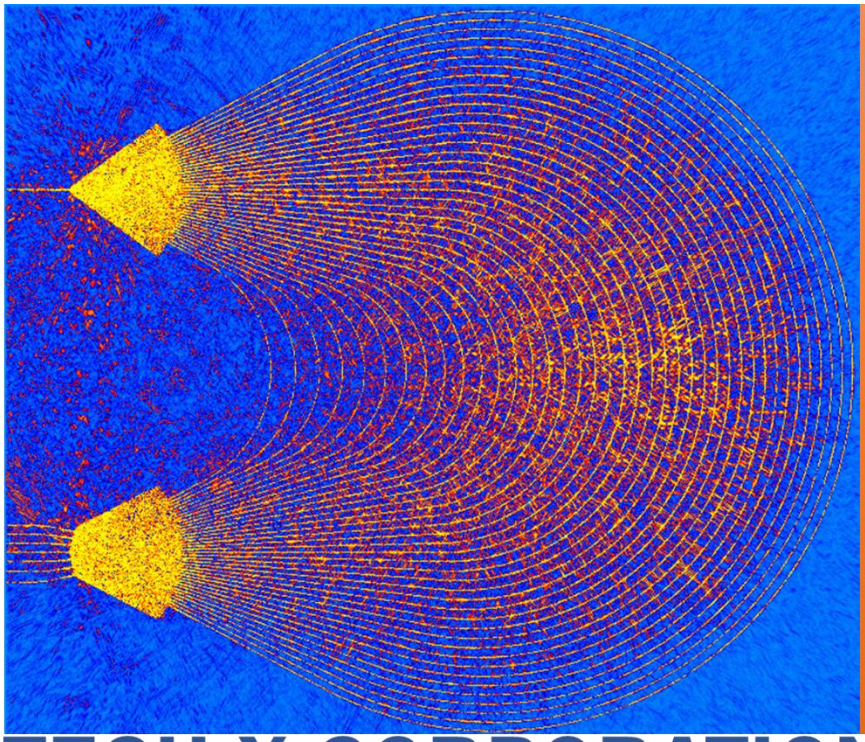
SBIR·STTR America's Seed Fund

U.S. DEPARTMENT OF ENERGY | SBIR/STTR Programs Office



DOE SBIR/STTR Success

Light propagation in an arrayed waveguide grating, simulated by *VSim*®

TECH-X CORPORATION

Since 1994 when it was founded, Tech-X Corporation (Tech-X) has been a consistent contributor to the mission of the Department of Energy (DOE) through the DOE SBIR/STTR Programs. Tech-X has been very successful at leveraging SBIR awards to deliver technologies that were instrumental in carrying out multiple scientific projects. Over the years, Tech-X has partnered with several DOE National Laboratories to address the most challenging demands in high-performance computational (HPC) software, simulation, and design. With a staff of 40 people between employees and consultants, Tech-X has been at the forefront of HPC code enhancement through porting to modern hardware, such as Advanced Vector Extensions (AVX) and high-performance visualization and graphical user interfaces.

FACTS

PHASE III SUCCESS
Tech-X is at the 70th percentile among all the SBIR awardees as judged by the Department of Defense commercialization ranking, and has collected over $33M in product sales and research services.

IMPACT
Designed to meet Federal R&D needs, *VSim*® has expanded to solve the most computationally intensive physics problems involving modeling of electromagnetic fields and charged particles.

DOE PROGRAMS
ASCR, HEP, BES, FES, NP.

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Although Tech-X has received numerous SBIR awards from DOE, and therefore, does not conform to the typical high-tech startup model, the company has been definitely responsive to SBIR programmatic objectives by 1) meeting Federal research and development (R&D) needs, and 2) increasing private-sector commercialization of innovations derived from Federal R&D funding. In particular, Tech-X has been much attuned to the message received by the DOE SBIR/STTR Programs following the 2011 reauthorization of the Programs and the associated stronger emphasis on commercialization requested by Congress. Since then, Tech-X has modified its overall approach to SBIR grants and looked for synergies between DOE mission's needs expressed by the SBIR solicitation topics and Tech-X own product development necessities and commercialization strategies. This has been implemented by visiting DOE facilities before applying for an SBIR grant to learn more about the project and determine the applicability of a concerted effort that would advance science and respond to a market need simultaneously. "We have learned to manage an SBIR grant effectively to add new features to our product and make it reliable", explained John Cary, CEO of Tech-X. "We strive to deliver what is needed for the DOE mission, but at the same time, take the prototype we have developed and make it robust for commercialization, package it for sale, and market it with help from a business consultant." This approach has paid off for Tech-X. In fact, the company is today at the 70th percentile among all the SBIR awardees as judged by the Department of Defense (DOD) commercialization ranking. Tech-X has collected over $33M in product sales, research services, and consulting fees. Of this total revenue, 12% consist of sales to private customers, and 57% consists of sales to Federal Agencies. The remaining percentage is made up of sales to export markets and other customers. In addition, Tech-X has secured over $64M in investments, of which over $600k come from private sources, ~ $50M are from Federal Government contracts, non-SBIR grants, and other sources. Tech-X has also self-invested about $15M in product development, particularly in cases where, once the SBIR project had been completed, additional product de-risking was needed for market launch.

