STATUS REPORT FOR MARCH–MAY 2002

Spartan IR Camera for the SOAR Telescope

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During this reporting period we finished many design tasks. We decided to include the f/21 channel. We measured a rotation stage and showed that it can be used for mirror insertion as well as for moving the filter and mask wheels. We report an analysis of labor for the first 8 months of the project. Labor is 28% over the baseline if tasks that were not in the baseline are included and 6% over baseline for completed tasks that were in the baseline. We have completed half of the milestones of the project.

1 Tasks

1.1 Requisition for mirrors

Axsys Technologies of Rochester Hills, MI, submitted a design (Figure 1) for the aspheric mirrors and the flat mirrors. We analyzed the surface deformation with gravity and the space envelope of the mirrors. The surface deformation is excellent. The thickness of the flat mirrors caused a problem; reworking the mirror support and moving the detector freed enough space behind the mirrors. We approved the design. Delivery will be in late October 2002.

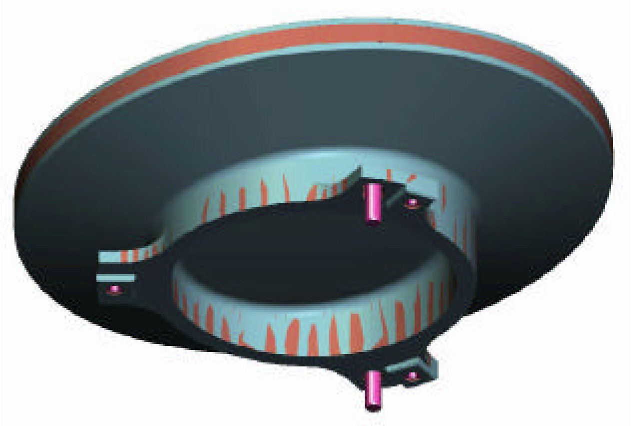

Figure 1 f/12 camera mirror, viewed from the rear. The mirror attaches to the mirror mount with three bolts on three pads. The pads prevent stresses on the mirror mount from deforming the mirror surface. Two pins locate the mirror. The thin nickel layer (shown in blue) enables polishing.

1.1.1 Surface Deformation

The surface deformation is much less than the requirement of a peak-to-valley of 80nm. Owen Loh determined the surface deformation with gravity with a finite-element-analysis. See figure 2. The f/12 collimator, the largest mirror, with gravity normal to the surface represents the most stringent case. The surface deformation is the sum of four terms: a piston of 145nm, a tilt of 0.1μrad, a change in the power (the radius of curvature is 200km), and a residual, which is less than 5nm. The piston and change of power shift the focus by 290nm, which is 100 times smaller than the requirement of 30μ. The tilt is caused by the slightly asymmetric placement of the mounting pads. The tilt is much less than the requirement of 6 μrad for alignment with the tip-tilt sensor. Since the residual is 16 times smaller than the requirement, the mirrors degrade of the Strehl ratio by an imperceptible amount.

With gravity parallel to the surface, the tilt is 0.9μrad. The other results are similar.

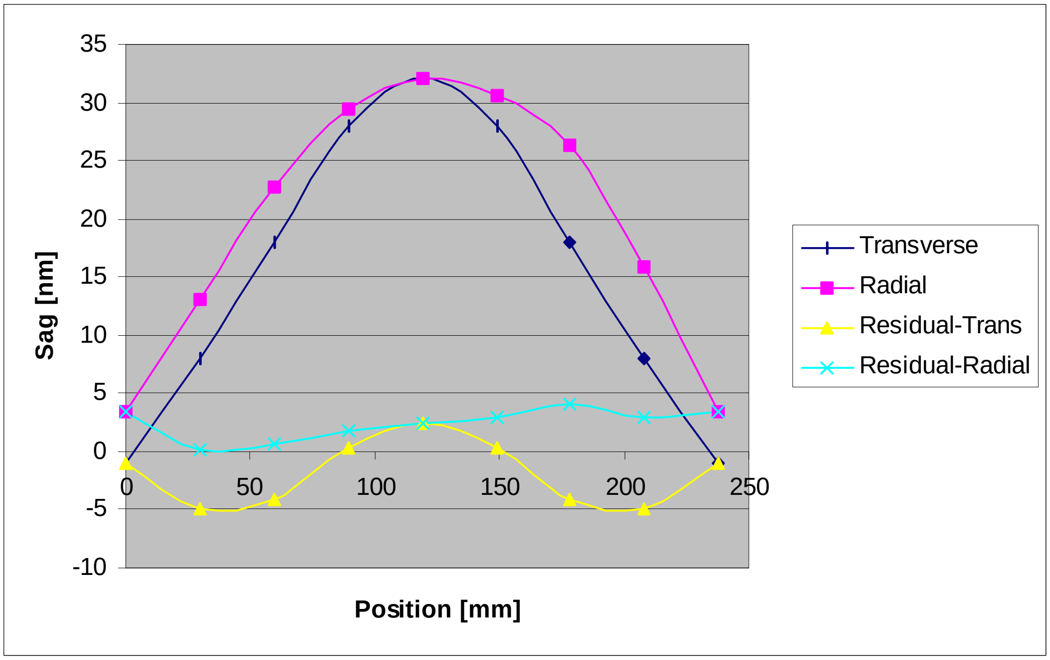

Figure 2 Sag of the f/12 collimator along the radius of the parent and transverse to it. The piston and tilt are removed. For the curves labeled “residual” the power is removed.

1.1.2 Support for Fixed Mirrors

The mirror support holds the f/21 collimating mirror between the two large plates of the cryo-optical box. Owen designed and analyzed the support (Figure 3). For the most taxing case where gravity is parallel to the face of the mirror, the mirror tilts by 1.3μrad, whereas the requirement is 6μrad.

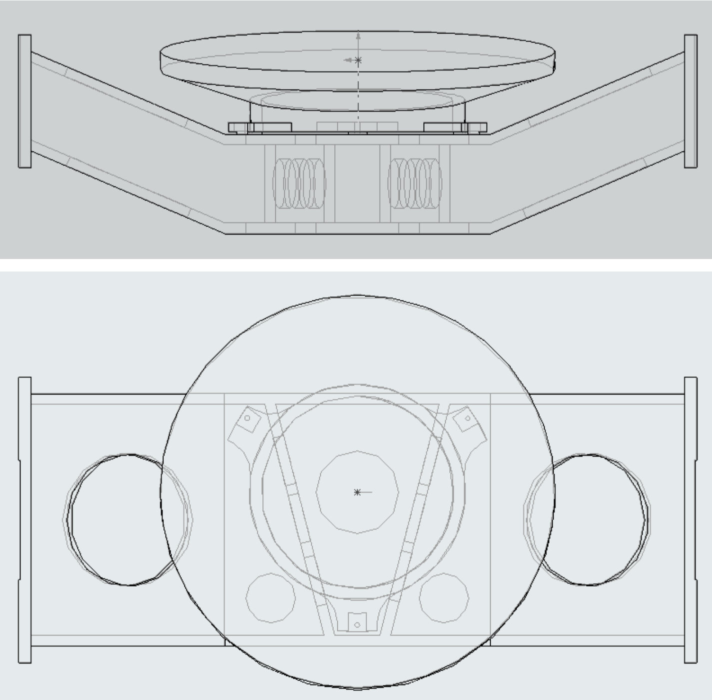

Figure 3 Support for the f/12 collimating mirror. The support connects at the left and right to the two plates of the cryo-optical box. The internal V-shaped beams stiffen the region near the pads of the mirror.

