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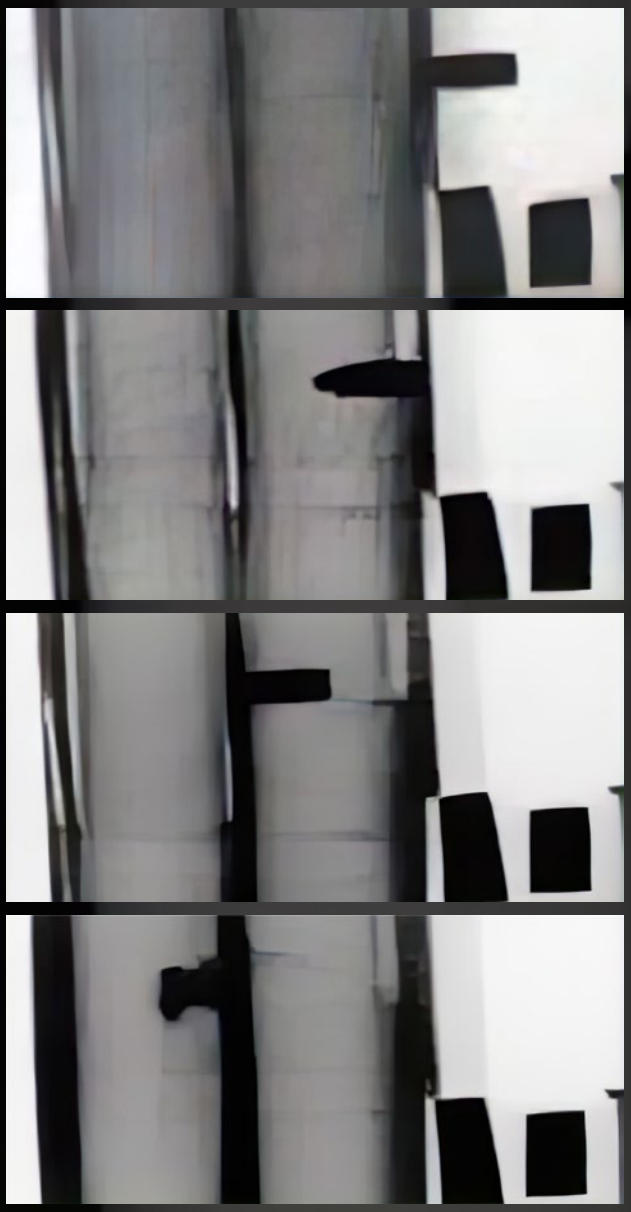
556 BALLISTICS WITH FLASH X-RAY CINEMATOGRAPHY



CAPTURE THE NUANCED DETAILS AS A BULLET PENETRATES A STEEL AND POROUS MATERIAL MATRIX

SCF450 FIXED-AREA TIME SEQUENCE IMAGING WITH MINIMUM PARALLAX

Abstract

The capabilities of the Flash X-ray (FXR) equipment used by the Faculty of Mechatronics, Armament and Aerospace at the Military University of Technology in Warsaw, Poland is demonstrated by visualizing the dynamics of 5.56 ammunition when penetrating a multi-layer matrix comprised of steel plates and a porous material. The images were recorded using the SCF450 4-channel MAT Cine FXR (Cinematic Flash X-ray) that can study a 'hot spot' with up to eight images from a near-single angle of view. The resulting high-speed time sequence of images produced is referred to as 'fixed-area time sequence imaging' – one dynamic event at a fixed area of interest is captured in order to study the progress of the event as it unfolds.

Courtesy

Bartosz Fikus, bartosz.fikus@wat.edu.pl
Department of Artillery and Ballistics, Military University of Technology, Warsaw, Poland
www.wojsko-polskie.pl/wat and wml.wat.edu.pl

Scandiflash core equipment

SCF basic channel setup + add-on channels
SCF450 MAT Flash X-ray source
Cinematic Imaging Detector (CID)

