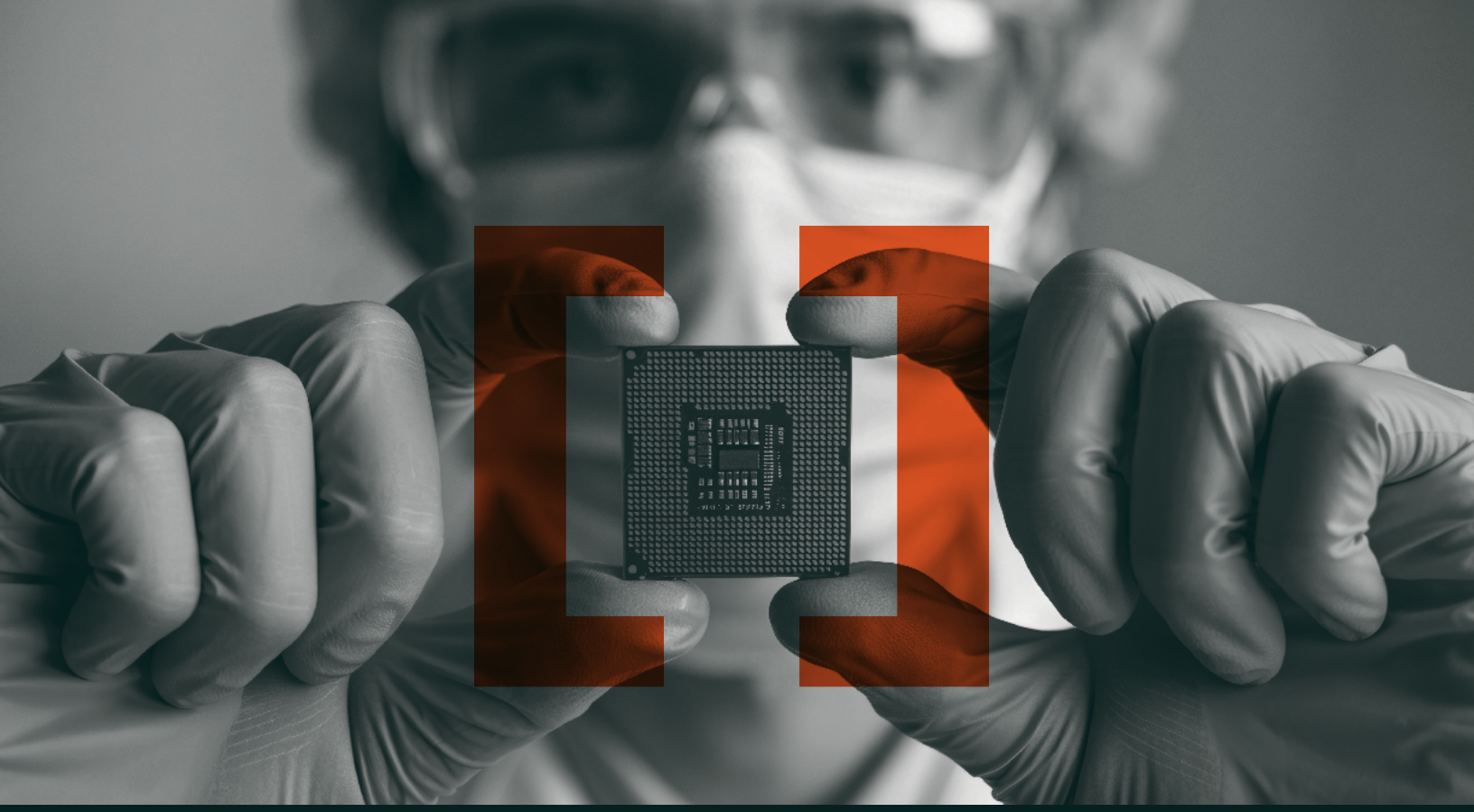

The Challenge of Building a Regional Semiconductor Workforce Pipeline

What Regions Can Learn from Austin, Texas and an Agenda for Cross-Regional Learning

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Formation
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Executive Summary

The bipartisan CHIPS and Science Act of 2022 solidified a national commitment to grow the domestic semiconductor industry and supply chain, prompting companies and regions around the country to prepare for a significant increase in demand for semiconductor jobs. Realizing this historic opportunity now depends on a small group of regions that face the formidable task of rapidly building responsive, accessible workforce pipelines into the semiconductor industry to prepare people for these jobs.

In this high-stakes moment, education and workforce development leaders in semiconductor hubs around the country are looking for guidance from peers in other regions. Many are under pressure to identify "plug and play" solutions that allow them to quickly ramp up training programs. But each of these regions is distinct, with unique regional industry dynamics that affect labor market demand and training needs. Each of these regions also has varying capabilities among education and workforce development institutions. This economic and institutional diversity makes it challenging for regions to learn from one another's experiences and identify replicable practices.

Austin, Texas, is one region that has deservedly attracted significant national attention. The region, and in particular Austin Community College (ACC), has developed a unique and innovative semiconductor workforce strategy based on more than ten years of intensive collaboration with semiconductor firms and deep industry relationships. ACC has been particularly successful in upskilling incumbent workers, acting as an embedded internal training provider for semiconductor companies. Through these deep relationships, ACC has been able to both shape companies' strategies and build programs that are attuned to their needs. This has resulted in robust training pathways that allow workers to advance within the industry through a series of programs that bridge for-credit and non-credit programs.

This paper aims to help other semiconductor hubs learn from Austin's experience to inform their semiconductor workforce strategies. It describes what Austin has done (and not yet done) to facilitate entry and advancement within the industry, the sophistication of its program offerings and the enabling conditions that contributed to its success. While Austin's story is often understood in programmatic terms, this paper also describes the largely invisible foundation on which ACC's programs are built – namely its ability, due to its own strategy and staff capabilities as well as state investments, to establish itself as a real partner to semiconductor companies.

The paper also demonstrates the need for a national learning network among regions receiving major CHIPS investments. While ACC has developed successful models for addressing some dimensions of the Austin region's semiconductor workforce challenges, observers should not assume that it has cracked the code on semiconductor workforce development comprehensively, nor that Austin's model would work in every region. Other regions need to understand the Austin context before they decide whether they can or should attempt to replicate its programs and practices, just as Austin needs to better understand other regions to determine whether they offer solutions to its unsolved challenges.

The underlying argument of this paper is that the complex workforce challenges of CHIPS regions cannot be addressed with a patchwork of discrete and disjointed programs, many borrowed hurriedly from other regions. Instead, regions need to embrace a systemic approach to partnering with firms to co-create local talent pipelines. These dynamic, strategic partnerships are essential for helping regions expand access to jobs while helping semiconductor firms meet their own hiring and retention goals in the near- and long-term. This paper describes what those partnerships look like and require in one region, in part to motivate the creation of a national semiconductor learning network that would allow regions to more quickly assess and adopt practices – not just programs – from other regions.

Austin's Unique Approach
What It Does and Does Not Do

For more than a decade, a small but growing ecosystem of workforce and education partners has been building a talent pipeline for Austin's semiconductor industry. Key to their success is an iterative process in which they help firms define their skill needs, cultivate trust across companies, build customized training programs and, over time, mold these into a unified approach across training institutions and public partners to build programs and pathways. ACC plays an integral role in this system. It serves as a highly credible training partner capable of both delivering and continually adapting training solutions to industry needs. Perhaps more notably, ACC steps far beyond the traditional role of a community college to act as a systems builder, which involves assessing industry demand and coordinating a response from the full ecosystem of public partners.

While the region lacks access to complete outcome data, there is evidence that this approach is working:

- ACC is training a significant number of students in the semiconductor industry. In 2024, it partnered with companies to train 2,856 unique learners across K-12 programs, associate and bachelor's degree programs, rapid training for immediate employment and incumbent worker training.

