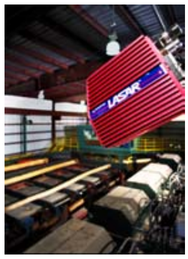
OMC Technical Brief – Laser Time of Flight



Time-of-flight systems measure the time for a pulse of light to travel to a surface and return, then calculate distance from the constant speed of light

What does it do?

Measure distance with an accuracy from a few centimetres to a few metres, over a range of a few metres to several kilometres, at a speed of around one sample per second.

Why use this technique?

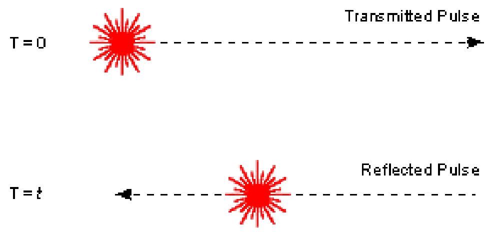
Laser time-of-flight instruments offer very long range distance measurement, with a trade-off between accuracy and speed. They can measure the distance to a single, small point without requiring a special target, or measure several kilometres with a retro-reflecting target. Instruments can be compact, and are often combined with a sighting device, such as a theodolite or binoculars.

Typical objects measured:

- survey points, using a staff and prism profiling rock faces in quarries to
- calculate volume of material
- tunnel profiling, producing a series of cross-sections
- hydrographic surveys of buoys, barges and oil rigs
- range and bearing information for motion control

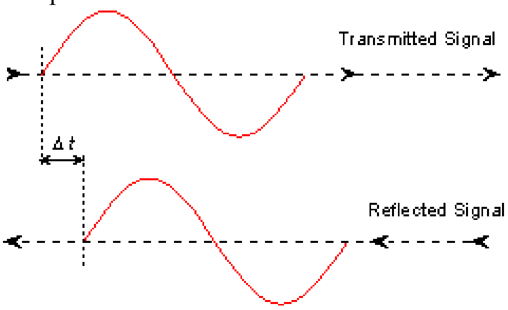
How does time-of-flight work?

There are essentially two methods used for determining distance in time-of-flight instruments: a short pulse of light is emitted and the delay until it returns is timed, or a phase difference between emitted and reflected waves is measured. Each method has advantages and disadvantages, which initially lead to them being used in very different applications. Continued development has improved both techniques and they are used in a wide range of surveying and engineering products.



Timed Pulse

A short pulse of laser light is emitted, and the delay until its reflection returns is timed very accurately. If the speed of light is known, the distance to the reflecting object can be calculated. A single timed pulse is not very accurate, so a large number of pulses are used and averaged to give a more accurate distance. Hence there is a trade off between the accuracy and speed of measurement.



Phase Difference

The laser or LED beam is modulated with a wavelength of 20 to 30m, and the phase of the emitted and reflected waves is compared. This phase difference, which is obtained by timing the delay between an emitted and a reflected wave-front, can be expressed as a fraction of the modulated wavelength. However, the distance to the object is ambiguous, since it could be any integer number of wavelengths away. By using several different wavelengths, and solving a simultaneous equation, the distance to an object can be calculated uniquely.

Both techniques rely on an accurate estimate of the speed of light in the current environment.

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Some instruments are certified to work within a limited temperature and humidity range, while others may include sensing devices to automatically compensate for the operating environment.

What are the benefits of this system?

- long distance measurement, up to 10 kilometres with a reflecting target
- range of around 1km without target, depending on surface type
- high relative accuracy, i.e. a few centimetres over several kilometres
- simple to use 'point and shoot'
- may be combined with a theodolite for range and bearing

What are the limitations of this system?

- line of sight required to measured point
- accuracy requires long sampling time, up to several seconds per point for high accuracy
- possible interference from bright sunlight
- surface characteristics of the target object limit the maximum range

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