Sloan Digital Sky Survey
Quarterly Progress Report
Fourth Quarter 2002

March 28, 2003

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1. OBSERVATION STATISTICS

1.1 Summary

In Q4, observing focused on the Northern Galactic Cap and the Southern Equatorial Stripe. We obtained 1,097 square degrees of new "unique" imaging data, or 93% of the baseline goal of 1,175 square degrees. We also completed 19 plates on the Northern Galactic Cap and 42 plates on the Southern Stripes, or 45% of our baseline goal of 136 plates. Several of the observed plates were specially designed plates approved as part of the Survey of the Southern Equatorial Stripe.

Overall, the cumulative area imaged remains ahead of the baseline for the Southern Survey, is tracking the baseline for the Southern Equatorial Stripe, and remains behind the baseline for the Northern Survey. In Q4, efficiency and system uptime were very good and the rate at which we acquired imaging data was near the rate anticipated when the baseline was prepared. Once again, weather continued to be the biggest impediment to overall survey progress. We lost 197 hours of potential moonless observing time to poor weather during the quarter. In December, weather was particularly poor, when conditions were suitable for observing only 34% of the time.

1.2 Q4 Imaging

Table 1.1 compares the imaging data obtained in Q4 against the baseline projection.

Table 1.1. Imaging Survey Progress in Q4-2002

	Imaging Area Obtained (in Square Degrees)			
	Q4-2002		Cumulative through Q4	
	Baseline	Actual	Baseline	Actual
Northern Survey[1]	307	312	4972	3731
Southern Survey[1]	0	0	745	738
Southern Equatorial Stripe[2]	868	785	2053	1906

1. "Unique" area
2. "Good minus Unique" area

We obtained 102% of the Q4 baseline goal for Northern Survey imaging data, 90% of the baseline goal for imaging data on the Southern Equatorial Stripe, and dedicated four hours to oblique scans that were required for calibration purposes. The area imaged for the oblique scans is not included in Table 1.1, since the area was not part of the survey footprint. Two hours of the time spent on the oblique scans occurred when neither the northern or southern areas were available and two hours were dedicated to oblique scans at the expense of standard imaging on the Southern Equatorial Stripe.

The decision to complete the oblique scans at the expense of Southern Equatorial data was appropriate, since obtaining the data required for calibrations was of higher priority. However, it is encouraging to note that if the two hours dedicated to oblique scans had instead been used for standard observing, we would have potentially gained an additional 38 square degrees of new "unique" data. This would have increased the area imaged on the Southern Equatorial Stripe to 823 square degrees, which is 95% of the baseline goal for Q4. To reiterate, allocating time to oblique scans was appropriate given the importance of acquiring this data to support calibrations, and Table 1.1 does not include the area imaged for the oblique scans. Nonetheless, we are quite encouraged by the fact that we came very close to matching the anticipated rate of collecting imaging data in Q4, despite marginal weather.

Cumulative imaging progress against the baseline for each of the survey areas is shown in the following graphs. Imaging efficiency is discussed in Section 2.5.

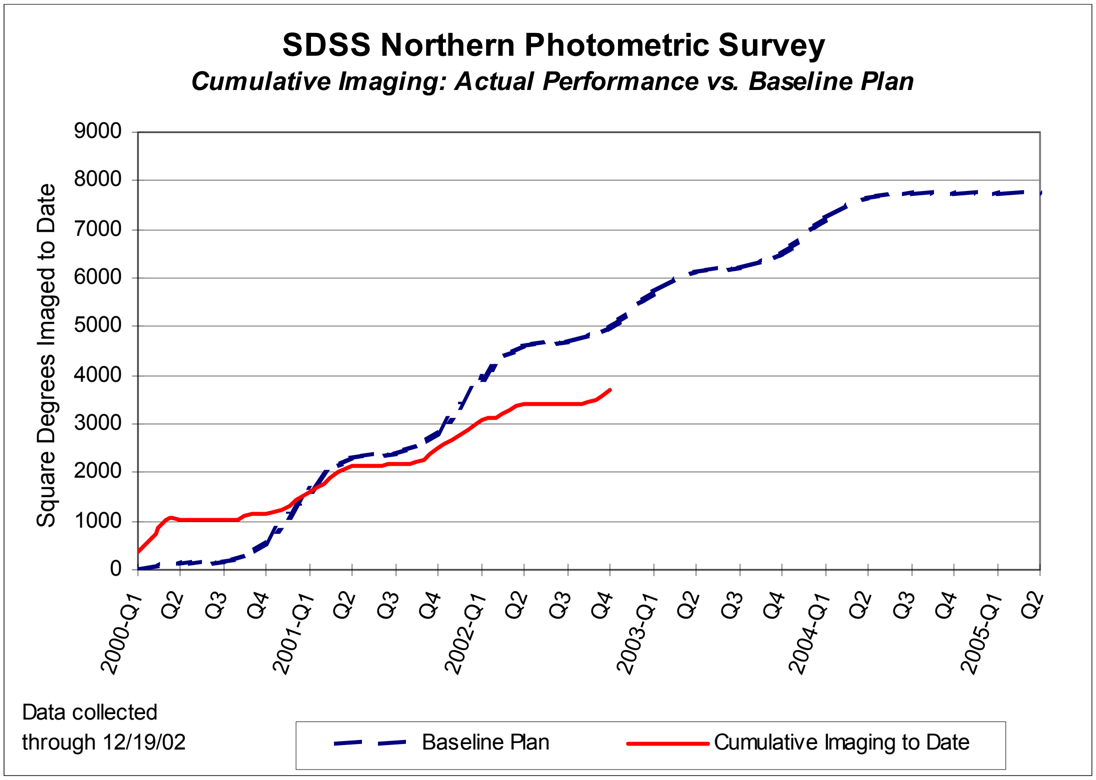
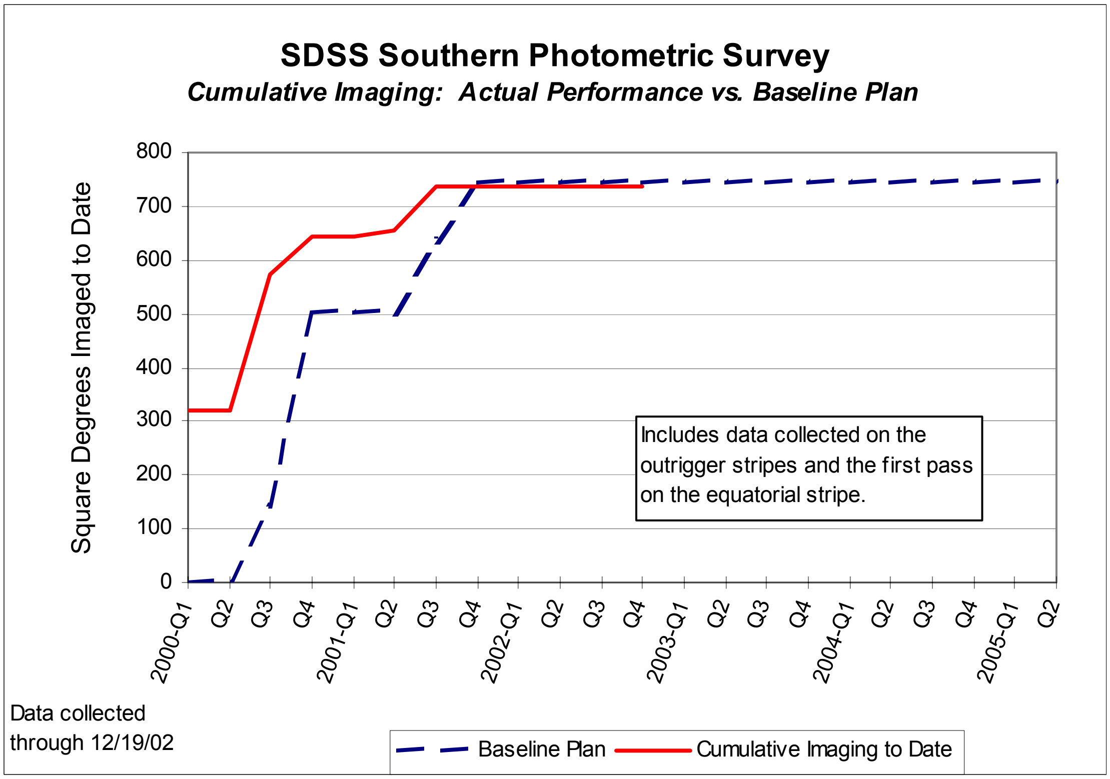


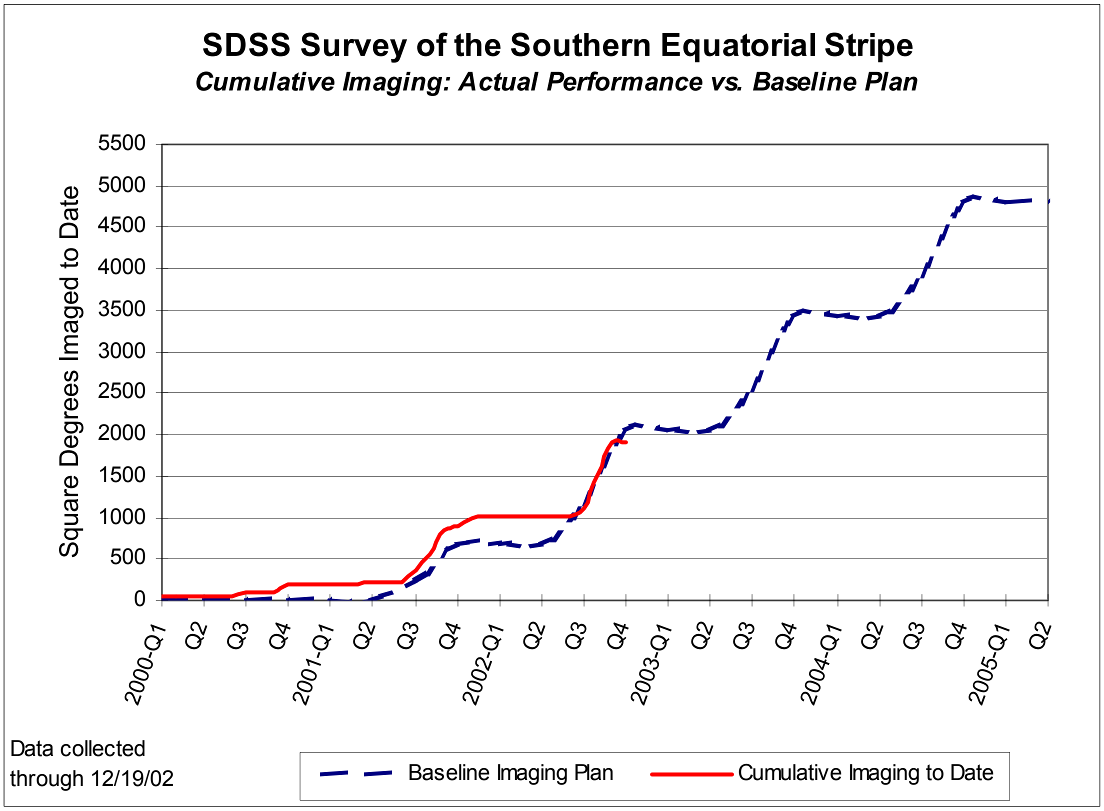
Figure 1.1. Imaging Progress against the Baseline Plan – Northern Survey



Includes data collected on the outrigger stripes and the first pass on the equatorial stripe.