- ACC's fully customized technician training programs were created in collaboration with multiple semiconductor companies over 10 years. The clearest indicator of the program's value is the growing employer investment. Beyond the significant financial contribution companies are making to cover employee wages while in training, these partners are also starting to fund the training costs directly as a line item in their annual budgets. In 2024, industry partners contributed approximately $380,000 in ACC tuition costs. In at least one case, this includes flying an ACC instructor to another state every month and covering the tuition, travel, room and board costs associated. ACC's work with companies is now expanding beyond technician training to onboarding new engineers and creating career bridge programs such as material coordinator to manufacturing floor and semiconductor technician to production engineer.

- Through the alignment between non-credit and credit programs, ACC's training is embedded in local companies' internal employee development programs for career advancement. It also matriculates to a one-year college certification and as many as 22 credits toward one of two ACC Associate's Degrees in Advanced Manufacturing and a Bachelor's of Applied Technology in Engineering Technology. Over 150 students have made this transition to ACC degree programs in the last couple of years thus far.

There are five critical elements of Austin's approach to building a semiconductor workforce:

1. Innovative community college leadership and staff with deep industry experience who can challenge traditional college approaches and institutional silos, designing for-credit and non-credit programs that support industry and students holistically

2. State funding for training that allows for experimentation while also requiring accountability and outcomes reporting from participating companies.

3. A strategic shift within the community college away from a static, workforce program-driven orientation to a dynamic, demand-driven relationship with industry.

4. A bridge between the credit and non-credit sides of the community college to build multiple programs that create easy-to-navigate pathways.

5. A credible, effective industry association that convenes companies to scale training across multiple companies.

The Austin approach can and likely should be replicated to some degree in other regions. But replicating discrete components of the Austin model – e.g., adopting a specific program or hiring more staff with industry experience – will not yield success without also replicating the largely invisible work that underlies the success of these programs. This work centers on guiding firms through a process to identify their individual and collective needs with precision and accuracy. It requires a willingness to make major changes to how community colleges and other training providers respond to those identified needs, emphasizing flexibility, responsiveness, and a commitment to continuous improvement.

On the other hand, other regions should understand that Austin does not represent a universal model for semiconductor sector workforce development since its industry, economic, and policy context is different from other CHIPS regions. For example:

- Austin needs to train fewer workers than a region like Phoenix, where interviewees estimated that there would be up to 5,000 new engineering jobs and 10,000 technician jobs as a result of TSMC and Intel investments. These Phoenix plants will receive a combined $95 billion in CHIPS funding, compared to the initial $23 billion for Samsung's plant in Taylor, Texas. Phoenix can learn much from Austin, but it also needs to operate with urgency which may make elements of Austin's approach impractical.

- Austin's policy context is different from a region like Syracuse, where semiconductor workforce development efforts not only more closely resemble Phoenix's in terms of scale, but are also guided by inclusion requirements in the state's Green CHIPS legislation. For example, the state of New York is investing $200 million via its On-Ramp program to create four new centers in disadvantaged communities that will combine training, outreach, and wrap-around services, and is investing $100 million in a community investment Framework.[1]

1. One of the criteria for organizations applying for funding to build ON-RAMP centers is: to establish a physical location(s) for central delivery of services, prioritize proximity to and reasonable access for historically disadvantaged communities that will be a focus of the training, contribute to a neighborhood setting together with other community uses and services.

These differences across regions suggest that there is value in facilitating learning and exchange across regions. There are also opportunities for teams from across regions to collectively work on solutions that no region has likely figured out.

Austin still has important lessons to learn from other regions, as its current approach is not yet comprehensive. Austin has scaled a customized earn-and-learn model that both helps students enter the semiconductor workforce quickly and advances their careers by taking classes aligned within their work schedules. However, the region has yet to develop at-scale K-12 engagement strategies to significantly expand the pool of students pursuing semiconductor careers. It has more work to do in expanding embedded internships and other work-based learning opportunities in semester-based academic programs where students have not yet started their careers with semiconductor companies. The region also lacks a robust data tracking system to measure placement, retention and wage outcomes. Without this, the region lacks key insights about what's working and why.

The Urgent Need for a Cross-Regional Action Network

Austin developed its model over the course of 10 or more years, actively iterating with firms as programs slowly grew in size. Today, several regions are being called to respond on a much larger scale than Austin, in a much shorter time frame, or both. They will not be able to easily test and refine workforce development models along the way; they need to get it right the first time, often without much input from firms that are to begin hiring in the next one to three years. These regions will be much more likely to get it right the first time if they have structured opportunities to learn with and from other regions.

The current moment calls for a cross-regional network with not only a learning agenda (i.e., sharing individual problems that have been successful in one region) but an action agenda, which includes a commitment to shared problem-solving and a willingness to jointly tackle deeper, strategic issues across regions. This network should be composed of cross-system regional teams made up of the multiple institutions and organizations that have roles to play in building a functioning workforce development ecosystem: community colleges, universities, K-12 partners, workforce development boards, community-based training providers, economic development organizations, and state partners. The system is already primed for this kind of network; interviews with key players in the regions with a major semiconductor industry presence reveal a readiness to collaborate across regions to engage the semiconductor industry more deeply and effectively.

A starting point for a cross-regional action agenda should include:

- Developing a consistent, rigorous, and rapidly deployable process to help firms identify their skills needs with precision, both within and across companies.
- Identifying the points of entry into the industry that are most likely to lead to economic mobility.
- Delivering upward economic mobility by improving entry-level roles, facilitating advancement from entry- to technician levels, and creating alternative pathways into bachelor's-level engineering jobs.
- Facilitating the development of pathways that bridge credit and non-credit programs to support student and worker advancement.
- Mapping and building out the best opportunities for workers to obtain skills and credentials that enable cross-sector mobility to weather the cyclical downturns that are part of the semiconductor industry.

Introduction

The bipartisan CHIPS and Science Act of 2022 solidified a national commitment to grow the domestic semiconductor industry and supply chain, prompting companies and regions around the country to prepare for a significant increase in demand for semiconductor jobs. While it is a national imperative to establish a large and competitive semiconductor industry, responsibility for preparing a skilled workforce for this industry now largely rests on a small group of regions that need to respond to an extraordinary surge in demand for a wide variety of jobs in an often unfamiliar and quickly evolving industry.

Moving thousands of workers into new jobs when unemployment rates are below four percent in many of these metro areas is a difficult task in any circumstance. But, adding to the complexity of this feat, the educational and workforce development institutions in these regions are trying to do so with little insight into the workforce needs of these firms. They are largely unaware of how many workers these firms will need, when they will be needed, which type of workers will be required, and what to expect as these firms' supply chains develop. Meanwhile, many of the workforce development nonprofits that need to be involved in these efforts are uncertain about key job characteristics – e.g., wages and advancement opportunities – and thus are hesitant to act. This is not only a reflection of capacity limitations among economic and workforce development actors, but a demonstration of the limited ability of semiconductor firms to describe in-demand roles, needed skills, and required credentials.

These regional education and workforce development organizations also have very little information about how their peers in other regions are approaching similar challenges. News about high-profile successes and failures spreads, but practitioners have little insight into the structures and systems that have been built in other regions, the resources and personnel that those systems require, and whether those models are replicable.

This lack of clarity threatens the ability of these regions to deliver on the promise of a renewed and strengthened American semiconductor industry. It also threatens their ability to harness these once-in-a-generation investments to connect local residents to good jobs.

In this high-stakes moment, education and workforce development leaders in semiconductor hubs around the country are looking for guidance from their peers in other regions. These leaders feel pressure to deliver, and there is a risk that cross-regional interactions will turn into a rushed effort to identify "plug and play" training solutions that appear to be easily replicable. There is, however, no such solution. Each region faces a complex set of workforce challenges that cannot be addressed with a collection of discrete and disjointed programs alone. Instead, regions need to embrace a systemic approach to partnering with firms to dynamically co-create responsive talent pipelines. This involves partnering with companies to discern workforce needs with precision, developing responsive training solutions in collaboration with firms, and creating mechanisms to evaluate success and course correct, identifying what both training providers and companies

need to change to build effective talent pipelines. These dynamic, strategic partnerships are essential for helping regions expand access to good jobs while helping semiconductor firms meet their hiring and retention goals in the near- and long-term.

