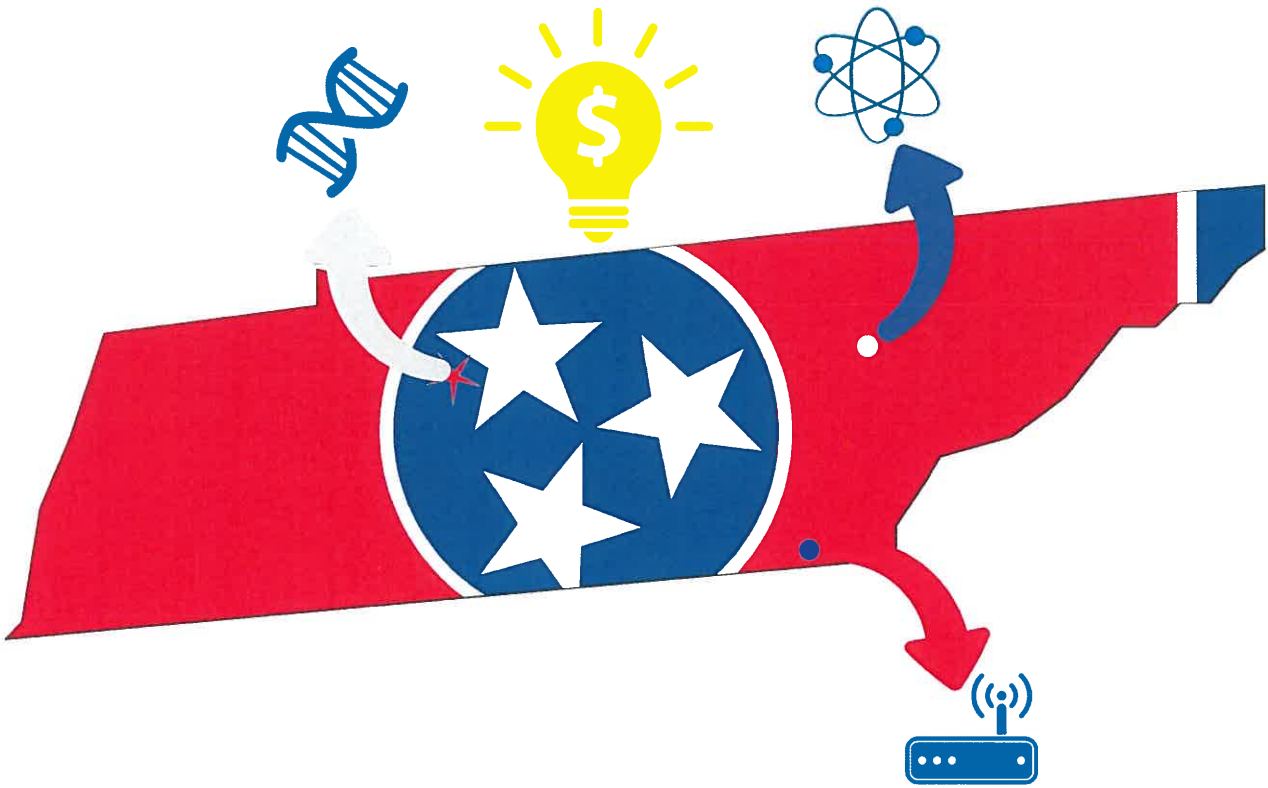


An Outlook on Future Entrepreneurial Growth Within the State of Tennessee

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Executive Summary

The objectives of this report are two-fold: to provide a snapshot of Tennessee's major industries within three of its central and growing cities, Nashville, Knoxville, and Chattanooga, while simultaneously extrapolating the data to identify future trends and the individual potential of the cities to be sites of new and experimental technology and innovations within established and rapidly expanding industries including, but not limited to, The Internet of Things (IoT), The Physical Web, Wearables, Big Data, Cloud Computing, Energy, Healthcare, Music, and Scientific Research. The following points are the highlights of this study:

- *Since 2012, businesses in Tennessee have brought in over \$945 million in investments, with \$280 million received in 2015 alone. Total investment will surpass \$1 billion as of early 2016.*
- *There are seven regional entrepreneurship centers throughout Tennessee linked through a public-private partnership, Launch Tennessee, and each of which provide mentorship, connections to investors, and accelerator programs in assisting new business ventures.*
- *Tennessee is ranked No. 1 in the Southeast and No. 2 in the US in medical equipment exports for five consecutive years. From January 2011 to February 2016, healthcare businesses working with TNECD made commitments to create 11,682 new jobs and invest \$1.26 billion, which will add to the 342,100 Tennesseans employed in the sector.*
- *\$682 million was awarded to Vanderbilt University to sponsor research efforts in 2015.*
- *The healthcare industry in Nashville has a \$40 billion impact on the local economy. Relative to the rest of the US, Tennessee's healthcare and medical research industries are significantly stronger.*
- *The music industry in Nashville has a \$10 billion impact on the local economy. Nashville has a ratio of 7.8 out of every 1000 jobs being specifically in the Nashville*

music industry, providing about 56,000 jobs in total. Nashville is ranked No. 1 in music publishing employment.

- *Nashville is a site for the Google Fiber project to bring gigabit internet to the public.*
- *The Oak Ridge National Laboratory is the largest science and energy facility in the United States and operates on a budget of \$1.65 billion. ORNL also houses the world's 2nd fastest supercomputer, Titan.*
- *Tennessee's advanced energy industry is one of the strongest in the nation, employing approximately 375,000 people with a 17.6% growth in employment since 2010, surpassing the national average of 13.7%. Tennessee is also No. 2 in the nation for energy reliability and smart grid deployment, due to TVA achieving 99.999% reliability every year since 2000. In total, the advanced energy industry generates \$33.4 billion for the GDP solely for the state of Tennessee.*
- *Large corporations such as Wacker Chemie, Volkswagen, Alstom Power Inc., and Amazon have made investments of \$2.4 billion, \$1.6 billion, \$300 million, and \$91 million within Chattanooga, respectively.*
- *In 2010, Chattanooga was the first city in the US to have a gigabit internet network. The speeds were over 217 times faster than the national average at this point in time. In October of 2015, a 10 Gbps speed became available from EPB in Chattanooga, being 793 times faster than the 2015 national average.*
- *Over the time period of 2011-2015, the gigabit network has had an estimated social and economic impact valued at \$865.3 million while creating an additional 2,800 jobs. The Smart-Grid infrastructure also saves millions of dollars a year for EPB and Chattanooga.*
- *Nashville, Knoxville, and Chattanooga, along with a number of other cities in Tennessee, all have thriving and growing entrepreneurial communities where Tennessee entrepreneurs have multiple outlets of available support to grow their businesses.*

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Introduction

In the large realm of entrepreneurship, startups, venture capitalism, incubators, and accelerators, the often thought of entrepreneurial hub pertaining to these fields is Silicon Valley. The regions of Palo Alto, Mountain View, San Jose, and the areas within close proximity of these locations, all have a technologically rich history. With the consistent influx of technological advancements in telecommunications, military hardware, and the silicon transistor, Silicon Valley continues to be a hub for technology, startups, and, as a result, economic growth. Silicon Valley's reputation for being an important location of technological growth and development is a major incentive for additional entrepreneurs, venture capitalists, and major technological firms to bring their ideas and investments along with them to try and found the next Google or Apple. Consequently, this influx of ideas and investments provides a natural positive feedback loop of economic growth for The Bay Area and, at a larger scale, the state of California.

