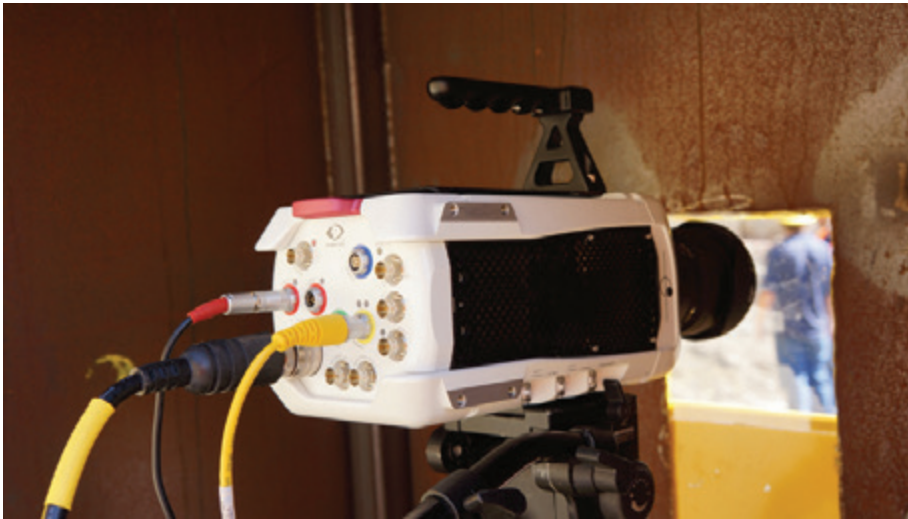


CASE STUDY

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Explosives Engineering: High Speed Imagery for Research and Experimentation



Phantom v711

WHEN IT'S TOO FAST TO SEE, AND TOO IMPORTANT NOT TO[®]

Put a high-speed camera in the hands of almost anyone, and the first thing they film is likely to be an explosion. It is fun watching a watermelon explode into thousands of micro-sized pieces in slow motion. However, the use of high-speed imaging to view and analyze explosives is serious business at the Colorado School of Mines. Understanding the best way to apply explosives to accomplish an objective is an area of continuous research and the results benefit industries ranging from construction to mining to defense.

The average explosion and blast pattern only lasts a couple of seconds. Seeing what really transpires during the explosion is virtually impossible to see with the naked eye. It is even more difficult to teach explosive engineering if you can't see and understand how these explosions work. This is why Vision Research is collaborating with the Colorado School of Mines, to develop a university-level short course offered every September on high-speed imaging and its

About the Colorado School of Mines

Colorado School of Mines is a public research university devoted to engineering and applied science. It has the highest admissions standards of any public university in Colorado and among the highest of any public university in the U.S. The Colorado School of Mines has distinguished itself by developing a curriculum and research program geared towards responsible stewardship of the earth and its resources. In addition to strong education and research programs in traditional fields of science and engineering, Mines is one of a very few institutions in the world having broad expertise in resource exploration, extraction, production and utilization. As such, Mines occupies a unique position among the world's institutions of higher education.

Since its founding in 1874, the translation of the school's mission into educational programs has been influenced by the needs of society. Those needs are now focused more clearly than ever before. The world faces a crisis in balancing resource availability with environmental protection and Mines and its programs are central to the solution.

The Colorado School of Mines offers all the advantages of a world-class research institution with a size that allows for personal attention.

Explosives Engineering

“This program was developed for professionals who already have a moderate degree of knowledge and training in high-speed imaging and explosives research. We use real commercial explosive materials and students participate in actual field testing of explosions, therefore it's extremely important that all of our students follow the courses rules and regulations and are mildly familiar using these types of explosive applications.”

– Dr. Vilem Petr,

Research Associate Professor,
Colorado School of Mines

Technical Director,
AXPRO Group

use, benefits and advantages while experimenting with explosives and ballistic applications. The course is a carefully structured introduction to the main topics in the field of explosive engineering and how to best use digital high-speed imaging when conducting experiences or research for military or civilian applications.

The course is the brainchild of Dr. Vilem Petr, a research associate professor at the Colorado School of Mines and technical director of the AXPRO Group in the mining and engineering department. AXPRO Group was established in 2005 on the encouragement of industrial partners to emphasize the unique strength in undergraduate and graduate engineering education at the Colorado School of Mines. The AXPRO Group performs applied and fundamental research in explosive engineering, energetic materials, as well as explosive processing of materials. The research scope is focused on developing practical solutions for unique applications in partnership with industry and government. The education goal of the AXPRO Group is to provide practical experience with explosives safety, handling, storage, and applied science for both students and explosive users. In addition, the AXPRO Group collaborates with the continuing education program at the Colorado School of Mines to offer world class seminars and short courses on a variety of explosives engineering topics.

