National Research Council

Committee on a Strategy Optimize the U.S. OIR System in the Era of the LSST

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RESPONSE TO WHITE PAPER QUESTIONS

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- Paper Title (if applicable): **Funding technology development and novel instrumentation today in order to enable breakthrough observing techniques tomorrow**

WHITE PAPER QUESTIONS

The National Academies' OIR System Study Committee is charged with identifying the principal federal and non-federal capabilities in the U.S. OIR System and making strategic recommendations to optimize the System for the best science return. It is vital for the committee to receive community input, so we welcome brief White Papers on any related topics of interest. Questions that might be addressed include, **but are not limited to**, the following:

Provide your responses below those questions you wish to answer. Please limit your entire response to 2 single-spaced pages, Time New Roman font, 12-point size.

This white paper is responsive to questions (4),(7),(8),(9).

NSF should continue to prioritize funding for technology development and experimental instrumentation. While often we focus on aperture size as the most important aspect of a telescope, increasingly the back-end technology is what makes the difference. Advances in detectors, optics, photonics, multi-object spectroscopy, and precision measurement keep Astronomy moving forward at a pace beyond the growth in aperture and regularly open up entirely new avenues of discovery.

The field of optical/IR interferometry has made many sensitivity and productivity gains in the past decades due to advances in technology, such as adaptive optics, low-read noise detectors, metrology, beam combination and spatial filtering with photonic devices. We can now routinely image surfaces of other stars beside the sun and can inspect the warm dust around young stars for the earliest signs of planet formation. But our field is not the only one to radically benefit from diverse efforts to develop new technology and from aggressively "borrowing" instrumentation advances from other technical fields to benefit Astronomy. The first detections of exoplanets did not come from using a bigger telescope nor did the discovery of Dark Energy – these came from exploiting novel instrumentation and observing methods.

One serious emerging concern is that "advanced *technology* development" is used synonymously with "*instrumentation* development" and that a disproportionate share of the overall technology budget is being used to fund "mid"- or large scale instruments that, while legitimately able to *transform* our astronomical science ambition, are based on past-generation technology. While it is surely appropriate for NSF-AST to support new expensive instruments and facilities to tackle the highest-priority scientific goals of the last Decadal Survey, we should not jeopardize our ability to tackle the challenges of the *next* Decadal Survey by inadequately investing in novel and experimental technologies today.

Many key technology breakthroughs in recent years have come from overseas groups. For example, integrated optics and photonic technology have been developed in private/public partnerships around Europe and Australia – these technologies are finding their way into a range of instruments such as interferometer beam combiners, "spectrometers-on-a-chip" concepts, modal-scramblers for high-precision RV measures, etc. Even in areas where the US has traditionally dominated – like visible CCD and IR detectors – we see that the new breakthroughs in high frame-rate, low-read-noise arrays – crucial for adaptive optics wavefront sensing and interferometry – have come from overseas (EM CCDS, and HgCdTe APD arrays which have 10x less noise than mainstream devices). These are worrisome trends.

NASA often can invest early in key technologies once they are recognized to be critical for mission goals. Indeed, NASA-funded lab efforts have led to breakthroughs in a number of areas such high-contrast imaging for planet-finding and certain novel new detector concepts. NASA has funded a number of "crazy ideas" that haven't turned out to be so crazy after all, such as using a formation flying occulter to block out starlight when looking for planets. Unfortunately, it seems that this kind of risky early work is often "non-competitive" in the NSF-ATI context due to the limited funds and the strong emphasis placed on delivering new science now. (We know that NASA can also change course abruptly in their priorities, which can be disruptive in a different way!)

The Decadal Panel did strongly support "balance" between small, medium, and large programs. The Decadal Panel also strongly recognized the importance of technology *development* to the long-term health of the overall enterprise of astronomical discovery. Each individual subpanel of the Decadal Survey process highlighted specific areas needing technology investment – indeed, the word "technology" appears in over 200 separate pages of the Astro2010 reports. As a specific example, the OIR panel committee recognized that continued investment in adaptive optics and optical interferometry is critical to developing capabilities of the future. The Planet Formation Imager (PFI, planetformationimager.org) is an international effort to plan for a next-generation infrared interferometer that can image *in situ* planet formation in the mid-infrared – but this ambitious effort will require continued technical development in fiber optics, lightweight telescopes, detectors, integrated optics, etc., in order to become practical and affordable.

We urge the NSF to protect funding for PI-based instrumentation groups which are both the incubators for new technology and the primary training vehicle for students. We warn against over-investing in large instruments and facilities at the expense of crucial technology seed money. If large professional groups of engineers and senior scientists monopolize the instrumentation budgets of the NSF, we will soon be finding ourselves in great shortage of young instrumentalists and the new innovations they inevitably develop.