Quarterly
SDSS Operations Report

January 1, 2000 - April 11, 2000

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Operations Report

Technical Accomplishments

The first quarter of operations in 2000 highlighted the recovery from an extended shut-down period, during which repairs were made to the secondary mirror and the secondary support system. To our delight, the secondary mirror is giving good images, and the telescope is close to meeting specifications for image quality. This quarter marks the transition from hardware and science commissioning to routine observing.

During this quarter, the spectrographs were thoroughly tested, and are now delivering survey-quality data. A number of imaging runs were carried out scanning away from the Celestial Equator, showing that the telescope, imaging camera, and software are fully capable of delivering science-quality data. Imaging data obtained this quarter have already yielded dramatic new scientific results, including the most distant object yet known, and a new class of extremely cool stars for which astronomers had been searching for some time.

During this quarter, code for mountain operations was system-tested for the first time, and some new code was written. This was a period of extensive development and testing of the observing software (in particular, IOP, the program that operates the imaging camera; SOP, the program that operates the spectrographs; the Motion Control Processor (MCP), the program that controls many aspects of the telescope and most notably the motion control system; and the Data Acquisition System (DA), which manages the data streaming from the instruments and writes it to disk and archival tape). By the end of the quarter, we were very close to full functionality and bug-free operation on the mountain.

In addition, much work was done to collimate and characterize the optics following the repair to the secondary mirror, to streamline observing procedures to make both imaging and spectroscopy more efficient, and to fully characterize the spectrographs.

All of this progress is due to a huge effort by many very hard-working people from all the SDSS institutions and the APO mountain staff.

The following are specifics on the results of this period:

- The secondary mirror seems to be giving very good images. With proper collimation, and a properly working secondary support system, the telescope is giving a more symmetric Point Spread Function (PSF) across the field of the imaging camera than it ever has before: whereas, we used to see substantially worse images in column 6 of the CCD than column 1, the two are now much better balanced. Thus the telescope and camera are closer to meeting the survey requirements on the uniformity of the SDSS PSF over the focal plane. However, it appears that there is a substantial remaining contribution from the optics to the seeing budget in excess of specifications; we are now in the process of assessing its effects. Hartmann data taken this quarter are being analyzed to understand the optics better.

- A pointing model was obtained, with residuals of 1.7" rms, which meets the requirements.

- The imaging camera took data both on and off the Equator. The image quality and astrometric solutions for the off-equatorial scans are as good as those on the Equator, which is a strong validation of the telescope axis controls.

- Reductions of imaging data have been appreciably streamlined. For example, imaging data taken on the night of February 7 were reduced fully at Fermilab in record time; Fan and Strauss of Princeton used the

ARC 3.5m telescope to obtain a spectrum of a high-redshift quasar candidate from the resulting catalog on the night of February 11; it turned out to be at z=4.25. Another exciting result from imaging data in the first quarter is the discovery of several examples of objects with surface temperatures of roughly 1300 K, based on follow-up near-infrared spectra taken with the United Kingdom Infrared Telescope: these are believed to be so-called ``L/T transition objects," representing failed stars just at the juncture at which methane begins to appear in the atmosphere. Over 500 square degrees of new imaging data were obtained in Q1 of 2000, all of which have been processed successfully. Follow-up spectroscopy confirmed a quasar at z = 5.28 based on SDSS photometry. Moreover, the new scans were reduced quickly enough to enable a z = 5.82 quasar to be confirmed in early April and announced on April 17. This latter object, which was reported in newspaper articles around the world, is the most distant object yet known.

- The newly modified 2.5-m enclosure went into full service this quarter, featuring a raised roof line (which enables necessary telescope motions inside the building), improved doors (which provide better clearance for the telescope), and a new climate conditioning system (which controls humidity, temperature, and dust). These are welcome improvements that have already begun to enhance operational efficiency.

- The interlock system had been extensively modified in December to allow motion inside the building, and these changes affected not only the interlock system but the Telescope Performance Monitor (TPM) and the MCP as well. Additionally, changes had been made in the MCP and TPM to improve performance and add features. The TPM and MCP were brought under full version control during the quarter and extensive testing of these systems exposed a number of problems, which are now mostly addressed.

- A number of complex problems were encountered with the DA system, and intensive work by the Fermilab DA team and the SDSS Observers have gotten essentially all of them under control.

- Substantial work has gone into IOP, including documentation of observing procedures. IOP is now being augmented to enhance observing efficiency, especially to minimize overhead associated with the start of each imaging scan.

- Major work was done on many aspects of SOP; it now has essentially all desired functionality, including all aspects of the guider. It was exercised extensively by the SDSS Observers, and documentation was produced and refined.

- Much progress was made on various commissioning tasks associated with the spectrographs: procedures for taking all relevant calibration observations (flat-field exposures, arc lamp exposures, diamond-pattern observations with binned readout) were developed and refined, sources of scattered light inside the spectrographs were tracked down and are now fixed, and data were taken to fully characterize the spectrograph CCDs. The fiber mapper was tested extensively; it is giving absolutely no problems.

- Data were taken of a plate of well-studied stars in M67 to measure the throughput and get an accurate measure of the redshift accuracy. Early results show that the throughput meets survey specifications; the stellar redshifts are reproducible to 10 km/s, which substantially exceeds specifications.

- Scientifically useful data were taken on 15 spectroscopic plates, with 640 fibers each. The performance of the spectrographs is exceeding expectations, with essentially all of the targeted galaxies yielding accurate and reliable redshifts.

