SBIR·STTR America's Seed Fund

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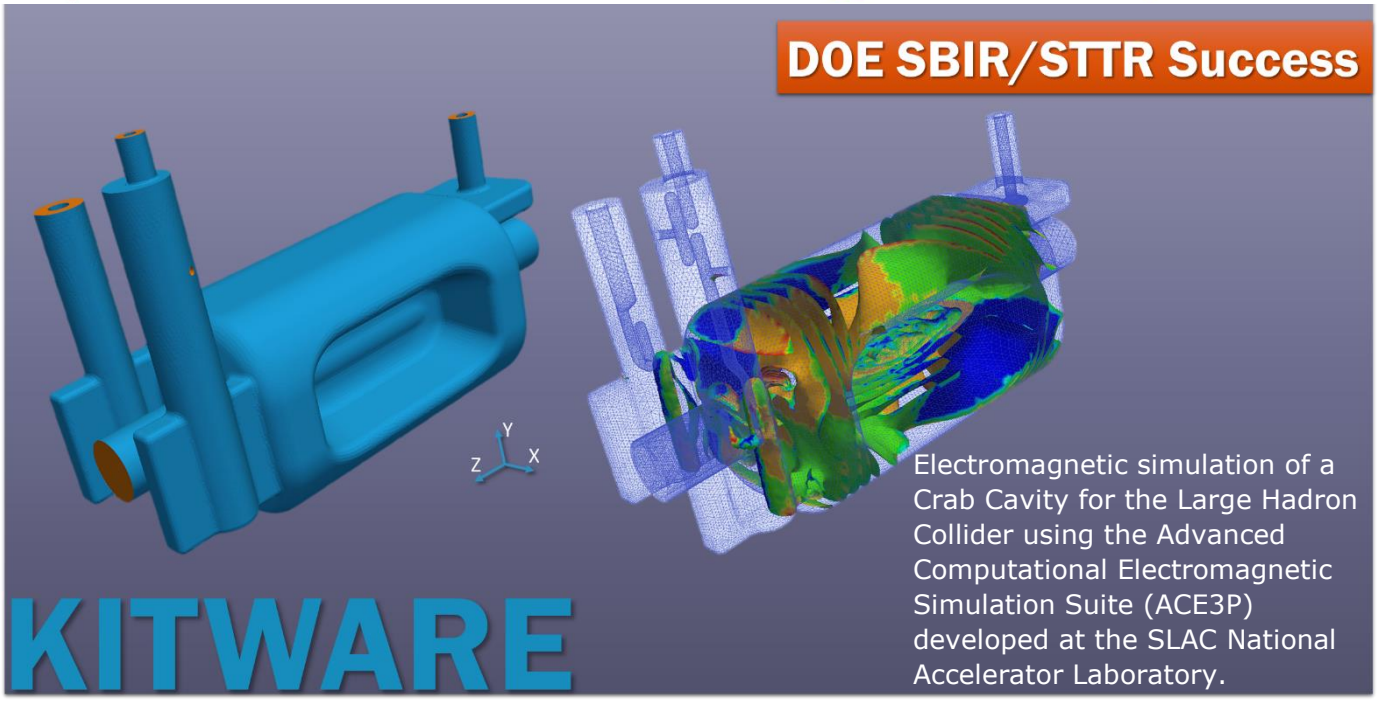
DOE SBIR/STTR Success



KITWARE

Electromagnetic simulation of a Crab Cavity for the Large Hadron Collider using the Advanced Computational Electromagnetic Simulation Suite (ACE3P) developed at the SLAC National Accelerator Laboratory.

Unlike for the majority of small businesses that obtain SBIR grants from the Department of Energy (DOE), Kitware's relationship with the DOE SBIR Program started after the company had already worked on several DOE projects under direct contract with DOE's National Laboratories, specifically Los Alamos National Laboratory (LANL), Lawrence Livermore National Laboratory (LLNL), and the Sandia National Laboratories (SNL). The relationship between Kitware and DOE dates back 20 years, and it was instrumental to the development of three major software platforms offered by the company: *VTK*, *ParaView*, and *CMB*. Kitware distinguishes itself from other SBIR recipients in another interesting way—Kitware's business model involves developing large and complex open source software platforms, which some might consider incompatible with a private business' objective to generate profits.

FACTS

PHASE III SUCCESS
Kitware has achieved a 4× return on the DOE SBIR investment. DOE SBIRs have contributed to the development of 3 software platforms, the company's growth from 7 to 147 employees, and contracts from DOE's Labs and other Federal Agencies.

IMPACT
Kitware has developed a successful open source software business model. Kitware's software platforms have made HPC modeling and simulation available to small and medium businesses.

