April 4, 2016

Attachment – Ed Morris, America Makes Responses to Additional Questions for the Record

Questions from the Honorable Tony Cardenas:

1. ***School, academic and public libraries are leveraging 3D printing technology to prepare students for participation in STEM fields. For example, at the K-12 level, 3rd graders at the David C. Barrow Elementary School in Athens, Georgia, used their library's 3D printer to design and build their own jewelry as part of a geologic lesson on rocks and minerals. How can the private and public sectors work with anchor institutions like libraries to build critical workforce skills through 3D printing?***
2. ***Los Angeles is a very innovative city, but we are also highly populated. Warner Brothers is using 3D printing to build small-scale models of the locations they are going to use as a pre-visualization tool for the director to determine how the set should be built and to identify the best shot set-up and movement. How can we take advance of this new technology as a tool in urban planning?***
3. ***Government decision-makers are beginning to realize the value of 3D printing technology. NASA recently launched a 3D printer into space to experiment with the creation of spare parts for the international space station, and the U.S. Department of Veterans Affairs recently administered a Prosthetic and Assistive Technology Challenge, through which makers engineered and printed items designed to help veterans with disabilities conquer daily challenges. How can anchor institutions like libraries and schools support government-led 3D printing efforts?***

To provide a more comprehensive response, the following is a combined response to Questions #1 and #3: "*How can private and public sectors work with anchor institutions like libraries to build critical workforce skills through 3D printing," and "how can anchor institutions like libraries and schools support government-led 3D printing efforts?"*

Successfully bringing 3D printing into education is about more than just putting a printer in a classroom. It's about building an ecosystem that includes access to resources, technology, training, curriculum and community. Libraries, including school libraries, public libraries and university libraries, are uniquely positioned to be at the center of this ecosystem.

Libraries are ubiquitous. They are in every state, every city, every county and every school district. Together, the country's public, school and academic libraries represent an unrivaled public infrastructure that decision makers in the public and private sectors can leverage to stengthen our economy and education infrastructure. There are approximately 120,000 libraries in the United States, of which over 16,000 are public library locations. Recent data that the American Library Association collected with the University of Maryland reveals 428 public library facilities that offer 3D printing services. That's a significant number, but even more important than the number is the growth. The 428 figure is up from about 250 the year before – a jump of over 40 percent – and it continues to rise higher all the time.

In school and academic libraries, anecdotes abound of students 3D printing everything from mathematical models, to engine blocks, to robot parts. The leadership of such institutions as the University of Nevada-Reno, which became the first University Library to provide 3D printing and scanning as a library service to all students in 2012, and the David C. Barrow Elementary School, cited in the question above, have set off a torrent of library-driven 3D printing opportunities for learners of all ages.

These opportunities, combined with the myriad of 3D printing activities in public libraries, yield economic, social, and scientific progress in every part of our country. The public and private sectors should work with libraries to expand this progress; specifically, they can pursue opportunities for library partnership and collaboration around 3D printing that promote STEM education, boost entrepreneurship, foster inter-disciplinary and transdisciplinary leaning and build critical workforce skills.

Provide Access to Resources

One of the most important mandates for public libraries is to provide robust, equal access to information and knowledge. Providing access to 3D printing technology like 3D printers, 3D scanners and 3D software is a key way that libraries can play a role in the democratization of learning, creativity and manufacturing. Putting a 3D printer in a classroom provides limited access, but putting a suite of 3D printers, 3D Software and 3D Scanners in a library ensures that not only multiple students, but multiple individuals, multiple classes, multiple teachers, multiples schools and multiple organizations can utlize the technology.

Learners can benefit a great deal from utilizing 3D equipment inside a classroom. Nonetheless, the scope of the knowledge they can pursue in this sort of setting is limited by the strictures of their instructors' lesson plans. When learners use 3D equipment in the informal learning environment of the library, their learning opportunities are limitless; they are free to harness CAD programs, 3D printers, scanners, and whatever else a library might have in its 3D arsenal, to pursue their personal learning passions. If a learner is interested in biology, he or she can print a DNA double-helix; if a learner is interested in paleontology, he or she can print replicas of Jurassic-era skeletal structures. This not only encourages intellectual curiosity, but also facilitates the acquisition of important skills for the modern economy. No matter what a person prints, he or she builds certain basic technical and engineering skills – e.g. how to create a CAD model and how to use plating and slicing programs. When a person prints something in which he or she is personally invested, that person is likely to pay particularly close attention in completing the processes that build these skills. As a result, he or she is likely to achieve higher competence in these skills than someone who 3D prints a compulsory output as part of a set course curriculum. In short, there is a difference betweeen learning and ***connected*** learning – and, moreso than any other education institution, libraries facilitate the latter.