Data collected through 12/19/02

Figure 1.2. Imaging Progress against the Baseline Plan – Southern Survey



Data collected through 12/19/02

Figure 1.3. Imaging Progress against the Baseline Plan – Southern Equatorial Survey

1.3 Q1 Spectroscopy

We report progress on spectroscopy in terms of the number of plates observed and declared done during a quarter. The successful observation of a plate will typically yield 640 unique spectra. In Q4, we observed a total of 61 plate-equivalents, which correspond to 45% of the baseline goal for Q4. Table 1.2 compares the spectroscopic data obtained in Q4 against the baseline projection.

Table 1.2. Spectroscopic Survey Progress in Q4-2002

	Number of Plates Observed					
	Q4-2002				Cumulative through Q4	
	Baseline	Actual Standard Science Plates Observed	Actual "Special" Plates Observed	Total # of Plate Equivalents Observed	Baseline	Actual
North	66	19	0	19	558	458
South	0	2	0	2	148	153
Southern Equatorial	70	0	32	40	165	114
Total plates	136	21	32	61	871	725

The concept of plate-equivalents is being introduced because many of the plates observed on the Southern Equatorial Stripe in Q4 were specially designed plates that required longer exposure times than standard survey science plates. Since the baseline was based on an average exposure time of 45 minutes per plate, it is necessary to apply a scale factor, or plate equivalent, to the number of special plates observed to allow an accurate comparison of survey progress with the baseline goals. For example, the exposure time required to complete one type of special plate was equivalent to the time required to observe seven standard survey plates. For Q4, Table 1.2 has been modified to include the number of standard survey science plates observed, the number of special program plates observed, and the total number of standard plate equivalents that would have been observed if all plates required the same exposure time as standard survey plates.

The following charts plot cumulative spectroscopic progress against the baseline for each of the survey areas. Spectroscopic efficiency is discussed in Section 2.6.

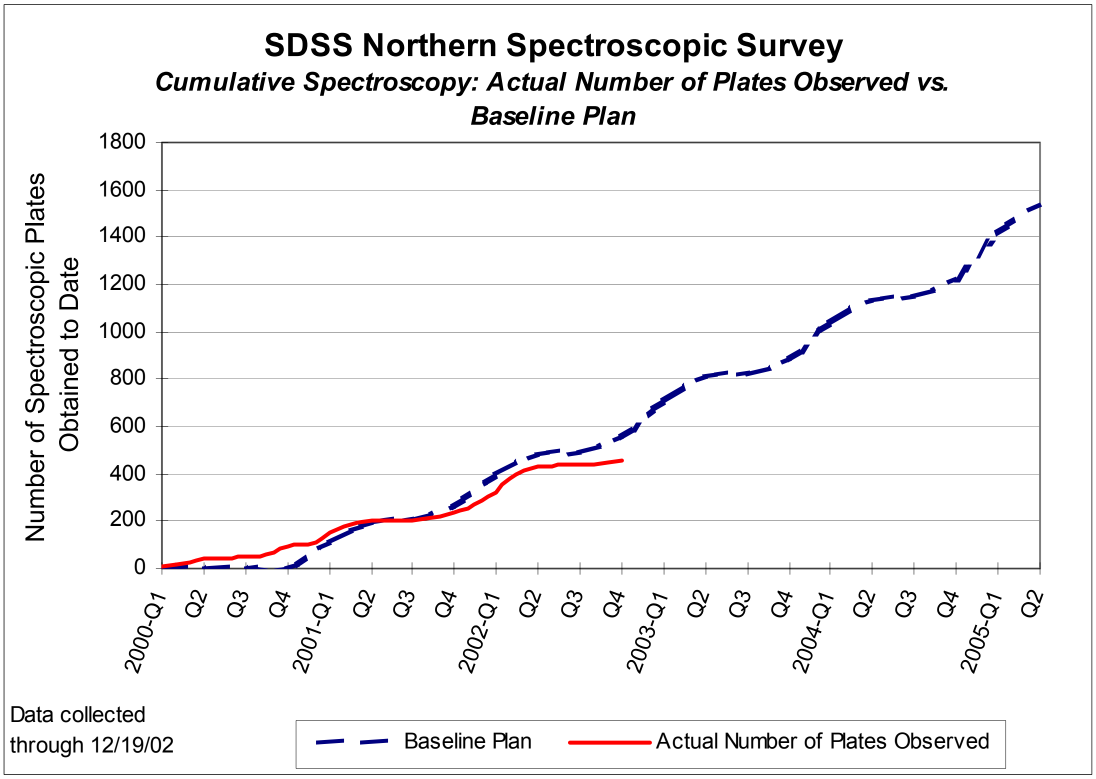


Figure 1.4. Spectroscopic Progress against the Baseline Plan – Northern Survey

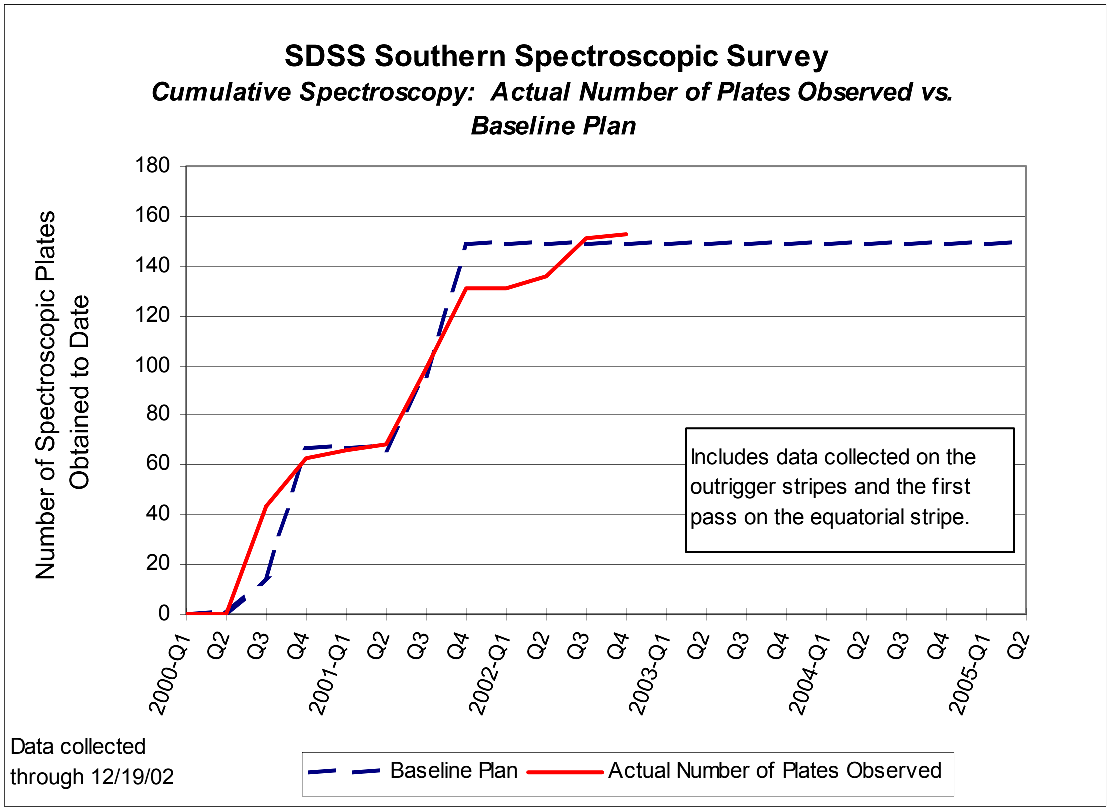


Figure 1.5. Spectroscopic Progress against the Baseline Plan – Southern Survey

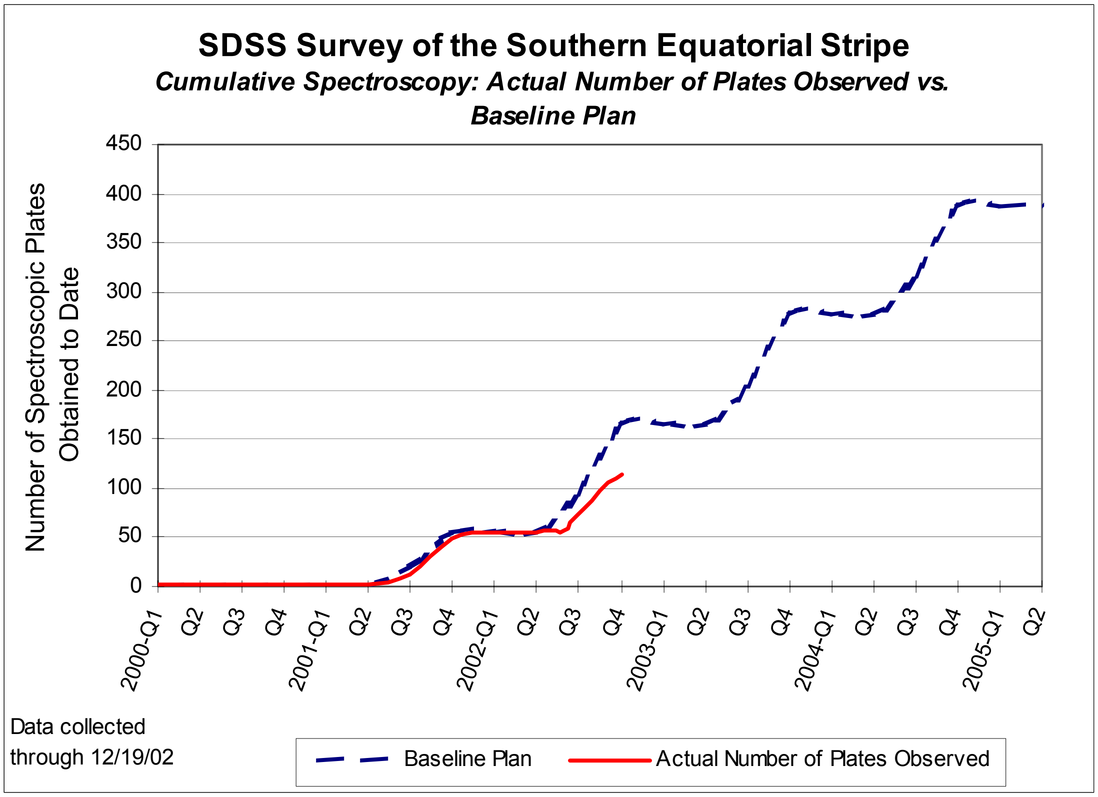


Figure 1.6. Spectroscopic Progress against the Baseline Plan – Southern Equatorial Survey

1.4 Status of Photometric Telescope Secondary Patches

A summary of the PT patches that have been observed and classified through the end of Q4 is shown in Table 1.4.

Table 1.4. Summary of Unique Secondary Patches Progress in Q4-2002

	Cumulative through Q4
Unique Patches	
“Done, verified”	1165
“Done, not verified”	0
Old patches available	30
Total Patches Done	1195
Total number required	1656
Percent observed (exclusive of old patches)	72%

Unique Patches consist of the number of patches under the current patch layout system that have been successfully observed. This criterion is analogous to the “unique” criteria for imaging data. Patches classified as “Done, verified” have been successfully observed at APO and their quality verified after data processing at Fermilab. Patches classified as “Done, not verified” have been observed and declared “good” at APO, but they still require data processing confirmation. There are currently no patches in this category. There are also 30 patches that were observed earlier, but that need to be re-observed under the current layout scheme. These patches are of sufficiently good quality, and their positions close enough to that in the current layout, that re-observing these patches has been given lower priority relative to observing new patches. These patches are classified as “Old patches available.” “Total Patches Done” is simply the sum of these three categories.

