Manhattan College Chooses PXI-Based Solution from Quantifi Photonics to Simplify PDV System Design & Maintenance

CASE STUDY

Author: Dr Medhi Omidvar, Associate Professor of Civil Engineering, Manhattan College.

Quantifi Photonics PXI Modules: LASER, DOPPLER and O2E (housed in a 9 slot NI chassis).

The Challenge

Creating a state-of-the-art experimental setup to produce high-resolution velocity-time measurements from vertical projectile penetration in soil targets using Photon Doppler Velocimetry (PDV).

The Solution

Using Quantifi Photonics' modular PXI-based PDV instrumentation to reduce system design and setup time, and streamline system control with single software user interface.

About the Author

Dr. Mehdi Omidvar is an associate professor of Civil Engineering in the Civil and Environmental Engineering department at Manhattan College. His research interests include infrastructure risk assessment, numerical and analytical modelling with applications in soil-structure interaction, high strain rate and extreme loading of soils, and earth retaining structures.

Dr. Omidvar has several years of industry experience where he was responsible for the design of earth dams, deep foundations, and earth retaining structures. In addition, he has conducted research as principal investigator and co-investigator on over $4.5M in externally-funded projects. He has received funding from the National Science Foundation, Department of Defense (through SERDP), Department of Transportation (through UTRC), and the United States Universities Council on Geotechnical Education and Research (USUCGER), among others. He has co-authored a book on penetration into granular media, and he has over 50 papers published in peer-reviewed journals and conference proceedings.

Introduction

Penetration in soils is a widely investigated topic that has been subject to extensive experimental, numerical, and analytical research. Our research group at Manhattan College, along with our collaborators at New York University and the Naval Postgraduate School, are interested in using the insights from projectile penetration tests in soils to predict the depth of burial (DoB) of unexploded ordnances (UxO) at Formerly used Defense Sites (FUDS). The research is funded by the Strategic Environmental Research and Development Program (SERDP) in the Department of Defense. The principal investigators of the project are Dr. Stephan Bless and Dr. Magued Iskander at New York University.

Experimental Setup

Prediction models generally require experimental data for calibration of parameters or validation of predictions. This necessitates collecting high-fidelity data of projectile penetration in various soils under a range of impact velocities. The laboratory at Manhattan College houses a state-of-the-art vertical single-stage gas-operated ballistics range, as shown in Figure 1. The launcher is capable of firing projectiles both vertically and with obliquity at velocities of up to 1,000 m/s. The team is currently focused on impact and penetration tests in sand and clay-based soils. Long rod projectiles and scaled munitions such as the M107 155 mm and M81 rounds are typically launched at impact velocities of 200-300 m/s into dry and wet soil targets. We have tested a variety of sands and clayey soils under dry and wet conditions, as well as layered soil systems. We use our high-fidelity data to calibrate numerical models and to develop phenomenological penetration models.

