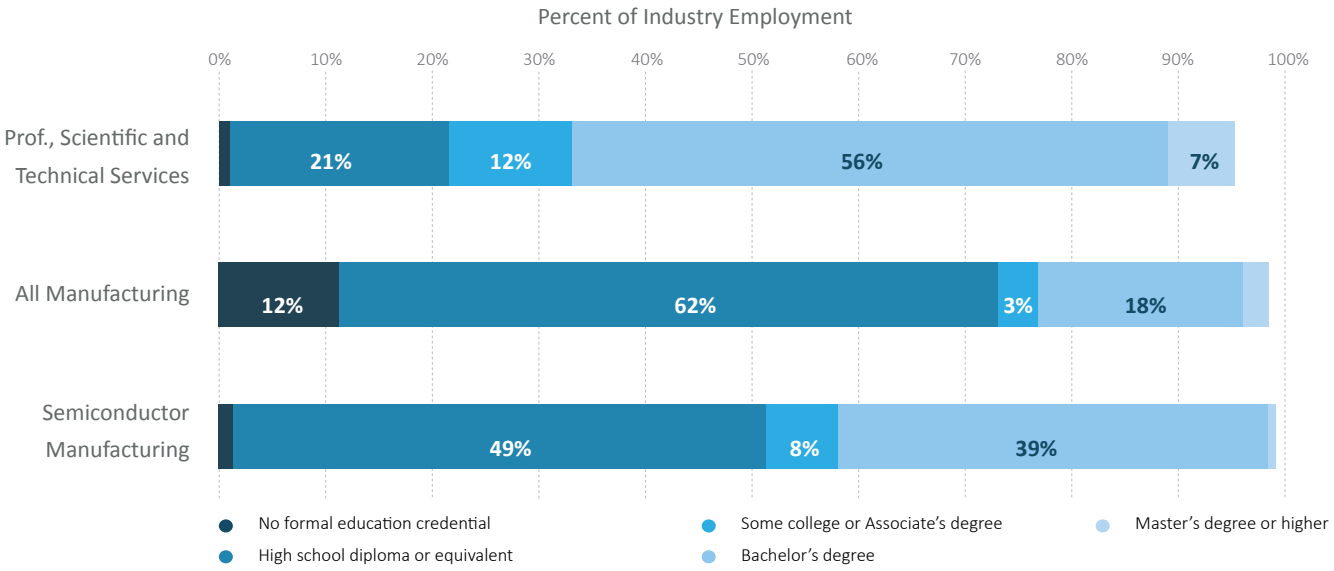
Analyzing data on typical entry-level education levels[3] for jobs in semiconductor manufacturing supports the statement that the industry offers job opportunities to workers with various skill levels. Put another way, the industry is well balanced between jobs typically needing a high school diploma or two-year technical degree and jobs needing a bachelor's degree or higher to be successful. **FIGURE 2** shows the breakdown of typical entry-level education levels needed for jobs in the semiconductor manufacturing industry compared to jobs in the broader manufacturing industry and the

(2) Data sourced from Lightcast in 2023 and based on counts of jobs reported in the Semiconductor and Other Electronic Component Manufacturing industry (NAICS 3344) in the four-county, Orlando region.

(3) https://kb.lightcast.io/en/articles/7934197-typical-entry-level-education

professional, scientific, and technical services industry.[4] Notice how more than half, 63 percent, of the jobs in the professional, scientific, and technical services industry need a bachelor's degree or higher. Meanwhile, in manufacturing, almost three-fourths, 74 percent, of jobs only need a high school diploma or less. Semiconductor manufacturing strikes a balance with half, 51 percent, of the jobs needing a high school diploma or less, eight percent needing a two-year degree, and 40 percent requiring a bachelor's degree or higher.

FIGURE 2: TYPICAL ENTRY LEVEL EDUCATION FOR OCCUPATIONS BY INDUSTRY, US 2022



Bars do not sum to 100 percent because jobs representing less than 0.1 percent of industry employment have been removed from the analysis. Source: Analysis of entry level education data and staffing patterns from Lightcast

Finally, reviews of real job posts and interviews with a local semiconductor manufacturer suggest that it is helpful to leave behind the technical classification systems described above and simply imagine three different categories of jobs that represent the types of workers needed by the industry.

1. **Category One – Operators** These are jobs with titles such as "Cleanroom Operator" or "Warehouse Specialist". Job postings for these occupations typically require only a high school diploma and no necessary, previous experience.[5]

   From one job description posted by Orlando-based Saw Street, the primary duties of a Cleanroom Operator are the "basic operation of equipment associated with backend semiconductor

(4) The semiconductor manufacturing industry is represented by employment in NAICS 3344, manufacturing overall is any NAICS beginning with 33 or 31, and professional, scientific, and technical services is NAICS 541000. Subindustries in professional, scientific, and technical services include legal services, accounting, computer systems design, technical consulting, and advertising, among others.

(5) The education levels required in employer job posts are explored more in the following section.

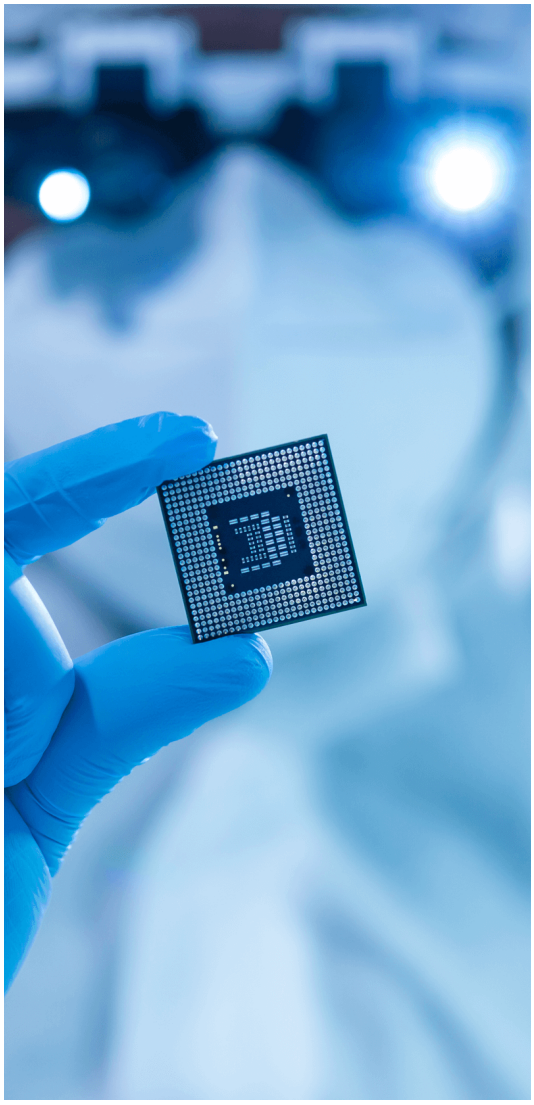
wafer production operations, including wafer dicing, pick and place and inspection." Necessary skills include being able to sit or stand for long periods of time, attention to detail, and the ability to handle delicate components.

2. **Category Two –Technicians** It is helpful to think of these occupations as requiring a higher level of knowledge about semiconductor manufacturing processes than category one jobs. These jobs have titles such as "Engineering Technician Specialist" or "Process Development Engineering Technician". Employer job posts typically ask applicants to have a two-year technical degree and/or up to five+ years of experience working in semiconductor fabrication facilities when applying for these jobs.

   From a job description posted in early 2023 by SkyWater, a Process Development Engineering Technician "perform(s) experiments for the Engineering team. They are responsible for documenting experimental observations carefully and proposing recommendations." Their responsibilities include "setting up new process run cards in a manufacturing execution system", "troubleshooting non-conforming material", and "developing work instructions, processes, and metrology recipes as well as refining for improved results".

3. **Category Three – Subject Matter Experts (SMEs)** While there are engineering roles in category two, think of category three as the engineers with multiple years, sometimes decades, of experience in their related field. Titles for these positions may sound something like "Advanced Packaging Metrology/Test Process Engineer" or "Senior Firmware Engineer". Job posts searching for these SMEs typically ask for applicants to have an education background ranging from a bachelor's degree to PhD in fields such as electrical engineering, microelectronics, or chemical engineering.

   Duties of a Senior Firmware Engineer at Advanced Micro Devices (AMD) include "performing complex software engineering tasks to contribute to the development of firmware components (bios, security features, etc.), diagnostics, and/or solutions" and "leveraging firmware/system software development expertise to support verification, silicon bring-up, validation, and/or design testing, throughout various stages of the silicon design cycle".



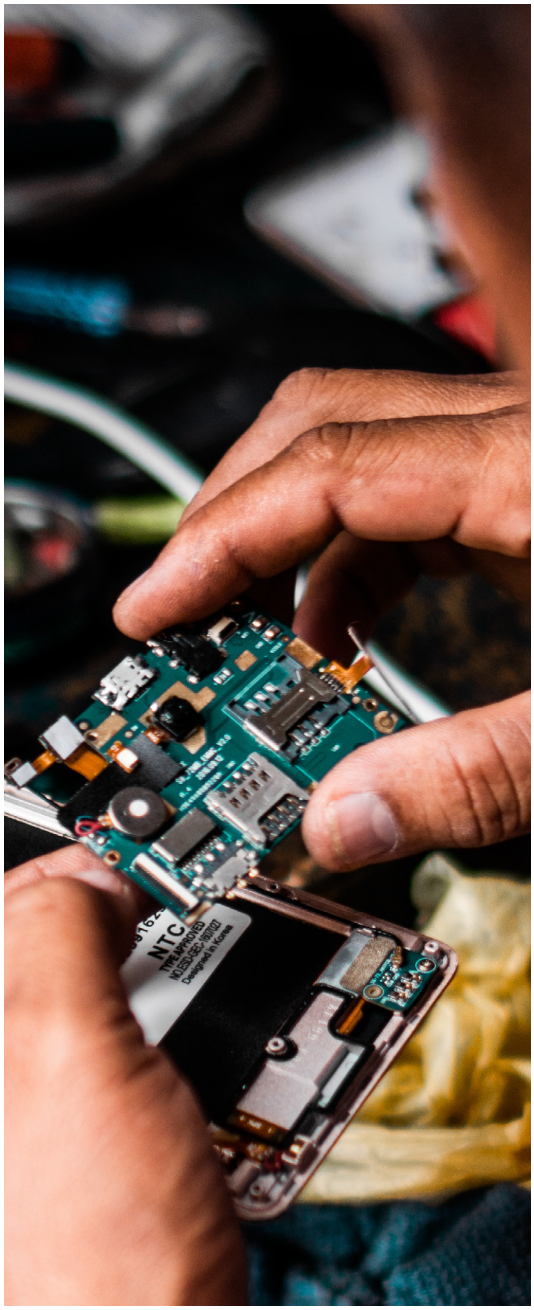
"...in manufacturing, almost three-fourths, ***74 percent, of jobs only need a high school diploma*** or less. Semiconductor manufacturing strikes a balance with half, ***51 percent, of the jobs needing a high school diploma*** or less..."

