

STATUS REPORT FOR 4TH QUARTER OF 2001

Spartan IR Camera for the SOAR Telescope

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Milestones Completed During Nov 01-Jan 02

8-Nov-01	Flex Cable Finished
13-Nov-01	A-Frame Strut Engineered
19-Nov-01	Requisition for Detector PCB Issued
23-Nov-01	Master Layout Designed
27-Nov-01	Requisition for Coordinate-Measuring Machine Issued
28-Nov-01	Cryo-Optical Box Engineering Finished
30-Nov-01	A-Frame Strut 3D Designed
3-Dec-01	Detector Assembly Concept Developed
10-Dec-01	Rotation Stage Test Fixture Engineered
10-Dec-01	Specification for Filter Wheels Written
11-Dec-01	Computers for Laboratory Delivered
12-Dec-01	Controller Card CA Tested (Existing Computer)
12-Dec-01	Vacuum Bulkhead Delivered
14-Dec-01	A-Frame Strut Fabricated
19-Dec-01	Project Plan Finished
3-Jan-02	Method for Optical Alignment Created
7-Jan-02	Rotation Stage Test Fixture Designed

The project plan is the main focus of this quarterly report. Major milestones that occurred since the October monthly report are completion of testing the controller circuit board and fabrication of the first mechanical part, the A-frame struts.

1 Tasks

1.1 Requests for quotes for mirrors

Request for quotes for four off-axis mirrors, two flats, and aluminum cells were sent to Space Optics Research Laboratory (SORL) of Waltham, MA, Hastings Controls of Pittsburgh, PA, REOSC of France, and Axsys Technologies of Rochester Hills, MI. The mirrors are to be delivered in aluminum cells. By ordering both the mirror and cell from the vendor, we avoid the problem of designing for the thermal contraction between the mirrors and our all-aluminum mounting posts.

We are still waiting for SORL to submit a concept drawing of their bid.

Axsys Technologies builds aluminum mirrors. (The other companies build glass mirrors.) E Loh visited Axsys on December 7. Axsys submitted a quote.

Aluminum mirrors have two advantages that save time during alignment and installation of the optics. Because the mirror and cryogenic optical box are both made of the same material, the focus does not shift between installation at room temperature and operation at 77K. Design and fabrication of a focus shifting jig and the cool-down cycles needed to check focus are avoided. Second and more important, the surface and reference holes are machined under computer control. Because the surface is located precisely with respect to the reference holes, we can position the off-axis aspheric mirrors with a coordinate measuring machine. Optical alignment, which involves measuring the Strehl ratio of the images and adjustment of the mirrors position by trial and error, is not necessary.

1.2 Telescope simulator (SOBER)

CTIO plans to build a telescope simulator to test the Instrument Support Box (ISB), and Mike Davis has determined that it will serve our needs. Two modifications are necessary. We need to build an infrared light source with the capability of fine motion (4μ) in the direction transverse to the optical axis. A 750-mm extension is needed since the simulator bolts on the side of the ISB that attaches to the telescope. See Davis, M., and Loh, E., "Questar Simulator," 10 December 2001.

1.3 Detector controller

The detector controller is being tested in three stages. (See Table 1.) Each stage requires more of the circuits to be installed and upgrading of the program in the field-programmable-gate-array (FPGA). Controller A (CA) emulates an existing CCD controller, and it has been used to test the board as far as possible without connecting it to a detector. Controller B is fully functional; it awaits the test dewar.

The umbilical card links up to four detector controllers and a computer data card. The umbilical card UA has been tested with an existing CCD controller and existing software and computer. As UB, it has also been tested with CA. Testing with the new computer card awaits the software.

The detector card and the flexible cable serve two purposes. They connect the controller on the outside of the vacuum wall and the detector on the inside. In addition they conduct very little heat to the detector.

Table 1 Status of the electronics cards

<i>Stage</i>	<i>Function</i>	<i>Status</i>
<u>Controller</u>		
CA	Test all functions without detector	Completed 21 Nov 2001
CB	Test with detector	Waiting for test dewar
<u>Umbilical</u>		
UA	Test with existing camera and computer data cards	Completed before start of plan
UB	Test with SCA and existing computer data card	Completed 25 Sept 2001
UC	Test with NI6533 data card	Waiting for test software
<u>Detector</u>		
	Test that traces are functional	In progress
	Thermal test	Waiting for test dewar
<u>Flex cable</u>		
	Test that traces are functional	Completed 12 Nov 2001
	Thermal test	Waiting for test dewar

The test of the controller without a detector, a major milestone, is complete, and the results are presented below.

1.3.1 Noise and bandwidth

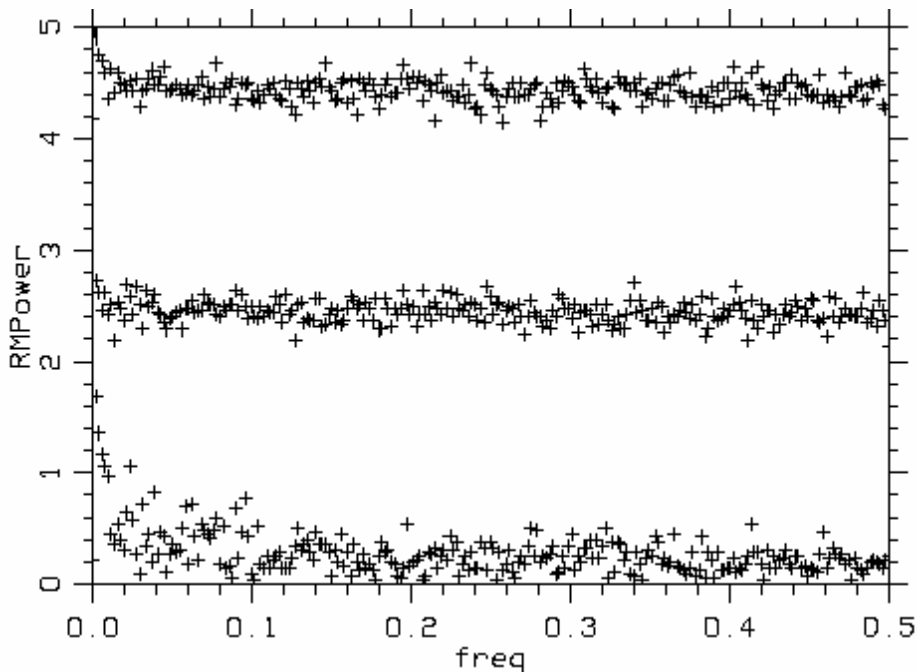
We measured the bandwidth of the signal chain to be 2.4 MHz, which means the time to settle to a part in 2^{12} is $0.55\mu\text{s}$.

