REENGINEERING RURAL INNOVATION

THE CASE FOR A TECHLAB AND MOBILE TECH TRAILER IN RURAL VIRGINIA

A FEASIBILITY STUDY

CONDUCTED BY

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FOR

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DECEMBER 2018 - DECEMBER 2019

This feasibility study was authorized through the financial support from The Commonwealth of Virginia Department of Housing and Community Development, on behalf of Regional Council 8, under the terms of the Virginia Growth and Opportunity Act.

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EXECUTIVE SUMMARY

San Jose, Silicon Valley's largest city in Northern California, which encompasses 180 square miles, is arguably the innovation epicenter of the USA. It has eight makerspaces within a five-mile radius. There are over sixty-two coworking facilities within this same area. Per capita, this equates to 128,765 people per makerspace and 16,614 people per coworking facility.

Compare that to Augusta County in the Shenandoah Valley, which draws an almost perfect 20-mile radius around Staunton City and encompasses 1,006 square miles inclusive of the independent cities of Waynesboro and Staunton. Within this area there is one makerspace and two co-working facilities. Per capita, this equates to 121,983 people per makerspace and 60,992 people per coworking facility. Our per-capita allocation is, perhaps not surprisingly, dissimilar. However, the strong disparity in the distance that our residents must travel to these facilities creates a tangible and challenging barrier to innovation and therefore economic growth.

As noted in the TEConomy study commissioned by GO Virginia, "encouraging the formation of new coworking spaces that offer incubation and have value-added place-based programming will greatly enhance new startup activity, creating a more entrepreneurial culture in the region." Unfortunately, the Commonwealth of Virginia lags behind its peers in start-up formations which is directly correlated to negative implications for long-term job creation and economic growth. The rate of new firm formation in the Shenandoah Valley from Lexington to Winchester (as a Percent of All Firms) in 2014 – was 5%. Compared to 7% for Virginia as a whole, and 8% for the United States, we can see a specific challenge to bolstering the region's economic opportunities. [i]

The solution to these challenges is to help our rural region gain access to these innovation facilities – reliably and frequently. These facilities must not compromise by teaching last decade's syllabus on hand-me-down equipment, but instead they must have the most modern tools and curriculum otherwise available to any major tech-hub – including Silicon Valley. Most importantly, we must help our rural communities connect to an innovation ecosystem where they are supported, inspired, and feel enabled to make the changes they envision.

It is pursuant to this goal that we propose the construction of two cutting-edge tech labs – the mobile "TechTrailer" and the stationary "TechLab".

The revolutionary TechTrailer is a highly modular, mobile lab designed and run in partnership with Massachusetts Institute of Technology (MIT)'s "Fab Lab" program, and is expected to cost approximately $140,000. It takes the "makerspace" idea on the road, bringing unique resources, lessons, programming, and credibility to local venues and rural areas throughout the Valley. Via partnerships with schools and community organizations, we will provide curriculum, training, and opportunities to areas where such resources are scarce. We will underpin all of

the equipment and programs with a focus on community building to create a self-energizing movement of rural innovation and possibility.

The stationary TechLab, a $410,000, 2,000 square-foot physical space in downtown Staunton, will serve as both a necessary "home base" for the TechTrailer and associated equipment, and also as a physical hub for students, entrepreneurs, businesses, and community members to be immersed in a fun, collaborative, and forward-thinking environment. It will be outfitted with commercial-grade 3D printers, laser cutters, robotics equipment, high-powered computers, and engaging prototype space intended to inspire innovation, collaboration, and creativity. It will be housed in "Phase 2" of the already successful Staunton Innovation Hub. Phase 2 is scheduled to open in late March 2020.

Together, these two integrated facilities will provide three key purposes:

1. Provide our region access to modern, high quality equipment, technology, and tools
2. Provide equally powerful programming, developed and curated with one of the top innovation and technology universities in the world, and
3. Serve as an integrator and collaborative force among area schools, businesses, citizens of all ages, and other area programs.

The funds to sustain the two labs long-term will come from three sources: grants, lab use fees, and product sales. Makerspace precedents similar to ours have been successful and sustainable because they represent the future of education and the evolution of the economy. Across the country, makerspaces are thriving because people of all ages recognize that developing skills such as programming, electronics, and advanced manufacturing opens up a wide range of high paying job opportunities and entrepreneurship options.

The Staunton Innovation Hub is our primary partner organization and is contributing an estimated $240,000 via the cost of the construction of the brick and mortar TechLab. Mary Baldwin University will be an anchor tenant in SIH, giving their graduate and undergraduate students access to the resources in our TechLab. Our support from The City of Staunton and Page County will provide connections to local businesses and facilitate access to the regional K-12 schools. We will partner with The Virginia School for the Deaf and Blind to bring resources that are uniquely powerful for students with vision and/or hearing impairment. The number of valuable relationships we have forged, and *will* forge, will ensure our Techlabs are not limited to one school or organization but will be a stimulating and meaningful community resource for our whole region.

"For every $1 expended on secondary and postsecondary CTE, $5.37 is returned to the state economy in direct earnings, increased productivity, and additional labor income and taxes," according to a report commissioned by Tennessee in 2006. [ii]We expect much the same return on our investment. In ten years, we expect to see an increase in the percent of graduates who remain in this region after graduation as a direct results of the opportunities supported by the tech lab initiatives. This will not only accomplish the goals of The Central Shenandoah

Planning District Commissions Comprehensive Economic Development Strategy,[iii] but will also achieve our ultimate goal: preparing our young people for this new economy, and providing a home in the Valley for entrepreneurs as they seek to take their ideas to market.

INTRODUCTION

Sunrise is at least two hours away on a damp slope of apple trees in the Shenandoah Valley. Despite the forecast, a cold front is pushing through and a swirl of cool air sends a shudder through the leaves. The only light in the orchard is mottled moonlight filtered through shifting clouds, until a diffuse glow of red briefly illuminates the underside of an apple leaf. A sensor the size of a stick of gum has picked up an unexpected half-degree temperature drop. Using a sip of current from its solar-charged battery, the sensor beacons a tiny signal to a hub in the orchard owner's house, a half mile away. At the same time, an array of three dozen identical sensors throughout the orchard sends their own data, painting a high-resolution picture of the conditions in the trees. In less than a second, the hub aggregates the data, sends it to a server two hundred miles away, and an automated script performs an analysis and determines the best course of action. A relay in the orchard clicks and a huge fan slowly rotates 28° to the east. The fan spins up to the calculated speed and blows for 46 minutes until the sensors indicate that the apple temperatures are back within the desired zone. The fan turns off and the sensors go back to silently monitoring, just as the orchard owner's coffee pot clicks on.

This is apple growing in the twenty-first century. The ubiquity of small, connected, inexpensive computing devices is changing apple growing, just as it is disrupting every other industry, from education to transportation to health care. The most successful grower is no longer the one with the most workers or even with the most land, but the one who is leveraging cloud computing, artificial intelligence, and robotics to automate their systems and maximize efficiency across their business.