Technological growth, venture capitalism, and accelerator programs however, are not solely restricted to the western United States or even cities that are traditionally or widely considered to be strongly business and economic oriented locations such as New York City, Boston, or Chicago. In recent years, one particular southern state has exceeded expectations in terms of statewide development. Specifically, for the state of Tennessee and its growing cities, this is precisely the case. Nashville is a main economic center of the south and of Tennessee itself with its large music, health care, automobile, and financial industries. Simultaneously, Chattanooga possesses some of the fastest internet speeds in the world and is appropriately called the "Gig City" for this reason. Knoxville is also a major city of both economic growth and scientific research, with the Oak Ridge National Laboratory being only thirty minutes from the Knoxville city center. In addition, cities such as Memphis, Cookeville, Johnson City, Tullahoma, Martin, and Jackson all have their own industry niches from healthcare and life sciences to information technology and advanced materials manufacturing.

With each of these cities possessing its own unique attributes, it has become of increasing interest to both entrepreneurs and venture capitalists alike to form their ideas

and allocate their investments within the state of Tennessee and while each of the aforementioned cities contributes uniquely to the overall economic growth of Tennessee, Nashville, Knoxville, and Chattanooga are three of the largest. The fact that each of these cities are capable of producing major technological and scientific advancements allows them to be key locations for entrepreneurial pursuits and, as a result, maintain a Silicon Valley-like environment where there exists an optimal combination of science, technology, available capital, and innovative ideas. In addition to this, with the south being known for its collaborative nature, Tennessee and three of its major cities have the potential to become a powerful hub for economic growth within the southeast and be the place of origin for the next generation of multiple revolutionary business services, apps, and ideas to be provided to the general consumer both within the United States and internationally.

Nashville: The City of Medicine and Music

Part I: A Leader in Healthcare



Image: The Children's Hospital at Vanderbilt, Wikipedia

According to data gathered by the Tennessee Department of Economic and Community Development, Tennessee is No. 1 in the Southeast and No. 2 in the United States for medical equipment and supplies exports for five consecutive years. In addition, more than 342,100 Tennesseans are employed in the healthcare and medical device industry.¹ In Nashville specifically, Vanderbilt University is an employer of almost 20,000 people, about 16,000 of which work at the medical center, along with being the location of innovative biomedical and pharmaceutical research efforts.² Several major healthcare companies, such as HCA Holdings Inc., are headquartered within Nashville and the surrounding areas of Franklin and Brentwood. In addition, there are numerous other pharmaceutical, biomedical, and healthcare related companies who have a presence

within Nashville and the surrounding area of which include pharmaceutical industry leaders such as Pfizer Inc. and Bayer Corporation.³

Since January 2011, Tennessee businesses in the health care and medical devices sectors made commitments to create new jobs and investment within the state of Tennessee. These investments have generated 11,682 in new jobs and a total investment of \$1.26 billion from January 2011 to February 2016. Of these investments, approximately 60% have occurred in Williamson and Davidson counties, of which include Nashville, Franklin, and Brentwood.^{1,3}

Relative to the rest of the Southeast and other parts of the nation, data from TNECD showed that Tennessee has a greater employment concentration for the health care and medical devices sectors by assigning a “Location Quotient” to specific sectors within the healthcare and medical devices industry that compares Tennessee’s employment relative to the national average. Some major sectors in the industry with their respective Tennessee LQs include: Surgical Appliance and Supplies Manufacturing, 3.28; Medical, Dental, and Hospital Equipment and Supplies Merchant Wholesalers, 1.71; and Medical Laboratories, 1.43. These LQs suggest that, relative to the rest of the nation, Tennessee is a leader in medical device manufacturing and healthcare research. The fact that Medscape ranked Tennessee No. 1 on the Places to Practice list for 2015 is also supportive of this conclusion. In addition, \$680 million worth of pharmaceuticals and medicine were exported from Tennessee in 2015.³

Of the many leading investors who are committed to expanding the already prominent healthcare industry within Nashville and the surrounding areas, Vanderbilt University is certainly one the largest while simultaneously being dedicated to medical research. According to Vanderbilt’s 2015 website and financial report, \$682 million was awarded to Vanderbilt to sponsor research efforts of which \$551.5 million was used to sponsor research at the Vanderbilt University Medical Center (VUMC) and \$265.3 million was received from the NIH. Overall, the total revenue from healthcare services was over \$2.8 billion for the fiscal year of 2015, only a small portion of the almost \$40 billion impact on Nashville’s economy.^{2,4,5,7}

For an entrepreneur in the Southeast interested in taking their ideas and innovations to revolutionize the healthcare industry, there would be no hesitation to look towards Nashville for opportunity. The Nashville Entrepreneur Center, or NEC, is well-aware of Nashville's thriving healthcare industry and, consequently, has an entire program at the NEC called "Project Healthcare" dedicated to transforming the healthcare industry. According to PH's press release in early February of 2016, "The initiative provides year-round create, launch and growth support to health care startups and entrepreneurs by connecting them to the critical curriculum, community, connections and capital resources needed to turn their ideas into realities."⁵

This initiative by the NEC to promote growth and innovation within the healthcare industry is not without strong support either. Google, along with selecting Nashville as one of the cities in the Southeast to receive Google Fiber, is additionally supporting Project Healthcare through their other initiative, Google for Entrepreneurs. At the NEC itself however, Google also provides the facility with the support and technology it needs to operate successfully as an business incubator within the state of Tennessee.^{5,6}

Part II: The Music Metropolis

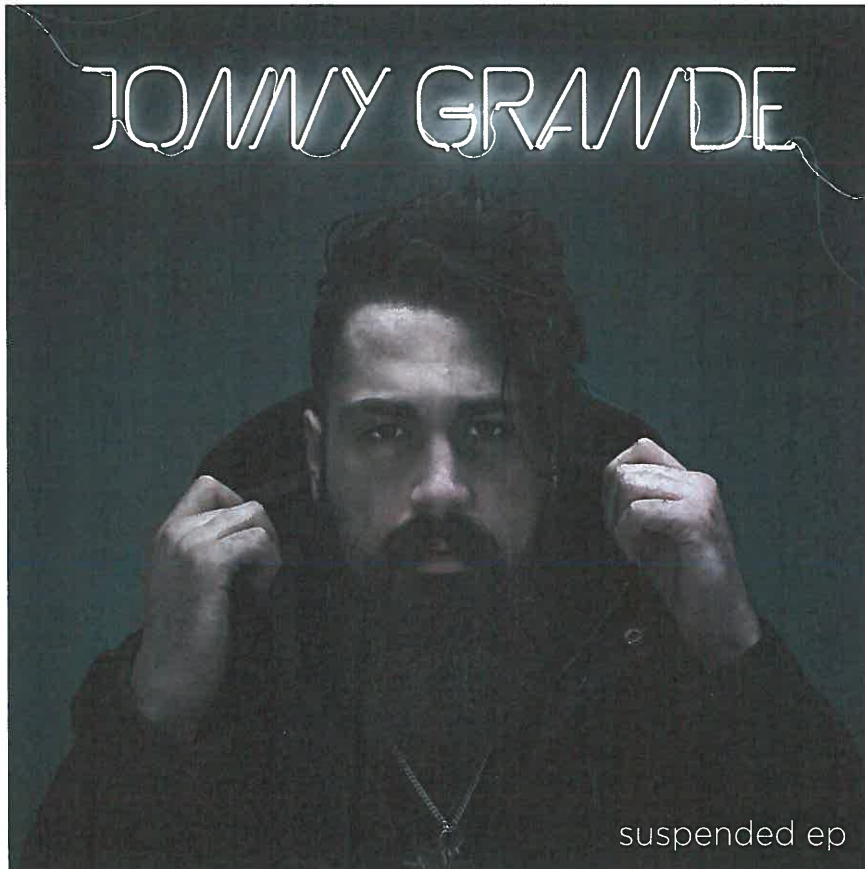


Image: Grande Haus Music, used with permission

With currently more than 80 record labels, 130 music publishers, and 180 recording studios, Nashville has been appropriately known as Music City, U.S.A. for decades and has evolved from being the center of country music to becoming the capital not only of Tennessee, but also of global entertainment. Overall, Nashville's music and entertainment industry provides a \$10 billion benefit across the region along with hosting some of the largest music publishers nationwide, such as Sony and Universal Music Group. The Nashville music and entertainment industry has grown to such a significant size that economist Richard Florida proclaimed Nashville as "The Silicon Valley of the Music Business".^{8, 9, 12}