We measured the noise of the controller board to be $14.8\mu\text{V}$ referenced to the input at a bandwidth of 2.4 MHz. The OPA350 op-amp and a $1\text{k}\Omega$ resistor contribute equally to the noise. The measured noise is within a few percent of the theoretically predicted noise.

The circuit will probably be run at $1/3$ the bandwidth, since the goal is to read at $3\mu\text{s}/\text{pixel}$. In that case the board produces a noise of $8.5\mu\text{V}$, which is equivalent to 2.4 electrons. The detector noise is less than 10 electrons (<http://www.rsc.rockwell.com/imaging/hawaii2/index.html>).

The $1/f$ noise is a concern, because the signal chain is DC coupled. The root mean power of the rows (middle spectrum in Fig. 6, offset by -2) is independent of spatial frequency. (The picture is read by rows.) The root mean power of the columns (top spectrum in Fig. 6) shows a slight rise at very low frequency. The root power of the average column (bottom spectrum in Fig. 6) shows a large amount of low frequency noise. The white noise is less by a factor of $\sqrt{512}$, but the low frequency excess is unchanged. This shows the low frequency noise is correlated over rows. The low frequency excess contains 5×10^{-4} of the power.

Figure 1 Caption: Root-mean-power of the columns (top) and of the rows (middle offset by 2) and the power of the average column (bottom) vs spatial frequency. For white noise, the standard deviation is $RMP/\sqrt{2}$. For sinusoidal noise, the amplitude is $RMP/16$. The picture is 512×512 .



1.3.2 High gain analog-to-digital converter

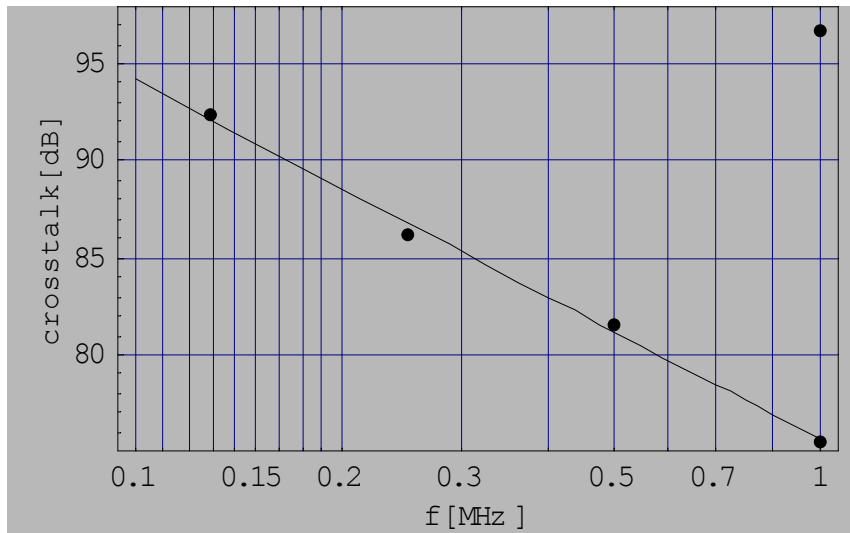
There are two analog-to-digital converters (ADC), one with gain 1 for large signals and one with gain 16 for low signals. The high gain ADC was mistakenly designed to operate for signal levels near saturation. This will be fixed in the next version of the board.

1.3.3 Crosstalk

We measured the crosstalk between channels. A sinusoidal signal was injected through the flexible cable, and we measured the signal in other channels. There is magnetic coupling on the circuit board: Placement of a steel Allen wrench near the board affects the crosstalk. Magnetic coupling between channels is not detectable on the flexible cable. The crosstalk (Figure 2) is directly proportional to frequency. At 1MHz, the coupling is 81dB between adjacent channels and 97dB between two channels separated by another.

The crosstalk is probably acceptable. A saturated channel ($400000e^-$) feeds $17 e^-$ into an adjacent channel and $1.5 e^-$ into the next channel with a pixel time of $4\mu s$. If not, the crosstalk can be removed with software.

Figure 2 Crosstalk between adjacent channels (line and points) and crosstalk between two channels separated by another channel (single point at 97dB).



1.3.4 Digital potentiometers

Digital potentiometers set the offset levels for each quadrant, the reset voltage, and bias gate. These are controlled by software. These function properly.

1.3.5 Temperature sensors

Diode temperature sensors are run and read out by a circuit on the card. The sensor that reads the board temperature functions properly. The circuit that reads the sensors that will be placed in the dewar functions properly.

1.3.6 Phase-locked loop

A phase-locked loop generates a clock from the master clock on the umbilical board. With a single master clock, all of the circuits are synchronous and no noise due to beating of different clocks is possible. The phase-locked loop has been checked.

2 Brazilian Collaboration

René Laporte has begun designing the filter wheels.

Project Management

We thank Neil Gaughan NOAO for teaching the PI rudimentary project planning and Dan Elkund of NOAO for making a well organized draft plan in Microsoft Project.

2.1 Budget

The budget (summary in Table 2) shows costs and labor. It includes the upgrade for the second focal ratio. It does not include the pyramidal mirror that is needed if more than two detectors are installed.

Costs in the budget are split into fixed costs and hourly costs. Fixed costs are purchases and fixed cost labor of J Biel, M Davis, and E Loh. Hourly costs, those that are charged by the hour, include the Physics-Astronomy machine shop, external shops, mechanical design, and mechanical drafting. Labor is split into fixed-cost labor, mechanical design, drafting, and the mechanical shops.

