OMC Project Description – Verification of Laser Tracker systems

Laser Trackers are expensive instruments that are used in many high value applications either in quality control, inspection or manufacturing. Verifying the performance of these highly accurate instruments is a non trivial task.

Overview

Laser Trackers have become the tool of choice for most large-volume, high-value applications due to their performance that is based upon high accuracy angle encoders, an interferometer and an absolute distance measurement system. While the number of systems in use numbers in the hundreds, the infrastructure for independently verifying their performance is relatively immature. Two approaches are commonly taken, either the instrument is trusted to be in calibration or some elementary tests are performed to test the performance. Neither is a satisfactory solution. OMC has worked closely with the end users and the National Physical Laboratory to devise a methodology to verify the performance of a laser tracker. This methodology has been published and put forward to the ISO 10360-2 committee for consideration in the next revision of this standard that will hopefully encompass large volume measurement systems. In the mean time, OMC are willing and able to provide advice on this topic.

Industrial partners

BAe Systems, Airbus, Bombardier Shorts, National Physical Laboratory.

Project duration

Three years, ending in September 2002.

Project value

£325,000 for project, approximately 50% for verification.

Intended beneficiaries

Laser Tracker users.

Current status

The lessons learned would be very useful to any company with a number of Laser Trackers who wants a rigorous and independent method of ensuring the quality control of these instruments. On an official level the methodology developed has been submitted to the ISO 10360-2 committee for consideration in the next revision of the standard for large-scale metrology. However, any revision of this standard is expected to take some considerable time.

Project Highlights

- Adaptation of the NPL large-scale length artefact for use with a Laser Tracker.
- Development of software to predict the length measuring capability of the Laser Tracker for any pair of distance measurements.
- Development of a methodology for assessing each of the sensors in the Laser tracker and hence a method of verifying whether the instrument is performing within its specification.
- Practical testing of the methodology with the NPL length artefact and a Laser Tracker.
- Publication of the results at Lambdamap 2001 and CMSC 2001.
- Submission of the methodology to the ISO 10360-2 committee for consideration in the next revision of the standard.

Background

The development of procedures for verifying the performance of systems such as Laser Trackers is not simple. Some key issues are the following:

- **Practicality** - any procedure has to be carried out within a time period acceptable to the end-user and the physical requirements and cost must not be prohibitive.
- **Confidence** - the procedure should have sufficient redundancy to ensure statistical reliability such that no significant shortcomings of the measurement systems go undetected.
- **Transparency** - the user should be able to easily understand the procedure, interpret the results and be able to make valid inferences about measurements made in similar working volumes and conditions.

The main components of the verification methodology developed in this project were: (1) a mathematical model of the nominal system behaviour described in

terms of statistical properties of the measurement sensors and the system configuration, (2) estimation of the uncertainty in the distance between any pair of points in the working volume derived from the mathematical model, (3) repeated measurement of a length artefact, (4) comparison of the measurement data with the uncertainty model, and (5) derivation of a statement of system performance.

Pictorial highlights

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 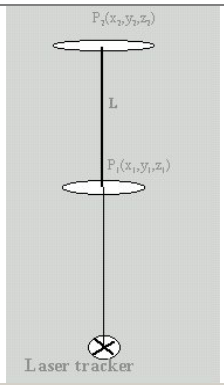
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<td>The methodology employed to verify the Laser Tracker used a NPL length artefact made of carbon fibre with well-known characteristics. Given the length ‘L’ it is a simple task to compare the known length with the measured length using the Laser Tracker. The error can then be compared to the expected error derived from the manufacturers specification.</td>
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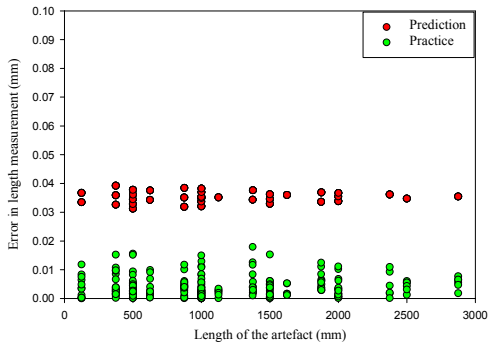
<td> 
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<td>The graph illustrates the difference between the predicted accuracy (red circles) and that obtained in practice for the interferometer (green circles) at a distance of 9 metres. In this case the interferometer was found to be within its specification by a clear margin. Similar tests would be carried out at various distances and also with the absolute distance measurement system instead of the interferometer.</td>
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 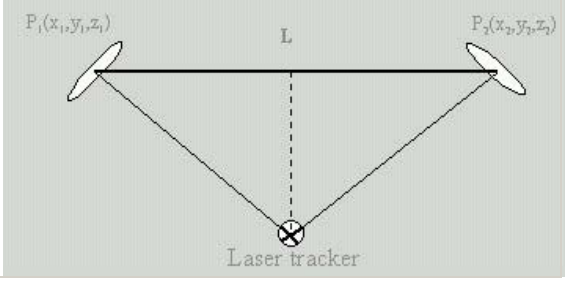
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<td>The angle encoders can be assessed using a similar procedure. In the previous case the angle encoders would not have contributed significantly to the length error. In this set up, for the horizontal encoder assessment, the expected errors for the angle measurement system can be determined.</td>
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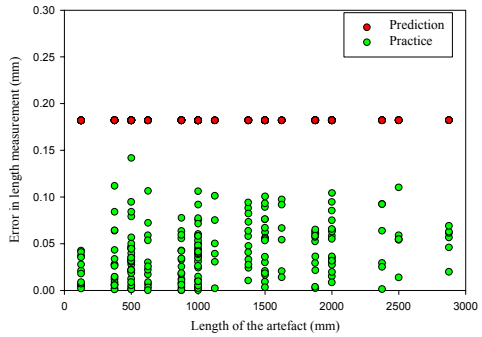

The comparison between the predicted accuracy and that obtained in practice for the angle encoders at 9 metres are illustrated in the graph. The system was again within its specification.