Breaking the Smallsat Barriers to Sub-50cm Imaging

Authors:
Hamilton Law, Alex da Silva Curiel*, Andrew Haslehurst, Steven Knox, Victoria Irwin, Prof Sir Martin Sweeting.
Surrey Satellite Technology Ltd, Guildford, Surrey, GU2 7YE, UK

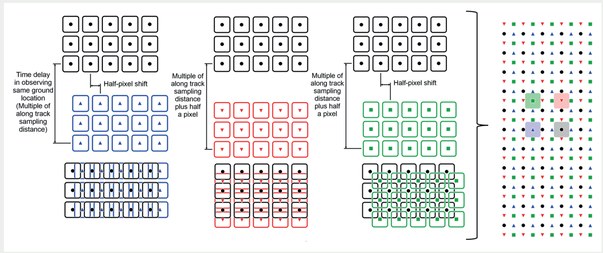
Abstract

New cutting-edge imaging sensors can now reduce instrument size and mass, leading to mission cost savings, and bring sub-50cm imaging capability into the realm of small satellites.
Whilst aperture is essential to achieving resolution, half-pixel shifted sensor architectures decouple achievable Ground Sampling Distance (GSD) from the native ground projected pixel. This facilitates the deployment of Very High Resolution (VHR) small satellite constellations featuring improved Signal-to-Noise performance and increased area collection rates compared to push-frame systems.

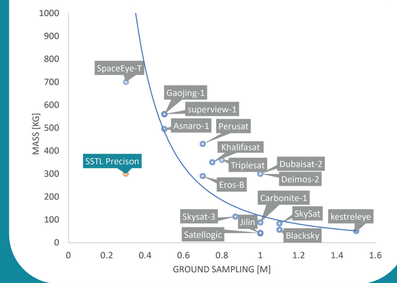
Funded under the European Space Agency (ESA) “Investing in Industrial Innovation” (InCubed) program, this paper reports on the build and verification campaign of a sub-50cm capable instrument Proto-Flight Model (PFM), the beneficial properties of half-pixel offset sensors, and the platform supporting such a payload.

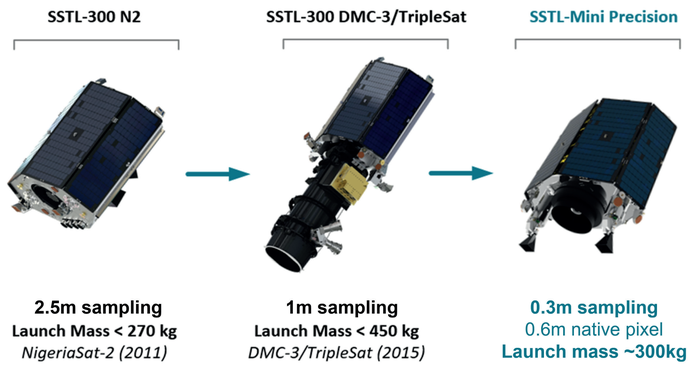
Maximising Optical Performance from a Small Satellite

- The aperture size of an optical payload places a fundamental limitation to the theoretical resolution performance of an optical system.
- This theoretical performance is degraded by optical aberrations, the detector performance, in-orbit platform stability effects and aliasing. Aliasing leads to artefacts in the final imagery.
- Half-pixel offset sensors produce overlapping pixels for improved sampling, without the limitations to signal of small pixels. This increases the Nyquist limit, reducing aliasing and enhancing imaging performance.



Breaking the Smallsat Barriers

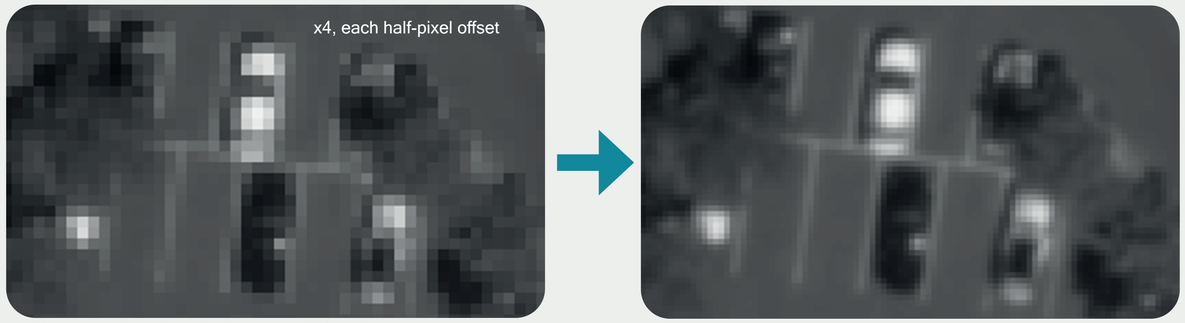




Simulated Imagery

Employing a half-pixel offset sensor with four banks of pixels, from a 500km altitude, the following performance is achieved:

- Native pixel: 0.6m
- Half-pixel sampling: 0.3m



60cm sampling - Nyquist frequency 100 cycles/mm
Base imagery convolved with imager PSF

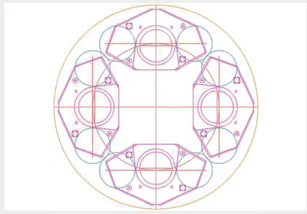
30cm sampling resultant imagery
Nyquist Frequency 200 cycles/mm, reduced aliasing

SSTL-Mini Spacecraft Performance

- Mass ~300kg
- Payload data storage capability of 3TB
- SSTL’s heritage X-band transmitter has been further developed for increased throughput and can support up to ~1.2Gbps data rate.
- Agility has also been enhanced beyond the heritage Triplesat mission baseline, with an increased number of reaction wheels. Allowing targets separated by 60 degrees to be imaged within 60s.
- Field of regard of 45°
- Modes: strip, inclined strip, ALT stereo, ACT Stereo, mosaic.

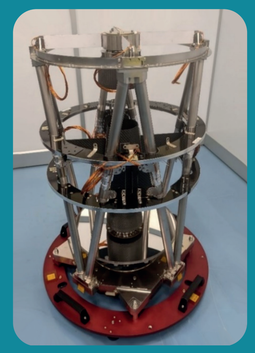
Designed for “Missions at Scale”

- Accommodation within PSLV faring:



Precision Optical Proto-Flight Model

- In alignment with SSTL’s current generation of smaller carbonite payloads, a metallic truss metering structure has been selected to allow the use of readily available and machinable materials.
- This reduces cost compared with heritage composite approaches and reduces lead times, whilst maintaining high performance.
- Optical Proto-Flight Model currently undergoing modulation transfer function testing
- Additionally collects multi-spectral R,G,B & NIR information.



*email: a.curiel@sstl.co.uk
tel: +44(0)1483 803803

sstl.co.uk

@surreysat