In this paper we describe some of our metrology methods, used in the manufacture of prototype, 1.4 m hexagonal, off-axis aspheric primary mirror segments for the 39 m European Extremely Large Telescope (E-ELT). These methods are applicable to similar projects currently under way for off-axis asphere fabrication. The traditional and required qualification for the ELT segments is a full-aperture interferometric test with verification of radius of curvature, conic constant and form error. To meet the requirements of the specification, and to enable corrective figuring and polishing, we have adopted a multi-instrument metrology approach using several tools including full-aperture interferometry, sub-aperture interferometry, and slope-measuring techniques based on scanning penta-prism devices. This work concentrates on hybrid interferometry for intermediate processing of segments and also for final qualification.

The prototype segments are qualified by a full-aperture test covering the whole of the segment at a specified spatial resolution. In the present optical test at the National Facility in North Wales parts of the segment are obscured by a fold mirror and ghost artefacts from a CGH null element. These obscured areas therefore inhibit the full-aperture test from providing complete coverage. Higher slope regions of the part can also pose problems for the full-aperture test during any stages of the segment processing. Increased slope capability can therefore provide valuable feedback at all stages of the processing. To mitigate these problems part of our metrology approach combines the full-aperture test with a separate sub-aperture interferometer in order to image obscured or higher-slope areas where no data is available from the full-aperture interferometric test. In the paper we describe the hardware of the sub-aperture interferometer and its use, in-situ, on board a 1.6 m CNC polishing machine, and how the sub-aperture data arrays are located in the master coordinate frame of each different mirror segment. The sub-aperture interferometer consists of a compact Twyman-Green dynamic interferometer mated to a refractive beam-expander providing a 190 mm diameter beam at the surface of the segment that is matched to the local radius of curvature of the segment. The calibration of the sub-aperture interferometer is also discussed in the context of wavefront errors of the interferometer optics. We then describe the properties and operation of the stitching software that is used to fuse each of the sub-aperture maps with the calibrated full-aperture phase map of the segment under test and we then explore the important properties of the segment that define the basic aspheric form over each sub-aperture area in the context of stitching.

We conclude the paper by presenting some data from a segment polishing run and how fusing the full-aperture data with the sub-aperture data renders the final data set acceptable for qualification of the segments. Suggestions and work towards for a fully automated system are then discussed in the context of mass-production of several hundred segments.