Ultra-Precision Reflective Surface Laboratory: A New Advance on Astronomical Instrumentation in Thailand

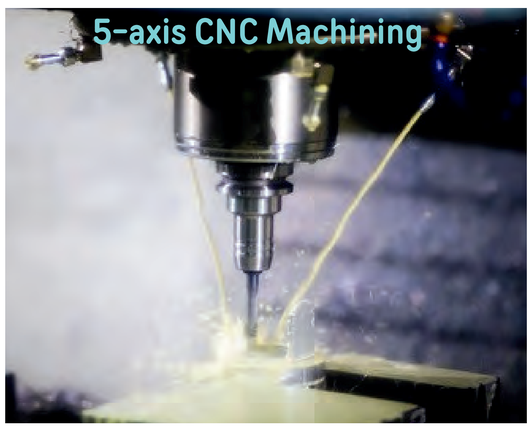
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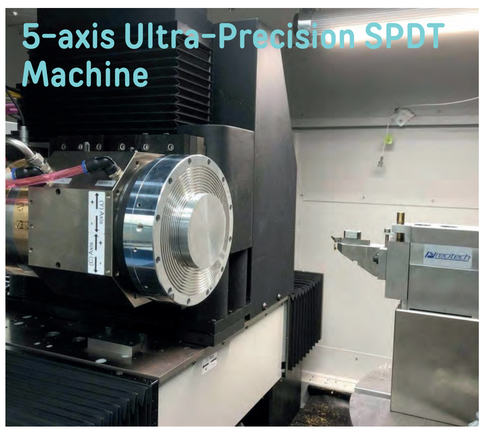
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NARIT's Machining Facilities and Infrastructures:

- **Decades in the building:** The National Astronomical Research Institute of Thailand (**NARIT**) has been expanding its instrumentation capacity for ground-based telescopes and small satellites. Yet Thailand's optical instruments still depend heavily on foreign expertise for critical components, especially high-precision reflective surfaces. The Ultra-Precision Reflective Surface Laboratory (UPRSL) addresses this bottleneck by creating a national facility for designing, manufacturing, and testing metal mirrors and freeform optics. The laboratory grew out of the **UK-Thailand Newton project "Towards Freeform Optics Manufacturing Capabilities,"** which aims to transfer skills in conventional and additive manufacturing to NARIT.
- **Freeform surfaces:** Optical elements with no axis of symmetry – offer compactness and improved imaging performance and are increasingly used in next-generation astronomical instruments.
- **Goals:** The SPDT Engineering, Assembly, and Laser Metrology Laboratory (SEAL Lab) aims to develop total solutions for ultra-precision surface design, substrate preparation, five-axis ultra-precision manufacturing, metrology, alignment, and assembly. This capability supports Thailand's participation in the Thai Space Consortium (TSC), whose first Earth-observation satellite (TSC-1) includes a hyperspectral imager with 30-m ground-sample distance and 10-nm spectral resolution. Building local ultra-precision reflective surfaces enables Thailand to supply mirrors for telescopes, spectrographs, and space payloads, reducing cost and fostering a skilled workforce.