Different types of libraries (whether a public library, a K-12 school library, or a university library) require a different mix of programs and strategies, and a number of suggested opportunities for public and private sectors to support libraries by providing access to resources include:

1. ***Support school libraries with resources and funding to build 3D Printing Labs***
   In order to achieve full integration of 3D printing across STEM subjects, every student in school needs to have access to a 3D printer. While putting one printer in a classroom is a start, a good ratio of students to printers is one printer for every five to eight students in a given class or program. In addition, students need access to more than just a printer – they need access to

CAD software to design and fully utilize the power of the printer, and if possible, 3D scanning technology to learn concepts like reverse engineering. One way to ensure access for all students is by supporting the creation of 3D Printing labs in school libraries. These labs should include computers which have 3D Design Software on them, as well as a suite of 3D printers.

These labs should also include curricular resources that instructors can use to maximize the learning their students can achieve through the printing process. Several 3D printing companies – like MakerBot and Tinkerine – offer discounted product "bundles" to education institutions that include lesson plans. More needs to be done among companies like these to offer pedagogic guidance to libraries and schools that have – or are seeking to acquire – 3D printers. The federal government should also consider making efforts to this end. For example, the Department of Education could consider a program or competition to encourage the development of 3D printed items that solve challenges for learners. Administratively, such a program or initiative could follow the model of Prosthetic and Assistive Technology Challenge, through which the Department of Veterans Affairs encouraged the development of 3D printed items designed to help veterans with disabilities conquer daily challenges.

Ultimately, the goal should be to create synergies between libraries and schools that will give learners full access to 3D technology and pedagogic resources both during structured class time as well as after school. Through these sorts of synergies, libraries will fill in gaps in teacher training, curriculum development and best practice sharing.

2. ***Support School Libraries and Public Libraries to integrate 3D Printers into current MakerSpaces and build new MakerSpaces.***
   MakerSpaces are creative, DIY spaces where people can gather to create, invent, and learn. In libraries they often have 3D printers, laser cutters, computer numerical control (CNC) routers, digital production equipment, software, electronics, craft and hardware supplies and tools, and more. MakerSpaces offer opportunity for not only skill building but for project-based learning. Currently, Federal agencies, companies, non-profits, cities, and schools are collectively making commitments to create over 1,000 maker-oriented spaces in the United States, which will expand access to tools and technologies for both students and entrepreneurs. There is an opportuntiy to expand these initiatives with a specific focus on supporting 3D printers in MakerSpaces in school and public libraries, and supporting those spaces with both technology and support materials like 3D Printing filament.

   Institutions and agencies have begun to provide funding to encourage the adoption of 3D printers in library MakerSpaces. For example, in response to President Obama's call to make science, technology, engineering and mathematics (STEM) education a national priority in 2010 as part of his Educate to Innovate initiative, the Institute of Museum and Library Services (IMLS) and the John D. and Catherine T. MacArthur Foundation launched the Learning Labs in Libraries and Museums program. This program provided sites in 24 cities and counties with $100,000 each for the planning and design of an "innovative teen space" known as a "Learning Lab." A number of learning labs offer 3D printing services, including those at the Anythink Wright Farms and Anythink Brighton libraries within the Rangeview Library District in Adams County, Colorado. IMLS and foundations across the U.S. should consider supporting similar initiatives moving forward.