The challenges in building these dynamic partnerships are not just limited to the semiconductor industry. Community colleges have long struggled to build the kind of sustained, strategic partnerships with industry that allow them to understand needs and co-create training solutions.[2] And even when industry is fully engaged, colleges face internal institutional silos that inhibit their ability to develop responsive programs and pathways, especially those that bridge for-credit and non-credit programs. This means that colleges must overcome longstanding structural challenges to build the kind of dynamic and strategic partnerships needed to meet semiconductor workforce demand. This task is far from easy.

To facilitate effective exchange and learning across regions working to meet semiconductor workforce needs, this paper seeks to:

- **Frame the semiconductor workforce challenge nationally**, characterizing the scope of demand across regions receiving CHIPS investments, identifying specific gaps that need to be addressed, and identifying where companies – not just education and training providers – bear primary responsibility for addressing these gaps.

- **Describe Austin's unique and innovative semiconductor workforce strategy**. ACC has been fielding requests from regional practitioners and national observers who are interested in replicating ACC's approach to working with semiconductor firms. To help respond to these requests, this paper describes what ACC has accomplished and how, what open questions and outstanding challenges remain, and what elements of its approach make sense to replicate in other regions.

- **Identify the strategic questions that should be answered through a national learning network of semiconductor regions**. This paper aims to clarify what questions are worth asking of Austin's education and workforce development leaders – and what questions Austin should be asking of leaders in other regions. In so doing, it outlines the basic contours of a national learning network among regions with significant or fast-growing semiconductor industries.

This paper is based on findings from interviews with leaders from ACC, Austin Regional Manufacturers Association (ARMA), and leaders from select semiconductor firms with operations in Austin. It also draws on insights from interviews with practitioners in other regions receiving major semiconductor investments including New York, Ohio, Arizona, and Oregon.

2. The Partnership Imperative: Community Colleges, Employers, and America's Chronic Skills Gap (Dec. 2022). Published by Harvard Business School. Link.

The Semiconductor Workforce Challenge in National Context

The Scale of the Challenge

Between 2020 and 2022, annual postings for semiconductor jobs tripled from about 8,000 to almost 25,000. Analysts expect that between 2023 and 2030, the industry will grow 33%, an increase of 115,000 jobs. At current degree completion rates, approximately 67,000 of those jobs would go unfilled. Over 26,000 of those unfilled jobs would be for technician roles that require a two-year degree or less. The potential workforce shortage among workers with at least a bachelor's degree will be even larger: about 13,000 computer scientists and 27,000 engineers, of which 17,000 will need at least a master's degree.

Assessing the Causes of Workforce Shortages

Analyses of the semiconductor industry consistently find that firms are not getting the workers that they need and that the problem is worsening. These statements are accurate descriptions of symptoms, but they are not diagnoses of the problem. If CHIPS regions are going to solve persistent workforce shortages, they need to better understand their root causes.

Identifying root causes requires considering four contributing factors:

- **Structural macroeconomic conditions affecting all industries:** Unemployment rates are below 4% and the working-age population is shrinking, making it hard to attract workers.
- **Structural conditions unique to the semiconductor industry:** The industry is inherently volatile, making it hard to retain entry-level workers long enough to invest in upskilling.
- **Capacity gaps among institutions that serve all industries:** Educational institutions and training providers lack the instructors and infrastructure necessary to provide relevant training.
- **Strategic decisions made by firms in the semiconductor industry:** Semiconductor firms are unwilling to change training/degree requirements despite very low unemployment.

These distinctions need to be central to national conversations about semiconductor workforce development to avoid pursuing interventions that are too superficial or narrow. For example, lack of industry awareness is often identified as a major impediment to growing workforce pipelines, but boosting awareness will have limited impact if very high rates of turnover among entry-level workers are not also addressed. Furthermore, the efficacy of awareness-building efforts may be overstated if the workforce is shrinking and wages are rising in non-manufacturing industries. As another example, some regions – notably Ohio – are investing in efforts to standardize curricula across community colleges as a means of addressing capacity gaps among training providers.

However such efforts are less effective than they would be if they were accompanied by a parallel effort to push semiconductor firms to examine whether their credential requirements are necessary or justifiable given current market conditions.

This point may seem obvious – the complexity of any economic or workforce development issue is rarely acknowledged in the discourse among practitioners or commentators. But, for the three reasons outlined below (and described elsewhere in this paper), it is especially likely that regional leaders will not consider the full range of contributing factors to semiconductor workforce shortages. And given how many jobs need to be quickly filled, the downsides of building a strategy on incomplete information are especially pronounced.

- **Economic development organizations and training providers are under pressure to deliver:** Recent semiconductor investments are often the biggest economic development wins in the history of those regions. Economic and workforce development actors are under tremendous pressure to show that they are capable of responding in this moment at the necessary scale and speed; this is a high-profile opportunity to demonstrate the region's business attraction prowess. This makes it difficult to be methodical in the development of training approaches or to push companies to reconsider their talent strategies.

- **Companies have limited insight into their talent needs and limited internal capacity for developing and implementing talent strategy:** Local actors often assume that the information that semiconductor companies share about their workforce needs is based on sophisticated internal assessment and that companies have the ability to guide entry-level workers along career pathways. As discussed elsewhere in this paper, many semiconductor companies have very small talent development teams with limited ability to shape their firms' practices.

- **There is a presumption that semiconductor jobs are good jobs, but little data to confirm or complicate that narrative:** It is often assumed, based on limited data, that semiconductor jobs are "good." There is, however, little critical assessment of the high median wages that are associated with CHIPS investments. But it is plausible that entry-level semiconductor jobs are barely, if at all, better than alternative jobs that require similar amounts of education and may be comparable when taking into account wages, mobility, flexibility, and other measures of job quality.[3]

Observations about the overall number of unfilled, high-wage sub-bachelor's jobs in the industry are not very revealing given that high median wages reflect, in Austin, a range of sub-bachelor's jobs with median wages ranging from $35,000 to $60,000. If jobs that pay $60,000 are routinely going unfilled, one might reasonably infer a skills gap. If the unfilled jobs tend to be those at the lower end of this range, skills gaps are, at best, a partial explanation.

3.Women, for example, are significantly under-represented at every level – which both suggests job quality problems exist and allows those problems to persist (due to the huge under-representation of women at the board, executive, and managerial levels).

A Comprehensive Regional Approach

A comprehensive regional strategy – one that considered all of the basic root causes of workforce shortages described above – would involve a portfolio of interventions described below. The first half of these challenges and interventions relate to what tends to be referred to as a "skills gap", whereas the second half relate to the strategic choices of firms. **This framework, summarized in the table and detailed below, is intended to help other regions situate Austin's approach relative to an ideal and relative to their regions**

Challenge	Intervention
Too few people pursuing semiconductor training pathways and careers	Ramp up exposure efforts to introduce young people, recareering adults, and people who are underrepresented in the industry to career opportunities in the industry. Connect them to training programs that have a track record of placing graduates in family-sustaining jobs with opportunities for upward mobility.
Too few skilled technicians	Design and ramp up training programs that prepare people for specific skilled technician roles, including formalizing pathways from entry-level operators into technician roles.
Too few engineers	Develop and ramp up engineering programs with strong hands-on components. Formalize advancement pathways from technician to engineering roles.
High turnover in entry-level operator roles	Create more structured and supported advancement pathways to help operators progress into technician roles. Invest in job quality improvements (wages and other) for entry-level roles.
Education and training providers have limited, inconsistent information about workforce needs	Convene firms to aggregate and analyze data on hiring needs, specific skills required for certain occupations, wages, and advancement pathways.
Education and training providers are fragmented and competing	Organize firms to collectively inform and influence workforce development systems.

