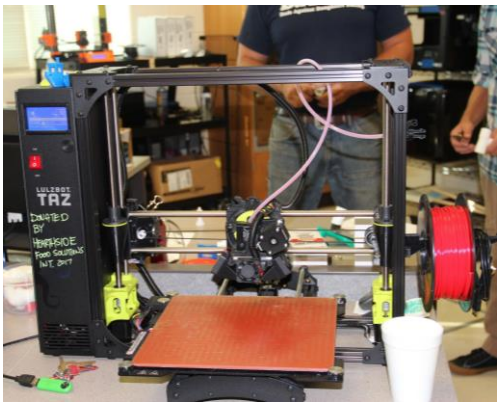
CASE STUDY 1: HEARTHSIDE FOOD SOLUTIONS- ADDITIVE MANUFACTURING INTEGRATION

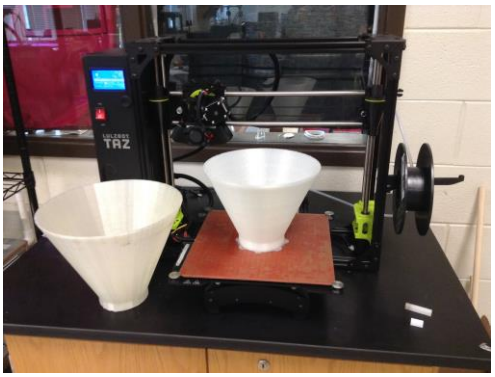
Hearthside Food Solutions is a global producer of baked goods with locations in the US and Europe. Like any volume producer, Hearthside relies on optimum equipment operation and minimizing downtime as much as possible to generate profits. As such, their facility maintenance and operation departments are key players in this regard, especially when it comes to unique replacement parts for their machines. But, like any similar maintenance team the world over, they typically have to rely on outside vendors to provide replacement parts. This was the problem when it came to a part in more than sixteen of their critical machines. The part is a custom made Nylon funnel used with sensing equipment at the end of the processing line prior to bagging, and cost their department over $800 each to replace. With over sixteen machines and a need to replace this part multiple times a year, it was drastic drain on their operational budget. So much so that they often had to try to repair the damaged parts themselves. Considering the downtime associated with the manufacturing and shipping of these funnel parts to their facility, the total costs, including lost productivity, were very significant.

Somerset Community College's (SCC) Additive Manufacturing (AM) department, in conjunction with the National Science Foundation's Advanced Technological Education grant program, offered Hearthside an opportunity they could not refuse. SCC agreed to partner with Hearthside's team to help them internalize the production of funnel, made with an FDA approved grade of Nylon, using Additive Manufacturing (AM). SCC AM Lab Technicians, using their expertise in both engineering and AM, selected the optimum, low cost, FDM 3D printer, helped Hearthside optimize the design, and determined the best production settings for the AM equipment to operate.



The result was that within less than 30 days, SCC AM Lab Technicians had developed the process that Hearthside needed to produce this previously $800 part for about $40 right in their own office area. Since the 3D printers can operate 24/7, with little or no oversight, Hearthside

was able to produce a funnel part every 32 hours. In savings alone, the initial price of the $2,500 desktop 3D printer was paid back in less than a week. But beyond that, AM has practically eliminated the previous downtime associated with the replacement of those parts by having a supply of replacement funnels ready to go and a regular replacement schedule.



Now that Hearthside has the ability to control the design and production of the funnel part, they can go even further and optimize its shape to control production speed and dispersion as the baked goods pass through the funnel. Additionally, when the 3D printer is not printing funnels, their team uses it to replace other parts and make upgrades on equipment throughout the facility. In fact, within four months of their initial AM integration, Hearthside has estimated their savings to be approximately $30,000 and growing. This results in nearly a 1,200% return on investment within only four months of AM equipment operation. Not only is this approach very direct, it is also very scalable, and the Hearthside team is taking steps to present their findings to the rest of their twenty-three facilities worldwide, which will bring the power and profits of Additive Manufacturing to their entire organization.