- All spectroscopic plates obtained thus far have been run through the spectroscopic pipelines, which are reaching full functionality. The reduced spectroscopic data have been distributed to the collaboration, where they are being used for studies of the luminosity function of galaxies, the fundamental plane of elliptical galaxies, the large-scale structure of the universe, the spectroscopic properties of quasars, various rare classes of white dwarf stars, and chromospheric activity in M dwarf stars.
- Many useful Photometric Telescope (PT) data were gathered; the PT observed without incident essentially every clear dark night during this quarter. After much experimentation and analysis, it appears that we are close to a final satisfactory method to flatten the PT images to better than 1%, even in the u' filter; this was the largest known systematic effect in the photometric calibration. Also, for the first time, secondary patches were observed by the PT on the same night the 2.5m was observing the same area of sky, which is necessary for routine observations.
- A large number of additions and modifications had been made to various telescope systems in the months preceding this period, and although these systems had been tested after they were modified, a fair number of problems were still encountered as these systems were brought on line and exercised. The majority of hardware problems were promptly addressed and resolved by the on-site engineering team with strong support from the system developers.
- Work has started on streamlining routine observations, with the aim of reducing setup time, and thus maximizing the time on the sky. This will be a particular focus of our efforts over the next quarter.

Details of Operations and Metrics

Here we report results of data collection and data processing from Q1 of 2000 (three dark runs, the third of which ended April 10). This quarter included engineering and training during some of the dark hours, which will generally not be the case in subsequent quarters. The accounting has been adjusted to apply to the science and science commissioning operations - specifically, the part of the first dark run for science was limited to the interval Feb 1 - 15. Table 1 gives an accounting for time that enables our observing efficiencies to be evaluated, separately for each of the dark runs.

The observing efficiency is defined by the observing time divided by the available time. The observing time is the time during which data were being collected on the sky that, as far as mountain-top information could discern, was scientifically viable. This quantity therefore does not include calibration exposures, setup time, and data known at the time of observing to be poor. The available time is the number of dark hours in each dark run minus time designated for engineering and minus time lost to weather. The specific definition of dark hours is the Sun more than 18 degrees below the horizon, and the Moon below the horizon. The limits of the dark runs are nights that have at least 3 hours of dark time, but Q1 was idiosyncratic because of the secondary mirror installation and check-out, and the engineering work. The spirit of the available-time measure is to capture the hours actually available to undertake scientific data collection.

The accounting for time used at APO is done via a tool employed by the Observers called TimeTracker. This involves a palette of clocks that are turned on and off according to pre-defined activities or conditions. Categories exist for time lost to weather, time designated as engineering, time used for instrument exchange, time used for cartridge exchange, etc. The time intervals are written to a file, which is then automatically formatted on the web page www-sdss.fnal.gov:8000/~sdssdp/timeUse.html. The “engineering” and “weather” hours for the second and third dark runs reported in Table 1 were taken directly from this web page. For the first dark run, before this web page was implemented, we used estimates based on observing logs.

Tables 2 and 3, discussed below, give the specifics of the scans and plates, respectively, that contributed to the "science hours" and "commissioning hours" listed in Table 1. Since a length of 15 degrees is equivalent to 1 hour of scanning, one can easily compute the time on the sky from column 4 of Table 2, and this what is listed in Table 1. Runs on survey strips are called "science," and runs in the FASTT astrometric fields are called "commissioning." Table 3 is similar: here the time entered in Table 1 is the sum of the exposure times for all plates with (good) listed in column 6 of Table 3.

Table 1 shows that the efficiency grew steadily from one dark run to the next, ending at 46%, which reflects among other factors growing experience with telescope and instrument set-up procedures. In the third dark run, a deliberate decision was made to emphasize imaging time with respect to spectroscopic time.

Table 1. Efficiency

Dark Run	1 Feb -15 Feb	27 Feb - 17 Mar	24 Mar - 10 Apr
total dark hours in run	137.9	130.1	134.0
hours lost to clouds	27.8	47.0	55.6
engineering time	22.6	26.3	8.4
net hours for science	87.5	56.8	70.0
science imaging	4.1	5.8	24.6
commis. imaging	0.6	2.5	2.2
science spectroscopy	1.0	7.8	5.0
commis. spectroscopy	-	2.0	0.5
hours collecting sky data	5.7	18.1	32.3
hours collecting sky data / net hours for science	6.5%	32%	46%

Tables 2 and 3 below report the specifics of science or commissioning data collected in Q1. We continue to develop practical procedures for declaring data to be good or otherwise. (Note that since the most recent data were collected on April 10, the existence of the evaluations in the right-hand columns of Tables 2 and 3 reflects the speed of data processing.) In the course of this development we will rationalize the details given in these tables with the survey progress depicted at http://sdss.fnal.gov:8000/~sdssdp/status.

Table 2. Science and Commissioning Imaging Runs

Date	Run	Stripe	Length	APO Report	DP Report
Science runs					
10-Feb-00	1133	36 N	7.51	good	astrom
12-Feb-00	1140	9 N	53.87	acceptable	stuffed
03-Mar-00	1229	22 N	13.84		
03-Mar-00	1231	9 S	33.03	acceptable	stuffed
04-Mar-00	1241	9 S	32.85	acceptable	stuffed
04-Mar-00	1242	9 S	6.66		
30-Mar-00	1302	36 N	66.45	light leaks	astrom
04-Apr-00	1331	36 S	42.47	good	frames
04-Apr-00	1332	36 S	11.06	acceptable	frames
04-Apr-00	1336	42 N	15.36	good	frames
04-Apr-00	1337	42 S	1.21		
04-Apr-00	1339	42 S	15.16	good	frames
05-Apr-00	1345	36 N	129.28	good	astrom
06-Apr-00	1350	37 S	70.54	good	psp
06-Apr-00	1356	43 N	17.72	good	psp
Commissioning runs					
08-Feb-00	1118	10 S	8.43	good	
03-Mar-00	1233	10 N	8.89	acceptable	ssc
04-Mar-00	1239	10 S	28.78	good	stuffed
15-Mar-00	1264	37 N	12.6	moon	
15-Mar-00	1266	37 S	12.6	moon	
17-Mar-00	1275	36 N	7.92	moon	
04-Apr-00	1329	10 N	8.81	good	astrom
04-Apr-00	1334	10 N	14.32	good	astrom
06-Apr-00	1352	10 O	9.66	good	

Notes to Table 2: Science and commissioning runs listed by dark run. The column headed “APO Report” gives information encoded in the idReports (except where blank, which indicates the field was not filled in); this column thus represents an assessment from the observing perspective of whether the data should be processed. No runs with comments “bad” or “ignore” are tabulated. The column headed “DP Report” gives further commentary based on data processing, taken from the status web page. The term “stuffed” means the run was processed successfully and entered into the database. Other entries describe the farthest-downstream pipeline the run has experienced to date.