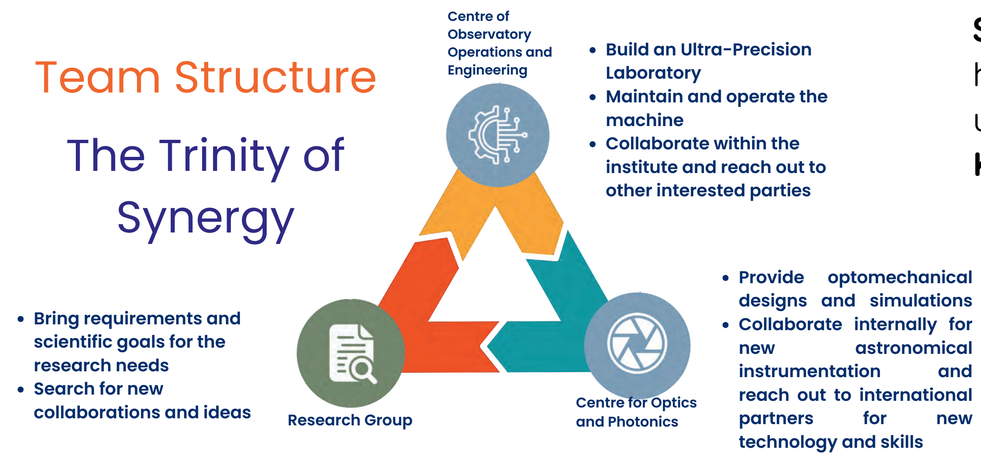












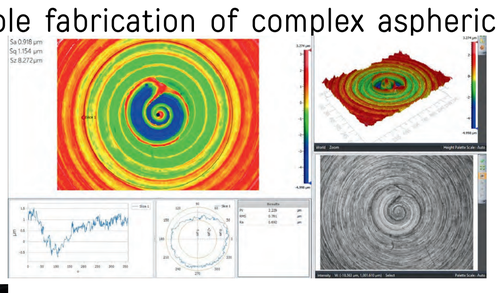
SEAL Lab: The heart of the SEAL Lab is the 5-axis single-point diamond turning (SPDT) machine housed in a temperature-controlled enclosure. SPDT uses a single-crystal diamond tool on an ultra-precision lathe to machine metal substrates with nanometre-level roughness and form accuracy.

Key characteristics include:

- **Sub-nanometric surface roughness** – Ra <5 nm.
- **High form accuracy** – peak-to-valley figure errors better than λ/10 enable diffraction-limited performance.
- **Deterministic machining** – CNC toolpaths allow repeatable fabrication of complex aspheric or freeform geometries.



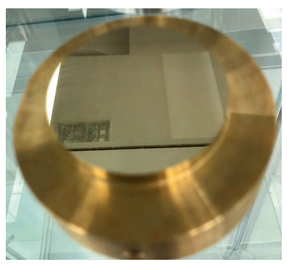
3D-printed secondary mirror for 6U cubesats



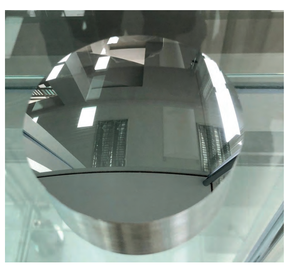
On-going Projects, Products, and Key Sciences



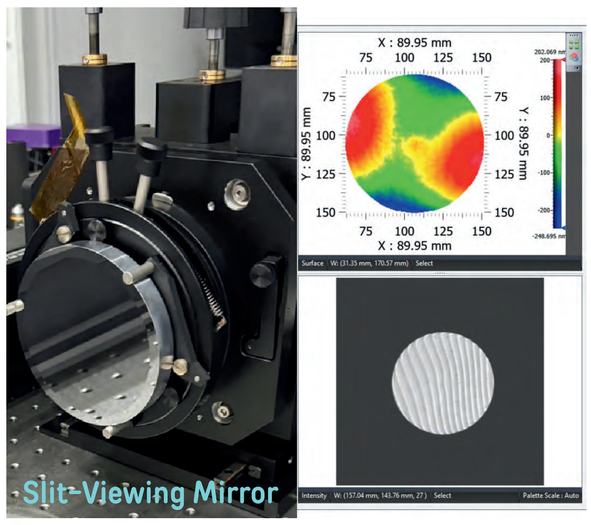
Spherical off-axis concave (similar to M3 of TSC-1's front telescope)
Substrate: RSA-6061



Tilted flat 50.8 mm diameter (similar to a folded mirror for a spectrograph)
Substrate: Brass