Table 2 Budget summary

WBS	Description	Cost [\$]			Labor [hr]				
		Cost	Continge	Total	FixedCos	Design	Drafting	Shop	Total
1	Spartan IR Camera	1,126,522	31,364	1,157,886	4,912	530	711	2,056	8,463
1.1	Project Management	161,619	0	161,619	1,020	0	0	0	1,020
1.2	System Engineering	1,148	0	1,148	336	38	0	0	374
1.3	Mechanical	361,560	24,004	385,564	1,029	368	647	1,696	3,885
1.4	Electronics	13,927	0	13,927	913	44	24	200	1,190
1.5	Software	10,800	0	10,800	0	0	0	0	100
1.6	Integration	3,800	0	3,800	1,089	40	40	80	1,249
1.7	Deliverables	20,800	0	20,800	328	40	0	80	448
1.8	Procurement	120,548	7,360	127,908	197	0	0	0	197
1.9	Preplan Spending	432,321	0	432,321	0	0	0	0	0

Project Management (detail in Table 3) includes creation and maintenance of the schedule and budget, meetings, reviews, reports, consultants for design reviews, travel in support of procurement, and fixed cost labor.

System Engineering (detail in Table 4) includes optical design, analysis, writing plans, writing requirements, and creating the master layout. The tasks in optical design are modifying the design to

fit with the mechanical design and creating a method of alignment. The master layout defines the envelopes of each assembly.

Mechanical (detail in Table 5) includes the cryogenic optical box, the thermal reflector, the vacuum enclosure, the filter wheels, rotational stages, mirrors and mounts, filters, and upgrades.

Electronics (detail in Table 6) includes the detector assembly and 4 electronic cards, which are the detector printed circuit board (PCB), the flexible cable between the detector PCB and controller PCB, the controller PCB, and the motor PCB. Most of the design work, fabrication of the controller, and fabrication and testing the umbilical PCB are in Preplan Spending, WBS 1.9.

Software is modification of ArcView.

Integration (detail in Table 7) includes the telescope simulator, installation of the optical assemblies in the cryogenic optical box using a coordinate measuring machine, check of the optical alignment, flexure tests, tests at 77K, tests of the images at 77K, and acceptance tests.

Deliverables (detail in Table 7) includes the manuals, the acceptance test plan, shipping, documentation, which are drawings of the parts as built, and installation at the telescope. The manuals are maintenance, operating, and software. Deliverables does not include commissioning.

Procurement (detail in Table 9) includes most of the purchased items. The mirrors, filters, and 2 rotation stages are in WBS 1.3.

Preplan Spending means funds that we spent or encumbered before 1 Sept 2001. The major item here is the cost of the detector, \$250,000, and labor spent in designing the instrument.

Contingency is done in this way: (1) For purchased item with a written vendor quote, the contingency is 5%. For purchased items without a formal quote, the contingency is 25% or greater. (2) For fixed-cost labor (Biel, Davis (1/2 time), and Loh), the number of hours in 22 months is 6600. With 4926 hours budgeted, the contingency is 25%. The addition of Laporte adds to the contingency. (3) For hourly labor, Gaughan and Loh tried to estimate times so that the task can be done comfortably.

Table 3 Summary budget for Project Management

WBS	Description	Cost [\$]			Labor [hr]				
		Cost	Continge	Total	FixedCos	Design	Drafting	Shop	Total
1.1	Project Management	161,619	0	161,619	1020	0	0	0	1020
1.1.1	Schedule & Budget	6,611	0	6,611	203	0	0	0	203
1.1.2	Weekly Meetings	0	0	0	270	0	0	0	270
1.1.3	Reviews	0	0	0	115	0	0	0	115
1.1.4	Monthly & Quarterly Reports	0	0	0	355	0	0	0	355
1.1.5	Manage	0	0	0	77	0	0	0	77
1.1.6	Consultants	10,000	0	10,000	0	0	0	0	0
1.1.7	Fixed Cost	140,008	0	140,008	0	0	0	0	0
1.1.8	Travel	5,000	0	5,000	0	0	0	0	0

Table 4 Summary budget for System Engineering

WBS	Description	Cost [\$]			Labor [hr]				
		Cost	Continge	Total	FixedCos	Design	Drafting	Shop	Total
1.2	System Engineering	1,148	0	1,148	336	38	0	0	374
1.2.1	Optics	0	0	0	41	0	0	0	41
1.2.2	Analysis	0	0	0	33	0	0	0	33
1.2.3	Plans	0	0	0	8	0	0	0	8
1.2.4	Requirements/ICDs/Review D	0	0	0	128	0	0	0	128
1.2.5	Software Requirements	0	0	0	109	0	0	0	109
1.2.6	Master Layout	1,148	0	1,148	17	38	0	0	55

Table 5 Budget summary for Mechanical

WBS	Description	Cost [\$]			Labor [hr]				
		Cost	Contingency	Total	FixedCos	Design	Drafting	Shop	Total
1.3	Mechanical	361,560	24,004	385,564	1029	368	647	1696	3885
1.3.1	Cryo-Optical Box	34,088	750	34,838	243	46	287	507	1229
1.3.1.1	MLI Blanket	4,047	750	4,797	37	16	23	0	75
1.3.1.2	CryoBox	19,880	0	19,880	171	16	160	270	741
1.3.1.3	Mask Plate	1,600	0	1,600	8	8	8	8	32
1.3.1.4	A-Frame	445	0	445	11	2	0	0	35
1.3.1.5	N2 Can	8,116	0	8,116	16	5	96	229	346
1.3.2	Thermal Reflector	3,880	0	3,880	31	16	16	0	63
1.3.3	Vacuum Enclosure	27,380	0	27,380	18	40	100	296	454
1.3.4	Filter Wheel	12,400	0	12,400	174	80	136	280	670
1.3.5	Rotational Stage	50,050	2,393	52,443	37	20	0	80	137
1.3.6	Mirrors & Mounts	98,575	4,799	103,374	187	20	8	80	295
1.3.6.1	Mirrors	95,975	4,799	100,774	47	0	0	0	47
1.3.6.2	Mounts	2,600	0	2,600	140	20	8	80	248
1.3.7	Filters	51,000	12,750	63,750	8	0	0	0	8
1.3.8	Upgrades	84,186	3,313	87,499	330	146	100	452	1029
1.3.8.1	2nd Channel Mirrors & Mounts	80,055	3,313	83,368	214	120	80	360	774
1.3.8.2	Mask Wheel Upgrade	4,131	0	4,131	116	26	20	92	255

