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PERSPECTIVE

Semiconductor Manufacturing Business Revisited: Good Old Days at AT&T Bell Labs Microelectronics Plant in Orlando, Florida

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ABSTRACT If there were ever a time to bring the people back to the AT&T Bell Labs Microelectronics plant in Orlando, Florida, it would be now. The big reset in U.S. domestic semiconductor manufacturing, exacerbated by the CHIPS Act of 2022 to reestablish semiconductor fabricators (known as fabs), is vulnerable to constraints in the global supply chain that remain from the COVID-19 pandemic. Considering the semiconductor manufacturing fabs paradox to recall onshore manufacturing from the golden days of globalization, this study focuses on the people and community impacted at the Orlando plant by offering a unique perspective for future fabs to reflect upon, rather than repeat the same mistakes of the past (i.e., layoffs, plant closings, overseas technology transfer, and abandoned education partners and communities). Rather than elucidating the complexity of companies' business decisions to offshore fab operations or shuttering plants, this study reminisces regarding the ''good old days'' at the AT&T Microelectronics plant in Orlando, Florida (renamed Lucent Technologies Microelectronics, Cirent Semiconductor, and Agere Systems) in conjunction with the enormous challenges fabs face today to coexist with our planet for a sustainable business strategy to positively benefit people, the planet, and profit. This retrospective examination reveals insights from the people who worked at the most advanced semiconductor fab in the U.S. Led by Bell Labs' highly competent leadership team and technical staff, the fab developed leading-edge technology, created economic wealth, instilled an organizational culture of intellectual human value, and established university partnerships for a high-skilled workforce.

INDEX TERMS Agere Systems, AT&T Bell Labs, CHIPS Act, Cirent Semiconductor, layoffs, Lucent Technologies, microelectronics, Orlando plant, people, semiconductor manufacturing.

I. INTRODUCTION

A recipe for success in bringing back the golden days of Bell Labs is well understood, but whether it could be recreated in today's world is a different story [1]. Arguably, if there ever were a time to bring back employees to the AT&T Bell Labs Microelectronics plant in Orlando, Florida, it would be now. Those reading the headlines about the 2022 CHIPS Act might have industrial amnesia, not recalling past decisions by companies that left the semiconductor businesses with massive layoffs and plant closings to maximize shareholder value, raise stock prices, and enhance executive compensation incentives. A wealth of empirical evidence on the effects of layoffs, downsizing, rightsizing, cost-restructuring, and reengineering on plant closings suggests that these were corporate survival strategies and common business practices. Rather than elucidating the complexity of companies' business decisions to offshore fab operations or shutter plants, this article reflects on the ''good old days'' of the people employed at the AT&T Microelectronics plant in Orlando,

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Florida (renamed as Lucent Technologies Microelectronics, Cirent Semiconductor, and Agere System) with enormous challenges the semiconductor industry faces today. This retrospective review provides insights from the operators, scientists, engineers, and executives who worked in the Orlando plant by examining historical archives, excerpts from the cultural transformation project, artifacts, and the personal memories of the author, a former member of the technical staff, MTS. In lieu of the semiconductor manufacturing fab paradox outlined, which was exacerbated by news of the CHIPS Act, this article focuses on the people and community impacted at the Orlando plant. This revived perspective is input for reflection by future fab engineers, scientists, managers, and executives to not repeat the same mistakes of the past, such as layoffs, plant closings, overseas technology transfer, and abandoned education partners and communities.

We offer readers four controversial topics in exploring answers to the following questions:

1. Will people's value continue to be lost in this historically layoff-prone business practice?
2. How will new managerialism change for the semiconductor executives who take advantage of the CHIPS Act incentives to build semiconductor fabricators (fabs)?
3. Will artificial intelligence (AI) techniques reverse management decisions to offshore semiconductor manufacturing?
4. What empirical evidence supports the change toward a sustainable business strategy?