DOE PROGRAMS
Advanced Scientific Computing Research (ASCR), Basic Energy Sciences (BES), High Energy Physics (HEP).

After a period of maturation that was mostly visible during the early days of Linux, open source software is today mainstream and represents the future of software and technology innovation. Scientific communities in Universities and National Laboratories are strong supporters of open source software and have embraced it from the very beginning as an effective way of speeding up R&D through the contributions of talented developers. In addition, open source software embodies the spirit of free dissemination of knowledge, which is one of the core objectives of unclassified scientific research. However, one of the objectives of the SBIR/STTR Programs is to increase private sector commercialization of innovations derived from R&D. In order to win an SBIR or STTR grant, a small business has to present a compelling case for how the technology developed through the grant will lead to commercialization and thus revenues, an outcome that in the past was considered at odds with the development of free software. Nevertheless, in today's age of digital transformation, disruptors like Netfix and Uber, and even giants like Cisco and Google have adopted and contributed to open source solutions, which allow them to perform at their very best by attracting and motivating top developer talent to quickly accomplish goals specific to their environment. Since the company was founded in 1998, Kitware has been a trailblazer in the adoption of such a bottom-up business model and has fully addressed the challenge of developing alternative funding methods while supporting the growth of its software platforms and serving the needs of its customers. Specifically, Kitware derives revenues from services such as training, installation, technical support, and especially from further software customization to integrate the open source platforms into enterprises' products and processes that remains proprietary. Customers are happy to pay for professional consulting in exchange for the benefits of fine-grained control, critical reviews and lack of vendor lock-in and IP issues related to patents and copyrights.

Kitware was founded in 1998 by Will Schroeder (Kitware's CEO until 2017) and his colleagues Bill Hoffman, Ken Martin, Lisa Avila (the current CEO), and Charles Law, who were working together at the General Electric Corporate Research and Development Center. The idea of starting the company stemmed from the response of the computational community to a publication by Dr. Schroeder and colleagues, specifically a textbook about visualization software and an example piece of software, the Visualization Toolkit, or *VTK*, which was included with the textbook. By 1995, the book had become an indispensable tool in the community, and both scientific institutions and industry were requesting support for further developing the demonstration software. This motivated Dr. Schroeder and his colleagues to build a technology business in addition to continuing doing research.

Soon after incorporation, some initial funding for Kitware came through the Advanced Simulation and Computing (ASC) Program, a program managed by the National Nuclear Security Administration to simulate, test, and maintain the United States nuclear stockpile. Created in 1995 to support the Stockpile Stewardship Program, the ASC program has funded the development of several different supercomputers with increasing power, in order to address stockpile aging and the consequent increasing complexity of the simulations involved. ASC's research has been carried out at supercomputing facilities in three National Laboratories: LANL, LLNL, and SNL. One of the big challenges faced by all three the National Laboratories when the program started was the lack of an adequate visualization software that would run on supercomputers, thereby enabling the analysis of the large amount of data being generated. While large simulations were performed on distributive memory on supercomputers, the data analysis and visualization tools were still running on desktop-type machines and, therefore, could not scale in performance the way the simulations did. This is because, while with distributed memory the size of a problem can be scaled simply by adding more supercomputer nodes, a desktop-based memory only scales with the number of processors physically present in the machine. The work performed under contract for

the ASC Program allowed Kitware to transition from research to production by building a software tool with a user interface that the Laboratories' scientists could easily use. This is how *VTK*, the original C++ software system for 3D computer graphics, image processing, and visualization, evolved into *ParaView*, an end-user tool, which enables scientists to exploit the *VTK* package outside of the C++ or Python command-line interface.

The open source character of the software platform was one of the requirements imposed by the ASC Program because it allowed the DOE Laboratories to partner and collaborate with Kitware, performing their R&D freely in the platform without having to wait for a commercial tool. Contracts related to the ASC Program have continued over the last 20 years and have resulted in an average of 3 to 4 full-time employees for Kitware. Moreover, because *VTK* is widely used in defense-related and medical computing applications, Kitware continues to receive funds in the form of contracts and grants from the Department of Defense (DOD), the National Institutes of Health (NIH), and numerous commercial customers and other research organizations. For example, the latest funds from NIH consist of a 4-year RO1 research grant (1R01EB014955) for maintenance and further development of *VTK* capabilities associated with medical analysis applications like *3D Slicer*, an image analysis tool that works with modalities such as MRI, CT, and ultrasound data.

