

A proven collaboration model for impact generating research with universities

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ABSTRACT

PRISM is one of a family of student sponsorship programmes initiated by the Armaments Corporation of South Africa (ARMSCOR). The programme facilitates the transfer of knowledge and fosters the development of skilled human capital in the disciplines of optics, electro-optics, image processing and computer vision. It is shown that this collaboration model has resulted in a pipeline of highly-skilled people, impact-generating outcomes and scientific publications.

INTRODUCTION

PRISM is one of a family of student sponsorship programmes initiated by the Department of Defence (DoD), collectively known as LEDGER, which is discussed below. LEDGER's goal is to enhance the Defence Technology Base (DTB). Research is the tool used to achieve this goal; the secondary goal is the training of highly skilled people. PRISM aims to enhance the DTB in the areas of optics, electro-optics, image processing and computer vision. To do this it funds post-graduate studies in the disciplines of chemistry, physics, computer science, mathematics and electronic engineering relating to these fields. This paper discusses the collaboration between ARMSCOR as the funding agent; the South African National Defence Force (SANDF) as the end user of the research; the Defence, Peace, Safety and Security (DPSS) group of the Council for Scientific and Industrial Research (CSIR) as the technical experts and the tertiary education institutions. The main DPSS role player that handles the PRISM contract is the Optronic Sensor Systems (OSS) group. This group specialises in the areas of optics, electro-optics, image processing and computer vision.

The LEDGER programme is funded by the DoD and has the following approach:

- To provide student grants for full-time postgraduate research in the Master of Science (MSc) and Doctor of Philosophy (PhD) degrees, and for providing funding for limited research studies by knowledgeable researchers at these institutions.
- Research at this stage is exploratory and generic. Specific contract research would be required to apply the knowledge generated to a specific military problem.
- It is expected that the normal academic freedoms exist. Students may publish in any conference or journal. Interchange of information, concepts and ideas is actively promoted.
- Any research of a militarily sensitive nature will be handled accordingly. The main goal of the LEDGER Programme, however, is to do research of a non-military sensitive nature.



Illustration 1: Col Neil Napier (DoD) and Dr. Dirk Bezuidenhout (CSIR, DPSS)

OUR COLLABORATION MODEL

The collaboration model can be summarised as follows:

- DPSS staff operates very closely to the military applications domain through the DoD.
- Through the SANDF and ARMSCOR, DPSS plays a technical leadership role with regard to the selection and guidance of research areas suggested to the universities.
- After a post graduate research activity is initiated at a university department, DPSS becomes responsible for the project management of this project.
- The project technical progress is monitored and project progress meetings are held through the course of an academic year. DPSS gives written feedback to ARMSCOR.
- The PRISM panel meets quarterly to discuss progress on student grants and activities at universities.
- Visits to the collaborating universities take place annually. The purpose of the visits is to meet with students which present their work and to discuss activities with study leaders. DPSS adds their own research outputs to the students' work to solve specific problems for the South African defence and security communities.
- The main goal of the LEDGER Programme is to do research of a non sensitive nature. Feedback from students obtained from CSIR visits to their campuses, has been incorporated into PRISM to better address the students' needs.

ARMSCOR ensures the following:

- To ensure reasonable return on investment in terms of capacity creation versus the financial investment.
- To help guide the research into areas of interest for the SANDF.

The final deliverables from a student are the masters or doctoral theses, which are documents accessible to the general public.

THE PRISM WORKSHOP

As part of the PRISM initiative, a workshop is held biannually. Representatives from the CSIR, universities, industry, air force, navy, DoD and ARMSCOR attend the workshops and presentations range from theoretical undergraduate project work, Master's research work to applied research in industry. Key areas of research include photogrammetry, image enhancement, image segmentation, feature detection and object tracking. Some of the real-world problems addressed are: lens distortion correction and image stitching, scintillation reduction in video, autonomous vehicle navigation and object tracking. These technologies are on

a par with research projects across the world and demonstrate maturity and commitment in maintaining excellence locally and internationally. The workshop has grown in numbers since its humble beginning in July 2007.