II. TECHNO-GEOPOLITICAL UNCERTAINTY

The boom-or-bust semiconductor industry has been susceptible to drought cycles due to low demand for chips brought about by many economic-centric business decisions resulting in plant closings in the U.S. over the years. The uncertainty of the semiconductor manufacturing business was revitalized with the CHIPS Act of 2022, which infused nearly a billion dollars into the U.S. semiconductor industry. Similarly, the European Commission approved its own European CHIPS Act, which entered into force on September 21, 2023, with an approved construction of a €292.5 million semiconductor plant in Catania, Sicily [2]. Growing techno-geopolitical uncertainty affects international business (IB) in several ways, calling for more scholarly attention to its causes [3] (p.1423). Present-day engineering managers are confronted with balancing a more complex and unpredictable world, reaching beyond classroom training and new software application capabilities. Engineering management in manufacturing tends to focus on the effective and efficient deployment of operational technologies and operational management [4] and has historically focused on integrating scientific, engineering, and management knowledge to contribute effectively to organizational and industrial functioning [5]. Today, scholars advocate AI techniques to improve performance and ensure higher efficiency, often relying on data-driven algorithms and modeling architecture and frameworks [6], [7]. Similarly, designing high-performance systems requires fast, dense, and high-bandwidth interconnects using copper (Cu) with a low-interlayer dielectric material. Examples include advances in the conductance of doped carbon nanotubes (CNTs), which provide up to 50% of resistance reduction, which is a milestone for future CNT interconnect technology [8] or scaling semiconductor devices into the deep sub-micrometer regime necessitating the advancement of methods to cope with metrology requirements by dopant mapping using secondary electrons (SEs) in a scanning helium ion microscope (SHIM) [9]. Hence, the state of technology has changed enormously over the last 25 years and the financial investment requirements to build semiconductor manufacturing facilities remain extremely high. People have always been the lifeblood of many companies [10] (p.72), despite being the first to be laid off during economic uncertainty in semiconductor manufacturing. Many view business-as-usual theme of cutting employees as an acceptable practice, an argument made by mainstream practitioners. They argue that people are replaceable stakeholders in any business; however, some organizations are successful at managing employees through difficult times rather than considering them as mere objects to be discarded. People's work creates value, which manifests throughout a business, and managers often define the heart and soul of an organization through their leadership [11], establishing the workplace environment and organizational culture through example.

The managerial focus on the economic value of business driven by profit maximization has been featured in a considerable quantity of academic literature [12]. Some of the most downloaded articles from *IEEE Transactions on Engineering Management,*counting among the top 10 lessons for managers concern effective communication [13]. It is important to effectively communicate the need for change and include employees, in addition to team members, to participate in the change [14]. Notably, the workers' voices have reemerged in recent global events, as labor activists call for profound change targeted at a better living wage. These global social movements have elevated the importance of social value in corporate governance; many leading scholars have attempted to influence change in management practices, such as Pfeffer's book *Dying for a Paycheck* [15], Cappelli's article *How Financial Accounting Screws Up HR* [16], and Mintzberg's book *Rebalancing Society* [17], to cite a few advocates for change. Past corporate and government economic decisions and policies have been re-exposed by the push to reestablish the U.S. domestic semiconductor market. U.S. shares of global semiconductor manufacturing decreased from 37% in 1990 to 12% in 2021 [18] as offshoring became the gold standard of business practices to outsourcing manufacturing overseas. The implosion of unions from the Industrial Revolution glory days has continued downward over several decades in the U.S. manufacturing sector. Union membership has declined steadily since 1983 [19]. By contrast, Taiwan has the world's largest supply chains of integrated

circuit (IC) industry, which has had a profound influence on the global market. Semiconductor manufacturers face a more competitive market with small quantities of many products and require hundreds of processes for production [20]. Texas, Arizona, and Ohio are among the U.S. states positioned to expand semiconductor manufacturing to decouple national security concerns from the IC supply chain. The CHIPS Act of 2022 signifies a move toward geopolitical techno-nationalism in American IB policy and its economic rivalry with China [3].

In the next section, we offer empirical evidence on the interrelated dichotomy between capitalist economies (profitability, growth, and increased production) and societal pressure toward other forms of economies related to environmental sustainability models, both of which are highly contentious worldwide in the post-COVID-19 era.

