Compact Clock for Small Satellite Applications

Project Case Study

Project Partners

University of Adelaide and QuantX Labs Pty Ltd

Project Overview

The value that precision timing onboard Global Navigation Satellite Systems (GNSS) enables such as GPS and Galileo, cannot be understated; it is used by hundreds of millions of people around the globe and generates trillions of dollars of economic benefits every year. GNSS is now used in a range of applications including navigation, defence, coordinating complex logistics, electricity supply, finance, and telecommunications. Although such innovations have led to enormous gains in productivity and efficiency, modern society is now heavily reliant on the provision of precision time via satellite, of which Australia does not have any sovereign capability.

This project addresses one of the key hurdles to achieving an alternate Positioning, Navigation and Timing capability for Australia through the development of space-qualified, compact clocks.

Over the last 5 years, the University of Adelaide has been developing a new optical atomic clock technology that uses small glass cells containing rubidium vapour. The new optical approach allows significant reductions in size and weight, while opening avenues to higher performance.

The University of Adelaide team has already demonstrated timing stabilities comparable to the very best Global Navigation Satellite Systems (GNSS) clocks in a system that is at Technology Readiness Level (TRL) 4. A technical pathway has been identified to improve this performance tenfold whilst at the same time reducing size, weight and power metrics. A "frequency comb" will also be developed that can take the output of the optical clock and deliver a Radio Frequency (RF) signal with the same superb timing stability – but which can be interfaced with traditional electronics.

To make the clock more suitable for space-based applications, the high-power consumption and heavy components need to be replaced with small, low-power alternatives. Under this project, a new laser interrogation and detection system will be built and much of the existing electronics will be replaced with compact digital versions.

In collaboration with QuantX Labs, a sovereign, premier provider of high precision timing and sensor products, this project will address these challenges and mature the compact clock technology to the point where it can be developed into an Engineering Model in a second phase suitable for functional testing and space qualification of components.

Utilisation

High precision timing is an underlying technology for distributed systems and systems resilience. As such, the space-based compact clock will feed into a multitude of different technologies, including:

- Defence seeks to incorporate the clock technology in Resilient Multi-mission Space STaR Shot missions for application in Position, Navigation and Timing. If it can outperform the clocks currently used onboard GNSS satellites, it will not only provide Australia with a sovereign GNSS capability, but it will also be more resilient to jamming or spoofing than current state-of-the-art;
- Secure communications networks whereby encoding could be achieved in time delays that require precise timing to decode;
- The technology is of interest to NASA for accurate clocks for deep-space and solar system navigation and timing information is essential to synchronise each satellite's observations.

Collaboration

QuantX Labs have provided invaluable engineering support and commercial know-how which has helped guide the development of a solution that will be manufacturable and deployable at the next stage of the project. This collaboration demonstrates the value of academia and industry working together to accelerate product development.

"This project has been a true collaboration between SmartSat, the University and QuantX Labs. The project team have delivered a manufacturable design through the invaluable input provided by the international space eco-system that has been created by SmartSat.

Prof Andre Luiten, University of Adelaide"