Table 3. Science and Commissioning Spectroscopy Plates

Date	MJD	Dark Run	Plate	Integration Time	APO Report	DP Report
3-Feb-00	51578	1	213	1x900	not combined	
8-Mar-00	51612	1	260	2x900	moon?	
27-Feb-00	51602	2	265	4x900	(good)	Low S/N
27-Feb-00	51602	1	266	4x900	Slitheads unlatched! Out of focus?	Good S/N
11-Mar-00	51615	1		1x900	not combined	Short exposure
26-Mar-00	51630	3		4x900	1.5" (good)	Good, done
4-Mar-00	51608	2	267	4x900	2.0" (good)	Good, done
29-Mar-00	51633	3	268	5x900	1.5" (good)	Good, done
6-Feb-00	51581	1	269	3x900	no entry in observing log?	Low S/N
27-Feb-00	51602	1	279	2x900		Low S/N
4-Mar-00	51608	2		3x900	2.0" (good)	Good, done
8-Mar-00	51612	2	280	4x900	(good)	Good, done
10-Mar-00	51614	2	281	4x900	(good) 1.5-2.5"	Good, done
26-Mar-00	51630	3	282	2x900	past optimal hour angle	Low S/N
25-Mar-00	51629	3	282	4x900	1.5" (integration time problems)	Low S/N
9-Feb-00	51584	1	283	4x900	3.5-4.0"	Low S/N
5-Mar-00	51609	2	292	4x900	2" seeing (good)	Good, done
5-Feb-00	51580	1	295	4x900		Low S/N
6-Feb-00	51581	1		2x900		Low S/N
7-Feb-00	51582	1		1x900		Short exposure
10-Feb-00	51585	1		4x900	(good)	Low S/N
3-Feb-00	51578	1	296	3x900	r2 could be problematic	Missing fibers
12-Mar-00	51616	2	302	4x900	1.7" (good)	Low S/N
06-Apr-00	51641	3	301	4x900	(good)	Good, done
10-Mar-00	51614	1	303	1x900	1.5-2.5"	Short exposure
11-Mar-00	51615	1		3x900	okay?, 1.5"	Good, done
05-Mar-00	51609	2	304	4x900	2" (good)	Good, done
09-Mar-00	51613	1	305	4x900	good possible flat field problems	Good, done
02-Apr-00	51637	3	306	4x900	1.5 (good)	Good, done
10-Mar-00	51614	1	310	2x900		Low S/N
12-Mar-00	51616	1		2x900	2.3", not yet run through 2d	Low S/N
06-Apr-00	51641	3	314	3x900	(good)	Good, done
14-Feb-00	51589	1	* 0317	3x900	no calibrations?, no flatfield petal control	
04-Feb-00	51579	1	* 0318	1x900	M67 Faint	4science exposures, bad headers

05-Feb-00	51580	1		3x900	r1 did not reduce?	
10-Mar-00	51614	1		3x900		
25-Mar-00	51629	3		2x900	1.5 (good)	
08-Mar-00	51612	1	* 0321	3x30, 3x60, 3x120, 3x240	M67 Bright (velocity standards)	Special
11-Mar-00	51615	1	* 0323	4x900	1.2" Stellar Locus	Good, done
12-Mar-00	51616	1	* 0324	1x900	poor S/N, 2.8" Stellar Locus	1 science exposure
02-Apr-00	51637	3		1x900	not combined	
23-Mar-00	51627	3		3x900	2.0 (past hour angle limits)	

Notes to Table 3: Science and commissioning plates listed in order of plate number (some plates have multiple exposures across different dark runs). The commissioning plates are indicated by an asterisk in column 4, and include exposures of the star cluster M67, for example. The third column indicates which dark run the exposure corresponds to. Exposure times are given in seconds. The column headed "APO Report" contains information based on observing logs; in general the notation "(good)" indicates the plate was considered scientifically useful from the point of view of APO operations. The last column (headed "DP Report") indicates results from the spectroscopic pipeline.

Data Processing

Column 6 of Table 2 gives the processing status (as of 20 April 2000) for runs obtained in Q1 of 2000 - see the Notes at the bottom of the Table. Except for the short runs 1133, 1229, 1242, and 1337, and the run 1302 known to have been affected by light leaks, all of the runs have either been successfully processed or are in process. The total of 563 square degrees science data processed during the quarter.

In addition, extensive reduction of data obtained in the Fall of 1999, in particular the first successful reductions of off-the-equator runs, was accomplished this quarter. The total number of square degrees observed in 1999 and processed in Q1 is 689.

Spectroscopic reductions in Q1 followed a similar path: the new data have been processed, and reductions of plates from 1999 were also done. This situation represents significant progress - in this quarter, as processing transitioned from using development versions of the "2D" and "1D" pipelines to using stable versions.

