OMC Technical Brief - Laser Tracker

A Laser tracker provides a relatively fast, accurate and intuitive method of measuring large objects in industrial environments

What does it do?

Measure the three-dimensional location of a mobile target with an accuracy of a few microns, over a range of tens of metres

Why use this technique?

Laser trackers provide fast measurement of a target which can be moved almost anywhere within line-of-sight of the base unit. A key factor in favour of the Tracker is the high relative accuracy that can be achieved. As a consequence Laser Trackers have largely superceded more traditional methods such as Theodolites or conventional metrology tools such as collimators.

What are laser trackers used for?

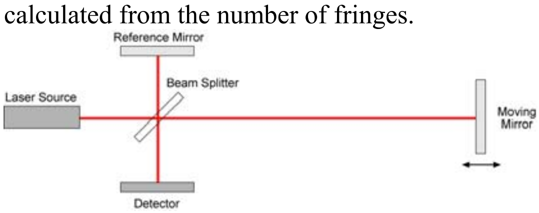
- Robot tracking, calibration, maintenance and testing
- Shipbuilding
- Aircraft manufacturing
- Automotive jig build and set up
- Verification of the design of manufactured structures
- Reverse engineering
- Inspection and alignment

Type of information gathered:

- Raw 3-D co-ordinates
- CAD models
- Surfaces
- Deformation
- Movement
- Reverse engineering data
- Tracking of objects

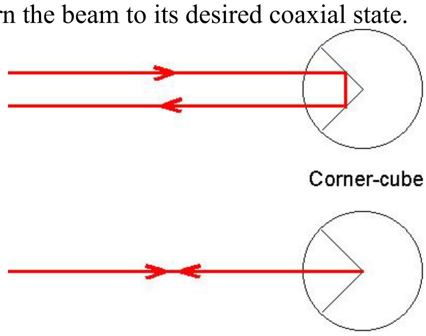
How do laser trackers work?

Laser trackers are based on the combination of two techniques: a laser interferometer to measure relative distance, and optical encoders to measure azimuth and elevation of a beam-steering mirror. Linear interferometers are a standard industrial measurement tool. They work on the principle of light interference. In a standard Michelson interferometer set up, a coherent light source (the Laser) is split into two beams. One beam is used as a reference while the other beam is reflected back from a mirror or retro-reflector at some distance. It is then merged with the reference beam, producing interference. The interference fringes are counted as the external path length changes. Because the wavelength of the Laser is known and is highly stable, the distance can be calculated from the number of fringes.



Principles of a Michelson Interferometer

These devices are restricted to linear measurement. A laser tracker overcomes this limitation by using a beam-steering mirror to direct the laser beam in a wide range of directions. The critical task is for the beam to follow the movement of a retro-reflective target. This is done by a feedback loop. When the laser beam hits the retro-reflective target off-centre, it is reflected back parallel to the incident beam, but displaced. A two dimensional sensor measures the displacement, allowing the laser tracker to adjust the beam-steering mirror to return the beam to its desired coaxial state.



Tracking mechanism using a corner cube reflector

When the beam hits the centre of the target it returns without displacement, indicating the

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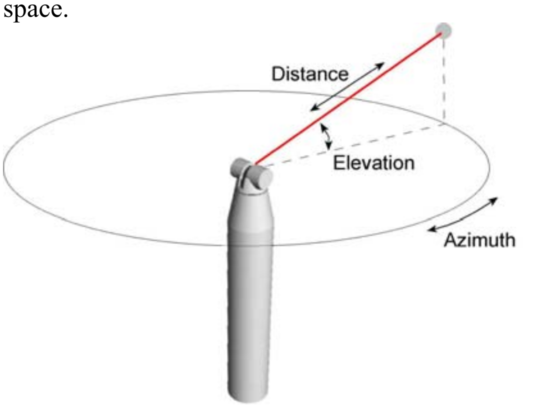
beam has hit the correct location. This mechanism allows the laser beam to follow the movement of the target of up to five metres per second.

Hence the laser tracker follows a retro-reflective target, recording the distance, azimuth and elevation. These polar co-ordinates are transformed into Cartesian co-ordinates, which can be centred anywhere in the measurement space.



Laser Tracker operation

The operator simply walks around the object being measured, placing the retro-reflective target in positions to be recorded. Care must be taken not to break the beam from the laser tracker to the target, since the distance count kept by the interferometer will be lost. If this happens, the target must be returned to a reference position to reset the co-ordinate system.

Additional features

Some Laser trackers also have a secondary method of distance measurement that can be used to measure to arrays of mounted targets. The Laser tracker points the beam towards a given retro-reflector and then a spiral search is used to establish a lock onto the target. The distance can be then be measured without the interferometer and the process repeated. In this way a structure can be monitored for deformation or movement without the operator being near the instrument. Alternatively, the operator can re-establish the interferometer tracking again without going back to the instrument. The accuracy of what is sometimes called an "Absolute Distance Meter" (ADM) is of the order of 50 microns.

A camera can be used with at least one laser tracker where the user can use a video camera to view the object being measured and for measurement points to be selected.

A "hidden point" device allows the user to measure using a small probe instead of the relatively large spheres that typically range from 12.7 to 37.5 mm.

What are the benefits of this system?

- Intuitive: operator places the target anywhere a co-ordinate is required
- Fast: each data point can be recorded in a few seconds
- Single user: one device and operator can record points working alone
- Range: typically tens of metres, creating a large working volume
- Reasonably large installed user base in high value operations

What are the limitations of this system?

- Occlusion: can only operate in line of sight; breaking the beam requires resetting the co-ordinate system
- Contact: target must physically touch the measured point
- Offset: recorded co-ordinates are offset from the actual surface
- Target size: size of the retro-reflector limits the minimum radius of curvature measurable
- Static scene: scene must remain static as the points measured
- Environment: changes in air temperature, pressure and humidity can affect measurements
- Cost: a Laser Tracker is an expensive piece of equipment.
- Portability: the Tracker is relatively large and heavy making it unsuitable for some applications.
- Ruggedness: the Tracker is a high precision piece of equipment and is unsuitable for use in many hazardous, dirty or unstable environments.

