I. PROPOSAL SUMMARY
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This proposal from Association of Universities for Research in Astronomy, Inc. (AURA) directly responds to direction from the Gemini Board, with advice from the Gemini science community and the NSF joint Visiting Committee and Mid-term Management Review, to fund the operation of the observatory, the development and exploitation of new instrumentation, and associated necessary enhancements to staff and general infrastructure over the five-year period from 2006 through 2010.

The central science case for this proposal derives from eight fundamental questions of modern astronomy posed by the Gemini community through the AURA managed Aspen Process, these are:

- How do galaxies form?
- What is the nature of dark matter on galactic scales?
- What is the relationship between supermassive black holes and galaxies?
- What is dark energy?
- How did the cosmic “dark age” end?
- How common are extrasolar planets, including Earth-like planets?
- How do star and planetary systems form?
- How do stars process elements into the chemical building blocks of life?

The role of the Gemini Observatory in tackling these fundamental challenges of modern astrophysics is described in six main Sections (I through VI).

This first Section is a high-level summary of the main proposal elements. It provides a brief history of the Partnership and a discussion of significant challenges that are essential to understanding the Universe around us, which led to the creation of the Gemini Partnership. Meeting these challenges remains the key driver for the science and instrumentation programs now being proposed for the future.

This is followed by a discussion of the impact of this prior support, including the science to date, the quality and nature of the observatory, resulting capabilities, and adjustments for the future. Each of Gemini’s two telescopes has a very-high-quality, 8.1-meter monolithic primary mirror. These highly automated telescopes incorporate active and adaptive optics to produce very-high-resolution capabilities. Moreover, they take advantage of two of the highest-quality developed observing sites on the planet. Collectively, they have provided coverage of both the Northern and Southern skies since 2001. Gemini’s imagers and spectrographs accesses most of the optical, near-infrared and mid-infrared spectral windows accessible from the ground. In managing its premier IR and optical ground-based facility for the six partner countries, Gemini has sought to optimize the scientific return both for the initial investment and the ongoing operations cost. The scientific results have been directly responsive to the original Science Requirements Document, which called for “observing and understanding the origins and evolution of stars, planetary systems, of galaxies and of the Universe itself”. Science highlights include:
• The discovery, using adaptive optics (AO), of short-lived temperate level clouds in the atmosphere of Saturn’s moons Titan.
• The discovery, again using AO, of a population of brown dwarfs as binary companions to low mass stars, changing our view of the formation mechanism of such low-mass stellar objects.
• The discovery, this time in the thermal infrared, of colliding planetesimals in the hypothesized Beta Pictoris planetary system as it goes through an era of heavy bombardment, much like our own Solar System did 4.6 Gyr ago.
• A new, second black hole of 1,300 solar masses has been found using Gemini AO orbiting around the center of our galaxy, holding together seven massive stars.
• The first detection of dust, again in the thermal infrared, possibly formed out of the metals synthesized in the explosion from the supernova that exploded in the Large Magellanic Cloud in 1987
• Deep near infrared observations of a candidate redshift $z = 10$ galaxy purportedly discovered by another 8m class observatory, led to a non detection at the greater depth obtained on Gemini, casting significant doubt on the reality of the $z = 10$ galaxy.
• The Gemini Deep Deep Survey (GDDS), an optical survey of unprecedented depth revealed that at least two-thirds of the massive galaxies are already in place after the first 3 billion years following the Big Bang, requiring a revision of most popular galaxy formation models

These results are not only being disseminated to our astronomical community, but shared with the broader public and schools through Gemini’s Public Information and Outreach program. In 2004 alone, over 37,000 school children and members of the public from our local Hawaiian and Chilean communities have attended Gemini outreach events, from planetarium shows, class room visits, family nights and teacher training sessions.

AURA’s proposed response to the Partnership’s future vision is described in Section III. This includes a substantial enhancement of the science program, enabled by their previous investments in Gemini, targeted explicitly to exploit the partnerships strengths and the unique capabilities of the telescopes.

Quite specifically, three new instruments are being proposed, an Extreme AO coronagraph, a high-resolution infrared spectrograph and a highly ambitious wide field multi-object optical spectrograph. In the latter case, a new paradigm is being explored. Given the enormity of the previously described WFMOS surveys, as well as the cost and complexity of a multi-object spectrometer that has a multiplexing gain nearly 10 times larger than any spectrometer built to date, Gemini is examining the possibility of building this instrument collaboratively with Subaru Observatory, where it would be deployed.

These instruments would be procured and managed by the Observatory, using rigorous program management techniques developed by AURA over the period of the previous award.

To complement these instruments two major facility enhances are proposed, an adaptive secondary mirror for Gemini North, to enable Ground Layer AO (GLAO), and a replacement and improved Acquisition and Guide (A&G) systems for both telescopes. The existing A&G
systems are nearing the end of their operational lifetime, and past design and manufacture problems have resulted in performance and reliability problems.

As part of the partnership examination of the Gemini operations model resulted in a request for a modified operations plan to include support for 100% queue scheduling, a more complete pipelined data reduction infrastructure and a new approach to managing the distributed model in partnership with the NGO’s. A full bottoms-up analysis of these requirements is described and the associated increase in staff and infrastructure costs required. In the latter case this includes a significant investment in an extension to the existing Hilo Base Facility, and a Dormitory for the nighttime Cerro Pachón staff and observers.

How this activity is managed, through our “two-telescopes one observatory” approach is described in Section VI. We demonstrate how at each level of decision-making, Gemini is able to engage its diverse stakeholder communities from Agencies, science community members and National Gemini Offices in both the developments and operation of the Observatory.

In responding to this vision, AURA also highlights the expected broader impacts of this proposed reinvestment in the Gemini Observatory and Operation, including improvements and enhancements to our successful outreach program, increased collaborations with industry and a continuing commitment to engaging a diverse workforce.

AURA is proposing for a total of $226,495,370, of which $113,517,215 would arise from the NSF. Funding would be conveyed to AURA by the NSF on behalf of the Gemini Partnership by means of a Cooperative Agreement with a performance period of January 1, 2006 through December 31, 2010.