Previously we had not realized that the mirror and support exerted a substantial torque on the cryo-optical box and caused the plates of the box to distort. Now the projection of the center of mass onto the feet of the support is within the feet; thereby there is no torque on the plates of cryo-optical box.

We examined the mirror surface to insure that the support not distort it. The mirror surface is tilted but not deformed (top panel of Figure 4). Without the v-beams, the mirror surface does distort (bottom panel of Figure 4).

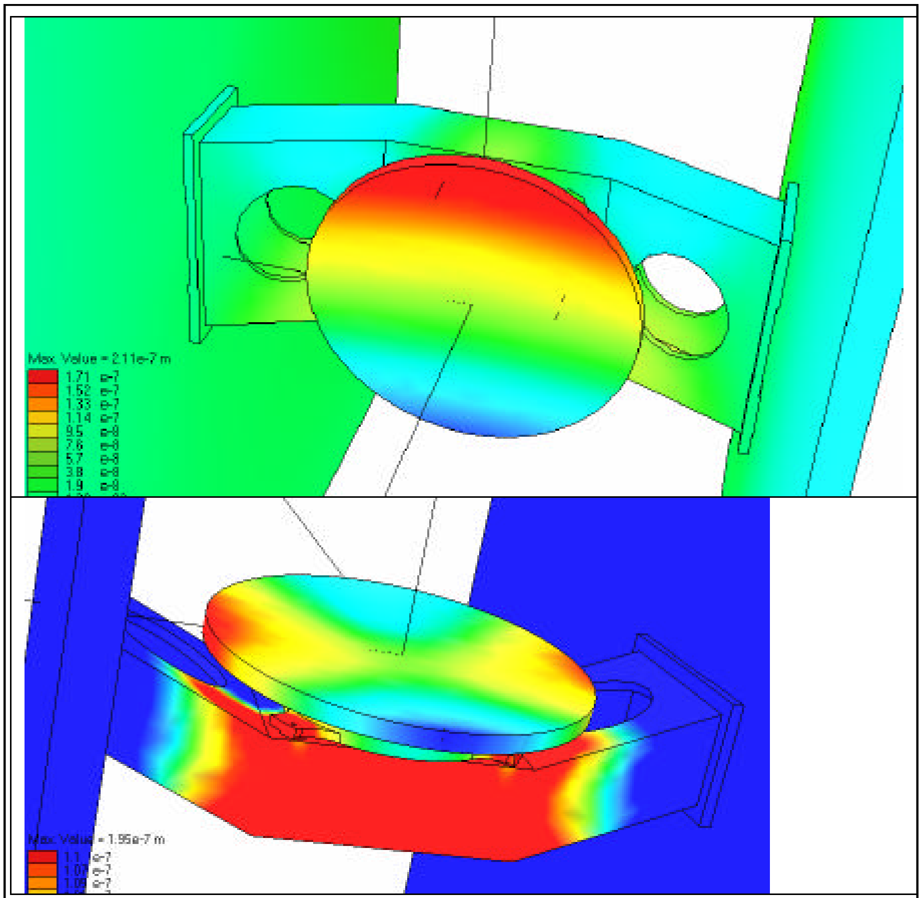

Figure 4 Sag normal to the mirror face for gravity parallel to the mirror. V-shaped beams are present in the upper panel and absent in the lower panel.

1.2 Software

Mike Davis and Tom Carter have written VIs (A software program is call a "virtual instrument" in LabView.) for most of the functions of the camera. The one unfinished function, reading a picture, does not yet store the picture into the space required by ArcView.

Jianjun Chen is writing the VI for the mechanisms. The VI drives the motor but needs to be incorporated into ArcView.

We have discovered that two VI in ArcView are specific to Linux whereas our software requires Windows. (There are no Linux drivers for our three NI cards.) We will find a solution to this problem.

1.3 Testing the rotation stage

We plan to use Phytron PRS-110 cryogenic rotation stages for all motions. The tightest requirement is for inserting the f/21 collimating mirror or the f/12 camera mirror. There the stage must tilt by less than 17 μrad to maintain boresight alignment with the tip-tilt guider to one pixel. Used to turn the filter wheel or mask wheel, the requirement is much looser.

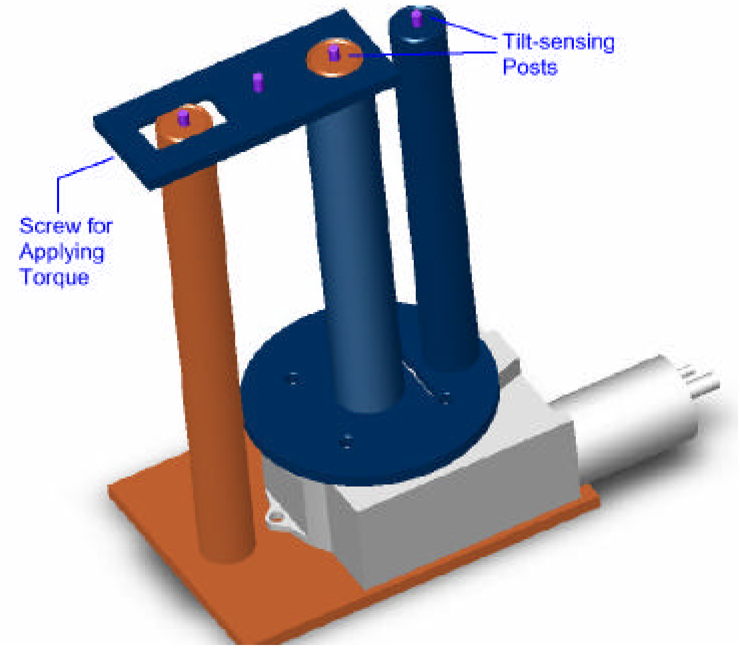

Figure 5 Jig for testing the rotation stage. The blue parts form a welded unit, and so do the red parts. A screw exerts a torque on the stage by forcing the long red post and the top plate together. . That was replaced by a weight, attached to a string, which runs through a pulley. The tilt is sensed by measuring the distance between the tilt-sensing posts.

We have tested the rotation stage for tilt. For this purpose, we built a test jig (Figure 5) for measuring the tilt when a torque is applied.

The measurement of the tilt of the stage at room temperature and at 77K is shown in Figure 6. The hysterisis evident in the figure is due to the measuring system: the same hysterisis occurs without the rotation stage.