3. ***Support Public Libraries and University by providing funding and resources for "3D Printing Check Out Kits."***
   Non-profit organizations like the Boy Scouts, the Girl Scouts and First Robotics, as well as numerous smaller and local organizations can leverage library resources to bring 3D printing to their after school programs. By providing check-out kits that contain 3D Printers, 3D Filament and 3D Scanners, libraries can help organizations expand programming to troops, students clubs and students teams. In the University Library, check-out kits can be accessed by students so that they can use 3D Printing for projects across disciplines including engineering, architecture, art, chemistry and math, among others. Check-out kits are useful for projects that take a print time of 12-hours or longer. The practice of libraries lending hardware to patrons is not new. Some libraries already operate successful check-out programs for Arduino projects (e.g. the Highland Campus Library of the Austin Community College in Texas and the Fond du Lac Public Library in Wisconsin) and mobile HotSpots (e.g. the New York Public Library and the Seattle Public Library). With adequate monetary support, libraries can follow best practices from these ongoing programs to successfully loan "3D Printing Check-Out Kits" to patrons.

4. ***Support University Libraries to build and expand 3D Print Labs, MakerSpaces, Fab Labs and 3D Printing Services***
   Placing 3D printers in univeristy libraries expands opportunities for advancing outreach, teaching and research programs as well as expands student opportunities for trans-disciplinary work across engineering, design, humanities, the sciences and entrepreneuriship. While 3D printers may be housed at different colleges and locations on campus, 3D Printing services and access at a university library ensures that students from across majors and colleges have access to the technology. It also provides opportunties for cross-disciplinary collaboration. Public and Private Partners can work with Universities libraries to develop open access 3D Printing Studios and 3D printing labs. Within the University, University admnistatration can work to ensure that faculty are trained on and familiar with 3D printing technology and provide opportunties for them to learn how this technology can be incorporated and leveraged into the courses, ensuring expanded use of the equipment by teachers and students.

An important note of caution, providing 3D printers must be accompanied by a long-term commitment to provide funding for the 3D printing materials (a consumable for every item created using 3D printing) and on-going maintenance of the 3D printers to keep them operating properly.

Partner with Libraries to support staff training and capacity building

Having technology at a library is one component of the equation to leverage libraries to support STEM integration and build workforce skills, but staff training and capacity building is critical to ensure proper maintenance and usage of the technology. In addition, a trained staff should be able to provide meaningful opportunties for program implementation and engage and educate users – whether the user is a student, a teacher, a professional accessing resources or any other community member. Capacity building also includes best practices sharing on how to stay on the cutting edge of new technology and new offerings and how to properly price usage of the equipment. Public and private insistutions can work with libraries to support staff training and capacity building in the following ways:

1. Public and private institutions can provide funding to organizations like the America Library Association to support staff training and capacity building for librarians through large scale programs that convene librarians and library administrators and allow them to share best

practices on topics like how to create introductory orientiation classses for patrons, or how to plan for and build out a state-of-the-art Library "MakersSpaces" or "Fab Labs."

2. 3D Printer Original Equipment Manufacturers (OEMs), local industry, and local subject matter experts can support libraries by providing volunteers to help maintain the equipment, interns to run library 3D printing programs on a semester basis, and industy experts to support programs.

3. Univeristies can support school libraries and public libraries by including 3D printing courses and certificate programs in bachelors and masters course and degrees, ensuring future librarians, administrators, school librarians and future teachers enter the workforce prepared to bring 3D printing technology into the library.

4. Public and private partners can expand library access to 3D printing curriculum and training through online platforms. One pathway to this is by supporting the expansion of Make It @ Your Library and particularly, expansion of 3D printing content and information on the site. In collaboration with Instructables.com and the American Library Association, Make it @ Your Library created makeitatyourlibrary.org, a website tailored to librarians interested in implementing makerspace projects in their libraries.