The shift toward automation and computerized systems is shifting workforce needs. Communities that are not keeping up with these changes are seeing a drain of human capital. Young people with these 21st century skills are moving to areas that promote and nurture technical skills, seeking modern job opportunities.

For decades, looking for a job in a technical field meant moving to one of three places: Silicon Valley, Boston, or New York. As recently as 2016, three quarters of all venture capital went to just three states.[iv] Fortunately, as more communities catch up with the shifting educational and job landscape, pockets of modern job opportunities are popping up all over the country. This redistribution has caught the attention of investors like billionaire Steve Case who, along with fellow Silicon Valley investor JD Vance, has been crisscrossing the country looking for innovation in communities overlooked by the first internet boom. Vance recently told a crowd in Chattanooga, "I see what's going on in the next wave of innovation, the next wave of technological change, as really depending on things that places like Chattanooga are good at,

as opposed to the things that Silicon Valley are good at … It's about changing a community's perception of itself, so that it can both play to its strengths and retain young talent that will otherwise flee."[v]

A BRICK AND MORTAR TECHLAB AND MOBILE TECHTRAILER

We are proposing the construction of two spaces dedicated to providing resources, training, connections, and economic growth to our communities. The TechLab and TechTrailer will be two connected labs – one a brick-and-mortar experience centralized in the valley in downtown Staunton and the other a flexible makerspace on wheels – both equipped to bring 21st century education to the Valley.

The TechLab, a 2,000 square-foot space in downtown Staunton, will be outfitted with 3D printers, laser cutters, robotics equipment, and high-powered computers intended to inspire innovation, collaboration, and creativity. A facility of this caliber is not in the fiscal or programming reach of our smaller schools. It is, however, within the reach of our region as a collaborative effort. We will continue to partner with nearby schools and organizations to offer classes and training, everything from app development to circuit board fabrication and small business planning. The space will also be open to entrepreneurs looking to develop their latest ideas. We believe in the power of bringing people together in a shared workspace and teaching creative and collaborative ways to use modern tools to develop new products and acquire new skills. The stationary TechLab will also serve as a storage and staging area for the modular equipment that will fill the TechTrailer (below). See Appendix A for proposed schematics of the TechLab and a detailed equipment list, including cost.

The revolutionary TechTrailer will take this idea on the road, bringing unique resources and experiences to local venues and rural areas throughout the Valley. It is a mobile maker lab designed and run in partnership with Massachusetts Institute of Technology (MIT)'s "Fab Lab" program. The highly modular design of the TechTrailer allows quick customization for each daily destination. It will travel through the region very frequently, bringing a cutting edge makerspace experience to the many areas of our region that will otherwise be without such opportunity. Partnering with schools and community organizations, we will provide curriculum, training, and opportunities to areas where such resources are scarce. The trailer will be modular and flexible so lessons and equipment can be custom tailored to the unique needs of each community. See Appendix B for a proposed layout of the TechTrailer and a detailed equipment list, including cost.

We will bring fresh, relevant ideas and modern tools to our communities that will inspire young people – and re-inspire folks who are leaving the workforce – to engage in shaping their world. We want students of all backgrounds to get out of the classroom and dive into learning through problem solving, teamwork, creating, and making. These are the experiences that will build the prosperous citizens, productive workers, and leaders of tomorrow. These are the building blocks for a valley that is an economic, educational, innovative, and vocational leader.

We need approximately $410,000 to build out the foundational 2,000 square-foot TechLab, as part of the renovation of the former News Leader building in downtown Staunton. This lab will feature the aforementioned equipment as well as: Augmented Reality, Virtual Reality, and the latest supporting software. More importantly, the TechLab will also serve the associated programming and culture necessary to fully maximize the experience of such a space. It will serve as a hub for students, entrepreneurs, and innovators. Our goal is to lower the barriers to innovation by providing education, training, and resources that prepare students to become innovators, be it via an entrepreneurial path or within current employers. We believe in the power of bringing people together in a shared workspace and teaching creative and collaborative ways to develop new products and acquire new skills.

An additional $140,000 will outfit a mobile TechTrailer – picture a large race car trailer, but filled front to back with computers and advanced manufacturing equipment – designed to bring these same resources and experiences of the TechLab to rural areas throughout the Valley. Figures 4 and 5 below are examples of other successful mobile labs. Partnering with schools and community organizations, we will provide curriculum, training, and opportunities to areas where such resources are scarce. The trailer will be modular and flexible so lessons and equipment can be custom tailored to the unique needs of each community.

Figure 5: MOBILE FAB LAB; RICHMOND, VA

Figure 4: CLEVELAND STEM HUB MOBILE TRAILER

We are partnering with Staunton City Schools, Augusta County Schools, Waynesboro Schools, Page County Schools, Mary Baldwin University, James Madison University, Valley Career and Technical Center, Community Foundation of the Central Blue Ridge, and the Virginia School for the Deaf and Blind. Through close collaboration with this diverse group, we intend to ensure that we appropriately tailor the offerings of the TechLab and TechTrailer to meet the needs of various localities throughout our region.

Our goal is to begin construction of the TechLab as the Staunton Innovation Hub Phase 2 building nears completion, in March of 2020. At the same time, we will purchase materials and begin outfitting the TechTrailer, as well as begin the search for a full-time employee to run the two labs. Both projects will be completed in December 2020.

ECONOMIC IMPACT

The last fifty years have seen a radical shift in nearly every aspect of life and sector of commerce. The information age and the internet boom have changed how we communicate, learn, relate, shop, and live - and the pace of change is only accelerating. A consequence of this exciting revolution in the jobs landscape has been the consolidation of high-tech jobs into only a few regions, namely coastal cities and areas like Silicon Valley. But a new era is upon us, what AOL founder Steve Case calls the "third wave." The ubiquity of low cost, low power connected computing devices – often called the "Internet of Things" – promises to decentralize 21st century jobs and bring opportunities to budding entrepreneurs in places like the Shenandoah Valley.

This third wave will open up markets to communities in ways not imaginable just ten years ago. Our project will ensure that young people and entrepreneurs in the Shenandoah Valley have the tools, experiences, and mindset necessary to best prepare them for this exciting future. As more and more businesses evolve to rely on automation and need technical talent, we want the Valley to be a rich source for them. As entrepreneurs seek to take their ideas to market, we want the Valley to be their home.

It is pursuant to this goal that we are proposing the construction of the two labs.

Conversations with local entrepreneurs, educators, and business leaders have revealed the demand and exciting potential of these labs. Business students at Mary Baldwin University will enjoy real time exposure to entrepreneurs and opportunities for internships and/or jobs with those entrepreneurs. These students will have access to the technologies and resources in our TechLab, none of which is typically available to business students and all of which will lead to the potential for above average pay as they become our future technology business leaders.

Our area high school students will have similar opportunities and hands-on experiences which will help embed the idea that challenging, high-tech, rewarding, high-paying jobs are to be had right here in the Shenandoah Valley.