1. To meet overall industry demand, more young people and re-careering adults need to be exposed to, and then choose to pursue, careers in the semiconductor industry. It stands to reason that young people lack exposure to the industry given its geographic concentration and the highly controlled environment within semiconductor manufacturing facilities. While it is difficult to quantify a lack of industry exposure, assessments of high school students have found that aptitude levels are much higher than interest levels for advanced manufacturing and computer and technology careers. Industry leaders agree that there is a need to broaden the pipeline at the earliest stages and encourage more people to pursue careers in the semiconductor industry at multiple levels. This includes connecting them to training programs that have a demonstrated track record of placing graduates in jobs with family-sustaining wages and opportunities for upward mobility. In a crowded field of manufacturing training programs, people considering semiconductor careers need help determining which programs offer the most direct path into the industry.

2. To address shortages of skilled technicians, the industry needs more students and incumbent workers in the pipeline for these roles. In the U.S. overall from 2019 to 2021, about 56,000 students graduated per year in programs relevant to skilled technician roles (e.g., industrial production, electrical maintenance), but annual demand over the next 10 years is expected to be about 69,000 jobs. Nationwide, there is a gap of approximately 13,000 students annually. This may understate the gap from the perspective of companies, who reported in interviews that few training programs truly provide the necessary hands-on skills for trainees to step into these roles immediately. One implication is that upskilling incumbent operator-level workers (who earn roughly $35,000 to $43,000 in Austin) into technician-level roles (roughly $50,000 to $60,000 in Austin) may be a more productive approach than trying to fill those technician-level roles through new hires, but companies report that these internal pathways are not well-developed.

3. To meet engineering demand, universities need to ramp up and industry needs to formalize pathways that help technicians pursue continuing education and advance into engineering roles. Even more challenging than developing a pathway from entry-level operators to skilled technicians will be a pathway from skilled technician to engineer. The semiconductor industry is looking at a major workforce shortage among workers with bachelor's degrees and above - current projections are that there will be a shortage of 13,000 computer scientists and 27,000 engineers by 2030. The semiconductor industry has not looked to local or incumbent talent to fill these positions. In fact, about 40% of high-skilled workers in the U.S. semiconductor industry were not born in the United States. The number of American-born students in semiconductor-related graduate programs has stagnated at 90k per year since 1990. Meanwhile, the number of foreign-born students in these programs has tripled from 50k to 140k (as of 2018).

Ramping up existing university programs may not be enough. Four-year colleges and universities have not been as flexible and nimble at creating solutions and working with industry to address specific workforce gaps. Undergraduate programs often lack hands-on skills and direct connections to industry experience. As a result, of the students who graduate with STEM degrees, few enter STEM occupations, and even fewer enter the semiconductor industry.[4] At the same time, there is not an upskilling pathway developed from skilled technician to engineer within

4.Chipping Away: Assessing and Addressing the Labor Market Gap Facing the U.S. Semiconductor Industry (July 2023). Published by the Semiconductor Industry Association. Link.

companies or between education and training providers. The career advancement track that comes closest to delivering this pathway is an apprenticeship, but semiconductor companies have not fully embraced the apprenticeship model. Even if they were to embrace this model, it would be challenging to deliver at the scale needed. At the graduate level, universities need to develop more flexible training opportunities that are tightly linked with industry, developing industry-relevant PhD programs or MS programs that incorporate industry-sponsored research and advising.

4. To address high turnover among entry-level operator roles, pathways to advancement need to be more structured and supported. If the most difficult-to-fill technician roles require a few years of industry experience (one interviewee suggested that two to four years is realistic), then unfilled positions and high turnover among entry-level operator roles are a major impediment to a more consistent pipeline of technician talent. In 2023, 53% of workers in the industry reported being at least somewhat likely to leave their jobs in the next 3 to 6 months (an increase from 40% in 2021). The most cited reasons for this desire were lack of career development and advancement opportunities and lack of workplace flexibility, with inadequate compensation not far behind. (Notably, those who leave jobs in the manufacturing sector are somewhat more likely to leave the sector altogether than are people who leave jobs in other sectors.) The industry needs to attract (and retain) people from other industries (e.g., retail) to semiconductor jobs, but the wage premium for production jobs in the manufacturing sector is generally shrinking (the weekly pay premium for a worker in a non-manufacturing job moving to a production job is probably only in the range of $40, which workers may see as not worth the tradeoff in terms of workplace inflexibility). Indeed, despite very high average wages, a large share of the semiconductor industry's jobs are relatively low-wage: eight occupations representing nearly 60% of total semiconductor employment in Austin have 25th percentile wages at or below the region's living wage of $50,000. In addition to "voluntary" turnover, the semiconductor industry is highly cyclical, so even entry-level workers who might want to stay in those roles long enough to be eligible for upskilling to technician roles may be laid off before then. Companies shed thousands of employees in 2023 and 2024 but are expected to hire thousands more in the next year or two.

Given these dynamics of entry-level semiconductor jobs, workers entering the industry need to see clear and realistic pathways to advancement into more highly skilled (and highly paid) jobs. This will require education and workforce development institutions to deeply understand skill requirements for advancement within the industry and to build pathways accordingly, including providing a flexible schedule and other supports that enable entry-level workers to pursue upskilling opportunities.

5. Individual semiconductor firms have not clearly defined (or at least not shared with key regional collaborators) their hiring needs, the specific skills required for specific occupations and associated wages, and the internal advancement pathways. Economic and workforce development leaders in regions with new CHIPS-funded semiconductor investments appear to be operating with very little insight into those firms' precise workforce needs. Sub-bachelor's training programs range from two weeks to two years; community college websites for a two-week program in Arizona and a two-year program in Ohio both describe these programs

as providing access to jobs that pay about $60,000 per year. There is simply very little visibility into the occupational structure of the industry, what skills are needed to get in, and what a given increment of additional skills yields in terms of wages thereafter.

This challenge is due, in part, to weak outcome data collection and reporting. Education and training institutions lack longitudinal data systems to capture and share outcomes from their training programs, particularly non-credit workforce programs. Further, industry is reluctant to self-report data on hiring, wages, and advancement within their firms. As a result, decisions about which training programs to invest in or expand are made based on an incomplete understanding of their outcomes.

Compounding the challenge is the lack of clarity among semiconductor firms about their hiring needs and internal pathways. An interviewee from one semiconductor facility that has been in Austin for decades and who has been part of a major multinational firm for about 10 years – and might thus be expected to be very familiar with the Austin labor market and have advanced HR capabilities generally – said that when they hire new employees "there are no clear pathways for them; promotional opportunities are not clear." They said that while the pathways theoretically exist, "they are in very, very rough draft format" and likely a year or two away from being finalized.

Someone from this facility also described significant internal barriers to adopting a registered apprenticeship program for critical and hard-to-fill jobs (largely due to resistance to reporting demographic data to the Department of Labor) and noted that they are only able to informally share wage data in interactions with workforce development collaborators like community colleges. (The same is true in Columbus and Syracuse, according to interviews with economic and workforce development leaders there.)

One leader at a community college suggested that the college often is better able to characterize a firm's skill needs better than the firm itself. They said that having dealt with both HR and technical staff at semiconductor firms, "companies don't know what they want – we need to provide them with a skeleton proposal" for how to, for example, upskill technicians.

There is also significant variation in occupational structures and skill requirements across firms, which makes it difficult for workforce development partners to know where and how much to invest. For example, an interviewee from one Austin firm noted that one of the occupations most central to their workforce development challenges doesn't even exist at more automated firms (like Intel or TSMC).

The industry has gone through a few recent changes that make the above information gaps especially problematic. One is that firms have less internal training capacity than they did before 2008, so they are generally more reliant on external partners to provide training. Another is that a rapid rise in automation has significantly changed training needs, but these external partners have not yet developed the infrastructure to develop that training.