An important element recently implemented is an objective way based on the computed signal-to-noise ratio to decide if the data from a plate can be considered "done," i.e., no further exposure for that plate is needed to meet the scientific requirements. While the criterion still needs to be tuned, we are very close to having a working practical system to make this important declaration. The plates marked "good, done" in column 7 of Table 3 represent those that passed the current test; these amount to 15 plates (taken and reduced in Q1). (Plate 295, which was observed on four separate nights, failed to satisfy the signal-to-noise ratio criterion on any of the nights. However, when the nights are combined, this plate does qualify and is thus designated "good, done.") An additional six plates that meet the same criterion were observed in 1999 but processed in Q1. Altogether these 21 plates yielded approximately 10,000 automated redshifts (galaxies, luminous red galaxies, and quasars).

Pipelined reductions of Photometric Telescope primary and secondary fields proceeded this quarter, keeping up with the acquisition of new data, and including re-reductions of data obtained in 1999. The status of

PT reductions is given at http://sdss.fnal.gov:8000/~sdssdp/status/mt/status_mt_data.html. We are devising a reporting scheme that will make the volume of PT data processed (e.g., the number of secondary fields) easier to determine.

SDSS Project Financial Report

Executive Summary

This report reviews the state of the SDSS project budget at the end of the first quarter of 2000 and provides an updated forecast for the remainder of the calendar year. The calendar year 2000 budget of $5,391K for the SDSS was approved by the ARC Board of Governors at its Annual Meeting in November 1999. This is the baseline budget for CY2000. It consists of an ARC funded portion in the amount of $3,700K and an in-kind level of effort from Fermilab and the USNO. The latter is estimated to have a value of $1,691K for CY2000. Fermilab and the USNO are providing the in-kind level of effort defined in the baseline budget. The current forecast of expenses in the ARC funded portion of the budget has risen to $4,250K. In spite of the anticipated increase in cost in CY2000, we forecast an encumbered balance of $950K on December 31, 2000.

The ARC funded budget and the forecast of expenses is summarized in Table 4. It presents a comparison of the first quarter expenses and the current forecast for CY2000 with the baselines for both periods. It should be noted that while some first quarter costs are based on invoices submitted to ARC, some costs are based on input from institution SSP managers and budget officers. As such, these reflect our best understanding of actual first quarter costs.

Table 4. 2000 Budget Status – ARC-Funded 1st Quarter Expenses and Proposed Forecast ($K)

	2000 - 1st Quarter		2000 - Total	
Category	**Baseline**	**Actual Expenses**	**Baseline**	**Forecast**
Project Management and Science Direction	107	92	244	336
Observing Systems	379	398	1,074	1,196
Data Processing and Distribution	193	172	686	701
Observatory Support	296	264	1,185	1,219
ARC – Corporate Expenses	20	22	139	167
Capital Improvements to the Site	0	0	0	498
Sub-total	995	948	3,328	4,116
Undistributed Contingency	159	0	372	134
Total	**1,154**	**948**	**3,700**	**4,250**

The sum of ARC-funded expenses for the first quarter was $948K. This is below the first-quarter baseline budget, without contingency, of $995K. First quarter expenses were less than the baseline for several reasons. First, some work that had been scheduled for the first quarter did not get done and it is now scheduled for later in the year. Second, a portion of budgets for summer salaries were uniformly distributed over the year instead of being concentrated in the summer. Consequently, these salary budgets appear under-spent in the first quarter. The summer salary portion of these budgets has been moved forward in the forecast to correctly budget for these costs during the summer. In addition to these adjustments, there were several unplanned costs in the first quarter. First, unanticipated 1999 carry-over costs of $64K were paid in the first quarter as a result of late invoicing by one of the university partners. Second, labor costs for spectrograph support and photometric telescope commissioning were $35K higher than budgeted. This was due to an error when the budgets were established; the work had been planned and authorized but the budget was not allocated correctly. In summary, unplanned expenses added $99K to the first quarter costs and planned expenses were less than the forecast because work was not completed and some salary distributions were made incorrectly.

The current forecast for the ARC funded costs in CY2000 is $4,250K, $789K above the baseline less contingency. Since part of the year has elapsed and the scope of work is much better understood the undistributed contingency has been reduced by $239K, thereby reducing the forecast overrun to $550K.

The SDSS Director has requested the $550K increase to proceed with two capital improvement projects and to cover the cost of unbudgeted project management support from JHU. The capital improvement projects include the construction of an engineering support building at Apache Point Observatory (APO) to address office, lab, and storage space needs, and an upgrade of the observatory phone system to mitigate a lightning hazard. The increase in project management support was requested by the Director to support the Observing Systems review held in April at APO and to prepare several reports for sponsor agencies. It is noted that the sum of three items is nearly $600K of the forecast increase of $789K.

The following sections discuss first quarter performance and provide details regarding proposed changes to the forecast budget. The sections are organized according to the project Work Breakdown Structure (WBS).

Project Management and Science Direction

The ARC funded budget for Project Management and Science Direction supports travel expenses and miscellaneous expenses at Fermilab, Princeton, the University of Chicago, the Johns Hopkins University, the University of Washington and the University of Pittsburgh. In addition it provides salary support at Johns Hopkins University and the University of Pittsburgh. The current forecast for ARC-funded project management support is $336K, which is $92K above the baseline budget of $244K. The forecast increase stems from a $94K cost increase in the JHU budget for project management support. Carry-over costs from 1999 account for $34K of the cost increase. JHU invoices for work as far back as July 1999 were submitted for payment in the first quarter of 2000. Moreover, the Director requested additional support to assist with the Observing Systems review at APO and the preparation of several sponsor reports. A shorter quarterly report will reduce the effort required in this area; therefore, no further support for project management will be requested from JHU beyond June 2000. The forecast expenses at the other institutions are all within a few thousand of the baseline budget.