III. EMPIRICAL EVIDENCE

A. A WEALTH OF EMPIRICAL EVIDENCE

Although research has demonstrated that layoffs have long-term detrimental effects on individuals and companies [21], corporate leaders and managers continue to utilize layoffs for short-term cost savings—despite evidence against such management practices [22]. Scholars have many motivations for empirically studying job displacement. There is a genuine interest in the economic difficulties that workers face when they have been employed on a sustained basis and lose their jobs owing to something beyond their control, such as large-scale layoff or plant closure [23]. Work in the 1990s focused on analytical techniques with the important methodological advancements in the context of job displacement (mass layoffs). For example, displaced worker earning loss estimates were calculated using methods postulated by Jacobson, LaLonde, and Sullivan [23] (p.693). The data covered a period of high unemployment in the heavily industrialized state of Pennsylvania characterized by disproportionate job losses in manufacturing. The first estimation used equation 1:

$$y_{it} = \alpha_i + \gamma_t + x_{it}\beta + \sum_{k \geq -m} D_{it}^{k}\delta_k + \varepsilon_{it} \qquad (1)$$

where,

Symbol	Description
y_{it}	Earnings of displaced worker i at time t;
α_{it}	Individual fixed effects;
γ_t	Microeconomic factors;
x_{it}	Time-varying vector of the worker;
β	Probability distribution of random variables;
D^k	Quarters prior to separation;
D_{it}	Dummy variable of displaced worker;
k	Indexes a set of dummy variables;
m	Event of worker displacement;
δ_k	Captures the impact of displacement;
ε_{it}	Stochastic error term

[23] (p.692-695).

With a severe drop in traffic, airline capacity cuts resulting from the COVID-19 pandemic mimicked the historical antecedent conditions and consequences of job displacement and plant closings. Airlines experienced a high level of cash burn during this unprecedented period. However, to ensure its survival, after a 50-year history without layoffs, Southwest Airlines used pay cuts, voluntary employee separations, and early retirement incentives to avoid layoffs or furloughs. Southwest took the opposite business approach by valuing its employees. Executives at no-layoff companies have argued that maintaining their ranks even in terrible times generates fierce loyalty, higher productivity, and the innovation required to enable them to snap back once the economy recovers [24].

Today, the semiconductor industry faces enormous challenges to coexist with our planet for a sustainable business strategy that emphasizes the triple bottom line of people, profit, and planet to transform capitalism. This transformation has been elusive to a substantial extent since it was postulated by Elkington over 25 years ago [25]. Sustainability is increasingly important for industry and academia, and efforts are being made to address this topic as holistically as possible [26]. Energy, water, rare earth metals, rare gases, power-grid outages, geopolitical conflicts, political wars, global pandemics, and the impact of increasing fires, floods, droughts, and other natural disasters are among the interrupters in the supply of chip production. Rebalancing the semiconductor industry to reduce its contribution to the climate crisis (energy, water, and hazardous waste) requires enormous changes to realign the industry worldwide.

Increased labor strikes in Europe and South Korea are among the growing movements for socioeconomic justice motivated by common causes worldwide (poor work conditions, salary disparity, inequality, fairness, dignity, and related concerns). The value of people continues to be lost as historical slash-and-burn business practices to improve the financial position in highly volatile sectors. People want their work to have value and to feel their work is meaningful for the company [27]. This requires replacing slash-and-burn capitalism with sustainable capitalism, which provides the economic and political infrastructure needed to support a healthy economy [28]. To honor the dignity of business participants and create collective value, scholars advocate a world where corporations exert self-control in the realm of market competition, social movements, and government oversight [29]. An interrelated dichotomy between capitalist economies (profitability, growth, and increased production) and societal pressure toward forms of environmental capitalism and other sustainable models are highly contentious considering the post-COVID-19 across the globe. In the capitalist model, people are considered expendable rather than being treated as assets, with employee benefits (holiday time, sick time, and health care) treated as liabilities. This counts among the root causes related to how financial accounting neglects consideration of human capital. U.S. companies now