Dr. Petr contacted Vision Research four years ago with the idea to work together for this joint class to teach engineers, scientists, students as well as military and law enforcement professionals the tools they needed to understand explosions and the best way to study them.



Dr. Petr and his team set the detonator to smokeless powder explosive.

“Every year we have been able to improve on this class and grow it to make it better and more informative for the students and professionals that partake in it.”

– Frank Mazella,
Learning Products Manager
Vision Research

“This program was developed for professionals who already have a moderate degree of knowledge and training in high-speed imaging and explosives research,” said Dr. Petr. “We use real commercial explosive materials and students participate in actual field testing of explosions, therefore it's extremely important that all of our students follow the courses rules and regulations and are mildly familiar using these types of explosive applications.”

“It has been an extremely rewarding experience partnering with Vision Research for the past four years on this course. Without the ability to be able to see and analyze the explosions in high speed, there would be no grounds for this course.

– Dr. Vilem Petr,
Research Associate Professor,
Colorado School of Mines
Technical Director,
AXPRO Group

The course is an intensive 4-day hands-on workshop that covers a wide range of material including detonation and shock wave physics, selection of explosives, an introduction to high-speed imaging, scaling experiments for high-speed imaging, lighting and selecting lenses for the best results, triggering strategies, analysis of high-speed imagery, and more. Each topic is presented by internationally renowned experts in their respective fields, and addresses an audience spanning a wide range of scientific backgrounds.

“Every year we have been able to improve on this class and grow it to make it better and more informative for the students and professionals that partake in it,” said Frank Mazella, Learning Products Manager at Vision Research. “Now



Students setup Phantom cameras inside specially built cabinets.

I feel that we have a truly remarkable class that is sold out every year. Utilizing the fact that so many of the students come from such diverse backgrounds and professions, we have been able to formulate the course into a truly unique learning experience that everyone benefits from.”

Every year, the class begins with a welcome and a safety overview for the entire course given by Dr. Petr. That is followed by an introduction to explosive, denotation, initiation and shock wave physics. Subsequently, Frank Mazella of Vision Research gives an introduction to high-speed imaging using the Phantom cameras, followed by lessons on illumination and lighting considerations and camera triggering and synchronization. Guest speakers also cover topics related to lensing and optics as well as motion analysis.

Over the next three days, the course proceeds to discuss and go into much further detail on a variety of explosive techniques and applications. The students then participate in numerous field experiments to test out different types of materials and how they react to certain types of explosions. During the experiments, the Phantom Miro cameras as well as Phantom v-series cameras are set up and used to record the explosions so they can be reviewed and analyzed later.

CASE STUDY

Explosives Engineering: High Speed Imagery for Research and Experimentation

About Vision Research:

Vision Research designs and manufactures high-speed digital imaging systems used in applications including defense, automotive, engineering, science, medical research, industrial manufacturing and packaging, sports and entertainment, and digital cinematography for television and movie production.

The Wayne, N.J.-based company prides itself on the sensitivity, high-resolution and image quality produced by its systems, robust software interfaces, and reliability and versatility of its camera family – all which continue to stand as benchmarks for the high-speed digital imaging industry.

Vision Research digital high-speed cameras add a new dimension to the sense of sight, allowing the user to see details of an event *when it's too fast to see, and too important not to*®. For additional information regarding Vision Research, please visit www.phantomhighspeed.com.

Vision Research is a business unit of the Materials Analysis Division of AMETEK Inc., a leading global manufacturer of electronic instruments and electromechanical devices.

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“It has been an extremely rewarding experience partnering with Vision Research for the past four years on this course,” said Dr. Petr. “Without the ability to be able to see and analyze the explosions in high speed, there would be no grounds for this course. Being able to utilize the Phantom cameras in this course and its experiments has not only allowed our students see explosions in a way that could never be seen before, but also allowed them to yield some incredible findings from their studies.”



Dr. Petr and his team prepare another charge that will be captured and analyzed by the students.

The course wraps up with group presentations on findings during the 4-day learning experience and awards are presented for various categories.

AMETEK Vision Research's digital high-speed cameras are subject to the export licensing jurisdiction of the Export Administration Regulations. As a result, the export, transfer, or re-export of these cameras to a country embargoed by the United States is strictly prohibited. Likewise, it is prohibited under the Export Administration Regulations to export, transfer, or re-export AMETEK Vision Research's digital high-speed cameras to certain buyers and/or end users.

Customers are also advised that some models of AMETEK Vision Research's digital high-speed cameras may require a license from the U.S. Department of Commerce to be: (1) exported from the United States; (2) transferred to a foreign person in the United States; or (3) re-exported to a third country. Interested parties should contact the U.S. Department of Commerce to determine if an export or a re-export license is required for their specific transaction.