6. Both education and training providers and semiconductor firms face disincentives to collaborate. To summarize the underlying problems we have described so far: the semiconductor industry needs to hire many more people, including in some regions with very low unemployment rates as the labor force shrinks and becomes less mobile. But the industry has, by its own admission, largely failed to communicate its workforce and skills needs to external partners, even as it has become more dependent on these external partners to be responsive and nimble collaborators. It has not clearly defined pathways into middle-wage jobs for incumbent workers, nor created sub-bachelor's entry points into those middle-wage jobs (e.g., apprenticeships).

This situation may not be unusual relative to other tech and advanced manufacturing industries, but it may be especially problematic for the semiconductor industry given the lack of exposure to the industry, especially in regions with new fabs, and the fact that many firms will need to hire hundreds or thousands of workers at once in the coming months and years.

The industry would benefit from an effort to come together to more clearly and consistently define certain roles and the skills they require, outline potential mobility pathways, provide an aggregated forecast of demand for occupations more specific than "technician", and so forth. Such efforts are common in sector partnerships in other industries.

It appears, however, that by and large semiconductor firms have failed to overcome the individual disincentives to collaborate and share workforce information with one another, even if it would empower education and workforce development actors to be far more effective partners for them. The leader of an industry association noted that semiconductor companies see no benefit in working with each other, other than pointing to an individual training program and demanding that it reach a certain scale. The industry association is pushing firms to collaborate, rather than firms pushing the association to facilitate their collaboration. The fundamental issue is the same as in any other industry – firms are concerned that spending on training will not be recouped as other firms "poach" talent that they have invested in.

Austin's Approach

Austin's approach to semiconductor workforce development is best understood against this backdrop of both structural and strategic challenges. Austin has developed a training system that addresses structural workforce problems: broadening the workforce pipeline through the entry-level Advanced Manufacturing Production program followed by a series of incumbent worker training programs that move workers into skilled technician roles and developing new programs that bring more undergraduate students into the semiconductor industry. They have also addressed strategic challenges by facilitating a decade-long iterative process to work with companies to define skills needs, cultivate collaboration and trust between companies, and invest in a unified approach across training institutions and other nonprofit training partners.

An entire ecosystem of partners has been involved in building a talent pipeline for Austin's semiconductor industry. ACC has played a central role that extends beyond a traditional typical college. In addition to developing and delivering programs, ACC has served as a "systems builder," working to understand industry demand in collaboration with industry partners and coordinating a response from the full ecosystem of public and nonprofit partners.

Austin is making progress, but its approach is not yet comprehensive. A key challenge is the absence of a strong data tracking and reporting system, a common issue among community colleges. ACC is working to build a data infrastructure that integrates both noncredit and credit programs, capturing completion, placement, retention, and wage metrics. Until this system is fully developed, however, the college is limited in its ability to measure program impact. Employers are generally reluctant to share placement and wage data and the college lacks alternative mechanisms to track outcomes among program graduates.

Despite imperfect data, there are promising signs that suggest other regions can learn from Austin's approach:

- In 2024, ACC partnered with semiconductor companies to train 2,856 unique learners. Allowing for some duplication across programs, this includes 91 students in K-12 academy programs, 340 students in one-year certificate, associate and bachelor degree programs, 125 learners enrolled in rapid training for immediate employment within the industry, which is currently in a slow hiring period, and another 2,656 incumbent workers who are paid their full hourly wage while attending customized ACC classes (many of which are offered onsite and at unique hours to accommodate production schedules) that prepare them for internal promotion, career advancement, and fully articulate to ACC degree pathways.

- ACC has developed rapid, fully customized technician training programs in collaboration with multiple semiconductor companies. The clearest indicator of the program's value is the growing employer investment. Beyond the significant financial contribution companies are making to cover employee wages while in training, these partners are also starting to fund the training costs directly as a line item in their annual budgets. In 2024, industry partners contributed approximately $380,000 in ACC tuition costs. In at least one case, this includes flying an ACC instructor to another state every month and covering the tuition, travel, room and board costs associated. ACC's work with companies is now expanding beyond technician training to onboarding new engineers and creating career bridge programs such as material coordinator to manufacturing floor and semiconductor technician to production engineer.

  Through the alignment between non-credit and credit programs, ACC's training is embedded in local companies' internal employee development programs for career advancement. It also matriculates to a one-year college certification and as many as 22 credits toward one of two ACC Associate's Degrees in Advanced Manufacturing and a Bachelor's of Applied Technology in Engineering Technology. Over 150 students have made this transition to ACC degree programs in the last couple of years thus far.

Other aspects of Austin's semiconductor workforce strategy are still evolving. Critical gaps that remain include:

- A comprehensive K-12 outreach strategy. Meeting the semiconductor industry's workforce demands will require a comprehensive outreach strategy that engages students as early as middle and high school. ACC has begun developing a K-12 Academy model that extends beyond a single independent school district (ISD) partner with 91 total students in 2024, but these efforts are still in their early stages. To create a truly effective pipeline, ACC is focused on expanding this program with at least five neighboring school districts and deepening the program within each to strengthen K-12 engagement and ensure that career awareness.

- Robust internship program for semester-based academic programs. While training for entry-level and incumbent workers is highly integrated with semiconductor companies, there are few internships available for students in traditional academic programs who have not yet entered the semiconductor workforce. Industry leaders have consistently emphasized the need for graduates with stronger hands-on skills that can only be developed through work-based learning. To meet this demand, Austin needs to expand and formalize internship programs among semester-based academic programs, ensuring that more students in academic pathways gain the experience needed to transition successfully into the semiconductor workforce.

- More formalized advancement structures within companies including developing and expanding apprenticeships. While ACC's customized upskilling programs have created structured pathways for workers to enter and progress within the industry, firms need to take further steps to institutionalize these pathways internally. Companies are working toward defining career progression among occupations and formalizing pathways through apprenticeships—both registered and unregistered—but many of these efforts are in the early stages of development. Establishing clear, structured career pathways at scale is critical to attracting talent, promoting worker mobility, and improving retention.

Addressing these and other ongoing challenges will require ACC and its regional partners to deepen their commitment to the strategies that have driven their successes thus far. Through interviews with ACC, semiconductor companies, and other key stakeholders, we identified five critical elements that have been foundational to Austin's progress:

- Innovative community college leadership and staff with deep industry experience.
- State funding for training allowed for experimentation and required accountability and outcomes reporting from participating companies.
- A strategic shift within the community college away from a static, workforce program-driven orientation to a dynamic, demand-driven relationship with industry.
- A bridge between the credit and non-credit sides of the community college to build multiple programs that create easy-to-navigate pathways.
- A credible, effective industry association convening companies to scale training across multiple companies.

A more in-depth look at these success factors follows an overview of the partners and programs that are foundational to Austin's approach to semiconductor workforce development.

Austin's Approach: The Partners and Programs

The semiconductor industry has deep roots in the Austin region going back to the presence of Sematech, a public-private semiconductor consortium, in the 1980s. Between 2007 and 2012, Sematech moved the majority of its operations from Austin, Texas, to Albany, New York. But Austin still had a strong semiconductor industry presence with several mature firms and major fabs including NXP, Samsung, Tokyo Electron, Applied Materials, and Infineon. During the 2008 downturn, semiconductor companies cut back on funding for internal training and did not make significant investments in upskilling workers. At the same time, semiconductor manufacturers increased the use of automation and other advanced technologies. This resulted in a training gap: more advanced training was needed, but there was no longer a robust internal training program to provide it. A coalition of partners aligned over time to respond to this gap including ACC, Workforce Solutions Capital Area, Austin Regional Manufacturers Association, and University of Texas at Austin, and the Texas Institute for Electronics.

Customized Training: Austin Community College and Upskill Now

The first step in responding to semiconductor workforce gaps was ACC's work with individual companies to build customized, non-credit training focused on upskilling full-time employees, which resulted in the program Upskill Now. This program was based on a significant amount of work to proactively map the skills requirements of operator and technician positions and to understand industry gaps and pain points.