Observing Systems

The Observing Systems consists of the 2.5-m telescope, the imaging camera, the two spectrographs, the plug plate operation (at APO and the UW), the photometric telescope (PT) and other smaller instruments used by the SDSS at APO. During the first month of the quarter there was a very large effort directed at resuming commissioning, which had been suspended in October because of the damage to the secondary mirror. Since nearly all of the subsystems were completed in the first quarter, there were a number of small to medium size unbudgeted costs, these are listed in Table 5. The UW engineering group encountered increased costs in bringing the plug plate drilling operation into production operation. In addition the travel budget of the UW engineering group was increased so that they could participate in the preparations at APO that precede the start of each dark run. Most of these costs have been incurred.

Table 5. Items Contributing to the Observing Systems Forecast Increase

Institution	**Unbudgeted Tasks for 2000**	**Projected Cost ($K)**
UW Telescope Engineering	Vertical mill thermal control	7.1
	M2 support system hardware	5.0
	Shipping of 4 cartridges to APO	5.0
	Plug-plate production cost adjustment	7.2
	Increased APO travel costs for UW engineering	6.8
PU Engineering	Miscellaneous hardware purchases	7.0
UC Engineering	Engineering effort to analyze Hartmann test data	8.1
	Miscellaneous hardware expenses	3.0
JHU Engineering	Salary charged at higher % of effort than budgeted	16.0
FNAL Engineering	Corrector lens cart and storage house fabrication	8.0
	Fiber cartridge cart storage house	5.0
	M2 support system machining	6.8
	Dewar scale parts fabrication	1.0
	Two APO trips for servo engineer	1.3
	Housing and per diem expenses for on-site staff	8.1
	Total Forecast Increase	**95.4**

The apparent $16K increase in salaries at JHU was actually the result of an error made during the budget allocation process. The level of effort expended had been approved but was not properly distributed in the baseline budget. The Fermilab engineering group designed and began fabrication of the corrector lens cart, it's storage house, and the cartridge cart storage house during the quarter. These were unplanned but were necessary to mitigate personnel and equipment safety issues associated with observing activities. The Fermilab Engineering group found it necessary to contract for additional machining and parts fabrication in order to complete the installation of the modified secondary mirror support structure after the mirror breakage. Travel costs have been added to the forecast to support a Fermilab electrical engineer who will work on telescope control system problems. He will join the project in the second quarter. Funds have also been added to extend the period in which housing expenses will be covered for one of the Fermilab technicians stationed at APO.

While the optical performance of the telescope has not met the seeing requirement of 1.2 arcseconds, it has consistently provided 1.5 arcseconds seeing. The degradation does not appear to affect the key science projects, nevertheless, it will limit the efficiency of operations. For this reason the project is taking steps to understand the discrepancy. This effort, heretofore unbudgeted, has and will lead to cost increases. The University of Chicago effort was increased in order to analyze the Hartmann screen data taken in January after the secondary mirror repair was completed. While the results of all of the tests of the optics made in January and February have established that the quality of the secondary mirror is at least as good as it was before it was damaged, the overall optical performance remains a matter of concern. In order to address the problem we propose to characterize the quality of the secondary mirror and the common corrector. We are developing a plan to send the secondary mirror and the common corrector lens to Lick Observatory for profilometer measurements during the summer 2000 shutdown. We have a preliminary but incomplete cost estimate of $38K for these measurements. The $38K includes shipping and insurance fees, fixture costs, and the cost of measurements at Lick. This task was not included in Table 5 or in the current forecast since it is still in the preliminary planning phase and has not been authorized. If it is determined that these measurements are necessary and the work authorized, then this item will be more fully addressed in the second quarter report. If this work is authorized, it will be funded out of undistributed contingency.

Data Acquisition, Processing and Distribution

Data processing and distribution includes pipeline and data processing development and support, development and support of the Science Archive (SX), and development of the photometric calibration system. A discussion of the budget situation in each of these areas is presented in the following sections.

Pipeline and Data Processing Development and Support

The ARC funded budget for pipeline and data processing development and support is spread among Fermilab, Princeton, and the University of Chicago and consists of salaries and supplies for staff at Princeton and Chicago and funds for travel for participants at all insitutions. The reimbursement of Fermilab data acquisition, processing and distributed cost is presently limited by agreement to travel expenses and the Fermilab staff effort is an in-kind contribution. The budget variations by institution are small and collectively sum to a net decrease of $8K in the forecast budget for the remainder of the year.

Data Archive Development and Support

The budget for data archive development and support covers the effort at JHU to develop the Science Archive database. The baseline budget is $167K; the current forecast is $193K. First quarter travel and support costs exceeded the baseline budget by $9K. The remaining $17K of the forecast increase was requested by the Head of Science Archive Development and approved by the Director. It includes salaries for additional graduate and undergraduate students to support database development and testing during the summer and fall of 2000. It also includes a new laptop computer and $2.4K to cover additional travel needs. The request was granted because data archive development is on the critical path for data distribution and the level of effort needs to be increased.

Photometric System Definition

Photometric system definition tasks in the first quarter included commissioning and operation of the Photometric Telescope and development of the primary standards catalog. The baseline budget for Photometric Telescope commissioning in 2000 was $204K; the current forecast is $230K. First quarter expenses were $63K against the first quarter baseline of $74K. This would have resulted in an under-run of $16K had it not been for a late invoice of $30K from July 1999 that was submitted during the first quarter. The addition of this late invoice brings the total first quarter charges to $93K, which results in a net first quarter cost increase of $19K. In addition to the first quarter increase, some of the work on the Photometric Telescope that had been scheduled for the first quarter did not get done. This work is now scheduled for later in the year and an additional $7K has been added to the forecast to support this work. The first quarter expenses and revised forecast results in a total forecast increase of $26K against the Photometric Telescope budget. This increase is offset by a $3K reduction in first quarter costs on the photometric system support provided by the University of Michigan. Summing, these adjustment results in a net forecast increase of $23K on the photometric system definition in year 2000.