The TechTrailer will augment the technical education classes already happening throughout the Valley. Math students will have an opportunity to create 3D visualizations of their lessons. Students in metal shop will learn to add mechatronic components to their inventions. Art students will explore painting and sculpture in augmented reality. And students at the Virginia School for the Deaf and Blind will design and build electromechanical devices custom made for their needs and will even help develop accessible curriculum.

The TechLab and TechTrailer will benefit from being outside of and not connected to any particular school. This brings novelty and real-world context to school lessons as well as makes our curriculum accessible to those beyond their school years. We have the flexibility to deliver

21st century content at soup kitchens, prisons, and city parks – providing regular content and assistance to adults looking to gain upward mobility.

As proposed, the TechLab and TechTrailer will require the recruitment of two full time employees. The proposed budget includes the salaries for these two hires for one year. Ongoing funding will be necessary to continue to retain these two positions. The responsibilities for running the TechLab and TechTrailer will be shared by these two employees. The primary goal of the staff will be education. When students visit TechLab, one or both employees will be responsible for facilitating activities, supervising equipment use, and delivering curriculum. The staff will also be responsible for equipment upkeep as well as experimenting with new technologies as they become available and deciding on appropriate implementation of new resources.

21ST CENTURY JOB OPPORTUNITES

This project's main goal – 21st century job opportunities – is based on research regarding factors generally contributing to economic growth and specifically tied to the goals of GO Virginia and the priorities laid out in the Region 8 Economic Growth and Diversification Plan.[vi]

A young person entering the workforce today might land a job as a "director of cloud transformation," an "augmented reality specialist," or a "machine interoperability manager." These jobs did not exist just a few years ago, and with the rate of technological change only accelerating, it is safe to assume that a decade from now, today's eighth grader will be looking for jobs that are as unimaginable today as "health informatics architect" was a few years ago. Our project aims to be a resource for schools and communities looking to best prepare students to thrive in this future dominated by technology and accelerating change.

Throughout the Shenandoah Valley, from elementary to high schools to higher education, teachers and administrators are responding to the shifting technological landscape. At McSwain Elementary in Staunton, Virginia, third graders are studying buoyancy by engineering 3D printed boats while fifth graders are coding drones to simulate how bees pollenate flowers. At Mary Baldwin University, entrepreneurship students get their hands dirty with product design and innovation in a new makerspace.

Yet conversations with these educators reveal a universal truth: all schools could use assistance when it comes to time, resources, and training. Even the most agile and well-funded schools struggle to stay up to date with trends such as programming languages, advanced manufacturing processes, and hardware platforms. And even if schools had the money to always own the latest 3D printer, purchasing said printer will not be an efficient use of funds if the printer will only be used an hour or so per day or if teachers are not trained to use it.

The TechLab and TechTrailer are built on a different framework, where a centralized source of up-to-date resources, training, curriculum, and tools are available to all schools in the Shenandoah Valley. Schools with already-flourishing STEM programs will augment their

activities with novel lessons and the latest tools. Schools that have struggled to secure funding and or staffing for such programs will receive an invaluable resource.

Both the brick-and-mortar TechLab and the roaming TechTrailer will be modular and flexible to meet the different needs of schools and organizations throughout the Valley. A fleet of 3D printers will allow a whole class of elementary students to design and fabricate speaker cones for their science unit on sounds while high school seniors will use virtual reality headsets to practice physical therapy techniques. Across the Valley, students of all ages will be given unprecedented opportunities to learn high-tech skills, collaborate on projects, and see how technology can mesh with their lives and interests. When these young people are ready to enter the workforce, they will have doors open to them in high-paying technical roles in local companies or as owners of their own start-up companies.

Across the Valley, as industries from health care to manufacturing adopt new technologies, these students will be the workforce that makes them run. A food packing plant looking to implement new sensors and data collection systems to streamline their processes will need creative, confident, and technologically literate employees. And that high school student who wrote a phone app to help their grandparents send health data to their doctors as part of her senior capstone project will know that the Valley is a good place to get her start-up off the ground.

Specifically, and in alignment with the Staunton-Augusta-Waynesboro Ten-Year Career and Technical Education Strategic Plan[vii] we aim to:

- Offer hands-on training, aligned to the Virginia Standards of Learning, specifically geared toward high-demand and high-paying workforce skills
- Develop project-based curriculum, where students collaborate on projects that can start in lower grades and add more technology as students progress
- Identify students who are not traditionally successful high school students and get them on the career and technical education (CTE) career path
- Provide more students more exposure to technical training and other CTE content
- Help students and parents understand that a 2 or 4-year college degree is not the only path to a successful career
- Connect local employers to students; connect learning to local workforce needs
- Expose students to the many career options that don't require a college degree

TIMELINE

Date	Milestone Description
March 2020	Open Phase 2 of the Staunton Innovation Hub
April 2020	Complete renovation of TechLab space in SIH Phase 2 building; begin construction of TechLab
April 2020	Hire full-time employee to lead outfitting of TechLab and development of curriculum
May 2020	Purchase trailer for TechTrailer, begin renovation
June 2020	Purchase pickup truck for TechTrailer
July 2020	Complete construction and outfitting (furniture, furnishings, equipment) of TechLab
July 2020	Complete renovation of TechTrailer
September 2020	Ribbon cutting for TechLab
January 2021	Inaugural road trip for TechTrailer

PERFORMANCE METRICS AND ROI

We are seeking approximately $300,000 in funding, perhaps from GO Virginia, and are expecting at least a 100% return on this investment in ten years, meaning that within ten years the TechLab and TechTrailer will provide at least $600,000 in value to the region. The value provided to the region by these two labs will be difficult to specifically quantify, given that their primary value will be in providing skills and opportunities to be realized over many years in myriad ways. But, it is important to assign some specific and measurable performance metrics to the project in order to demonstrate its success.

The Central Shenandoah Planning District Commission Comprehensive Economic Development Strategy published in August 2018 identified several performance metrics connected to its vision for enhanced job opportunities in the region, including the number of telecommuting workers, the percent of graduates who remain in the region after graduation, and the number of high school students enrolled in workforce training programs.[viii]

Another quantifiable measure of success of this project is the number of students pursuing education beyond high school. Not everyone needs to go to a four-year college, but there is a clear link between post-secondary education and income, and therefore tax revenue for localities. The College Board [ix] has estimated that 2015 median annual taxes (federal, state, and local) range from $5,200 for individuals with less than a high school diploma to $10,100 for associate's degree holders to $14,500 for bachelor's degree holders.