A Contradiction in The Data

The frameworks used above for defining semiconductor manufacturing jobs contain a contradiction. On one hand, **FIGURE 2** shows that the required education levels for jobs in the industry are broken down mainly into high school diplomas and bachelor's degrees. There are very few jobs, 0.7 percent, that require a master's degree or PhD to enter the field (so few, they are barely visualized in **FIGURE 2**). On the other hand, the three categories defined from a review of job posts paint a different picture of educational needs. Operators require only a high school diploma, Technicians require some form of a technical or two-year degree, and Subject Matter Expert job posts tend to ask applicants to have anything from a bachelor's degree to a PhD.

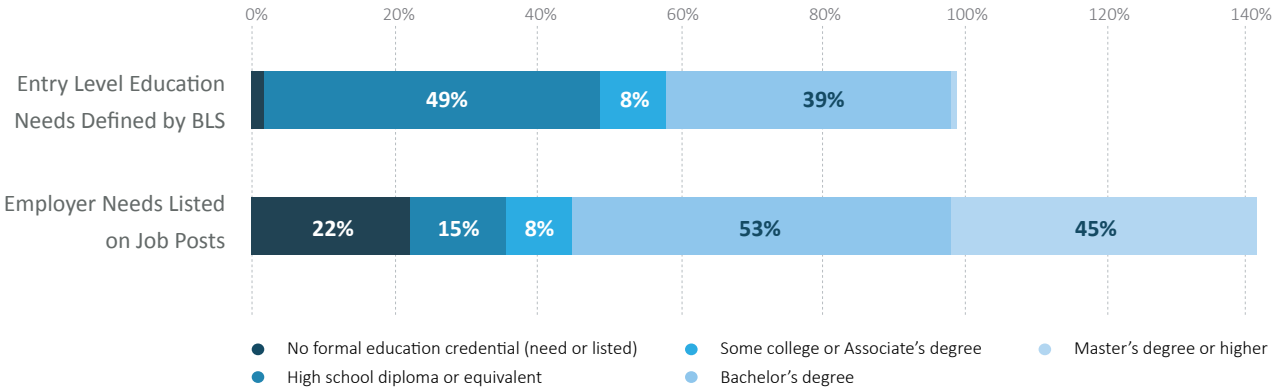
This contradiction arises because there is a difference between the education necessary to learn the background knowledge and skills needed for a job versus the formal education levels employers tend to list on job posts in their hunt for talent. Through their own research and surveys, the Bureau of Labor Statistics (BLS) has defined the typical education, work experience, and on-the-job training needed for entry into every formal occupation measured by government sources (more than 800 job titles).[6] But this does not necessarily align with how employers advertise their jobs or how employers tend to use educational attainment as an identifier of an applicant's skill level. **FIGURE 3** visualizes this contradiction. The top bar shows the education requirements as defined by the BLS (also visualized in **FIGURE 2** above) and the bottom bar shows the education levels listed by employers in semiconductor manufacturing job posts across America in 2022. Notice how the bottom bar sums to a value greater than 100 percent because employers may list more than one education level as a qualification on a job post. Also note that 45 percent of job posts in the semiconductor manufacturing industry list a master's degree or PhD as a possible qualification for employment, compared to almost zero in the BLS data.

> ***"45 percent*** of job posts in the semiconductor manufacturing industry ***list a master's degree or PhD as a possible qualification*** for employment"



(6) https://www.bls.gov/emp/tables/education-and-training-by-occupation.htm

FIGURE 3: PERCENTAGE OF JOBS IN SEMICONDUCTOR MANUFACTURING BY EDUCATION REQUIREMENT, US 2022



It is safe to say that this contradiction exists in many, if not all industries.[7] It is the result of degree inflation, a phenomenon that began when employers started using four-year degree requirements on job posts to signal their interpersonal skill needs to potential hires and accelerated during the Great Recession as a way for employers to eliminate large swaths of applicants from the candidate pool during a time of high unemployment.

A NOTE ON DEGREE INFLATION AND SKILLS-BASED HIRING: Today, degrees are still used as proxies for skills on job posts as employers use degree requirements to signal to applicants the level of expertise they expect someone to bring to a role. However, the unintended result has been confusion among applicants who may feel discouraged from applying to a particular job and general a lack clarity about the knowledge, skills, and abilities it takes to succeed in a job. In 2020 the Foundation for Orlando's Future produced a report on how to reverse this phenomenon by transitioning to skills-based hiring practices. More information on skills-based hiring can be found **here**.[8]

The data in **FIGURE 3** suggests that semiconductor manufacturing is also an industry where employers are using degrees to signal the level of expertise needed to fill a role. The large percentage of job posts that list a master's degree or doctorate degree (45 percent in 2022) as a qualifying background for employment suggests that employers have a pressing need to find those subject matter experts who bring years' worth of earned skills and knowledge to the table. This is not shocking, given the sudden US increase in semiconductor investment and fab construction combined with the

(7) https://www.vox.com/policy/23628627/degree-inflation-college-bacheors-stars-labor-worker-paper-ceiling

(8) https://orlando.org/l/skills-based-hiring-report/

bottlenecks that currently exist in the semiconductor manufacturing talent pipeline.

Current State of the Semiconductor Talent Pipeline

Recall from Part I that today the US makes only 12 percent of the world's semiconductors, a drop from 37 percent in the 1990s.[9] Decades of slipping investment in domestic semiconductor making capacity, matched by growing investment in East Asia, have created two major forces that define the current talent pipeline.

1. **A lack of awareness about the industry.** There is a general lack of awareness about semiconductor manufacturing as an industry and the types of jobs it offers workers. In Phoenix Arizona, behemoth Taiwanese chip manufacturer TSMC is spending billions building out a semiconductor fab while local workforce development professionals are commenting on the struggles to recruit talent to the industry. The deputy human services director at the Phoenix Business and Workforce Development Board said in an interview, "You say 'semiconductor manufacturing' [to potential recruits], people look at you like you have two heads. It's just unfamiliar." [10]

   This lack of awareness contributes to a smaller talent pipeline and more competition with other industries for workers. Staffing pattern data from Lightcast show that other manufacturing industries such as motor vehicle parts, plastic products, and turned products (screws, nuts, and bolts) along with general engineering services employ a higher percentage of the talent needed in semiconductor manufacturing than the semiconductor manufacturing industry does itself. In Orlando specifically, aerospace product and parts manufacturing along with engineering services and commercial industry machinery manufacturing (which could be anything from manufacturing balancing equipment to coffee makers) are the top industries the semiconductor manufacturing industry competes with for talent.

2. **A plethora of foreign-born talent.** Consider these statistics from a report on the US semiconductor workforce from Georgetown University.[11]

Source: https://www.ft.com/content/f098bf3f-1ec6-4433-b4e2-fc1acde05628

"You say 'semiconductor manufacturing' [to potential recruits], ***people look at you like you have two heads.*** It's just unfamiliar."

(9) https://www.mckinsey.com/industries/public-sector/our-insights/the-chips-and-science-act-heres-whats-in-it

(10) https://asia.nikkei.com/Business/Business-Spotlight/From-somebody-to-nobody-TSMC-faces-uphill-battle

(11) https://cset.georgetown.edu/publication/the-chipmakers-u-s-strengths-and-priorities-for-the-high-end-semiconductor-workforce/

- 40 percent of high-skilled semiconductor workers in the US were born abroad, mainly in India followed by China.
- In 2011, 87 percent of semiconductor patents awarded to top US universities had at least one foreign-born inventor.
- Since 1990 the number of American students enrolled in semiconductor-related graduate programs (around 90,000) has not increased. In that same period, the number of international students nearly tripled from 50,000 to 140,000.
- From another source, 75 percent of the STEM PhDs in the US semiconductor manufacturing industry are born abroad.[12]

A high number of foreign-born workers is not a bad thing. In fact, many recent policy briefs note that in order for the United States to staff the new fabs being built around the country, there must be immigration reform that allows more engineers and researchers to gain work visas in America. A policy brief from the Brookings Institution noted,

> *"The industry needs to recruit more talent, from top PhDs to tradespeople specializing in fab construction. Targeted interventions in immigration policy are needed to allow skilled manufacturing and R&D personnel who can help to build up these fabs and R&D facilities, and incentives are needed to ensure that many more U.S.-trained graduates with semiconductor-relevant doctorates remain in the United States after their study ends."* [13]

Another article from The Hill notes,

> *"The most serious problem is a cap on green cards that has not been updated since the 1990s. As of 2021, 1.4 million people were waiting to receive employment-based green cards, with backlogs leading to projected wait times of several decades for hundreds of thousands of high-skilled applicants — and these problems are only getting worse."* [14]

(12) https://www.computerworld.com/article/3665111/tech-talent-shortage-slows-reshoring-of-chip-manufacturing-in-us.html

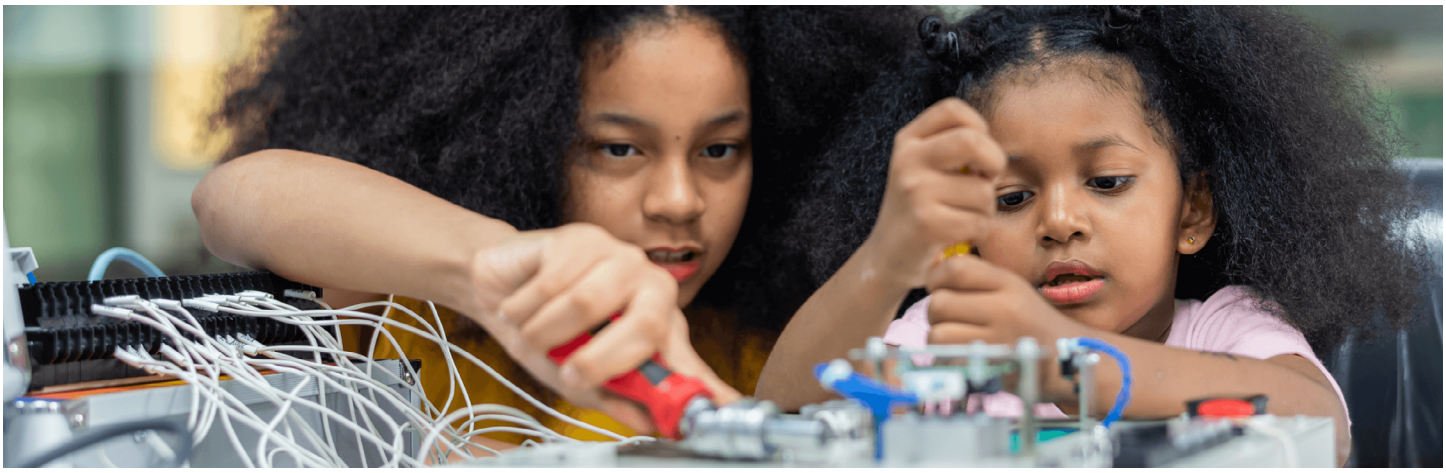
(13) https://www.brookings.edu/wp-content/uploads/2022/11/FP_20221103_semiconductor_strategy.pdf

(14) https://thehill.com/opinion/immigration/3495673-want-to-secure-u-s-supply-chains-reform-high-skilled-immigration/

At the time of publication, Congress has been unable to pass any kind of immigration reform that would lessen this backlog and open up the talent pipeline for the semiconductor manufacturing industry.[15]

This lack of awareness about semiconductor manufacturing as a career combined with a smaller share of American-born SMEs has created a talent squeeze in the industry. This is especially true for companies such as SkyWater, which is fully US-owned and limited to hiring only US citizens for their operations. The result is manufacturers must compete heavily on pay, company culture, and highlight the meaningfulness of their work to a workforce that values being on the cutting edge of technology.[16]

There are solutions to this talent squeeze, but no overnight fixes and they have varying time horizons. On one hand, the industry needs to invest now in the development of a future talent pipeline by creating specialized training programs and building relationships with students, starting all the way in K-12. This is already happening in Orlando and around the country.[17] However, the industry also needs immediate solutions for sourcing and developing talent. The final section of this report goes into the skills required for specific semiconductor manufacturing jobs and broadens the talent pool of potential recruits to include those individuals who have transferable skills from other occupations or industries.