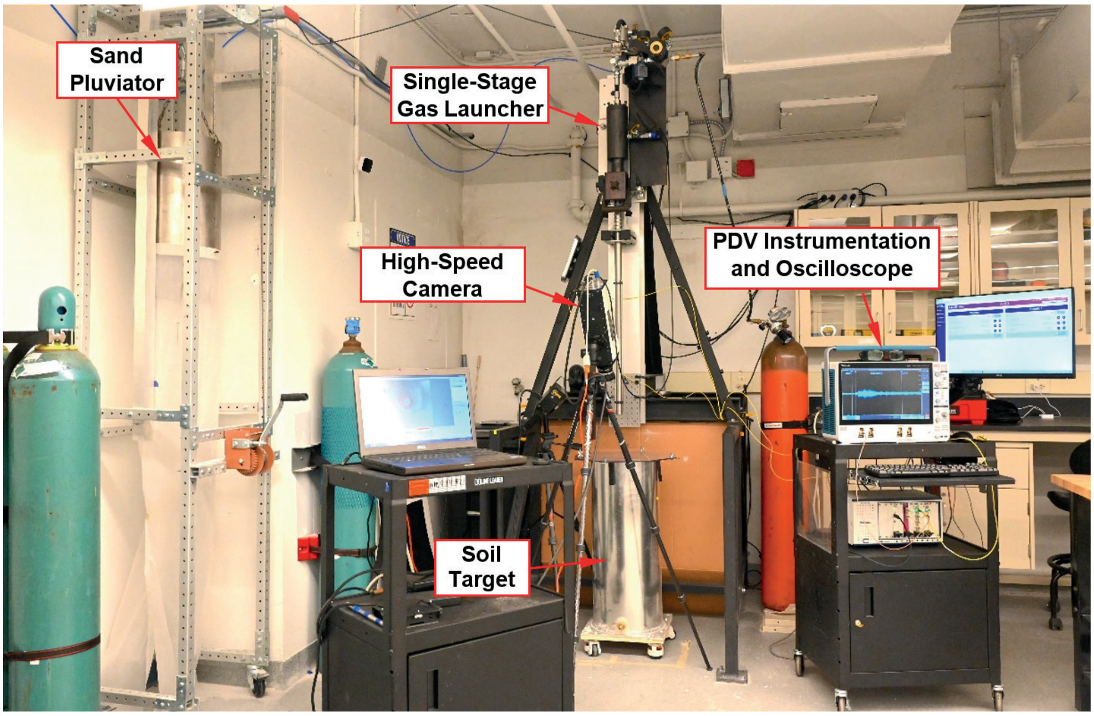


Figure 1:

Experimental setup used to launch projectiles in soil targets.

We use a range of instrumentation and diagnostics equipment to study the dynamics of projectile penetration in soil targets, including a high-speed camera, two-channel PDV housed in an NI chassis, a 4 GHz digital oscilloscope capable of obtaining samples at a rate of 25 GS/s, magnetic proximity sensors, and photogate arrays for measuring in-flight projectile speed. Through a collaboration with NYU, we also have access to μCT scanner, a scanning electron microscope, and a dynamic image analyzer for post-mortem analysis of exhumed projectiles and soil samples.

PDV System Design

We could have easily focused on the capital costs and designed the PDV system in-house, and there is a wealth of literature on how to build PDV systems and the components to use. However, we recognized the need to take a broader perspective on solution selection.

We considered the following criteria:

- **Development Time:** We wanted to focus our efforts on application of the PDV setup in our research, and avoid the effort needed to assemble, interface, and ensure compatibility of individually-sourced components.
- **Ease of Purchase:** Sourcing all the components can also take up significant effort. Quantifi Photonics was able to provide all the key components, ensuring their compatibility.
- **Maintenance:** The system needs to be supported and serviced intermittently. A commercial-off-the-shelf (COTS) solution allows us to offload that effort to the supplier.
- **Training:** As new students and staff join the team, the support resources and documents from Quantifi Photonics can help us reduce the ramp up and learning time.
- **Usability:** All of Quantifi Photonics' modules can be controlled using a web-based GUI, CohesionUI, which enabled us to be able to control all modules from one user interface. We operate the PDV equipment remotely from a control room.
- **Physical Footprint:** By leveraging PXI technology, we were able to build a compact and mobile system.

The two-channel PDV system was designed as a frequency-shifted configuration (Figure 2) using PXIe optical modules from Quantifi Photonics. The following PXIe modules are used for each of the two channels:

- **LASER-1052** is a 1527-1568 nm laser source with 8-15 dBm output power.
- **DOPPLER-1001** incorporates the key components of PDV in a single module.
- **O2E-1101** is a low noise (40 pW/√Hz) AC coupled photodetector with 25 GHz bandwidth and 900 V/W gain.

The PDV PXIe modules are housed in a NI chassis, and are operated using the Quantifi Photonics CohesionUI controller software, as shown in Figure 3. Two optical probes are mounted approximately 25 mm from the launcher barrel central axis, and on opposite sides of it, as shown in Figure 4. Mounting posts are used to adjust the alignment of the probes to different depths into the soil target. Retroreflecting tape is used to reflect signals from the back of the projectile during ballistic experiments.

Figure 2:

Frequency-shifted PDV configuration used in this study.

