First steps towards automated optical bench assembly for eLISA

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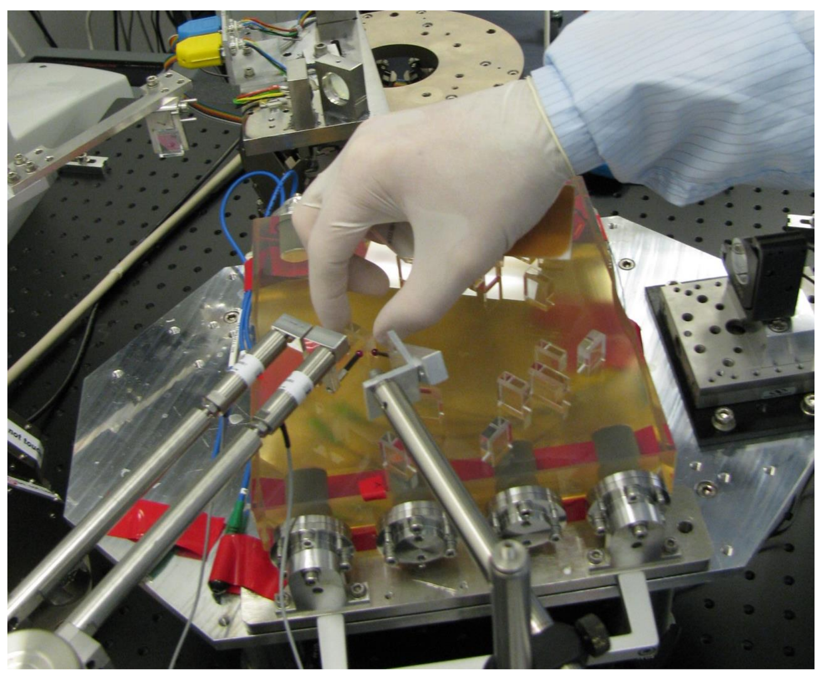
Introduction

The optical benches (OB) envisaged for eLISA are significantly more complex and numerous than the single bench developed for LISA Pathfinder. Constructing each eLISA bench is expected to involve hydroxide catalysis bonding of both a higher quantity and higher density of optical components than has been previously attempted.

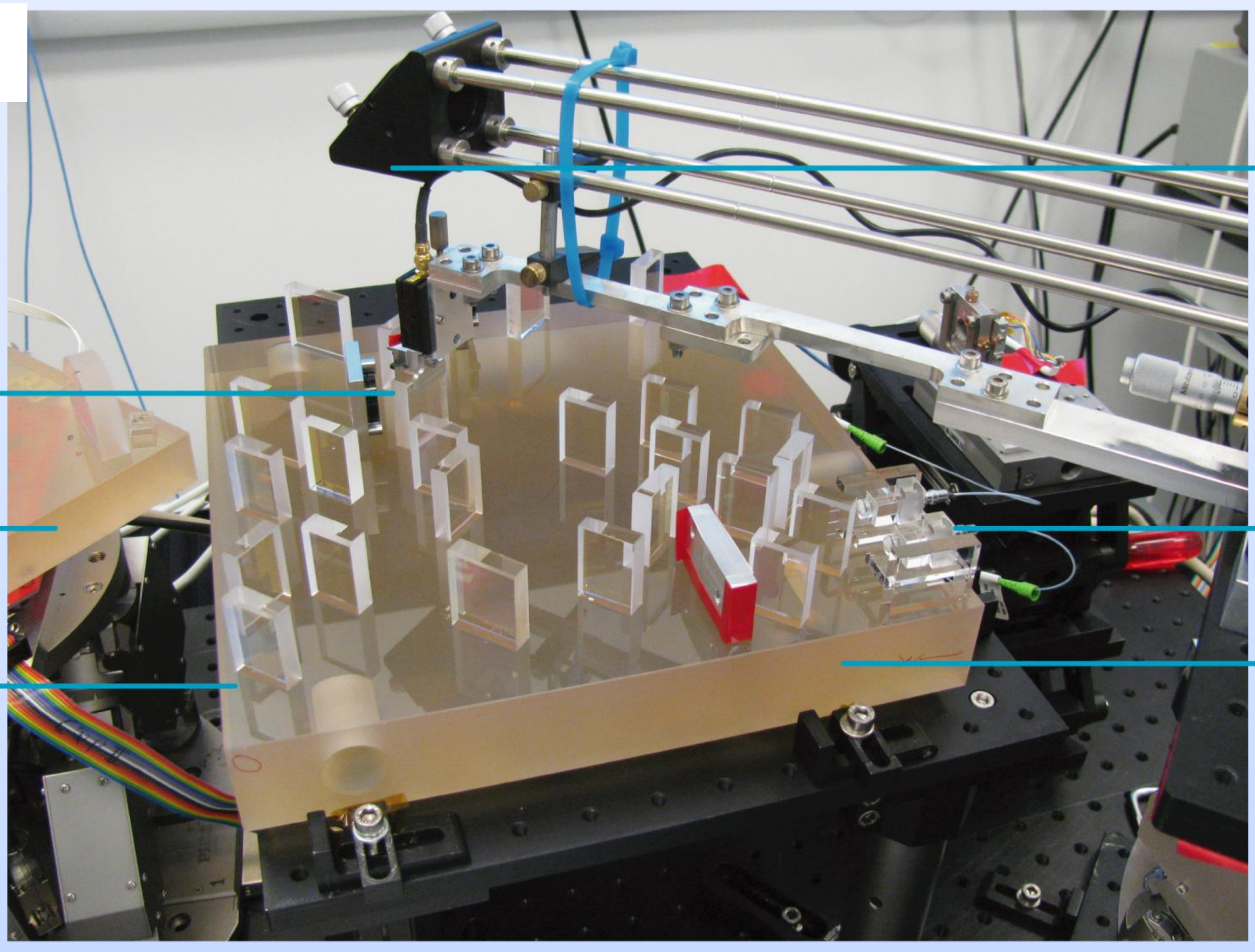
To address this challenge and at the same time reduce risk and reduce assembly time, we have been working towards a more automated bonding approach. We present the current state of our developments which include interferometric readout of component-to-baseplate angular orientations as a component is brought to the point of bonding.