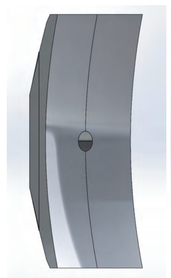


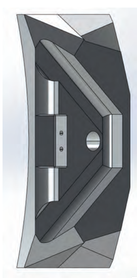
Convex 76.2 mm diameter (similar to a secondary mirror of a RC telescope)
Substrate: RSA-6061







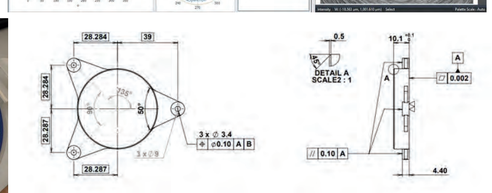


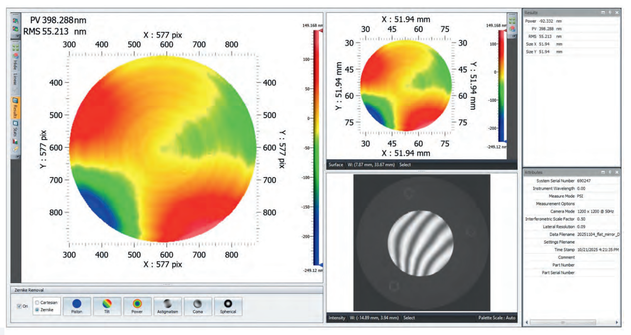


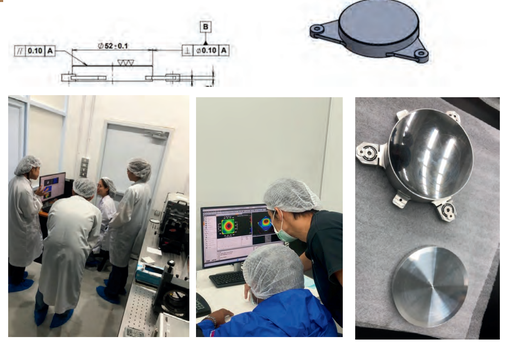
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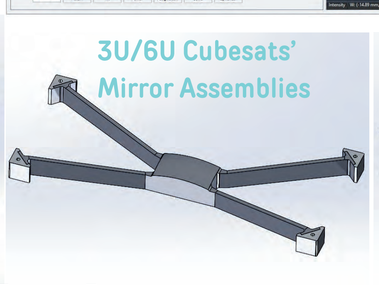
1. **Slit-viewing mirrors for DARTS**
2. **Flat secondary mirrors for 6U** cube sats (UKATC model), both conventional version and additive manufacturing version
3. **Off-axis parabolic mirrors**

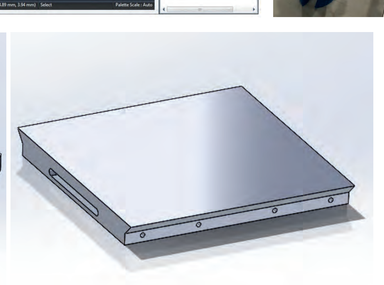












Welcome any new collaborations!

Future Outlook:

Technology Readiness Level 6:

1. **Verification & benchmarking** – Commission a dual-mode interferometer and ultra-precision CMM to close the manufacturing feedback loop and benchmark surfaces against international standards.
2. **Additive manufacturing optimization** – Optimise printing parameters for aluminium alloys and adopt hot-isostatic pressing to reduce porosity; explore nickel-phosphorus coatings and post-polishing to achieve roughness below 1 nm.
3. **Freeform optics research** – Develop freeform reflective surfaces for next-generation hyperspectral imagers and integral-field units.
4. **SEAL National Facility** – Establish the laboratory as a national **"one-stop shop"** for ultra-precision machining, metrology, and assembly, serving astronomy, space, medical, and industrial sectors for domestic and international partners.

Key Collaborations: CfAI · Durham University · RAL Space · UKRI Science and Technology Facilities Council – UK Astronomy Technology Centre