The fraction of sky over which we have obtained good patches is greater than the fraction of sky that we have successfully imaged. In fact, all areas that have been imaged with the 2.5 m telescope have had at least one set of patches successfully observed, and we have observed patches for most of the area scheduled for imaging in the immediate future. The remaining patches will be observed when available with a higher priority than other unobserved patches.

As the survey progresses, we occasionally find it necessary to obtain additional patches for scans that have been covered by only one set of patches. We have also added patches in some areas to increase the density in certain areas of the sky. These steps significantly improve the photometric accuracy of the imaging data at a small cost in PT observing time. They also cause the statistics on the number of patches reported in Table 1.4 to fluctuate from one quarter to the next.

2. OBSERVING EFFICIENCY

2.1. Overview of Observing Efficiency in Q4

Table 2.1 summarizes the breakdown of observing time in 2002-Q4 according to the categories used to prepare the baseline projection.

Table 2.1. Comparison of Efficiency Measures to the Baseline

		October		November		December	
Category	Baseline	Dark	Dark + Gray	Dark	Dark + gray	Dark	Dark + gray
Total time (hrs)	Oct: 88:26	88:26	116:34				
	Nov: 131:32			131:32	177:35		
	Dec: 142:56					142:56	197:49
Imaging fraction	0.27	0.60	0.56	0.34	0.27	0.26	0.17
Spectro fraction	0.63	0.34	0.42	0.55	0.65	0.65	0.77
Weather	0.60	0.47	0.41	0.58	0.59	0.34	0.44
Uptime	0.90	1.00	1.00	0.98	0.99	0.98	0.98
Imaging efficiency	0.86	0.90	0.90	0.90	0.90	0.85	0.85
Spectro efficiency	0.65	0.56	0.63	0.64	0.63	0.66	0.60
Operations	0.90	0.94	0.94	0.97	0.96	0.97	0.95
Hours lost to problems		0:00	0:00	2:10	2:21	2:49	4:16
Hours lost to weather		46:33	68:14	55:40	72:57	94:54	110:29

2.2 Allocation of Time between Imaging and Spectroscopic Operations

The fraction of time reported for imaging and spectroscopic operations includes actual observing time and overhead. In practice, weather dictates the allocation of science time between imaging and spectroscopy and whenever the weather is potentially suitable for imaging, we image.

The fraction of time allocated to imaging was significantly higher than the baseline in October and slightly higher in November and December. We had several nights in October and November when conditions were photometric with good seeing nearly all night.

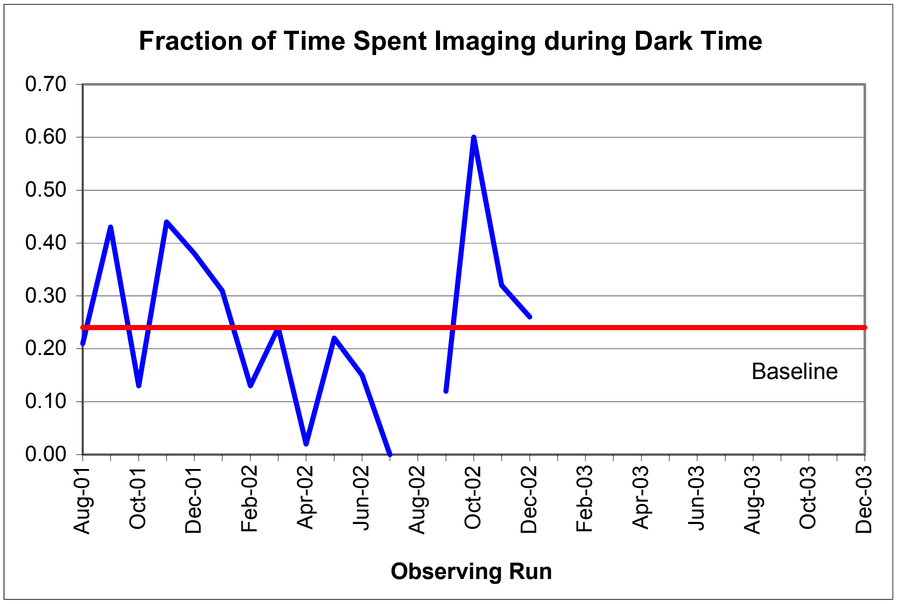


Figure 2.1. Fraction of time allocated to imaging in 2002 Q4, compared to the 5-year Baseline

2.3. Weather

The weather category represents the fraction of scheduled observing time when the weather is suitable for observing. The baseline plan assumed that when the weather was good enough to have the telescope on the sky, it was also good enough to complete a spectroscopic plate in 45 minutes of exposure time. In reality, we are able to take useful spectroscopic data when the weather is much worse, by taking longer exposures to achieve the required signal-to-noise ratio.

Figure 2.2 compares the fraction of dark time that the weather was suitable for observing at APO against the baseline weather assumption. Over the past year, we have seldom exceeded our baseline expectation for good weather, and Q4 was no different. Fortunately, we are able to offset some of the lost time by conducting spectroscopic observations during gray time. In Q4, we gained an additional 74.5 hours of science time by observing during gray time. In addition, the thermal and efficiency improvements we have made over the past year allowed us to capitalize on every imaging opportunity we had in the quarter.

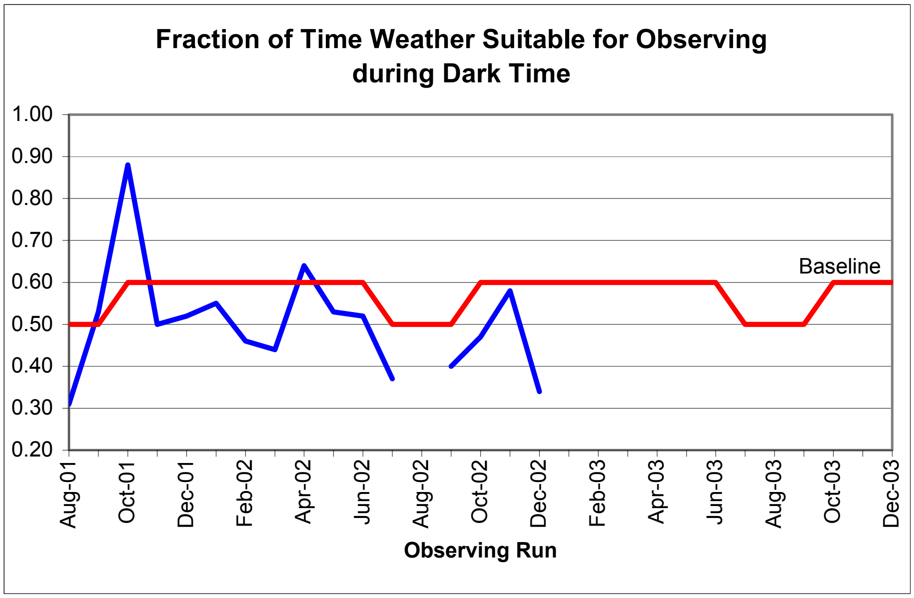


Figure 2.2. Comparison of the fraction of time that the weather was suitable for observing during dark time, compared to the 5-Year Baseline Plan.

2.4 System Uptime

System uptime measures the availability of equipment when conditions are suitable for observing. We comfortably exceeded the baseline goal throughout the quarter and in October, recorded our first observing run with 100% system availability. We note that although measured system availability is high, we do occasionally experience minor equipment problems during observing operations. Fortunately, the observers and technical staff have become very good at developing quick work-arounds that minimize the impact of minor problems and prevent the loss of observing time.

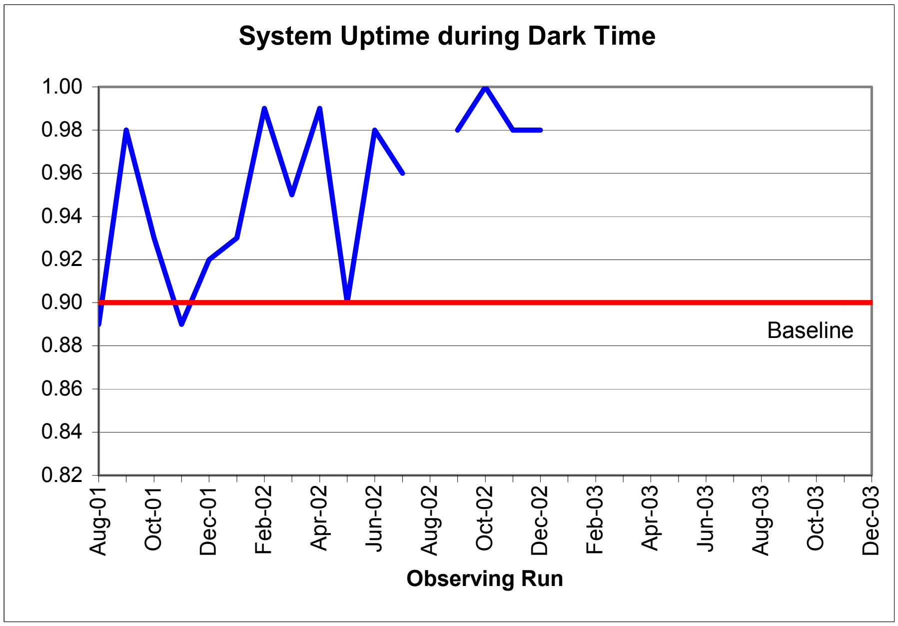


Figure 2.3. System Uptime During Observing Periods

2.5 Imaging Efficiency

Figure 2.4 shows the improvement in imaging efficiency since August 2001. Imaging efficiency exceeded the baseline goal of 86% in October and November and was 1% below the baseline in December. This is a vast improvement over the 63% imaging efficiency we reported in October 2001. Our efforts to modify observing procedures and improve confidence in telescope pointing have paid off in improved efficiency.

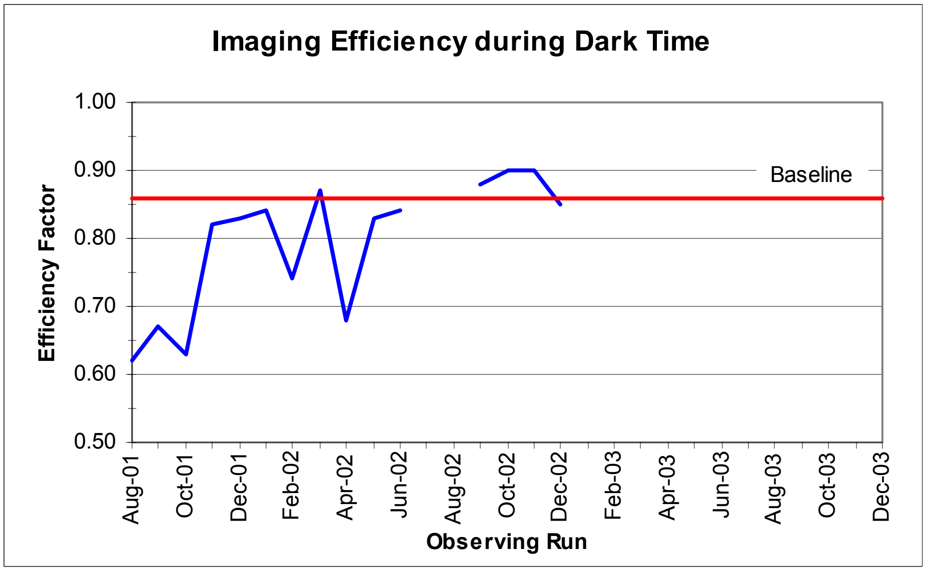


Figure 2.4. Imaging Efficiency during Observing Periods

In addition to trending efficiency, we use two simple statistics from our time tracking data to measure imaging efficiency: the imaging efficiency ratio and the imaging effectiveness ratio. The first, a measure of observing efficiency, is the ratio of science imaging time to the sum of science imaging time plus imaging setup time. The second, a measure of how effectively we use available imaging time to acquire new survey quality data, is the ratio of imaging area obtained to the science imaging time.