The work started in 2014 when ACC used the Texas Skills Development Fund (SDF) to develop customized training for Samsung. The SDF has provided more than $8 million to date, including $5.09 million for Samsung supporting over 4,000 workers, which both directly funded community college training and equipment and incentivized companies to directly engage in designing and delivering training that aligned with their workforce needs. These grant funds also required that companies report job placement and wage outcome data post-completion. Dr. Laura Marmolejo, currently Dean of Advanced Manufacturing at ACC, and other ACC staff worked on-site at Samsung Austin Semiconductor (Samsung) to extensively document roles, processes, and equipment. ACC analyzed training needs on-site, then presented Samsung with a proposal for how ACC could provide training to upskill employees with an initial $2 million in funding from the state. According to Dr. Marmolejo, it took a year of intensive work with Samsung to build a program based on their needs. During this time, ACC was not just building a program; it was building a relationship with Samsung. With subsequent rounds of funding from the state, ACC took the customized courses to more semiconductor companies, including Applied Materials and NXP, while continuing to innovate, build on the approach, and gain the trust of the individual companies. ACC found that the majority of the customized training curriculum was transferable between companies, and this in-depth work is currently the foundation for all of their collaboration with semiconductor companies.

ACC now refers to its suite of upskilling training programs as Core Automation and Semiconductor Training, or CAST. Today, CAST offers four different series consisting of short, 8- or 16-hour courses, mostly held on-site at semiconductor companies during off hours. Students are paid their hourly wage during their time in training and courses are also offered as open enrollment so that any worker can enroll directly rather than waiting to be selected by their employer.

ACC's experience developing CAST programs was foundational in understanding the industry's workforce needs and gaining experience developing responsive, nimble programming. Building from this foundation, the college has since worked with other regional partners to build out a three-part stackable pathway, beginning at the entry-level to help students get hired (AMP) and ending with a capstone training to prepare workers for skilled technician roles (STARS).

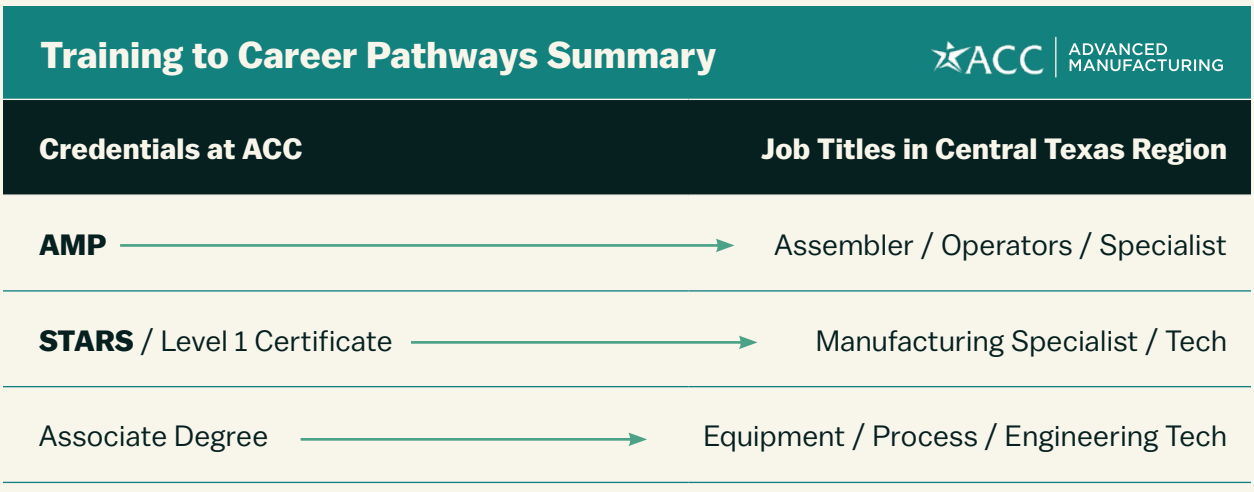

Figure 1 This graphic describes the generic pathway across multiple semiconductor companies; actual pathways vary across firms and involve more job titles.

Notes: Programs in **BOLD** are non-credit; pathways and job titles reflect a summary of those found within various regional industry partners such as Applied Materials, NXP, and Infineon

Broadening the Pipeline: Workforce Solutions Capital Area and the Certified Production Technician Program (CPT)

After five years focused on developing upskilling programs with semiconductor companies, ACC worked with regional partners—including the regional workforce board, and Workforce Solutions Capital Area—to create a new program focused on the front end of the talent pipeline. The Certified Production Technician (CPT) program focuses on providing the minimum training needed for entry-level positions and broadening the pipeline of people entering semiconductor jobs. The program was developed in collaboration with semiconductor companies, facilitated by Workforce Solutions Capital Area and the Austin Regional Manufacturers Association (ARMA), with Samsung playing a strong leadership role. The program provides foundational training in the manufacturing sector in general—not specific to semiconductors—which allows graduates to work in a variety of manufacturing facilities during times when semiconductor hiring is low. In 2024, ACC refined the CPT program into the new Advanced Manufacturing Program (AMP), a month-long program that prepares people who have no work experience in the semiconductor industry for entry-level positions including assemblers, operators, and specialists. It includes 170 hours of lessons and six applied labs.

After one year of on-the-job experience, which includes continued training with CAST upskilling courses, AMP graduates can either stay in their entry-level positions and continue earning work experience for up to four years before progressing to a manufacturing technician, or they can participate in ACC's Semiconductor Technician Advanced Rapid Start (STARS) program to accelerate that shift, which is described in the next section. The original CPT program is now growing regionally, being offered by several training providers outside of ACC including the nonprofit SkillPoint Alliance and the regional campus of the Texas State Technical College System.

Most of ACC's AMP graduates are placed in jobs or continue on a training pathway. ACC receives frequent feedback from industry on the program, including regular requests from employers to meet with their students. Through a national partnership with America's Frontier Fund and Merit America, ACC is now developing an AMP program that can be offered in other regions across the country.

Rapid Skills Acceleration: The Semiconductor Technician Advanced Rapid Start Program (STARS) and Austin Regional Manufacturing Association

As ACC continued to work with semiconductor companies in the region, they identified a significant training gap for skilled manufacturing technicians. Through its work to develop customized training programs led by Dr. Laura Marmolejo, ACC surfaced common needs across companies that would be best addressed with a collective, industry-wide solution. ACC worked with the Austin Regional Manufacturers Association (ARMA) to bring five major semiconductor companies together to coalesce around these common needs and create a joint, expedited training program designed to meet industry needs for skilled technicians.

ARMA became a forum for understanding industry demand for hiring and skills – a trusted entity that gained insight not from static labor market data alone, but primarily from dynamic interaction with industry partners. With this collaboration in place, ACC and ARMA worked with Samsung, NXP, Tokyo Electron, Infineon, and Applied Materials to create the Semiconductor Technician Advanced Rapid Start (STARS) program.

The STARS program compresses and rapidly accelerates the pathway for incumbent workers to advance from an entry-level assembler or operator (a position that caps at approximately $52,000 as of 2023[5]) to a manufacturing technician (which caps at approximately $65,000). Before the creation of STARS, moving along this pathway required either a two-year associate degree or as many as four years of on-the-job experience. In contrast, the STARS program is a month-long, 40-hour-a-week capstone training. Before starting the program, participants are encouraged to first complete CAST courses and work in the fab for six to twelve months. Participating companies pay the employee's salary for the duration of the STARS program. At the end of the first month-long STARS pilot, the success of the program was clear – the participants were promoted to technician positions, a progression that typically takes four years.

ACC has developed a seamless path of training that responds to industry demand, furthers individuals along their career paths to positions with higher wages, and bridges the credit and non-credit sides of the college. The next step in developing a fully integrated pipeline is underway now: developing an upskilling pathway between the programs offered at ACC (including non-credit pathways, a certificate program, an associate's degree program, and an applied bachelor's program) and university undergraduate programs for engineers and related STEM fields.