HFS Previous costs - $31,507.77
AM equipment costs - $2,188.50
<u>HFS Savings - $29,319.27</u>

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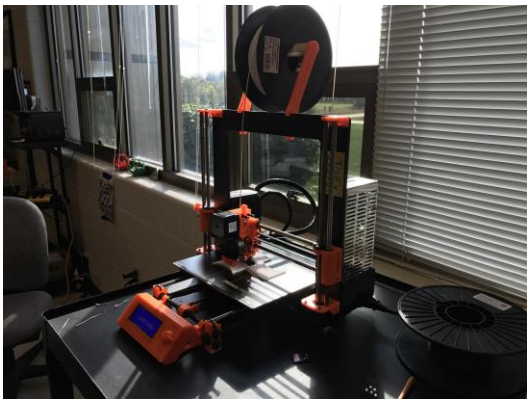
CASE STUDY 2: FULTON'S ESSENTIAL OILS PRODUCTS-
ADDITIVE MANUFACTURING PRODUCTION

One of the biggest challenges to all entrepreneurs that are developing new physical products is the obtaining the capital necessary to facilitate the prototyping and production process. Costs associated with engineering, design, tooling, labor, and equipment are almost always daunting and can easily exceed over $100,000 before the developer ever sells their first product. This typically means that a great deal of excellent products never hit the market because raising the funds can be nearly impossible for some inventors due to a lack of fundraising experience, demographic background, or even just a lack of the right networking connections.

This was the experience for Joshua Fulton. He and his wife had come up with an excellent concept for a product, and the concept was well received by their target market within the essential oils industry. However, they faced several problems. Although the market was primed for their product, their current estimated costs and time of manual production were far too high and too long, and they didn't have $150,000 just lying around to throw at this project. An even bigger problem was the complexity of their product; the design was such that conventional plastic injection molding could not be used as a production method. So even if they had the money and 8 to 12 months to get the molds made, it would still be impossible to produce what their market research said the consumers wanted.

Fortunately, Somerset Community College's (SCC) Additive Manufacturing (AM) department in conjunction with the National Science Foundation's Advanced Technological Education grant program offered the Fultons an opportunity they could not have imagined. SCC AM Lab Technicians agreed to collaborate with the Fultons to do something many would have said was impossible; to help them bypass all of their problems regarding funding and conventional manufacturing, and show them how to produce their end product with low cost FDM 3D printers. What would have cost tens of thousands to even begin development, cost less than $3,000 to begin testing and final production. The design development time spanned a period of only forty-five days, and involved only five actual days worth of design work.



The current result is that the Fultons

went from prototype concept to startup production in just one-hundred days with an equipment and parts budget of less than $5,000. An expense that, given their income of nearly $40 dollars per unit, will have an incredibly short return on investment period. Due to this eye opening experience, the Fultons are applying the training and expertise given to them by SCC AM Lab Technicians to purchase more desktop FDM units and set them up for a higher volume production of nearly 900 units a month. Additionally, with 24 to 28 hour print cycles, the Fultons only have to check on the equipment, unload, and reload them approximately once a day. This automation and minimum labor/overhead concept seemed virtually unimaginable before for such a low equipment cost.

Although the Fulton's business endeavors related to this product are less than four months old, their products are not only already available for purchase, but their opportunities are endless. Given the speed and flexibility of their Additive Manufacturing methods, they can continually iterate their primary product and block out competitors, introduce new features and artistic variations, and explore new markets with a minimum amount of research and development resources and time.