Precision bonding of mirror M1 on the LTP flight OBI.

LPF component positioning capabilities:
<1 micrometre
<20 microradians

The set-up



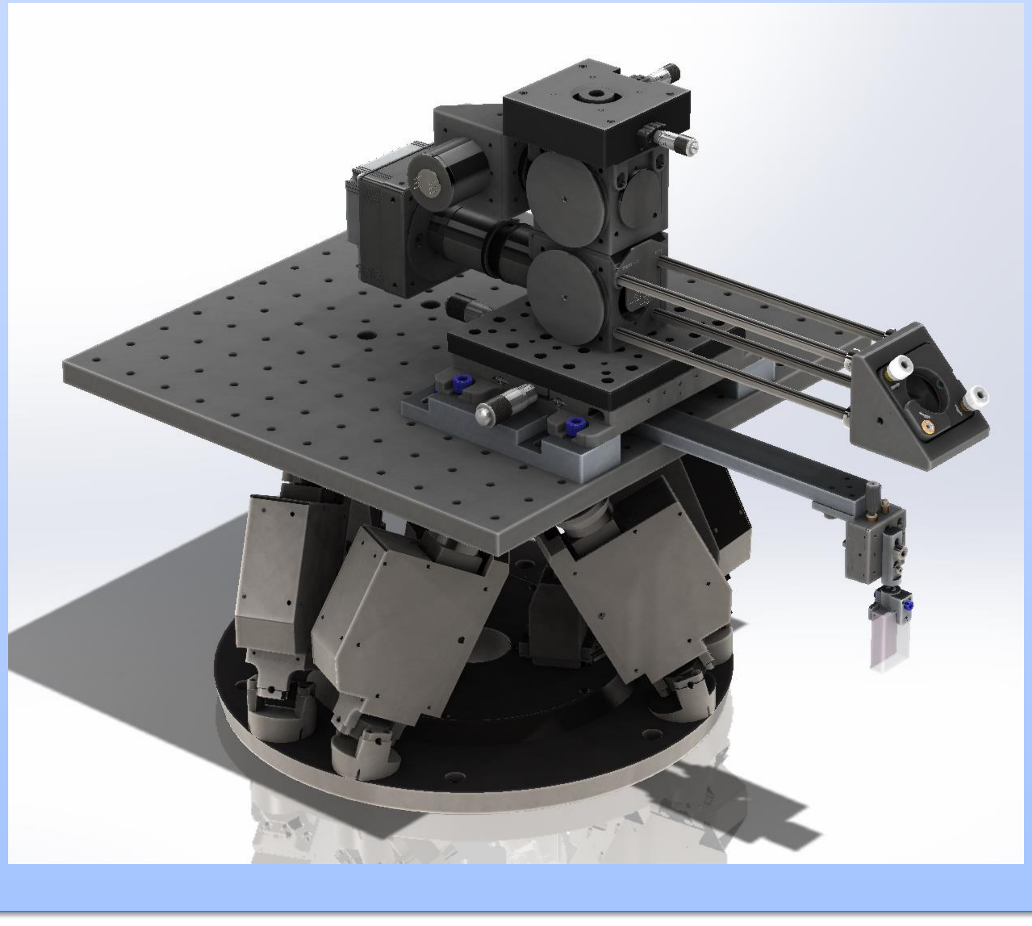
We have designed, built and tested an automated bonding set-up consisting of a hexapod with component placement arm and an interferometric readout system. The set-up is used in conjunction with beam alignment target, or calibrated quadrant photodiode pair, which measures the position of the reflected beam vector. This is equivalent to the configuration used for the precision bonds in LPF.

The interferometric readout provides a controlled method of bringing the component toward the OB such that the bottom surface is co-planar with the top surface of the OB baseplate. A *Labview* interface drives the hexapod to lower in millimetre to micrometre steps until the component comes in to contact with the baseplate.