Reliance on public assistance, as well as the probability of unemployment, decline in lockstep with level of education. In particular, Trostel (2008) estimates total savings to state and local governments to be roughly $34,773 for each individual who completes a college degree instead of stopping after high school, in addition to the tax benefits described above.[x]

There are also intangible and indirect benefits that ultimately provide financial value to the region. According to the Urban Institute, higher levels of education lead to decreased spending on policing and incarceration and are correlated to improved health and productivity measures.[xi]

In 2011, the Center for American Progress published a study of more than 9,000 school districts across the country, evaluating their educational efficiency, or return on investment, meaning how do dollars spent per pupil translate to achievement. Their findings found that strong community relationships were a recurring factor in those school systems deemed the most efficient. According to the study, "Many of the highly productive districts worked closely with their communities to help maximize education spending. Franklin Public Schools in Massachusetts, for example, merged its technology department with that of the town to reduce costs."[xii]

Another 2011 study conducted by the National Research Center for Career and Technical Education, looked in particular at the effects of Career and Technical Education (CTE) training for high school students and adults beyond secondary school. Both groups saw significant gains in income and a reduced reliance on government assistance. That is a win-win for localities looking to boost their economic growth. The post-secondary group saw their hourly wages increase by over $3.00 and their quarterly earnings were greater by more than $1,500.[xiii]

Finally, a meta-analysis conducted in 2010 by Advance CTE summarized three state-funded studies that found significant benefits to the individual and the state when students went through CTE programs. A 2008 study in Oklahoma found that CTE-trained students earned nearly $4,100 more per year than those without such training. As a result, the state sees direct benefits in terms of tax revenue as well as indirect multiplier effects. Their estimate is that Oklahoma made $157 million over the life of CTE-completers by investing in their education. In 2006, Tennessee commissioned a report, finding "that for every $1 expended on secondary and postsecondary CTE, $5.37 is returned to the state economy in direct earnings, increased productivity, and additional labor income and taxes. In total, over 16,000 jobs were created or impacted by those expenditures and earnings." In Washington in 2006, the Upjohn Institute released a report that found similar benefits to the individual in terms of significantly increased funds and to the state in terms of tax revenue and decreases in public assistance.[xiv]

REGIONAL COLLABORATION

Our project will serve the entire Shenandoah Valley. Due to the mobile nature of the TechTrailer, we will have the ability to reach schools and communities throughout the region, from Winchester down to Lexington. The project will be centered in Staunton, with the brick and mortar TechLab in downtown Staunton at the Staunton Innovation Hub (SIH) serving as home base for the TechTrailer. From there, just about any corner of our region can be reached within a two-hour drive (see Appendix C).

Initially as the project gains traction, the radius of service will be smaller, focusing on schools and organizations in Staunton, Harrisonburg, and Page County. Our partners include Mary Baldwin University, James Madison University, Valley Career and Technical Center, Community Foundation of the Central Blue Ridge, the City of Staunton, Page County, and Augusta County.

PARTNER ORGANIZATIONS

The idea of the TechLab was born out of a series of conversations with businesses and learning institutions about the lack of access to technology and the mindset that higher paying jobs through technology are out of reach for rural constituents. We convened meetings with Mary Baldwin University, James Madison University, Valley Career and Technical Center and area school systems to discuss how we can work together to change the way that people in the

Valley think about invention and innovation. We found that there was no centralized location or a designated leader to put all of these moving parts together.

STAUNTON INNOVATION HUB ("SIH")

SIH is our primary partner organization, and is contributing to the project via the cost of the construction of the brick and mortar TechLab itself, estimated at $240K. This renovation will allow SIH to quadruple available space and create a home for its key anchor tenants: Staunton Creative Community Fund, The News Leader, Mary Baldwin University, and Skyler Innovations. The mission of SIH is reducing barriers to innovation by supporting innovators of all ages and abilities through the entrepreneurial continuum that takes an idea from conception to maturity.

PAGE COUNTY

Page County has one of the highest unemployment rates in the Valley. Only 10% of its population has attained a degree from an institution of higher learning.

Page County Public Schools (PCPS) is the epitome of a school system recognizing the seminal shift in living and learning that has happened in the last two decades. PCPS is already using 21st century technologies to break down the walls between subjects and give young people authentic problem solving opportunities. However, conversations with teachers and technology leaders in Page County reveal that their resources are limited. Visits from the TechTrailer will enable teachers in Page County to take their lessons to the next level.

Discussions with Page County administrators also reveal the importance of bringing TechTrailer resources to institutions other than schools. We envision the TechTrailer parking outside a food pantry or community center to offer classes on electronics repair. The TechLab and TechTrailer have the potential to upskill workers throughout the Valley who are struggling to find employment. We have the opportunity to give lessons on new technologies and with those lessons, hope.

Our conversations also gave rise to the vision of a co-operative network of people throughout the Valley boosting their skills in everything from welding to programming. When a local company is looking to hire a lab technician, we hope that the TechLab network will be the first place they look.

CITY OF STAUNTON

The population of Staunton is 23,743 with an unemployment rate of 3.7 % and 23% of the population attaining a degree from an institution of higher learning. The average median income for Staunton is $42,948.

The City of Staunton and Page County will be contributing to the study by providing connections to local businesses and facilitating access to the regional K-12 school. For both

localities, the most important factor contributing to long-term success is access to a well-trained workforce. We have letters of support from both school systems.

MARY BALDWIN UNIVERSITY

Mary Baldwin University (MBU) is already an important part of the SIH community. MBU's Vantage Point office of student engagement is a member of SIH and holds regular office hours within our Phase 1 facility. The Vantage Point has already performed matchmaking for student interns and SIH member companies. Mary Baldwin's first-in-the-nation For-Benefit MBA and Business Leaders Living Learning community will be housed in Phase 2 of SIH. They will have designated classroom and study space. The MBU-SIH partnership will create a full entrepreneurial experience for current and future MBU students by giving students real time exposure to entrepreneurs and opportunities for internships and/or jobs with those entrepreneurs. Undergraduate students learning about product innovation and design as well as MBA students learning about entrepreneurship will have a unique opportunity to engage in hands on activities in the TechLab. According to business professors at MBU, forming future technology business leaders will require bringing technology into the business curriculum. The TechLab will be the perfect place for that.

Conversations with faculty at MBU revealed the need and potential power of building a TechLab in Staunton. Hands-on, multi-disciplinary experiences in the TechLab will attract a broad range of students – in particular, genders and nationalities not typically represented in technical and business field – to MBU programs.

JAMES MADISON UNIVERSITY X-LABS

The James Madison University (JMU) X-Lab is a fully functional makerspace on their campus. According to this X-Lab website, the combination of course work, tools, and critical thinking available through the X-Lab is why X-Lab graduates earn 33% more than their peers.[xv] We believe a similar opportunity will occur for the MBU students.

JMU X-Labs will be a mentor in the early stages of our project. They also serve as a vivid example of how new technologies like 3D printing and drones are not merely fads, nor the toys of technology geeks. For example, a multi-department group of JMU students recently studied how to reverse the declining oyster population off the Virginia coast. Using 3D scanning and printing technologies, these students manufactured concrete replicas of oyster beds to begin bringing back the oyster population.

VIRGINIA SCHOOL FOR THE DEAF AND BLIND

We will partner with the Virginia School for the Deaf and Blind (VSDB) to bring resources that are uniquely powerful for students with vision and/or hearing impairment. As expressed by the VSDB's superintendent, if you are making education accessible to students with impairments, then you are just making education accessible which is one of the primary aims of our project.

As an example, learning geometry is particularly difficult for the visually impaired. Discussing concepts such as acute versus obtuse angles or conic sections can be frustratingly abstract. Using advanced manufacturing, the TechLab will provide students at the VSDB with tactile on-demand learning tools that will bring geometry and other lessons to life.