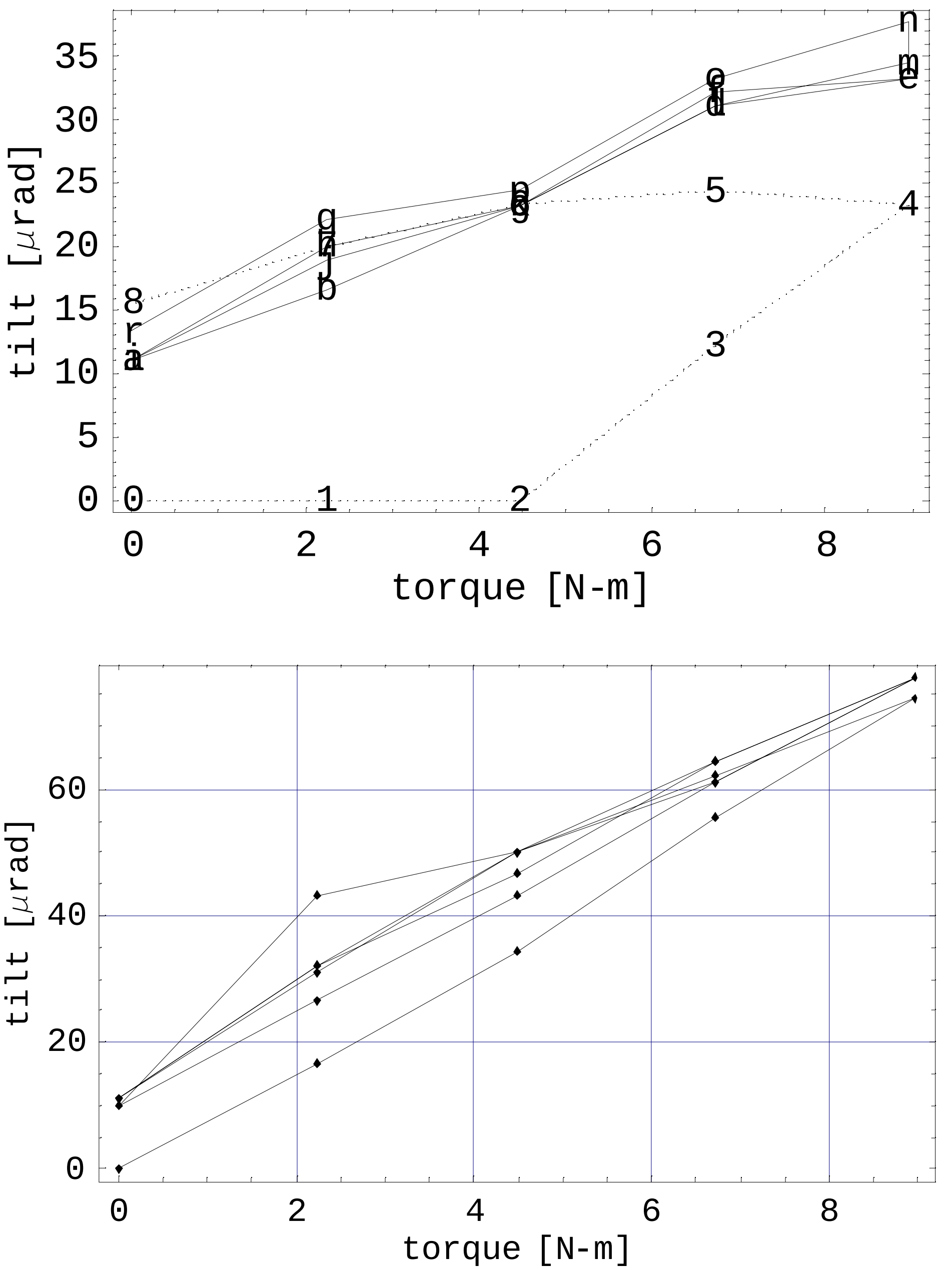

Figure 6 Tilt vs torque at room temperature (upper panel) and at 77 K (lower panel) For points 0–8, the torque was changed gently. For the other points, the top plate was tapped to remove hysterisis.

The abstract of the test report, Biel & Loh, 09 April 2002, “Test of the PRS-100 Rotation Stage”:

> We report a measurement of the tilt of the Phytron PRS-100 rotation stage when subjected to a torque. The hysterisis is small compared to the tilt. The response is 2.3 μrad/(N-m) at room temperature and 6.7 μrad/(N-m) at 77 K. For mirror insertion, the load is at most 1 N-m, and the tilt is less than 7 μrad, which corresponds to 0.4 pixel for both the f/21 collimating mirror the f/12 camera mirror. The Phytron PRS-100 rotation stage is acceptable for all mechanisms of the instrument.

1.4 Mechanical design

1.4.1 Vacuum Enclosure (WBS 1.3.3)

The vacuum enclosure is divided into two parts: a bathtub and a hat. Both the instrument support cage (ISC) of the telescope and the cryogenic optical box attach to the bathtub. The bathtub contains electrical connectors and feed-throughs for nitrogen. The vacuum value and gauges are on the hat. The hat lifts off without having to disconnect wires or plumbing.

Dave Keesaer designed the vacuum enclosure; detailing is underway.

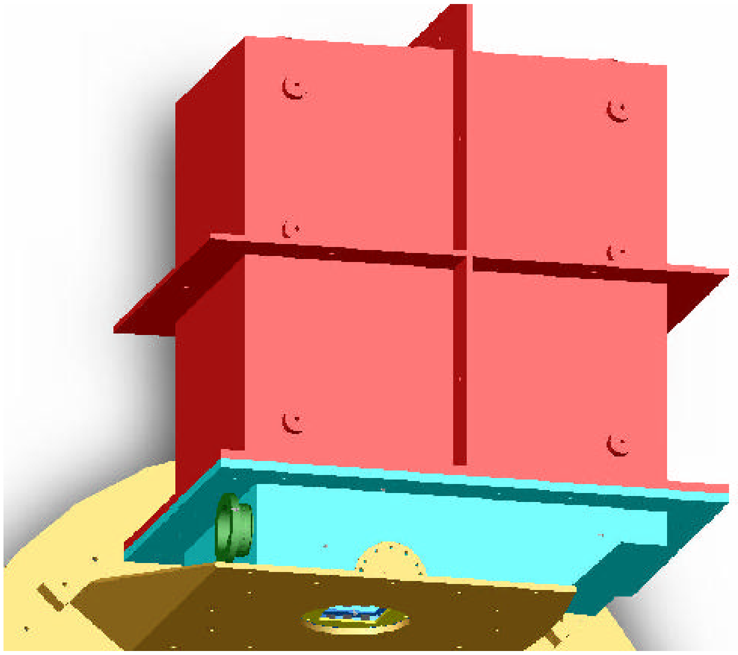

Figure 7 Vacuum enclosure (hat shown in red and bathtub in cyan) attached to the ISC (tan). The green part is the port for motor wires and nitrogen.

1.4.2 Cryogenic Optical Box (WBS 1.3.1.2)

Dale Circle has nearly finished designing and detailing the cryogenic optical box.

1.4.3 Filter Wheels (WBS 1.3.4)

Filter wheel #1 holds 18 filters; wheel #2 holds 11 filters or Lyot stops. See Figure 8.

Filters can be changed without disassembling the instrument, although warming the instrument and breaking vacuum is required. They can be inserted through a port in the vacuum enclosure. The filter holder slides into the wheel and is secured by a sprung latch.

René Laporte conceived the idea of changing filters without disassembling the instrument, and he designed and detailed the filter holder and wheel.