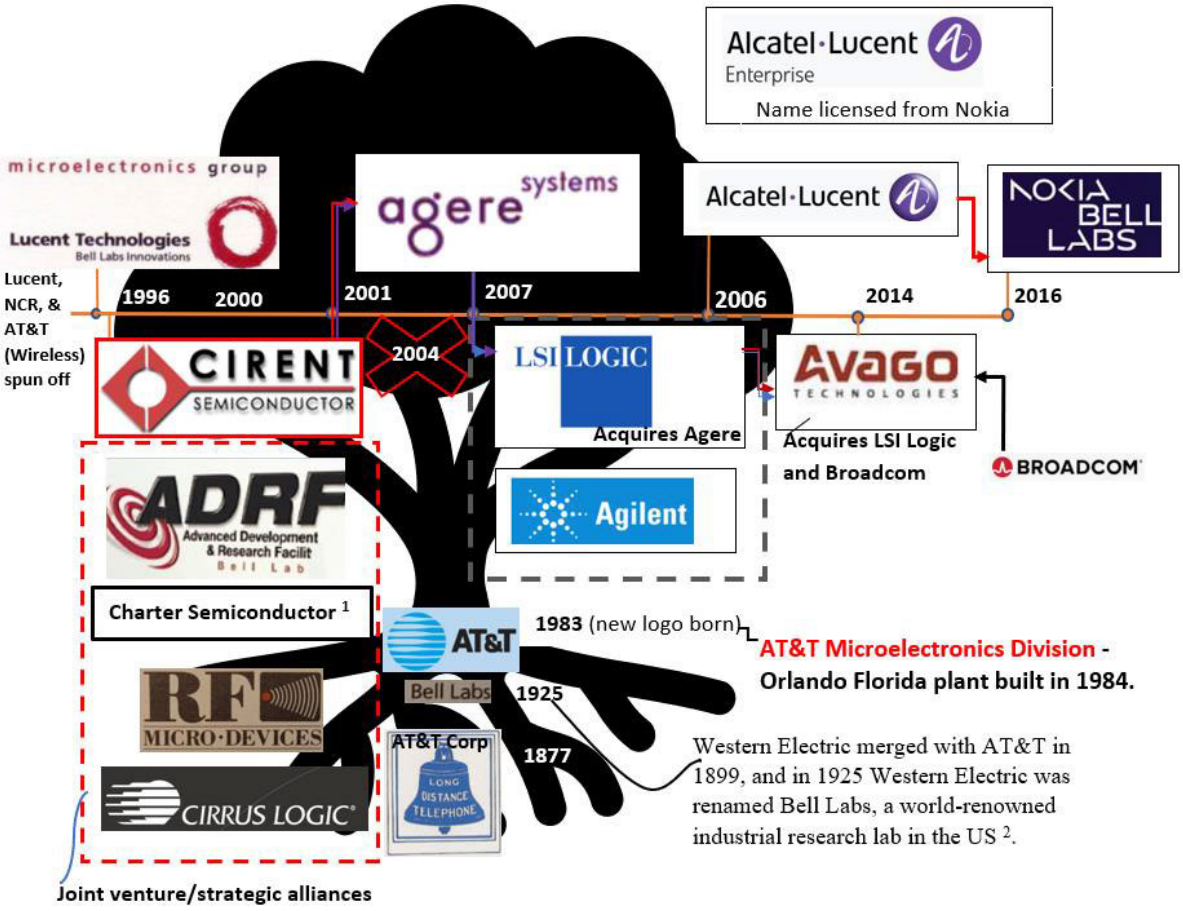

FIGURE 1. High-tech tree of life (and death) for AT&T Microelectronics/Bell LabsLucent AgereLSI LogicAvago/Broadcom.

fill almost 70% of their vacancies with outside hires, as companies cannot depreciate investments in human capital the way they can physical assets—they have no equivalent way to plan and budget for the replacement of critical talent [16].

Fig. 1 illustrates the birth of Lucent in 1996 and the 2004 demise of the semiconductor manufacturing plant (as Lucent's spinoff, Agere System, closed the Orlando plant). LSI Logic acquired Agere Systems in 2007, and the former remnants of Lucent are now rooted in Avago Technologies following the 2014 Broadcom acquisition. The demarcation in 2004 depicts the article of dissolution signed on March 31 for Cirent. Charter Semiconductor was acquired by Global Foundries in 2009[1]. By the 1970s, AT&T, with almost 1 million employees, was the largest company in the world, with total assets exceeding those of General Motors, the Exxon Corporation, and the Mobil Corporation combined[2].

B. LESSONS LEARNED: THE PEOPLE

Bell Labs' highly competent leadership team and technical staff led the Orlando plant, which incorporated leading-edge technology, generated economic wealth for the company, and instilled an organizational culture built on intellectual human value. Those with industrial amnesia might not recall the birth of the new $300 million Advanced Development Research Facility (ADRF) at 9333 South John Young Parkway, which was announced in 1997 by Lucent Technologies and opened in 2000 (Fig. 2). According to Dr. Peter T. Panousis, the CEO of the AT&T Bell Laboratories semiconductor plant, the fab was ''unquestionably the most sophisticated manufacturing facility in the state of Florida'' [30].

