OPTICS REQUIREMENTS FOR THE GENERATION-X X-RAY TELESCOPE

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US, European, and Japanese space agencies each now operate successful X-ray missions—NASA's *Chandra*, ESA's XMM-*Newton*, and JAXA's *Suzaku* observatories. Recently these agencies began a collaboration to develop the next major X-ray astrophysics facility—the *International X-ray Observatory* (IXO)—for launch around 2020. IXO will provide an order-of-magnitude increase in effective area (Table 1), while maintaining good (but not sub-arcsecond) angular resolution.

Table 1. Comparison of X-ray telescopes

Mission	Status	Launch	Aperture area	Resolution
Chandra (*nee* AXAF)	Operating	1999	0.08 m^2	0.5″
XMM-*Newton*	Operating	1999	0.43 m^2	15″
Suzaku (*nee* Astro-E2)	Operating	2005	0.18 m^2	120″
International X-ray Observatory (IXO)	Planning	≈ 2020	3.5 m^2	≤ 5″
Generation-X	Concept	≈ 2035	50 m^2	≈ 0.1″

X-ray astronomy beyond IXO will require optics with even larger aperture areas and much better angular resolution. We are currently conducting a NASA strategic mission concept study to identify technology issues and to formulate a technology roadmap for a mission—*Generation-X* (*Gen-X*)—to provide these capabilities.

Achieving large X-ray collecting areas in a space observatory requires extremely lightweight mirrors. For (2-reflection) X-ray optics with graze angles of order 0.01 radian, the mirror surface area is about 200 times the aperture area. Thus, the Gen-X requirement for 50 m^2 aperture area implies 10000 m^2 of mirror surface area—i.e., 10 tonne of mirrors at an areal density of 1 kg m^{-2}. NASA's plan for the Ares V heavy-lift capability will enable the insertion of *Generation-X* into an Earth-Sun L2 (second Lagrange-point) orbit, in a single launch of a single observatory (Figure 1).

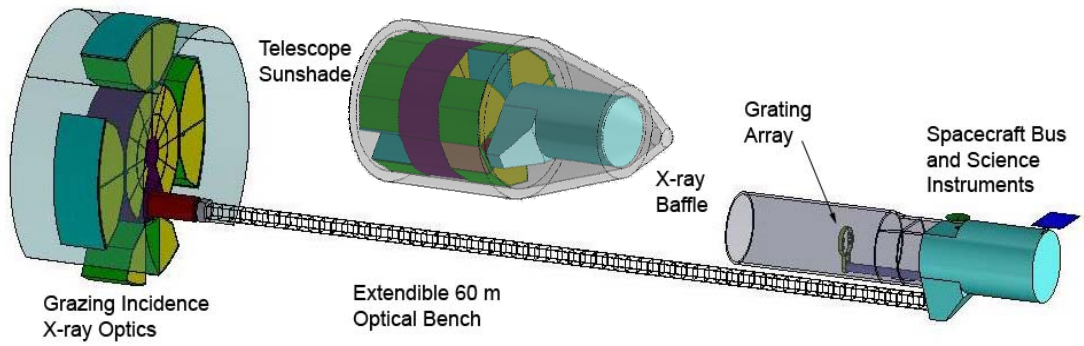

Figure 1. Conceptual configuration of the *Generation-X* telescope. The diagram shows the telescope stowed within an Ares-V 10-m-diameter shroud and deployed for in-space operation.

Achieving 0.1″ X-ray imaging with lightweight mirrors presents a major technological challenge. Accomplishing this will require excellent mirror surfaces (≤0.1 μradian RMS deviations), precise alignment, and exceptional figure control to compensate for mounting stresses. Very likely, achieving and maintaining alignment and figure control will involve active X-ray optics (Figure 2).

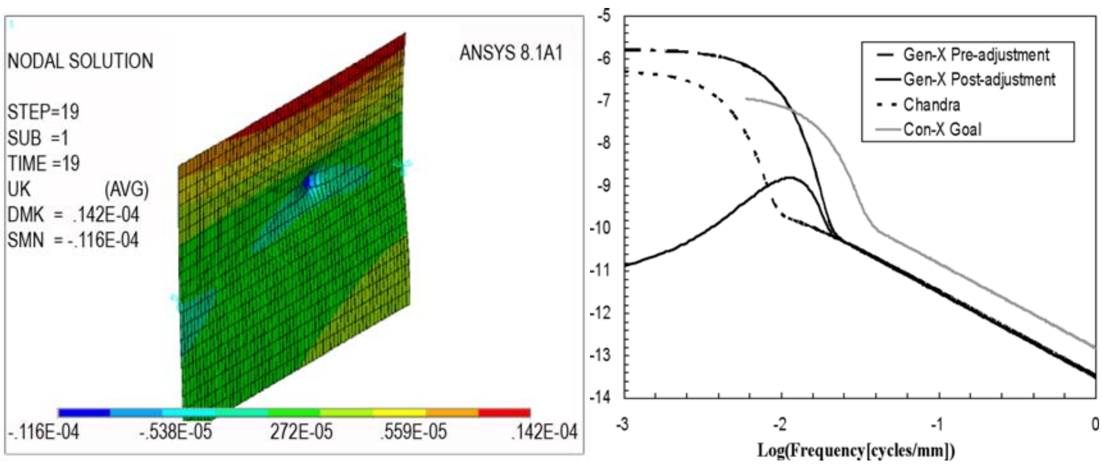

Figure 2. (Left) A finite-element analysis of the influence function for a piezoelectric bimorph zone on a thin mirror; (Right) schematic illustration of the suppression of low-frequency figure errors to correct a mounted mirror to meet the Gen-X requirements on imaging quality.

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