The baseline plan established the imaging efficiency ratio to be 0.86; in Q4, our measured efficiency ratio was 0.89. The monthly imaging efficiency ratios for Q4 are shown in Table 2.2.

Table 2.2. Imaging Efficiency Ratios for Q4-2002

	October	November	December	Aggregate
Imaging Efficiency Ratio	0.90	0.90	0.85	0.89
Baseline	0.86	0.86	0.86	0.86
Efficiency relative to baseline	105%	104%	99%	103%

In addition to an overall improvement in the efficiency ratio, we achieved an improvement in the imaging effectiveness ratio. In Q4, our measured effectiveness ratio was 19.0 square degrees/hour, which exceeded the baseline goal of 18.6 square degrees/hour by 2%. In reality, we should not be able to exceed 18.6 square degrees/hour, since the maximum yield rate is determined by the physical properties of the imaging camera and data acquisition system. The reason we recorded a slightly higher yield in Q4 is due to the manner in which imaging time is declared "science time" by the observers and the manner in which imaging data is declared "acceptable" by the data processing factory. When imaging data is collected, the amount of time recorded in the time-tracker as "imaging science time" is based on the observers' assessment of observing conditions (e.g., photometricity and seeing). When the data is reduced, it is possible that more data actually meet acceptability criteria than the observers anticipated, which is precisely what happened last quarter. By pushing the limits of observing conditions, the observers obtained additional survey quality imaging data.

The final measure of imaging efficiency is the product of the efficiency and effectiveness ratios. This ratio was 106% for Q4, which is a significant improvement over the 76% effectiveness ratio we achieved in the same period one year ago. Again, the ratio exceeded 100% in Q4 for the reason described in the preceding paragraph.

2.6 Spectroscopic Efficiency

Spectroscopic observations occur during both dark and gray time. As measured by the time tracker, spectroscopic efficiency during Q4 ranged from 62% to 64%; the baseline is 65%. However, direct measurement of spectroscopic efficiency from the time tracking data is strongly affected by poor weather. We therefore derive a more accurate measure of efficiency by assessing the time spent performing various activities associated with spectroscopic operations. Table 2.3 provides the median time, by month, for various overhead activities associated with spectroscopic operations. Units for all categories are minutes except for efficiency, which is given as the ratio of baseline science exposure time (45 minutes) to total time required per plate.

Table 2.3. Median Time for Spectroscopic Observing Activities

Category	Baseline	October	November	December
Instrument change	10	5	5	5
Setup	10	14	15	11
Calibration	5	14	13	13
CCD readout	0	3	3	3
Total overhead	25	36	36	32
Science exposure (assumed)	45	45	45	45
Total time per plate	70	81	81	77
Efficiency	0.64	0.56	0.56	0.58

Using these measures, the average spectroscopic efficiency for Q4 was 57%. As shown in Figure 2.5, spectroscopic efficiency over the past twelve months has averaged 58%.

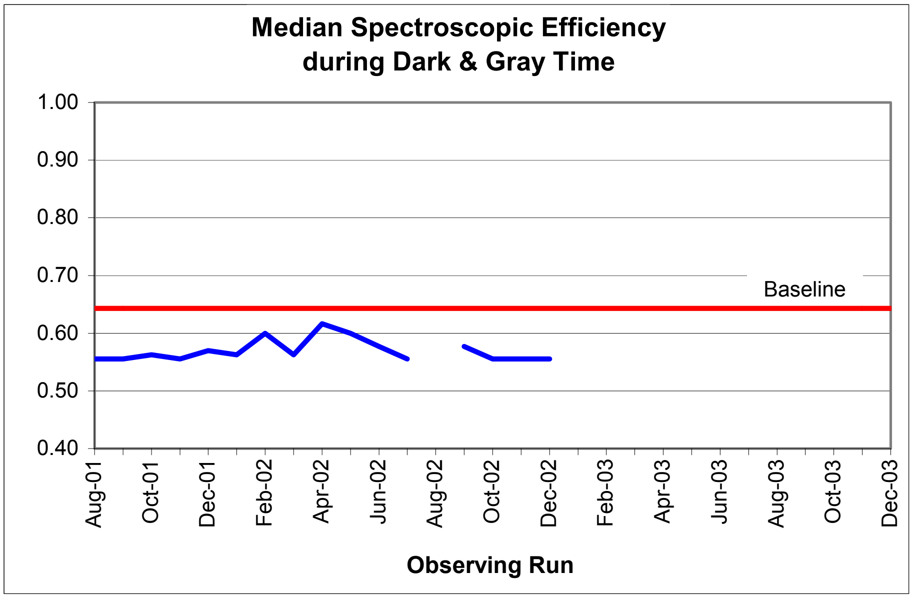


Figure 2.4. Spectroscopic Efficiency during Observing Periods

Instrument change time remained at 5 minutes per cartridge, which is well below the baseline. Setup time, which includes field acquisition and focus, was significantly above the baseline in October and November, and close to the baseline in December. Given weather conditions, it is likely that the observers took a little more time during these months than they otherwise would under good observing conditions. While there is nothing wrong with their approach, it does have an adverse effect when we look at efficiency numbers. We do anticipate improving efficiency by improving telescope guiding and by implementing the Hartmann focusing scheme that we've discussed in past reports. With regard to the new focusing scheme, all of the hardware and code modifications are done and the system is undergoing testing and fine-tuning. We expect the new system to be fully implemented in Q1. Improved guiding is still something we need to work on.

Average calibration time was 13 minutes in Q4, which exceeds the baseline goal of 5 minutes. Calibrations currently include flat fields and arcs, and smears for spectrophotometric calibration. Nominal time to complete flat fields and arcs is 5 minutes and is the basis for the baseline. Since spectrophotometric calibration was a feature that was added to the standard repertoire of operations after the baseline was created, we will not be able to achieve the baseline goal. Our current level of performance is as good as we can do.

Finally, the CCD readout time of 3 minutes reported in Table 2.3 is the nominal readout time required for a 3-exposure sequence on a plate; it is not the median readout time actually measured in each reporting period. The CCD readout time is fixed at 1 minute per exposure, regardless of exposure length. When we observe in good weather conditions, three exposures are required and so total CCD readout time is 3 minutes. When we observe in less than optimal conditions, additional exposures are often required and each additional exposure increases total CCD readout time. Since any increase in CCD readout time above 3 minutes is the result of poor weather, not operating efficiency, we fix the readout time in our analysis to 3 minutes to exclude weather effects.

2.7 Summary of Efficiency Observations

In summary, weather was once again worse than predicted throughout the quarter. Equipment availability met or exceeded baseline goals. Earlier improvements in imaging efficiency continue to pay dividends, as imaging efficiency in Q4 was consistently higher than in the past. Spectroscopic efficiency remains below the baseline.

3. OBSERVING SYSTEMS

In Q4, we had no serious instrument problems and very few significant hardware or software problems. We completed a number of planned engineering tasks and held an engineering planning meeting to develop the work plan for 2003.

3.1. The Instruments

There were no problems with the imaging camera in Q4 and very few problems with the spectrographs and fiber cartridges. During the November run, the observers noted guider focus problems and raised questions about the cleanliness and alignment of guide fibers in the spectroscopic fiber cartridges. A follow up inspection by the engineering staff confirmed variations in guide fiber alignment that exceeded acceptable limits. They corrected the problem by inspecting each cartridge and shimming guide fibers until all guide fibers were located to within 0.001" of their desired position. In December, the observers found it necessary to re-collimate the spectrographs in the middle of an observing night, which resulted in the loss of nearly 2.5 hours of spectroscopic observing time. Cloudy conditions at the time meant that we could not have observed more than two plates during this time, nonetheless the collimation problem likely cost us a couple of plates.

3.2. The 2.5m Telescope

Although there were no significant problems with the 2.5m Telescope or associated hardware systems in Q4, there were a number of nuisance problems that caused minor disruptions. One such problem was associated with the flat field screen petals. On several occasions, the flat-field screen petals failed to seat properly against the microswitches that sense the petals are in their "closed" position, which caused the interlock system to abort telescope motion. The system is designed to prohibit motion inside the enclosure and below certain elevations when the petals are open, in order to protect the petals from damage. Re-adjusting the switches provided a temporary fix, but a more permanent solution may be required if the problem persists. Since the petals are open during observing, this problem does not affect observing operations; however, it does cause operator frustration and it increases the time required to open and close the telescope. A second nuisance problem involved difficulty engaging the pin to position the imager cart over the instrument lift during instrument change operations; the problem was fixed by readjusting the alignment of the cart shock absorber.

3.3. The Photometric Telescope

The major source of trouble with the Photometric Telescope (PT) involved PT filterwheel runaways, in which the filterwheel controller fails to properly increment to the next filter in the calibration sequence. In earlier progress reports, we discussed plans for procuring a commercially available controller board and redesigning the system. However, the runaway problem was nearly non-existent in Q3 and so in the spirit of minimizing system changes, we decided at the Fall 2002 engineering meeting to table the filterwheel redesign project. This turned out to be a mistake, because the filterwheel runaway problem returned with a vengeance in Q4. Efforts to redesign the system were quickly reinstated and commercial parts ordered, with final assembly, installation and testing of the new system scheduled for 2003-Q1.

3.4. Operations Software and the Data Acquisition System

All observing software is under formal version control and changes are reviewed, approved, and planned during the bi-weekly observing software meetings.

There were no problems with the data acquisition system that prevented us from acquiring data, but there were several minor problems that required system reboots. One problem involved difficulty executing the "getAllFrames" command to save engineering data from the end of an imaging run. A second involved trouble executing goDrift commands during afternoon engineering tests.

Other minor problems involved unexplained error messages during commands to move the telescope to instrument change and after completing Apache Wheel scans, and a bug in the time-tracking software that was triggered by instrument change software commands. Problem reports (PRs) were filed in each instance and addressed appropriately.

Regarding the Apache Wheel scans, recall that this is a new observing procedure currently under consideration that has the potential to improve photometric calibrations by tying local calibrations together in a survey-wide, highly accurate calibration. The process involves taking cross scans across the imaging camera's CCD array in such a way that will provide a comparison of every CCD with every other CCD. The technique takes its name from the manner in which the cross scans will be made. The "rim" of the wheel is the celestial equator and will be scanned in short 45-degree long segments. The "spokes" are scans in declination at fixed right ascensions (RAs). There will be 24 spokes defined every 15 degrees in RA. The observing procedure has been tested and is reasonably well understood but the data analysis process is still under evaluation; because of the binned scan mode of acquiring the data, software must be developed to effectively reduce the Apache Wheel data. If adopted, the current strategy would be to complete approximately 2 spokes per month over the course of the survey. Each spoke would take approximately 80 minutes to observe, and when instrument change, setup, and calibration time is factored in, the monthly time devoted to Apache Wheel scans could approach 4 hours. Since Apache Wheel scans require photometric conditions but only marginal seeing, these scans would not pre-empt imaging but they would pre-empt spectroscopy. Therefore, if incorporated into the monthly observing plan, Apache Wheel scans have the potential to pre-empt the observing of up to four spectroscopic plates per observing run. Since this is a significant impact in terms of the number of plates foregone over the course of the survey, we are evaluating the potential benefits of the Apache Wheel program against this cost very carefully.

