GSMT Science Working Group meeting
Institute for Astronomy, University of Hawaii
Honolulu, HI December 4-5, 2002

02/12/04 9:00

Participants: Matt Mountain, Wayne van Citters, Mike Bolte, Rolf Kudritzki, Steve Strom, Paul Ho, Chris McKee, Ron Probst, Francois Rigaut, Betsy Gillespie, Jill Bechtold, Jeremy Mould, Terry Herter, Claire Max, Doug Simons, Irene Cruz-Gonzalez and Larry Stepp; Ray Carlberg, Alan Dressler and Jonathan Lunine by phone; and Matthew Colless and Joan Najita on video connections.

Remarks by Wayne van Citters (NSF)

(1) Wayne would like the SWG to develop a powerful science case that he can take to the National Science Board as a first step toward evoking federal funds to support GSMT activities. The SWG must develop clear, quantitative arguments that illustrate the essential contributions of GSMT in the JWST/ALMA era. At a top level, the SWG must develop a "four viewgraph" case that is compelling not only to astronomers, but to biologists, engineers and science policy makers.

(2) The primary role of the SWG is to develop key science drivers and an understanding of how design parameters for a next generation telescope enable addressing those drivers. The SWG will not be asked to choose among proposed designs.

(3) Wayne presented strawman budget models that incorporate funds for GSMT. In no case are funds for GSMT design, development or operations assured. However, with good arguments and hard work, we can evoke the needed support even in a very competitive environment for MRE and other funds.

(4) Wayne believes that the Adaptive Optics roadmap has developed compelling arguments and sufficient community support to merit his efforts to help find funds to begin implementing its recommendations.

(5) Wayne would like the SWG to present a summary of its planned 'white paper' in time to inform decisions regarding the FY 04 budget presentation: that is, prior to June, 2003. The goal would be to begin funding some technology development & support design efforts in FY04.

Remarks by Jeremy Mould

Jeremy commented that AURA's role is to facilitate public-private partnerships to enable one or more GSMT projects (national or international) to succeed over the next decade. To the extent possible, AURA's NIO will support such projects.

He urged the SWG to focus on science drivers, particularly those that influence key design parameters. He noted that the SWG will need to hear presentations from proponents of specific concepts for GSMT, in order to have a confident assessment of the scientific capabilities of a GSMT, rather than an abstract idea.

He asked Wayne van Citters on possibilities for international participation. Wayne noted that it is logical and desirable to have international participation in a GSMT project. Toward that end, he has held preliminary talks with ESO, Canada and others.

Remarks by Matt Mountain

Matt (in his role as telescope scientist) discussed the current status of JWST.

TRW has proposed a 7-m telescope. There is an image quality specification of 75% energy within 150 mas. TRW expects to deliver a Strehl of 0.8 at 2.2 microns.

Matt showed a plot of sensitivity as a function of wavelength; JWST wavelength cutoff is 0.8 microns.

Their schedule shows launch readiness in mid 2010.

The current JWST costs are above the NASA headquarters guidelines. In response, NASA has started a re-planning process.

- 13 risk/descope studies will be initiated.
- Independent cost review – must agree within 20%
- Make final recommendation in March 2003.

NASA has mandated the primary mirror must be mostly filled and no smaller than 6 meters diameter.

A major concern is that the mid-IR capability may be descoped; CAA and other groups have commented.

Matt reviewed the comparison between JWST and GSMT capabilities. GSMT excels at spectroscopy in the 1 to 2.5 micron region; in crowded fields; and in other cases where high angular resolution is required. More detailed comparisons are needed in order to clarify GSMT's pace-setting and complementary roles.

Science and AO summaries

Powerpoint presentations are available on the NSF GSMT SWG website.

02/12/05 8:45 Reconvene

Participants: Wayne van Citters, Mike Bolte, Rolf Kudritzki, Steve Strom, Paul Ho, Chris McKee, Ron Probst, Francois Rigaut, Betsy Gillespie, Jill Bechtold, Terry Herter, Irene Cruz-Gonzales, Claire Max, Doug Simons, Larry Stepp, Jeremy Mould and Jeff Kuhn in Honolulu; Matthew Colless and Joan Najita on video; Alan Dressler, Ray Carlberg.

Remarks by Jeff Kuhn (IfA)

Jeff presented a concept study for a 'high dynamic range telescope' (HDRT) designed to deliver superb image quality through its clean point spread function. It also enables wide-field spectroscopy.

His presentation is available on the GSMT website.