Post-COVID-19 pandemic economic recovery has trigged a rebirth in fab plant investment in the U.S. and Singapore, two countries with roots in the ADRF before shutting down in 2004. Nearly 20 years since the above quotation by Dr. Panousis, the global semiconductor manufacturing shortage is experiencing a rebirth in the construction of new fabs (i.e., Singapore hosting GlobalFoundries's new billion 300-mm (12-inch) wafer fab in 2023 [31], and United Microelectronics Corporations' new advanced Fab12i that is planned to open in 2024 [32]). The rising cost of labor in developing countries, high oil prices, increased transportation costs, and a growing awareness of global supply chain risks have contributed to making the U.S. a more attractive location for manufacturing companies [33]. Florida continued to be the home for many of the members of the technical staff (MTS) and distinguished members of the technical staff (DMTS)

FIGURE 2. AT&T Microelectronics-Lucent Technologies-Cirent agere system front entrance at 9333 South John Young Parkway, Orlando, FL (fab was closed in 2004 and bulldozed in 2010).

FIGURE 3. Advanced development research facility at 9333 South John Young Parkway, Orlando, FL (fab was closed in 2004 and bulldozed in 2010).

after the plant's closing in 2004. Their workplace included Cirent Semiconductor, the former AT&T; a joint venture of Lucent Technologies, an AT&T spinoff; and Cirrus Logic, a manufacturing division of Agere Systems, to which many of these Bell Labs colleagues had relocated from the ivory tower confines at Murray Hill, New Jersey (NJ); Allentown, Pennsylvania (PA); and Reading, Pennsylvania (PA) when it became Lucent (after AT&T's triple divestiture into the three independent companies AT&T (wireless), National Cash Register (NCR), and Lucent Technologies). Many MTS and DMTS researchers were embedded within manufacturing operations as part of its new organizational strategy, forming the Lucent Microelectronics Integrated Circuit Division (ICD).

C. CORE PEOPLE SKILLS IN SEMICONDUCTOR MANUFACTURING

A core group of Bell Laboratories' research and development organization remained intact in Florida. They developed the next-generation semiconductor manufacturing processes, which caused a bit of a conundrum for some of those working on pure research efforts back in NJ and PA or transferring to the new 200-mm manufacturing work in Orlando after AT&T's divestiture. The Florida facility was the largest manufacturer of semiconductor devices in the southeast region, with nearly 2,000 employees by 2000. The Orlando plant occupied 250 acres of lush central Florida landscape surrounded by a lake that employees often circled during lunch breaks, seeking a reprieve from wearing class 1 cleanroom garments or enjoying the benefits of living in the "sunshine state." The people at the Orlando plant were proud to receive awards for safety and environmental protection by the Occupational Safety and Health Administration (OSHA), as well as achieving star status in the OSHA voluntary protection program [34]. The new 21,000-square-foot ADRF opened on February 16, 2000 (Fig. 3), with more than 1,000 International Brotherhood of Electrical Workers (IBEW) union members working inside the facility as process analysts, maintenance technicians, and senior operators responsible for producing the 200-mm wafers. Orlando 1 (OR1) and Orlando 2 (OR 2) included a manufacturing facility with the ADRF as a separate facility for developing advanced semiconductor processes and technologies. According to IBEW Local 2000 President Nick Frisco, "The union had been part of the operation since 1985, a year after the Orlando plant opened" [34].

D. CLOSE WORKING RELATIONSHIPS AND THE TECHNOLOGY

Vice President Felix Disla stated, "Orlando possesses a highly skilled technical workforce that can meet the challenges of producing quality electronic products" [34]. The IBEW union members, engineers, and scientists worked together in close proximity to the manufacturing team at Cirent Semiconductor. The key ingredient for the microchip plant was the partnership between local universities to help train technical workers for the plant [35]. A strategy to introduce technology to the market more expediently with the advanced complementary metal oxide semiconductor (CMOS), using a technology mix of 0.35 micron (um), 0.3 um, 0.25 um, 0.20 um, and 0.16 um, aligned with the state of the technology at that time. Scientists and engineers worked on innovations such as copper circuitry, cobalt silicide transistors, silicon-germanium devices, FLASH memory devices, RF bipolar flip-chips, and new photolithography process techniques, among many other forms of prototype equipment for next-generation technologies. Fig. 4 illustrates the supply chain process for the first Bluetooth RF module bipolar flip-chip technology designed by Ericsson. It was initially manufactured by the Cirent plant in Orlando (wafer sawed in Arizona). The flip-chip was assembled in Asia. Subsequently, RF was tested in the U.S., and the final assembly was assembled in Asia for output to the cellular phone manufacturer. This is an example of the interdependent complexities required to link technological needs in the