3.5. Thermal Issues

In Q4, one of the SDSS observers, Jurek Krzesinski, completed an analysis of 2.5m telescope seeing as a function of wind direction. We expected two effects to show up here: 1) seeing is intrinsically bad when the wind comes from the East; and 2) 2.5m telescope seeing is additionally worse with East winds due to the wind blowing the warm air exhausted from the lower level back towards the telescope. To separate the two effects, Jurek also looked at the seeing at the 3.5m telescope as a function of wind direction. His results based on wind direction are shown in Figures 3.1 and 3.2, which show seeing as a function of wind direction for the 2.5m and 3.5m telescopes respectively. The full set of plots can be seen at: http://hello.apo.nmsu.edu/~jurek/seeing.html

It may be helpful to begin by explaining what is shown in each figure. The top half of each figure is a histogram showing the number of recorded seeing measurements used in the analysis, as a function of wind direction. Wind direction is plotted on the x-axis (each tick mark indicates 10 degrees in azimuth) and the number of seeing measurements, binned in 10-degree intervals in azimuth, is plotted on the y-axis. In Figure 3.1, the histogram labeled “imager” shows the number of data points, by azimuth position, recorded during imaging operations. Likewise, the histogram labeled “guider” shows the number of data points recorded during spectroscopic operations. The bottom half of the figure plots the seeing, as measured by the 2.5m telescope, as a function of wind direction. Wind direction is plotted on the x-axis and seeing, in arcsec, is plotted on the y-axis. The data sets labeled imager and guider refer to data collected during imaging and spectroscopic operations, respectively.

Now, consider the data presented in Figures 3.1 and 3.2, beginning first with the data from the 3.5m telescope. Using data collected over a two-year period (2000-2002), the histogram for the 3.5m telescope (see the top half of Figure 3.2) shows a relatively small number of seeing measurements recorded when the wind direction is ± 60 degrees of due east. The bottom half of Figure 3.2 shows that measured seeing was within 1.2” to 1.5” throughout the entire azimuth range, with slightly more scatter in the data when the wind is from an easterly direction. When the upper and lower halves of Figure 3.2 are taken together, the implication is that the 3.5m telescope experiences fewer instances of good seeing (i.e., 1.2 – 1.5”) when the wind is ± 60 degrees of due east than when the wind is ± 120 degrees of due west. This suggests that the seeing is typically worse when the wind is from the east.

A similar trend is seen in the data taken from the 2.5m telescope. The histogram for the 2.5m telescope (see the top half of Figure 3.1) shows a relatively small number of seeing measurements recorded during imaging operations when the wind direction is ± 60 degrees of due east. In the bottom half of Figure 3.1, the data show more of a pronounced ~0.25" increase in 2.5m seeing with the wind directions within 90 degrees of East, compared to wind directions within 90 degrees of West, and an additional ~0.6" increase in seeing around wind directions from ~60-80 degrees (as indicated in the bottom chart in Figure 3.1). The latter is roughly the direction in which the heat from the lower level of the 2.5m telescope enclosure is exhausted. Thus, the data taken from 2.5m telescope operations suggest two things. First, there are fewer instances of good seeing when the wind is from the east than when the wind is from the west, which agrees with the data from the 3.5m telescope. Second, there is a noticeable increase in the measured seeing when the wind is blowing over the lower level exhaust port. Since the wind can potentially come from this direction 5% of the time, the lower level heat exhaust has the potential to affect 2.5m telescope seeing approximately 5% of the time.

Based on this preliminary analysis, we plan to investigate the options, cost and benefit to relocate the outlet of the exhaust vent further away from the 2.5m telescope. Since the outlet is currently located in the center of the 2.5m telescope concrete pier, re-routing will likely involve core-drilling through a section of the pier. Additional factors to be considered include the optimal direction and distance away from the telescope to obtain the greatest benefit given project cost. Based on the results of this cost-benefit analysis, we will be able to determine whether rerouting the exhaust vent is economically prudent. We anticipate completing this analysis in 2003-Q2.

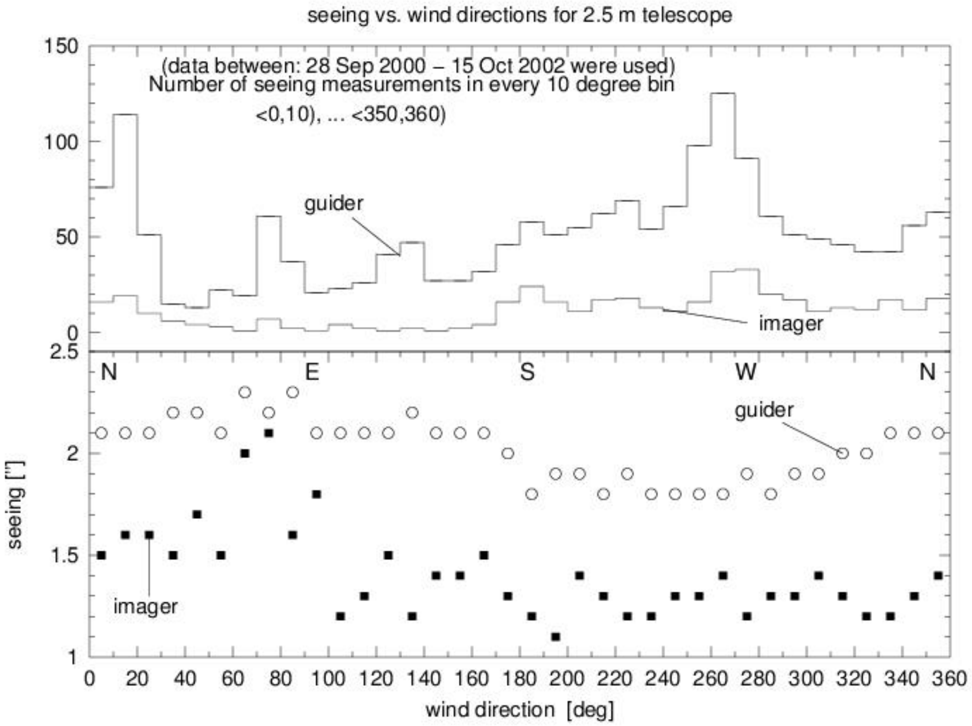


Figure 3.1 . Seeing vs. Wind Direction for the 2.5m Telescope

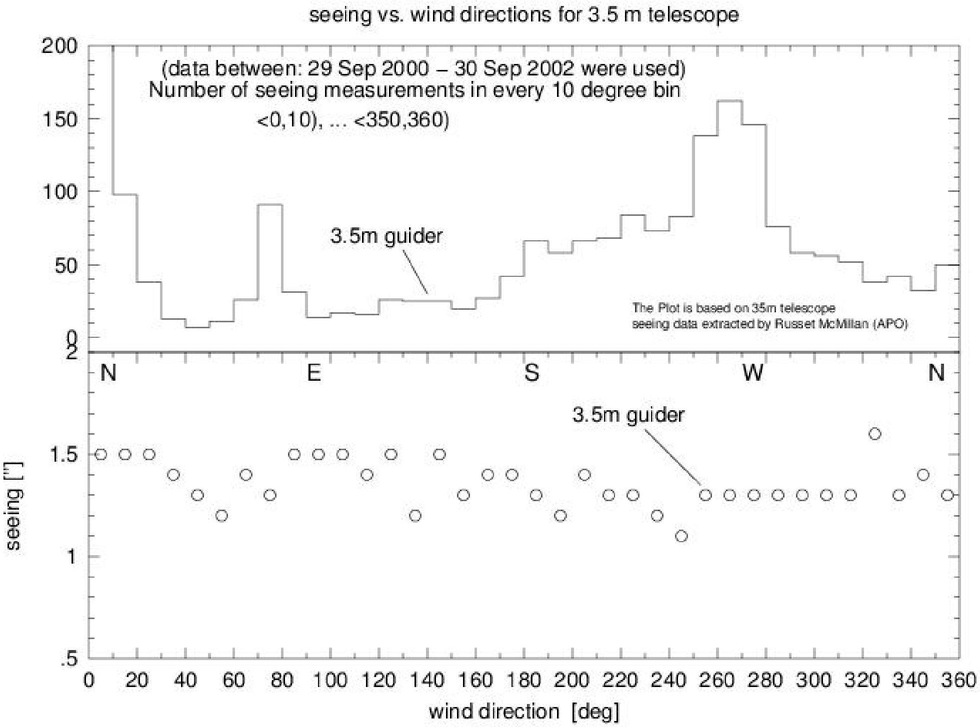


Figure 3.2 . Seeing vs. Wind Direction for the 3.5m Telescope

3.6. Status of Engineering Tasks Scheduled for Q4

Table 3.1 reports the status of the more significant engineering tasks that were scheduled for completion in Q4-2002. Asterisks mark carry-over tasks from Q3.

Table 3.1. Status of Engineering Tasks Scheduled for Q4-2002

Task	Responsible	Driver	Priority	Status
Fabricate and install enclosure stair upgrade*	Carey	Safety	High	100%
Upgrade telescope bump switches	Brinkmann	Reliability	High	100%
Test and debug instrument change interlocks*	Anderson	Equip prot.	High	90%
Finish PM program for telescope systems*	Leger	Reliability	High	85%
Finish counterweight upgrade conceptual design	Leger	Reliability	Medium	100%
Finish implementation of slip detection system*	Czarapata	Equip prot.	Medium	100%
Finish installation of new Cloud Camera	Gunn	Reliability	Medium	90%
Install and commission new DIMM	Gunn	Efficiency	Medium	80%
Refurbish PT Cryotiger compressor	Brinkmann	Reliability	Medium	50%
Design / fabricate plug plate drilling fixture	Carey	Efficiency	Medium	0%
CMM control system upgrade	Owen	Efficiency	Low	100%

It is worth noting that several important and long-standing tasks were completed in Q4 with satisfying results. First, the engineering team finished installing the new enclosure stairs and the response from site personnel has been very positive. The new stairs provide a significantly safer means of moving between the upper and lower levels of the enclosure. Second, the telescope drive slip detection system was completed and placed into regular service. Although it took quite a while to finish commissioning and get all of the bugs worked out, the slip detection system has been working without problem since placed into full-time service. Third, we replaced the telescope bump switches with a much simpler and more robust design. The bump switches detect and record when the telescope and windbaffle bump into one another, but the old switches were highly unreliable and of no use in troubleshooting telescope motion aborts caused by telescope-windbaffle contact. The new switches are significantly more reliable and are already proving to be a helpful diagnostic in troubleshooting telescope aborts.

Regarding the tasks in Table 3.1 that were not completed as planned, their current status is as follows:

- The interlock instrument change PLC code still requires a few minor changes that were determined through preliminary system testing. However, conflicting priorities at Fermilab have limited the amount of time that the developer is able to work on revising the PLC code. We anticipate that code changes will be made and we will install and test new code in the first quarter of 2003, with the system fully implemented in the second quarter.
- Although the preventive maintenance program for the telescopes remains under development, it is nearing the point that it is a living document, in the sense that new maintenance tasks are added as the need is identified. Nonetheless, the task status remains at less than 100% because we have yet to complete a comprehensive review to identify all areas requiring preventive maintenance. We will strive to complete this during 2003 on a best effort basis.
- Significant progress was made on the commissioning of the new cloud camera. All hardware is in place and enough software has been developed to make the cloud camera

useful as an observing tool. In fact, the cloud camera is regularly used to determine the presence of cloud cover at APO. Remaining work includes finishing system document, determining whether a correlation exists between the values reported by the cloud camera and PT calculated extinctions, and determining whether a short circular-buffer running movie would be useful and practical to code.