Once Kitware's leadership learned about the SBIR program, it became clear that it was a perfect fit for the company's business model. "The SBIR funding mechanism is an irreplaceable venue to build core pieces of technology, which we embed into open source platforms," explains Dr. Schroeder. The open source platforms are then grown and serviced by engaging customers in collaborative R&D, consulting, custom application development, and support. Kitware has been awarded 7 Phase II SBIR projects from DOE starting in 2003, and over the past ten years, SBIR funding has contributed approximately 20% to the total company revenues, indicating that for every $1 million in SBIR revenue received, Kitware realizes over $4 million in additional revenue.

The SBIR Program has helped Kitware grow from 7 to 147 employees and establish offices in four United States locations. In addition, particularly through the commercialization assistance offered by NSF grants, SBIR has educated Kitware on how to plan and execute a tailored commercialization strategy that serves the open source business model. Kitware has successfully leveraged the SBIR Program to expand to new areas by seeding new platforms through the support for 1 to 2 experts for 3 years for each project. Most of the SBIR grants Kitware received from DOE involved the work of Kitware's scientific computing team to expand the visualization tools *VTK* and *ParaView*, resulting in developments of which the DOE and its Laboratories are major beneficiaries.

The outcomes produced by the DOE SBIR grants awarded to Kitware are exemplified by two recent Phase II projects. The first one, funded by the High Energy Physics (HEP) Program, expanded a previous Department of Defense (DOD) SBIR grant to develop *in situ* capabilities based on *ParaView*. In the fast-paced progress towards increasingly powerful supercomputers, from the previous petascale to the current exascale effort, the traditional way of doing data analysis and simulation is breaking down. In the old paradigm, referred to as post-processing, simulation results were written at regular intervals to disk, and once the simulation was completed, *ParaView* could be run to explore and visualize the collected data. As computer power grows, the ability to save data to disk does not grow proportionally with it because the size of the disk lags considerably behind the ability to run large simulations. In a petascale supercomputer like the Oak Ridge National Laboratory's Titan, only 10% of the data is captured as a simulation is performed. Going to exascale, this figure will decrease to 1%. In this framework, post-

processing no longer makes sense, and visualization tools need to be embedded into the simulation as data is generated, without having to save it to disk. This is what the computational community refers to as "*in situ* visualization." Closer integration with the simulation code demands a new paradigm in which there is not enough time to interactively analyze and explore the data, so decisions on what needs to be extracted have to be automated using smart algorithms to capture salient features, while still leaving to the user the ability to perform some interactive exploration after the fact. These aspects are of great importance to the latest Exascale Computing Project (ECP) launched by DOE in 2017 to oversee the R&D of an exascale system by 2023. "The DOE SBIR on *in situ* visualization allowed us to develop capabilities by which *ParaView* could be embedded into the simulation," explains Dr. Berk Geveci, Kitware's Senior Director of Scientific Computing and Principal Investigator for the project. "Without the infrastructure developed with the SBIR, we will not be able to effectively contribute to the ECP because the technology will not be there yet, and we will have to start from ground zero." Kitware's revenue from work performed for the ECP is over $1M per year for 3 years. The SBIR award was received in 2011 for a total of $904 K. Over the following years Kitware has tracked resulting commercial revenues and determined that approximately $5,167 K of direct sales and collaborative R&D revenue has accrued that can be linked to the same SBIR project. This figure excludes revenue from Kitware's foreign operations involving a French subsidiary with 19 employees.

The second example is an SBIR project that yielded a similar return on investment and was funded by the Advanced Scientific Computing Research (ASCR) Program. The project focused on developing a software suite that could eliminate the barriers to adoption of High Performance Computing (HPC) modeling and simulation tools for small- to medium-sized manufacturing and engineering firms. The result, built on previous work funded by the U.S. Army Research and Development Center (ERDC), was the development of Kitware's Computational Model Builder (*CMB*), which provides customizable open source tools for simulation modeling in fields as diverse as manufacturing, astrophysics, and climate science. *CMB* addresses several challenges involved in the practical use of HPC simulation, particularly the limited availability of tools that can support the entire simulation lifecycle. Many powerful, specialized tools and applications that address various parts of the simulation workflow already exist but lack interoperability and flexibility. *CMB* pulls them together and integrates them into an application framework that can be easily adapted to specific problems. *CMB* promises a significant impact on the productivity of small- and medium-sized businesses by promoting the full realization of the impressive HPC technology, which is likely to result in a major leap forward in competitiveness for U. S. businesses. In order to appreciate the significance of Kitware's software, one need only consider that one of Kitware's core platforms—*CMake,* a central pillar for managing, building, and controlling the quality of multiplatform code—is downloaded 3,000 to 4,000 times a day from sites around the world; is included in standard Linux distros; and is routinely used by large companies like Netflix.

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