supply chain during the early development process. Collaborative development with equipment manufacturers accelerated the development cycle for manufacturing future chip generations. For instance, scattering with angular limitation projection electron beam lithography was the photo technique of the time. Advanced laboratory equipment for product analysis including the scanning electronic microscope, transmission electron spectroscopy (TEM), focus ion beam, auger electronic spectroscopy, and high-power ZEISS microscopes for optical inspection of wafers were available in the failure analysis lab. Products ranged from wireless, digital signal processors, and radio frequency devices to a wide selection of integrated circuitry for multimedia, computer modems, consumer devices, application-specific circuitry, switching devices, broadband, and other technologies.

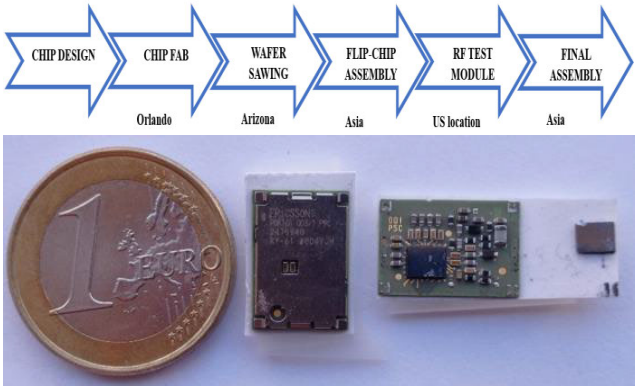

FIGURE 4. Bluetooth supply chain process flow and ROK1 module.

Fig. 3 shows the first Bluetooth RF module bipolar flip-chip technology, the ROK1 module, designed by Ericsson and manufactured in Orlando. It followed the trajectory noted above for the cellular phone manufacturing process. The early development progression was known as the ''chip around the world'' to meet the early introduction phase of the product life cycle for customers. Currently, the vertically disintegrated framework of Taiwan's IC industry with IC design, manufacturing, packaging, and testing is unique in its efficient segmentation [36]. Changes in the semiconductor industry in the late 1990s de-emphasized the vertical integration business model as divestiture began the demise of AT&T Microelectronics. It was ranked as the global leader in delivering communications chips by the marketing research firm iSuppli Corp in 2003 [37]. Remarkably, this occurred just a year before the Orlando plant was closed.

Some of the leaders at the Orlando plant included Dr. Peter Panousis (Chief Executive Officer), Dr. William Cockran (Silicon and Interconnect Technology Vice President), Dr. Dale Ibbotson (Process Development Director), Dr. Morgan Thoma (Engineering Vice President), Dr. David Williams (President and Chief Executive Officer), Mr. Bob Koch (Operations Vice President), Mr. Ken Fraiser (Director of Human Resources and Financial Services), Ms. JoAnn Newman (Operations Vice President), and Mr. Steve Goldsmith (Public Relations Director) with management, engineering, and executive oversight.

IV. DISCUSSION

In 2000, Central Florida University and the University of South Florida served as community education partners, creating highly skilled graduates for employment at the semiconductor plant. This Orlando hub education community is congruous with the CHIP Act of 2022, which indicates that Intel Corporation plans to employ educational institutions as a pipeline for highly skilled people for its two new chip factories in the Midwest. Has the industry (or government) learned from the experiences at the Orlando plant?