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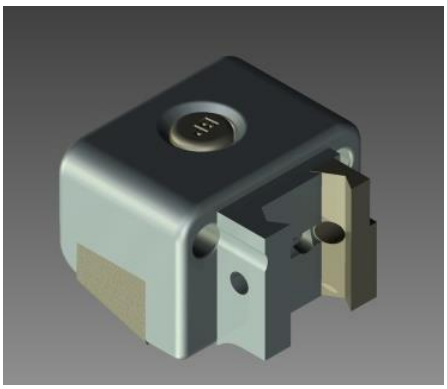
CASE STUDY 3: BULLPUP UNLIMITED-
RESPONSE TIME IN A SLUMPING FIREARMS MARKET

In the personal weapons industry, the American market is saturated with manufacturers both small and massive. National trends, politics, trade agreements, and government oversight regulations contribute a great deal to sales and performance of such companies. For example, after the 2016 elections, there was a severe slump in firearm sales. As a result, many large and small manufacturers were struggling to move products, and in some cases, even stay alive.

A trend that began to occur during this slump was sales generated from firearm accessories, versus the firearm products themselves. As the typical weapons consumer no longer felt a need or desire to purchase firearms, they instead began to purchase accessories like holsters, sights, modified magazines, tactical adapters, etc. Therefore, the market was primed for new add-ons to their existing equipment.

However, for the related manufacturers, scaling up and producing new accessories is typically a slow and expensive undertaking, and with many companies suffering from lack of expendable funds, their options were limited. Therefore, when the the Bureau of Alcohol, Tobacco, Firearms and Explosives (ATF) issued a new memo regarding a, somewhat vague but acceptable, use of assisting and stabilizing devices in place of typical rifle stocks, it opened up a new market for weapons accessory producers. However, investment funds and time-to-market conditions were again not ideal for most manufacturers. Bullpup Unlimited (BU), a small but well-received weapons manufacturer located in the rural region of central Kentucky, was one such company.



Somerset Community College's (SCC) Additive Manufacturing (AM) department, in conjunction with the National Science Foundation's Advanced Technological Education grant program, offered Bullpup Unlimited an opportunity to take advantage of these conditions and expedite the research and development processes necessary to enter an untapped market ahead of everyone else.

SCC Additive Manufacturing Lab Technicians agreed to collaborate with Bullpup Unlimited and using SCC's AM applications and expertise, went from BU's concept design to production-ready models in less than two months. Although the final products will be machined from metal, the reduced

prototype development time and expense was significant, and will hopefully allow Bullpup Unlimited to beat out all other competition to market by several months with their first version of this new product, which is a crucial factor. Because trends within the weapons industry are always changing, any new accessories will have to work with the most popular guns at the time, which means that rapid response and flexible manufacturing are critical. Being able to adapt quickly is what allows smaller companies like BU to compete with the larger and more well-established companies in this industry when considering normal market sales. Therefore, using new technologies like Additive Manufacturing to accelerate production is a foundational component to their survival.

Although this demonstration was based on just the first product line variation, Bullpup Unlimited has their sights set on four different product line variations to corner the market with their concept.

Therefore, BU will immediately be looking to use AM on the next three versions, as well.

Bullpup Unlimited's chief officer has already reported that if they had internalized this approach with additive manufacturing earlier, they could have theoretically had all four different designs iterated and finalized in approximately two to three weeks after the ATF announcement, and could have started shipping all four different variations in under two months from that point. This potentially would have allowed BU to establish branding on these lines of products and own the market in under four months, a completely unheard of possibility for most in the weapons manufacturing industry; especially considering the sales slump and the multitude of cases of company downsizing and layoffs that are occurring.

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CASE STUDY 4: AMERICAN WOODMARK CORP-
ADDITIVE MANUFACTURING INTEGRATION

American Woodmark Corporation (AWC) specializes in a variety of mass production wood cabinetry and furnishings worldwide and maintains 9 manufacturing facilities. Over the past 4 years, AWC's revenue sales have grown significantly, and posted over one billion in sales in 2017. And although markets and accent style trends will always change, AWC is at heart a manufacturer and thereby highly focused on optimization of their manufacturing process and always on the lookout for new ideas.

One idea specifically involved a unique stage of their manufacturing process involving cabinet doors, at the AWC plant located in Monticello, KY. The process involved the application of a specific adhesive to several components for assembly. The adhesive process consisted of the manual use of an adhesive bottle being squeezed, a bead of adhesive applied, and then brushed by hand for coverage. As the process was rudimentary in nature, and continually had varying results requiring addition post processing work and cleanup, it was seen as an ideal opportunity for improvement.