Developing an Engineering Upskilling Pathway: University of Texas at Austin and the Texas Institute for Electronics

The University of Texas at Austin has a long history of research and coursework that supports the semiconductor industry, much of which was developed during Sematech's presence in the region over thirty years ago. More recently, Texas launched the Texas Institute for Electronics (TIE) at UT Austin in 2022 to renovate the Sematech campus and to support a consortium of state and local government, preeminent defense electronics and semiconductor companies, and national labs and academic institutions. The consortium, which includes more than twenty industry partners (regional and national), has four focus areas: a technology roadmap to guide R&D efforts, comprehensive workforce development, a pilot manufacturing fab, and technology transfer. TIE's workforce development goal is to create seamless and coordinated education pathways between universities, community colleges, and other regional partners to address every skill set on the semiconductor workforce continuum.

To address the projected shortage of engineers, UT Austin is also developing new programs that will bring more students into the field – an undergraduate minor, a graduate certificate, and a master's of science in engineering. These programs will be open to students in STEM majors in addition to engineering students.
One major step toward seamless education pathways involves a joint training center led by TIE and ACC that will include training for the full semiconductor career ladder with seamless stackable credentials. The goal is to have aligned pathways between UT and ACC, starting with improved transfer alignment and eventually expanding to full co-enrollment opportunities. The joint training center would also offer bootcamps for engineers to build hands-on skills needed in the fab.

5. Based on unpublished research conducted by Education Equity Solutions.

Austin's Approach: Five Critical Success Factors

The programs described above stand out for their customization to industry needs and comprehensiveness in facilitating entry into and mobility within the industry. They are also uniquely integrated–bridging for-credit and non-credit programs within ACC and extending to other workforce training partners and academic institutions within the region. While there are still significant gaps in the region's strategy, the cohesiveness of Austin's approach offers potential as a model of workforce development that is both responsive to industry needs and scalable.

This model did not develop overnight: it is the product of more than a decade of sustained collaboration, experimentation, and innovation among forward-thinking workforce development leaders, academic institutions, and committed employers. The foundational elements that have been the driving force behind Austin's success to date include:

1. Innovative community college leadership and staff with deep industry experience.
When it comes to developing a talent pipeline, ACC learned that companies are not looking for a "partner" but a "peer" who understands the nuances of what is required of different positions and who can offer proactive solutions. ACC's program leads had industry knowledge gained from careers in semiconductor manufacturing. (By the end of 2024, ACC's training team has grown to over 40 former engineers, all with previous industry experience, working as part-time or full-time instructors). The program leads knew enough to navigate internal contacts at the company, speak to the right technical staff to understand job requirements and skills gaps, find the decision-makers who knew what the company would pay for, and develop relationships with hiring managers who needed help filling positions. Through this insider knowledge, program leads were able to connect the dots between what companies need and what the community college can offer.

ACC also plays a major coordination role, both internally between the credit and non-credit sides of the college and externally with companies. This level of relationship- and trust-building with companies is time-intensive and requires a dedicated team. ACC has transformed how it works with semiconductor companies in the region. ACC's chancellor devoted internal resources through the Office of Strategic Initiatives to ensure the college was proactive in its work with companies and able to overcome internal barriers to developing responsive solutions. The goal has been to develop a culture of adaptability and flexibility, responding to industry needs with, "Why can't we?" instead of, "No, we don't do that."

2. State funding for training allowed for experimentation and required accountability and outcomes reporting from participating companies.
Semiconductor companies understood the value of collaborating with community colleges on training due in part to the availability of state funding for training subsidized by the Texas Skills Development Fund. The Texas Skills Development Fund allowed ACC to approach semiconductor companies and offer free training, giving them valuable opportunities to build relationships with and better understand the workforce needs of these companies. The funding also helped ACC to purchase some of the equipment it needed for its new programs.

The funding allowed for experimentation, but it also held ACC and the semiconductor companies accountable; they had to report back to the State of Texas on who found employment and what their wages were upon completion of the training. To continue receiving funds, a certain percentage of employees had to be working in the job for which they were trained.

Over time, companies were convinced of the value of the training and were willing to pay for it themselves when the grants ended. When the STARS program was created, they were willing to pay for both the training and the wages of the full-time program participants.

3. A strategic shift within the community college away from a static, workforce program-driven orientation to a dynamic, demand-driven relationship with industry.
A dynamic, demand-driven relationship with industry is not just about responding to sporadic input from industry but, instead, proactively collaborating with industry to build a talent pipeline. As a result of over ten years of work with multiple semiconductor companies, ACC understands talent needs in the manufacturing industry deeply and thoroughly enough to build out an entire pathway of programs. This involved partnering with other talent providers like UT Austin and compressing and accelerating training for the most in-demand positions.

ACC worked with a group of companies – first, individually on customized training, then collectively in partnership with ARMA to develop joint programs. This gave ACC the level of ongoing input from industry needed to continue to innovate and refine their programs and strategies. If one company's interest in building out demand-driven talent strategies diminished, ACC would continue the work by engaging other companies

While it is tempting to refer to the behavior of "the industry" or of specific companies, ACC's experience suggests that companies should not be thought of as having a clear, centralized policy related to training and advancement. Instead, there are generally individuals within these companies that have significant leeway to shape strategy, but it is not always easy to identify these individuals. Their roles are not always clearly defined and they may not themselves recognize their potential to assume this level of responsibility. ACC's history with this type of training in general, and with key semiconductor companies in particular, enabled it to seek out the right individuals to serve as internal champions (i.e., individuals who were close enough to hiring/training processes to have the requisite insight, but also close enough to executive management to have the requisite influence)

And while the work began with individual companies, it has evolved to a sector-wide approach to talent development with ARMA playing an important role as convener. Companies are now in touch with one another to define shared talent needs and work together to design pathways made up of multiple programs. The exact framework for collective, demand-side work is not as important as the focus on building relationships and doing the deep and dynamic work of understanding industry demand.

4. Bridging the credit and non-credit sides of the community college to build multiple programs that create easy-to-navigate pathways.
The Austin Regional Manufacturers Association (ARMA) served as a neutral platform for semiconductor companies to come together, despite competitive dynamics, to define and jointly solve shared workforce needs. ARMA describes itself as "a third party and project manager," leveraging the trust it has built over years with manufacturing companies to facilitate collaborative solutions that benefit the industry as a whole. As a trusted, neutral convener, ARMA was able to convene all of the major semiconductor companies to jointly design and support training programs that met common needs. By identifying commonalities across companies, ARMA helped encourage companies to develop collaborative solutions to achieve greater scale than would otherwise be possible.

This convening role is now expanding to include the Texas Institute for Electronics (TIE) at UT. As the recipient of the Next-Generation Microelectronics Manufacturing $840 million grant through the Defense Advanced Research Projects Agency (DARPA), TIE is partnering with ARMA to expand Central Texas' semiconductor convening role both regionally and nationally through its new consortium of industry partners.

What's Needed Next: Priorities for Strengthening Austin's Approach

Austin has laid a foundation for a comprehensive workforce development approach: deep, sustained employer partnerships and a commitment to responsive, integrated solutions that span internal silos and institutions. Building on this foundation, the region is ready to expand both the breadth and depth of programs along the workforce continuum, from career awareness at K-12 levels into pathways that span production, technician, engineering, and scientist roles.

Some of this work is in progress, but much is in the very early stages of development. To achieve the hiring scale needed, Austin will need to double down on four major strategies:

- **Building out a robust outcome and data tracking system.** Without a mechanism to consistently track outcomes among program graduates (completion, placement, wages, and retention), ACC and other partners rely on incomplete measures of programmatic success to make strategic decisions. This makes it difficult to test assumptions that are key to program design. For example, do graduates of the month-long STARS program consistently earn wages equivalent to four years of work experience in the fab, as has been anecdotally reported? How much is the wage premium for entry-level employees who have completed the AMP program as compared with those who enter the industry directly with no prior training?