Observatory Support

The baseline observatory support budget was $1,185K; and the current forecast, excluding the telephone system upgrade, is $1,219K. First quarter costs are below the baseline budget by $31K because not all costs for the quarter have been submitted to ARC for payment. We anticipate that NMSU will invoice ARC for an additional $46K, which will result in a total cost increase of roughly $15K over the first quarter baseline. The increased costs include $4.2K in housing for a Princeton astronomer who stayed near the observatory for an extended period to work on software development. The cost increase also includes higher than budgeted overtime usage during the long winter nights. The extra hours enabled the observers and technical staff to complete the extensive commissioning effort and observations that were required to make the transition from engineering commissioning to operations. While the baseline budget provided for a certain level of overtime, it had been averaged linearly over the year rather than being seasonally adjusted. The result is that summer labor costs will be lower than the monthly average due to shorter observing nights and the summer shutdown. This will partially offset the higher winter overtime usage rate. The remainder of the forecast increase over the baseline reflects increased janitorial costs to support the increased SDSS visitor load at APO, higher than budgeted plug plate technician salaries, a surge protector for lightning protection in the telescope enclosure, night-vision cameras to allow observers to see the telescopes from the control room at night, and the housing and catering costs associated with the Observing Systems Review at APO in April 2000. To ensure that adequate funds remain in the observatory support budget, unspent funds from the first quarter have been moved forward into quarters 2-4.

ARC Corporate Expenses

Corporate-level expenses cover such items as audit and insurance expenses, CD's for limited data distribution, and aluminizing costs for the 2.5-m telescope primary mirror. The current forecast for ARC expenses is $69K compared to a baseline budget of $40K. Items included in the $29K cost increase are shown in Table 6.

Table 6. ARC-Corporate Budget Add-ons

Item	Projected Cost ($K)
Observing Systems Readiness Review	10.1
Advisory Council miscellaneous support	10.0
AAS meeting expenses	6.7
O'Hare meeting room expenses	2.0
Total	**28.8**

Capital Improvements to the Site

Two capital improvement projects that were not included in the baseline budget are the APO engineering support building and the APO phone system upgrade. Together, these make up $498K of the forecast increase in the 2000 ARC funded budget. The costs for these projects are included in the ARC Corporate budget and the projects will be administered by the ARC Business Manager. Both of these improvements are necessary to improve personnel and equipment safety and provide for efficient survey operations.

The APO engineering support building is needed to alleviate a severe shortage of operations, lab, and storage space at the observatory. While plug-plate operations at APO have been made substantially more orderly and routine during the past three months, we now realize that we do not have sufficient space to carry out these operations with the throughput needed to process 10 plates per night. In addition, the lab space required for maintenance tasks on the telescope and instruments and the storage space for the spare parts inventory are not adequate. This had been known for some time and in November the Director proposed to set aside $300K of the undistributed contingency, if it were not needed for more extensive repairs of the secondary mirror than were being planned in November. At the time, the building requirements had not been established, there was no firm design and hence no real cost estimate for the engineering support building. A conceptual design based on our experience of operating and maintaining the observing systems during this quarter was developed with an Architect-Engineering firm and it is the basis of the current cost estimate.

The engineering support building will provide sufficient room for plug plate operations; the 2.5-m instrument laboratory, including the relocation of the operations building clean room; increased space for plug plate storage; machine shop; and office space for SDSS engineering and technical staff, which is currently provided by the trailer located south of the current support building.

It is proposed to relocate the 2.5-m instrument laboratory in order to improve the ease of moving the imaging camera from the 2.5-m telescope platform to the 2.5-m instrument laboratory. The relocation will eliminate the risks of loading and unloading the camera onto a truck for its journey to and from the operations building to the 2.5-m telescope platform. The laboratory space in the operations building presently used for the 2.5m instruments will be converted to office space for the observers. In principle, the two temporary office trailers could be eliminated. Moreover, the SDSS will not need any further expansion of the operations building.

The machine shop will be moved to the basement of the proposed engineering support building. The space that will be vacated will be used exclusively for welding and limited storage. Since this should be viewed as an option, the basement will be significantly reduced or eliminated if the contract cost exceeds the construction estimate of $416K.

The current estimate for the engineering support building, including architect fees, is $448K. The Director is recommending that ARC proceed with this building even though it will be a major contributor to the forecast increase of $550K for the year 2000. If authorized, construction could begin in September 2000 with occupancy in early 2001.

The APO phone system upgrade will mitigate the lightning hazard associated with copper phone wires traversing the site and entering sensitive areas within observatory buildings. The copper wires will be eliminated either by using fiber optic or wireless communications. It should be noted, however, that the phone system upgrade is not purely a lightning protection issue since the phone system is near the end of its useful life. A Request for Proposal has been authorized to solicit bids for this project and the SDSS is prepared to pay up to $50K of the cost for the phone system upgrade. Any additional costs will be borne by the 3.5-m project. If necessary, this project can be deferred to 2001.

It should be noted that once the phone system upgrade and the engineering support building are complete, no further capital improvements of the conventional facilities are planned for the five-year operations period.

Contingency

The baseline budget contained $372K in undistributed contingency. The amount of the forecast increase will be partially offset by reducing the undistributed contingency by $239K. The revised budget will still have a contingency of $134K for the remainder of 2000. It is clear that we need to be tight-fisted with the budget in order to meet the current forecast with such a small contingency at this point in the year. We will closely track work and expenses by institution to ensure that we adhere to the current plan and forecast.

Appendix

Five-Year Plan for SDSS Operations

Northern Survey

The progress of the SDSS will be evaluated with respect to a projection that accounts for the available observing time and how efficiently we use it. Table A1 gives a model that takes as input the number of dark hours in each quarter, the allocations of that time (imaging versus spectroscopy), and various efficiency factors. The result is total hours spent collecting data for imaging, and separately for spectroscopy. These two numbers can then be converted into square degrees and plates, which allows a straightforward comparison with the data actually collected.