COST EFFICIENCIES

The most powerful cost efficiency identified is the repurposing of the old News Leader building in downtown Staunton. Rather than building a standalone space for the TechLab, we will benefit from tying our lab into the already underway renovation in that building. Nearly 2,000 square feet of space formerly occupied by printing machines stands ready for a 21st century overhaul.

Our labs will also benefit from existing precedents and guidance from the Sigma Lab at Charlottesville High School, the X-Labs at JMU, Design Lab at the University of Virginia, and a partnership with Massachusetts Institute of Technology (MIT)'s "Fab Lab" program. By collaborating with these precedents, we will benefit from the lessons they have learned and not repeat mistakes they have made.

The Fab Foundation was founded in 2009 with the express purpose of supporting the growth of similar labs as well as the development of regional capacity-building organizations. Collaborating with the Fab Foundation and leveraging a decade of experience will directly enhance the efficiency of our efforts.

Additionally, we are reaching out to truck and trailer manufacturers for discounts in the development of the TechTrailer. The two vehicles together will cost nearly $50,000, but through partnering with manufacturers, we expect to reduce that cost.

BARRIERS TO SUCCESS

In order to anticipate all possible barriers to success, we have met with and interviewed dozens of stakeholders for this project. We have spoken with students, teachers, school administrators, university faculty, industry leaders, and officials in cities and counties throughout the Shenandoah Valley. And all of our discussions have included brainstorming around potential hurdles and pitfalls. Fortunately, as soon as any potential stakeholder learns of the project, their initial reaction is invariably some version of "This sounds amazing! I wish I had something like this when I was in school!" Therefore, we are confident in the success of this project, but a few potential challenges have emerged.

BUY-IN

The most common challenge mentioned by stakeholders is buy-in. As put by one teacher, "you can't just drive a trailer up to the front door of a school." Throughout the Valley, teachers and administrators are busy and are already implementing high-quality curriculum. If teachers perceive this project as a burden or not directly tied to the success and learning of their students, there will be pushback. We are already actively mitigating this challenge by speaking with stakeholders about their needs and asking them for specifics about what resources will be most beneficial for them. In particular, several teachers told us that they do not have the bandwidth to develop new curriculum, but if the TechLab and TechTrailer could provide packaged curriculum specifically tied to Virginia Standards of Learning, they will embrace the idea.

An administrator from a rural area told us "Don't just show up with a 3D printer; show up with hope." Some students and community members have a hard time envisioning a bright future for themselves. By bringing a resource to them from outside their communities yet tied to their experiences, the TechTrailer has the potential to link their current situations to future success. We will work with teachers and locals within each community to ensure that curriculum and activities are connected to the local context while pointing to exciting opportunities in the future.

According to the Central Shenandoah Planning District Commission Comprehensive Economic Development Strategy, the lack of understanding of career pathways amongst residents impedes career advancement in some sectors presents a threat.[viii]

BUDGET

Another potential barrier is the budget required to run the TechLab and TechTrailer successfully. Once built and running, both facilities will require regular upkeep and materials replenishment. Considerable effort has gone into devising a streamlined and efficient model for the TechLab and TechTrailer, in order to minimize costs, but ongoing fundraising will be required. To mitigate this hurdle, we have detailed these anticipated costs and have identified potential sources of revenue, detailed below.

STAFFING

Due to the technical nature of the TechLab and TechTrailer coupled with their novelty, finding full time staff to run them and deliver curriculum presents a potential hurdle, but also an opportunity. The Shenandoah Valley is full of current college students and recent college graduates who could serve as part time employees of the Labs. For example, nearly 1,900 students were enrolled in the College of Integrated Science and Engineering at James Madison University (JMU) last year, as well as 487 in the College of Education. Partnering with JMU could provide a steam of young and talented volunteers and paid interns to help staff the Labs.

PREREQUISITE ACTIVITIES

It would be impractical if not impossible to run a five-year pilot for a program such as the TechLab and TechTrailer before launching the actual project, but our project has what is probably the next best thing. We will directly benefit from the experience gained through the design, construction, outfitting, and five-year history of the Sigma Lab at Charlottesville High School. The primary consultant for the TechLab and TechTrailer projects, Dr. Matthew Shields, is also the designer and founder of the Sigma Lab, which he conceptualized in January of 2013 and opened to students in the fall of the following year.

Dr. Shields earned his master's degree in mechanical and aerospace engineering from the University of Virginia and worked as an engineer at General Dynamics, one of the world's largest engineering firms before entering the world of education. He completed his PhD in curriculum and instruction, also from the University of Virginia, in 2011. Dr. Shields was instrumental in securing grants to build an 8,000 square foot STEM lab, later renamed the Sigma Lab, at Charlottesville High School.

Running the Sigma Lab for five years has essentially served as a prerequisite activity for the launch of the TechLab and TechTrailer projects. Since the Sigma Lab opened its doors in the fall of 2014, Dr. Shields has written the entire five-year – soon to be seven year – project based engineering curriculum taught in the lab and has overseen the purchasing and upkeep of the lab's equipment.

It is easy to spend a lot of money on STEM curriculum and equipment that does not directly benefit students. The nascent market of STEM education is full of expensive kits and packaged curriculum and it is a difficult market to navigate. Dr. Shields has spent the last five years weeding through existing curriculum, piloting software, and testing hardware. Charlottesville City Schools is a small public school system with a limited budget, so Dr. Shields has focused on eliminating waste and maximizing efficiency in his purchases. He now consults part time with school systems, helping them pare down their shopping lists to the essentials to be used and enjoyed by students.

3D printers are now available for as little as $14 and can cost over $100,000. Dr. Shields has spent five years testing and evaluating 3D printers in the context of education to determine the best mix of price, reliability, speed, flexibility, ease of use, and other factors. Similarly, laser cutters range from a couple hundred to hundreds of thousands of dollars. Dr. Shields has tested dozens of laser cutters to determine size and power that works well with students. CAD software is available free and in your browser. CAD software is also available as a desktop installation for $30,000 per seat. Dr. Shields has evaluated the entire range, including beta testing new programs yet to come to market. The world of electronic controls and robotics was revolutionized largely because of the Arduino Uno microcontroller board, released in 2010. Since then, the microcontroller market has exploded. The Arduino brand now sells dozens of boards and other familiar brands in the market include Raspberry Pi, Beaglebone, Particle,

SparkFun, Circuit Playground, Micro:Bit, Microsoft, and Adafruit. Dr. Shields has put each of these boards in the hands of students to test their features and determine their power, durability, ease of use, and available support. With Dr. Shields's experience and expertise, we are confident that we have already cleared many of the initial hurdles that the TechLab and TechTrailer would encounter if it were to launch as a new and untested model.