Results

The automated bonding set-up was used to build the eLISA in-field pointing interferometer for *Airbus Defence and Space GmbH*. The final combining optics for three interferometers were bonded using this set-up. All three components were aligned to better than 10 microradians of their nominal position. This process was very representative of bonds required for an eLISA optical bench.

For more information on the in-field pointing experiment see Christina Brugger's poster entitled "System performance of In-Field Pointing for eLISA".



Current automated bonding component positioning capabilities:
<1 micrometre
<10 microradians

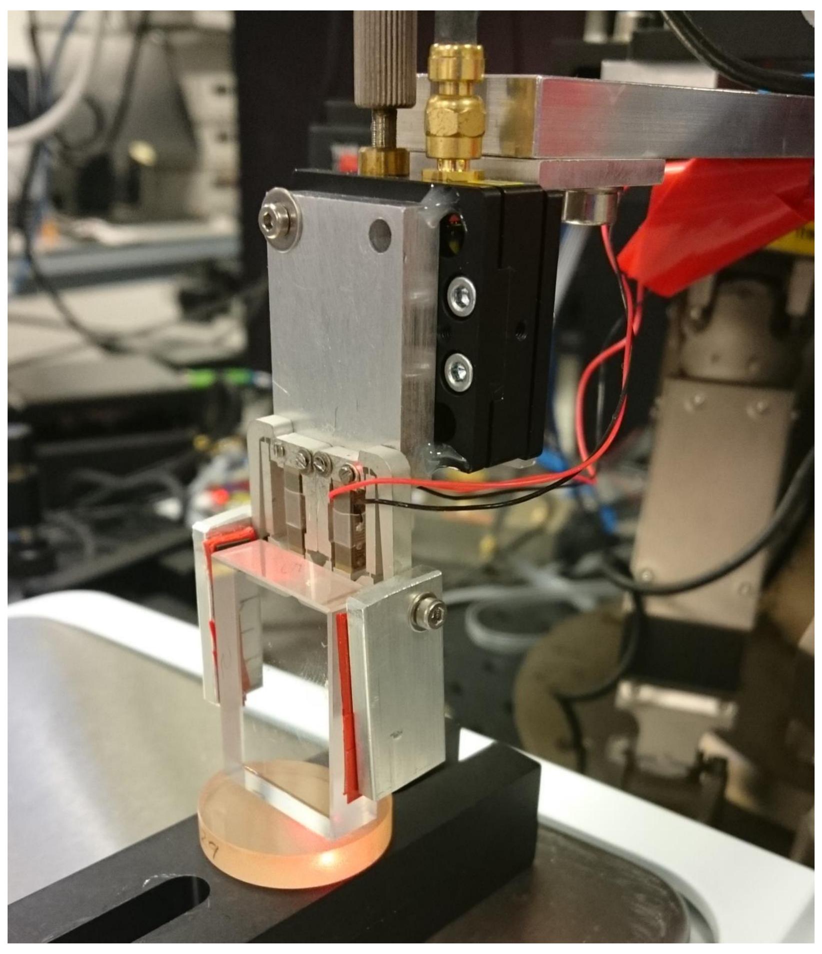
CAD rendering of the automated bonding set-up. Note that, in comparison to the photograph above left, the CAD model shown has a more typical short arm arrangement of the interferometric readout mechanism.

Recent Improvements

An undergraduate summer student, Mathew Oliver, worked on testing an automated component gripping mechanism based upon two amplified piezo actuators. The component is held by metal fingers attached to the end of each actuator.

Whilst these tests proved successful, allowing controlled gripping and release of the component, they highlighted several aspects to be improved in future designs.

Amplified piezo-actuated gripping fingers:



Future Work

Further enhancements will make it possible to manufacture very complex optical assemblies in a more industrial manner leading to the development of a full eLISA assembly facility. A design study to refine the component clamping mechanism is now underway and a stable test rig is being developed to allow characterisation of the automated bonding process and lead to further optimisation and understanding of the mechanics. Sensing of the component height above the baseplate will also be implemented.

To enable these enhancements to the automated bonding set-up design the *UK Space Agency* (UKSA) are funding UGL through a National Space Technology Programme (NSTP) Fast Track project[1]. Development of the overall OB assembly line will be completed in collaboration with the *UK Astronomy Technology Centre (UK-ATC)* subject to a bid being accepted for the ESA "Optical bench manufacturing Industrialisation study".

Conclusions

We have taken a well refined, but difficult to execute, technique and automated the most challenging steps. This first attempt has demonstrated results at a similar level to those seen for LISA Pathfinder: submicron optical component placement with 15 microradian angular component positioning. Quality and robustness of the approach was confirmed through vibration testing to LPF qualification levels. This work was completed in collaboration with *Gooch and Housego (UK) Ltd*. as part of a *UKSA* funded programme led through the *Centre for Earth Observation and Space Technology* (CEOI-ST)[2].

1) UKSA NSTP-2, Round 2, Space Technology Fast Track project, contract number: RP10G03484220
2) CEOI-ST 7^{th} Technology Call, contract number: RP10G0327C14

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