More than a quarter of music publishers within the United States are located specifically in Nashville. In addition, Nashville has ratio of 7.8 out of every 1000 jobs specifically in the Nashville music industry, providing about 56,000 jobs in total. Nashville also outpaces some of the largest cities in the nation in terms of music industry activity and has seen a 5.5% growth within the entertainment industry over the past five years. In comparison, New York, Austin, and Los Angeles have music industry employment ratios of only 2.0, 2.6, and 2.8, respectively. ^{8, 9, 10, 13}

According to a RIAA study on the Nashville music industry, some branches of the music industry within Nashville possess some exceptionally large location quotients. For the music publishing, record production, and sound recording studies branches and their respective LQs of 31.3, 12.5, and 4.1, their strong presence will only be matched by their future growth. RIAA additionally found that, relative to other cities known nationally for their strong music and entertainment industries, Nashville’s average industry earnings and industry establishment are unproportionally greater, as is illustrated in figure one.¹³



Fig. 1: Nashville’s overall level of earnings within the music industry relative to other major cities.¹³

Just as Vanderbilt University serves as an educator for students seeking to work in the healthcare industry, Belmont University plays a similar role for those seeking to play an active role in Nashville's visual and musical entertainment industry. Belmont's Mike Curb College of Entertainment & Music Business has been accredited by the AACSB International and the ABET for their high standards and achievement for both business and technology related studies, respectively, within the music and entertainment industry. In addition, the Curb College has also been featured in *Billboard*, *Time Magazine*, *Rolling Stone*, and *Business Week*. Through the combination of a thriving music industry and a strong university focused heavily on visual and musical arts that is able to educate and connect students to the industry, Belmont will serve, in part, to provide the next generation of producers and artists with the experience and skill sets needed to continue the growth of Nashville's world-renowned music scene.^{9, 14}

As with the healthcare industry, the Nashville Entrepreneur Center also clearly recognizes Nashville's booming music and entertainment industry. Appropriately, the NEC has also established an accelerator program titled "Project Music" to promote technological innovation through the building and support of music or entertainment-oriented startups. The program seeks to help its selected participants step-by-step through educating them on their industry, connecting them to mentors and industry experts, and helping them with their pursuit of potential investors. Music-based startups should also be hopeful in seeking the right talent for their venture, as employment in Nashville's entertainment industry is expected to grow by 2.7% over the next five years. Overall, Nashville is highly ranked as an industry leader in the music and entertainment industry, being No. 1 for employment in music publishing, No. 2 for number of music publishing establishments, and No. 3 for employment in sound recording industries, record production, integrated record production and distribution, musical groups and artists, and musical instrument manufacturing.⁹

Part III: Nashville, Beyond the Data

While it is clear that Nashville possesses a strong grip on both the healthcare and entertainment industries, there exists an exceptional potential for growth, expansion, and innovation of these industries through the development and utilization of existing and future technologies. If the necessary technological innovations are properly implemented, Nashville has the potential to be one of the “smartest” cities in the nation, being a leading example for cities across the world seeking to invest the required resources into becoming a smart city. Nashville in particular, due to its strong healthcare industry and due to it being a site for the Google Fiber project, could become a community that entirely embodies advanced health and wellness. With a gigabit network infrastructure entirely developed by Google along with IoT through the usage of personal “wearables”, real-time health data of individuals throughout the Nashville community could be relayed to and monitored by health professionals consistently. This data would provide a much more detailed progress report of individual health and wellness and, through the usage of computer algorithms, could detect irregularities within an individual’s heart rate, body temperature, or other vital signs and promptly alert the doctors and nurses much more quickly than a traditional check-up or even an emergency call at the time of an incident would be able to offer. Consequently, maintaining the health of Nashville residents would become a much more proactive process rather than a reactive process, saving thousands of lives.

At a larger level, the data used to monitor the health of individual residents could provide a picture of Nashville’s health as a whole. Detecting abnormalities in the general population during particular flu or cold seasons would allow the CDC to better assess seasonal trends in illness and reduce the likelihood of viral or bacterial outbreaks within Nashville for the future. Given Nashville’s large, capital-city population, the sample size of the data has potential to provide valuable, life-saving data to be used and extrapolated appropriately in the implementation of effective sanitary procedures in cities across the nation and even worldwide.

If people are feeling well more often than not, there is no doubt that they want to go out and celebrate. Through a combination of Google Fiber and Nashville’s music

industry, residents of Nashville will be able to experience entertainment like never before. Just as wearables will provide constant monitoring of health-related data, so will the physical web be able to enrich people's experience of the visual and musical arts, eventually providing opportunities for virtual reality experiences. Companies such as the Nashville-based BKON Connect, Inc. are seeking to provide this type of experience. Through the usage of small devices that link a mobile device to a specific URL describing the nearby object (person, place, or thing), residents of Nashville will be able to instantly be better connected to the events within their community. If for example a person hears a song by an artist unknown to them, they can quickly utilize the power of the physical web to get additional information about the artist, suggestions to similar artists, nearby events, upcoming concerts, and much, much more, simply by connecting to the nearby information beacon. The potential for this technology extends far beyond entertainment however, and can be utilized for healthcare, transportation, dining, tourism, and a number of other industries that will inevitably provide a significant benefit to the Nashville economy.^{17, 18}

With such an innovative and unique entertainment infrastructure, Nashville's music industry and, consequently, its popularity, will continue to grow, hosting more concerts and shows than ever. The question may then arise, if this increase in event activity will further congest Nashville with an undesirable amount of traffic at times of high activity. However, given that Google already has an interest in the growth of Nashville, there is likely to be future collaborations between Google and the city of Nashville. That being said, Google may seek to use Nashville as a pilot city for its self-driving car technology, and while this technology is already being tested in places such as Austin, Texas and Mountain View, California, Nashville may be one of the first cities to experience this technology within the Southeast. In addition, as of late January of 2016, there were several reports that Senator Mark Green, R-Clarksville, has pushed for an amend to the Tennessee driving laws to allow for the operation of Automated Vehicles (AVs). In utilizing AVs for such large music events in Nashville, there is a huge potential to avoid unnecessary traffic jams that result in wasted time and fuel along with an increase in overall CO₂ emissions. Through the combination of the two innovative Google technologies: Google Fiber and Google self-driving cars, Nashville transportation could be

revolutionized, with a personal taxi-system more time-efficient and cost-effective than ever.¹⁹

The Nashville entrepreneurial scene is as just as progressive socially as it is with its business operations. According to a study performed by Wallet Hub, Nashville is the best city in the United States for women entrepreneurs and women-owned businesses for 2016. In addition, Chattanooga was the next best city for women entrepreneurs, taking the No. 2 position on the Wallet Hub ranking, Memphis taking No. 4, and Knoxville No. 15.^{89, 90} Business Insider also ranked Nashville as the 4th best city for millennial entrepreneurs, with Knoxville ranked number No. 7. A study from Thumbtack also stated that Tennessee was ranked No. 7 on the top 10 list of the best states for overall friendliness towards small businesses.^{91, 92, 93, 94} For Nashville and for Tennessee, these rankings suggest a bright future ahead for entrepreneurial growth within these particular regions of the Southeast.