Rob Calitz (ARMSCOR) commented on the success of the 7th Workshop in Image Processing that took place on 28 January 2010 at the Knowledge Commons, CSIR: "The 7th Prism Workshop was an unqualified success! It was pleasing to see so many students, academics, Industry and Defence Institute delegates attending which allowed everyone to present their research in an informal environment and discuss and exchange ideas. This can only result in a dynamic and expanding image-processing community within South Africa, which is able to solve real-world problems."

KNOWLEDGE TRANSFER

When a student's work has direct application to problems that the CSIR is concerned with, it makes sense to have more focused and in-depth discussions. Knowledge transfer is the name given to these follow-up discussions. The aims of the knowledge transfer are to rapidly exchange experience between students and staff, as well as, where possible, to transfer working algorithm implementations from students to the CSIR. The student is invited to the CSIR for typically a one-week period where staff calendars are cleared to focus on the discussions and interaction. Successful knowledge-transfer sessions have taken place with Zygmunt Szpak (UKZN) and Philip Robinson (UJ). Szpak's work features strongly in the WASP system discussed earlier.

SOME OF THE SUCCESSES WITHIN THE LEDGER AND PRISM INITIATIVES

Students and Universities

Asheer Bachoo, a current CSIR DPSS employee, was funded by the LEDGER programme during his Master of Science (MSc) studies at the University of KwaZulu-Natal (UKZN). He graduated in April 2007 with specialisation in image processing – his area of study was iris image segmentation. During the course of his studies, he produced three conference papers. Bachoo is currently an image processing researcher in the OSS Group where he conducts research in the area of optical target tracking.

Mr Zygmunt Szpak completed his MSc at the UKZN in 2008. One area of his research, motion detection and target tracking, has had a direct influence on the Wide Area Surveillance Prototype (WASP) developed by OSS. Using Mr Szpak's algorithms, the WASP is able to detect and track moving objects in the scene in real-time (a tracking scenario is demonstrated in **Illustration 2**). During his studies, Mr Szpak produced 2 conference papers and a journal paper.