(15) https://www.forbes.com/sites/stuartanderson/2022/08/22/what-happened-to-the-bills-on-employment-based-immigration/?sh=61626b005658

(16) Statements based on interviews with a semiconductor manufacturer.

(17) This is a rich topic. It deserves its own report examining existing training programs, those planned to come online, and efforts to increase awareness about the industry for students at a young age.

A Transferable Skills Solution

The following and final section of this report highlights the skills needed in semiconductor manufacturing jobs and identifies other jobs in Orlando that require similar skill sets. The goal of doing this is to highlight occupations where a move into semiconductor manufacturing would represent gains for workers (in the form of higher wages) while also widening the available talent pool for semiconductor manufacturers and minimizing training costs. In short, the following analysis promotes the idea of skills-based hiring and recruitment; where a potential new hire is judged based on her/his knowledge, skills, and abilities rather than credentials such as degrees or years of experience in the industry.

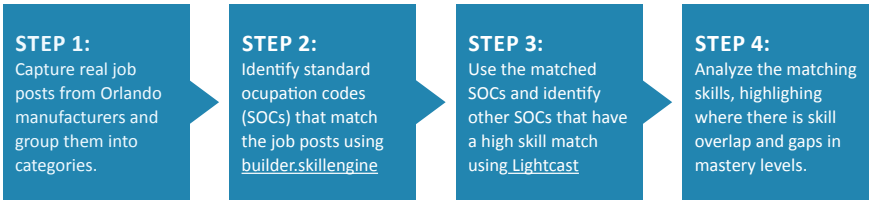
To keep the analysis relevant for the intended audience, the study specifically uses Orlando MSA labor market data and analyzes occupation matches for each of the three job categories identified above: operators, technicians, and subject matter experts.

A NOTE ON METHODOLOGY:

The greatest challenge matching jobs based on skills is always converting job titles and job descriptions written by real employers into the taxonomies and categories used in government data sources. Employers do not reference government sources when writing descriptions or titling jobs. They base their descriptions on need and titles on their own organizational hierarchies. This is why a job titled "Advanced Packaging Metrology/Test Process Engineer" might be a 99 percent match to the government-defined "Industrial Engineer" but simultaneously a 60 percent match to "Electronics Engineers", and 57 percent match to "Manufacturing Engineers".

To convert real job posts into government taxonomies, 14 posts from Orlando semiconductor manufacturers (listed between December 2022 and March 2023) were analyzed through the text analysis tool, builder.skillsengine.com. This produced a list of formal occupation codes that matched the real job post on a percentage basis. Those identified occupation codes were then used to find lists of compatible jobs based on skills. See steps one through four in **FIGURE 4** below.

FIGURE 4: SKILL MATCHING METHODOLOGY EXPLANATION



Finally, note the switch in terminology from skills to "knowledge, skills, and abilities" or "KSAs" for short. This is because while the general public may think of anything from written communication to the ability to lift 40 lbs. as a skill, government data sources differentiate knowledge about a topic (ex: mathematics) from learned skills (ex: reading comprehension), from the physical abilities required to do a job (ex: finger dexterity). This provides a deeper level of understanding about which elements are required to perform a job and more context about what type of upskilling individuals may need to successfully perform a new job.

Category One: Operators

These are jobs with titles such as "Cleanroom Operator" or "Warehouse Specialist". Job posts for these occupations typically require only a high school diploma and no previous experience. Job posts from SkyWater and Saw Street in this category matched most closely with the standard occupation codes (SOCs) for "Supervisors or Production Workers", "Production Workers, All Other", and "Semiconductor Processing Technicians". Given its specificity to the industry, Semiconductor Processing Technicians is used to represent category one jobs and identify other occupations where workers have the necessary skills to transfer into the semiconductor manufacturing industry.

Profile of Semiconductor Processing Technicians

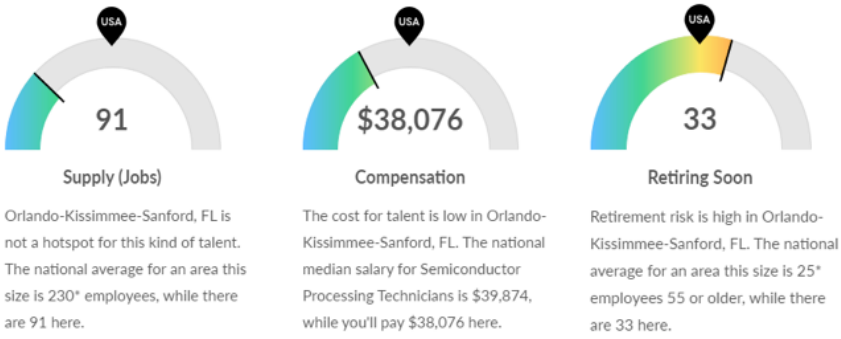
Data from Lightcast shows that there are 91 Semiconductor Processing Technicians employed in the Orlando region, making a median wage of $38,100 annually or $18.31 an hour.[18] For added context, other sources show Semiconductor Processing Technicians making higher median wages of $41,600 annually or $19.98 an hour.[19] Of note, a larger percentage of these workers are approach-

(18) Median means that half of the workers make below this amount and half make above this amount. Semiconductor Processors have a wage range of $33,400 at the 25th percentile and $50,900 at the 75th percentile. Data sourced from Lightcast.

(19) https://www.onetonline.org/link/localwages/51-9141.00?zip=32803

ing retirement age compared to other regions. This amplifies the need to create pipelines of workers from other industries.

FIGURE 5: OVERVIEW OF SEMICONDUCTOR PROCESSING TECHNICIANS IN ORLANDO



**National average values are derived by taking the national value for Semiconductor Processing Technicians and scaling it down to account for the difference in overall workforce size between the nation and Orlando-Kissimmee-Sanford, FL. In other words, the values represent the national average adjusted for region size. Source: Lightcast Occupation Snapshot Report.*

The KSAs required of a Semiconductor Processing Technician involve understanding production and processing lines and many physical abilities such as arm-hand steadiness and strong near vision. The table below lists the top KSAs that are necessary to perform this job, sourced from detailed occupation profiles from O*NET, a program of the US Department of Labor.[20]

TABLE 1: TOP KNOWLEDGE AREAS, SKILLS, AND ABILITIES NECESSARY FOR SEMICONDUCTOR PROCESSING TECHNICIANS

IMPORTANCE SCORE	KNOWLEDGE, SKILL, OR ABILITY	DESCRIPTION
73	Knowledge	Production and Processing
70	Knowledge	English Language
66	Ability	Near Vision
66	Skill	Operation Monitoring
63	Ability	Written Comprehension
63	Ability	Arm-Hand Steadiness
60	Knowledge	Public Safety and Security
60	Skill	Reading Comprehension
60	Skill	Critical Thinking

(20) These are the KSAs with importance scores of at least 50. This is a standardized value, ranging from 0-100. Importance score data was originally collected using a scale of 1-5 with 1 being "Not Important" to 5 being "Extremely Important". The KSAs used in this analysis must have been ranked at least a 3, equaling a standardized score of 50. For more information, see https://www.onetonline.org/help/online/scales#score.

IMPORTANCE SCORE	KNOWLEDGE, SKILL, OR ABILITY	DESCRIPTION
60	Ability	Oral Comprehension
59	Knowledge	Computers and Electronics
57	Knowledge	Education and Training
56	Skill	Quality Control Analysis
56	Skill	Monitoring
56	Skill	Active Listening
56	Ability	Finger Dexterity
56	Ability	Oral Expression
56	Ability	Control Precision
56	Ability	Deductive Reasoning
56	Ability	Inductive Reasoning
56	Knowledge	Chemistry
53	Ability	Written Expression
53	Ability	Information Ordering
53	Ability	Manual Dexterity
53	Ability	Problem Sensitivity
53	Ability	Multilimb Coordination
50	Ability	Perceptual Speed
50	Ability	Visualization

Top Occupations with Transferable Skills

The very physical and production based KSAs make Semiconductor Processing Technicians a strong match to other types of manufacturing jobs such as Grinding and Polishing Workers or Team Assemblers. **TABLE 2** lists the occupations in Orlando that have a compatibility index of at least 90 percent[21] with Semiconductor Processing Technicians. In addition, the list has been limited to the occupations in Orlando that make significantly less than

(21) The compatibility index is calculated by Lightcast using data on the KSAs required in each occupation. From Lightcast's glossary of terms, "this number is intended to score the compatibility of two occupations in terms of the knowledge, skills, and abilities they require: a score of 100 means complete compatibility, while a score of 0 means no compatibility. The compatibility index is a synthetic number generated by a proprietary algorithm that uses O*NET's data on the required Levels and Importance of competencies."

Semiconductor Processing Technicians. In order to be shown in the table, the job must have median hourly earnings less than $14.65 an hour. At this wage, someone moving into a semiconductor processing technician role would experience wage gains of 25 percent. Put another way, individuals employed in the occupations shown in **TABLE 2** would experience annual wage gains of at least $7,600, if not more, by moving into semiconductor processing technician roles.

The result is a list of 25 matching occupations that represent an expanded talent pool of 95,500 individuals. Note just how many different types of production jobs in Orlando meet these criteria. Also note that the jobs not part of the broader production family, such as Laborers and Freight, Stock, and Material Movers, have similar enough skillsets to be included and have an employment base of more than 20,000 people in Orlando.