- Significant progress was made on the installation of the DIMM telescope onto the 2.5m telescope pier. By the end of Q4, the dome structure was in place and control electronics were being installed and tested. We anticipate that final code development and commissioning will occur in the first quarter of 2003.
- A Cryotiger® closed-cycle refrigerator is used on the PT to cool the CCD. A similar unit used on the 3.5m telescope but with more hours than ours, was showing signs of wear. With roughly 34,000 hours of operation on our unit, we decided to have it refurbished before it fails. In Q4, we installed our spare unit and sent the original back for refurbishment. Turn-around time was longer than expected and so we keep this task open until the unit is returned, tested, and placed into the spares pool.
- We made essentially no progress on the design of the new plug plate fixture. This had no operational impact since we have a working, albeit less efficient fixture currently in use. The new fixture will meet two needs: it will increase the efficiency of the plug plate production operation and will provide a spare drilling fixture that we will use to certify a back-up vendor. We anticipate finishing the new fixture in Q2.

3.7. Engineering Tasks Scheduled for Q1-2003

Table 3.2 lists the more significant engineering tasks scheduled for completion in the first quarter of 2003. Tasks marked with asterisks are carry-over tasks from Q4-2002.

Table 3.2. Engineering Tasks Scheduled for Q1-2002

Task	Responsible	Driver	Priority
Install temporary Holloman AFB light baffles	Leger	Data Quality	High
Complete sky data analysis on Holloman light	Rockosi	Data Quality	High
Upgrade plugging station interlock system	Leger	Safety	High
Finish testing instrument change interlocks*	Anderson	Equip prot.	High
Finish instrument change system display code	Lupton	Equip Prot.	High
Refurbish existing imager umbilical assembly	Loomis	Reliability	High
Finish design of counterweight system upgrade	Leger	Reliability	High
Install new imager electronics enclosure and re-cable calibration system	Gunn	Equip prot. / Efficiency	Medium
Develop imager electronics and firmware QA	Rockosi	Data Quality	Medium
Complete imaging camera system baseline tests	Rockosi	Data Quality	Medium
Finish installation of new Cloud Camera*	Gunn	Reliability	Medium
Finish installation of DIMM telescope*	Gunn	Efficiency	Medium
Fabricate secondary mirror actuator spares	Carey	Reliability	Medium
Design plug plate drilling fixture*	Carey	Efficiency	Medium
Complete telescope optics and hardware lifting fixture assessment	Boroski	Equip prot.	Medium
Upgrade CMM sware for plate drilling operation	Owen	Efficiency	Low
Fabricate/calibrate thermometer spares	Gunn	Reliability	Low
Fabricate spare thermometer A/D boards	Brinkmann	Reliability	Low
Develop PMSS bench test system	Brinkmann	Efficiency	Low

An engineering planning meeting was held in October 2002 to review performance against the plan developed in May, develop the revised plan for the remainder of the year, and develop the engineering work plan for 2003. The number of major tasks is diminishing rapidly and effort is shifting to preventive maintenance and system improvement to maintain data quality, improve reliability, and ensure uptime. Major outstanding projects include finishing the DIMM installation, finishing the software for the cloud camera upgrade, upgrading the 2.5m telescope counterweight system, and replacing the PT filterwheel controller. This is a substantially reduced list from that generated at the December 2001 planning meeting.

3.8 APO Staffing and Facility Improvements

In Q4, Howard Brewington joined the staff at APO as our eighth observer. Maintaining and developing the scientific expertise of the observing staff is a critical component of the SDSS closeout plan. To that end, Howard's arrival now makes available approximately 5 hours per week per observer, which the observers can use to collaborate on science projects using SDSS data with scientists and mentors at SDSS participating institutions.

A bid package was prepared to have a contractor conduct a fire fuel-reduction project (i.e., removal of some trees and ground slash) in the down-slope, up-wind direction near the observatory. It is expected this work will begin in February 2003 and be substantially completed before the spring fire season begins.

4. DATA PROCESSING AND DISTRIBUTION

Data processing operations ran smoothly throughout Q4, with all newly acquired data promptly processed and loaded into the operations database for access by the collaboration. The processing of newly acquired data was carried out with the authorized production versions of the photometric and spectroscopic pipelines and the processed data was made available to the collaboration.

At the beginning of Q4, we discovered a problem in the calculation of the model magnitudes in Photo v5_3, which had been used to reprocess all of the imaging data taken prior to July 1, 2001. The photometric pipeline developers put forth a significant effort in Q4 to fix the problem and a new version of the imaging pipeline, Photo v5_4, was delivered to the DP factory for testing. In addition, a new version of the spectroscopic pipeline, Spectro1D, was developed and delivered to the DP factory for testing. We also continued the development of the software code and tools that will be used to access the DR1 data through the Data Archive Server (DAS) and the Catalog Archive Server (CAS). Although we worked very hard on these tasks, we still fell behind schedule and failed to meet the January DR1 release date. Details on the slippage are provided in the following sections.

4.1. Data Processing

4.1.1. Pipeline Development and Testing

A systematic offset between model and Petrosian magnitudes of galaxies was found in the output of Photo v5_3 at the beginning of Q4. This was traced to a deep-down bug in the model-fitting code and a major effort was dedicated to finding and fixing the bug during the quarter. A new version of Photo, v5_4, was cut and an extensive series of tests of the new code was conducted. Comparisons were made between the outputs of v5_4 and the previous version, v5_3, looking at the systematics of star-galaxy separation, galaxy colors, the difference between Petrosian and model magnitudes as a function of galaxy size, the galaxy sizes themselves, and target selection. Although early indications are that Photo v5_4 corrects the photomagnitude problem found in Photo v5_3, several other problems were found during testing. It is clear that additional development and testing will be required in 2003-Q1 before the code can be authorized for production processing in the data processing factory. Since it is not clear whether additional substantial problems will be found, the extensive testing effort will continue into 2003-Q1. When Photo v5_4 is declared production-ready, all imaging data collected to date will be re-processed through the new pipeline and calibrated with new flat fields. Until Photo v5_4 testing is complete, a schedule for reprocessing the data cannot be prepared.

Changes to the spectroscopic pipelines were minor in nature and consisted mainly of changes to improve object classification. During Q4, the main activity for spectro1D was to implement bug fixes for DR1 and beyond, and to manually inspect post-DR1 plates. The bug fixes were implemented in spectro reruns 20 and 22. They include correcting a unit problem in the 2d header file, improving the calculation of Lick indices (galaxy absorption line measurements) and their errors, and changing the galaxy spectral class for which galaxy velocity dispersions are calculated (necessitated by an earlier change in the PCA spectral eigentemplates used to classify galaxies). In addition, a smaller number of DR1 spectra were re-inspected and corrected. These results have been tested by (1) cross-comparison of spectro1D outputs with specBS done by Knapp and Strauss for all 186240 spectra included in DR1, and (2) comparison with truth tables done by SubbaRao for the ~40 testbed+validate plates, on which every fiber has been manually inspected. It was found that roughly 1% of objects (other than sky fibers) are of too low S/N to be classifiable; for the majority of these, spectro1D correctly indicates the objects as 'unknown'. Of the remainder, the total number of discrepant redshifts is less than 1%. When all is said and done, the total number of erroneous redshifts in the DR1 data is a few hundred at most, indicating that spectro1D classifications and redshifts are correct at the ~99.7% level or so. This impressive accomplishment exceeds our requirements.

4.1.2. Data Processing in Q4

All imaging and spectroscopic data collected through the end of Q4 were processed with Photo v5_3_58, idlSpec2D v4_9_8, and spectro1D v5_7_3. The DP group routinely processed new imaging data within 2-3 days and spectroscopic data within 24 hours. They also delivered a total of 45 plate designs on schedule to the UW machine shop for the November and December plate drilling runs.

As noted earlier, a significant problem was found with the calculation of the model magnitudes in Photo v5_3. It turns out this problem had existed in earlier versions of Photo as well, it had just never been detected. The DP group reprocessed existing imaging data several times to support the development and testing of Photo v5_4 and to verify the quality of new flat fields generated to improve photometric calibration accuracy.

The data processing hardware and disk servers performed reasonably well with only minimal problems experienced in Q4. To ensure data availability, an extensive effort was undertaken to back up all of the data for Data Release 1 onto the Enstore tape robot at Fermilab. The robot is used extensively by the DP group to back up other critical survey data as well.

4.2. Data Distribution

4.2.1. Development of Data Distribution Systems

In Q4, a considerable effort went into preparing the data and developing the interfaces to support DR1. The exact contents of DR1 were defined and approved by the Project Scientist in an announcement to the collaboration in early November. Development of the two main interfaces that will provide the collaboration and public with access to the SDSS data continued throughout Q4. These interfaces are the Data Archive Server (DAS) and the Catalog Archive Server (CAS). Through a web interface, the DAS provides access to pixel data (spectra, atlas images, raw frames, corrected frames, binned frames), as well as color images and plots in the form of flat files. The CAS is a Structured Query Language (SQL) database of objects, loaded from the DAS files, that enables the construction of catalogs of various classes of astronomical objects.

4.2.1.1. Data Archive Server

A very preliminary set of tools for accessing data through the DAS were developed and released to the collaboration on November 11 for testing and evaluation. This initial set of DAS tools included a web interface to provide access to the DR1 binary FITS files, a finding chart maker, and an interim DAS-SQL interface. The finding chart maker produces a JPEG image, optionally with spectro and imaging objects superimposed, and a corresponding FITS image file in a selected band. The interim DAS-SQL interface provides easy access to the "target" and "best" versions of the imaging data, and to the spectroscopic data for DR1. Early testing of the interim DAS-SQL interface proved useful in verifying that all of the input files were on disk and correctly named and in generating the coverage charts for DR1. When the CAS is fully developed and tested, we plan to replace the interim SQL interface with the CAS. Since the release of the preliminary set of tools in November, a great deal of effort has gone into improving the operation of the interfaces and the speed of query response times, and addressing problems uncovered as a result of the testing effort.

In Q4, we began developing web-based documentation to support the DR1 and we created a help desk at Fermilab to support the public's use of the data. When we released the DAS to the collaboration in November, we announced the existence of the help desk and asked for the collaboration's help in testing and evaluating its functionality, in preparation for the public release. The responsibilities of the helpdesk will be expanded to include support for the CAS, once it is loaded with the complete DR1 data set. This phased implementation will give us time to work out bugs, gain an understanding of unforeseen problems, and improve as necessary the operation of the helpdesk.

4.2.1.2. Catalog Archive Server

While we made significant progress on the development of the CAS, we could not release a fully-loaded DR1-CAS to the collaboration as we had planned. The CAS includes many tools for loading and validating the data prior to release, including file converters to convert FITS files into the comma-separated value (CSV) file format required for the SQL Server load; "loaders" to load the CSV files into a temporary database; and "validators" to verify that the data in the temporary database is loaded correctly and that data values are within defined parameters. The CAS operation also includes a "publish" step which merges new data from the temporary database into a production database. A functional version of the tools for loading imaging and spectra data was completed at the end of Q4 and a test suite consisting of several imaging runs, with corresponding spectra, was loaded into a prototype database for evaluation by the testing group. Tiling data was not included in the initial prototype release because development work on the tiling loader and validator was not finished. While the testing group continues to evaluate the initial test load release of the CAS, the development team is finishing the remaining elements of the CAS. When this is done, the development team will load, validate, and publish the full DR1 data set and release it to the testing group for evaluation.

In preparation for moving the CAS loading process to Fermilab, we developed a system plan for the computing hardware that will be needed to load and serve SDSS data to the collaboration and the public. The CAS hardware plan was approved in November and purchase requisitions were placed soon thereafter. As of the end of Q4, all of the hardware required for the CAS cluster at Fermilab has been received and is being installed.