5. Non-profit organizations can partner with libraries to leverage 3D printing technology at libraries to help expand their programs to more communities. One example is the e-NABLE Community Foundation. e-NABLE is an international network of passionate volunteers using 3D printing technology to design, deliver, and distribute free upper-limb prosthetics to children and other underserved populations around the world. e-NABLE can partner with libraries across the country who have 3D printing technology to create extended community programs for students and individuals to learn 3D printing skills by printing and building prosthetic hands. Another example is Benetech, a Silicon Valley-based non-profit technology company. Benetech realizes that one of the greatest opportunities for progress on disability issues lies at the confluence of education, technology, science and public policy. They encourage individuals from across these fields – both with and without disabilities – to work together to develop solutions to accessibility challenges. Benetech's latest effort on this front: An IMLS-funded initiative to bring the library, museum and school communities together to level the playing field for learners with disabilities through 3D printing. Last summer, Benetech convened leaders from across these fields in San Jose, California to discuss strategies for implementing the initiative. The convening led to the creation of a "starter guide" for using 3D printed objects in education, and a program proposal for the 2016 SxSWedu Conference, which was accepted, and held in March in Austin, Texas. As impactful as Benetech's initiative has been, it requires additional financial support to continue. Public and private institutions, as well as foundations, can and can continue to back initiatives like this one, so that learners with disabilities can enjoy the opportunities for growth and success that they deserve.

6. Public and private institutions can provide targeted support for rural and small libraries, where demand for 3D technology may be high, but a lack of space, resources and technical know-how may make the adoption of 3D services especially difficult. The popularity of 3D technology is not bounded by urban borders. Individuals living in Manhattan, Kansas are just as likely to be interested in 3D printing, modeling and scanning as those living in Manhattan, New York. Nonetheless, library staff working in areas similar to the former may not feel equipped to administer the hardware and software maintenance, staff and patron training and heavy user

workflow that attends the public provision of 3D printing services. 3D printing companies and agencies like the Department of Agriculture and Department of Education should consider working with the Association of Rural and Small Libraries (ARSL) – a division of the American Library Association – to support technical training and assistance, as well as the provision of 3D equipment and materials, to rural and small libraries in the United States.

Expand, Replicate and Scale Successful Programs and Initiatives

Public and private institutions are investing to expand access to spaces for students and entrepreneurs where they can design, prototype, and make products using technology including 3D printers, 3D Scanners and 3D Software. Public and private institutions can partner with each other and with public, school and university libraries to expand, replicate and scale successful programs. For example:

1. 3D Systems, in collaboration with the Young Adult Library Services Association (YALSA), a division of the American Library Association (ALA), and the Association of Science and Technology Centers (ASTC), is committed to expanding public access to 21st century tools like 3D design, 3D scanning through a program called the MakerLab Club. This program provides up to four printers to libraries that have committed to having trained staff and developing 3D printing programs for the community. It also provides a platform for libraries to share best practices and curriculum. Organizations like America Makes can partner with public and private institutions, industry and OEMs to expand the MakerLab Club and ensure that libraries across the country have access to platform programs and initiatives. According to 3D Systems, over 1300 libraries expressed interest in the MakerLab Club, and over 100 received 3D printers in the first iteration of funding, so there is a great opportunity to expand and replicate the program.

2. The *Department of Education* recently launched CTE Makeover Challenge to transform or create new "21st century maker spaces," in conjunction with their career and technical education programs. This opportunity can be both continued and expanded to focus specifically on makeover challenges at School Libraries.

3. The Economic *Development Administration (EDA)* is spurring regional innovation by supporting the development of maker spaces equipped with the tools, mentors, and programs that allow them to rapidly design and prototype their ideas and bring them to market. Earlier this year, the i6 Challenge of the Regional Innovation Strategies Program issued $10 million in grants to 26 awardees focused on capacity building. This program can be expanded to focus more deeply on maker spaces at public libraries.

4. The *Institute of Museum and Library Services* is working with the Children's Museum of Pittsburgh and other partners to create a framework for effective spaces for making and learning in museums and libraries. Public and private institutions can continue to support and work with IMLS and the ALA to turn frameworks, lessons learned and best practices into hands-on training for library administrators and staff.

5. Universities libraries like the W.E.B. Dubois Library at the University of Massachusetts at Amherst has gone so far as to open a facility entirely devoted to encouraging entrepreneurship through 3D printing. The facility, known as the MakerBot Innovation Center, includes 50 3D printers, and officials there plan to launch an entrepreneur-in-residence program, hold business plan competitions and offer coaching services for start-ups. Public and private institutions can

work across the nation to provide funding and support for centers like these at universities across the country.