TABLE 2: OCCUPATIONS HIGHLY COMPATIBLE WITH SEMICONDUCTOR PROCESSING TECHNICIANS

OCCUPATION TITLE	MAJOR OCCUPATION FAMILY	MEDIAN HOURLY EARNINGS	ORLANDO MSA EMPLOYMENT 2022	COMPATIBILITY INDEX
Paper Goods Machine Setters, Operators, and Tenders	Production	$14.62	162	96
Grinding, Lapping, Polishing, and Buffing Machine Tool Setters, Operators, and Tenders, Metal and Plastic	Production	$14.55	238	95
Food and Tobacco Roasting,Baking, and Drying Machine Operators and Tenders	Production	$13.40	23	95
Heat Treating Equipment Setters, Operators, and Tenders, Metal and Plastic	Production	$14.04	75	94
Photographic Process Workers and Processing Machine Operators	Production	$14.58	39	94
Textile Knitting and Weaving Machine Setters, Operators, and Tenders	Production	$13.43	23	93
Team Assemblers	Production	$14.46	6,975	93
Cleaning, Washing, and Metal Pickling Equipment Operators and Tenders	Production	$14.04	17	93
Packaging and Filling Machine Operators and Tenders	Production	$13.89	1,768	93
Helpers--Production Workers	Production	$13.34	1,162	93
Laundry and Dry-Cleaning Workers	Production	$11.50	2,051	93
Mail Clerks and Mail Machine Operators, Except Postal Service	Office and Admin.	$14.52	364	92

OCCUPATION TITLE	MAJOR OCCUPATION FAMILY	MEDIAN HOURLY EARNINGS	ORLANDO MSA EMPLOYMENT 2022	COMPATIBILITY INDEX
Food Cooking Machine Operators and Tenders	Production	$13.87	25	92
Laborers and Freight, Stock, and Material Movers, Hand	Transportation and Material Moving	$14.36	20,204	92
Meter Readers, Utilities	Office and Admin.	$14.56	165	92
Sewing Machine Operators	Production	$14.38	661	92
Agricultural Equipment Operators	Farming, Fishing, and Forestry	$10.12	220	91
Stockers and Order Fillers	Transportation and Material Moving	$14.30	25,660	91
Baristas	Food Preparation and Serving Related	$10.59	31,790	91
Bakers	Production	$13.59	1,788	90
Gambling Change Persons and Booth Cashiers	Sales and Related	$10.14	109	90
Tire Repairers and Changers	Installation, Maintenance, and Repair	$13.12	668	90
Tailors, Dressmakers, and Custom Sewers	Production	$14.25	101	90
Cooks, Short Order	Food Preparation and Serving Related	$10.60	1,192	90

Skill Comparison – Semiconductor Processing Technicians & Laborers and Freight, Stock, and Material Movers

TABLE 2 highlights the many jobs in Orlando that require skillsets similar to Semiconductor Processing Technicians. The following example digs deeper into the KSA comparisons between Semiconductor Processing Technicians and laborers who move freight and stock material by hand.

Take the following graphic as an illustration of the top knowledge, skills, and abilities shared by these two occupations. laborers have a very ability-heavy set of important KSAs. Meaning, when it comes to abilities such as near vision, control precision, manual dexterity, and multilimb coordination that are important for Semiconductor Processing Technicians to have, laborers possess those same abilities.

FIGURE 6: IMPORTANT KNOWLEDGE, SKILL, AND ABILITY COMPARISON BETWEEN SEMICONDUCTOR PROCESSING TECHNICIANS AND LABORERS AND FREIGHT AND MATERIAL MOVERS

SEMICONDUCTOR PROCESSING TECHNICIANS			LABORERS, FREIGHT AND MATERIAL MOVERS		
KSA	NAME	IMPORTANCE	KSA	NAME	IMPORTANCE
Knowledge	Production and Processing	73	Ability	Static Strength	69
Knowledge	English Language	70	Ability	Trunk Strength	63
Ability	**Near Vison**	**66**	**Ability**	**Multilimb Coordination**	**63**
Skill	Operation Monitoring	66	**Ability**	**Control Precision**	**56**
Ability	**Written Comprehension**	**63**	**Ability**	**Near Vision**	**53**
Ability	Arm-Hand Steadiness	63	Ability	Stamina	53
Knowledge	Public Safety and Security	60	**Ability**	**Oral Comprehension**	**53**
Skill	Reading Comprehension	60	**Ability**	**Manual Dexterity**	**53**
Skill	Critical Thinking	60	Ability	Extent Flexibility	50
Ability	**Oral Comprehension**	**60**	Ability	Far Vision	50
Knowledge	Computers and Electronics	59	**Ability**	**Written Comprehension**	**50**
Knowledge	Education and Training	57	**Ability**	**Problem Sensitivity**	**50**
Skill	Quality Control Analysis	56	Ability	Dynamic Strength	50
Skill	Monitoring	56	Ability	Speech Recognition	50
Skill	Active Listening	56	**Ability**	**Deductive Reasoning**	**50**
Ability	Finger Dexterity	56			
Ability	Oral Expression	56			
Ability	**Control Precision**	**56**			
Ability	**Deductive Reasoning**	**56**			
Ability	Inductive Reasoning	56			
Knowledge	Chemistry	56			
Ability	Written Expression	53			
Ability	Information Ordering	53			
Ability	**Manual Dexterity**	**53**			
Ability	**Problem Sensitivity**	**53**			
Ability	**Multilimb Coordination**	**53**			
Ability	Perceptual Speed	50			

*Source: Data accessed through Lightcast where competency data is taken directly from the O*NET database.*

The final step in this analysis of category one jobs is to discuss where additional training or upskilling may be needed depending on the background of a potential new hire. So far, this analysis has only focused on data related to the overall importance of each knowledge area, skill, or ability as it relates to these different roles. There is another dimension to consider, which is the "level" required of each of these KSAs. Consider this explanation from O*NET which describes the difference between the importance of a skill and the level of that skill. "While the same skill can be important for a variety of occupations, the amount or level of the skill needed in those occupations can differ dramatically. For example, the skill "speaking" is important for both lawyers and paralegals. However, lawyers (who frequently argue cases before judges and juries) are required to have a higher level of speaking skill, while paralegals only need an average level of this skill."[22]

Applying this concept to the comparison above exposes a few nuances. 1) It is possible that laborers possess skills such as reading comprehension and critical thinking but they are not listed in the graphic because they are not highly important to the job. 2) Just because a skill is important to both jobs, near vision for example, does not mean the same level of mastery is required for that skill.

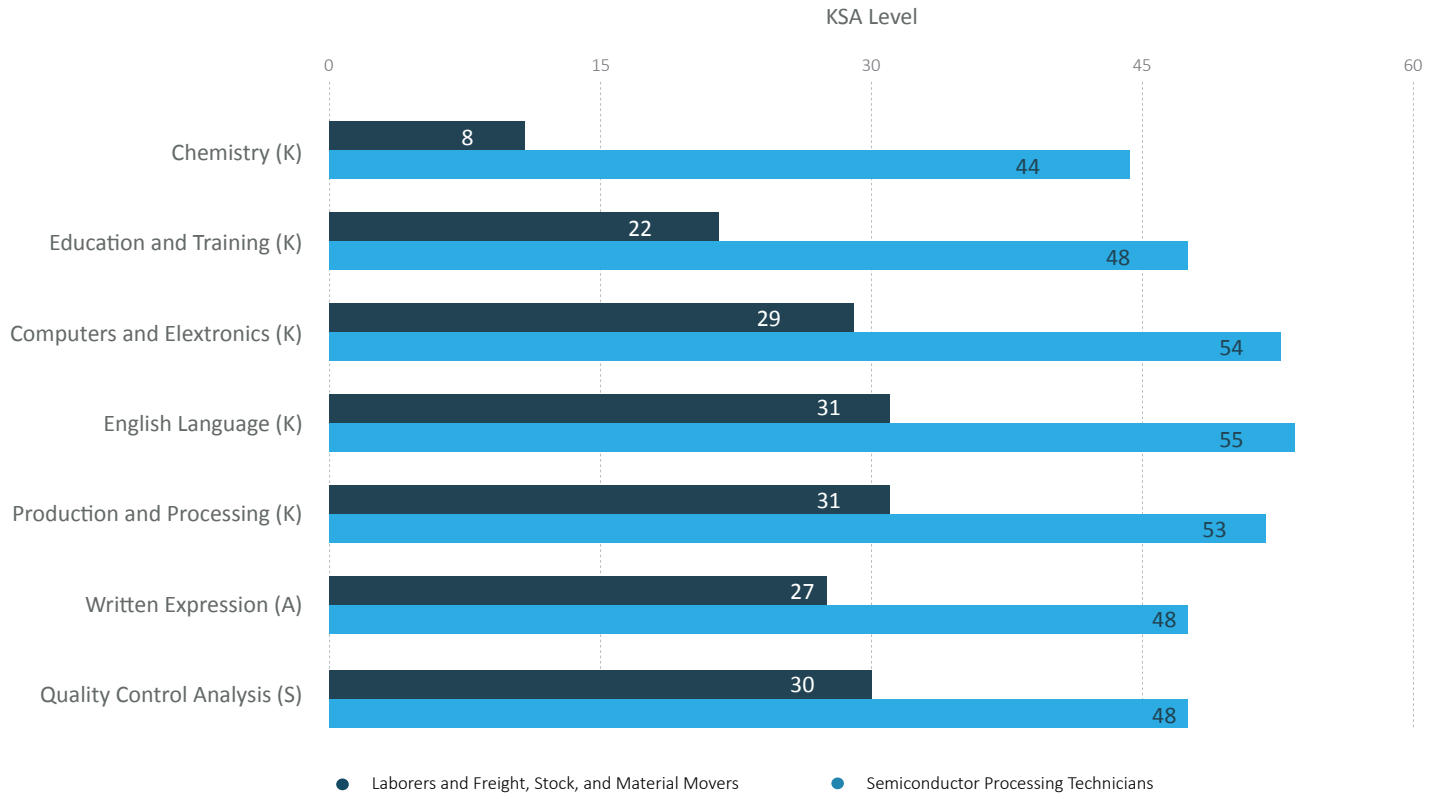
To identify the areas where individuals transitioning to Semiconductor Processing Technicians from Laborer positions may need more training, see **FIGURE 7**. **FIGURE 7** lists the important KSAs with the largest mastery gaps between the two occupations. These seven KSAs have gaps largest enough that they signify a substantially different level of mastery required to perform the job.[23]

Note how five of the seven areas where more training is needed are knowledge-based areas. Chemistry is the first and the area with the largest gap. But also note that even for Semiconductor Processing Technicians the level of required chemistry knowledge is only at 44, less than half on a scale that ends at 100. Meaning, a previous warehouse laborer with zero knowledge of chemistry does not need to be upskilled to the level of someone with a PhD in chemistry before they can take on the role. Instead, they likely need some basic chemistry training and knowledge of essential chemical interactions, danger signs, and disposal methods. Descriptions of the seven KSAs are included below **FIGURE 7.**

(22) https://www.onetonline.org/help/online/scales#foot2

(23) This is signified by gaps larger than 14.3 points. KSA level is measured on a scale of 0-7 and then converted to a standardized score from 0-100. Given this, a gap of more than 14.3 standardized level points is equivalent to bumping the score up or down an entire scale-point. Put another way, it is the difference between a score of 3 to 4, 4 to 5, 5 to 6, etc.