Table 6 Budget summary for Electronics

WBS	Description	Cost [\$]			Labor [hr]				
		Cost	Contingency	Total	FixedCos	Design	Drafting	Shop	Total
1.4	Electronics	13,927	0	13,927	913	44	24	200	1190
1.4.1	Detector Assembly	6,920	0	6,920	535	44	24	200	803
1.4.2	Electronic Hardware	7,007	0	7,007	378	0	0	0	387
1.4.2.1	Detector PCB	1,802	0	1,802	79	0	0	0	79
1.4.2.2	Flexible Cable	4,125	0	4,125	49	0	0	0	49
1.4.2.3	Controller Card	80	0	80	227	0	0	0	236
1.4.2.4	Motor PCB	1,000	0	1,000	24	0	0	0	24

Table 7 Budget summary for Integration

WBS	Description	Cost [\$]			Labor [hr]				
		Cost	Contingency	Total	FixedCos	Design	Drafting	Shop	Total
1.6	Integration	3,800	0	3,800	1089	40	40	80	1249
1.6.1	Telescope Simulator	3,800	0	3,800	271	40	40	80	431
1.6.2	Integration	0	0	0	818	0	0	0	818
1.6.2.1	Install optics	0	0	0	48	0	0	0	48
1.6.2.2	Optical Alignment	0	0	0	155	0	0	0	155
1.6.2.3	Flexure Test	0	0	0	44	0	0	0	44
1.6.2.4	Cold Tests	0	0	0	375	0	0	0	375
1.6.2.5	Image Tests	0	0	0	117	0	0	0	117
1.6.2.6	Acceptance Tests	0	0	0	79	0	0	0	79

Table 8 Budget summary for Deliverables

WBS	Description	Cost [\$]			Labor [hr]				
		Cost	Continge	Total	FixedCos	Design	Drafting	Shop	Total
1.7	Deliverables	20,800	0	20,800	328	40	0	80	448
1.7.1	Manuals	0	0	0	183	0	0	0	183
1.7.1.1	Maintenance	0	0	0	48	0	0	0	48
1.7.1.2	Operating	0	0	0	48	0	0	0	48
1.7.1.3	Software	0	0	0	87	0	0	0	87
1.7.2	Acceptance Test	0	0	0	120	0	0	0	120
1.7.3	Pack & Ship	4,600	0	4,600	25	0	0	80	105
1.7.4	Documentation	1,200	0	1,200	0	40	0	0	40
1.7.5	Installation	15,000	0	15,000	0	0	0	0	0

Table 9 Budget summary for Procurement

WBS	Description	Cost [\$]			Labor [hr]				
		Cost	Continge	Total	FixedCos	Design	Drafting	Shop	Total
1.8	Procurement	120,548	7,360	127,908	197	0	0	0	197
1.8.1	Procure Computers for Labora	2,400	0	2,400	7	0	0	0	7
1.8.2	Procure Solidworks License	1,645	0	1,645	0	0	0	0	0
1.8.3	Procure Dust-free Hood	3,000	150	3,150	11	0	0	0	11
1.8.4	Procure Parts for Test Dewar	2,000	500	2,500	20	0	0	0	20
1.8.5	Procure Field-flattening Lens	2,000	0	2,000	40	0	0	0	40
1.8.6	Procure Vacuum Bulkhead	4,300	0	4,300	6	0	0	0	6
1.8.7	Procure 4 Additional Rotation	62,040	3,102	65,142	4	0	0	0	4
1.8.8	Procure Parts for Vacuum End	7,163	358	7,521	62	0	0	0	62
1.8.9	Procure Parts for Telescope S	500	125	625	20	0	0	0	20
1.8.10	Procure Window	8,000	2,000	10,000	20	0	0	0	20
1.8.11	Procure Coordinate Measuring	22,500	1,125	23,625	8	0	0	0	8
1.8.12	Misc Supplies	5,000	0	5,000	0	0	0	0	0

2.2 Schedule

A summary Gantt chart is in Figure 3. The density of milestones indicates the succession of the tasks. System Engineering tapers off around Jan 2002. Mechanical has a high density during design and fabrication, which tapers off around September 2002. Electronics is mostly finished by February 2002.

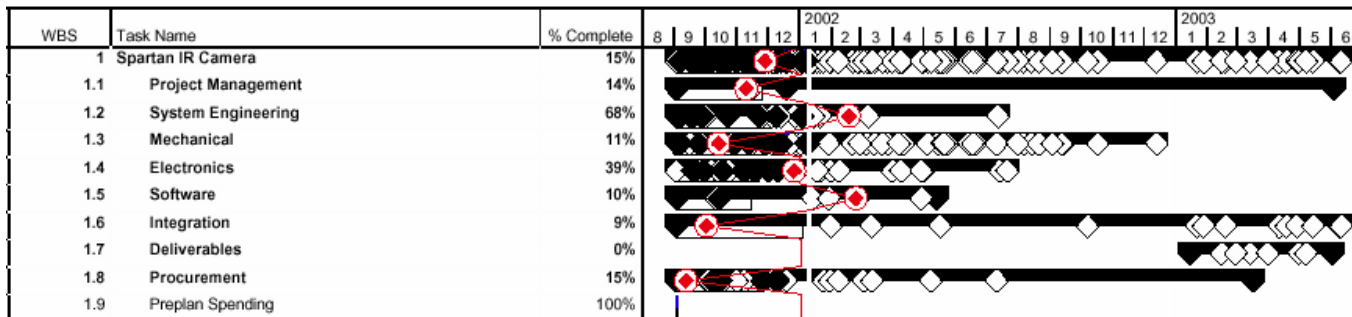


Figure 3 Gantt chart of top-level and next-to-top-level tasks. Milestones are marked with empty diamonds at the scheduled time and with filled diamonds at the actual completion date. The red progress line drawn to the right (left) of the 6 Jan 2002 indicates the task to be ahead (behind) schedule.

