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Project of multi-purpose optical tracking system: design and deformations of optical system's transmitting path

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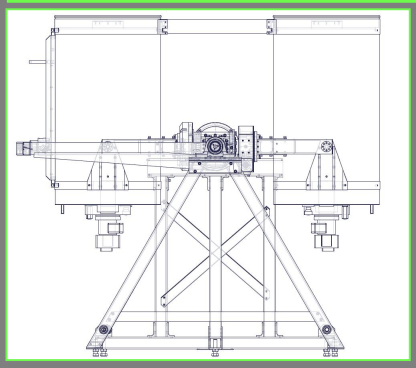
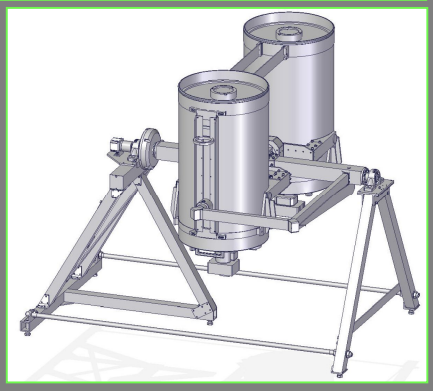
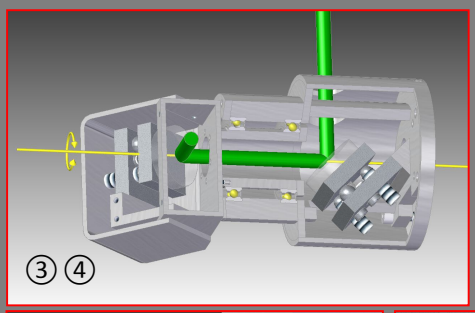
Introduction

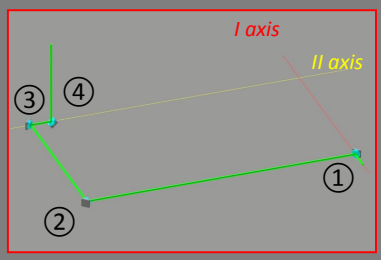
The ESF-funded project of multifunctional optical tracking device is under construction in the Institute of Geodesy and Geoinformation and Institute of Physics of the University of Latvia.
The result of the project must be a functional prototype of new multi-purpose optical tracking system for both positional and laser ranging observations of near-Earth objects (NEO).
This tracking system will be operating in both active (light-transmitting) and passive modes. In case of the active mode a pulsed laser (Nd:YVO4, 50 Hz, 18 mJ, 28 ps) for SLR purposes or other light-emitting source for target illumination purposes can be used. As active mode observations of NEO require precise pointing of transmitted beam and object tracking, an original optical scheme is being designed.
Computer controlled high-performance tripod design actuators will be used for compensation of deformation effects in the beam path. Each actuator ensures beam deflection to 2,4 mrad.
Taking into account the fact that manufacturing possibilities of mechanical parts with complicated configuration and high precision are very limited, technical decisions are optimized using CAD design program.
The design of mechanical units and system deformation calculations are presented.



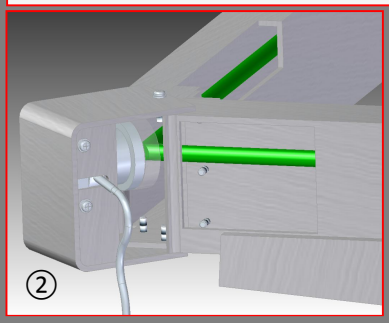


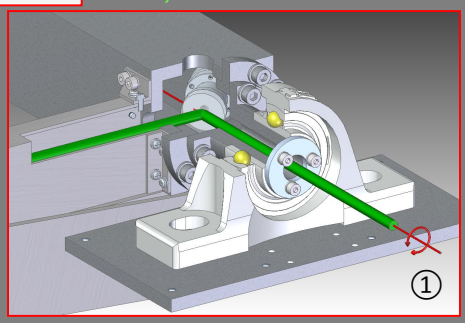
Design of multi-purpose optical tracking system.





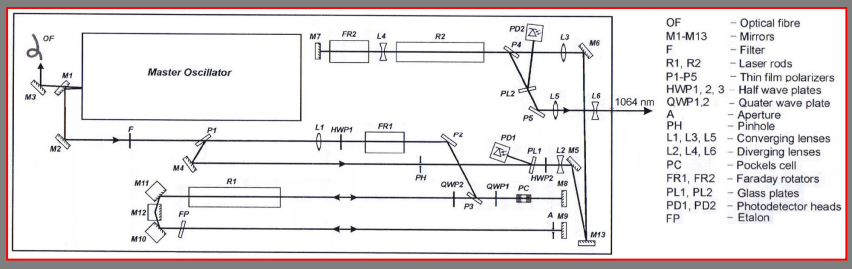
Laser path in beam turning mirrors' assembly.