Lastly, our research has revealed that the concept of a mobile makerspace is not unprecedented. We will benefit from the experience of other educators and makers who have embarked on similar projects. In particular, we have been in communication with the FabLab Houston Mobile Unit and the Fab Foundation to learn from their experiences taking the makerspace idea on the road. As part of his prerequisite research, Dr. Shields visited the FabLab Houston Mobile Unit at a recent conference in Dallas, Texas. Conversations with that team helped us evolve our initial plan to outfit an old school bus into the current plan to use an enclosed cargo trailer, towed behind a truck. This provides many benefits including AC power, interior lighting, and a full-sized low access door ramp.

SUSTAINABILITY

Neither the idea of the TechLab, a brick and mortar makerspace, nor the TechTrailer, a makerspace on wheels, are unprecedented. Schools and communities around the world have been embracing the power of centralized making resources for years. And, as explained earlier, the TechTrailer will benefit from the mobile FabLab precedents.

Nothing like this exists in the Shenandoah Valley. In particular, our efforts are unique in that our goal is to be a shared community resource, not limited to one school or organization. The TechTrailer, in particular, seeks to bring 21st century resources far and wide throughout the Valley. When the dissemination of high-tech resources depends on the tax revenue of a particular school district, that only serves to entrench further socioeconomic conditions. Our labs will seek out those localities who will most benefit from our resources, and bring both economic diversification and higher paying jobs to those areas.

Makerspace precedents similar to ours have been successful and sustainable because they represent the future of education and evolution of the economy. Across the country, makerspaces are thriving because people of all ages recognize that developing skills such as programming, electronics, and advanced manufacturing opens up a wide range of high paying job opportunities and entrepreneurship options.

THE BUDGET

(See appendices for detailed cost breakdown.)

TechLab construction	$240,000
TechLab equipment	$170,000
TechTrailer	$140,000
Annual salary for one full time TechLab employee	$50,000
Total	$600,000

After the TechLab is constructed and outfitted with equipment and the TechTrailer is purchased, one employee will be necessary for the first year to set up the TechTrailer, to develop curriculum, and to start building the schedule for the following year. In year two, once both labs are fully functional, we will ideally hire a second full time employee who will ensure that both labs are fully functional and available during normal business hours, Monday through Friday. If necessary, costs could be reduced by only staffing one full time employee and relying on hourly interns. The labs could also reduce the number of available hours. But in the ideal case, ongoing annual cost estimates are as follows:

TechLab and TechTrailer consumables	$50,000
TechLab and TechTrailer new equipment and upgrades	$50,000
Annual salary for two full time TechLab employees	$100,000
Total	$200,000

The funds to sustain the two labs long-term will come from three potential sources: grants (local, state, federal and private), lab use fees, and product sales.

GRANTS AND DONATIONS

According to the Foundation Center (2018), there were more than 86,203 grant-making foundations in the United States in 2015. Their grants totaled $62.8 billion. According to the same study, total charitable giving has been increasing every year since 2014 and reached

$410.02 billion in 2017. Education organizations received the second-highest share of private charitable contributions, after religious organizations, at 14.3 percent. [xvi]

These statistics, particularly the level of giving to educational organizations, gives us confidence that charitable donations and grant funds are available. The website grants.gov currently lists nearly 1,000 educational grants available, including 74 from the National Science Foundation. As an example, the National Science Foundation grant 18-571, Advanced Technological Education, is unrestricted (open to any entity type) and has an estimated $66 million available for "the education of technicians for the high-technology fields that drive our nation's economy."

We also hope to be able to secure money through the Carl D. Perkins Vocational and Technical Education Act, an act first authorized by the federal government in 1984, with the aim of increasing the quality of technical education within the United States in order to help the economy. The Perkins Act provides $1.2 billion in federal support for career and technical education programs in all 50 States.

On July 31, 2018, the Perkins Act was reauthorized for the fifth time as Perkins V, the Strengthening Career and Technical Education for the 21st Century Act, with some amendments that support the eligibility of projects like the TechLab and TechTrailer to secure Perkins funds.

A portion of the $1.2 billion each year is designated as Perkins Reserve funding. Perkins V increases that portion to 15 percent, or $180 million. According to an Excel in Ed brief (2018), Perkins V expands the definition of eligible local recipients and Perkins Reserve funds can now be awarded to areas with disparities or gaps in performance, in addition to areas that meet geographic and student enrollment requirements. These changes provide states with the flexibility to invest in innovation and creativity in local areas.[xvii]

FEES FOR SERVICES

Finally, the TechLab and TechTrailer will receive revenue through fees for use. While SILI is a nonprofit organization and the Labs are intended to be free community resources, we occasionally intend to provide services for payment both in single use situations and through a subscription model.

The TechLab will primarily be occupied during the week by non-paying student groups and community members, predetermined as needing the TechLab resources. However, the Lab will charge a fee for occasional evening classes and Saturday workshops aimed at more affluent customers. Hobbyists and local companies that make frequent use of the TechLab's resources will have the option to pay a monthly subscription for access. Similarly, the TechTrailer will spend most of its time serving rural areas throughout the Valley, freely providing much needed resources, but will also be available for rent for events.

PRODUCT SALES

One of the benefits of partnering with organizations like James Madison University (JMU) is the boundless source of experience and ideas. During our research, faculty at JMU suggested investigating the potential of selling products out of our TechLab and/or TechTrailer. Students or local entrepreneurs could team up to create an online presence to market and sell products and services from the labs. Students will benefit from the experience of starting and running a business and the labs will benefit from receiving a portion of the profits.

CONCLUSION

The Shenandoah Valley is poised to be a vanguard in the next wave of innovation. With many industries ripe for disruption and innovation, it is critical that young people be given tools and opportunities to best prepare them for this new economy. High paying jobs and entrepreneurial opportunities await a generation of innovators if they are willing and prepared to grab them. We will provide job opportunities to individuals and open up markets to communities not imaginable just ten years ago. We can ensure that young people and entrepreneurs in the Shenandoah Valley have the tools and experiences necessary to best prepare them for this exciting future. As more and more businesses evolve to rely on automation and need technical talent, the Valley will be a rich source for them.

The apple orchard owner's daughter saw apple growing as a dead end until she saw the data from her first hand-soldered sensor show up on the phone app she coded. Now her plans are not only to take over ownership of the orchard, but also to market her devices to apple growers worldwide.