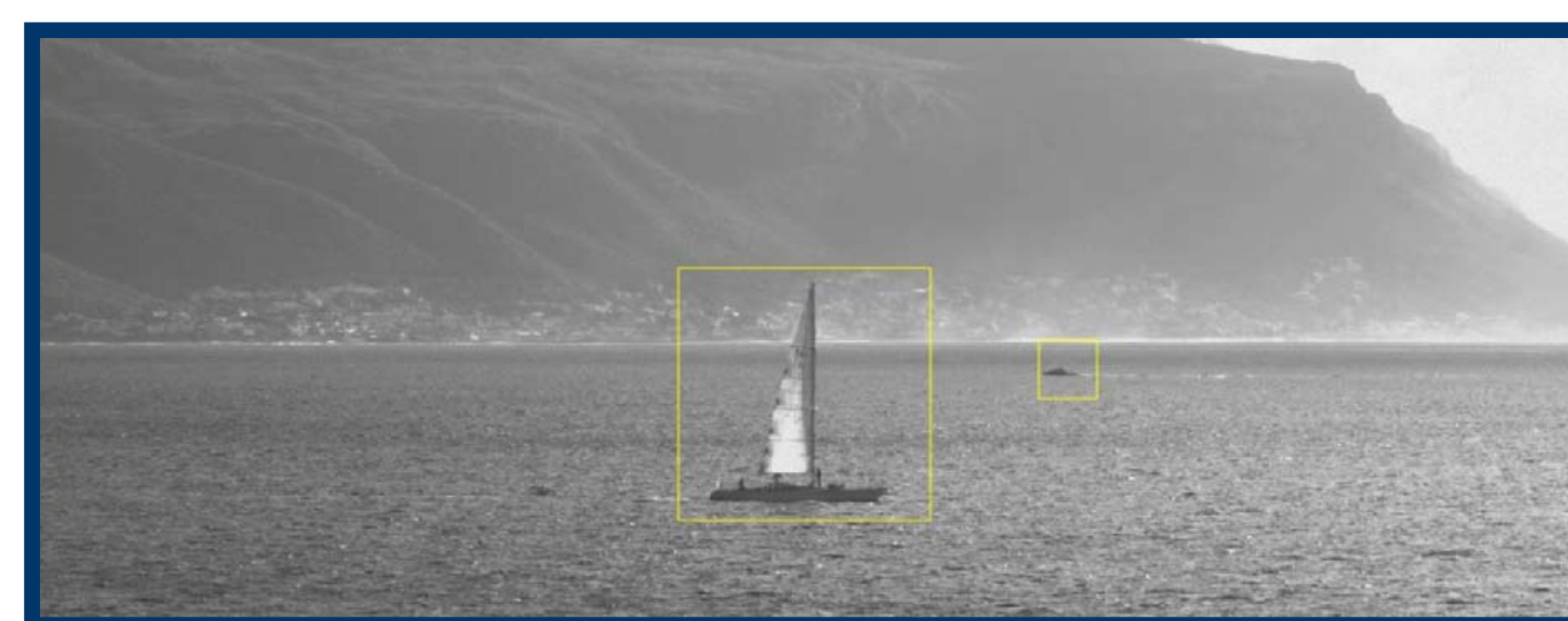


Illustration 2: Multiple target tracking

One of our collaborations with the University of Johannesburg's Mr Philip Robinson has seen the integration of his image enhancement work into our image processing software library. His work focused on heat shimmer (scintillation) reduction in video which is an extremely relevant topic in optical systems. Mr Robinson graduated in 2009 with his MSc and is currently a PhD student under PRISM. An example of heat shimmer is shown in **Illustration 3**.

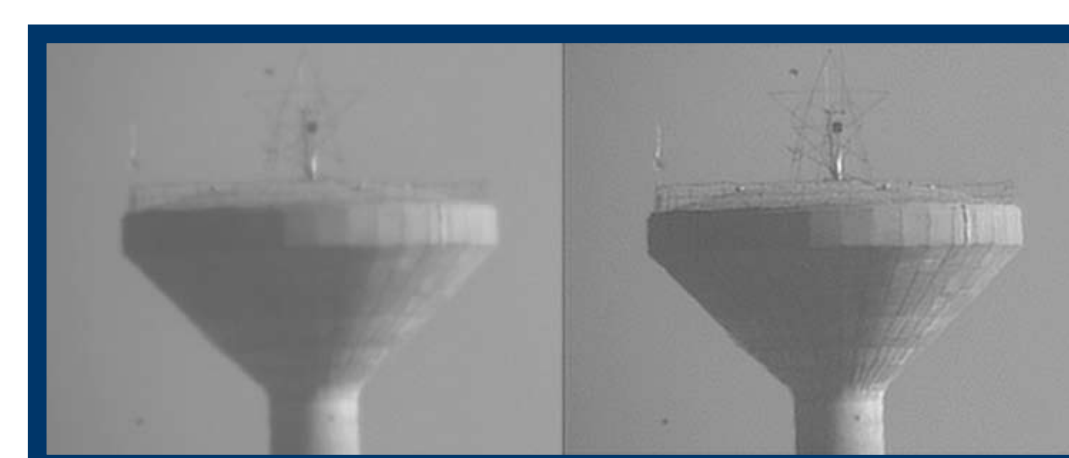


Illustration 3: Effects of scintillation in video: Original image (left) and enhanced image (right)

Z-scan Test Facility

One example of the practical application of laser research is the development of a Z-scan test facility for the research that is presently being done at the chemistry department of Rhodes University. The Z-Scan is an automated, easy to use setup for performing Z-scan measurements. **Illustration 4** shows Rob Calitz of ARMSCOR meeting with scientists from Rhodes University and Stellenbosch University. The Z-scan equipment is shown in **Illustration 5**. A Z-scan experiment entails measuring the transmitted energy through a sample as a function of position of the sample, as the sample is moved along the beam path through the focus of a tightly focused laser beam.



Illustration 4: Rob Calitz (ARMSCOR), Prof Tebello Nyokong (Rhodes University) and Dr Pieter Neethling (University of Stellenbosch)

A programme that facilitates the transfer of knowledge and fosters the development of skilled human capital in the disciplines of optics, electro-optics, image processing and computer vision.