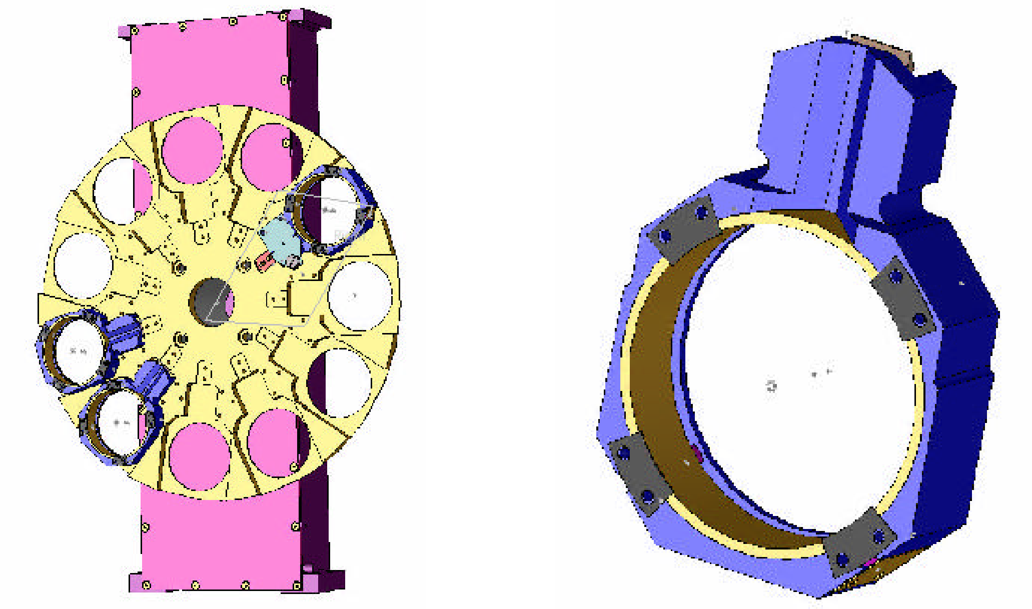

Figure 8 Filter holder (right) and post with rotation stage, wheel, and three holders (left). Four steel springs (gray) push axially on the filter, and four Teflon cylinders under the springs push radially. A half cylinder on a spring (light green), which fits on the V-groove of the filter holder, and a shoulder at the end of the groove define the location of the holder. A latch behind the holder secures it.

1.4.4 Box for Filter Wheels, Mask Wheel, and Mirror Insertion (WBS 1.3.4)

A box holds the rotation stage for the filter wheels, mask wheels, and the mirror insertion. The ends of the box attach to the cryogenic optical box.

Dale Circle designed and detailed the box.

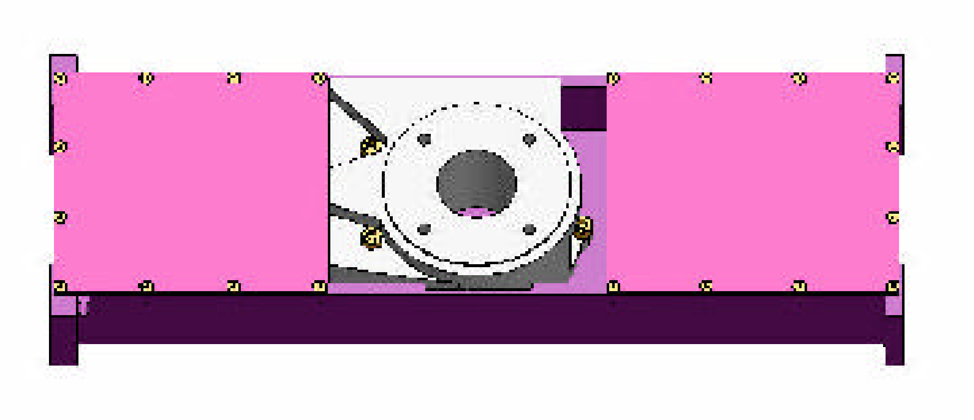

Figure 9 Box for rotation stage

1.4.5 Mask Plate (WBS 1.3.1.2)

The mask plate holds field stops, slits, and coronographic masks. Dale Circle designed and detailed the mask plate.

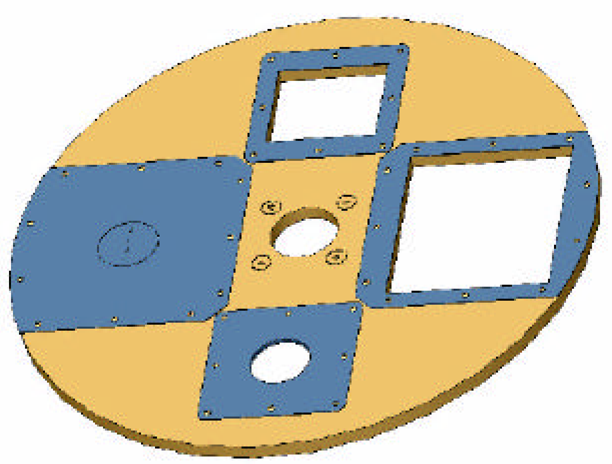

Figure 10 Mask plate with the f/12 field stop (large open square), the f/21 field stop (small open square), and slits.

1.4.6 Thermal Reflector (WBS 1.3.2)

Dale Circle completed the design and detailing of the thermal reflector.

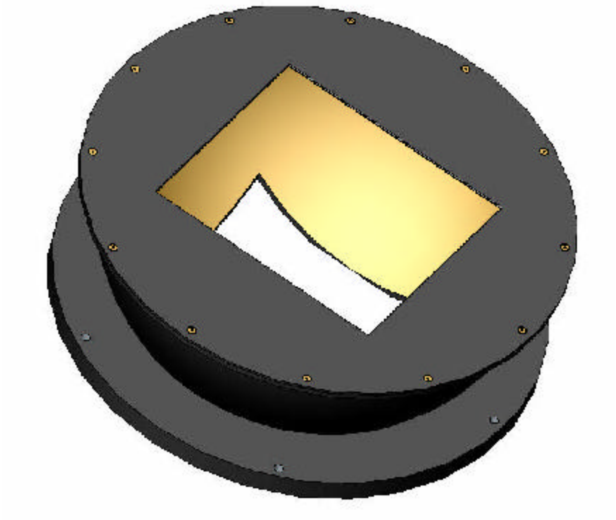

Figure 11 Thermal reflector

1.5 Thermal test of detector mount

The detector is cooled by straps to a small liquid nitrogen can and is heated primarily by the cable to the outside. We are testing the thermal design.

The shop finished modifications of an existing dewar. The dewar has been checked for leaks. The shop is fabricating the detector mount. We are assembling the detector PCB with temperature sensors. The software for reading the temperature sensors has been written.

After the thermal test, we will install the multiplexer (a detector with functioning logic and amplifiers but no HgCdTe sensing material) to take a picture. The final test is to install a detector.

1.6 Move to new building

On March 11, we moved the laboratory to the new Biomedical Physical Sciences Building. Our new lab is large enough to house the project, including the coordinate-measuring machine. It has easy access to the shop and to the outside. The move, packing, unpacking, and setting up took 120hr of labor. Jason Biel was responsible for the move.

2 Project Management

The project summary is in Table 1.

Table 1 Project summary

Status date	6/1/2002		
Dates			
Start:	Tue 9/4/01	Finish:	Tue 6/10/03
Baseline Start:	Mon 9/3/01	Baseline Finish:	Tue 6/10/03
Actual Start:	Tue 9/4/01	Actual Finish:	NA
Start Variance:	0 d	Finish Variance:	-1 d
Duration			
Scheduled:	460 d?	Remaining:	265 d?
Baseline:	461 d?	Actual:	195 d
Variance:	-1 d?	Percent Complete:	42%
Work			
Scheduled:	11,042 h	Remaining:	5958 h
Baseline:	8,733 h	Actual:	5,084 h
Variance:	2,309 h	Percent Complete:	46%
Costs			
Scheduled:	$1,097,385	Remaining:	$442,451
Baseline:	$1,131,372	Actual:	$654,934
Variance:	($33,987)		
Task Status		Resource Status	
Tasks not yet started:	323	Work Resources:	8
Tasks in progress:	73	Overallocated Work Resources:	9
Tasks completed:	283	Material Resources:	0
Total Tasks:	679	Total Resources:	17

2.1 Labor

Labor is the greatest concern. During the period March–May 2002, 2533 hours of labor were expended, and the remaining labor decreased only 1103 hours. See Figure 12 for the expenditure of labor over time. Where did the hours go? Can the project finish with the preset labor resources? Should labor be managed differently?