  Outcome data is also needed to bolster the case for pursuing careers in the semiconductor industry. Meeting workforce demand will require attracting several thousand new workers to the semiconductor industry. Students and job seekers need to know what economic returns they can expect from pursuing various training pathways and need help determining which programs offer the most direct point of entry into good jobs.

ACC is currently building out much of the data infrastructure needed to answer these questions. It plans to build a data system that integrates both credit and noncredit programs, something many colleges do not have. This will be an important step toward gaining full transparency into the successes and limitations of the region's strategies to date.

- **Expanding K-12 outreach and engagement.** To meet hiring demand, the industry will need to engage in significant career awareness and recruitment efforts starting at middle and high school levels. Sparking interest in semiconductor careers is not sufficient on its own; students also need help navigating the array of training programs offered in the region to find the pathway most likely to yield an economic return. ACC has started to develop a K-12 Academy model with the potential to extend beyond a single ISD, but this program is in the early stages of development. The region will need to pursue a comprehensive, coordinated K-12 engagement strategy that is tightly linked to postsecondary institutions to support more students in pursuing and succeeding in semiconductor careers.

- **Expanding work-based learning and apprenticeship models.** Much of ACC's success in developing entry-level and incumbent worker training stems from its close partnerships with industry which actively shape programs and embed relevant training and experiences. Semester-based academic programs, however, still offer few internships for students to gain applied experience within the industry. Integrating internships and other work-based learning opportunities across the training continuum is an essential part of preparing students for the workforce. This will require deeper commitment from industry partners as well as training providers to build and scale work-based learning for these semester-based programs

- **Clarifying and formalizing pathways to advancement within the industry including alternate pathways into bachelor's-level jobs.** Facilitating economic mobility within the semiconductor industry will require a finely tuned understanding of specific skill requirements at each level of the workforce as well as a carefully structured and supported set of training pathways that facilitate worker advancement. While ACC has made significant progress in this arena, semiconductor firms are relatively early in the process of defining their internal pathways, clarifying skills needed at each level, and defining minimum training requirements with precision. This complicates the task of fine-tuning career pathway programming. Further, while ACC has developed an impressive set of stackable programs, more needs to be done to ensure that workers have the support they need to pursue these programs and credentials, balancing continued training with long work hours.

  The biggest opportunity—and challenge—in facilitating advancement within the industry is building alternate pathways into bachelor's level engineering and scientist roles. This is a heavy lift; it will require significant flexibility and commitment among both companies and educational institutions to re-think pathways that integrate industry-relevant experiences with academic training. No region across the country has yet developed a model for facilitating the technician-to-engineer transition but, given the close partnership between UT and ACC, Austin is already exploring options with other national partners and may be able to pave new ground.

The Urgent Need for a Cross-Regional Action Network

Regions across the country are responding to the challenge of providing a prepared semiconductor workforce, some at a larger scale than Austin and in a shorter time frame. If the country is to achieve its economic and national security ambitions, there needs to be a mechanism that enables regions to collectively move more quickly through the learning cycle. Austin developed its current strategy through ten years of progressively deepening partnerships with firms; other regions need to make a similar amount of progress, at a greater scale, within just one to five years.

Interviews with key players in the regions with a major semiconductor industry presence reveal a readiness to work across regions to engage the semiconductor industry more deeply and effectively. **A cross-regional network needs to move beyond a learning agenda (i.e., sharing individual programs that have been successful in one region) to an action agenda that includes a commitment to shared problem-solving and a willingness to jointly tackle the deeper, strategic issues.**

The cyclical nature of the industry and the fact that many regions will only have one to three dominant firms/facilities means that this work needs to be aggregated at the national scale to persist when hiring slows in one region or another. Incentives of regional actors and companies can inhibit learning (e.g., there is an incentive to overstate capacity). Furthermore, since only one or two companies dominate most regions with active semiconductor industries, there are few opportunities for true industry-wide experimentation. A national learning network can address both issues, creating a "safe space" for practitioners to dig into open questions, identify sticking points, and experiment together. This network will need to encourage discussions of failure (versus yet another forum to showcase successes only). By aggregating workforce challenges across regions, a national network could have an important role to play in signaling which of these challenges require greater attention (or coordinated attention) from semiconductor firms and bringing these firms together to address shared challenges.

A starting point for a cross-regional action agenda would include:

- **Developing a consistent, rigorous, and rapidly deployed process to help industry identify their skills needs with precision, both within and across companies.** Education and training providers need in-depth and accurate information on the real labor market needs of semiconductor firms. However since firms themselves often lack a full understanding of their own hiring needs and advancement pathways, traditional methods of gathering information like surveys, focus groups, and advisory committees are not sufficient to gain needed insights. Firms and workforce training partners need a process by which they can work together to clarify skill requirements and advancement pathways, working from straw models and testing assumptions with real data. This process needs to apply both within individual firms and across the industry overall, using the support of trusted, credible conveners to bring companies together.

- **Defining points of entry into the industry that are most likely to lead to economic mobility. Not all jobs in the semiconductor industry offer the same opportunities in terms of earnings or upward mobility.** If a goal of workforce development is to promote economic mobility, education, and training partners need to identify and focus on the roles that provide the greatest potential for advancement and work to ensure that pathways into those roles are accessible to all.[6] This requires establishing a clear definition of what a "quality job" looks like in terms of wages and working conditions and creating accessible pathways that lead to these roles as directly as possible.

- **Designing pathways that deliver upward economic mobility.** Regions need a forum to collaborate in mapping out pathways to advancement within the industry and designing training approaches at each level to maximize opportunities for advancement. This includes identifying and addressing barriers that prevent students and workers from accessing and succeeding in training programs and pathways. Important questions include:

  Entry-Level: What are the wages, working conditions, and pathways to mobility for entry-level operators? How might we work with companies to improve these entry-level roles and ensure training requirements are commensurate with wages? What are the most efficient/effective training models for these roles?

  Entry-Level to Technician Pathways: What are the pathways to advancement into technician roles? How much experience is required? What combination of work-based learning and classroom training can prepare someone for these roles? What is the most efficient and effective pathway? How do we expand access to these pathways?

  Production to Engineer: What are realistic alternate pathways into bachelor's level jobs? How do we expand access to these pathways? Where are regions experimenting? What are they learning?

  Transitions from other fields or military: How can training providers support re-training for individuals with bachelor's degrees in other disciplines into semiconductor roles? How can the pathway for transitioning veterans be structured to build on military experience?

- **Identifying 'shortcuts' for community colleges to bridge credit and non-credit programs to facilitate student and worker advancement.** Are there ways for colleges to more effectively bridge the non-credit/credit divide to facilitate worker and student advancement? What works in building pathways that span for-credit and non-credit?

- **Mapping and building out the best opportunities for workers to obtain skills and credentials that enable cross-sector mobility to weather the cyclical downturns that are part of the semiconductor industry.** Given the cyclical nature of the semiconductor industry, what training approaches and strategies equip workers with the skills needed to succeed in other manufacturing sectors beyond semiconductors? Answering this question will not only support workers in navigating downturns but will also put pressure on the industry to improve job quality to compete with other manufacturing sectors for skilled workers.

  Regions are actively grappling with these challenges as they design and implement semiconductor workforce strategies and are eager to uncover "what works" from their peers. There are also challenges that no region has yet solved—for example, helping technicians make the leap into engineering roles. A national learning network would help all CHIPS regions collectively work through these problems and develop innovative solutions together.

  Funding for the creation of such a network exists through the NSTC Workforce Center of Excellence and the National Network for Microelectronics Education. With the right regional players involved and the right areas of focus, this network could play a powerful role in shifting from experimentation and trial and error to rapid acceleration of effective practices across semiconductor hubs.