INTRODUCTION
The answer to the question in the title is: no. But, there has been significant progress recently and the end is in sight. This paper will discuss the progress made and address the steps that need to be taken, before the answer is more optimistic.

TRACEABILITY AND CALIBRATION
An important issue that must be addressed to bring surface topography into compliance with manufacturing quality systems is the measurement traceability of the instruments. Whilst there is a traceability infrastructure for stylus instruments operating in a profile mode [ref], there is not yet a satisfactory infrastructure for areal surface topography measuring instruments. To fill the traceability chain from the definition of the metre to an areal measurement in industry, a number of steps are required. Firstly, primary instrumentation that can measure areal surface topography in needed. A number of national measurement institutes (including NPL) have developed stylus instruments with displacement measuring laser interferometers that can determine the position of the stylus tip [refs]. Knowledge of the laser source wavelength in the interferometers assures traceability to the definition of the metre. Secondly, transfer artefacts are needed that can be calibrated via the primary instrumentation (either directly or indirectly) and be used in turn to calibrate instruments in industry.

NPL has been working towards a traceability infrastructure for areal measurement for a decade. A stylus-based primary instrument has been developed and methods for calculating uncertainties using this instrument have been devised based on a Monte-Carlo approach [refs]. And, NPL (with the University of Huddersfield) recently produced reference software for calculating areal surface texture parameters (at least for the areal field parameters [ref] – work on the areal feature parameters is ongoing). NPL (with others in ISO TC 213 WG 16) has also developed a series of metrological characteristics which determine the scale calibration of an instrument. The metrological characteristics, which should be common to all instrument types, are the noise and residual flatness; the scale, linearity and squareness of the instrument axes; and the lateral resolution [ref]. A series of transfer artefacts [ref] have been developed to allow a user to determine the metrological characteristics of an instrument. Complex machining methods have been employed (for example, fast tool servo diamond turning at the University of Bremen and electron-beam lithography at the Karlsruhe Institute of Technology) to manufacture master artefacts, and nickel electroforming has been used to produce replicas. The artefacts include an optical flat, step heights, a series of crossed square wave gratings with different pitches, star patterns, a pseudo-random surface and a ball on a plane. This replication process allows the commercial cost of the artefacts to be kept at a minimum. NPL will now supply a set of calibrated artefacts along with a good practice guide that will allow the user to calibrate the metrological characteristics of a surface topography instrument, therefore, giving confidence in measurements taken with the instrument, and measurement uncertainties to be addressed in a limited number of
measurement scenarios. To date, artefacts and good practice guides have been developed for stylus instruments; phase stepping and coherence scanning interferometers; and scanning confocal microscopes. Artefacts and guides for focus variation microscopy will follow shortly. However, the general philosophy behind the calibration scheme developed at NPL should extend to most of the instrument types that are commercially available.

Results and figs in longer paper...

**A TRANSFER FUNCTION APPROACH**

But this is not the whole story. With the new calibration scheme it is possible to determine the characteristics of the instrument scales. Whilst this is a step in the right direction, it does not calibrate the instrument to be used to measure a complex surface – for this the ability of the instrument to measure slopes on the surface must be characterized.

An instrument will have a finite spatial frequency response, i.e. it will transmit some spatial frequency components of the surface, it will block some components and others will be partially measured. If it is assumed that this process is linear, then the instrument simply acts as a linear filter with a specific transmission characteristic. To calibrate how the instrument responds to surfaces, the transmission characteristic needs to be determined. In the case of optical instruments (and assuming spatially coherent illumination), the transmission characteristic is given by the optical transfer function (OTF) [ref] which, in most of the cases encountered for optical surface topography measuring instruments, is given by the inverse Fourier transform of the point spread function (PSF). In turn, the PSF is the impulse response of the instrument and will contain information about the resolution of the instrument and any aberrations in the optics.

Calibration of optical instruments using the OTF will also include all the information given by the ISO metrological characteristics (for example, the flatness or scale linearity). However, such a calibration also gives information about how the instrument responds to slopes on the surface. Measurement of the OTF (or the instrument transfer function – the OTF treats raw output data, for example the fringes in an interferometer, and does not consider how this data is converted into a height map) has been carried out by several groups [refs], but the research work is still in its infancy. Theoretically, to obtain an impulse response, an infinitely small point needs to be measured, but this is difficult in practice. NPL and Loughborough University have developed a model for coherence scanning interferometry based on weak scattering (known as the foil model [ref]). In this case, a surface with a uniform Fourier transform is used as the calibration artefact, i.e. a sphere that is smaller than the field of view. It is worth noting that the sphere technique requires the form of the sphere to be calibrated with the same accuracy as that required of the instrument to be calibrated. This means that a method for measuring the form of spheres with diameters less than 100 µm is needed with nanometre accuracy. Current methods for small sphere form measurement (using larger reference spheres in the micro-CMM area) are only accurate to 40 nm [ref], so a new method of sphere calibration is required. NPL is currently undertaking a project to develop a reference small sphere form measuring instrument. The sphere approach is now being applied to confocal microscopy and focus variation microscopy, and will be reported to ISO for potential standardization in due course.

The weak scattering assumption implies that there are no multiple reflections from the surface being measured – in most cases this in turn implies that there are no slopes on the surface that are outside the slope limitation of the numerical aperture. With rough surfaces, multiple reflections can be a significant source of error [ref]. Also, if multiple reflections occur, the linear assumptions implicit in the transfer function
models no longer apply. Further research is required to firstly, calculate the magnitude of the measurement uncertainties caused by the various assumptions, and secondly, to produce calibration techniques that apply to rough (strongly scattering) surfaces.

CONCLUSION

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REFERENCES

To be completed for full paper