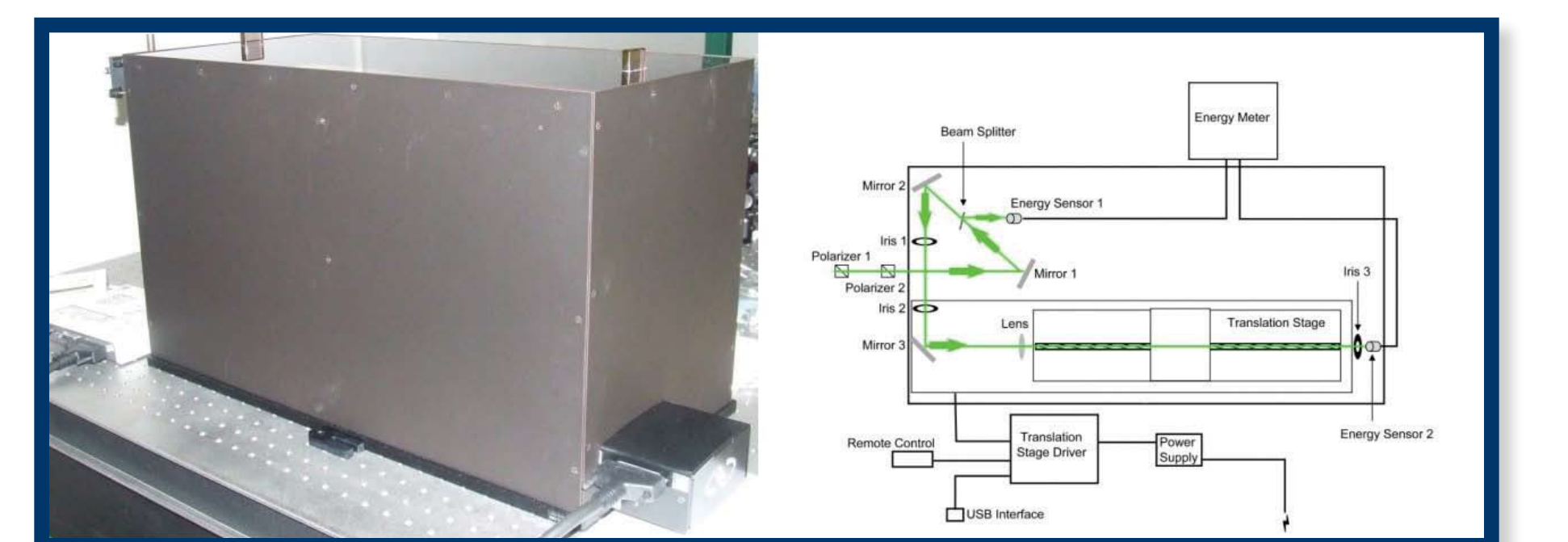


Illustration 5: Z-scan equipment

CURRENT STATUS

The current status of the PRISM is now summarised. The universities involved are shown in **Table 1**.

Table 1: Universities involved with PRISM

Name of University	Department
University of Pretoria	Applied Mathematics
University of Pretoria	Engineering
University of Johannesburg	Engineering
University of KwaZulu-Natal	School of Computer Science
University of KwaZulu-Natal	School of Physics
Nelson Mandela Metropolitan University	Physics
Rhodes University	Chemistry
University of Stellenbosch	Physics
University of Stellenbosch	Applied Mathematics
University of Cape Town	Engineering
University of the Free State	Chemistry
University of the Witwatersrand	Engineering

THE WAY FORWARD

The following points are important in paving the way forward for long term research success:

- Creating and maintaining national and international scientific networks
- Attracting and developing potentially strong research students through multiple degrees i.e. develop a single student from Honours to MSc and then, possibly, to PhD. In this way promising researchers are given the opportunities to achieve their full potential.
- Ensuring real impact through close collaboration with the DoD and ARMSCOR and providing relevant sample data in real world conditions.
- In order to make the the research objectives relevant, gaps must be identified in industry where the technologies can be applied.

CONCLUSION

PRISM has become one of the most successful of ARMSCOR's student sponsorship programmes. With the close link between, tertiary education institutes, the CSIR, ARMSCOR and the SANDF, a balance has been found between academic freedom and application focused research. This has resulted in a growing pipeline creating both highly-skilled people in the electro-optic and vision community, scientific papers, and solutions to problems experienced by the SANDF in its role ensuring the sovereignty and security of South Africa.