Although we managed to complete a test load of the CAS by the end of the quarter, the effort to develop and test the many file converters, loaders, and validators has taken longer than anticipated. Much of the work proved more challenging and time-consuming than we had expected and progress slowed at times because people were not available due to conflicting priorities outside of the SDSS. Moreover, during the quarter we learned that we had to devote a greater than planned effort to establishing a secure computing environment at Fermilab for the CAS and to develop a better way of preserving the integrity of the data on disk at Fermilab. Implementing the CAS-SQL Server database system into the Fermilab computing environment was very challenging given DOE computer security requirements. Researching, configuring and testing security schemes at times diverted resources away from other development tasks. As the quarter ended, we had developed a basic plan that was accepted by the developers and the Fermilab computer security team.

A number of data integrity issues also arose during Q4 that had to be researched and addressed. While loading the DR1 dataset into the CAS, several sets of files were found to be either missing or corrupt. Some of the missing files were fpAtlas images generated from very early imaging data processed with now outdated versions of the photometric pipeline (Photo). Since we were not running comprehensive backups at that time, we are not able to easily restore these files and since the data is of limited value, we have decided not to reconstruct these auxiliary files from the raw data and historic versions of the imaging pipelines.

Another class of files identified as missing during the CAS loading process turned out not to be necessary because they are associated with holes in the imaging data due to bad telescope tracking. In this case the problem was matching the bookkeeping procedures for the CAS CSV files and the FITS files that are used to create those CSV files. The loading process has the positive ability to detect and flag corrupt data files and through the loading process, we identified 40 corrupt fpAtlas files out of a total of 150,000 files; the corrupt files were successfully recovered and restored. While this is a very small fraction, it did create time-consuming difficulties for the developers. We are nonetheless encouraged by the ability of the CAS loading and validation process to provide a strong additional check of the integrity and completeness of the data.

4.2.2. Early Data Release

The Early Data Release (EDR) contains about 460 square degrees of imaging data and 54,000 spectra that were taken as we commissioned the 2.5m telescope and instruments. The data were made available to the public in June 2001 and although they do not meet survey quality requirements, they are nevertheless of sufficiently high quality to support many important scientific investigations. A log of the maximum number of concurrent users each day is maintained on-line at: http://www-sdss.fnal.gov/sdssdp/sxstats/EDR/2002_Max_Concurrent_Users_by_Day. Usage was steady throughout the quarter as shown in Figure 4.1.

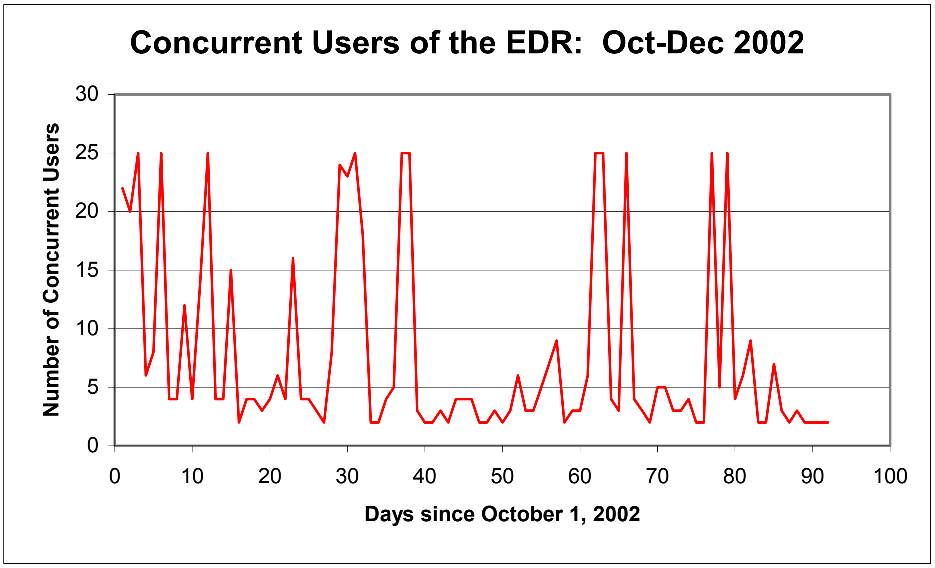


Figure 4.1. Concurrent users of the EDR during 2002-Q4.

4.2.3. Status of Data Release 1

To summarize, although we made significant progress on the DAS and CAS and released a preliminary version of the DAS to the collaboration in Q4, we were not able to release the DR1 data to the public in January 2003 as planned. There are several reasons for this. First, finishing the development and validation of Photo v5_4 is not complete. Since it appears that additional work is required before Photo v5_4 is authorized for production use, and since imaging data processed with Photo v5_3 will be of great value to the astronomical community in spite of the problems that were uncovered in Q4, the Management Committee has elected to release imaging data processed with Photo v5_3 to the public as soon as the DAS is fully functional. Second, the DAS and CAS interfaces were not complete at the end of Q4. While the DAS was released to the collaboration for testing and use in November, the final interfaces and documentation necessary for a public release were not finished. We fully anticipate that the DAS will be functional in early Q2-2003.

4.2.4. Data Processing and Distribution Goals for 2003-Q1 and 2003-Q2

The following goals has been established for data processing and distribution through the second quarter of 2003:

1. Finish coding, testing and validating Photo v5_4;
2. Begin re-processing the entire imaging dataset in Q2-2003 after Photo v5_4 is validated and authorized for production;
3. Continue routine processing of imaging data with Photo v5_3 in order to design plates for scheduled tiling runs;
4. Finish the development and documentation of the DAS interfaces;
5. Release the DR1-DAS beta version, loaded with Photo v5_3 and spectro rerun 20 reductions, to the collaboration and public at the beginning of Q2-2003;
6. Release the a beta version of the DR1-CAS to the collaboration in Q2-2003;

7. Finish the development and documentation of the software needed to load the DR1 data into the CAS SQL Server database;
8. Integrate the SQL Server database tools into the production operation at Fermilab and train the production staff in their use;
9. Load the SQL Server databases with the full set of DR1 imaging, spectro, and tiling data;

5. SURVEY PLANNING

5.1 Observing Aids

Several programs are used to aid in observing: HoggPT, Son-of-Spectro, the plate inventory database, and the patch database. No changes were made to any of these.

Several programs are used to aid in planning observations.

1. The plate layout program determines the exact parameters to be used for designing new plates. This program is relatively stable. No changes were made.

2. The plate planning program helps decide which areas of sky should be imaged next in order to maximize plate availability at all times during the night. No changes were made.

3. The plate design program does the detailed layout of plug plates and generates several files for the machine shop and the plug-plate technicians. No changes were made.

5.2 Target Selection

No changes were made to the primary survey target selection code or algorithms.

A special committee was appointed by the SDSS Director to evaluate proposals for spectroscopy to be conducted in the southern survey equatorial region once the main survey plates have been exhausted, which should occur this fall. A total of 16 proposals were approved, of which two require small amounts of imaging as well. The proponents for each proposal are responsible for defining target lists and, in some cases, providing plate designs based on existing designs from the main survey. In other cases programs with low densities of targets are merged together. For this quarter, 96 plates were designed and drilled in one drilling run, covering parts or all of 10 programs.

6. COST REPORT

The operating budget that the Advisory Council approved in November 2001 for the year 2002 consists of $2,291K of in-kind contributions from Fermilab, US Naval Observatory (USNO), Los Alamos National Laboratory (LANL), and the Japan Participation Group (JPG); and $3,425K for ARC funded expenses.

Table 6.1 shows the actual cost performance by project area for ARC-funded cash expenses in Q4 2001. A more complete table comparing actual to baseline performance is included as an attachment to this report.

Table 6.1. ARC-Funded 4th Quarter and Final 2002 Expenses ($K)

	2002 – 4th Quarter		2002 – Total	
Category	Baseline Budget	Actual Expenses	Baseline Budget (Nov 2001)	Actual Expenses
1.1. Survey Management	48	49	249	260
1.2. Collaboration Affairs	4	0	16	6
1.3. Survey Operations				
1.3.1. Observing Systems	189	167	870	854
1.3.2. Data Processing & Dist.	151	178	641	651
1.3.3. Survey Coordination	0	0	0	0
1.3.4. Observatory Support	340	341	1,360	1,364
1.4. ARC Corporate Support	40	15	88	63
Sub-total	772	749	3,225	3,197
1.5. Management Reserve	50	0	200	0
Total	822	749	3,425	3,197

6.1 Adjustments in Q1-Q3 Expenses

ARC-funded expenses in the first three quarters have been adjusted to reflect revised expenses reported by several institutions. Actual Q1 expenses decreased by $5K, or 1% due to minor adjustments on several SSP accounts. Actual Q2 expenses decreased by $36K, or 4% due to adjustments in the ARC Observing Systems Support, ARC Corporate Support, and JHU Software Testing and Validation accounts. An adjustment of $2K has also been made in the value of the USNO in-kind contribution for Q2; the previously reported amount had been estimated.

6.2 Fourth Quarter Performance - In-kind Contributions

The sum of in-kind contributions for the fourth quarter was $361K against the baseline forecast of $572K, and was provided by Fermilab, Los Alamos, the U.S. Naval Observatory (USNO), and the Japan Participation Group (JPG).

Fermilab provided support for the data acquisition system at APO, the software programs used by the observers to operate the telescopes and instruments, and the data processing systems at Fermilab as agreed. The level of support provided for survey management was slightly less than the baseline due to reduced availability of administrative personnel throughout the quarter. The level of support provided for engineering support at APO was as planned, whereas the level of engineering support provided by Fermilab technical staff working at Fermilab was less than anticipated in the baseline plan. In some cases this was because the level of support required was less than we thought would we would need, and in some cases because Fermilab technical staff had been temporarily assigned to work on the Fermilab accelerator and were unavailable to support SDSS engineering needs. The level of in-kind support for data processing and distribution was substantially below the Q4 baseline forecast for several reasons. First, the level of personnel support was reduced by 0.5 FTE because one individual was re-assigned to work half-time on another Fermilab project. Second, the equipment budget in the baseline plan was spread evenly throughout the year, when in fact the majority of the budget was spent in the first quarter. Third, the baseline anticipated an in-kind equipment budget of $228K; due to Fermilab budget constraints, the actual equipment budget allocated to the Fermilab EAG group was $100K. When these factors are combined, the total value of the Fermilab in-kind contribution for Q4 was $298K, or 37% below the baseline forecast of $475K. For the year, the total value of the Fermilab in-kind contribution was $1,497K, or 21% below the baseline forecast of $1,903K.

Los Alamos provided programming support for the Telescope Performance Monitor and testing support in preparation of DR1. The level of in-kind support provided in Q4 was substantially lower that the baseline forecast because one of the individuals included in the baseline forecast is no longer working on the SDSS project. This person had been slated to work on an improved interface for the Telescope Performance Monitor in the latter half of 2002. In light of the change in his availability, we re-assessed the need for the TPM upgrade in consultation with the observing staff and decided to postpone it indefinitely. For the year, the value of the Los Alamos in-kind contribution was $251K, or 8% above the baseline forecast of $231K. The increase reflects the greater-than-anticipated support provided earlier in the year for data testing and evaluation.

USNO provided support as required for the astrometric pipeline and other software systems they maintain. Q4 activities focused on quality assurance testing and support in preparation of DR1. The level of in-kind support reported for Q4, and for the year as a whole, is in close agreement with the baseline forecast.

No in-kind support was provided by the JPG in Q4 because no support was required for the imaging camera filters or calibration system. In fact, for the year 2002 we required virtually no technical support from the JPG.