Cirent executives included Peter Panousis, David Williams, and Bob Koch, who led the organization in semiconductor manufacturing technology and the recruitment of high-skilled workers in the Orlando area through the Florida I-4 High-Tech Corridor Council, which was established by the 1996 Act of the Florida Legislature. The council's principal partners included 24 members from universities, businesses, and government, such as Betty Castor, President, University of South Florida; John Hitt, President, University of Central Florida; Joe Antinucci, Lockheed Martin; George Mezo, Oracle Corp.; Dick Nunis, Walt Disney Attractions; Owen Wentworth, AT&T; Johnnie Breed, Breed Technologies; and Randy Berridge, Executive Director, Florida High-Tech Corridor Council [38]. The council included Harris Semiconductor, which lay one hour away from the Orlando plant. Jon Cornell, former president of Harris Semiconductor in Palm Bay, Florida, stated, ''The semiconductor industry is struggling to cope with diminishing pool of skilled workers, the strategic issue is people'' [38]. The Council's goal was to attract the construction of more plants in Florida, targeting organizations such as Intel, IBM, Motorola, LG Semicon, Hyundai, Toshiba, and Europe's Siemens for future growth and talent attraction. If we fast-forward 28 years from the inception of the Council that espoused educational training, government tax incentives, and U.S. National Science Foundation (NSF) funding to support the high-tech future in Florida, it reveals history repeating itself. Intel plans to invest millions over the next 10 years in semiconductor manufacturing education and research collaborations with Midwest schools [39]. The executives at Cirent Semiconductor had the foresight for the Orlando plant, with its close relationships with public–private partnerships, to bolster the diminishing pool of skilled workers and use the ADRF for manufacturing future generation chips. That is, until its demise after Lucent Technologies' financial follies, the high debt burden remnants of the AT&T breakup, the telecom crash, and the effect of the relentless forces of globalization on U.S. manufacturing. This goal appears to be espoused by Intel and other semiconductor manufacturers inspired by the CHIP Act of 2022 through educational partnerships, domestic manufacturing, and advanced chip technologies. History repeats, mirroring the previous strategies practiced by erudite people

at Cirent Semiconductor in Orlando. Conversely, according to the U.S. House of Representatives bill #4346, the CHIP Act of 2022 included no government funding to protect highly skilled people from future layoffs. Notably, months after the signed legislation, Intel stock trended on the October 11, 2022 news regarding its transformation initiative to improve structural inefficiencies by driving accountability and costs back to decision-makers [40].

A. CHARTER FOR CHANGE: PEOPLE AND CUSTOMER-CENTRIC INITIATIVES

A cultural transition occurred from 1996 to 2001, with astute human resource managers' foresight to establish a customer-centric organization built on open, trusting relationships with customers. ''Delight Our Customer'' resulted in earning the reputation of the ''best semiconductor company in the world.'' This was the value proposition. ICD took the critical step of setting goals, endeavoring to become the most admired, desired, and essential semiconductor company. Senior executives at the corporate headquarters in Allentown, PA, signed off on this Changecraft Charge for Change on July 25, 1996. On December 5, 1996, an extensive report of the culture at ICD (New Jersey, Pennsylvania, Florida, and California in the U.S.; Japan, Singapore, and Thailand in Asia; and Germany, the United Kingdom, and Spain in Europe) identified gaps between the people and the organization [41]. Lucent's history of mergers and divestitures caused many employees to feel betrayed or abandoned. Some had fond memories of Western Electric without much affinity to Lucent. Only affinities with strong loyalty expressed by the people at the Orlando plant were primarily associated with Bell Labs. The Bell Labs culture of innovative spirit and the capability to deliver products resonated with engineers and scientists; however, the organizations in Orlando, Japan, Singapore, Thailand, Germany, the United Kingdom, and Spain had corporate cultures that distinctly differed from the culture in Pennsylvania. The former parent company, AT&T, was a monopoly, and customer-centricity was less of a focus than an overriding product-driven orientation. Today, the roots of AT&T's metaphorical tree find Bell Labs branded by Nokia Bell Labs after the acquisition of Alcatel-Lucent in 2016. Oddly, the name extends to Bell Labs LLC [42] and Bell Labs Inc. [43], which are, a rodenticide business in Wisconsin and a limited liability company in Mongonia Park, Florida, respectively. Cirent Semiconductor and the people at the Orlando plant incorporated a quality circle approach (labor and management initiatives) to transition the organization toward a more customer-centric approach. The process for change implementation engaged 30 volunteers who helped transform the new organization as change agents. The change agents were instrumental in identifying and organizing change initiatives, recruiting a change team, and identifying champions for advancing the initiative. Champions were individuals with access to authority, power, and resources. Change coaches helped teams alter internal processes, regardless of the project with which the team was engaged. On April 25, 1997, change agents drafted a Charter for Change, with the support of senior leadership at Lucent headquarters in PA and the Orlando plant. Excerpts from the Charter for Change read [44]:

''We will be an excited, creative, innovative, energized workforce, fully empowered to delight our customers. Failure defined as loss of customers, dissatisfied employees and creation of new bureaucracy. . .or jeopardize quality certifications.''