APPENDICES

APPENDIX A – TECHLAB LAYOUT (TENTATIVE) AND COST ESTIMATE

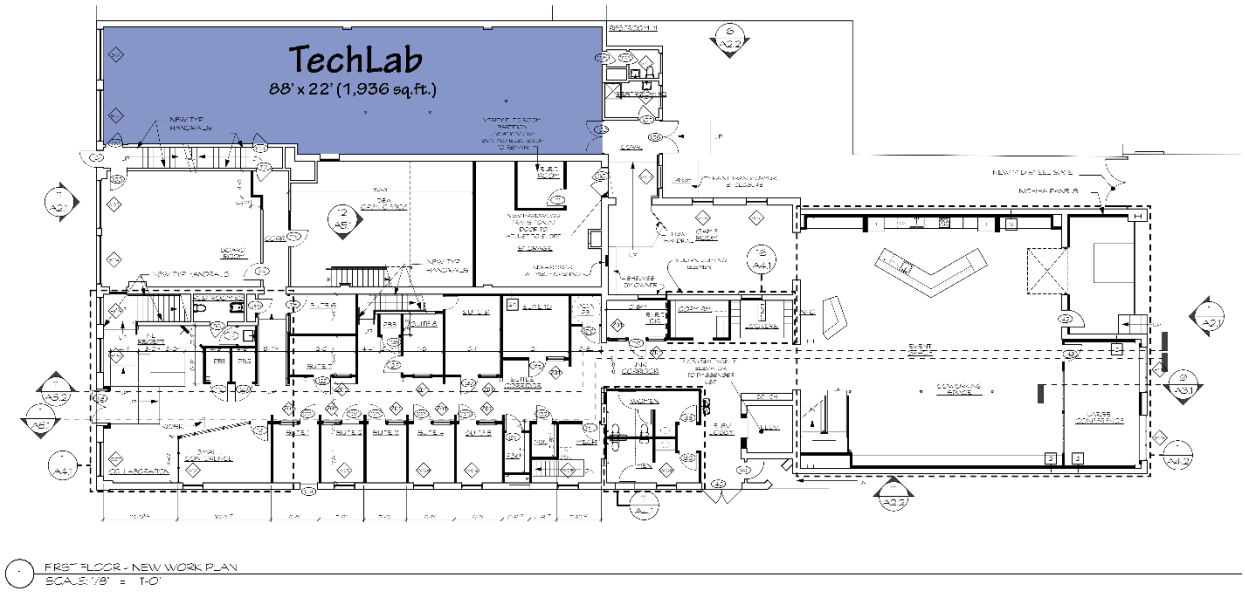

FIGURE 1 - PROPOSED TECHLAB SPACE - 88' X 22' (1,936 SQ. FT.)

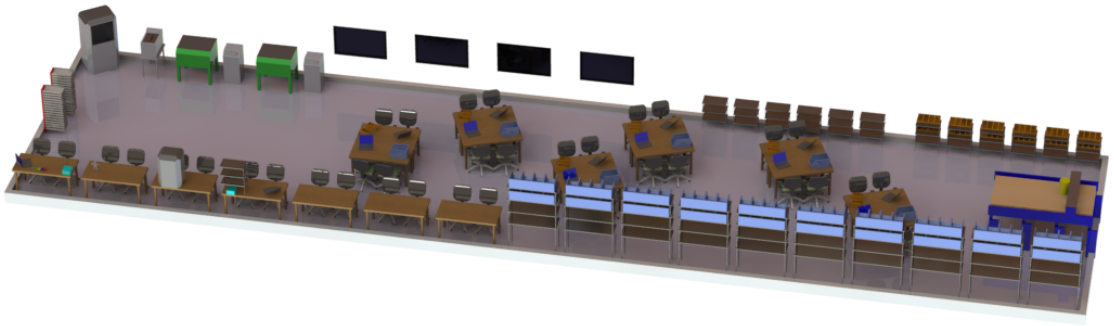

FIGURE 2 - TENTATIVE TECHLAB LAYOUT (ORTHOGRAPHIC)

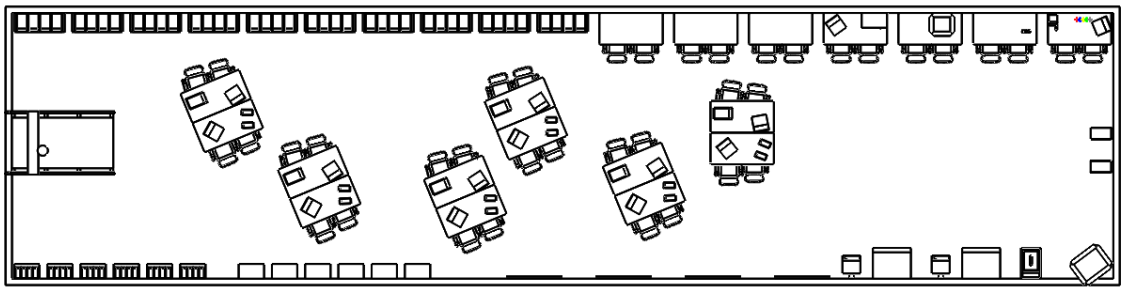

FIGURE 3 - TENTATIVE TECHLAB LAYOUT (PLAN)

APPENDIX A (CONT.) - COST ESTIMATE

Description	Model	Unit Price	Quantity	Total
Fume extraction	BOFA AD Oracle iQ fume extraction system	$ 6,799.00	2	$ 13,598.00
Laser cutter	Universal Laser Systems VLS 3.60 laser cutter	$ 18,923.00	2	$ 37,846.00
3d printer	Makerbot Method 3D printer	$ 6,499.00	1	$ 6,499.00
Desktop CNC	Carbide3D Nomad 883 Pro desktop CNC machine	$ 2,599.00	1	$ 2,599.00
3D printer	Ultimaker s5 3D printer	$ 5,995.00	1	$ 5,995.00
Laptop	Lenovo ThinkPad X1 Carbon	$ 1,139.00	10	$ 11,390.00
Large scale CNC	ShopBot PRSalpha	$ 46,914.00	1	$ 46,914.00
Medium scale CNC	Carbide3D Shapeoko XL CNC Router	$ 1,599.00	1	$ 1,599.00
Printer/scanner	HP Color LaserJet Pro M477fnw Laser Printer	$ 379.00	1	$ 379.00
Monitor	Dell P Series 42.51" Screen Monitor P4317Q	$ 855.00	4	$ 3,420.00
Tool storage	OEM Tools 24615 Stainless Steel Rolling Cabinet	$ 1,049.00	2	$ 2,098.00
Hand tools	Hand tools (screw drivers, pliers, etc.)	$ 1,000.00	2	$ 2,000.00
Electronics tools	Electronics tools (soldering stations, wire, etc.)	$ 1,000.00	2	$ 2,000.00
Elec. components	Electronics components (LEDs, resistors, etc.)	$ 1,000.00	2	$ 2,000.00
Balsa wood	Assorted balsa wood	$ 500.00	2	$ 1,000.00
Acrylic	Assorted acrylic	$ 500.00	2	$ 1,000.00
Furniture material	Wood for shelving, cabinets	$ 1,000.00	2	$ 2,000.00
Internet	Wi-Fi hardware	$ 500.00	1	$ 500.00
Software	Software licenses	$ 2,000.00	1	$ 2,000.00
3d printer	Stratasys F170	$ 20,000.00	1	$ 20,000.00
Total				**$ 164,837.00**