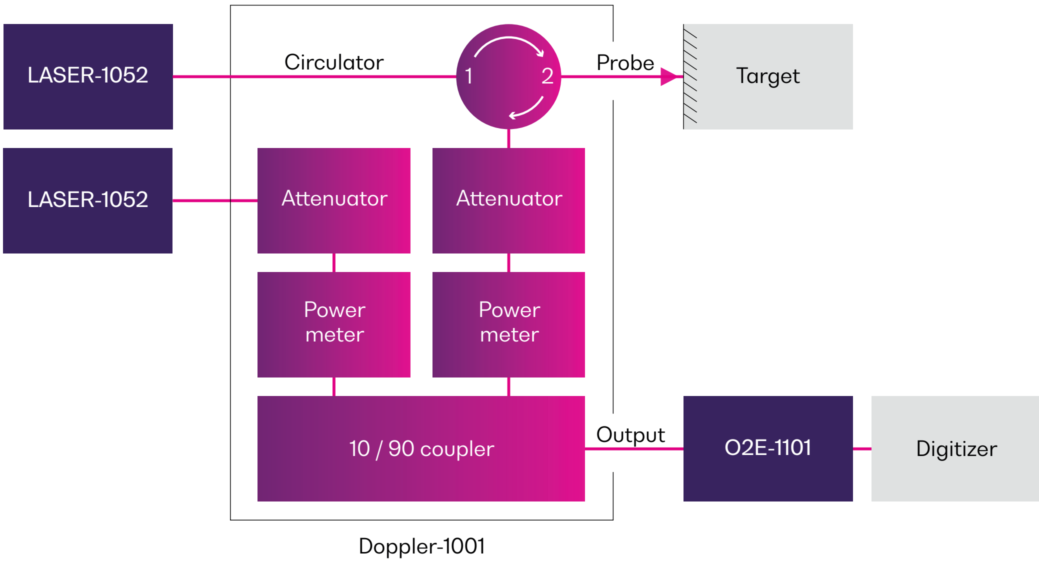


Figure 3:

PDV configuration used in the experiments

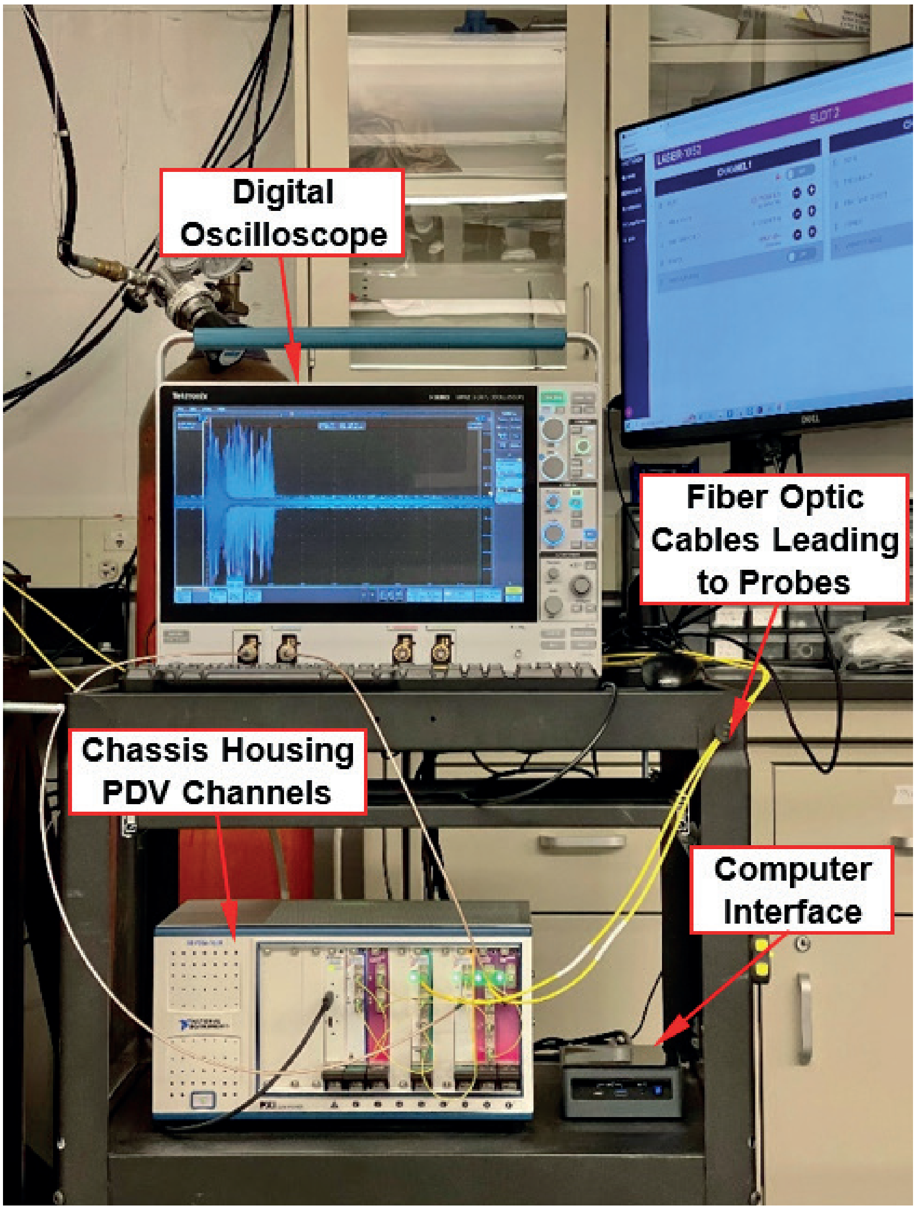
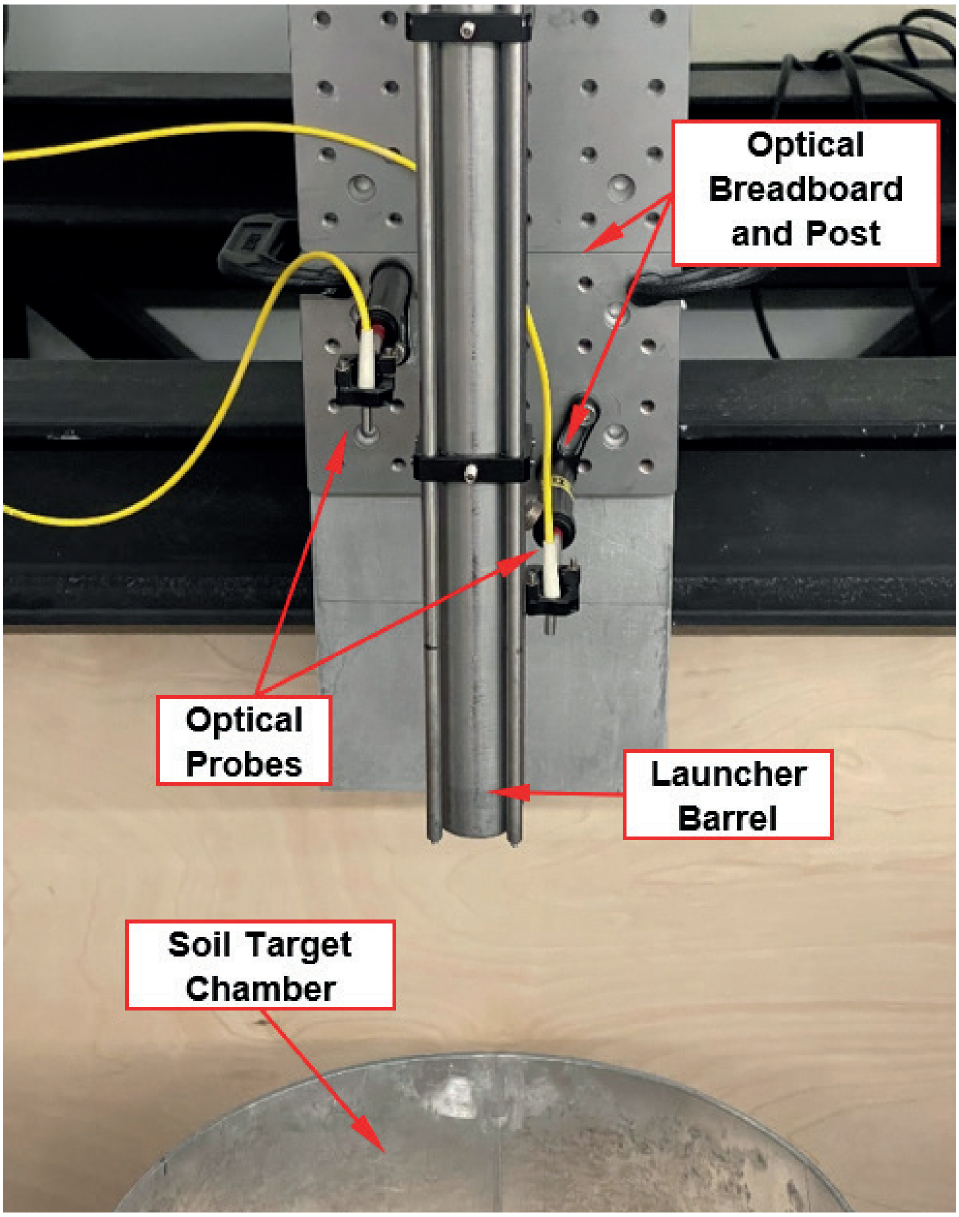


Figure 4:

Probe mounting and alignment



Conclusion

Quantifi Photonics' PDV system has allowed us to obtain unprecedented data on ballistic penetration of projectiles in soil targets. We started the work using a one-channel system, and have expanded it to a two-channel system in early 2022. Using two channels has allowed us to extend the depth of field of velocity measurements in our experiments. The modular platform of Quantifi Photonics' PDV system has allowed us to expand our PDV channels as needed. We recently completed our 100th test, and continue to explore possibilities of expanding the setup and increasing our depth of field.

Test. Measure. Solve.™

Quantifi Photonics is transforming the world of photonics test and measurement. Our portfolio of optical and electrical test instruments is rapidly expanding to meet the needs of engineers and scientists around the globe. From enabling ground-breaking experiments to driving highly efficient production testing, you'll find us working with customers to solve complex problems with experience and innovation.

To find out more, get in touch with us today.

General Enquiries sales@quantifiphotonics.com
Technical Support support@quantifiphotonics.com
Phone +64 9 478 4849
North America +1-800-803-8872

quantifiphotonics.com

QUANTIFI PHOTONICS®