Therefore, a preliminary concept was introduced utilizing a design for a unique adapter plus a mechanical process that would remove the need for the manual squeezing. Potentially reducing excess adhesive being applied, reduce application time, reduce post processing work and cleanup, and reduce worker fatigue.

Although the mechanical process was fairly straight forward, the required new adapter design had to be internally complex to perform correctly. However, what was soon determined was that the adapter design simply could not be produced using conventional manufacturing methods, such as CNC or even plastic injection molding due to that internal complexity. Alternatives that could actually be produced using conventional manufacturing were considered, however, such alternatives were not close enough to the needed design to be effective, including internal design issues and physical external profile shapes. Additionally, the conventional alternatives came with a price tag of $500 to $1000 per adapter set. Therefore, the project remained at a standstill due to the costs and limitations of conventional manufacturing.

AM PROCESS & SOLUTION

After some time, the idea of using low cost, desktop additive manufacturing (AM) equipment to potentially produce the adapter was introduced. Since AM technology, also known as 3D printing, is ideal for internally complex designs, the adapter design was a perfect candidate for consideration. Therefore, AWC began purchasing and utilizing low cost AM equipment as well as experimenting with the variety of materials that such equipment can employ.

FINAL COSTS

Although several AM units were purchased, the final one used for adapter production was a Lulzbot Taz 6, with an investment expense of approximately $2,500. The 3D printed versions of the adapter, which are digitally inventoried within AWC's system, and printed on demand, can be produced in under 6 hours, and for less than $5, with no labor or post processing required. Additionally, with a digital inventory of the adapter and the "print on demand" format, no physical part storage is necessary.

Comparatively, assuming some form of a conventional manufacturing produced adapter been possible, AWC estimates that the expense would have been over $120,000 to reach the same operational state. With an additional $500 per replacement adapter as needed, which would also involve shipping costs and be subject to lead times.

CONCLUSION

The new process involving the low cost AM produced adapter and the mechanical process, referred to as "The Glue Cat," has reduced the cycle time of this specific adhesive process down from 13 seconds to 2 seconds in time studies. Also, quality control issues of sanding and repair occurrences have been reduced by 95%.

Overall, AWC estimates that because of this system, made possible by low cost AM equipment and integration, AWC Monticello is saving at least $160,000 per year. A very impressive accomplishment, considering that the total one-time AM equipment investment was less $5000.

Because of the Monticello plant's extraordinary success, 4 of the 9 AWC plants now have some form of low cost AM equipment available. As positive data such as this is shared, and the return on investments are realized, that ratio is likely to grow quite quickly.

AWC potential conventional costs - $120,000 (initial) + $500 per part
AM comparative equipment costs - $3500 (initial) + $5 per part
AWC annual savings and process improvement - $160,000 per year

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THE IMPACT OF ADDITIVE MANUFACTURING ON KENTUCKY REVENUE

Additive Manufacturing Center of Excellence at Somerset Community College

Additive Manufacturing (AM), also referred to as 3D printing, is currently impacting the future of almost every industry. Already estimated to be a **$12 billion** industry this year alone[1], AM has quickly transitioned from a new method of creating prototypes to an end-use production method. Many companies are manufacturing their consumer products using AM technology, as opposed to conventional manufacturing methods. Large companies such as GE[2], Boeing, Airbus[3], Caterpillar[4], John Deere[5], Ford[6], Adidas[7], BMW[8], Porsche[9], Warren Buffett at Berkshire Hathaway[10], Honeywell[11], Seimens[12], Lockheed Martin[13], and all of the armed forces[14], are spending millions, and in some cases, billions of dollars on Additive Manufacturing. These companies are citing the significant savings, reduction of supply chain issues, and advanced products they are now able to create using AM technology that were previously impossible via conventional manufacturing. Because AM also allows for part consolidation versus combining an assembly of parts, it even further reduces the need for multi-part contracts and vendors. In some cases, AM has also completely replaced the need for casting parts and services.