The detailed tracking Gantt chart is attached at the end of this document. A very long chart, it is best read with the organization of next-to-top-level chart (figure 3) in mind. Identifications of predecessor tasks are shown to the left of the task bar, and identifications of successors are shown to the right. For most tasks, the link is “finish-to-start,” the finish of one triggers the start of the successor. Where that is not the case, the indication SS means “start-to-start,” and FF means “finish-to-finish.”

2.3 Project summary

The project summary is in the table below.

The project dates have not changed.

The Duration is amount of time need for a task, which is 460 working days for the entire project. The Actual Duration is the product of Duration and Percent Complete, which is the total length of time of the completed tasks divided by the length of time for all tasks. As far as I can tell this is not a useful metric, since the Duration of tasks is weighted more heavily toward the beginning of the project.

Work is the amount of labor needed for a task. The scheduled work is 160 hr less than the baseline amount. The major variances are 238 hr less for the design and fabrication of the A-frame struts, 75 hr less for the design of the nitrogen can, and 137 hr more for electronics.

The cost is \$4851 less than the baseline. The major cost variances are \$5155 less for the design and fabrication of the A-frame struts, \$1945 less for the design of the nitrogen can, and \$1000 more for the motor PBC, which was not in the baseline.

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:	389.44 d?
Baseline:	461 d?	Actual:	70.56 d
Variance:	-1 d?	Percent Complete:	15%

Work			
Scheduled:	8,572.83 h	Remaining:	7,115.57 h
Baseline:	8,733.15 h	Actual:	1,457.27 h
Variance:	-160.32 h	Percent Complete:	17%

Costs			
Scheduled:	\$1,126,522	Remaining:	\$601,986
Baseline:	\$1,131,372	Actual:	\$524,536
Variance:	(\$4,851)		

Task Status		Resource Status	
Tasks not yet started:	440	Work Resources:	4
Tasks in progress:	47	Overallocated Work Resources:	7
Tasks completed:	128	Material Resources:	0
Total Tasks:	615	Total Resources:	11

2.4 Earned value analysis

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.

The earned value analysis of the schedule shows several tasks are behind schedule. (See columns BCWS, BCWP, and SV of Table 10.) The “schedule variance,” SV, shows \$92k of work should have been performed but has not. The greatest part is in WBS 1.3, “Mechanical,” and the major problem is that the mirrors have not been ordered. The second largest part is WBS 1.8, and that is

due to the late delivery of the coordinate measuring machine caused by the delay in the completion of the new science building.

The earned value analysis of the cost shows small variances. (See columns BCWP, ACWP, CV, and VAC of Table 10.) The “cost variance,” CV, and “variance at completion,” VAC, are small. The task with the largest cost variance is WBS 1.3.1.4, “A-Frame Struts,” where the budgeted and actual costs are \$5600 and \$445. However, the orders for the mirrors, the most costly items, have not been placed.

Table 10 Earned value analysis. A positive “schedule variance,” SV, indicates the project is ahead of schedule. A positive “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	\$623,726	\$531,233	\$523,936	(\$92,493)	\$7,298	\$1,126,522	\$1,131,372	\$4,851
1.1	Project Management	\$40,673	\$39,403	\$39,561	(\$1,270)	(\$158)	\$161,619	\$161,619	\$0
1.2	System Engineering	\$720	\$720	\$1,088	\$0	(\$368)	\$1,148	\$720	(\$428)
1.3	Mechanical	\$92,250	\$32,410	\$24,365	(\$59,840)	\$8,045	\$361,560	\$368,060	\$6,500
1.4	Electronics	\$8,785	\$5,785	\$6,007	(\$3,000)	(\$222)	\$13,927	\$12,705	(\$1,222)
1.5	Software	\$7,955	\$0	\$0	(\$7,955)	\$0	\$10,800	\$10,800	\$0
1.6	Integration	\$0	\$0	\$0	\$0	\$0	\$3,800	\$3,800	\$0
1.7	Deliverables	\$0	\$0	\$0	\$0	\$0	\$20,800	\$20,800	\$0
1.8	Procurement	\$41,024	\$20,595	\$20,595	(\$20,429)	\$0	\$120,548	\$120,548	\$0
1.9	Preplan Spending	\$432,321	\$432,321	\$432,321	\$0	\$0	\$432,321	\$432,321	\$0

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 value cost variance; $CV=BCWP-ACWP$.
 EAC Estimate at completion
 BAC Budget at completion
 VAC Variance at completion; $VAC=BAC-EAC$

2.5 Milestones

The time-phased completion of the milestones is in Figure 2, and a complete list of milestones is in Table 12 in the Appendix. The number of milestones grows until June 2002, and then slows when the design work ramps down and fabrication ramps up.

