The Support Capability Requirements of 8-m Telescope Science

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ABSTRACT

Science workshops were held throughout the Gemini partnership during the second half of 1997 with the aims of identifying and quantifying the supporting capabilities required to enhance the utility and efficiency of the Gemini 8m telescopes. These workshops, held separately in the US, UK, Canada and South America, ensured representation of a wide range of scientific interests by astronomers from the community. At each workshop many scientific programs were considered in detail sufficient to understand the requirements for their execution on Gemini as well as for any preparatory observations. The desire for wide-field optical and near-infrared imaging was frequently identified with an average of one-half to one night of these survey observations per night of Gemini follow-up. Two other common themes were high angular resolution imaging and rapid response to target-of-opportunity events.

Keywords: Gemini telescopes, support requirements

1. INTRODUCTION

It has long been recognised that efficient and effective use of large telescopes relies on supporting observations and data from complementary facilities. A classic example is the influence of Schmidt surveys and 1-2m telescopes on the utilisation of 4m-class telescopes. These have been primary sources of interesting scientific targets as well as providing complementary observations, for example of the brighter objects in a sample, astrometry, simultaneous data, and preparatory and calibration observations. To identify and quantify these connections and understand their application to the Gemini 8m telescopes a study of science programs drawn from the Gemini partner communities was undertaken in 1997.

To make allowance for any specific national biases of science interests or access to supporting facilities, science workshops were held separately in the US, UK, Canada and jointly amongst the South American Gemini partners. These workshops all followed a similar scheme that involved the examination of a number of potential Gemini science programs in detail sufficient to understand their requirements for successful execution, both for Gemini and from supporting facilities. In this context the ‘supporting facilities’ are taken to include other optical and IR telescopes, for specific targets as well as surveys, telescopes operating at other wavelengths and satellites, measuring machines, data processing systems and archives. Examples of supporting programs are identification or selection of samples of targets, calibration, accurate brightness of colour measurements and observations of the brighter members of an object list.

In the following sections we review the top-level requirements of the programs (section 2) and present an initial assessment of the common themes (section 3). As a complete set of information from the last of the workshops is still to be compiled, the South American programs have not been included in this analysis. Full details of all the science programs will be published as a Gemini report, as will proceedings of the South American “Science with Gemini” meeting.

2. THE SCIENCE PROGRAMS

Titles of the programs presented at the US, UK and Canadian science workshops are given in Figure 1. It is first necessary to understand if the ensemble of workshop science programs is truly representative of "Gemini science". In Figure 2 we present a summary of the programs sub-divided according to the Gemini telescope and instrument

Program ref.	Program title
US1	Physical and population studies of Kuiper Belt objects
US2a	Three ages of the mass-luminosity relation
US2b	Age of the Galactic disk
US2c	Variations in the sub-stellar mass function
US3a	Physical parameters of luminous stars in extragalactic environments
US3b	Gravitational microlensing
US4a	Nature of protostars
US4b	IMF in nearby star-forming regions
US5	Cosmological evolution of starburst galaxies
US6a	Halo populations in the local group
US6b	Galaxy formation and evolution: dwarf spheroidals
US6c	Galactic disks 10Gyr ago
US7	Formation and growth of galaxies
US8	Large-scale structure at high redshifts
UK1	Galaxy scaling relations in clusters at intermediate redshift
UK2	Accurate compact object masses
UK3	Spectroscopy of classical novae in external galaxies
UK4	Molecules in the ISM
UK5	The age of the Galaxy from abundances in halo stars
UK6	The star formation history and growth of LSS in the universe
UK7	Surface features and environment of bright stars
UK8	Chemistry of evolving galaxies
Can1	Searching for undetected protostellar companions to late-B Rosat sources
Can2	Velocity dispersions in the core of elliptical galaxies
Can3	Wolf-Rayet stars in galaxies – the case of I Zw 18
Can4	Search for intergalactic globular clusters
Can5	Youngest and most massive stars and dust embedded super star clusters
Can6	The cluster environment of a z=2 QSO triplet
Can7	The formation of elliptical galaxies
Can8	Hot massive stars in clusters
Can9	Searching for the first barred galaxies
Can10	The age of the Galaxy
Can11	The chemistry of the outer discs of galaxies
Can12	Probing the stellar content and evolutionary histories of galaxy centres
Can13	Chemical evolution of the halos of nearby galaxies

Figure 1: a list of the programs presented at the US, UK and Canadian science workshops

capabilities they would seek to exploit. (Note that because the US workshop was concerned with science programs on all of its 8m-class telescopes, and not just Gemini, not all of the US science programs match to specific Gemini capabilities. Where it was feasible, instrumentation on these other telescopes has been mapped to their nearest Gemini equivalent).