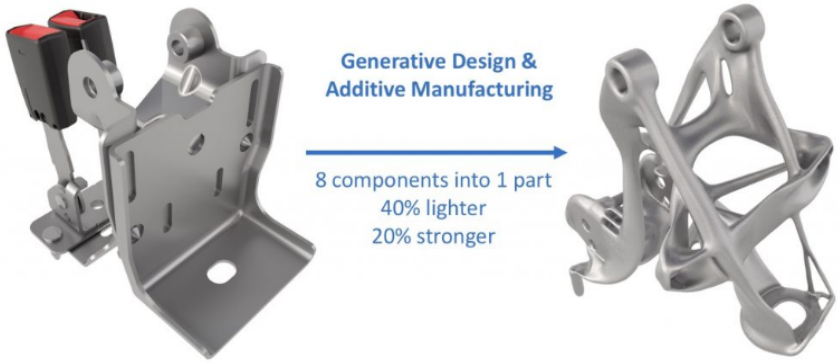

Figure 1: Consolidation of conventional 8-part seat belt bracket, down to a single part produced by metal 3D printing, General Motors publication.

These trends and announcements stand to have extreme significance, and possibly a dangerous impact, on Kentucky's economics. According to the Kentucky Cabinet for Economic Development, in 2017 Kentucky made nearly **$31 billion** in exports, and close to **$12 billion** of that income was specifically from aerospace products and parts. The next highest was the automotive industry generating roughly half that value with **$5.5 billion** in exports. Although automotive and agricultural industries are a vital part of our state's economic makeup, the fact is that aerospace manufacturing generates **38%** of Kentucky's export income. Although this type of work is a boon for Kentucky as a contract manufacturing state, the majority of this work is currently done by conventional manufacturing processes.

Yet, many Tier 1, or enterprise level companies, are spending millions, and in the case of GE and Warren Buffett, **billions of dollars to transition toward additive manufacturing**. The industry specific sector that is the most aggressive in this transition through research, infrastructure and acquisition, is the aerospace sector. The aerospace companies that Kentucky works for, such as GE, Boeing, Honeywell, and Lockheed Martin, are moving

toward production contracts that are based on additive manufacturing as the primary production method. Like many states, **Kentucky has little additive manufacturing production capability and almost no technicians trained in the technology**. Given our heavy reliance on aerospace contracts for a stable economy, the threat of the loss of those production contracts is very real. In fact, other states such as Arizona, are promoting themselves as being the destination for aerospace additive manufacturing [15,16] in efforts to capture those production contracts during this manufacturing transition.

Figure 2 & 3: GE fuel nozzle, 20 conventional parts replaced by a consolidated metal, 3D printed production version (left). Airbus metal, 3D printed single hydraulic assembly (right).

Somerset Community College (SCC), a member of the Kentucky Community and Technical College System (KCTCS), has been funded to create an Additive Manufacturing Center of Excellence in efforts to combat the losses this manufacturing transition is poised to create on our state's economics. In 2016, SCC created the state's first technician certificate in 3D printing/additive manufacturing and has been a leader in making the training in this technology available statewide. SCC's AM program has already introduced nearly 600 students to the technology through our courses. SCC has created the curriculum and laid the groundwork to convert this economic disruption into an incredible opportunity for Kentucky.

SCC is now expanding the program to included advanced powder-based additive manufacturing technician training, including polymers and full metal 3D printing. SCC is expanding through KCTCS to create more skilled technicians and bringing the power of this advanced manufacturing technology to our industry partners, contract manufacturers, entrepreneurs, and small businesses.

SCC is inviting partners to join us in raising awareness of the technology and the potential disruptive impact on the heart of Kentucky's export industry. With the help of industry, educational, and political partners, SCC is uniquely positioned to not only save jobs statewide, but open the door to new aerospace, automotive, and manufacturing production opportunities that were previously inconceivable.

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