FIGURE 7: KNOWLEDGE AREAS, SKILLS, AND ABILITIES WITH THE LARGEST GAPS BETWEEN SEMICONDUCTOR PROCESSING TECHNICIANS AND LABORERS AND MATERIAL MOVERS



- **Chemistry:** Knowledge of the chemical composition, structure, and properties of substances and of the chemical processes and transformations that they undergo. This includes uses of chemicals and their interactions, danger signs, production techniques, and disposal methods.
- **Education and Training:** Knowledge of principles and methods for curriculum and training design, teaching and instruction for individuals and groups, and the measurement of training effects.
- **Computers and Electronics:** Knowledge of circuit boards, processors, chips, electronic equipment, and computer hardware and software, including applications and programming.
- **English Language:** Knowledge of the structure and content of the English language including the meaning and spelling of words, rules of composition, and grammar.
- **Production and Processing**: Knowledge of raw materials, production processes, quality control, costs,

*The K, S, or A next to each phrase indicates if that element is a knowledge area, skill, or ability. Source: O*NET occupation profiles.*

and other techniques for maximizing the effective manufacture and distribution of goods.

- **Written Expression:** The ability to communicate information and ideas in writing so others will understand.
- **Quality Control Analysis:** Skill. Conducting tests and inspections of products, services, or processes to evaluate quality or performance. (24)

Category Two: Technicians

As a reminder, it is helpful to think of these occupations as requiring a higher level of knowledge about semiconductor manufacturing processes than category one jobs. These jobs have titles such as "Engineering Technician Specialist" or "Process Development Engineering Technician". Employer job posts typically ask applicants to have a two-year technical degree and/or up to five+ years of experience working in semiconductor fabrication facilities when applying for these jobs.

Four out of four job posts from SkyWater Technologies for category two jobs matched closely with the standard occupation titled "Electrical & Electronic Engineering Technologists and Technicians" (referred to as Electrical Engineering Technicians moving forward). Given that Electrical Engineering Technicians appeared as a job match four of four times (three times as the number one match), it will be the standard occupation used to represent category two jobs in the following skills analysis.

Profile of Electrical Engineering Technicians

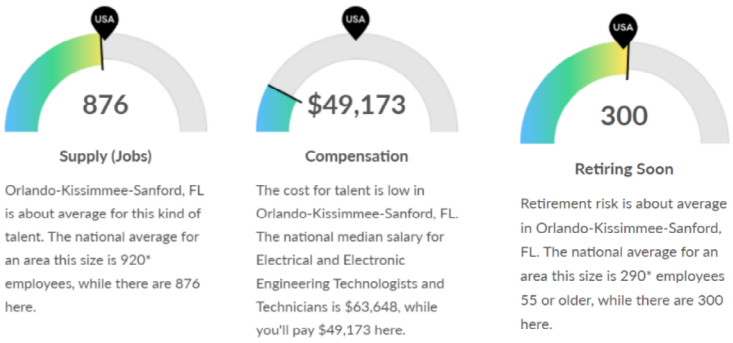
Data from Lightcast shows that there are 880 Electrical Engineering Technicians employed in Orlando, making a median wage of $49,200 annually or $23.64 an hour.(25) For added context, other sources show Electrical Engineering Techs making higher median wages of $57,400 annually or $27.59 an hour in the region.(26) Again it is of note that a larger percentage of these workers are approaching retirement age compared to other regions. This amplifies the need to create pipelines of workers from other industries.

(24) https://www.onetonline.org/link/details/51-9141.00

(25) Electrical Engineering Techs have a wage range of $45,300 at the 25th percentile and $73,900 at the 75th percentile. Data sourced from Lightcast.

(26) https://www.onetonline.org/link/localwages/17-3023.00?zip=32803

FIGURE 8: OVERVIEW OF ELECTRICAL ENGINEERING TECHNICIANS IN ORLANDO



**National average values are derived by taking the national value for Electrical Engineering Technicians and scaling it down to account for the difference in overall workforce size between the nation and Orlando-Kissimmee-Sanford, FL. In other words, the values represent the national average adjusted for region size. Source: Lightcast Occupation Snapshot Report.*

The KSAs required of Electrical Engineering Technicians involve having strong knowledge of computers and electronics as well as engineering principles. Like category one jobs, these jobs still require physical abilities such as near vision, but the important skills and abilities also include high levels of critical thinking, written and oral comprehension, and inductive reasoning. **TABLE 3** lists the top KSAs that are necessary to perform this job. Note how a higher number of KSAs listed in **TABLE 3** meet the importance score cutoff compared to category one jobs. As semiconductor manufacturing jobs become more advanced, the number of required skills increases.

TABLE 3: TOP KNOWLEDGE AREAS, SKILLS, AND ABILITIES NECESSARY FOR ELECTRICAL ENGINEERING TECHNICIANS

IMPORTANCE SCORE	KNOWLEDGE, SKILL, OR ABILITY	DESCRIPTION
85	Knowledge	Computers and Electronics
84	Knowledge	Engineering and Technology
72	Ability	Problem Sensitivity
70	Ability	Near Vision
70	Ability	Deductive Reasoning
69	Knowledge	English Language
67	Skill	Critical Thinking
67	Ability	Written Comprehension
67	Ability	Inductive Reasoning
66	Knowledge	Design
66	Ability	Oral Comprehension
64	Skill	Reading Comprehension
63	Knowledge	Mathematics
63	Skill	Complex Problem Solving
62	Ability	Information Ordering
60	Skill	Active Listening
58	Knowledge	Customer and Personal Service

IMPORTANCE SCORE	KNOWLEDGE, SKILL, OR ABILITY	DESCRIPTION
57	Knowledge	Mechanical
57	Skill	Troubleshooting
56	Skill	Speaking
56	Ability	Visualization
56	Ability	Visual Color Discrimination
56	Ability	Written Expression
56	Ability	Mathematical Reasoning
56	Ability	Finger Dexterity
56	Ability	Flexibility of Closure
56	Ability	Perceptual Speed
55	Knowledge	Production and Processing
55	Skill	Mathematics
55	Skill	Monitoring
55	Ability	Category Flexibility
55	Skill	Operation Monitoring
54	Skill	Judgment and Decision Making
53	Knowledge	Telecommunications
53	Skill	Active Learning
53	Skill	Writing
53	Skill	Systems Analysis
53	Ability	Speech Recognition
53	Ability	Speech Clarity
52	Skill	Quality Control Analysis
52	Ability	Selective Attention
52	Knowledge	Physics
52	Skill	Time Management
52	Ability	Fluency of Ideas
51	Skill	Coordination
51	Ability	Arm-Hand Steadiness

Top Occupations with Transferable Skills

As the number of important skills increases along with the technicality of the job, the number of highly compatible jobs decreases. Given the high amount of background knowledge required of Electrical Engineering Technicians and the level of physical abilities still required, the analysis finds that there are four other occupations in Orlando where individuals may have the transferable skills required to do the job. Broadcast Technicians, Camera Equipment Repairers, Computer and Office Machine Repairers, and finally, Surveying and Mapping Technicians are those jobs that combine a similar level of background knowledge and physicality as Electrical Engineering

Technicians. Together, these four occupations represent 1,700 jobs in the region expanding the talent pipeline to 2,600 (when the 900 Electrical Engineering Technicians are included).

Note, just like the highly compatible jobs for category one positions, **TABLE 4** only shows jobs with lower median wages than Electrical Engineering Technicians. A move from one of these four occupations to a category two semiconductor manufacturing job would represent a 25 percent increase in pay. If the filter for pay were removed, many more jobs would be compatible with this role, including Photonics Technicians, Aerospace Engineering Technologists, and Nanotechnology Technicians, to note a few.

Jobs shown in **TABLE 4** must make median hourly wages less than $18.91. Moving into an Electrical Engineering role from these positions would result in wage gains of at least $9,900 annually.

TABLE 4: OCCUPATIONS HIGHLY COMPATIBLE WITH ELECTRICAL ENGINEERING TECHNICIANS

OCCUPATION TITLE	MAJOR OCCUPATION FAMILY	MEDIAN HOURLY EARNINGS	ORLANDO MSA EMPLOYMENT 2022	COMPATIBILITY INDEX
Broadcast Technicians	Arts, Design, Entertainment, Sports, and Media	$18.76	204	94
Camera and Photographic Equipment Repairers	Installation, Maintenance, and Repair	$16.12	70	91
Computer, Automated Teller, and Office Machine Repairers	Installation, Maintenance, and Repair	$17.91	614	90
Surveying and Mapping Technicians	Architecture and Engineering	$18.06	763	90

Skill Comparison – Electrical Engineering Technicians and Surveying and Mapping Technicians

This example digs deeper into the relationship between Electrical Engineering Technicians and Surveying and Mapping Technicians to understand which skills make them compatible and where Surveying and Mapping Technicians may need upskilling if they were to transition to the semiconductor manufacturing industry. Surveying and Mapping Technicians were chosen for this skill comparison because this job represents the largest portion of employment, almost 800 jobs, of the four jobs highlighted in **TABLE 4**.

FIGURE 9 is an illustration of the most important KSAs for these jobs and the links between them. There are many. It is not until the Electrical Engineering Technicians list reaches the 19th most important KSA that there is not a direct match in the list of most important skills for Surveying and Mapping Technicians. In fact, six of the

10 most important KSAs for Electrical Engineering Technicians are also in the top 10 most important KSAs for Surveying and Mapping Technicians. They are knowledge of computers and electronics, problem sensitivity, near vision, knowledge of the English language, critical thinking, and written comprehension. Notice how this list of most important skills is not purely based on technical knowledge or purely ability-based. It is a mix of knowledge-based KSAs, physical abilities, and skills typically thought of as important interpersonal skills such as critical thinking and written comprehension.

FIGURE 9: IMPORTANT KNOWLEDGE, SKILL, AND ABILITY COMPARISON BETWEEN ELECTRICAL ENGINEERING TECHNICIANS AND SURVEYING AND MAPPING TECHNICIANS

ELECTRICAL ENGINEERING TECHNICIANS			SURVEYING AND MAPPING TECHNICIANS		
KSA	NAME	IMPORTANCE	KSA	NAME	IMPORTANCE
Knowledge	Computers and Electronics	85	Knowledge	Computers and Electronics	79
Knowledge	Engineering and Technology	84	Ability	Near Vision	72
Ability	Problem Sensitivity	72	Knowledge	Geography	72
Ability	Near Vision	70	Ability	Written Comprehension	67
Ability	Deductive Reasoning	70	Knowledge	Mathematics	67
Knowledge	English Language	69	Knowledge	English Language	65
Skill	Critical Thinking	67	Ability	Mathematical Reasoning	64
Ability	Written Comprehension	67	Skill	Reading Comprehension	63
Ability	Inductive Reasoning	67	Skill	Critical Thinking	63
Knowledge	Design	66	Ability	Problem Sensitivity	63
Ability	Oral Comprehension	66	Knowledge	Engineering and Technology	62
Skill	Reading Comprehension	64	Skill	Mathematics	61
Knowledge	Mathematics	63	Ability	Deductive Reasoning	61
Skill	Complex Problem Solving	63	Ability	Information Ordering	60
Ability	Oral Expression	62	Ability	Oral Expression	59
Ability	Information Ordering	62	Ability	Oral Comprehension	59
Skill	Active Listening	60	Ability	Finger Dexterity	58
Knowledge	Customer and Personal Service	58	Knowledge	Design	57
Knowledge	Mechanical	57	Skill	Speaking	55
Skill	Troubleshooting	57	Ability	Active Listening	55
Skill	Speaking	56	Ability	Far Vision	55
Ability	Visualization	56	Knowledge	Customer and Personal Service	54
Ability	Visual Color Discrimination	56	Skill	Active Learning	53
Ability	Written Expression	56	Skill	Writing	53
Ability	Mathematical Reasoning	56	Ability	Flexibility of Closure	53
Ability	Finger Dexterity	56	Ability	Inductive Reasoning	53
Ability	Flexibility of Closure	56	Ability	Speech Recognition	53
Ability	Perceptual Speed	56	Skill	Complex Problem Solving	53
Knowledge	Production and Processing	55	Skill	Time Management	52
Skill	Mathematics	55	Skill	Judgement and Decision Making	52
Skill	Monitoring	55	Ability	Written Expression	52