TABLE 1 - TECHLAB COST ESTIMATE

APPENDIX B – TECHTRAILER PRECEDENTS, LAYOUT, & COST ESTIMATE

FIGURE 4 - CLEVELAND STEM HUB MOBILE TRAILER

FIGURE 5 - MOBILE FAB LAB; RICHMOND, VA

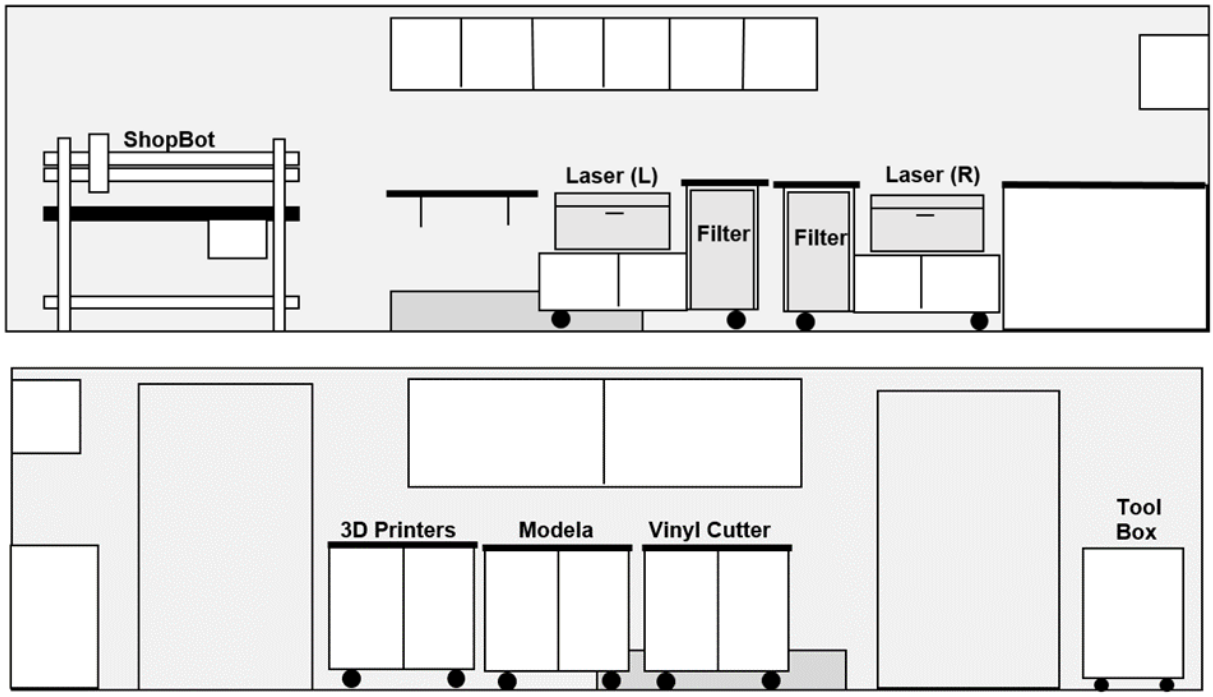

FIGURE 6 - SAMPLE MOBILE FAB LAB LAYOUT; DRIVER AND PASSENGER SIDES

FIGURE 7 - PACE AMERICAN SHADOW GT TRAILER GALLERY

Length	31’10” (9.70 m)
Width	102” (8’6”; 2.59 m)
Height	102” (8’6”; 2.59 m)
Interior Length	27’7” (8.41 m)
Interior Width	96” (8’; 2.44 m)
Interior Height	78” (6’6”; 1.98 m)
Rear Opening Height	75” (6’3”; 1.91 m)
Rear Opening Width	96” (8’; 2.44 m)
Gross Vehicle Weight Rating	9900 lbs.
Curb Weight	4180 lbs.
Payload Capacity	5770 lbs.
MSRP	$17,775

TABLE 2 - PACE AMERICAN SHADOW GT RACE CAR TRAILER, MODEL SCX8.5X28TE3 SPECS

APPENDIX B (CONT.) – TECHTRAILER COST ESTIMATE

Item Description	Quantity	Unit Price	Total
Pace American Shadow GT race car trailer, model SCX8.5X28TE3	1	$ 17,775.00	$ 17,775.00
Ford F-150	1	$ 27,705.00	$ 27,705.00
BOFA AD Oracle iQ fume extraction system	2	$ 6,799.00	$ 13,598.00
Universal Laser Systems VLS 3.60 laser cutter	2	$ 18,923.00	$ 37,846.00
Makerbot Method 3D printer	1	$ 6,499.00	$ 6,499.00
Carbide3D Nomad 883 Pro desktop CNC machine	1	$ 2,599.00	$ 2,599.00
Ultimaker s5 3D printer	1	$ 5,995.00	$ 5,995.00
Lenovo ThinkPad X1 Carbon	10	$ 1,139.00	$ 11,390.00
Carbide3D Shapeoko XL CNC Router	1	$ 1,599.00	$ 1,599.00
HP Color LaserJet Pro M477fnw All-in-One Laser Printer	1	$ 379.00	$ 379.00
Dell P Series 42.51" Screen LED-Lit Monitor P4317Q	1	$ 855.00	$ 855.00
OEM Tools 24615 Stainless Steel Rolling Tool Cabinet Combo	1	$ 1,049.00	$ 1,049.00
Hand tools (screw drivers, pliers, etc.)	1	$ 1,000.00	$ 1,000.00
Electronics tools (soldering stations, wire strippers, etc.)	1	$ 1,000.00	$ 1,000.00
Electronics components (LEDs, resistors, etc.)	1	$ 1,000.00	$ 1,000.00
Assorted balsa wood	1	$ 500.00	$ 500.00
Assorted acrylic	1	$ 500.00	$ 500.00
Wood for shelving, cabinets	1	$ 1,000.00	$ 1,000.00
Wi-Fi hardware	1	$ 500.00	$ 500.00
Software licenses	1	$ 2,000.00	$ 2,000.00
Total			**$ 134,789.00**

TABLE 3 - TECHTRAILER COST ESTIMATE

APPENDIX C – GO VIRGINIA'S REGION 8 HIGH SCHOOLS

School	Locality	Distance from SIH (miles)
Buffalo Gap HS	Augusta County	10.5
Fort Defiance HS	Augusta County	9.3
Stuarts Draft HS	Augusta County	10.3
Wilson Memorial HS	Augusta County	6.6
Riverheads HS	Augusta County	10.1
Bath County HS	Bath County	54
Clarke County HS	Clarke County	103
James Wood HS	Frederick County	96.9
Millbrook HS	Frederick County	96.7
Sherando HS	Frederick County	88
Harrisonburg HS	Harrisonburg City	26.5
Highland HS	Highland County	43.3
Page County HS	Page County	47
Luray HS	Page County	57.9
Rockbridge County HS	Rockbridge County	35.5
Broadway HS	Rockingham County	39.7
East Rockingham HS	Rockingham County	35.2
Spotswood HS	Rockingham County	26.3
Turner Ashby HS	Rockingham County	21.8
Stonewall Jackson HS	Shenandoah County	118
Central HS	Shenandoah County	63.5
Strasburg HS	Shenandoah County	76.8
Staunton HS	Staunton City	1.7
Stuart Hall School	Staunton City	0.4
VA School for Deaf and Blind	Staunton City	0.6
Skyline HS	Warren County	81.4
Warren County HS	Warren County	92.5
Waynesboro HS	Waynesboro City	11.3
John Handley HS	Winchester City	94.5

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