Additional equipment

Ultra high-speed camera & sync

SCANDIFLASH™

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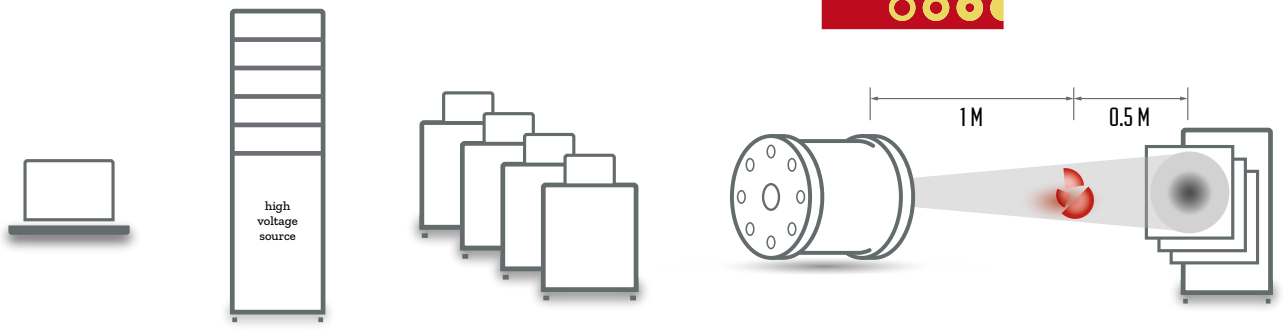

Scandiflash Cine Flash X-Ray setup – working distances are flexible

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Visualize film-like motion with Cine FXR
In the laboratory of Bartosz Fikus at the Faculty of Mechatronics, Armament and Aerospace of the Military University of Technology, a Cinematic Flash X-ray system is used to visualize film-like motion inside a dynamic event where a' hot spot' is studied by capturing multiple images from a near-single angle of view. The benefit of Cine FXR Imaging is that it enables 'fixed-area time sequence imaging' which produces a high-speed time sequence of images of one event at a fixed area of interest in order to study the progress of the event as it unfolds. Cine FXR Imaging is achieved with a specialized flash X-ray tube known as a Multi-Anode Tube (MAT) paired with a Cinematic Imaging Detector that converts the X-rays into visible light and detects images at microsecond intervals.

Observe a speeding bullet stopped in its path
In this study, the Cine FXR potential is demonstrated using 5.56 ammunition fired with a velocity of approximately 1005 m/s into a steel and porous material matrix. The matrix was constructed by Bartosz and his students for this study using 25 mm thick porous structures of approximately 800 kg/m^3 density sandwiched between a series of steel plates. Although the actual porous material used is a type of plastic, the density is similar to wood. In order of penetration, the first steel plate is 0.3 mm thick, the second steel plate is 0.755 mm thick, and a third steel plate structure consists of 2 x 0.75 mm plates in the bullet axis and 120 mm in the X-ray light optical axis.

The Flash X-ray source is operated at an energy of 300 keV. The distance from the flash X-ray source to the target is approximately 1 m and from the target to the front of the image detector is approximately 0.5 m.

The four consecutive images showcasing the dynamics of the event recorded are at 16 microsecond intervals. In the first image, the bullet penetrates the first steel plate. In the second image, the bullet continues traveling toward the second steel plate which it penetrates in the third image. In the fourth and final image, the bullet is stopped in the porous material before reaching the third steel plate.

"Scandiflash instruments are perfect for research and education! The system is relatively easy to use and sync all the components. We have many options for X-ray windows, anode & cathode swapping, and it's cost effective to run many tests. My students can actually hold and look at the parts from inside the X-ray tubes to better understand how they work. It's perfect for students!" Bartosz Fikus

Cost effective research and teaching
Once the initial investment in Scandiflash instruments is made, the payoff is quickly realized due to very low operating costs. Bartosz commented, "I work with at least twenty students per year, and because we can so easily change anodes and cathodes in Scandiflash tubes, my students have the freedom to make many studies as compared to the cost limitations of using glass tubes." Beyond teaching in the lab, research is not limited by the operating costs or durability of the instruments used to study dynamic events.

Hands-on learning
The purpose of this specific experiment was to observe how the bullet deforms as it penetrates various materials. When asked what was learned from this experiment, Bartosz enthusiastically replied, "My students were surprised to see real progress of the bullet deformation process inside the potential protective structure."

Nothing beats real hands-on learning! In the lab, Bartosz encourages his students to play with all the various settings and setups they can imagine. Use our website contact form and let us know what you've accomplished with our technology?

Reference: B. Fikus; Presentation at the 13th International Conference on Mathematical Modeling in Physical Sciences, 2024.