*Source: Data accessed through Lightcast where competency data is taken directly from the O*NET database.*

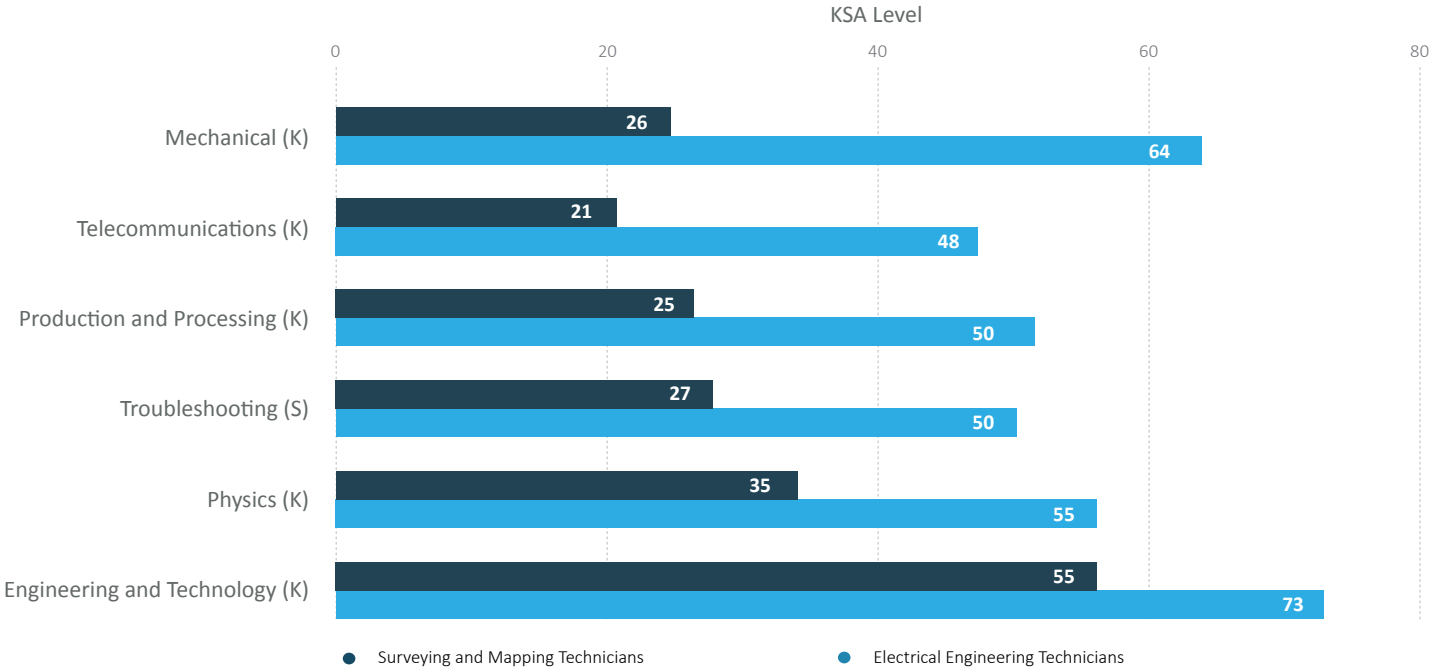
Lastly, this analysis answers the important question of where there are KSA gaps between these roles. For example, knowledge of computers and electronics is the most important KSA for both occupations, but it may be required at different levels for each. **FIGURE 10** highlights the KSAs where there are significant gaps between the two jobs. From a list of 47 KSAs, only six have large enough gaps to be listed. Those areas with the largest gaps in the level of mastery are:

- **Mechanical:** Knowledge of machines and tools, including their designs, uses, repair, and maintenance.
- **Telecommunications:** Knowledge of transmission, broadcasting, switching, control, and operation of telecommunications systems.
- **Production and Processing:** Knowledge of raw materials, production processes, quality control, costs, and other techniques for maximizing the effective manufacture and distribution of goods.
- **Troubleshooting:** The skill of determining causes of operating errors and deciding what to do about it.
- **Physics:** Knowledge and prediction of physical principles, laws, their interrelationships, and applications to understanding fluid, material, and atmospheric dynamics, and mechanical, electrical, atomic and subatomic structures and processes.
- **Engineering and Technology:** Knowledge of the practical application of engineering science and technology. This includes applying principles, techniques, procedures, and equipment to the design and production of various goods and services.[27]

These are the topics where higher education providers may consider creating new training programs if they were to build out this specific talent pathway. Alternatively, employers may consider beefing up their onboarding training for new hires into category two jobs in these areas. **FIGURE 10** shows the data behind this analysis and the size of the skill gaps.

(27) https://www.onetonline.org/link/summary/17-3023.00

FIGURE 10: KNOWLEDGE AREAS, SKILLS, AND ABILITIES WITH THE LARGEST GAPS BETWEEN ELECTRICAL ENGINEERING TECHNICIANS AND SURVEYING AND MAPPING TECHNICIANS



Category Three: Subject Matter Experts

While there are engineering roles in category two, think of category three as the engineers with multiple years, sometimes decades, of experience in their related field. Titles for these positions may sound something like “Advanced Packaging Metrology/Test Process Engineer” or “Senior Firmware Engineer”. Job posts searching for these SMEs typically ask for applicants to have a bachelor’s degree, master’s, or PhD in fields such as electrical engineering, microelectronics, or chemical engineering.

The SME job posts from Orlando semiconductor manufacturers have descriptions that suggest these roles require many types of engineering expertise. The five job posts for SMEs matched closely with Industrial Engineers, Electronics Engineers (not including computers), and Manufacturing Engineers (which is a specific subset of industrial engineering). Because manufacturing engineering is a type of industrial engineering and because Industrial Engineers were most often the number one match to Orlando job posts for SMEs, the Industrial Engineers occupation code is used to represent category three jobs and identify other occupations where workers have similar skillsets.

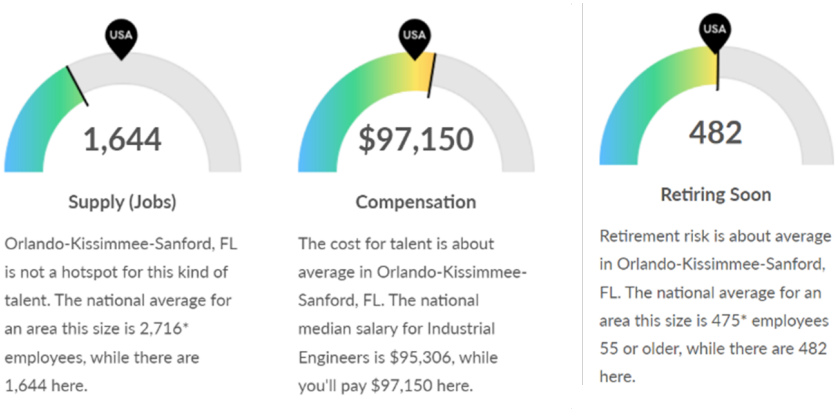
*The K, S, or A next to each phrase indicates if that element is a knowledge area, skill, or ability. Source: O*NET occupation profiles.*

Profile of Industrial Engineers

Data from Lightcast shows that there are 1,600 Industrial Engineers

employed in Orlando, making a median wage of $97,200 annually or $45.93 an hour.[28] For context another source shows Industrial Engineers make median wages of $98,900 annually or $47.53 an hour in the region.[29] Unlike category one or two jobs, retirement risk for industrial engineers is about average in Orlando.

FIGURE 11: OVERVIEW OF INDUSTRIAL ENGINEERS IN ORLANDO



**National average values are derived by taking the national value for Industrial Engineers and scaling it down to account for the difference in overall workforce size between the nation and Orlando-Kissimmee-Sanford, FL. In other words, the values represent the national average adjusted for region size. Source: Lightcast Occupation Snapshot Report.*

It is easy to see which types of skills are valued the most for Industrial Engineers. The top four KSAs are knowledge areas, which reinforces the point that this category of job is now considered expert-level. The next nine KSAs are then either skills or abilities that have to do with communication and reasoning. To put it another way, just after the technical knowledge required to be an engineer, the most important skills and abilities an engineer can have are strong interpersonal skills.

Again, note just how long the list of important KSAs is for Industrial Engineers (those KSAs with an importance score higher than or equal to 50). There are 49 KSAs listed in **TABLE 5**, two more than category two jobs. As semiconductor manufacturing jobs become more advanced, the number of required skills increases.

(28) Electrical Engineering Techs have a wage range of $45,300 at the 25th percentile and $73,900 at the 75th percentile. Data sourced from Lightcast.

(29) https://www.onetonline.org/link/localwages/17-2112.00?zip=32803

TABLE 5: TOP KNOWLEDGE AREAS, SKILLS, AND ABILITIES NECESSARY FOR INDUSTRIAL ENGINEERS

IMPORTANCE SCORE	KNOWLEDGE, SKILL, OR ABILITY	DESCRIPTION
85	Knowledge	Engineering and Technology
82	Knowledge	Production and Processing
80	Knowledge	Mechanical
77	Skill	Design
75	Skill	Active Listening
75	Skill	Critical Thinking
75	Ability	Oral Expression
75	Ability	Written Comprehension
75	Ability	Written Expression
75	Ability	Oral Comprehension
75	Ability	Inductive Reasoning
75	Ability	Deductive Reasoning
74	Knowledge	English Language
72	Knowledge	Mathematics
72	Skill	Speaking
72	Skill	Complex Problem Solving
72	Ability	Problem Sensitivity
69	Knowledge	Computers and Electronics
69	Skill	Writing
66	Ability	Information Ordering
66	Ability	Near Vision
61	Knowledge	Administration and Management
61	Knowledge	Customer and Personal Service
60	Skill	Monitoring
60	Ability	Category Flexibility
60	Ability	Selective Attention
59	Knowledge	Education and Training
56	Skill	Active Learning
56	Skill	Mathematics
56	Skill	Systems Evaluation
56	Skills	Systems Analysis
56	Ability	Fluency of Ideas
56	Ability	Originality
56	Ability	Speech Recognition
56	Ability	Speech Clarity
53	Knowledge	Public Safety and Security
53	Skill	Judgement and Decision Making
53	Skill	Coordination
53	Ability	Visualization
53	Ability	Mathematical Reasoning
53	Ability	Number Facility
53	Knowledge	Physics
50	Knowledge	Clerical
50	Skill	Social Perceptiveness
50	Skill	Instructing
50	Skill	Time Management
50	Ability	Flexibility of Closure
50	Ability	Far Vision

Top Occupations with Transferable Skills

Given the high levels of technical knowledge required of Industrial Engineers, readers may be surprised to find that over 35 different occupations are highly compatible with the role. This list includes other types of engineers, but also drafters, construction managers, and information security analysts – likely due to the high importance of interpersonal skills for industrial engineering. After filtering the list for occupations that make significantly less in pay than Industrial Engineers,[30] 12 occupations remain that represent 19,300 individuals employed in Orlando. **TABLE 6** lists those 12 occupations that have a high compatibility index score with Industrial Engineers.