GSMT SWG Reflections

The SWG identified 5 key science areas for further detailed studies:

Cosmology and large scale structure
Birth and evolution of galaxies
Birth and evolution of massive black holes
Birth of stars and planetary systems
Observing exo-planets

Rolf will take the **action** to examine whether supernova studies in service of bounding key cosmological parameters should also merit inclusion on the list.

The goal will be to develop both briefing slides for Wayne for internal and external use; and detailed science cases for vetting and comment by our astronomical colleagues.

Science cases must clearly spell out the role of GSMT in the era of ALMA, JWST and other major facilities. Relevant reports ("Beyond Einstein"; NGST DRM; ALMA science documents; planetary science decadal survey; etc.) must be examined carefully to establish context.

Action items are summarized below.

Rolf Kudritzki will summarize the GSMT SWG charge, actions to date, and planned activities at the NOAO town meeting at the Seattle AAS meeting. Wayne will attend as well. Rolf will use the occasion to encourage community input to the SWG.

Ron Probst presentation re Science Merit Functions

Ron outlined an approach aimed at quantifying returned scientific value as a function of key design parameters (e.g. aperture; field of view; Strehl; Strehl vs FOV; etc.). He showed how developing a series of such 'merit functions' could be used as part of a design-to-cost optimization. Ron's presentation will soon be available on the GSMT website.

Rolf suggested that although the SWG might eventually develop a merit function, the first task is to further develop the science cases.

Next SWG Meeting

Holly Novack will poll the committee for availability during the period 15-28 February. The proposed site for the next meeting is the Los Angeles area (Pasadena the likeliest locale).

Action Items

(1) Further develop key science cases

- Cosmology and large scale structure: ***Colless***
- Birth and assembly of galaxies: ***Barton-Gillespie***
- Birth and evolution of massive black holes: ***Bechtold***
- Birth of stars and planetary systems: ***Strom***
- Exploring exo-planetary systems: ***Strom***

The individuals noted above are responsible for preparing a detailed powerpoint presentation for distribution to the SWG one week prior to the next SWG meeting in mid-February. In preparing these presentations, they should consult with colleagues on the SWG and in the community. To facilitate discussion and constructive criticism, the following template should be followed in presenting each GSMT science programs proposed under each category.

(i) *Statement of problem and its importance*
This should be written at two levels: congressional staff briefing; science community briefing

(ii) *Status of current understanding, what advances are expected in the next decade, and why a next generation ELT is needed*
This section should provide summaries at two levels: (a) a qualitative description, suitable for OMB and Congressional staff; and (b) quantitative arguments indicating what thresholds in angular resolution; sensitivity; sample size....must be crossed to enable significant progress.

(iii) *Description of key measurements needed*
Here what is needed is a quantitative summary of (a) angular resolution; (b) spectral resolution; (c) photometric accuracy; (d) sample size, etc. needed to address key problems. Include example of flux limits; signal/noise needed; integration times to reach flux limit at required signal/noise.

(iv) *Quantitative comparison with JWST*
Prepare quantitative examples clearly delineating the role of JWST and NGST in addressing the problem and carrying out key measurements. The goal is to illustrate the synergy of GSMT with JWST in a 'system' sense, and to indicate clearly the unique role played by GSMT. The audience here is again twofold: staffers and colleagues. Prepare slides at each level. In preparing comparisons, refer to the JWST design reference mission.

(v) Qualitative discussion of GSMT role in ALMA, Con-X, SKA.....era.
The goal here is to provide our colleagues, agencies and staffers with straightforward arguments summarizing the complementarily of GSMT to other planned ground- and space- based facilities expected to mature over the next 10-15 years. Responsible individuals should consult: (1) the AASC Decadal survey; (2) the planetary science decadal survey; (3) the "beyond Einstein" report; and (4) the science cases for ALMA; Con-X; etc. as described on their websites.

(vi) Quantitative examples illustrating performance as a function of key design parameters.
What is suggested here is a comparison of performance of GSMT in providing key measurements as a function of (a) aperture; (b) delivered image quality; (c) field of view; (d) emissivity; (e) wavelength range available. The goal is to refine our understanding of the potential scientific impact of differing GSMT designs. Recall that the role of the SWG is not to *choose* between or among such designs, but to *provide context* for understanding the relative merits of different designs. It may well turn out that public-private partnerships could result in more than one GSMT, perhaps with each optimized to provide certain capabilities.