Indications of success of the change initiative:

1. Continuous improvement in customer report cards.
2. Increased number of suppliers of the year awards.
3. Increased sales.
4. Improved employee satisfaction.
5. Decreased bureaucracy.
6. System to support the high performance required by our customers.
7. Employees who know who the customer is and how their work impacts the customer and Lucent Integrated Circuit Division relationship.
8. Improve shareholder value.

V. CONCLUSION

Bell Labs' highly competent leadership team valued the technical excellence that infused the Bell Labs culture of innovation and respect for human value including manufacturing operations, engineers, and scientists. This culture was engrained in people's behavior at the Orlando plant. ''To consider what occurred at Bell Labs, to glimpse the inner workings of its invisible and now vanished 'production lines', is to consider the possibilities of what large human organizations might accomplish'' [45] (p.5). The Orlando plant exemplified American innovation, yet many complex factors contributed to its demise. ChangeCraft and Cirent are two defunct companies in Florida [46], [47]. The controversial questions postulated in the introduction section can inspire those in semiconductor businesses to reflect upon rather than repeat past mistakes (i.e., layoffs, plant closings, overseas technology transfer, and abandoned education partners and communities). Change agents are crucial advocates of an organization and resist mainstream management practices that emphasize solely achieving economic goals. Caring for employees, retaining employees during challenging business periods, and balancing economic benefits and human ends are practical lessons for the industry. The lessons learned at the Orlando plant can influence changes in the boom-or-bust semiconductor business—a business model that yearns to be reimagined in line with other companies boasting remarkable histories of avoiding the implementation of layoffs.

Companies such as Barry-Wehmiller (BW) Manufacturing, Southwest Airlines, Scripps Health, Wegmans Food Markets, and others employ business models that aspire to emulate the success of other companies with impressive track records in avoiding layoffs. BW exemplifies the shared sacrifice involved in having zero layoffs during the global financial crisis [48].

Including quantitative data on the regional economic impact to support the plants' existence was beyond the scope of this study and was not fully realized to build a case. A comprehensive analysis by the former CEO, Dr. Panousis, and colleagues at the University of Central Florida (UCF) highlighted its $1.277 billion combined impact on the region's economic output in 2003 [49]. UCF was a key strategic community partner of Agere Systems and acted as a direct feed of employment for highly skilled people at the Orlando plant. Ample research evidence shows that layoffs not only kill people through increased suicide rates but also lead to an increase in the mortality rate by as much as 20% over 20 years. Furthermore, employment cuts do not improve company performance [15]. Companies that lay people off and have work arrangements that stress and overwork their employees also impose externalities that others pay for even as they reduce their own costs [50].

Regarding the company that investors coined "Lucent Technologies, the darling jewel of Wallstreet" [51], this study offers a novel perspective for future semiconductor fabs as was established by the people and community at the Orlando plant. The AT&T Microelectronics-Lucent Technologies Microelectronics Integrated Circuit Division-Cirent Semiconductor-Agere System was Orlando Florida's technology jewel. "At some point, if you do not make these long-term investments, it will come back to haunt you. . . even in this era of having to get more profitable and prove themselves to Wall Street, you cannot be that shortsighted" [52]. As domestic semiconductor manufacturing investment returns to the U.S. from its overseas economically incentivized journey, semiconductor manufacturers are admonished to remember that the mass layoffs, community abandonment, and environmental impact, which had a highly detrimental effect on the people and community in Orlando are unsustainable business practices that must not be repeated by future fabs.

VI. ACKNOWLEDGMENT

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Figure 1 was adapted from personal documents, corporate press releases, and historical archives from AT&T available at https://www.att.com/Common/files/pdf/logo_evolution_factsheet.pdf and the Encyclopedia Britannica; Figure 2 was courtesy of MRI architecture in Orlando, Florida; Figure 3 was courtesy of the IBEW Union; Figure 4 was created by the author.

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