The Evolving Roles of the Gemini, Blanco and SOAR Telescopes

REPORT TO THE AAAC

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GBS Sub-Committee Chair

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Charge

Assess scientific utility and priorities for the Blanco, SOAR and Gemini Telescopes for the first half of the upcoming decade.

Specifically the sub-committee was asked to

- Assess to which degree each of the telescopes provides critical complementary data for LSST, MMA, time domain and dark energy science
- Provide a short list describing and evaluating highest impact science in other areas given the planned suite of instruments
- Assess whether the current US share in Gemini and SOAR is adequate
- Evaluate modes of multi-facility use
- Point out missing instrumental and adaptive optics capabilities needed for the highest priority programs

Our interpretation

We consider Gemini, Blanco and SOAR telescopes to be three parts of a multi-facility “GBS” system, and develop an assessment of its scientific utility for the first half of the 2020’s, given the likely priorities of the US astronomical community.

The purpose of our report is to provide NSF with timely advice on the renewal of agreements for two of the GBS facilities, and DOE on whether there is need and priority for use of these facilities to enhance Dark Energy investigations.

We point out how the importance of the GBS system for many high priority sciences cases, identify missing capabilities, and discuss benefits attainable when operating the facilities as part of an OIR system.

GBS Sub-Committee Timeline

8/15/2018 Charge received

Mid November Start of Gemini Renewal Discussion

limited time

fast paced committee*

GBS Sub-Committee Membership

Klaus Honscheid, Chair	Ohio State University
Federica Bianco	University of Delaware
Ian Dell'Antonio	Brown University
Phil Hinz	University of Arizona
Lynne Jones	University of Washington
Alex Kim	Lawrence Berkeley National Laboratory
Phil Marshall	SLAC National Accelerator Laboratory
Gregory Rudnick	University of Kansas
David Sand	University of Arizona

Strong committee with expertise covering the wide range of GBS science

GBS Sub-Committee Timeline

8/15/2018	Charge received
	Committee established
8/24/2018	First committee meeting (telecon)
10/13/2018	In-person meeting @ NOAO, Tucson
11/6/2018	Preliminary report to AAAC
Mid November	Start of Gemini Renewal Discussion
1/19/2019	Report submitted to AAAC
2/25/2019	Final (?) presentation to AAAC

Our approach to address the charge questions

Weekly telecons

Team split into sub-groups to address science cases:

- Small bodies, Exoplanets
- Star Formation, Stellar Astrophysics
- Supernovae, Transients and Variable Stars
- Galaxies, Multi Messenger Astronomy
- Dark energy and matter, OIR System

Insufficient time to solicit community* input but the sub-committee requested and received information from all 3 observatories.

In-person meeting at NOAO, Tucson

Presentations by D. Elmegreen, observatory directors, AEON/Antares, LSST

*) after consulting with agencies and AAAC chair

Report on the Evolving Roles of the Gemini, Blanco and Soar Telescopes

Outline

- Executive Summary
- Introduction
- The GBS System
- Science with the GBS System
  - Small Bodies, Exoplanets, Variables and SNe, Multi Messenger,
  - Star Formation, Stellar Astrophysics, Galaxies,
  - Dark Energy and Dark Matter
- Evolving Roles
  - GBS as part of an OIR System
  - Completing the Instrumentation Portfolio
  - Investment in Instrumentation R&D
- Assessment of the GBS System
- Appendices

The GBS System Section

Inventory of current and planned instrumentation at the 3 telescopes.

The Science Cases

- Science
- Impact of the GBS System
- What is missing from the GBS System
- Benefits from a coordinated OIR System
- GBS Assessment

The Evolving Roles

- Developments for an OIR System
- Instrument Portfolio and R&D

Science Case	SOAR	Blanco	Gemini	Other Data Needed	Tools Needed
Astrometric followup		DECam			
Broadband colors / lightcurves	Goodman	DECam	GMOS, NIRI, SCORPIO	Mid IR photometry	
Taxonomic classification/ minerology (composition)	Goodman		GMOS, SCORPIO	NASA IRTF	Single object, high throughout, wide wavelength spectrograph
Outburst activity	SAMI		GMOS, GEMS		

GBS Assessment for Small Bodies

An Example: Multi-Messenger Astronomy

Science:

Gravitational Waves

The advanced detectors (LIGO/Virgo) will start the next run with increased sensitivity soon.
Numerous binary black hole, neutron star – neutron star, and neutron star black hole mergers with possible electromagnetic signature
Localization uncertainty on sky between 10-100 deg^2.
Requires same night optical and NIR imaging and high cadence spectroscopy.

Neutrinos

0.1 - 1 PeV neutrino alerts from IceCube (Blazars, core collapse SNe) at a rate of a few per month.
Localization uncertainty on sky ~1 deg^2.
Requires imaging and spectroscopy.

GBS:

DECam+Blanco are unsurpassed for localization.
Gemini/Flamingos-2 can be used for pure red kilonovae.
Gemini is well setup for intense optical and NIR imaging and spectroscopy campaign at high cadence (daily). SOAR can do the same for brighter objects.

Missing:

NIR imager on SOAR to follow up red kilonova events

OIR System:

Significant benefits from an ANTARES/AEON like system expanded for MMA alerts.
Has to be able to take in input from multiple teams.
Encourage development of a public search for optical MMA signatures with Blanco+DECam

Findings

The sub-committee reviewed the science opportunities afforded by Gemini, Blanco, and SOAR over the next 5 years and found them to be strong.

All three telescopes are important and valuable assets to the US OIR program.

- Preparations are well underway to support time domain science in the LSST.
- The GBS system provides strong support for multi-messenger astronomy.
- The traditional science areas reviewed by the sub-committee can be done excellently with the GBS system.
- New instruments and extended AO support are under development.