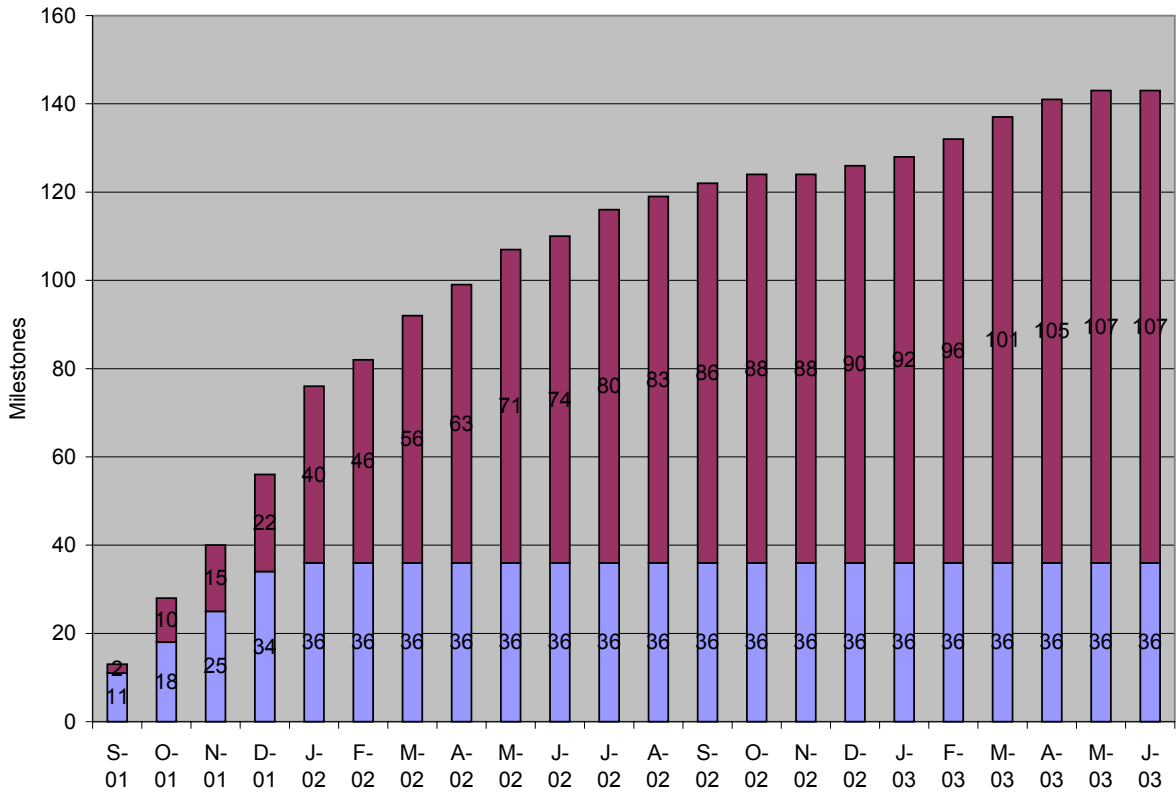
At the end of December 2001, 34 milestones are complete, and 24 are unfinished, and 2 that are due later are finished.

Table 11 Reasons for missed milestones.

Reason	Milestones Missed Sep-Dec 2001
Vendor	6
Schedule	2
Designer/Drafter	5
Manager	1
Technician	4
Engineer	4
Analyst	2
	24

An analysis shows the causes (Table 11) for delays. Vendors are responsible for 6. Changes in schedule are delay in the new building and a delay in a decision on whether a dust-proof hood is needed. A full-time designer/drafter would have alleviated 5 missed milestones. Loh (manager & engineer), Biel (technician), and Davis (analyst) are over committed.

Figure 4 Cumulative number of milestones completed (blue) and not completed (magenta) vs. date.



2.6 Critical Issues

Although all tasks have some slack at present, several issues need work.

The mirror fabrication must start soon. We have set a deadline for SORL of 16 January to submit a quote.

Mechanical design and drafting are behind schedule. We are trying to hire a mechanical designer. The plan is for the Cyclotron to hire him and to assign him to this project for 6 months.

3 Appendix

Table 12 Milestones

























Milestone	Date			Variance
	Baseline	Completed	Scheduled	
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 Requisition for Vacuum Blukhead Issued	17-Sep-01	7-Sep-01		-6 d
6 A-Frame Strut Engineered	17-Sep-01	13-Nov-01		42 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 CA Tested (Existing Computer)	21-Sep-01	12-Dec-01		58 d
10 Detector Physical Dimensions Measured	24-Sep-01	20-Sep-01		-2 d
11 Requisition for Detector PCB Issued	28-Sep-01	19-Nov-01		36 d
12 Requisition for Mirrors Issued	28-Sep-01		18-Dec-01	
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 Dust-free Hood Issued	4-Oct-01		4-Oct-01	
17 Requisition for Coordinate-Measuring Machine	5-Oct-01	27-Nov-01		37 d
18 Detector Assembly Concept Developed	8-Oct-01	3-Dec-01		40 d
19 Solidworks License Delivered	11-Oct-01	9-Oct-01		-2 d
20 Mounting Blocks Engineered	12-Oct-01	26-Sep-01		-12 d
21 Select SW Vendor	12-Oct-01	16-Oct-01		1 d
22 Test-Dewar Concept Sketch Finished	15-Oct-01	19-Oct-01		4 d
23 Vacuum Bulkhead Delivered	15-Oct-01	12-Dec-01		42 d
24 N2 Can Designed	18-Oct-01		18-Oct-01	
25 Requisitions for Computer for Laboratory Issued	19-Oct-01	17-Oct-01		-2 d
26 Detector Holder Prototype Designed	25-Oct-01		25-Oct-01	
27 Mounting Blocks Designed	29-Oct-01		29-Oct-01	
28 Rotation Stage Test Fixture Engineered	31-Oct-01	10-Dec-01		28 d
29 Coordinate-Measuring Machine Delivered	2-Nov-01		2-Nov-01	
30 Rotation Stage Test Fixture Designed	7-Nov-01	7-Jan-02		44 d
31 Flex Cable Finished	9-Nov-01	8-Nov-01		-1 d
32 Computers for Laboratory Delivered	9-Nov-01	11-Dec-01		22 d
33 Cryo-Optical Box Engineering Finished	16-Nov-01	28-Nov-01		8 d
34 Project Plan Finished	16-Nov-01	19-Dec-01		24 d
35 Detector Holder Prototype Fabricated	19-Nov-01		19-Nov-01	
36 Test-Dewar Fabricated	19-Nov-01		19-Nov-01	
37 Detector PCB Finished	21-Nov-01		21-Nov-01	
38 Master Layout Designed	26-Nov-01	23-Nov-01		-1 d