IoT. AVs. Gigabit Internet. All these innovations and the ones to proceed them have an exceptional amount of potential to continually revolutionize the life and well-being of Nashville residents. The Nashville population will become one of the first to experience an environment and, consequently, live a lifestyle unlike anything that is currently implemented today. Their way of living will be efficient, productive, healthy, informed, and, most importantly, connected to the city of Nashville that adapts to its needs, just as they do.

Knoxville: Atomic Work, High-Energy Potential

Part I: The Atomic Advantage

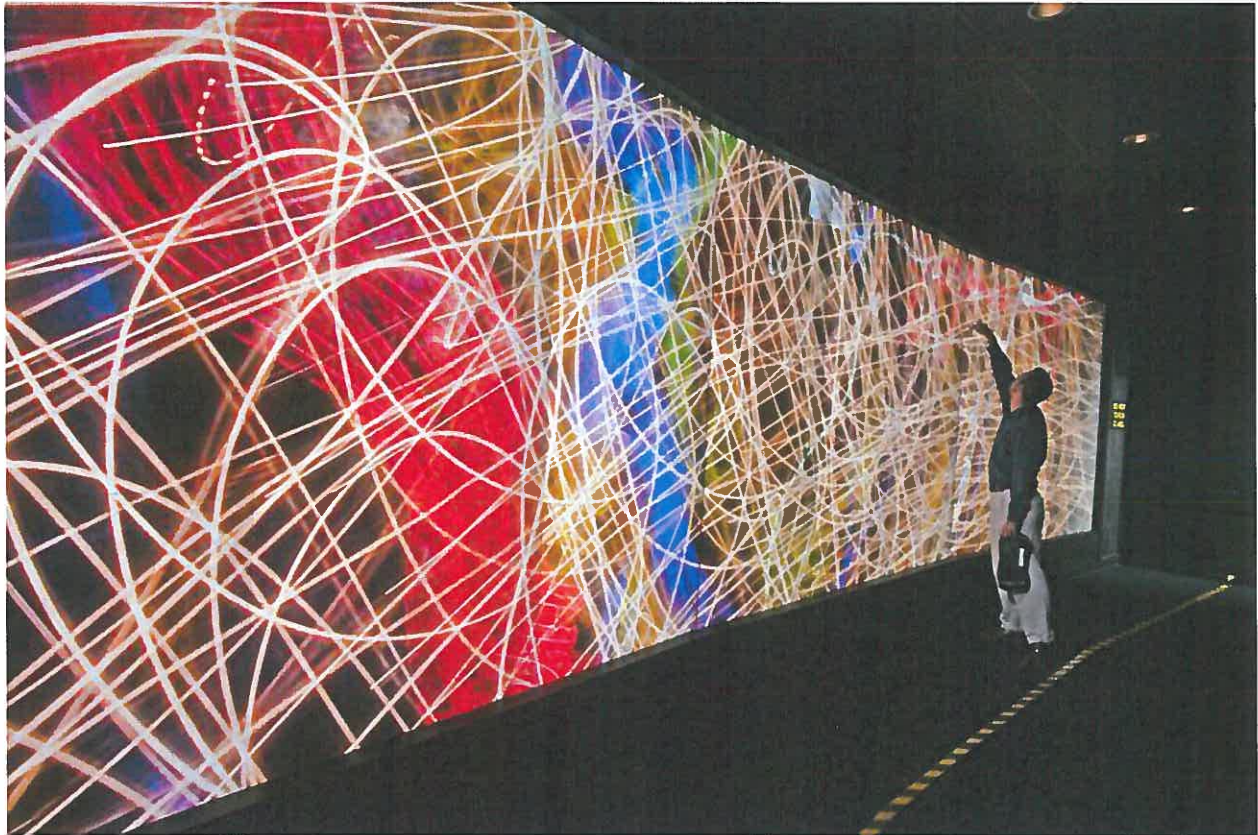


Image: The EVEREST Room powered by the Titan Supercomputer at Oak Ridge National Laboratory, Wikipedia

While the Oak Ridge National Laboratory may be located in “The Secret City”, it is no mystery that ORNL is on the forefront in researching advanced technologies in neutron science, computation, materials, and renewable and nuclear energy. ORNL is the largest science and energy lab in the United States and employs 1,600 scientists and engineers along with 3,000 guest researchers in more than 100 disciplines while operating on a budget of \$1.65 billion.²⁰ As of the year 2000, the University of Tennessee, Knoxville and Battelle have maintained a 50-50 limited liability partnership to manage operations at ORNL and to achieve the research goals set by the Department of Energy. Whether the numerous research groups are dedicated to better understanding the

nature of quantum mechanical systems or overcoming challenges in national security, the researchers at ORNL are working to implement the infrastructure necessary for the general public to live in a safer, more efficient, and technologically advanced community.^{20, 21}

Although ORNL's research efforts are as various as they are impressive, a significant portion of their research is dedicated to advanced materials and nuclear science for the generation and storage of energy. The United States, along with other nations around the globe, will require more energy while simultaneously seeking alternative, cleaner, more sustainable forms. Although the amount of fossil fuels left available for global usage could be considered a matter of debate, the impact on the environment due to the burning of fossil fuels is not. In any event, the matter of finding alternative forms of energy while still meeting national and international power consumption is necessary. Likewise, a similar set of challenges to overcome in the realm of energy, in addition to the creation of energy, are the storage and transfer of energy. At ORNL, technological solutions to both of these challenges are being sought, as the advanced materials research efforts are focused both on the development of new materials while simultaneously improving the performance and lowering processing costs of materials. Through this combined effort, ORNL is and will continue to be one of the forerunners in developing state-of-the-art technologies for both the generation and storage of energy within the United States and internationally.^{22, 23, 24, 25, 26}

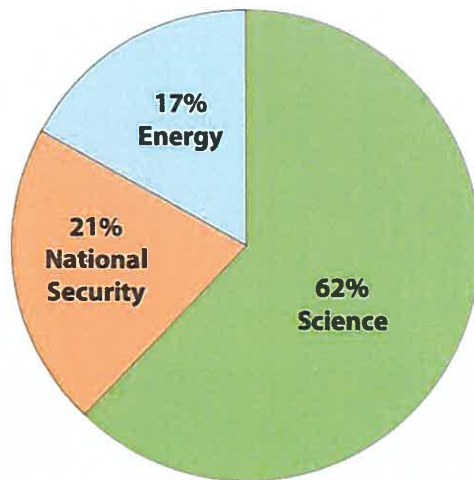


Fig. 2: Composition of ORNL's research portfolio.²⁰

As a whole, Tennessee's advanced energy industry is one of the strongest in the nation, employing approximately 375,000 people with a 17.6% growth in employment since 2010, outpacing the national average of 13.7%. From 2015 to 2025, the employment within this industry is expected to grow an additional 13.2% with 24,530 establishments already directly involved in the advanced energy industry. Tennessee is also No. 2 in the nation for energy reliability and smart grid deployment, due to TVA achieving 99.999% reliability every year since 2000. In total, the advanced energy industry generates \$33.4 billion for the GDP solely for the state of Tennessee.^{40, 51, 52}