Findings

The NSF focus on multi-messenger astronomy and time domain science is supported by all three telescopes.

Development of the necessary software tools is underway.

Discussions on coordinated observations, data sharing policies have started.

The DOE focus on dark energy science is supported by all three telescopes.

The Alert Broker system is critical for the time domain (SN Ia)

GBS spectroscopy supports probes of dark matter physics using dwarf galaxies and stellar streams. Spectroscopy of cluster galaxies provides critical calibration of photo-z's to enable cluster cosmology.

Gemini AO assisted imaging and spectroscopy will be needed to use hundreds of LSST time delay gravitational lenses for cosmology

Recommendations

Exciting scientific opportunities warrant the extension of the Gemini and SOAR agreements. A particularly strong case is using GBS as a coordinated LSST follow-up system. It will rely on facilities being secured and optimized together rather than separately.

Recommendation 1

NSF should renew the Gemini agreement at the current level.

Recommendation 2

NSF should renew the SOAR agreement at the current level.

Recommendation 3

The Gemini, Blanco and SOAR observatories should continue to optimize and coordinate their position for follow-up observations in the LSST and MMA era while maintaining a strong PI based program covering a broad range of science.

To take full advantage of the scientific opportunities afforded by these telescopes, continuing cooperation among the observatories and coordinated development of the required tools and policies to support an OIR system will be required.

Recommendation 4

Continue to implement the OIR system related recommendations from the 2015 NRC report and support development of OIR system tools and policies.

Recommendation 4a

Engage the community in both process and development.
Encourage community contributions to the requirements, interfaces and functionality of software tools like the Astronomical Event Observation Network (AEON), Event Broker (i.e. Antares)/Target and Observation Managers (TOMs). Ensure that all interfaces are open and provide the options to accept inputs from 3rd party (i.e. user) applications and alert streams. Consider organizing a series of workshops on OIR system tools.

Recommendation 4b

Coordinate efforts in software development for OIR system operation (Brokers, TOMs, Schedulers etc) to ensure cooperation, particularly between institutions and with international partners.

Recommendation 4 (continued)

Continue to implement the OIR system related recommendations from the 2015 NRC report and support development of OIR system tools and policies.

- **Recommendation 4c**
- Develop the necessary policies including a protocol to avoid duplicate observations and encourage data sharing for Target of Opportunity (ToO) and follow up events. Redundant requests should be merged across the OIR system.
- **Recommendation 4d**
  Develop strategies for coordinated, public follow-up of high value transient events such as GW alerts. Establish clear rules for proprietary data rights for target of opportunity observations.
- **Recommendation 4e**
- Enable queue observing for Blanco and SOAR while retaining a visitor mode, possibly by adopting the Gemini model.
- **Recommendation 4f**
  Implement the time exchange program as was recommended by the 2015 NRC report.

In order to secure the long term future of the Gemini, Blanco and SOAR (GBS) system, a science plan or roadmap is needed for these facilities.

Recommendation 5

Start development of a coordinated scientific program for GBS for the second half of the next decade (2025 - 2030).

- **Recommendation 5a**
  Continue to evolve the OIR system and define the role of the GBS system for the era of extremely large telescopes.
- **Recommendation 5b**
- Develop an instrumentation concept for the Blanco telescope for the time following the 5-year (public) DECam period, i.e. beyond 2024.
- **Recommendation 5c**
  Develop an instrumentation concept for the SOAR telescope that builds SOAR's strength in time domain science and fast and flexible follow-up of targets of opportunities.

Recommendation 5 (continued)

- **Recommendation 5d**
  Continue to invest in AO capabilities for Gemini North and South including wide-field and high contrast imaging, spectroscopic capabilities, and long and broad wavelength coverage.
- **Recommendation 5e**
  While outside the scope set by the charge, we recommend to also include the Mayall telescope on Kitt Peak in future planning efforts.

What instrumentation is missing from the GBS system? Some of these recommendations have also been suggested by the Elmegreen and Kavli reports on the future of the OIR system. The committee acknowledges that the future capabilities of the OIR system should be determined in the context of the Decadal Survey.

Recommendation 6

Continue to develop the GBS system, and more broadly the entire US OIR system, by adding capabilities currently lacking from the portfolio.

- **Recommendation 6a**
  Consider enhancing NIR imaging capabilities: a smaller field of view instrument for targeted follow up observations, e.g with SOAR, and a wide field of view instrument (~¼+ deg^2 like Newfirm), possibly for the Blanco.
- **Recommendation 6b**
  Consider adding a high-throughput, low-resolution, single-object, optical-NIR wavelength spectrograph capabilities with IFUs on 4-8 m class telescope to efficiently observe the broad range of target magnitudes.
- **Recommendation 6c**
  Expand support for visitor instruments, for Gemini in particular, to make them available to a larger community.

Recommendation 6 (continued)

- **Recommendation 6d**
  Establish a joint university-observatory R&D program on instrumentation, detectors and adaptive optics capabilities for the next decade.
- **Recommendation 6e**
- A highly-multiplexed, multi object, wide field of view spectrograph on an 8-10 m class telescope in the southern hemisphere remains missing from the US OIR portfolio. The science case for such a facility is very strong, as detailed in many recent studies including the 2015 NRC report and the 2016 Kavli Report on Maximizing Science in the Era of LSST.
  Explore options with international partners to provide access to such a facility, preferably in the Southern hemisphere for the second half of the next decade, such as access to the Prime Focus Spectrograph (PFS) on Subaru and/or contributing to the Mauna Kea Spectroscopic Explorer (MSE) project at the CFHT site.