39	Rotation Stage Delivered	29-Nov-01		29-Nov-01	
40	A-Frame Strut 3D Designed	30-Nov-01	30-Nov-01		0 d
41	Specifications for Vacuum Enclosure Written	6-Dec-01	24-Oct-01		-31 d
42	Requisition for Field-flattening Lenses Issued	7-Dec-01		7-Dec-01	
43	Rotation Stage Test Fixture Fabricated	7-Dec-01		10-Dec-01	
44	Mask Plate Engineering Finished	7-Dec-01		7-Dec-01	
45	Requisition for Window Issued	10-Dec-01		10-Dec-01	
46	MLI Requisition Issued	10-Dec-01		10-Dec-01	
47	Flex Cable/Bulkhead Assemble Finished	11-Dec-01		11-Dec-01	
48	Specification for Filter Wheels Written	14-Dec-01	10-Dec-01		-4 d
49	Rotation Stage Tested	14-Dec-01		14-Dec-01	
50	Mounting Blocks Fabricated	14-Dec-01		14-Dec-01	
51	Requisition for Parts for Test Dewar Issued	14-Dec-01		14-Dec-01	
52	Joined Filter Consortium	14-Dec-01		14-Dec-01	
53	Requisitions for Vacuum Parts Initiated	20-Dec-01		20-Dec-01	
54	Requisition for Rotation Stage Controller & 2nd	25-Dec-01		25-Dec-01	
55	Cable for Motors Analyzed	28-Dec-01		28-Dec-01	
56	Mask Plate Designed	28-Dec-01		28-Dec-01	
57	Detector Holder Prototype Thermal Test Finishe	1-Jan-02		1-Jan-02	
58	Vacuum Enclosure Engineered	3-Jan-02	31-Oct-01		-46 d
59	MLI Designed	8-Jan-02		8-Jan-02	
60	Thermal Reflector Engineered	9-Jan-02		9-Jan-02	
61	Communications Test Software Delivered	14-Jan-02		14-Jan-02	
62	Requirements for Window Written	15-Jan-02		15-Jan-02	
63	Requirements for Field-Flattening Lens Written	15-Jan-02		15-Jan-02	
64	Requirements for Telescope Simulator Modified	15-Jan-02		15-Jan-02	
65	Requirements for Pyramidal MirrorWritten	15-Jan-02		15-Jan-02	
66	Motor PCB Designed	18-Jan-02		18-Jan-02	
67	Filter Wheel Mounting Block Specified	21-Jan-02	21-Sep-01		-87 d
68	MUX Tested at Room Temperature	22-Jan-02		22-Jan-02	
69	Parts for Test Dewar Delivered	25-Jan-02		25-Jan-02	
70	Basic Software Delivered	30-Jan-02		30-Jan-02	
71	Motor Software Delivered	30-Jan-02		30-Jan-02	
72	Complete Software Delivered	30-Jan-02		30-Jan-02	
73	Reworked Software Delivered	30-Jan-02		30-Jan-02	
74	Cryo-Optical Box Drawings Finished	30-Jan-02		13-Feb-02	
75	Vacuum Parts Delivered	31-Jan-02		31-Jan-02	
76	Telescope Simulator Engineered	31-Jan-02		31-Jan-02	
77	MUX Tested at Cold Temperature	1-Feb-02		1-Feb-02	
78	Requistions for Parts for Telescope Simulator Is	8-Feb-02		8-Feb-02	
79	Motor PCB Fabricated	8-Feb-02		8-Feb-02	
80	Vacuum Enclosure Designed	22-Feb-02		22-Feb-02	
81	Hardware & Software Tested	26-Feb-02		26-Feb-02	
82	Upgrade Decision for 2nd Channel Made	28-Feb-02		28-Feb-02	
83	Dust-Free Hood Delivered	5-Mar-02		5-Mar-02	
84	MLI Blanket Delivered	7-Mar-02		7-Mar-02	
85	Thermal Reflector Concept Analyzed	8-Mar-02		8-Mar-02	
86	Telescope Simulator Designed	11-Mar-02		11-Mar-02	
87	Parts for Telescope Simulator Delivered	13-Mar-02		13-Mar-02	
88	A-Frame Strut Fabricated	15-Mar-02	14-Dec-01		-65 d
89	Mask Plate Finished	22-Mar-02		22-Mar-02	
90	Thermal Reflector Designed	22-Mar-02		22-Mar-02	