Examination of the work summaries shows a surprisingly good picture. Consider the work of Biel, Circle, Davis, Keesaer, and Loh (for the others, the information is brief). For the tasks that are in the baseline and are complete, the variance is 6% (147 hours with a baseline of 2366 hours.) For the tasks that were added to the baseline, the variance is 28% (1643 hours on top of the baseline of 5969 hours.)

The tasks for which the variance is more than 40 hours (Table 2) serve as studies of tasks where the expectation and actuality are very different. The biggest problem is that essential and time consuming tasks were not in the baseline. Most of tasks 1–8 were added because they are essential for the project. Task 8 was added to the project because of the imminent addition of the third and fourth detectors. With hindsight we should have stopped task 1 earlier and assumed more risk.

For most tasks in the baseline, the overrun is due to problems encountered. Learning from the other tasks, we have reassigned work to match individual strengths.

Table 2 Tasks with large work variance

	Task	**Baseline [hr]**	**Variance [hr]**	**Overrun**	**Completed**
Tasks not in Baseline					
1	Analyze Cable for Motors		142		y
2	Test Rotation Stage		141		y
3	Manage [personnel, external meetings & communications]		134		n
4	Initiate Procurement of Vacuum Parts		130		y
5	Move Laboratory		93		y
6	Modify Telescope Interface		68		y
7	Cryo-Optical Box 3D Design [oversight]		57		n
8	Design Focal-Plane Mechanism		45		n
Tasks in Baseline					
9	Install & Test Controller Card	80	123	153%	y
10	Replace CTIO Camera with Spartan in ArcView	32	108	338%	n
11	Cryo-Optical Box 3D Design	116	88	76%	n
12	Design Mounting Blocks	20	55	273%	y
13	Prototype Thermal Test in Test-Dewar	40	51	126%	n
14	N2 Can 2D Drafting (12 Dwgs)	160	(152)	-95%	y

Can the project finish with the present work resources? At the crudest level, the remaining work for a graduate student, a technician, and the PI is 20 months. If the work takes as long as the work in the baseline has so far, the remaining work will take 21 months (1.09*19.8mo). If the work takes this long and more will be added to the baseline, then the remaining work will take 28 months (1.39*19.8 mo). Since the remaining time for these three is 30 months, the project can finish with the current resources. In addition, Rene Laporte can potentially spend 6 months to help with integration.

In spite of the optimistic projection, there are two unknowns. We have yet to begin fabrication of major parts, and we may encounter major problems in integration. Since we have no new information on these two questions, we put them aside.

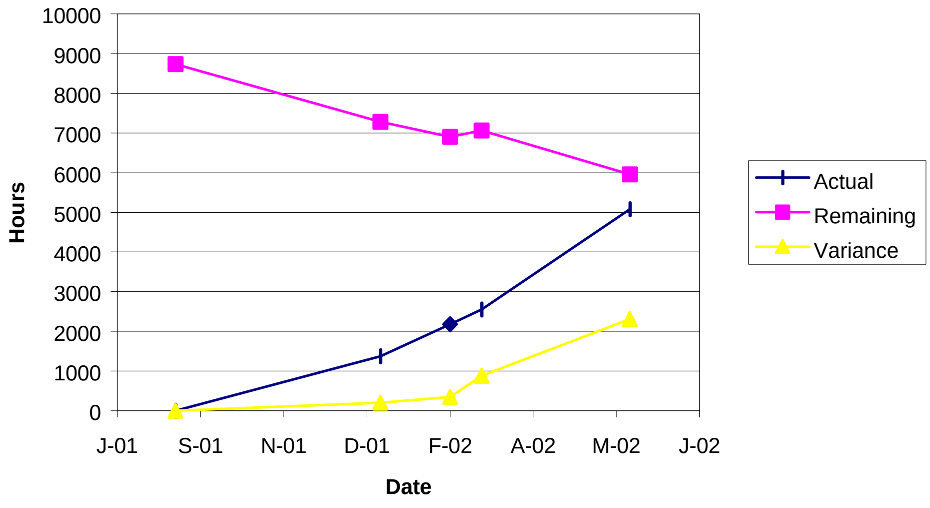

Figure 12 Labor vs date. "Actual" is the number of hours expended. "Remaining" is the estimated hours to complete the project. Variance = Actual + Remaining – Baseline.

2.2 Earned value analysis

The earned value analysis of the schedule shows several tasks are behind schedule. (See columns BCWS, BCWP, and SV of Table 3.) The “schedule variance,” SV, shows $244k of work should have been performed but has not. The greatest part is in WBS 1.3, Mechanical.

Earned value analysis does not apply here to work done by Biel, Davis, and Loh; therefore it cannot show problems in work done by them. It can show problems with purchased parts and labor that is charged by the hour.

Table 3 Earned value analysis and % complete. A positive “schedule variance,” SV, indicates the project is ahead of schedule. A positi “cost variance,” CV, or “variance at completion,” VAC, indicate the project is less costly than budgeted.

WBS	Task	BCWS	BCWP	ACWP	SV	CV	EAC	BAC	VAC
1	Spartan IR Camera	$906,956	$663,349	$648,891	($243,608)	$14,458	$1,097,385	$1,131,372	$33,987
1.1	Project Management	$75,937	$71,251	$66,269	($4,686)	$4,982	$163,638	$161,619	($2,019)
1.2	System Engineering	$720	$779	$2,312	$59	($1,532)	$2,312	$720	($1,592)
1.3	Mechanical	$289,236	$99,790	$83,353	($189,445)	$16,437	$336,700	$368,060	$31,360
1.4	Electronics	$10,533	$7,985	$7,510	($2,548)	$475	$12,864	$12,705	($159)
1.5	Software	$10,800	$5,600	$10,540	($5,200)	($4,940)	$5,540	$10,800	$5,260
1.6	Integration	$3,800	$0	$0	($3,800)	$0	$3,800	$3,800	$0
1.7	Deliverables	$0	$0	$336	$0	($336)	$21,136	$20,800	($336)
1.8	Procurement	$83,610	$45,622	$46,250	($37,988)	($628)	$119,075	$120,548	$1,473
1.9	Preplan Spending	$432,321	$432,321	$432,321	$0	$0	$432,321	$432,321	$0
1	Change from 3/8/02	$161,498	$92,710	$88,770	($68,788)	$3,940	($2,279)	$0	$2,279

BCWS	Budgeted cost of work scheduled
BCWP	Budgeted cost of work performed
ACWP	Actual cost of work performed
SV	Earned value schedule variance; SV=BCWP-BCWS
CV	Earned valve cost variance; CV=BCWP-ACWP.
EAC	Estimate at completion
BAC	Budget at completion
VAC	Variance at completion; VAC=BAC-EAC

What can we do to reduce the schedule variance by the next report? Consider the tasks with the greatest schedule variance (Table 4). Work is in progress for almost every task. Comments about specific tasks are in the table.