ORNL however, is not alone in its matters of national security and nuclear fuel resources. The Y-12 National Security Complex is also situated on ORNL's campus and is dedicated to developing advanced technologies related to nuclear energy and national security along with performing work for other government and private sectors. The Uranium Processing Facility on site is used frequently to store nuclear material and to process old nuclear weapons for the purpose of extracting the valuable contents and using them to fuel the nation's naval reactors. Another partner at ORNL, the Electric Power Research Institute, Inc., is dedicated to researching and developing innovative solutions for the generation, transportation, and storage of electricity.^{33, 34}

While research in all disciplines has been performed for thousands of years simply through lab-based experiments and trials, computers, in some instances, are simultaneously able to serve as both a cheaper and extraordinarily informative alternative to traditional experimentation. Some of the biggest challenges in energy solutions, advanced materials, quantum mechanical systems, transportation, and climate change, can be approached through the usage of computational methods. At ORNL, the usage of the Titan supercomputer is fundamental for modeling these complex systems. The Titan was also ranked as the No. 1 supercomputer at the time of its establishment in late October of 2012 and as of the latest TOP500 ranking in November 2015, Titan still holds the No. 2 position of the TOP500 supercomputer ranking project. For modeling the complex challenges of the future however, even the Titan is not enough. In response, ORNL will be replacing the Titan with their newest addition, Summit, which will have a peak performance of over 100 petaFLOPS and is to become operational in the year 2018.

In comparison, Titan has a peak performance over 20 petaFlops, meaning that the Summit will be about five times more powerful than the Titan.^{27, 28, 29, 30, 31}

As with any scientific or technological pursuit, researchers and entrepreneurs alike within a particular field are aware that innovative ideas can often be found outside of their specific discipline. Likewise, ORNL fully recognizes the importance of interdisciplinary collaboration, and consequently maintains a number joint institutes with the University of Tennessee, Knoxville and Vanderbilt University pertaining to the biological, computational, neutron, nuclear, and material sciences. Due to UTK's partnership with ORNL, the university has been classified by the Carnegie Commission as a "research university with very high research activity (RU/VH)".²¹ ORNL has also formed additional partnerships with more than 250 universities across the nation to both train and excite young undergraduates and graduates for the future of scientific innovation.²⁰

Along with ORNL promoting an interdisciplinary environment on their campus, ORNL plays a key role in two "Innovation Hubs". The two hubs, the Consortium for Advanced Simulation of Light Water Reactors and the Critical Materials Institute, focus on the advanced modeling and simulation of nuclear reactors and technologies that enhance the performance of already existing materials along with finding alternatives to materials that are subject to large fluctuations or disruptions in supply. ORNL also hosts a number of other centers, institutes, and laboratories on their campus to pursue a variety of scientific endeavors.³²

As a whole, the relationships amongst UTK, ORNL, Y-12, and the EPRI is collectively known as The Knoxville-Oak Ridge Innovation Valley. Together, they are a center for scientific innovation within the Southeast, specifically in the state of Tennessee, and have exceptional potential for providing the next generation of technologies for the future. Outside of ORNL however, Knoxville also has the Knoxville Entrepreneur Center (KEC) dedicated to turning ideas into working products and businesses. Through the various accelerator programs, entrepreneurs can take their ideas or products at different stages and slowly develop them into profitable startup businesses.⁴¹ Whether the development period exists as a short time span of 48 hours or a 12 week training program, the KEC is helping entrepreneurs connect with investors and move their businesses to the next

stage.³⁷ In addition, UTK has the Anderson Center for Entrepreneurship & Innovation to expose students to the fundamentals of entrepreneurship while simultaneously providing them with access to mentors and the necessary resources to mould their ideas into profitable businesses.³⁹ Tech 2020, a public-private partnership established in 2000, is yet another program funded by UTK, ORNL, and Y-12 to promote new business development and economic growth which has created 2,000 jobs and made a \$275 million impact on the region.⁴² Overall, through the combination of ORNL, the KEC, and the various accelerator programs and entrepreneurship centers within the Knoxville area, there exists a healthy business climate to promote entrepreneurship and innovation for developing the ideas within the population of Knoxville and the surrounding areas.^{35, 38, 40}

Part II: Knoxville, Beyond the Data

For Tennessee to maintain a Silicon Valley-like environment, the operations at ORNL and Innovation Valley are crucial to promoting entrepreneurial pursuits and economic growth and development. As the number of devices begins to increase with the growth of the IoT movement, electricity generation and storage will become an increasingly important issue. Batteries and electronics for devices that are wearable, washable, and ultimately durable, will be a necessity for the future of IoT. Both the processing and operation of these devices will need to be improved, as the next generation of handheld and wearable devices will be constantly communicating with each other, relaying data and dynamically adapting to user input.

Although these devices will be small, they will nevertheless be numerous and, as such, must be manufactured appropriately. These devices will constantly relay sensitive information about its user, thus making the secure transfer of this relayed information perhaps the number one challenge for IoT. If the encryption algorithms used for these numerous devices are not secure, countless privacy and security issues will arise, with knowledgeable and even amateur hackers being a significant source of criminal activity in the future. ORNL, with 21% of its research dedicated to national security, will play an important role in internet and electronic security for over 300 million United States citizens.²⁰

While IoT will require smaller batteries and electronics, there still exists the issue of providing the necessary power for the more complex systems of the future. Given that ORNL is largely dedicated to the study of fusion energy, researchers at ORNL could be some of the various research groups around the globe to better understanding this technology. A global program titled International Thermonuclear Experimental Reactor (ITER), could provide an alternative source of enormous amounts of energy with no greenhouse gas emissions, no long-lived radioactive waste, no risk of nuclear meltdown, and no potential for nuclear proliferation.^{25, 43, 44} Additionally, there is potential for ORNL to create innovations in solar technology that will be capable of much higher quantum efficiencies, causing solar to be a more affordable option for everyone. Users with improved solar panels, in combination with improved battery storage, will become

self-sustaining entities, relying less and less on a central grid for power or even being producers of electricity that can be transferred to other residential areas connected through the same local power grid. Solar panels are only one example however, as there are likely multiple different types of materials and chemical reactions currently being tested at ORNL for their conductive and electricity generating potential, respectively.

All this research will ultimately require a number of trials and various experimental testing conditions to determine materials with the highest potential of becoming the next building-block of future electronic devices. To pursue this research however will require an extensive amount of funding, as the starting materials and testing conditions are as expensive and intensive as the experiments are numerous. If multi-variable, multi-particle systems can be simulated through the use of a more powerful supercomputer, this will significantly reduce the amount of lab-based experiments that will need to be run, allowing a number of failed experiments to be circumvented while only performing experiments that are highly favorable for total product yield or whose theoretical probability of success is particularly high.

Even for a supercomputer such as Titan or Summit however, there is an eventual classical limit to the fundamental composition and operation within traditional processing. Transistor size on a microchip is slowly approaching a classical limit, signaling that the end of Moore's Law is likely near, being slowly replaced by Rose's Law for qubits in a quantum computer.⁵⁰ To date, the smallest transistor technology capable sits at 14 nm, with the speculated physical limit being 5 nm.^{47, 48} However, if a true quantum computer can be developed and implemented at ORNL, it will have serious potential to solve particular problems, specifically discrete optimization problems, much faster than any classical computer or supercomputer would ever be capable of. A quantum computer would also make certain data encryption methods obsolete while simultaneously creating a new type of encryption method, specifically the BB84 protocol, providing a useable and effective method of Quantum Key Distribution (QKD). The question for ORNL, then, is not if it will ever have a quantum supercomputer, but when the time will come when a true quantum supercomputer is developed, implemented, and utilized to accelerate the discovery of new scientific innovations while simultaneously lowering the cost of experimentation.^{45, 46, 49}

Collectively, the environment created by ORNL and the surrounding institutes, universities, innovation hubs, entrepreneur centers, and various other programs, allow the Knoxville region to play a serious role in the development and manufacturing of state-of-the-art technologies that will significantly change the day-to-day operations of normal private and public life for the entire globe. For Tennessee as a state, this collection of institutions is a significant factor in creating the most optimal, Silicon Valley-like environment.