Program Reference	GAOS	NIRI					NIRS					GMOS				Michelle			HROS			MIRI		Phoenix
		JHK & nb 0.02, 0.05	LM & nb 0.02, 0.05	JHKL & nb 0.11	JHK grism	coronograph	JHK spec	LM spec	cross-dispersed	IFU JHK	IFU LM	imaging	long slit	MOS	IFU	10-20um imaging	low & med res spec	high res spec	long-slit	cross-dispersed	MOS	10-20um imaging	spectroscopy	1-5um spec
US1				■								■												
US2a		■											■											
US2b													■	■										
US2c							■						■											
US3a																				■				
US3b																				■				
US4a							■	■										■						■
US4b							■			■														
US5	■	■												■										
US6a														■										
US6b														■										
US6c														■						■				
US7				■			■							■	■									
US8				■			■																	
UK1														■										
UK2				■									■											
UK3													■											
UK4																		■						■
UK5																				■				
UK6												■												
UK7	■					■																		
UK8	■									■														
Can1	■	■					■																	
Can2	■									■														
Can3															■									
Can4				■																				
Can5					■					■							■						■	
Can6				■																				
Can7														■										
Can8														■	■									
Can9	■									■					■									
Can10				■																				
Can11														■										
Can12	■	■								■														
Can13														■										
Totals by	7	4		7	1	1	6	1		6		2	5	11	4		1	2		4			1	2
instrument (/35)	7	13					13					22				3			4			1		2

Figure 2: Use of the Gemini instrument complement by the example science programs. The instrument capabilities are (from left to right) Gemini adaptive optics system, near-IR imager, near-IR spectrometer, optical multi-object spectrograph, mid-IR imager and spectrometer, high-resolution UV and optical spectrograph, mid-IR imager and spectrometer and IR high-resolution spectrograph.

One interesting aspect to Figure 2 is that it appears that appreciation of several of the technical areas that Gemini has been designed to excel in (i.e. high-resolution images and a low thermal infrared background) is yet to impact the science interests of the wider community. Thus there are relatively few programs using the mid-IR instrumentation (Michelle and MIRI) and a similar paucity of programs which would make use of the Gemini AO system to further improve the image quality. It is noteworthy that principal amongst requests for GAOS are the Canadian programs presumably due to that communities exposure to one of the first common-user AO systems (the AOB on CFHT).

Nevertheless, the workhorse imagers and spectrometers are called upon by the majority of science programs and explore the wide range of modes and capabilities offered. The programs themselves cover a very wide range of science interests from solar system studies to the distant universe. Therefore we interpret this ensemble of programs as a relatively conservative extension of on-going optical and near-infrared imaging and spectroscopic studies.

In Figure 3 we highlight another aspect of the programs which is their overall scope expressed simply as the Gemini and support capability time required to carry out the observations. The most obvious feature is the great variety amongst small and large programs again reflecting the structure of the separate workshops with presentations either by individuals (UK and Canada) or by larger groups instructed to be ambitious (US).

Program Reference	Gemini Time Required (hours)	Time on Supporting Facility (hours)						
		optical imager		infrared imager		opt/UV spectr.	IR spectr.	radio & mm
		wide FOV	narrow	wide FOV	narrow			
US1	600	1100						
US2a	3000					250		
US2b	300	100						
US2c	400	100		120				
US3a	150	400						
US3b	30							
US4a	1500			1000			500	
US4b	1000	50		700			(same as 4a)	
US5	730	50			300	450		160
US6a	500	320						
US6b	1000	600						
US6c	480	180				120		
US7	2450	1350		v. large (see text: 3a)				
US8	1300	600		3000				
Total time	13440	4850	0	4820	300	820	500	160
Hrs wrt Gemini (excl US7)…		0.32	0.00	0.44	0.03	0.07	0.05	0.01
UK1	350		20					
UK2	90		5		30			
UK3	25	200						
UK4	75				10		60	
UK5	30							
UK6	60	80						
UK7	25		5		5	10		
UK8	50							
Total time	705	280	30	0	45	10	60	0
Hrs wrt Gemini…		0.40	0.04	0.00	0.06	0.01	0.09	0.00
Can1	60				60			
Can2	40		20					
Can3	20	60						
Can4	10							
Can5	20			60				
Can6	40		30					30
Can7	60	60						
Can8	20				40			
Can9	40							
Can10	40		150					
Can11	50	150				60		
Can12	50			20				20
Can13	80			60				
Total time	530	270	200	140	100	60	0	50
Hrs wrt Gemini…		0.51	0.38	0.26	0.19	0.11	0.00	0.09

Figure 3: Time usage on Gemini and generic telescopes providing supporting capabilities.

We conclude that the programs summarised in Figures 1-3 provide a representative snapshot of science interests amongst the wider Gemini community circa 1997, albeit one that will surely change over next few years as Gemini moves into its operational phase.

3. COMMON SUPPORT REQUIREMENTS

As to be expected, the wide variety of science areas have a range of supporting requirements, however there is a striking interest in wide field (30 arcmin or greater) optical and near-infrared imaging surveys across the community. These surveys would be used to construct multi-colour databases to identify suitable candidates for spectroscopic or high-resolution imaging observations with Gemini. Whilst the amount of time requested for these surveys shows large variance, on average a ‘typical’ night of Gemini follow-up requires between one-half and one night of supporting observations. It is also apparent that this ratio is approximately constant between the countries and applicable equally to large and smaller scale programs.

Imaging with good angular resolution (~0.2 arcsec or better), though less frequent, is another common theme that appears in the detailed science cases. Into this category fall preparatory observations with ground-based telescopes having AO systems as well as the HST and its archives. The number of example Gemini programs concerned is too small to derive reliable statistics. Another enabling capability identified in a few programs and essential to their execution is quick-response access to Gemini to follow-up an external event triggered by a variety of telescopes and satellites. The Gemini Science Operations Plan supports these non-traditional operational modes.

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We thank the many participants in the Gemini science workshops. A fuller version of this material containing details of the sample science programs and an introduction to the Gemini capabilities will shortly be published as a Gemini document. Pre- and reprints of Gemini SPIE papers and other relevant documents are available via the Gemini web site at URL http://www.gemini.edu.

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