Table 4 Tasks with the greatest schedule variance.

WBS	Task	SV	BAC	Will SV not increase at next monthly report?	
1.3.6.1.4.2	Vendor Mirror Fab	($64,984)	$95,975	y	In fabrication
1.3.8.1.17	Procure F/21 Collimator & Camera Mirrors [Upgrade]	($28,664)	$66,255	y	Requisition issued
1.8.7	Procure 4 Additional Rotation Stages [Upgrade]	($26,400)	$62,040	y	Requisition issued
1.3.3	Vacuum Enclosure	($26,180)	$27,380	y	Seeking vendors
1.3.5	Rotational Stage	($16,820)	$49,450	y	In fabrication
1.3.1.2	CryoBox	($15,180)	$19,880	y	Design in progress
1.3.7.3	Fab Basic Filters [3]	($13,378)	$51,000	y	In fabrication
1.1.6	Consultants	($9,450)	$10,000	n	Need has not arisen
1.5.3	Write Minimal Software	($6,500)	$10,000	y	In progress
1.3.1.5	N2 Can	($5,581)	$10,061	?	Awaiting tests on charcoal getter
1.6.1	Telescope Simulator	($3,800)	$3,800	y	In progress
1.3.8.1.5	2nd Collimator and Camera Mirror 3D Design	($3,600)	$3,600	y	Will start soon
1.8.8	Procure Parts for Vacuum Enclosure	($3,386)	$7,163	y	Waiting for delivery
1.3.1.1	MLI Blanket	($3,000)	$4,047	y	Will finish requisition in 2 wks
1.3.2	Thermal Reflector	($3,000)	$3,880	n	Slack is long

The estimated cost at completion (EAC) is $34k under the budgeted cost at completion (BAC). The item with the largest variance is Fabricate Mirrors. (See Table 5.)

Table 5 Items with the largest Variance at Completion. A positive number means the Estimated Cost at Completion is lower than the Budget at Completion.

WBS	Item	BAC	VAC	%WC	%C	Reason
1.3.6.1.4	Fabricate Mirrors	$95,975	$14,613	100%	35%	Axsys's quote is lower.
1.3.4	Filter Wheel	$12,400	$5,342	39%	48%	Brazil's contribution
1.8.7	Procure 4 Additional Rotation Stages [Upgrade]	$67,040	$5,295	100%	2%	Rotation stage is less; NI's motor controller is less
1.5	Software	$10,800	$5,260	51%	40%	Some labor is in fixed cost.
1.3.1.4	A-Frame	$5,600	$5,155	100%	100%	Times for detailing and fabrication are lower.
1.3.1.5	N2 Can	$10,061	$4,089	12%	28%	Time for detailing is lower.
1.3.3	Vacuum Enclosure	$27,380	$3,454	34%	36%	Preliminary quote for fab is lower
1.3.1.1	MLI Blanket	$4,047	$2,771	46%	20%	Quote is lower than ballpark estimate.
1.3.5	Rotational Stage	$44,450	$2,655	100%	87%	NI's motor controller is less
1.3.6.2	Mounts for Mechanisms	$2,600	($2,770)	71%	60%	Design & detailing are higher
1.8.2	Procure Solidworks License	$1,645	($2,998)	100%	100%	Licenses needed for Circle & Laporte
1.3.8.3	Focal Plane Assembly	$0	($3,120)	43%	29%	Focal plane assembly is now for 4 detectors
1.3.6.3	Mounts for Mirrors	$0	($4,568)	6%	3%	Erroneously left off of plan

EAC	Estimate at completion
BAC	Budget at completion
VAC	Variance at completion; VAC=BAC-EAC
%WC	Work completed
%C	Percent completed; (duration of the task) / (total duration)

2.3 Schedule

A simple metric for analyzing the schedule is the slack between construction of the parts and integration (Table 6). The task with the shortest slack is the mounts for the f/12 camera and f/21 collimator, the mirrors that are inserted. The engineering for this is in progress. The slack is most likely much longer, since the time estimate for 3-d design of 43 days is very generous.

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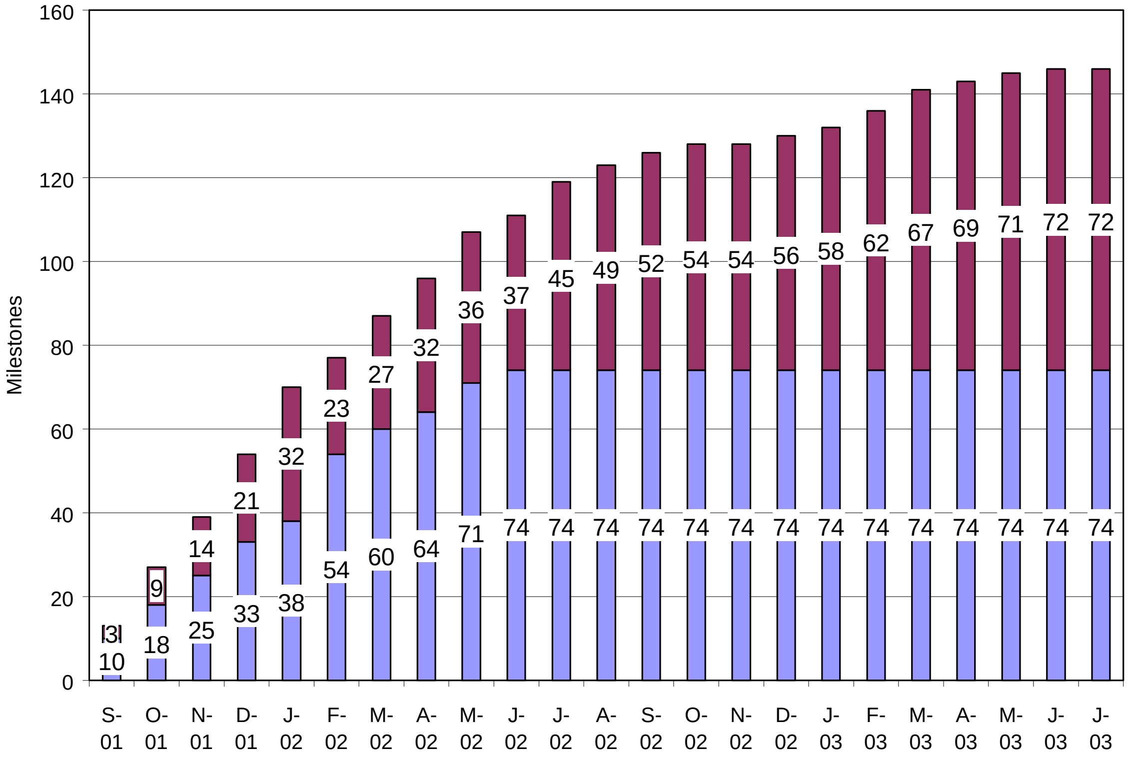
Table 6 Slack for tasks that precede integration