6.3. Fourth Quarter Performance – ARC Funded Expenses

The sum of ARC-funded expenses for the fourth quarter was $732K, which is $40K or 5% below the fourth quarter budget of $772K.

Survey management costs were within $1K (2%) of the Q4 budget. Travel expenses related to the Office of the Project Scientist were lower than anticipated. The Fermilab survey management account was overspent because some of the Project Spokesperson's travel was arranged and billed through the survey management account and because expenses incurred by Fermilab for SDSS teleconferences were charged to ARC. The latter costs were not included in the 2002 baseline budget. ARC Support for Public Affairs was underspent because we chose not to produce new brochures for DR1; funds had been budgeted for these brochures in Q4. Finally, we entered into a consulting contract with Gary Ruderman to serve as the new SDSS Public Information Officer on a part-time, as-needed basis under the direction of the Project Spokesperson. This position was not budgeted for in the baseline. For the year, survey management costs were $260K, or $11K (4%) above the baseline budget of $249K.

The budget for Collaboration Affairs provides for Working Group travel and technical page charges and is held in an ARC corporate account. No expenses were incurred in Q4. For the year, expenses for Collaboration Affairs were $6K, or $10K (63%) below the baseline budget of $16K.

Observing Systems costs were $23K (12%) below the Q4 budget. Funds had been allocated to the ARC Observing Systems Support account to cover the cost of potential thermal improvement projects or other unanticipated engineering needs that might arise over the course of the year. Since these funds were not required in Q4, the ARC budget appears underspent. In addition, the baseline budget for FNAL-Observing Programs and DA Support included salary and travel support for one FTE to maintain observing software and serve as a part-time observer. In Q4, the level of effort charged to ARC was only 0.5 FTE because the individual performing this work was re-assigned to work part-time on another Fermilab project. In addition, because of the addition of an eighth observer on the APO staff, this same individual is no longer required as a part-time observer. Because he was not traveling to the site monthly, Q4 travel costs were less than budgeted. For the year, total expenses for Observing Systems were $854K, or $16K (2%) below the baseline budget of $870K.

Data Processing and Distribution costs were $27K (18%) above the Q4 budget. Fermilab costs exceeded the budget due to the purchase of computer hardware to support the deployment of the Catalog Archive Server for DR1. Procurement of the necessary computers, disk storage devices, and web servers was not included in the baseline budget, but was approved by the Management Committee in November. The Princeton software support budget was slightly overspent due to annual and other salary increases that had not been planned for in the baseline. The JHU software testing and validation account was overspent in Q4, but these additional costs are partially covered by funds allocated for this effort that were not spent earlier in the year. The baseline plan had spread the costs for this effort evenly over the year but due to the delay in Photo v5_3 development, there was minimal need for testing support in Q1. Since no expenses were incurred in that quarter, the budget for testing was moved forward to cover work in subsequent quarters. The UW testing effort was slightly underspent in Q4 because of personnel availability to support the testing effort. Finally, the JHU data archive development account was overspent in Q4 because of personnel costs associated with DR1 preparations. Since the account was underspent in quarters Q1 and Q2, the excess budget from these quarters has been brought forward to cover Q4 expenses. For the year, total Data Processing and Distribution expenses were $651K, or $10K (2%) above the baseline budget of $641K.

Observatory Support costs were within $1K (0%) of the baseline budget for Q4. Salary costs were slightly below normal in Q4. Staff vacations, which had already been expensed earlier for the year, were taken during the fall, which effectively reduced the actual salary expenses in the Q4. For the year, salary expenses were 1% more than planned; the variation is partly because the eighth observer was hired in December without a formal budget amendment and partly because of variations in staff overtime use during the year. Travel expenses in Q4 were greater than forecast because some costs were incurred in Q3 but paid in Q4 and because of an increase in travel in December related to meetings. For the year, the travel budget was spent to within 1% of the baseline plan. Expenses for Operations, Equipment, and Miscellaneous settled out in Q4 to expected levels, and were slightly below the baseline plan for the year. The savings more than offset the small overrun in salaries. For the year, Observatory Support expenses were $1,364K, or $4K (0%) above the baseline budget of $1,360K.

ARC Corporate Support costs were $25K below the Q4 budget. Q4 expenses included petty cash and the SDSS Advisory Council meeting held in November. The budget is largely underspent because funds set aside in the ARC Corporate Support budget for periodic readiness reviews and additional scientific staff support were not used in Q4. For the year, total ARC Corporate expenses were $63K, or $25K (29%) below the baseline budget of $88K.

6.4 Management Reserve

During the first half of 2002, it appeared that a number of items not included in the baseline budget would need to be funded through the allocation of management reserve. These items, with estimated costs, are listed in Table 6.2.

Table 6.2. Potential Allocation of 2002 Management Reserve Funds.

Item	Estimated Cost ($K)
8th Observer at APO	21
Observers Research Fund	12
Larger Trailers for Engineers and Observers	68
Survey Management Teleconference Charges	24
Part-time Public Information Officer	25
LAMOST collaboration support	9
Total	159

Descriptions and justifications for each of these items were provided in the 2002-Q2 report. The status of each item as of the end of 2002 is as follows:

- The 8th observer has been hired and started work at APO in December. Because he came on board so late in the year, salary costs for 2002 were much less than expected.
- The Observers Research Fund was established and has been used by the observers to support their research activities. Total expenses for 2002 were $5K.
- Larger office trailers were installed at APO for the observers and engineering staffs, but final costs exceeded earlier estimates. The overrun was due largely to site preparation costs, which were much higher than we had estimated.
- Survey management teleconferences are now paid for by ARC. We started using a new vendor in 2002 and monthly costs have decreased dramatically.
- A Public Information Officer has been hired to work on an as-needed basis, under the direction of the Project Spokesperson. Actual costs are in line with the estimate.
- No funds have been expended on LAMOST collaboration support because the Chinese scientists who had planned to work with SDSS staff at Fermilab and APO have not been granted work visas. It is not clear at this time when the visa situation will be resolved.

In June, the Advisory Council formally approved the Director's request to increase the 2002 management reserve by $140K to cover the expenses listed in Table 6.2. In the end, however, we have been able to accomplish the additional items, to the extent noted above, within the baseline budget of $3,425K that was approved in November 2001, without using any management reserve. Given final expenses of $3,181K, we anticipate that we will move $244K in unspent funds forward into future years to complete the survey and pay down unpaid invoices. The final amount moved forward will be established once all final 2002 invoices are received and paid.

7. SCIENCE RESULTS

Several papers were given at the American Astronomical Society meeting in Seattle January 6-9 2003, some based on the Early Data Release, others on recently acquired data. A substantial fraction of the papers related to stellar astronomy, not surprising given the Special Session we had organized on that topic. The following gives an overview of these papers as a way to capture some of the research accomplished in Q4 2002.

7.1 Quasars and AGN's

Ten papers were contributed in this category, covering both the statistics of populations (luminosity functions and the evolution of the space density), and physical processes within AGN's from diagnostics such as line profiles, continuum shape, X-ray and radio flux, and variability. One paper presented a list of three new $z > 6$ quasars and was the subject of a press conference. Two additional papers concerned a search for strongly lensed quasar images, and an analysis of the Lyman alpha forest in the SDSS spectra.

7.2 Clusters of Galaxies and Galaxies in Clusters

Papers in this category concerned a determination of the rich cluster mass function and implications for constraints on sigma-8 and omega-m; an analysis of cluster profiles to derive the size-richness relation; a comparison of data to N-body simulations of the circular velocity function for galaxies in a range of environments; and a study of the "dominance function" of brightest cluster galaxies as revealed by the targeting of Luminous Red Galaxies.

7.3 Properties of Galaxies

Topics in this category included analysis of defined samples (low-surface-brightness, HI-selected, satellites of larger galaxies, and merging pairs), as well as the pursuit of analysis techniques (morphology from shapelet decomposition, weak lensing constraints on halo shapes, and comparison of luminous and dynamical masses for ellipticals as a function of other physical properties).

7.4 Galactic Structure and Stellar Systems

The unique power of the SDSS data for study of the distribution of stars in the Milky Way and its satellites has become increasingly evident, as illustrated by several papers at the meeting. These addressed the scale height of the thick disk, a search for new satellites of the Milky Way that might or might not be associated with high-velocity clouds, and a large structure that can be interpreted as tidal debris in a ring that is roughly in the plane of the Milky Way disk (this last result also being the subject of a press conference). All of these studies invoke a mapping of photometric properties (and in some cases spectroscopic properties) onto luminosity; a number of other papers demonstrated how well we can derive [Fe/H] and other abundance ratios, log g, and log T from SDSS spectra. Still other papers concerned the derivation of reddening from the photometry, another prerequisite for interpreting the star counts and colors.

7.5 Astrophysics of Stars

SDSS has now acquired tens of thousands of spectra of stars, and this meeting featured a number of presentations on samples of different kinds of stars. Carbon stars are being found, many with detected proper motions, and some with relatively high surface temperatures. Two thousand white dwarf stars have been identified, including a catalog of white dwarf/red dwarf spectroscopic binaries. Several kinds of stars with active chromospheres and magnetic activity have been discovered using colors, variability, or spectroscopic signatures (low-mass main-sequence stars, and T Tauri stars). The SDSS is proving to be very efficient at the identification of cataclysmic variable stars, where follow-up observations to obtain orbital periods have discovered two extreme cases of cyclotron humps. Finally, the search for brown dwarf stars and the construction of the local luminosity function as a probe of the mass function have advanced since previous reports. This work exemplifies the power of combining SDSS discoveries with other surveys (2MASS) and with follow-up spectroscopy (UKIRT).

7.6 Asteroids

Asteroid detections (now over 60,000) are being posted to a web site (www.sdss.org/science/index.html) to enable follow-up so that orbits can be determined. With an expanded sample of asteroids with known orbits and high-precision SDSS multi-band photometry, it will be possible to refine the classification of asteroids into families based both upon orbital characteristics and upon color types.

8. PUBLICATIONS IN 2002-Q4

A Low Latitude Halo Stream around the Milky Way
ApJ submitted - Brian Yanny et al.

A Survey of z>5.7 Quasars in the Sloan Digital Sky Survey II: Discovery of Three Additional Quasars at z>6
AJ accepted - Xiaohui Fan et al

The Overdensities of Galaxy Environments as a Function of Luminosity and Color
ApJL accepted - David W. Hogg et al

A Catalog of Broad Absorption Line Quasars from the Sloan Digital Sky Survey Early Data Release
AJ accepted - Timothy A. Reichard et al.

Red and Reddened Quasars in the Sloan Digital Sky Survey
AJ submitted - Gordon T. Richards et al.

Determining the Lensing Fraction of SDSS Quasars: Methods and Results from the EDR
AJ accepted - Bart Pindor et al

Luminosity Function of Morphologically Classified Galaxies in the SDSS Survey
AJ accepted - O. Nakamura et al.

The Galaxy Luminosity Function and Luminosity Density at Redshift z=0.1
ApJ submitted - Michael R. Blanton, et al.

The Sloan Digital Sky Survey: The Cosmic Spectrum and Star-Formation History
ApJ accepted - Karl Glazebrook, et al.

Hdelta-Selected Galaxies in the Sloan Digital Sky Survey I: The Catalog
PASJ submitted - Tomotsugu Goto, et al.

SDSS catalog of stars in the Draco dwarf spheroidal galaxy
ApJS accepted - Heather A. Rave et al

The following publications are based on public SDSS data:

X-Ray Emission from Radio-Quiet Quasars in the SDSS Early Release Data
AJ accepted - Christian Vignali