The following are notes related to the columns and their contents.

The number of dark hours listed in Table A1 for which the northern survey region is available is an approximate average for each quarter of each year. The values depend on decisions about 1) minimum horizon distance of Sun (nominal -18 deg); 2) minimum horizon distance of Moon (nominal 0 deg); 3) maximum airmass (nominal 2.2); 4) minimum interval of time for observing on a given night (nominal 3 hrs). The hours for Q3 are low because of July/August weather and lack of survey region availability in September. The observatory will undertake routine maintenance during this period, and we will lose one dark run (here assumed to be split between July and August). Moreover, we will re-aluminize the primary mirror of the 2.5-m telescope each October, and we will inevitably lose part of a dark run then. The Q4 hours have been adjusted for this.

Twenty percent of the astronomically useful time is supposed to be photometric and good seeing. The spectroscopic survey is planned to start Q1 of 2001, which enables the necessary head start for imaging. The 0.3 of the available dark time through Q2 of 2002 reflects the intent to front-load imaging (assuming, of course, that atmospheric conditions permit this relatively high fraction). The plan is that imaging ends early and spectroscopy then has 100% of the available time beginning Q4 of 2004. In practice the proportions will be adjusted as the survey progresses to yield the best strategic advantage in terms of finishing both the imaging and the spectroscopy in the minimum time.

The "weather" column shows the fraction of time that is astronomically useful, i.e. conditions (clouds, seeing) support at least spectroscopic work. Based on historical records for 3.5-m telescope operations at APO, 60% of time is astronomically useful in all months except for the monsoon months of July and August. In those two months, 40% of the time is astronomically useful.

Uptime is the fraction of the observing time the hardware and software are working well enough to enable data collection. The steady-state value of 90% is of course a projection, but it is not unrealistic compared to the operations of other observatories.

The next columns refer to the efficiencies of data collection, separately for imaging and spectroscopy. Some time is lost due to inevitable factors, for example the ramps for imaging, focusing, calibration exposures for spectroscopy, etc. These intervals of lost time can be estimated relatively precisely ahead of time, and these efficiencies are entered in the "imaging efficiency" and "spectroscopic efficiency" columns. Other time is lost due to conditions that are in principle within our control, and these represent places where we can devise methods to enhance the use of telescope time. An example of this would be loss of time at the end of a night because a run has finished and insufficient time remains to do anything else. Estimates of these factors are entered in the columns headed “imaging operations” and “spectroscopic operations.”

The imaging efficiency is estimated as follows. Simulations show that a night of imaging has an average length of 5.8 hours and will typically include two runs. The ramps require about 8 minutes at the beginning and end of each run, and time must be allocated also to focus and set the rotator, say 15 minutes per run. Allowing the setup for the first run to have been concluded in the twilight, the best possible efficiency is then 0.86.

Spectroscopic efficiency assumes 25 minutes lost to calibrations, cartridge exchange, and field acquisition for each 45 min plate exposed. That’s an efficiency of 0.65. (Currently we are meeting our goal of exchanging a cartridge in less than 10 minutes, and it may be possible to improve the time taken for calibration exposures.)

The next columns are estimates of additional factors that affect how much time we expose on the sky. For example we can lose time at the beginning or end of a night (or clearing or onset of clouds); exchanges between imaging and spectroscopy takes additional time; and if the seeing deteriorates during imaging, it takes time to make a decision concerning a switch to spectroscopy. The values shown here, separately for imaging and spectroscopy, indicate that as the work progresses we will become more expert in minimizing such losses.

The column labeled endgame anticipates that late in the survey, there will be times when none of the unmapped survey region is available, and we cover no new area. Currently this is set equal to 1.0 in all quarters to reflect our intention to optimize the strategy for data collection.

These factors allow the hours spent in imaging and in spectroscopy to be computed. The camera covers 20.5 square degrees per hour, so the number of square degrees observed is just this multiplied by the number of hours. Similarly, the net spectroscopic time refers to the actual time integrating on the sky; to get the number of plates, one simply divides hours by 0.75 hours per plate.

Adopting these choices for the efficiencies and other entries, Table A1 shows that 8400 square degrees will be scanned. The actual footprint is about 20% smaller because of the overlap between scans. (The full survey region of pi steradians requires 12,900 square degrees to be scanned, including overlapped area.) Jon Loveday’s simulations of the adaptive tiling suggest that 2100 plates are needed; the number 1540 plates is 73% of this, and the fraction between imaging and spectroscopy is pretty well balanced.

As we gain more experience in survey operations and can refine the elements of this projection, we will revise the plan accordingly. For the moment, the expected progress shown here serves as a point of departure for planning, and for consideration of the impact on the core scientific goals should the five-year run time be insufficient to cover the full survey area. Such a situation is characteristic of ground-based optical astronomy: the uncertainty caused by an incorrect projection of weather trends can be as significant as any failure to predict operational efficiencies.