TABLE 6: OCCUPATIONS HIGHLY COMPATIBLE WITH INDUSTRIAL ENGINEERS

OCCUPATION TITLE	MAJOR OCCUPATION FAMILY	MEDIAN HOURLY EARNINGS	ORLANDO MSA EMPLOYMENT 2022	COMPATIBILITY INDEX
Commercial and Industrial Designers	Arts, Design, Entertainment, Sports, and Media	$25.10	221	94
Logistics Engineers	Business and Financial Operations	$31.12	1,334	94
Civil Engineering Technologists and Technicians	Architecture and Engineering	$23.07	547	94
Mechanical Drafters	Architecture and Engineering	$29.07	291	92
Industrial Engineering Technologists and Technicians	Architecture and Engineering	$28.59	118	92
Architectural and Civil Drafters	Architecture and Engineering	$23.83	1,433	92
Health and Safety Engineers, Except Mining Safety Engineers and Inspectors	Architecture and Engineering	$29.21	251	92
Cost Estimators	Business and Financial Operations	$29.58	2,156	91
Electrical and Electronics Drafters	Architecture and Engineering	$28.45	183	91
Construction and Building Inspectors	Construction and Extraction	$29.64	1,431	91
Sustainability Specialists	Business and Financial Operations	$28.98	11,331	90
Occupational Health and Safety Technicians	Life, Physical, and Social Science	$23.13	52	90

(30) Occupations must make median hourly wages of $36.74 or less in Orlando to be included in the final list. This accounts for jobs where movement into Industrial Engineering would represent at least a 25 percent pay bump, an additional $20,800 annually.

Skill Comparison – Industrial Engineers and Sustainability Specialists

This example digs deeper into the relationship between Industrial Engineers and Sustainability Specialists to illustrate where there are skill overlaps and where there are skill gaps. Sustainability Specialists were chosen for this skill comparison because this job represents the largest portion of employment, almost 11,300 jobs, of the 12 jobs highlighted in **TABLE 6**.

FIGURE 12 is an illustration of the most important KSAs for these jobs and the links between them. It is clear where there is skill overlap, especially for the more important skills for Industrial Engineers. Knowledge of engineering and technology is the number one most important KSA for Industrial Engineers, and it just makes the list of KSAs for Sustainability Specialists. After that, the nine interpersonal skills mentioned earlier all overlap with the skills required of Sustainability Specialists. It is clear that there are gaps between the two jobs in their knowledge bases. While Sustainability Specialists need knowledge of law and government and building construction, Industrial Engineers need knowledge of production and processing techniques, mechanics, and design.

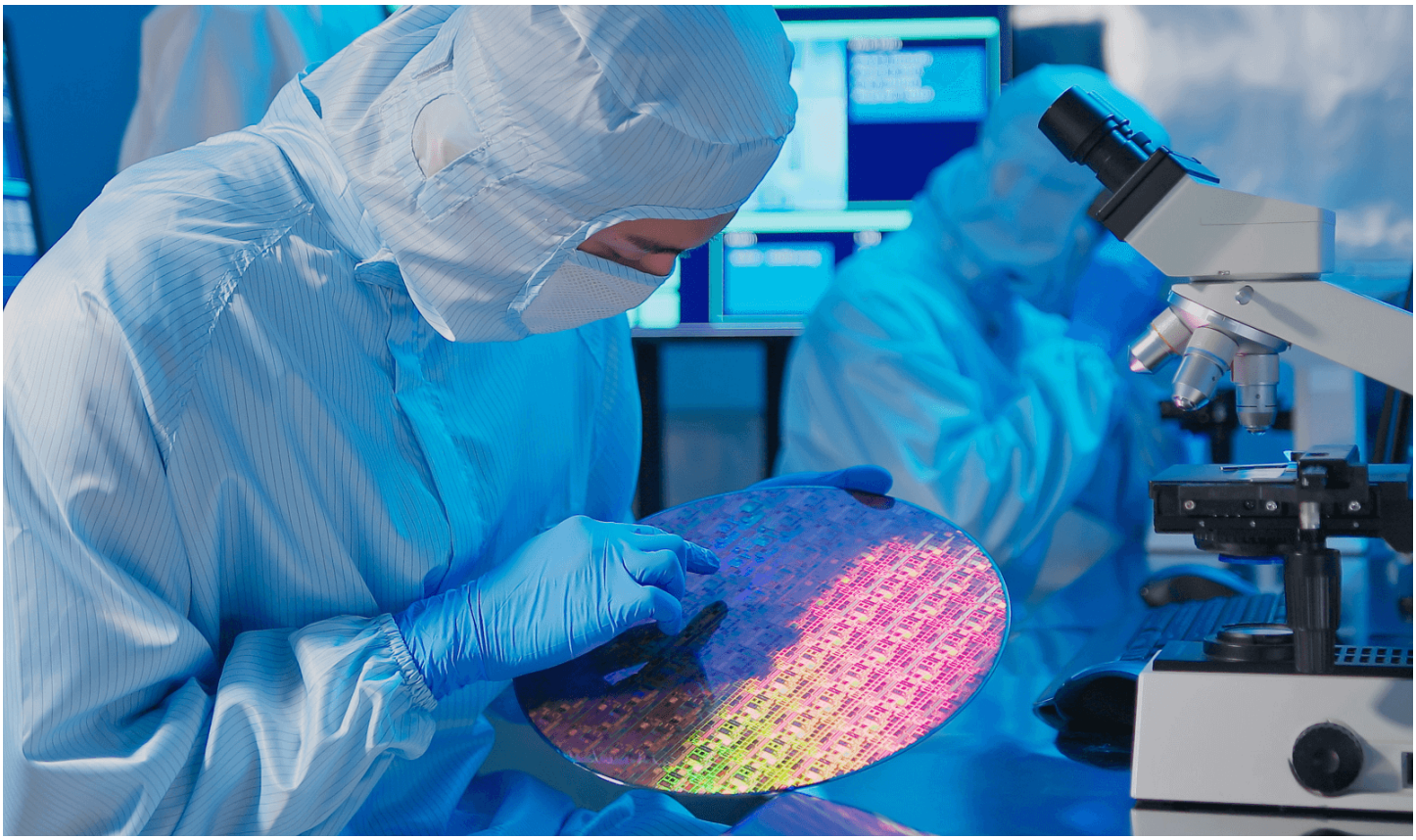
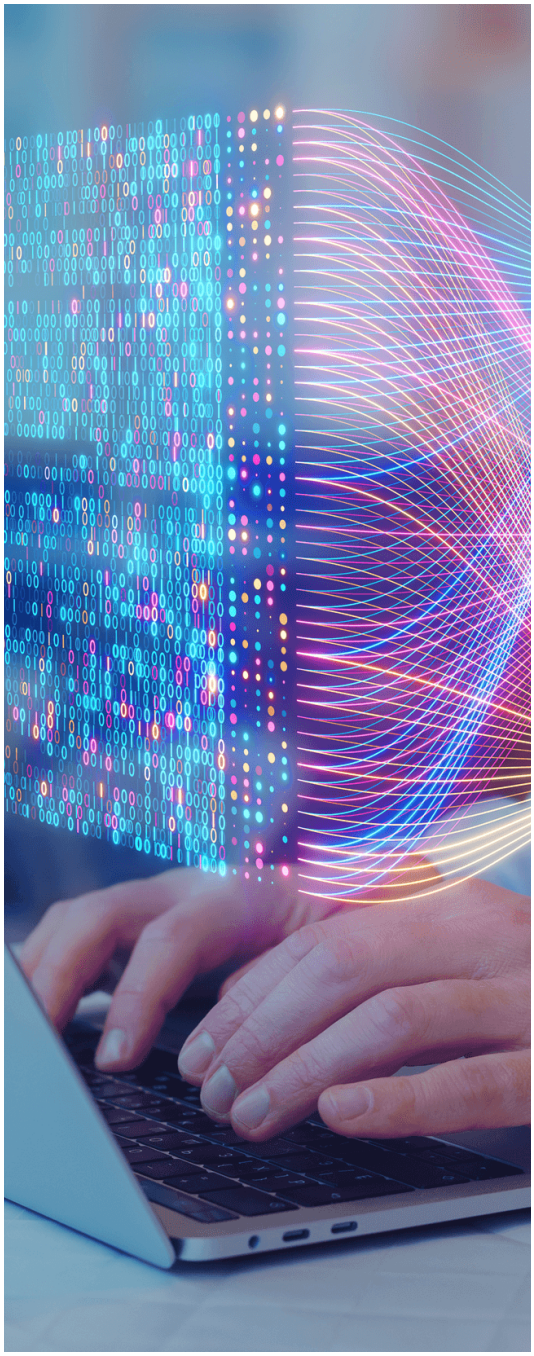


FIGURE 12: KNOWLEDGE, SKILL, AND ABILITY COMPARISON BETWEEN INDUSTRIAL ENGINEERS AND SUSTAINABILITY SPECIALISTS

INDUSTRIAL ENGINEERS			SUSTAINABILITY SPECIALISTS		
KSA	NAME	IMPORTANCE	KSA	NAME	IMPORTANCE
Knowledge	Engineering and Technology	85	Skill	Speaking	75
Knowledge	Production and Processing	82	Skill	Reading Comprehension	75
Knowledge	Mechanical	80	Skill	Writing	75
Knowledge	Design	77	Ability	Written Expression	75
Skill	Reading Comprehension	75	Ability	Written Comprehension	75
Skill	Active Listening	75	Skill	Critical Thinking	72
Skill	Critical Thinking	75	Skill	Active Listening	72
Ability	Oral Expression	75	Ability	Oral Expression	72
Ability	Written Comprehension	75	Ability	Oral Comprehension	72
Ability	Written Expression	75	Ability	Deductive Reasoning	69
Ability	Oral Comprehension	75	Ability	Inductive Reasoning	69
Ability	Inductive Reasoning	75	Knowledge	Administration and Management	69
Ability	Deductive Reasoning	75	Skill	Judgement and Decision Making	66
Knowledge	English Language	74	Skill	Complex Problem Solving	66
Knowledge	Mathematics	72	Ability	Problem Sensitivity	66
Skill	Speaking	72	Ability	Speech Clarity	66
Skill	Complex Problem Solving	72	Knowledge	Law and Government	64
Ability	Problem Sensitivity	72	Skill	Monitoring	63
Knowledge	Computers and Electronics	69	Ability	Originality	63
Skill	Writing	69	Ability	Information Ordering	63
Ability	Information Ordering	66	Knowledge	Education and Training	62
Ability	Near Vision	66	Knowledge	English Language	62
Knowledge	Administration and Management	61	Knowledge	Building and Construction	60
Knowledge	Customer and Personal Service	61	Ability	Fluency of Ideas	60
Skill	Monitoring	60	Ability	Speech Recognition	60
Ability	Category Flexibility	60	Skill	Systems Evaluation	56
Ability	Selective Attention	60	Skill	Coordination	56
Knowledge	Education and Training	59	Skill	Active Learning	56
Skill	Active Learning	56	Ability	Category Flexibility	56
Skill	Mathematics	56	Knowledge	Customer and Personal Service	54
Skill	Systems Evaluation	56	Skill	Persuasion	53
Skill	Systems Analysis	56	Skill	Systems Analysis	53
Ability	Fluency of Ideas	56	Skill	Social Perceptiveness	53
Ability	Originality	56	Skill	Learning Strategies	53
Ability	Speech Recognition	56	Ability	Near Vision	53
Ability	Speech Clarity	56	Knowledge	Communications and Media	52
Knowledge	Public Safety and Security	53	Knowledge	Engineering and Technology	51
Skill	Judgement and Decision Making	53	Skill	Time Management	50
Skill	Coordination	53	Skill	Negotiation	50
Ability	Visualization	53	Skill	Instructing	50
Ability	Mathematical Reasoning	53	Ability	Mathematical Reasoning	50
Ability	Number Facility	53			
Knowledge	Physics	53			
Knowledge	Clerical	50			
Skill	Social Perceptiveness	50			
Skill	Instructing	50			
Skill	Time Management	50			
Ability	Flexibility of Closure	50			