As an example, among various products developed by Tech-X, one that has grown in capabilities in response to DOE-oriented tasks is *VSim*®, a flexible electromagnetic, particle, and plasma simulation tool. *VSim*® is capable of exploiting modern computer hardware to solve computationally intensive problems, especially problems requiring the modeling of charged particles. *VSim*® consists of two major parts: the engine (*Vorpal*) and the graphical user interface (*VSimComposer*). The engine is used to compute physics, while the *VSimComposer* sets up problems, runs data analyzers, and visualizes results. *Vorpal* was originally conceived at the University of Colorado, by Dr. Cary and his research teammates, and is now licensed to and further developed by Tech-X. *VSim*® was designed to meet the research needs of the Federal Government for coupled physics simulations and its capabilities have expanded with time, some of those funded by the DOE SBIR Program, as various DOE projects required new features.

The ability to perform simulations of Silicon Photonic (SP) components is one of the latest extensions of *VSim*®, and is described here as an illustrative example of the strategy employed by Tech-X for product development and commercialization supported by the SBIR Program.

SP is a relatively new development destined to dramatically increase the processing speed and power of computers. Instead of copper wires, Si and other semiconductor-based devices are used to propagate and control light, which can carry far more data in less time than electrical conductors, between and within microchips. This is due to the advantage that many wavelengths, each one carrying information, can be packed and manipulated in a single device. The biggest application of SP is in supporting faster

interconnects between data centers. In addition, SP technology is instrumental in building new types of microchips for the next generation of exascale computing.

During the DOE SBIR Phase I and Phase II of the SP project, Tech-X developed a visual set up for the simulation parameters and a 2nd order algorithm that allows the user to adopt smaller grids but still obtain the same accuracy as a regular algorithm would deliver on finer grids, thereby saving significant computing resources, especially when simulating the response of devices comprising multiple materials and complex shapes. To understand the importance of these developments it is useful to recall that SP device simulations require billions and billions of cells and would be impossible to carry out without an effective algorithm even on a supercomputer. Tech-X uses an HPC workflow established at the National Energy Research Scientific Computing Center (NERSC) to simulate the electromagnetic response of specific devices offered by potential customers, therefore tackling real customer's needs. This allows Tech-X to work on problems that have a direct market applicability. At the same time, relevance to the DOE mission is insured by the further development of *VSim*® capabilities, which will both contribute to the Exascale Computing Project (ECP) launched by DOE in 2017, and make HPC software available to industry engineers, thus increasing U.S. competiveness in digital manufacturing.

During the Phase IIB of this project, Dr. Svetlana Shasharina, VP of Computational Infrastructure, and her team worked on simulating the response of devices fabricated by two companies: Finisar and PhoeniX, which sought services from Tech-X staff after listening to their presentations at topical conferences. Both devices are multiplexing photonic instruments that act as an array of waveguides and are able to separate a large number of wavelengths to have individual fibers propagate a single wavelength each by means of light diffraction and interference phenomena. In this way, data transmission capacity is strongly enhanced, which dramatically increases processing speed.

"Simulating the response of an SP device scales with the number of wavelengths in the device" explained Dr. Shasharina. The size of the problem is so large (600 wavelengths in horizontal dimensions) so that any computer simulation attempt has been so far inadequate. "At the same time" Dr. Shasharina points out, "an electromagnetic simulation is necessary to fine tune the device's complex design and obtain a clear separation of wavelengths without significant loss of signal, which is key to the device's performance and competitiveness." As an example, Tech-X computational effort for the Finisar's device involved 6.2 billion cells, 82,000 steps and used 8,192 NERSC cores for 5 hours!

Once the device's specifications provided by the customer are translated into input for the visualization software, the simulation proceeds by meshing the 3-dimensional device's structure in distributed memory parallelization. The latter is a process in which the partial differential equations describing the physical evolution of the system are solved by a succession of steps, each one carried out in a single core, which acts as a single memory. The need for massive computational resources stems from the fact that each step needs to communicate with all its nearest neighbors to share boundary conditions for the full state to be calculated. In the end, each simulation file contains 300 billion bytes of data—not a file that can be easily shared!

The revenues from the SP project to date have not been as large as expected. Nevertheless, Tech-X holds positive expectations for the future due to the company's advantage relative to competitors. Tech-X has demonstrated the ability to solve real customer problems and is currently working with a commercialization consultant to better identify customers' needs. "The business consultant has been

very useful in teaching us how to approach a customer in the private market, which is very different than pitching to DOE program managers, who have a deep technical understanding of our product's capabilities." said Dr. Shasharina. This insight is emblematic of the challenges involved in the commercialization process. Although the technical aspect of the product may progress to the point that real customers' needs can be tackled and solved, technical success does not immediately lead to significant private sales. In addition to deep domain knowledge and use of state of the art equipment, business knowledge is required to be able to introduce the product to customers.

The next step in product development for Tech-X is to provide a new service model designed to assist customers who generally do not have access to a supercomputer. For this purpose, Tech-X is using internal funding to explore cloud computational resources in order to remove the need for a supercomputer and render their product accessible to many more customers.

Written By Claudia Cantoni, Commercialization Program Manager, DOE SBIR/STTR, June 2018.