Chattanooga: The “Gig City”

Part I: Big Data in a Small Town



Image: Downtown Chattanooga, Wikipedia

In a speech given by President Barack Obama in January of 2015, Obama described the “Scenic City” as a “tornado of innovation”.⁵⁴ One of the many aspects of Chattanooga that matches its innovation is its beauty. Chattanooga is the only city to win *Outside* magazine Best Town of the Year Award twice, once in 2011 and again in 2015.⁵⁵ For all its praise however, this beautiful and historic city was not always this way and came from rather humble beginnings. Chattanooga, during its industrial era, was said to be “the Dirtiest City in America” in October of 1969 during an evening CBS news broadcast with Walter Cronkite. Over 40 years later however, Chattanooga is home to some of the most advanced technologies commercially available such as 3D printing and,

most importantly, a gigabit internet infrastructure. In addition, the city was also given the 2010 Entrepreneurial Livable Award by the Partners for Livable Communities.^{55, 56, 57}

Chattanooga is also a city that major manufacturers and distributors such as Wacker Chemie, Volkswagen, Alstom Power Inc., and Amazon have begun to call home. These corporations have invested \$2.4 billion, \$1.6 billion, \$300 million, and \$91 million, respectively, and created an additional 650, 4,000, 360, and 1,249 jobs for Chattanooga, respectively.^{66, 79, 80} Given Chattanooga's immense growth and improvement over more than 40 years, this small southeastern tech-town has big potential to become an entrepreneurial hub for the newest apps and services, the big data industry, internet communications, 3D printing, and 3D hologram technologies.

In 2010, EPB was the first company to offer 1 Gbps network speeds in the United States to the city of Chattanooga. 1 Gbps, relative to its time, was over 217 times faster than the reported national average of 4.6 Mbps.^{58, 59} For citizens of the United States and especially for the residents of Chattanooga, this was a significant breakthrough in network infrastructure. The capabilities of this technology are as numerous as they are impressive, and allow for processes such as seamless streaming of Ultra High Definition (UHD) 4K content, transferring multiple files quickly across a network, and large video conferences. There are also a number of other uses suited to residential interests, although those who will truly harness the power of this infrastructure will be businesses and other professional institutions and organizations who either generate and/or transfer large amounts of data. An empowering example of Chattanooga's gigabit network utilization was performed by the University of Southern California and STEM School Chattanooga, where a live stream from a 4K UHD microscope at USC was transmitted to the STEM School students in Chattanooga, allowing them to observe microorganisms within their own classroom and manipulate and interact with the microscope in real-time, giving them the opportunity to further analyze the microbial samples that were being placed on the sample slide, all from 1,800 miles away.⁶⁰

The fact that this educational opportunity was feasible is excellent for the future of Chattanooga. In addition, EPB had been working on continually upgrading its infrastructure and, consequently, on October 15, 2015, EPB introduced its next innovation for Chattanooga's network: 10 Gbps internet service. Relative to the most

current national average speed of 12.6 Mbps, EPB's 10 Gbps service is over 793 times faster than the national average. Even EPB's "regular" 1 Gbps service is almost 80 times faster than the reported national average for 2015.^{61, 62, 63} And while faster internet speeds for the public allow for better streaming, more downloads, and faster uploads, the fiber optic service from EPB also created a significant, positive impact on the local economy. Over the time period of 2011-2015, the gigabit network has had an estimated social and economic impact valued at \$865.3 million while creating an additional 2,800 jobs. For the residents of Hamilton county, this provides an economic benefit of \$2,832 per resident.⁶⁶

While the upgrade in EPB's fiber optic infrastructure certainly provided Chattanooga residents with access to some of the fastest internet speeds in the world, equally as important are the EPB's Smart Grid capabilities. The \$232 million project installed about 170,000 smart meters and a number of other infrastructural upgrades throughout Hamilton County, saving EPB about \$1.6 million in operating costs solely through automated meter readings. The automated switching system also significantly reduced the number of workers necessary to identify malfunctions or damaged areas of the grid. During a particularly severe storm on July 5, 2012, EPB saved about \$1 million in costs associated with the restoration effort. The automated system also reduced the need for trucks and scouts in the troubleshooting process, resulting in a reduction of 630,000 truck driving miles and 4.7 million pounds of carbon emissions. The Smart Grid also allowed EPB to reduce peak demand by up to 30 MW per month, resulting in an additional \$2 million in savings. Overall, EPB's Smart Grid has reduced power outages by an average of 60%. EPB estimates that a power outage costs about \$100 million per year due to lost productivity and, therefore, the Smart Grid saves about \$60 million annually.

^{67, 68}

Part II: The Journey to Another Dimension

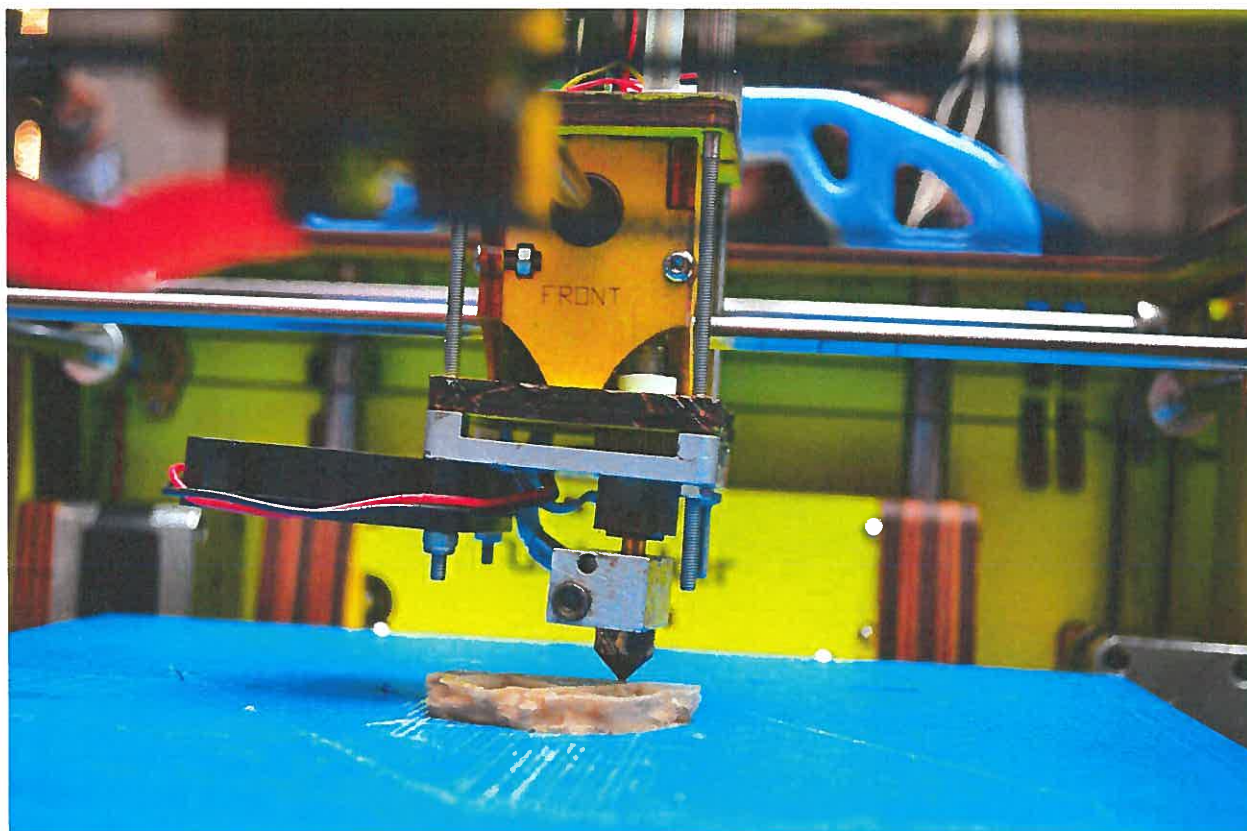


Image: 3D Printer, Wikipedia

3D printing is an industry that is still in its infancy and has found a home and purpose in Chattanooga. Whether the 3D printer is being used to generate a pair of shoes, a model of a human organ, or a house, Chattanooga startups Feetz[®], 3D Ops, and Branch Technology are looking to revolutionize a number of industries through 3D printing.

