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EXHIBIT B
Requirements
Primary Mirror Segment Gravity Performance Verification
TMT.OPT.SPE.09.001.DRF01

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Exhibit B of RFP (TMT.BUS.MGT.09.313.REL01)

Scope

This document describes the requirements for the measurements of the optical surface of the Prototype-2 (P2) Mounted Segment Assembly (MSA) (the “Surface Measurements”) that are to be used for the performance verification testing described in SOW TMT.OPT.CON.09.004.REL01

Requirements

Configuration Requirements

[SPE-M1.SEG.P2TEST-1010] The surface measurements shall cover the full aperture of the MSA optical segment.

[SPE-M1.SEG.P2TEST-1020] Surface measurements shall be made in sufficient orientations to enable full characterization of the P2 MSA gravity response in 3 orthogonal directions. After processing the data measured at multiple orientations, it shall be possible to determine separately the surface deformation due to axial gravity (g_z), and two directions of lateral gravity (g_x and g_y), based on the coordinate system shown in Figure 1.

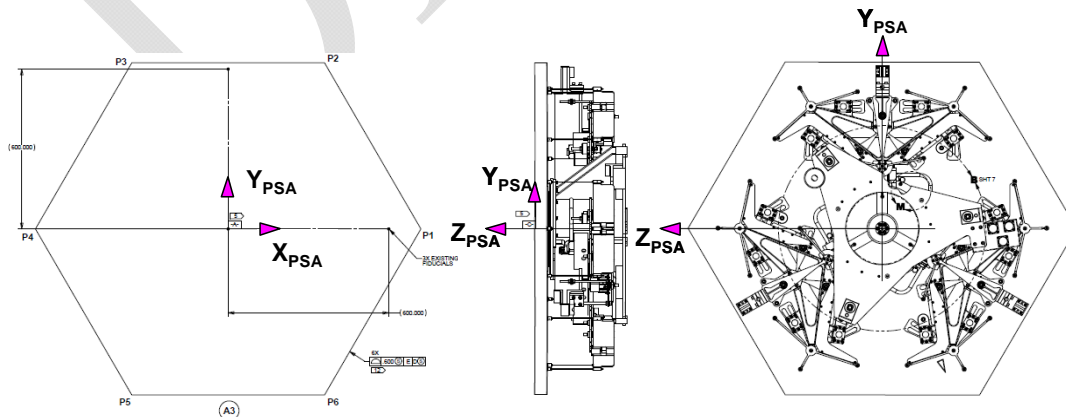


Figure 1. Prototype Segment Assembly Coordinate System

[SPE-M1.SEG.P2TEST-1030] The surface measurements shall collect data that permit the calculation of the change in surface error between the zenith-pointing, nadir pointing and two horizon-pointing configurations: rotation around the X_{PSA} -axis and rotation around the Y_{PSA} -axis.

[SPE-M1.SEG.P2TEST-1040] All Surface Measurements shall be conducted at a reference temperature $T_{ref} \pm 0.5^{\circ}C$. T_{ref} may be chosen by the Contractor. Actual temperature of the P2 hardware during each surface measurement shall be measured and recorded.

Performance Requirements

[SPE-M1.SEG.P2TEST-2010] The Surface Measurements shall permit the calculation of zenith-angle-dependent gravity-induced surface change over the full aperture of the optical segment with a 1σ accuracy of ≤ 15 nm RMS surface.

[SPE-M1.SEG.P2TEST-2020] Describe the zenith-angle-dependent gravity-induced surface change using a series of Zernike polynomials over the hexagonal aperture. The surface measurements shall permit the calculation of up to the 4th order terms of the zenith-angle-dependent gravity-induced surface change, over the full aperture of the optical segment, with the 1σ accuracies given in Table 1 below:

Table 1. Measurement Accuracy for Full Segment Surface Aberrations

Aberration Term	Measurement Accuracy (1σ) for given aberration term	Zernike Polynomial Equation
Focus Z_{20}	4 nm RMS surface	$2r^2-1$
Astigmatism Z_{22}	8 nm RMS surface	$r^2\cos(2\theta)$
Astigmatism Z_{2-2}	8 nm RMS surface	$r^2\sin(2\theta)$
Coma Z_{31}	2 nm RMS surface	$(3r^3-2r)\cos(\theta)$
Coma Z_{3-1}	2 nm RMS surface	$(3r^3-2r)\sin(\theta)$
Trefoil Z_{33}	2 nm RMS surface	$r^3\cos(3\theta)$
Trefoil Z_{3-3}	2 nm RMS surface	$r^3\sin(3\theta)$
4 th order and higher	No specific requirement levied, but measurement accuracy of all terms combined must comply with requirement -2010	

[SPE-M1.SEG.P2TEST-2030] The surface measurements shall permit the calculation of finer resolution of zenith-angle-dependent gravity-induced surface change over a $\varnothing 40$ cm subaperture centered on the Segment, with a 1σ accuracy of ≤ 9 nm RMS surface.

Discussion: This requirement allows finer resolution in the center to better understand the deformation caused by the segment center structure.

Table 2. Measurement Accuracy for Central 40cm Diameter of Segment Surface Aberrations

Aberration Term	Measurement Accuracy (1σ) for given aberration term	Zernike Polynomial Equation
Focus Z_{20}	2.5 nm RMS surface	$2r^2-1$
Astigmatism Z_{22}	5 nm RMS surface	$r^2\cos(2\theta)$
Astigmatism Z_{2-2}	5 nm RMS surface	$r^2\sin(2\theta)$
Coma Z_{31}	1.25 nm RMS surface	$(3r^3-2r)\cos(\theta)$
Coma Z_{3-1}	1.25 nm RMS surface	$(3r^3-2r)\sin(\theta)$
Trefoil Z_{33}	1.25 nm RMS surface	$r^3\cos(3\theta)$
Trefoil Z_{3-3}	1.25 nm RMS surface	$r^3\sin(3\theta)$
4 th order and higher	No specific requirement levied, but measurement accuracy of all terms combined must comply with requirement -2030	

[SPE-M1.SEG.P2TEST-2040] The lateral resolution of the surface measurements shall be ≤ 20 mm over the full aperture of the Segment.

Discussion: as an example, if the Surface Measurements are performed at discrete locations on the optical surface, the spacing between measurement points should be ≤ 20 mm.

[SPE-M1.SEG.P2TEST-2050] The lateral resolution of the Surface Measurements shall be ≤ 10 mm over a $\varnothing 40$ cm subaperture centered on the Segment.

[SPE-M1.SEG.P2TEST-2060] The Surface Measurements shall be repeatable to within TBD nm RMS at each orientation with respect to gravity under conditions that the measurements are taken in an orientation, the P2 MSA is moved from that orientation, then returned to that orientation and remeasured.

[SPE-M1.SEG.P2TEST-2060] The Surface Measurements shall be repeatable to within TBD nm RMS at each orientation with respect to gravity under conditions that, at each orientation, measurements are taken over a time duration that is at least as long as required to collect enough measurement data to characterize the surface at that orientation.