

# Autonomous Vision-based Space Objects Detection and Tracking in Orbit

## Project Case Study

### Project Partners

Thales Australia, University of Sydney, HEO Robotics

### Project Overview

This project is undertaking a comparison study of different sensor technologies, including ground and space-based optical, radar and RF sensors for space objects detection and tracking. In addition, it is investigating efficient machine learning algorithms and hardware architectures based on modern FPGA technologies for onboard data processing. The feasibility of the selected approaches will be demonstrated using existing sensor technology (telescope, hyperspectral imager and star tracker).

Space debris has become a concern in recent years due to increased traffic in low earth orbit. This has created a congested and contaminated environment with the proliferation of orbital debris. With the development and commercialisation of small satellites, the small satellite market is expected to reach \$15,686.3 million by 2026. Any impact or collision of space debris with the operational satellites can jeopardise or even end their life, yield significant loss to the space economy, and trigger the so-called Kessler Syndrome which refers to the possibility that collisions will create more debris collisions.

To avoid potential traffic problems in orbit, at the same time the number of sensors of all types—primarily optical, but also radar, and active and passive Radio Frequency (RF) both ground- and space-based—being used for Space Situational Awareness (SSA) has been growing. Space-based optical systems have a few advantages over ground-based optical data collection in that challenges with time-of-day lighting are somewhat mitigated, and weather/atmospheric conditions are not an issue. Sensors in space are also more sensitive and allow for the detection of dimmer objects including space debris. Space-based SSA assets are typically a single satellite or a constellation of satellites conducting SSA on space objects using optical sensors.

This scoping study is:

- Investigating a constellation approach offering the potential to track and monitor objects in low earth orbit (LEO) by using onboard optical cameras and related innovative sensor types;
  - Exploring gaps in currently available products and technology and to identify and recommend concepts and technologies for detailed research that have the potential to improve system performance and provide a sovereign capability for Australia;
  - Examining the feasibility of different constellation configurations and assess their coverage of the celestial sphere and their suitability for Australian surveillance objectives;
  - Developing machine learning algorithms to analyse the data and perform studies on hardware implementation of machine learning algorithms onboard satellites, which will enable the space traffic monitoring system in orbit and improve the downlink efficiency.
- The outcomes of this proposal will inform a larger phase 2 activity, which will propose a space traffic monitoring system via satellite constellation in orbit. By constructing such a constellation system in space, onboard optical sensors can track and monitor objects in LEO. This will give much more detailed information about the Earth orbiting objects and can be further extended to build space traffic management capabilities.
- Undertaking a literature survey of existing space surveillance technologies with a focus on in-orbit sensors and monitoring systems;

## Utilisation

This project will contribute to the sustainable exploitation of the LEO traffic for future space missions. This project has the potential to boost Australia's SSA market and space industry by pursuing commercialisation of space tracking services and SSA hardware and software packages. Dealing with space debris is a national security issue. This project will strengthen Australia's competencies and capabilities in detection and tracking of unknown space objects, in fusion of Australia's ground-based tracking facilities.

## Collaboration

This project will allow an Australian SME to benefit from collaboration with an existing global player in the space business to facilitate access to global market opportunities, and work with a leading Australian research organisation.

Thales Australia has an interest in Space Situational Awareness (SSA), and is currently seeking market opportunities to deliver capabilities to the Australian Department of Defence. The strategy is to leverage technologies from the Thales Alenia Space global product portfolio, while also developing research relationships with Australian entities and researchers able to offer unique and innovative new components and subsystems in support of their solutions.

The study activity is a great facilitator to help grow the knowledge and understanding of Thales Australia staff in this area of technology that is relatively new to Thales' Australian operations. The literature survey of existing space surveillance technologies and the associated scoping study are identifying gaps and opportunities and will help guide Thales as to where best to focus efforts in this SSA domain.

Collaboration with The University of Sydney is also enabling the broader objective of creating true sovereign capability for Australia, at both the industrial and research levels.

HEO Robotics provides on-demand analytics for in-orbit asset management. HEO uses space-based cameras to capture high quality imagery of LEO and GEO assets, and its own suite of analytics software to provide valuable insights on the assets. The outcomes of this project will help HEO scale current Space Domain Awareness capabilities.



Thales is a large prime with global credentials in the space sector, and this activity is an important step in building knowledge and capability in the Australian part of our organisation.

**Michael Clark, Director Technical Strategy,  
Thales Australia**

The University of Sydney offers Space Engineering education and research program to the talented students since 2001. This project shows an example of knowledge transfer in the university-industry collaboration project and helps build Australian space industry capabilities in the domain.

**Xiaofeng Wu, Senior Lecturer in Space Engineering,  
University of Sydney**

HEO Robotics values the opportunity to collaborate with Thales and the University of Sydney in this project.

**Dr. William Crowe, Co-founder and CEO,  
HEO Robotics**