WBS	Task	Slack[wk]	Status	Resource
1.3	Mechanical			
1.3.1	Cryo-Optical Box	8		
1.3.1.1	MLI Blanket	14	Reqisition in preparation	BL,JB,AP
1.3.1.2	CryoBox	8	Design in progress	EL
1.3.1.5	N2 Can	10	Awaiting test of getter	BL
1.3.2	Thermal Reflector	17	RFQ to be started	
1.3.3	Vacuum Enclosure	7	Design & detailing in progress	DK,DC
1.3.4	Filter Wheel	13	Fab to be started	
1.3.5	Rotational Stage	13	In fabrication	Phytron
1.3.6	Mirrors & Mounts	4		
1.3.6.1	Mirrors	4		
1.3.6.1.4	Fabricate Mirrors	4	In fabrication	Axsys
1.3.6.2	Mounts for Mechanisms	26	Engineering in progress	OL
1.3.6.3	Mounts for Mirrors	4	Engineering in progress	OL
1.3.8	Upgrades			
1.3.8.1	2nd Channel Mirrors & Mounts [Upgrade]	1		
1.3.8.1.4	Complete 2nd Collimator & Mirror Analysis	1	Engineering in progress	OL
1.3.8.2	Mask Wheel Upgrade	19	Fab to be started	
1.3.8.3	Focal Plane Assembly	16	Design in progress	RL
1.4	Electronics			
1.4.1	Detector Assembly	6	Test in progress	JB
1.4.2	Electronic Hardware			
1.4.2.4	Motor PCB	37	Awaiting response to RFQ	JB
1.5	Software			
1.5.3	Write Minimal Software	17	In progress	MD,JC,TC
1.5.4	Write Baseline Software	17		
1.5.5	Software for Upgrades	17		
1.6	Integration			
1.6.1	Telescope Simulator	10	Engineering in progress	BL,OL,AP
1.8	Procurement			
1.8.5	Procure Field-flattening Lens	14	Awaiting design of detector assembly	
1.8.7	Procure 4 Additional Rotation Stages [Upgrade]	2	Requisition issued	
1.8.8	Procure Parts for Vacuum Enclosure	19	A few parts to be ordered	JB
1.8.9	Procure Parts for Telescope Simulator	38		

2.4 Milestones

The time-phased completion of the milestones is in Figure 13, and a complete list of milestones is in Table 7 in the Appendix. During March–June, we completed 20 milestones. We have finished half of the 146 milestones.

Figure 13 Cumulative number of milestones completed (blue) and not completed (magenta) vs. date.



3 Personnel

René Laporte has been working since 20 March. Ben Lien and Jaijun Chen, two graduate students, joined the project.

4 Appendix

Table 7 Milestones

	Milestone	Date			
		Baseline	Completed	Scheduled	Variance
1	Requisition for Flexible Cable Issued	4-Sep-01	1-Oct-01		19 d
2	Requisition for Rotation Stage Issued	6-Sep-01	6-Sep-01		0 d
3	Optical Design Finished	7-Sep-01	7-Sep-01		0 d
4	N2 Can Engineered	7-Sep-01	7-Sep-01		0 d
5	A-Frame Strut Engineered	17-Sep-01	13-Nov-01		42 d
6	Requisition for Vacuum Blukhead Issued	17-Sep-01	7-Sep-01		-6 d
7	Requirements for Optical Alignment Written	17-Sep-01	17-Sep-01		0 d
8	Vacuum Enclosure & Cryo Box ICD Written	18-Sep-01	28-Sep-01		9 d
9	Controller Card SCA Tested (Existing Compute	21-Sep-01	12-Dec-01		58 d
10	Detector Physical Dimensions Measured	24-Sep-01	20-Sep-01		-2 d
11	Requisition for Mirrors Issued	28-Sep-01	21-Feb-02		104 d
12	Requisition for Detector PCB Issued	28-Sep-01	19-Nov-01		36 d
13	Software Requirements Written	28-Sep-01	28-Sep-01		0 d
14	Method for Optical Alignment Created	1-Oct-01	3-Jan-02		68 d
15	Specifications for Telescope Simulator Written	3-Oct-01	3-Oct-01		0 d
16	Requisition for Coordinate-Measuring Machine	5-Oct-01	27-Nov-01		37 d
17	Detector Assembly Concept Developed	8-Oct-01	3-Dec-01		40 d
18	Solidworks License Delivered	11-Oct-01	9-Oct-01		-2 d
19	Mounting Blocks Engineered	12-Oct-01	26-Sep-01		-12 d
20	Select SW Vendor	12-Oct-01	16-Oct-01		1 d
21	Test-Dewar Concept Sketch Finished	15-Oct-01	19-Oct-01		4 d
22	Vacuum Bulkhead Delivered	15-Oct-01	27-Feb-02		97 d
23	N2 Can Designed	18-Oct-01	10-Jan-02		60 d
24	Requisitions for Computer for Laboratory Issue	19-Oct-01	17-Oct-01		-2 d
25	Detector Holder Prototype Designed	25-Oct-01	4-Feb-02		72 d
26	Mounting Blocks Designed	29-Oct-01	8-Mar-02		95 d
27	Rotation Stage Test Fixture Engineered	31-Oct-01	10-Dec-01		28 d
28	Coordinate-Measuring Machine Delivered	2-Nov-01	12-Feb-02		73 d
29	Rotation Stage Test Fixture Designed	7-Nov-01	7-Jan-02		43 d
30	Flex Cable Finished	9-Nov-01	8-Nov-01		-1 d
31	Computers for Laboratory Delivered	9-Nov-01	11-Dec-01		22 d
32	Project Plan Finished	16-Nov-01	19-Dec-01		24 d
33	Cryo-Optical Box Engineering Finished	16-Nov-01	28-Nov-01		8 d
34	Detector Holder Prototype Fabricated	19-Nov-01		19-Nov-01	
35	Test-Dewar Fabricated	19-Nov-01	24-Apr-02		113 d
36	Detector PCB Finished	21-Nov-01	4-Mar-02		73 d
37	Master Layout Designed	26-Nov-01	23-Nov-01		-1 d
38	Rotation Stage Delivered	29-Nov-01	6-Feb-02		50 d
39	A-Frame Strut 3D Designed	30-Nov-01	30-Nov-01		0 d
40	Specifications for Vacuum Enclosure Written	6-Dec-01	24-Oct-01		-31 d
41	Rotation Stage Test Fixture Fabricated	7-Dec-01	8-Feb-02		45 d

