

# 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.

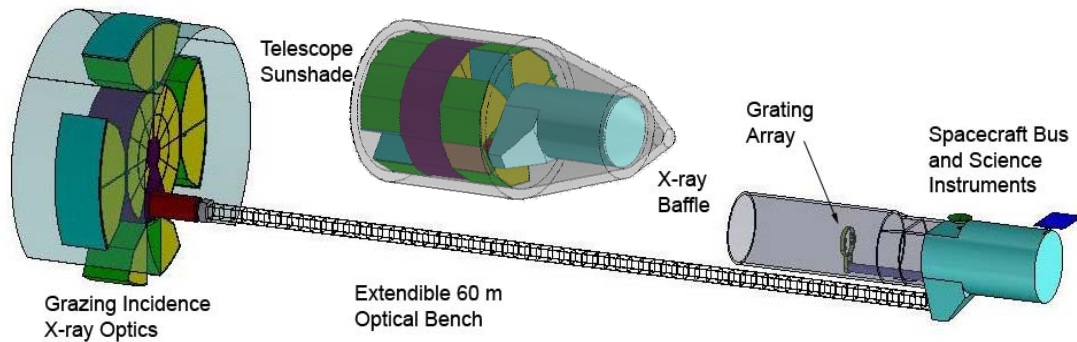
**Table 1. Comparison of X-ray telescopes**

Mission	Status	Launch	Aperture area	Resolution
<i>Chandra</i> (nee AXAF)	Operating	1999	0.08 m <sup>2</sup>	0.5"
<i>XMM-Newton</i>	Operating	1999	0.43 m <sup>2</sup>	15"
<i>Suzaku</i> (nee Astro-E2)	Operating	2005	0.18 m <sup>2</sup>	120"
<i>International X-ray Observatory</i> (IXO)	Planning	≈ 2020	3.5 m <sup>2</sup>	≤ 5"
<i>Generation-X</i>	Concept	≈ 2035	50 m <sup>2</sup>	≈ 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.

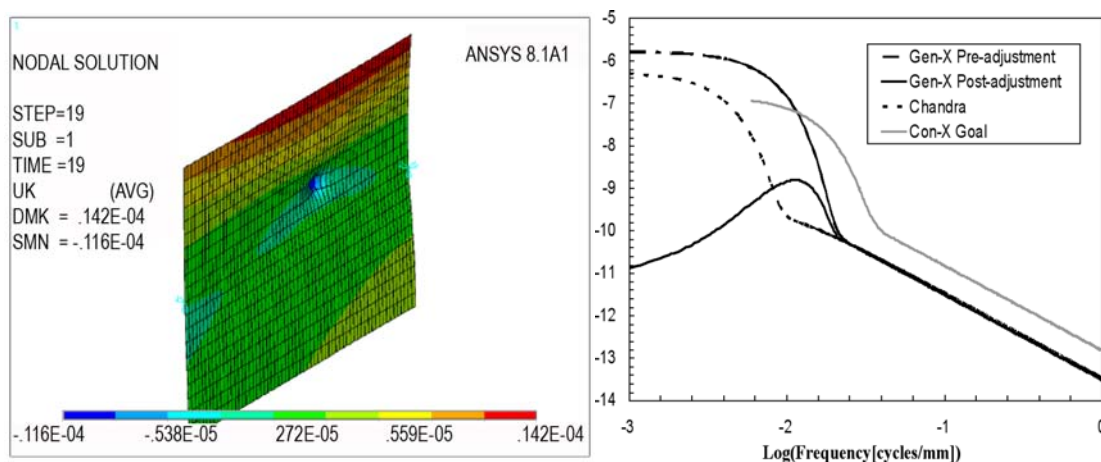
Achieving large X-ray collecting areas in a space observatory requires extremely lightweight mirrors. For (2-reflection) X-ray optics with graze angles of order 0.01 radian, the mirror surface area is about 200 times the aperture area. Thus, the Gen-X requirement for 50 m<sup>2</sup> aperture area implies 10000 m<sup>2</sup> of mirror surface area—i.e., 10

tonne of mirrors at an areal density of  $1 \text{ kg m}^{-2}$ . 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 ( $\leq 0.1 \mu\text{radian}$  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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