Table A1. SDSS 5-Year Model Projection - Northern Survey

2000	Q1	dark hrs.	im. Frac.	sp. frac.	weath	uptime	im. eff.	sp. eff.	im. ops.	sp. ops.	end	im. hr.	sp. hr.	sq. deg.	no. plts
	Q2	277	0.3	0	0.6	0.7	0.86	0.65	0.25		1	7.5	0	153.7	0
	Q3	40	0.3	0	0.5	0.8	0.86	0.65	0.5		1	2.1	0	42.3	0
	Q4	196	0.3	0	0.6	0.9	0.86	0.65	0.75		1	20.5	0	419.4	0
2001	Q1	464	0.3	0.7	0.6	0.9	0.86	0.65	0.9	0.75	1	58.2	85.5	1191.5	114
	Q2	277	0.3	0.7	0.6	0.9	0.86	0.65	0.9	0.9	1	34.7	61.3	711.3	82
	Q3	40	0.3	0.7	0.5	0.9	0.86	0.65	0.9	0.9	1	4.2	7.4	85.6	10
	Q4	196	0.3	0.7	0.6	0.9	0.86	0.65	0.9	0.9	1	24.6	43.3	503.3	58
2002	Q1	464	0.3	0.7	0.6	0.9	0.86	0.65	0.9	0.9	1	58.2	102.6	1191.5	137
	Q2	277	0.3	0.7	0.6	0.9	0.86	0.65	0.9	0.9	1	34.7	61.3	711.3	82
	Q3	40	0.3	0.7	0.5	0.9	0.86	0.65	0.9	0.9	1	4.2	7.4	85.6	10
	Q4	196	0.2	0.8	0.6	0.9	0.86	0.65	0.9	0.9	1	16.4	49.5	335.5	66
2003	Q1	464	0.2	0.8	0.6	0.9	0.86	0.65	0.9	0.9	1	38.8	117.3	794.4	156
	Q2	277	0.2	0.8	0.6	0.9	0.86	0.65	0.9	0.9	1	23.2	70.0	474.2	93
	Q3	40	0.2	0.8	0.5	0.9	0.86	0.65	0.9	0.9	1	2.8	8.4	57.1	11
	Q4	196	0.2	0.8	0.6	0.9	0.86	0.65	0.9	0.9	1	16.4	49.5	335.5	66
2004	Q1	464	0.2	0.8	0.6	0.9	0.86	0.65	0.9	0.9	1	38.8	117.3	794.4	156
	Q2	277	0.2	0.8	0.6	0.9	0.86	0.65	0.9	0.9	1	23.2	70.0	474.2	93
	Q3	40	0.2	0.8	0.5	0.9	0.86	0.65	0.9	0.9	1	2.8	8.4	57.1	11
	Q4	196	0	1	0.6	0.9	0.86	0.65	0.9	0.9	1	0.0	61.9	0.0	83
2005	Q1	464	0	1	0.6	0.9	0.86	0.65	0.9	0.9	1	0.0	146.6	0.0	195
	Q2	277	0	1	0.6	0.9	0.86	0.65	0.9	0.9	1	0.0	87.5	0.0	117
Totals		5162										411.0	1155	8417.9	1540

Southern Survey

A very similar exercise can be undertaken to model the progress of the survey in the Autumn (September, October, and part of November) - see Table A2. In practice we observe the North whenever possible, with the remainder of the time allocated to the South. Adjustments specific to the Southern Survey are as follows (much of this logic is taken from the Project Book, section on Survey Strategy).

A 40/60 split between imaging and spectroscopy is assumed for the time allocation, which is the appropriate balance for a deeper survey in a smaller area.

The weather is assumed to be a bit better (0.7 as opposed to 0.6) because we may be able to tolerate conditions that are less than ideal - the notion is that variability studies can be based on relative fluxes alone, which do not require the best seeing and long-term stability of atmospheric transmission, and moreover target selection for spectroscopy can be based on only the best scans.

The spectroscopic exposure times are assumed to be 45 minutes, as before. In fact we may want to increase the exposure times to reach somewhat fainter fluxes. In that case, the total number of plates goes down, but there is some compensation in that the spectroscopic efficiency will go up.

The result of this exercise is that once the two outlying stripes are accounted for, the equatorial stripe gets imaged 39 times.

Table A2. SDSS 5-Year Model Projection - Southern Survey

2000	Q1	dark hrs.	im. frac.	sp. frac.	weath	uptime	im. eff.	sp. eff.	Im. ops.	sp. ops.	end	Im. hr.	sp. hr.	sq. deg.	no. plts
	Q2											0.0	0	0.0	0
	Q3	195	0.4	0.6	0.7	0.9	0.86	0.65	0.5	0.25	1	21.1	12.0	432.7	16
	Q4	277	0.4	0.6	0.7	0.9	0.86	0.65	0.75	0.5	1	45.0	34.0	922.1	45
2001	Q1											0.0	0.0	0.0	0
	Q2											0.0	0.0	0.0	0
	Q3	195	0.4	0.6	0.7	0.9	0.86	0.65	0.9	0.9	1	38.0	43.1	778.9	57
	Q4	277	0.4	0.6	0.7	0.9	0.86	0.65	0.9	0.9	1	54.0	61.3	1106.5	82
2002	Q1											0.0	0.0	0.0	0
	Q2											0.0	0.0	0.0	0
	Q3	195	0.4	0.6	0.7	0.9	0.86	0.65	0.9	0.9	1	38.0	43.1	778.9	57
	Q4	277	0.4	0.6	0.7	0.9	0.86	0.65	0.9	0.9	1	54.0	61.3	1106.5	82
2003	Q1											0.0	0.0	0.0	0
	Q2											0.0	0.0	0.0	0
	Q3	195	0.4	0.6	0.7	0.9	0.86	0.65	0.9	0.9	1	38.0	43.1	778.9	57
	Q4	277	0.4	0.6	0.7	0.9	0.86	0.65	0.9	0.9	1	54.0	61.3	1106.5	82
2004	Q1											0.0	0.0	0.0	0
	Q2											0.0	0.0	0.0	0
	Q3	195	0.4	0.6	0.7	0.9	0.86	0.65	0.9	0.9	1	38.0	43.1	778.9	57
	Q4	277	0.4	0.6	0.7	0.9	0.86	0.65	0.9	0.9	1	54.0	61.3	1106.5	82
2005	Q1											0.0	0.0	0.0	0
	Q2											0.0	0.0	0.0	0
Totals		2360										434.4	463.5	8896.6	618