According to The Company Lab website, Chattanooga's main business incubator, "Feetz[®] is a 3D printing manufacturer and retailer that creates custom-fit footwear for consumers of all shoe sizes".⁶⁹ This particular startup participated in Chattanooga's GIGTANK 2014 3D Printing Track that sought to connect 3D printing entrepreneurs with seed money from investors. Feetz[®] is also the first GIGTANK startup to secure an investment from The Jump Fund, which is a women's angel fund based in Chattanooga

along with being a recipient of the 2015 Chattanooga Technology Council's Early Innovator Award.⁶⁹ Having received \$1.5 million in confirmed seed funding as of May 2015, (an additional "six-figure" investment was made by former Reebok CEO, Uli Becker), along with heading to Silicon Valley to grow the startup, this early-stage company has certainly started off on the right foot.^{70, 95}

There is no doubt that multiple industries will be affected by 3D printing technologies, but revolutionizing healthcare with this technology will have a significant impact on both practicing healthcare professionals and the people paying for healthcare services. This is exactly where 3D Ops hopes to play a role. 3D Ops is, "a 3D printing manufacturer that provides patient-specific 3D printed models to hospitals and surgeons for enhanced presurgical planning. Using patient-specific data, the company creates anatomical 3D models that enable surgeons to plan procedures before operating on patients".⁷¹ The startup's business model is based around a subscription service, leasing their services of 3D printing organs through the utilization of MRIs, CAT scans, or visual outputs from other imaging devices. The modeled organs are then shipped to the hospital for further use within 24 hours. 3D Ops has also formed a contract with Erlanger Hospital in Chattanooga and plans to extend their services to other hospitals in the upcoming years.^{71, 72, 73}

While 3D printing is traditionally thought to be done on a smaller scale, the 3D printing startup Branch Technology has moved into bringing innovation to the housing industry. After participating in GIGTANK 2015, the startup won the Demo Day Investor's Choice Award and was selected to participate in The TENN statewide master accelerator.⁷⁵ The startup's idea is to use a large robotic arm to generate a 3D matrix to be used as a supporting framework for a building. Once the framework is complete, foam insulation, concrete, and other traditional construction materials can be layered over the framework to increase overall durability and aesthetics. As of the summer of 2015, Branch Technology has collected more than \$900,000 in seed funding, a portion of which was a personal investment by Founder and CEO, Platt Boyd.^{74, 76}

Part III: An Entrepreneurial Ecosystem



Image: Chattanooga's Innovation District, used with permission

The previously mentioned 3D printing startups, while they have gained significant momentum and, consequently, have brought even more recognition to Chattanooga as a home for up and coming entrepreneurs, are just some of the startups Chattanooga has fostered. The Company Lab, known better as The Co.Lab, is Chattanooga's startup accelerator for businesses seeking mentorship and funding and has had a number of companies graduate from their accelerator programs. A total of 67 companies have graduated from the Co.Lab's 100-day growth and mentorship program and a total of 40 companies have graduated from the GIGTANK365 program, an accelerator suited for entrepreneurs developing ultra high-bandwidth business services.⁷⁷ The Co.Lab also hosts other programs to give early-stage entrepreneurs an opportunity to pitch their ideas or formulate their thoughts into working ideas within 48 or 24 hours.⁷⁸

For southeastern startups seeking seed money for their early-stage companies, there are multiple, industry agnostic investment firms looking to support Chattanooga's local entrepreneurs. Blank Slate Ventures, The Jump Fund, the Chattanooga Renaissance Fund, and the Lamp Post Group are just some of the investors in Chattanooga's and Tennessee's startups throughout the years, and continue to play an active role in Tennessee's entrepreneurial scene.⁸² In addition to the startup investors based in Chattanooga, the city continues to plan and build upon the 140 acre Innovation District in the heart of its downtown region. To promote a space of collaboration and growth, the Edney Innovation Center has a number of floors available for lease for startups wanting access to ideas, mentorship, and other startups to partner with. Already housed in this building are The Co.Lab, the Enterprise Center, and the Society of Work, all of whom seek to promote growth and collaboration for all startups seeking to develop their ideas into businesses within Chattanooga's business climate.⁸³

Part IV: Chattanooga, Beyond the Data

3D printing is an industry that is likely still in its infancy. Nevertheless, it possesses great power to revolutionize manufacturing industries of all sorts. 3D printing has expanded from small, handheld objects to creating frameworks for houses. If a prototype of an object is to be made, a 3D printed version of the object will most likely be made first. Ball bearings, gears, cranks, and other intricacies are all possible using 3D printers and, consequently, 3D printing provides a cheaper alternative to building an actual model of the device using the potentially expensive or rare materials of the object's composition. If an object can be constructed using 3D modeling software, the object can be created. On the industrial scale, 3D printers have potential to reduce R&D costs for experimental prototypes. The healthcare industry will be largely affected by this, as synthetic body parts could be printed and used to replace damaged parts, such as bones. If an electrically conductive polymer could be used within a 3D printer, muscle loss or atrophy in patients involved in serious accidents could have the damaged muscle replaced with a synthetic muscle mesh that could be printed and then surgically transplanted into the affected area, restoring normal activity and usage of the muscle group for the patient. As 3D printing technology becomes more prominent, 3D printers will serve as a tool for replacing parts cheaply or, at least, temporarily until a proper replacement can be installed for residential maintenance issues. 3D printers will also serve as a bit of a toy, as enthusiasts and hobbyists utilize 3D printers to make their imaginations a reality. Overall, 3D printing will create a number of subsidiary markets ranging from casual usage to industrial application with a number of other materials to be implemented into the devices, ranging from quick-drying polymers and plastics to metals and synthetic meshes.

Just as the internet has non-exclusively allowed people of diverse backgrounds to access information all around the world, a gigabit internet connection will only strengthen this benefit, allowing anyone to have access to technology and information that would have otherwise been unavailable to them, just as the STEM School students were able to experience. For Chattanooga to have a gigabit network infrastructure is, at the moment, "...like being the first city to have fire. We don't know all the things we can

do with it yet".⁵⁴ Nevertheless, the possibilities for city-wide growth and expansion are potentially limitless.

The first of many capabilities of a gigabit network is working with big data. Big data can take a number of general forms such as audio, video, images, and text, but general forms of information and data can be broken into three categories: private information, commercial information, and public information. Each of these information types will then be affected uniquely through the utilization of gigabit internet.