(vii) Simulations or calculations needed to quantify or further illustrate each science program.
Identify calculations or simulations that would advance quantitative understanding of each science program (flux limits; photometric accuracy; sample size;......). For example, in discussing large scale structure problems, quantify (a) time needed to reach the required S/N for a R~10000 spectrum of a distant quasar; (b) the number of lines of sight that must be probed in order to sample intergalactic gas at sufficient intervals *expressed in a way that it becomes clear how our understanding increases as a function of sample size.* Circulate the need for simulations to other members of the SWG as soon as possible, in service of identifying responsible individuals on the SWG or in the community who might provide those simulations or calculations.

(2) Develop key AO simulations

The below tasks were identified by the SWG for further study. However, no specific individual was identified as the lead for each. I am therefore asking ***Francois Rigaut*** to take responsibility in consultation with ***Claire Max*** to develop an action plan based on the below summary ***no later than 22 Dec, 2002.*** This plan should identify a (realistic) prioritized group of tasks; responsible individuals; and a time by which the SWG might expect initial results.

(i) Develop more realistic simulations for crowded field photometry.
Here the goal is to use more realistic PSF variations over the field; fractional pixel centers for stellar images; and changes in delivered Strehl. As with the initial simulations in the NIO GSMT book, the AO simulators should provide a series of test fields that are presented to 'observers' who will use various techniques to produce color-magnitude diagrams. The simulations should span a wide enough range in assumed parameters to assess the

potential gains of a GSMT as a function of delivered AO performance. Understand, for specific cases the trade between higher Strehl in the near-IR and lower Strehl at optical wavelengths (for using R/R-I vs J/J-K photometry to distinguish metallicity distributions in crowded fields).

(ii) Develop realistic simulations of 'extreme-AO' performance.

The SWG has identified planet detection and characterization as a potential key science driver. Both achieved flux limits and star/planet contrast ratios are key to assessing GSMT performance for this problem. Simulations should include: (a) current AO system performance (based on extant wavefront sensors; DMs; etc); (b) 'best estimate' AO system performance (based on defensible projections of AO component and system capabilities a decade hence); and (c) likely uncorrected and uncorrectable wavefront errors introduced by imperfections and noise in the AO system components and the telescope (for example, wavefront errors likely to be introduced by segment alignment errors; wind-buffeting, etc. Identify the simplest path forward to either simulating the effect or assuming 'reasonable' values for uncorrected wavefront errors.

For a 'plausible' set of assumptions, explore more quantitatively the potential of suggested techniques (e.g. imaging in and out of Methane bands) for reducing speckle noise; closely correlated errors in delivered PSF (for example the pattern produced by segments and field rotation).

(iii) Develop a deeper understanding of the astrometric performance of AO systems on GSMT

Define models to assess stability of astrometric measurements for AO systems of different design: (a) 'classical' AO with a bright natural guide star within an isoplanatic patch; (b) CAO with a laser guide star for high order wavefront correction and a 'typical' NGS for tip-tilt correction; (c) MCAO. The goal is to assess whether there are approaches that could fully exploit centroiding near-diffraction-limited images and produce astrometry at the 0.01 to 0.1 mas level.

(iv) Develop models to predict delivered image quality vs field angle for ground-layer-compensated AO.

Here the goal is to produce -- from traceable assumptions regarding atmospheric turbulence vs height -- guidelines to the science programs that can best exploit seeing-limited images delivered by a 30m GSMT (e.g. IGM probes at high z; abundances and kinematics of stars in relatively uncrowded regions).

(v) Estimate the cost of CAO and MCAO systems as a function of telescope aperture.

The goal here is to understand the cost of various types of AO systems as a function of telescope aperture. Specifically, some have argued that, to zero order, implementing an MCAO system is nearly independent of telescope aperture over the range 20-50m. If true, and if the cost of an ELT MCAO system falls between $75M and $100M, then such systems make the most sense on as large a telescope as can be afforded.

(3) Further develop an Integration Time Calculator

As the SWG further quantifies science cases, it is essential that achievable flux limits; signal/noise estimates; photometric accuracy; etc. be based on common assumptions regarding atmospheric transmission and emission; detector performance; instrument efficiency; etc. Brooke Gregory has developed an initial version of an ITC. ***Gregory and Mike Bolte*** have the action to pool ITC experience and provide (at minimum) a common set of assumptions and agreed upon algorithms for estimating exposure times; delivered S/N; etc. for the range of science cases currently being explored by the SWG. An initial list of ITC capabilities that might be available on what schedule should be provided ***no later than 31 Dec.***