42	Requisition for Field-flattening Lenses Issued	7-Dec-01		29-May-02	
43	Mask Plate Engineering Finished	7-Dec-01	25-Feb-02		56 d
44	Requisition for Window Issued	10-Dec-01	8-Feb-02		44 d
45	MLI Requisition Issued	10-Dec-01		15-May-02	
46	Flex Cable/Bulkhead Assembly Finished	11-Dec-01	27-Feb-02		56 d
47	Specification for Filter Wheels Written	14-Dec-01	10-Dec-01		-4 d
48	Rotation Stage Tested	14-Dec-01	4-Apr-02		79 d
49	Mounting Blocks Fabricated	14-Dec-01		1-May-02	
50	Joined Filter Consortium	14-Dec-01	21-May-02		112 d
51	Requisitions for Vacuum Parts Initiated	20-Dec-01	19-Apr-02		86 d
52	Requisition for Rotation Stage Controller & 2nd	25-Dec-01	1-Mar-02		48 d
53	Cable for Motors Analyzed	28-Dec-01	8-Feb-02		30 d
54	Mask Plate Designed	28-Dec-01	15-May-02		97 d
55	Detector Holder Prototype Thermal Test Finishe	1-Jan-02		1-Jan-02	
56	Vacuum Enclosure Engineered	3-Jan-02	31-Oct-01		-46 d
57	MLI Designed	8-Jan-02	12-Feb-02		25 d
58	Thermal Reflector Engineered	9-Jan-02	17-May-02		92 d
59	Deliver Communications Test Software	14-Jan-02	30-Jan-02		12 d
60	Requirements for Window Written	15-Jan-02	18-Jan-02		3 d
61	Requirements for Field-Flattening Lens Written	15-Jan-02	8-Feb-02		18 d
62	Requirements for Telescope Simulator Modifiec	15-Jan-02	10-Dec-01		-26 d
63	Requirements for Pyramidal MirrorWritten	15-Jan-02	8-Feb-02		18 d
64	Motor PCB Designed	18-Jan-02	3-Jun-02		72 d
65	Filter Wheel Mounting Block Specified	21-Jan-02	21-Sep-01		-87 d
66	MUX Tested at Room Temperature	22-Jan-02		22-Jan-02	
67	Parts for Test Dewar Assembled	25-Jan-02	8-Feb-02		10 d
68	Cryo-Optical Box Drawings Finished	30-Jan-02		17-Jun-02	
69	Vacuum Parts Delivered	31-Jan-02		27-May-02	
70	Telescope Simulator Engineered	31-Jan-02		21-Jun-02	
71	MUX Tested at Cold Temperature	1-Feb-02		1-Feb-02	
72	Requistions for Parts for Telescope Simulator Is	8-Feb-02		8-Feb-02	
73	Motor PCB Fabricated	8-Feb-02		24-Jun-02	
74	Communications with NI6533 Card Tested	20-Feb-02	20-Feb-02		0 d
75	Vacuum Enclosure Designed	22-Feb-02		10-Jun-02	
76	Upgrade Decision for 2nd Channel Made	28-Feb-02	10-Jun-02		31 d
77	Web Site Created	28-Feb-02	8-Mar-02		6 d
78	MLI Blanket Delivered	7-Mar-02		12-Jul-02	
79	Thermal Reflector Concept Analyzed	8-Mar-02	1-Mar-02		-6 d
80	Telescope Simulator Designed	11-Mar-02		19-Jul-02	
81	Parts for Telescope Simulator Delivered	13-Mar-02		13-Mar-02	
82	A-Frame Strut Fabricated	15-Mar-02	14-Dec-01		-65 d
83	Software Drives Detector Controller	20-Mar-02	14-Mar-02		-4 d
84	Mask Plate Finished	22-Mar-02	5-Jun-02		53 d
85	Thermal Reflector Designed	22-Mar-02	30-May-02		49 d
86	Vendor for Thermal Reflector Selected	22-Mar-02		15-Mar-02	
87	N2 Can Fabricated	28-Mar-02		6-Aug-02	
88	Detector Tested in Lab	2-Apr-02		2-Apr-02	
89	ArcView Drives Detector Controller	3-Apr-02		22-May-02	
90	Rotation Stage Controller & 2nd Stage Delivere	8-Apr-02		2-May-02	
91	Cryo-Optical Box Fabricated	9-Apr-02		23-Aug-02	
92	Detector Tested with Sky	10-Apr-02		10-Apr-02	
93	Software Drives Filter Wheels	10-Apr-02		31-May-02	

94	Filter Wheel Designed	12-Apr-02	26-Apr-02		10
95	Minimal Software Complete	24-Apr-02		19-Jun-02	
96	Detector Assembly Designed	30-Apr-02		30-Apr-02	
97	Reworked Electronics Finished	1-May-02		1-May-02	
98	GUI Complete	1-May-02		19-Jun-02	
99	Mirrors Delivered	6-May-02		4-Nov-02	
100	Window Delivered	9-May-02	2-May-02		-5
101	Baseline Software Complete	14-May-02		3-Jul-02	
102	Thermal Reflector Fabricated	15-May-02		23-Jul-02	
103	Telescope Simulator Fabricated	17-May-02		26-Sep-02	
104	Mirrors Installed in Mounts	20-May-02		18-Nov-02	
105	Mask Wheel Engineered	21-May-02	25-Feb-02		-61
106	Vacuum Enclosure Finished	24-May-02		29-Aug-02	
107	Mirror Mounts Engineered	31-May-02		31-May-02	
108	Mirror Mounts Detailed	12-Jun-02		12-Jun-02	
109	Collimator and Camera Mirror Mount Designed	14-Jun-02		24-Sep-02	
110	Mask Wheel Designed	18-Jun-02	15-May-02		-24
111	Cryo-Optical Box Thermal Test Finished	21-Jun-02		27-Sep-02	
112	Mirror Mounts Fabricated	10-Jul-02		10-Jul-02	
113	Filter Wheels Fabricated	12-Jul-02		12-Jul-02	
114	Field-Flattening Lenses Delivered	12-Jul-02		28-Aug-02	
115	Test Plan for Filter Wheel Written	12-Jul-02	13-May-02		-36
116	Detector Assembly Fabricated	15-Jul-02		15-Jul-02	
117	Detector Assembly Finished	22-Jul-02		23-Oct-02	
118	Focal-Plane Assembly Designed	23-Jul-02		23-Jul-02	
119	Mask Wheel Fabricated	31-Jul-02		27-Jun-02	
120	Filter Wheel #1 Tested Warm	7-Aug-02		7-Aug-02	
121	Focal-plane Assembly Fabricated	13-Aug-02		13-Aug-02	
122	Filter Wheel #1 Tested Cold	15-Aug-02		15-Aug-02	
123	Filter Wheel #2 Tested	22-Aug-02		11-Sep-02	
124	Mask Wheel Tested	3-Sep-02		31-Jul-02	
125	F/21 Collimator & Camera Mirrors Delivered [U	13-Sep-02		25-Dec-02	
126	2nd Collimator and Mirror Mount Fabricated	13-Sep-02		24-Dec-02	
127	Telescope Simulator Finished	7-Oct-02		14-Oct-02	
128	2nd Collimator and Mirror Mount Tested	17-Oct-02		23-Jan-03	
129	Basic Filters Delivered	13-Dec-02		13-Aug-02	
130	All Filters Delivered	13-Dec-02		13-Dec-02	
131	Instrument Assembled & Aligned at Room Tem	21-Jan-03		3-Mar-03	
132	Flexure Tested	28-Jan-03		10-Mar-03	
133	Draft Maintenance Manual Written	14-Feb-03		14-Feb-03	
134	Draft Software Manual Written	14-Feb-03		14-Feb-03	
135	Cold Test #1 Finished	18-Feb-03		31-Mar-03	
136	As-Built Drawing Package Assembled	28-Feb-03		28-Feb-03	
137	Draft Operating Manual Written	14-Mar-03		14-Mar-03	
138	Maintenance Manual Finished	31-Mar-03		31-Mar-03	
139	Software Manual Finished	31-Mar-03		31-Mar-03	
140	Draft Acceptance Test Written	31-Mar-03		31-Mar-03	
141	Shipping Container Finished	31-Mar-03		31-Mar-03	
142	Cold Tests Finished	11-Apr-03		22-May-03	
143	Operating Manual Finished	30-Apr-03		30-Apr-03	
144	Acceptance Test Written	7-May-03		7-May-03	
145	Pre-Ship Acceptance Test Finished, Integration	14-May-03		29-May-03	
146	Project Complete	10-Jun-03		18-Jun-03	