In transmitting personal information, people will be able to capture, send, and receive UHD content regularly and seamlessly. The supply of UHD media is, and will continue to be, as widely available as it will be expected by the consumer within Chattanooga. Other cities will inevitably follow Chattanooga's example as the gigabit technology becomes increasingly prominent within the United States and internationally. With Chattanooga being on the forefront for internet communications, this aspect will be an important factor for people contemplating future plans of residence within the Southeast and the United States. Of the people staying or moving, Chattanooga is particularly attractive to the millennial generation, who will become the foundation for new and innovative businesses.⁶⁶ Likewise, residents of Chattanooga who were born there are more likely to stay given the technological prosperity within their hometown. With these two factors combined, Chattanooga will potentially outgrow traditionally larger cities such as Knoxville.⁶⁵

With more people deciding to reside within a particular region, businesses will undoubtedly do the same. If Chattanooga is to become an entrepreneurial hub, this population and business growth positive feedback loop is not only inevitable, but necessary. As people decide to take their business ideas to Chattanooga searching for talent and investors, this will only strengthen Chattanooga's entrepreneurial environment, as even more people will likely follow, which, in turn, behaves as another positive feedback loop. For entrepreneurs looking to develop their next app or provide their next service to supplement the already prominent leisure economy, Chattanooga's population will serve as a strong sample size to test the popularity and overall reception of an app or service.

As Chattanooga's entrepreneurial environment continues to expand in the upcoming years, Chattanooga businesses will begin to see and experience first-hand the entrepreneurial innovations of the future within their own city. Given Chattanooga's leading internet infrastructure, new technologies and services will be implemented much more readily relative to other cities within the nation. Chattanooga businesses will no longer be restricted by distance insofar as business transactions or meetings go. With a gigabit internet network, large conference calls streaming video in UHD will be possible, making long-distance meetings simultaneously more personal and professional. Dropped calls or poor connections will be problems of the past while clarity and detail will be the new standard. With 3D hologram technology, granted both parties have the capabilities, executives and board members of same or separate businesses will be able to have discussions in a virtual meeting room with holograms of each member being transmitted. All documents, files, or other objects that are to be discussed in a meeting will be seemingly tangible using this technology, appearing readily in the hands of each member to be virtually manipulated and reviewed as necessary. Instances such as doctor's appointments could be performed from home, allowing both a patient and a doctor to meet each other within a virtual space to discuss certain health issues. The amount of time, energy, and resources that are saved through this technology will result in a significant increase in productivity and efficiency for businesses in Chattanooga and, eventually, everywhere.

With all of this information being transmitted through a gigabit network, big data will only continue to play a dominant role in everyone's lives. In addition, big data, cloud computing, and machine learning are and will continue to be intimately connected. Businesses will continue to use data to improve their corporate policies, reduce turnover, increase employee happiness, and track overall company productivity. On a larger scale, businesses will also become more proactive in adapting to economic fluctuations in their respective markets by utilizing financial information and predictions based off machine learning algorithms.

As Chattanooga continues to expand and upgrade its total infrastructure, Chattanooga will become one of the first cities in the Southeast and even the nation to

fully embrace IoT. Street lights, door locks, steam pipes, water lines, and public security cameras are just some of the things that will inevitably be connected through Chattanooga's future infrastructure. A connected city will behave more like an organism than as a series of separated, inanimate life forms. The city will continually check its trash levels, lighting outages, road irregularities or damages, broken power lines, and a number of other characteristics, all while keeping public workers aware of these issues. With these systems being constantly monitored, public workers will spend more time resolving the more pressing issues while simultaneously preventing future infrastructural problems. An implemented smart-grid is already present within the city of Chattanooga and this grid will only increase in complexity as time proceeds.

With public cameras and integrated facial recognition software, traditional street crime will significantly decrease, as any observable criminal activity will be recorded, stored on a server, and even interpreted by the camera as a potential crime and, consequently, alert local authorities immediately. With crime typically occurring in particular parts of the city, crime spots will be mapped along with a description of the crime in various regions throughout Chattanooga, which will give authorities a greater perspective on the location and time of particular types of criminal activity. This complete connectivity however, also raises some privacy issues: who has access to this data? How secure is this data? Where is the line between security and privacy? All of these questions and more will continue to make information ethics and privacy a topic of constant discussion amongst citizens. This topic of discussion will consequently affect public policy as lawmakers and politicians seek to enact and revise state and federal laws.

As mentioned in the previous section on the future of Knoxville, the criminals of the future will not be traditional. Theft will no longer be performed using a knife or handgun, but rather a keyboard and a mouse. A connected city is a malicious hacker's playground, being able to manipulate the infrastructure as they please and potentially causing serious damage in the process. Being able to access public records would allow a hacker to manipulate or even wipe any information from a server, allowing someone to be digitally erased from history. With the potential of all these serious issues, there is no doubt that network and electronic security will be the number one priority if IoT is to be properly implemented.

Conclusion

Although Tennessee may not be one of the largest states, it nonetheless is an innovative state. Tennessee's strengths in the healthcare, music, and internet industries, will allow for a significant amount of growth as time progresses. In addition, Tennessee has a number of other realms in which it plays an important role: energy, scientific research and development, industrial manufacturing, aerospace and defense, transportation, and other forms of social and technological innovation are all contributors to Tennessee's economic growth and statewide development.

While only three cities in this report were discussed, a number of other cities within Tennessee are promoting entrepreneurship and innovation in their own way and have particular strengths that pertain to the industries above along with a few other others. In fact, since 2012, businesses in Tennessee have brought in over \$945 million in investments, with \$280 million received in 2015 alone. Given this rate of investment, the total investment will surpass \$1 billion as of early 2016.⁸⁴ That being said, this report, while it seeks to provide a clear and detailed snapshot of the current situation pertaining to business and entrepreneurship in Tennessee, is not entirely exhaustive. There are a number of excellent studies on industries in Tennessee that, for anyone interested in a specific market, are easily accessible on the internet. As for anyone interested in knowing more about the general growth and development of business in Tennessee, the websites of Launch Tennessee and the Tennessee Department of Economic and Community Development have a number of excellent reports with accumulated data on general statistics, major business events and growth, and investments within the state of Tennessee.

While history may not exactly repeat itself, it certainly rhymes. That said, something that should be noted are the historical parallels between Silicon Valley and Tennessee, as they begin to tell a similar story. Likewise, there exists strong support for the conclusion that Tennessee has the potential to become a center for entrepreneurial ventures within the Southeast.

About the Author



As a senior chemistry major, German minor, and soon to be 2016 graduate at the University of the South, Daniel has a passion for innovation in any and every field whether it is science, technology, art, or literature, and enjoys taking the entrepreneurial route in his work. He considers himself to be a definite optimist, as he strongly believes and plans on making the future better than today. Daniel also fully believes that innovation in any industry can promote innovation in another: science is as much of an art as art is a science.

Daniel is a recipient of study abroad scholarships pertaining to German and business and has been abroad twice now to Europe for both academic and professional obligations. Daniel has also studied at the Stanford Graduate School of Business and has travelled through Germany with the German-American Chamber of Commerce learning about IoT, Big Data, and startups. He is also part of the GACC alumni network and is fluent in German. Daniel is a Chattanooga native and is excited for the future of his home state of Tennessee.

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All precautions aside, the future of a gigabit network and a connected city will provide benefits that would otherwise be unfeasible. A smart city will be the new standard for cities across the globe, and Chattanooga will be the one of the early testing sites for available technologies and infrastructure related to such a project. As for Chattanooga as a whole, successful startups within Chattanooga will attract more investors, more investors will allow for more successful startups, which, in turn, will be a provider of new jobs in a variety of industries. New and successful businesses will bring social and economic growth to the Chattanooga area, causing this entire process to repeat itself. The effects of this positive feedback loop are what make a city grow to become a center for innovation, and, given the city's environment and growth, it is likely that Chattanooga will take on the role as an important site in the southeast for entrepreneurial ventures.