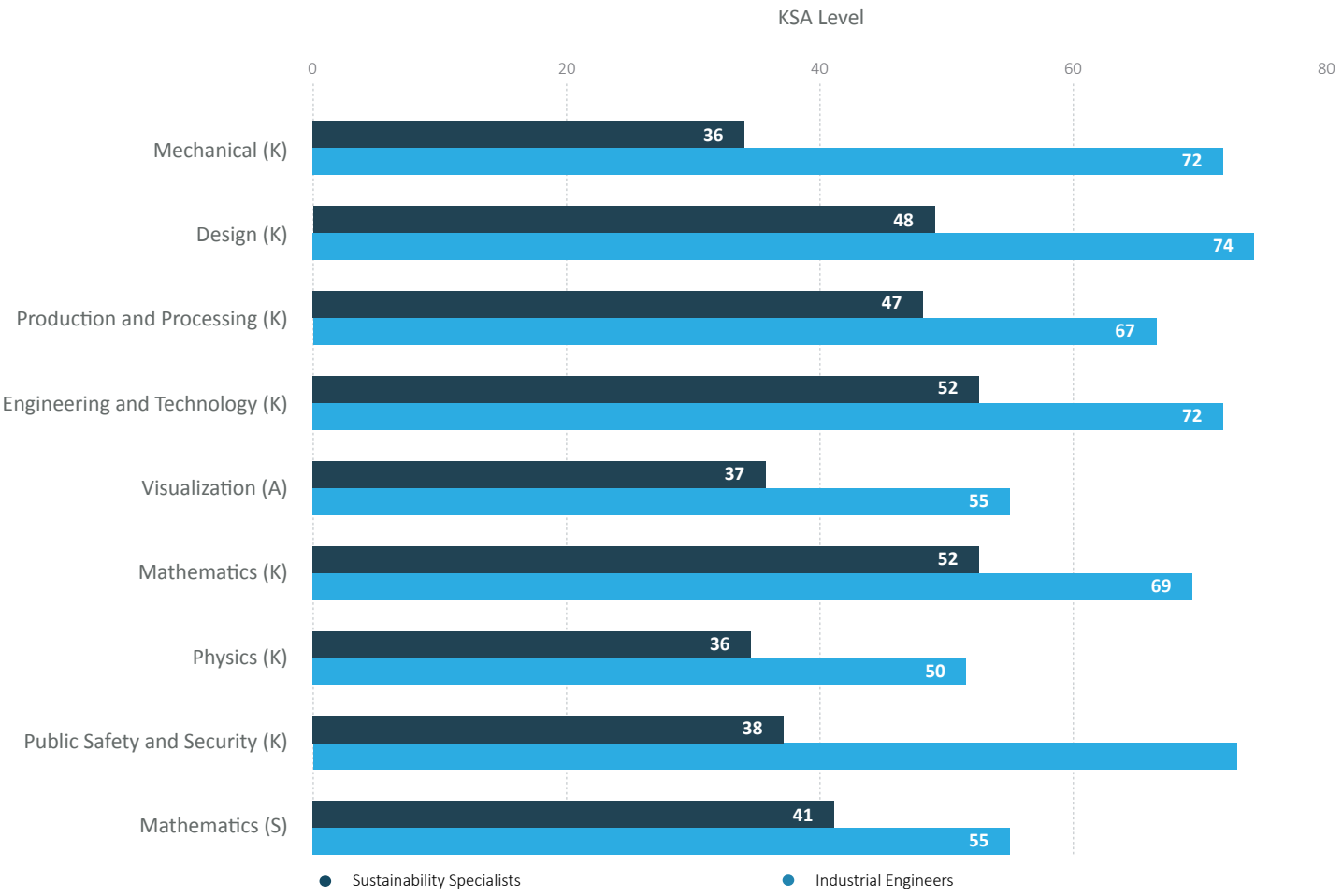
Finally, **FIGURE 13** looks at the gaps in these KSAs in more depth. The KSAs with the largest gaps between the two occupations are, not shockingly, the areas of technical knowledge. The definitions of the KSAs with the largest gaps are listed below.

- **Mechanical:** Knowledge of machines and tools, including their designs, uses, repair, and maintenance.
- **Design:** Knowledge of design techniques, tools, and principles involved in production of precision technical plans, blueprints, drawings, and models.
- **Production and Processing:** Knowledge of raw materials, production processes, quality control, costs, and other techniques for maximizing the effective manufacture and distribution of goods.
- **Engineering and Technology:** Knowledge of the practical application of engineering science and technology. This includes applying principles, techniques, procedures, and equipment to the design and production of various goods and services.
- **Visualization:** The ability to imagine how something will look after it is moved around or when its parts are moved or rearranged.
- **Mathematics:** Knowledge of arithmetic, algebra, geometry, calculus, statistics, and their applications.
- **Physics:** Knowledge and prediction of physical principles, laws, their interrelationships, and applications to understanding fluid, material, and atmospheric dynamics, and mechanical, electrical, atomic and sub-atomic structures and processes.
- **Public Safety and Security:** Knowledge of relevant equipment, policies, procedures, and strategies to promote effective local, state, or national security operations for the protection of people, data, property, and institutions.
- **Mathematics:** Using mathematics to solve problems.[31]



(31) https://www.onetonline.org/link/summary/17-2112.00

FIGURE 13: KNOWLEDGE AREAS, SKILLS, AND ABILITIES WITH THE LARGEST GAPS BETWEEN INDUSTRIAL ENGINEERS AND SUSTAINABILITY SPECIALISTS



*The K, S, or A next to each phrase indicates if that element is a knowledge area, skill, or ability. Source: O*NET occupation profiles.*

Conclusion

Many people may not believe the idea that a Sustainability Specialist, for example, could easily step into the role of an Industrial Engineer and therefore represent a Subject Matter Expert in the Semiconductor Manufacturing industry. This is a valid critique. Realistically, not every Industrial Engineer in Orlando would be the perfect fit for the semiconductor manufacturing industry, nor would everyone employed in a highly compatible job listed in the tables above.

In fact, part of the reason employers list degree requirements or requirements for years of experience on job posts is that it signals the employer does not have the capacity to train or upskill new workers. Semiconductor manufacturers need employees who can walk into a newly built fab and immediately know what to do.

However, talent pipeline constraints outlined earlier mean that practically, the semiconductor manufacturing industry needs new talent. Employers need workers who can get up to speed quickly. Higher education providers and workforce developers need to target people who can afford to and are motivated to take part in in-depth training programs that help workers pivot into the industry. Consider the lists of highly compatible occupations, especially for category three jobs, lists of occupations where the distance to skill and knowledge proficiency is the smallest. These are the occupations where it is likely to find employees who have similar enough skills, abilities, and backgrounds that they could pivot into the semiconductor manufacturing industry with the least amount of effort.

This report recognizes the long game. Workforce development takes time. It takes time to build new programs, to recruit potential workers, and to inspire a new generation of engineers and specialists. The hope is that, by highlighting lists of occupations that have a high level of skills overlap with the semiconductor manufacturing workforce a few things will happen.

1. **Existing and new manufacturers** in the region will be encouraged to beef up their skills-based hiring practices, especially when it comes to recruiting category one and category two jobs.
2. **Workforce development professionals** gain a better sense of the semiconductor ecosystem and see semiconduc-

> "Semiconductor Manufacturers ***need employees*** who can walk into a newly built fab and ***immediately know what to do"***

tor manufacturing as an attractive and attainable road to employment for their clients.

3. **Higher education providers** build strong pipelines of students into their semiconductor manufacturing training programs by targeting nontraditional students (working adults over age 25) who already have some of the required knowledge, skills, and abilities. The same goes for employers who do have the capacity to train their own workforce.

If these things happen, the timeline to creating a robust talent ecosystem for the domestic semiconductor manufacturing workforce will shrink drastically. This is critical to long-term success of the industry.

America is not alone in the rapid reinvestment in semiconductor manufacturing capabilities. "The American Jobs Plan, the European Digital Compass 2030, and China's 14th five-year plan all contain specific measures for the semiconductor sector, which has become a stage for genuine geopolitical competition."[32] As competition for global talent heats up and without immigration reform, America's success will come down to the capabilities of regional workforce developers, local manufacturers, and community higher education providers to craft their own, resilient talent pipelines.

In Orlando specifically, the focus and future of the industry is in advanced packaging. Local semiconductor manufacturers are able to capitalize on the needs of the defense industry to produce low-to-mid volume specialized chips that are essential to national security. The region has a plethora of non-profits that exist solely to make connections between industry and use collective impact to develop niche industry clusters. That collaborative spirit between non-profits, research institutions, and government bodies is partly what lead to the Orlando region's successful bid for Build Back Better funding from the US Economic Development Administration; the award itself is another proof point in the claim that Orlando represents the future in advanced packaging for the semiconductor industry. For more information on advanced packaging, see Part I of this series at Orlando.org/upskillsemiconductor.

For more information on how to capitalize on these regional assets or to connect on workforce development efforts, contact Tammy Humphrey at the Orlando Economic Partnership.

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(32) https://www.ispionline.it/en/publication/microscopic-three-way-competition-30188

FOUNDATION FOR ORLANDO'S FUTURE

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The Orlando Economic Partnership is a public-private, not-for-profit economic and community development organization. The Partnership represents seven counties in Central Florida, including the City of Orlando, and hundreds of the region's top private businesses.

Through the power of our partnerships, we strengthen our regional assets and businesses, advocate for regional priorities and write the next chapter of Orlando's story. We are injecting fresh resources and perspectives while harnessing the strength of the region's culture of collaboration and innovation to create a new future for our diverse and growing population.

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