Even if a library does not have a facility like a MakerBot Innovation Center that's explicitly dedicated to entrepreneurship, if it offers 3D printing servies, it encourages important contributions to the entrepreneurship ecosystem. Ideas for new products and services are generated all the time. Two major challenges facing any entrepreneur seeking to bring his or her idea to fruition are a lack of access to prototyping equipment and the significant cost of producing a prototype. Libraries that offer 3D equipment eliminate some of these challenges. At many of these libraries, with nothing more than a library card and a brief time investment in completing a training module, entrepreneurs can use 3D equipment and its accompanying design software to bring their ideas into the world for the first time. Generally, the only cost associated with using this equipment for this, or any other purpose, is a modest charge per ounce of material used in the production process. In addition to its low cost, prototyping at the library affords entrepreneurs the ability to create in a safe and friendly environment.

In short, libraries facilitate the procedure of demonstrating proof of concept by relaxing and democratizing the product prototyping process. Recent uses of 3D printing services at the Westport Library in Connecticut illustrate the utility of the library as a space for product prototyping. A woman with no background in business or entrepreneurship used a 3D printer at Westport to prototype a square-shaped headband that imitates the look of wearing sunglasses atop your head. She has now received financial backing and has begun marketing her headband in a variety of colors. Another patron used a Westport printer to a prototype a device that attaches to cell phones and prevents drivers from texting and performing other smart phone functions while operating a car. SafeRide is now being successfully marketed as a downloadable mobile app that locks the smartphones of drivers when they are in motion. Agencies like the Small Business Administration, as well as entities like Small Business Development Centers and chapters of the Service Corps of Retired Executives (SCORE) Association – which already work closely with libraries, in some cases – can work with libraries to publicize and support the work libraries do to help people bring their ideas for new products into the world for the first time.

In conculsion, libraries are leading the way towards the "democracy of creation" and through access to resources are engaging patrons to move from the "information age" to the "imagination age." Cross-sector collaboration and partnerships between government, industry, non-profits, academia and the library community will help to accelerate awareness and adoption of 3D printing technologies and applications across the United States.

Response to Question #2: ***"How can we take advance of this new technology as a tool in urban planning?"***

Summary Response:

To further accelerate the use of 3D printing technology as a tool in urban planning, new projects can now afford to require the creation of 3D printed physical models for evaluation and design optimization. Both large and small projects can now take advantage of the significantly reduced time and cost to produce physical 3D models.

The 3D printer OEMs have identified this market as a sales opportunity and are therefore promoting the technology for urban planning and are working with Universities to include 3D printing training for architects and urban planners.

Explanation:

It has long been a standard practice for architects and urban planners to create three-dimensional (3D) models of their design concepts in cases where the cost and time to create the models was justified by the cost and potential risks for a construction project.

Prior to the use of computer-based design tools, architects and urban planners created two-dimensional (2D) drawings to develop and define their designs. The drawings were historically known as "blue prints" due to the final color of the paper used in the past to reproduce the original master drawings. Converting the 2D drawings to 3D scale models made it much easier to visualize the end product and refine the design. The 3D models are also significantly easier for the client or customer to assess and accept the proposed designs. The changes made during the design optimization process must then be incorporated as revisions to physical model and the master drawings and blue prints.

However, creating the 3D architectural and urban models has traditionally been a time consuming, labor intensive, expensive process. Skilled modeling artisans used wood, thin cardboard, foam board, carved Styrofoam, and other modeling materials to create properly dimensioned scale models of the designs from the original 2D renderings for evaluation. Even after computer software programs for buildings and urban infrastructure designs advanced from 2D computer-based drawings to 3D computer-based models viewable on the computer screen, physical 3D models were made using traditional manual methods. In this case, changes to the design that could be rapidly made in the computer meant delays and increased cost to change the physical 3D model for final evaluation and acceptance by the client.

Combining 3D computer-based models with the ability to rapidly and affordably create physical models using 3D printing, architects and urban planners are now rapidly embracing additive manufacturing to create high fidelity models. Benefits cited by Stratasys for 3D printed architectural models include reducing lead times by 50 to 80 percent, reducing the cost of the models by 40 to 75 percent, and increased model stability over time, eliminating distortion. Another benefit is the ease of updating the physical 3D model by updating the computer model and rapidly printing the refined physical models.