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Space Studies Board
Board on Physics and Astronomy
Division on Engineering and Physical Sciences

September 24, 2001

Dr. Edward Weiler
Associate Administrator for Space Science
NASA Headquarters
300 E. Street, SW
Washington, DC 20546-0001

Dear Dr. Weiler:

As you requested in your letter of May 10, 2001, to Space Studies Board Chair John McElroy, the Committee on Astronomy and Astrophysics (CAA) has reviewed NASA's plans for the Next Generation Space Telescope (NGST). NGST is the highest-priority new initiative for astronomy in the recently completed report of the National Research Council's Astronomy and Astrophysics Survey Committee (AASC), *Astronomy and Astrophysics in the New Millennium* (National Academy Press, Washington, D.C., 2001). As described in the AASC's report, NGST was to have been an 8-meter-class, infrared optimized telescope in space. Recently, due to budget and schedule constraints, your office began to consider modifications to the original mission concept and asked the CAA to assess the scientific merits of a descoped NGST with a 6-meter-class mirror.

At its meeting on April 9-10, 2001, the CAA received presentations from the NGST project office; the AASC's Panel on Ultraviolet, Optical, and Infrared Astronomy from Space; Alan Dressler, chair of NASA's Origins subcommittee; and groups involved in large ground-based telescope programs that might have complementary near-infrared capabilities.

The CAA notes that the proposed new baseline plan for the NGST project no longer includes the NEXUS precursor mission that was intended to test the technologies needed for the 8-meter NGST. The NGST project office testified that the plan for a descoped NGST would reduce the technical risk sufficiently that the NEXUS mission would no longer be necessary. The CAA was not asked to consider the engineering and technical risks involved in abandoning NEXUS and cannot offer an expert opinion on the matter. The scientific capabilities of the descoped NGST plan will not be affected by the loss of NEXUS.

The proposed new baseline plan for NGST involves three changes that might have an impact on the scientific performance of the observatory. The first, and most significant, change is the replacement of the 8-meter mirror by a 6-meter mirror. This reduction in mirror size will result in a 25% loss in spatial resolution ($\lambda/2D$ = 0.0344 arcseconds at 2 microns instead of 0.0258 arcseconds) and a ~44% loss in collecting power. As a result, the limiting point source brightness for a fixed observing time will be increased by a factor of ~1.8, while the observing time ($\sim D^4$) required to reach a point source of a given brightness will increase by a factor of ~3. As a result,

the number of observations that the descoped NGST will be able to make to a given sensitivity limit during its lifetime will be reduced by a factor of ~3. The CAA regards this loss in observing capability as the most serious consequence of the proposed descope.

The second change is the specification of a near-infrared camera detector with 48 megapixels rather than 64 megapixels as planned originally. This cost-saving change is appropriate given the loss of angular resolution inherent in the proposed reduced aperture of the primary mirror. Assuming that the camera will be designed to provide Nyquist sampling at a wavelength of 2 microns, the new detector will provide roughly the same field of view as the original baseline design (~4 arcminutes).

The third change is the specification of a baseline operating temperature of 45 K for the telescope instead of 25 K. This change, according to the NGST project office, will reduce the level of technical risk by permitting active thermal control and improved dimensional stability of the telescope assembly. The increase in operating temperature will not affect the scientific performance of the observatory as specified in the original baseline design. The thermal background of the observatory will be greater than that of the zodiacal light only for wavelengths greater than about 12 microns, but this background is expected to be dominated by stray light from the sunshield rather than the thermal radiation from the telescope itself. The increased temperature proposed for the observatory would adversely affect the observatory's scientific performance at the longer wavelengths only if the thermal background from the sunshield could be reduced by more than an order of magnitude, a reduction that the NGST project office does not regard as likely.

The AASC report (p. 36) outlined five major science goals for NGST: (1) measure the light from the first epoch of star formation in the universe, (2) trace the evolution of galaxies from their birth to the present, (3) observe the birth of stars and planets in our own galaxy, (4) study Kuiper Belt objects in our own solar system, and (5) observe dust emission in galaxies out to redshifts of 3. The report emphasized that the NGST's capability to address the latter three goals will depend substantially on whether its sensitivity in wavelength will extend to 27 microns.

The CAA finds that all these major science goals can be met with the descoped option, despite the substantial loss in observing capability noted above. For detecting faint sources at wavelengths greater than 2.5 microns, the descoped NGST will still be 100 to 1,000 times more sensitive than the Space Infrared Telescope Facility (SIRTF), the most sensitive existing or planned facility for observing in this wavelength band (see the AASC report, Figure 3.2), and it will have nearly an order-of-magnitude better angular resolution than SIRTF. It will, for example, provide a unique capability to observe newborn star clusters at redshifts greater than 5. With the capabilities to achieve this goal and comparable milestones addressing the other major science goals listed above, the descoped NGST retains the priority recommended by the Astronomy and Astrophysics Survey Committee.

In his March 15, 2001, letter to Origins Theme Director Anne Kinney, Alan Dressler, on behalf of NASA's Origins subcommittee, stressed the importance of retaining the mid-infrared (5 to 27 microns) imaging and spectroscopy on NGST. The CAA concurs. The mid-infrared wavelength region offers the greatest potential improvement in sensitivity compared to the wavelength regions accessible to existing and planned telescopes on the ground and in space. At mid-infrared wavelengths, NGST will be able to study dust-enshrouded galaxies, newly forming stars, and planetary systems that may be invisible at shorter wavelengths. It will provide a unique capability for extending the process of discovery that will be initiated with SIRTF. NASA should

make all possible efforts to preserve the mid-infrared capability and instrument package as described in the current project plan.

In considering the scientific capability of the descoped NGST, the CAA regards the new baseline plan provided by the NGST project team as a sound approach. The CAA did not consider the possible trade-offs among scientific performance and technical capability that led to this plan. If further major adjustments in the baseline capability of NGST are required, however, it will be important to engage the scientific community in considering the necessary scientific and technical trade-offs.

Sincerely,

/s/

John H. McElroy, *Chair*
Space Studies Board

/s/

John P. Huchra, *Chair*
Board on Physics and Astronomy

Attachments:

Letter of request from E. Weiler to J. McElroy
Letter from A. Dressler to A. Kinney
Presentation to CAA by NGST Project Office

cc: Richard M. McCray, Co-chair, CAA
Wendy L. Freedman, Co-chair, CAA
Joel R. Parriott, Study Director, CAA
Joseph K. Alexander, Director, Space Studies Board
Donald C. Shapero, Director, Board on Physics and Astronomy