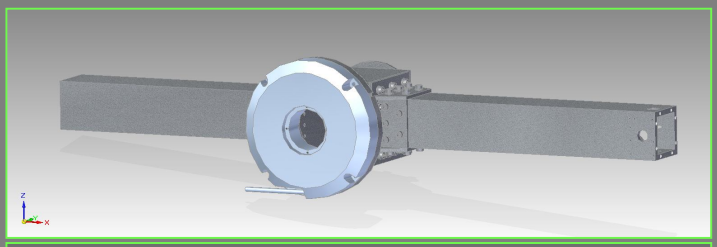
The design of separate optical units.

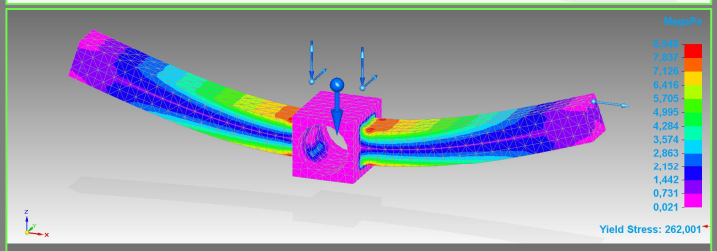
- *Laser beam turns at the mirrors with optimised performances at 532 nm wavelength.*
- *Each mirror reflects 99,5 % of laser beam light.*
- *The first two mirrors of laser path are equipped with actuators.*
- *Laser beam diameter is 6 mm.*

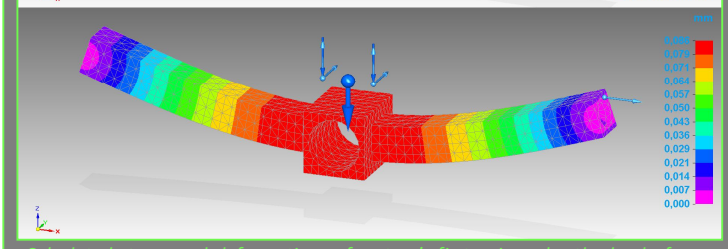


Optical layout of the PL2241 laser.

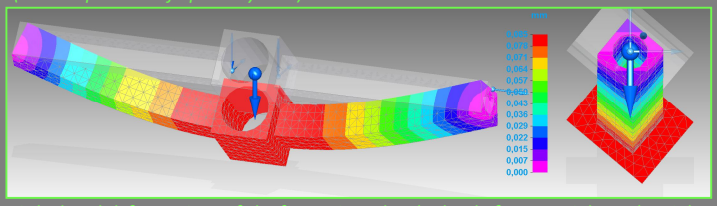
- *Output energy is 18 mJ at 532 nm wavelength, pulse duration – 28 ps, repetition rate – 50 Hz.*
- *Energy stability (standard deviation) – 2,5 %.*



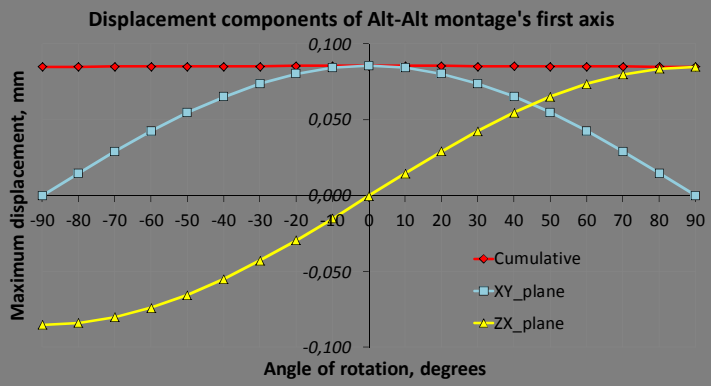




Calculated stress and deformations of system's first axis under the load of own weight and weight of corresponding montage's parts (≈ 1200 N) at an angle of 0° (vertical position of optical system).



Calculated deformations of the first axis under the load of own weight and weight of corresponding montage's parts (≈ 1200 N) at an angle of 40°.



Comparing different profile bars for the system's first axis, values of maximum displacement were obtained: round profile bar has approximately two times greater displacement in comparison with square profile bar. On diagram shown above, red curve represents displacements of the square profile bar. Maximum displacements according to an angle of rotation (from -90° to +90°) are 85 mkm with variations up to 0,7 mkm.

Conclusion: further actions

- ✓ Deformation of system's first axis causes additional turning of the first mirror. For the compensation of this additional turning 3D actuator associated with mirror will be used. As the actuator is fixed at the first axis, it must compensate displacements in two planes in similar way as shown on the diagram: blue curve represents displacement in XY plane, yellow curve – in ZX plane.
- ✓ Tests will be performed after montage's installation with the aim to determine additional error sources which impact laser beam pointing. It will be achieved by star observations.