91	Vendor for Thermal Reflector Selected	22-Mar-02	22-Mar-02
92	N2 Can Fabricated	28-Mar-02	28-Mar-02
93	Detector Tested in Lab	2-Apr-02	2-Apr-02
94	Rotation Stage Controller & 2nd Stage Delivered	8-Apr-02	8-Apr-02
95	Cryo-Optical Box Fabricated	9-Apr-02	23-Apr-02
96	Detector Tested with Sky	10-Apr-02	10-Apr-02
97	Filter Wheel Designed	12-Apr-02	12-Apr-02
98	Detector Assembly Designed	30-Apr-02	30-Apr-02
99	Scripts Tested	30-Apr-02	30-Apr-02
100	Reworked Electronics Finished	1-May-02	1-May-02
101	Mirrors Delivered	6-May-02	8-Aug-02
102	Window Delivered	9-May-02	9-May-02
103	Thermal Reflector Fabricated	15-May-02	15-May-02
104	Telescope Simulator Fabricated	17-May-02	17-May-02
105	Mirrors Installed in Mounts	20-May-02	22-Aug-02
106	Mask Wheel Engineered	21-May-02	21-May-02
107	Vacuum Enclosure Finished	24-May-02	24-May-02
108	Collimator and Camera Mirror Mount Designed	14-Jun-02	14-Jun-02
109	Mask Wheel Designed	18-Jun-02	18-Jun-02
110	Cryo-Optical Box Thermal Test Finished	21-Jun-02	21-Jun-02
111	Filter Wheels Fabricated	12-Jul-02	12-Jul-02
112	Field-Flattening Lenses Delivered	12-Jul-02	12-Jul-02
113	Test Plan for Filter Wheel Written	12-Jul-02	12-Jul-02
114	Detector Assembly Fabricated	15-Jul-02	15-Jul-02
115	Detector Assembly Finished	22-Jul-02	22-Jul-02
116	Mask Wheel Fabricated	31-Jul-02	31-Jul-02
117	Filter Wheel #1 Tested Warm	7-Aug-02	7-Aug-02
118	Filter Wheel #1 Tested Cold	15-Aug-02	15-Aug-02
119	Filter Wheel #2 Tested	22-Aug-02	22-Aug-02
120	Mask Wheel Tested	3-Sep-02	3-Sep-02
121	Procure F/21 Collimator & Camera Mirrors Delivered	13-Sep-02	18-Sep-02
122	2nd Collimator and Mirror Mount Fabricated	13-Sep-02	13-Sep-02
123	Telescope Simulator Finished	7-Oct-02	7-Oct-02
124	2nd Collimator and Mirror Mount Tested	17-Oct-02	17-Oct-02
125	Basic Filters Delivered	13-Dec-02	13-Dec-02
126	All Filters Delivered	13-Dec-02	13-Dec-02
127	Instrument Assembled & Aligned at Room Temp	21-Jan-03	21-Jan-03
128	Flexure Tested	28-Jan-03	28-Jan-03
129	Draft Maintenance Manual Written	14-Feb-03	14-Feb-03
130	Draft Software Manual Written	14-Feb-03	14-Feb-03
131	Cold Test #1 Finished	18-Feb-03	18-Feb-03
132	As-Built Drawing Package Assembled	28-Feb-03	28-Feb-03
133	Draft Operating Manual Written	14-Mar-03	14-Mar-03
134	Maintenance Manual Finished	31-Mar-03	31-Mar-03
135	Software Manual Finished	31-Mar-03	31-Mar-03
136	Draft Acceptance Test Written	31-Mar-03	31-Mar-03
137	Shipping Container Finished	31-Mar-03	31-Mar-03
138	Cold Tests Finished	11-Apr-03	11-Apr-03
139	Image Quality Tested in Laboratory	18-Apr-03	18-Apr-03
140	Image Quality Tested on Sky	28-Apr-03	28-Apr-03
141	Operating Manual Finished	30-Apr-03	30-Apr-03
142	Acceptance Test Written	7-May-03	7-May-03
143	Pre-Ship Acceptance Test Finished, Integration Complete	14-May-03	14-May-03
144	Project Complete	10-Jun-03	10-Jun-03

ID	WBS	Task Name	% Complete	2002												2003											
				8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	
1	1	Spartan IR Camera	15%																								
2	1.1	Project Management	14%																								
3	1.1.1	Schedule & Budget	28%																								
4	1.1.1.1	Create Project Plan [Gaughan & Eklund]	100%																								
5	1.1.1.2	Modify Project Plan	100%																								
6	1.1.1.3	Project Plan Finished	100%																								
7	1.1.1.4	Maintain Schedule & Budget	11%																								
27	1.1.2	Weekly Meetings	19%																								
118	1.1.3	Reviews	0%																								
119	1.1.3.1	Cryo-Optical Box Review	0%																								
120	1.1.3.2	Rotational Stage Review	0%																								
121	1.1.3.3	Detector Assembly Prototype Review	0%																								
122	1.1.3.4	Progress Review	0%																								
123	1.1.4	Monthly & Quarterly Reports	21%																								
144	1.1.5	Manage	1%																								
145	1.1.6	Consultants	0%																								
146	1.1.6.1	Engineering	0%																								
147	1.1.7	Fixed Cost	23%																								
170	1.1.8	Travel	21%																								
174	1.2	System Engineering	68%																								
175	1.2.1	Optics	100%																								
176	1.2.1.1	Iterate Optical Design	100%																								
177	1.2.1.2	Optical Design Finished	100%																								
178	1.2.1.3	Create Method for Optical Alignment	100%																								
179	1.2.1.4	Method for Optical Alignment Created	100%																								
180	1.2.2	Analysis	0%																								
181	1.2.2.1	Analyze Thermal Reflector Concept	0%																								
182	1.2.2.2	Thermal Reflector Concept Analyzed	0%																								
183	1.2.2.3	Analyze Cable for Motors	0%																								
184	1.2.2.4	Cable for Motors Analyzed	0%																								
185	1.2.3	Plans	0%																								
186	1.2.3.1	Write Test Plan for Filter Wheel	0%																								
187	1.2.3.2	Test Plan for Filter Wheel Written	0%																								
188	1.2.4	Requirements/ICDs/Review Designs	89%																								
189	1.2.4.1	Write Requirements for Optical Alignment	100%																								
190	1.2.4.2	Requirements for Optical Alignment Written	100%																								
191	1.2.4.3	Write Vacuum Enclosure & Cryo Box ICD	100%																								
192	1.2.4.4	Vacuum Enclosure & Cryo Box ICD Written	100%																								
193	1.2.4.5	Review Vacuum Enclosure Design	100%																								
194	1.2.4.6	Write Specifications for Vacuum Enclosure	100%																								
195	1.2.4.7	Specifications for Vacuum Enclosure Written	100%																								
196	1.2.4.8	Specify Filter Wheel Mounting Block	100%																								
197	1.2.4.9	Filter Wheel Mounting Block Specified	100%																								
198	1.2.4.10	Write Specification for Filter Wheels	100%																								
199	1.2.4.11	Specification for Filter Wheels Written	100%																								
200	1.2.4.12	Write Requirements for Window	0%																								
201	1.2.4.13	Requirements for Window Written	0%																								
202	1.2.4.14	Write Requirements for Field-Flattening Lens	0%																								
203	1.2.4.15	Requirements for Field-Flattening Lens Written	0%																								
204	1.2.4.16	Modify Requirements for Telescope Simulator	0%																								
205	1.2.4.17	Requirements for Telescope Simulator Modified	0%																								
206	1.2.4.18	Write Requirements for Pyramidal Mirror	0%																								
207	1.2.4.19	Requirements for Pyramidal Mirror Written	0%																								
208	1.2.5	Software Requirements	100%																								
209	1.2.5.1	Write Software Requirements	100%																								
210	1.2.5.2	Software Requirements Written	100%																								
211	1.2.6	Master Layout	95%																								
212	1.2.6.1	Engineer Master Layout	100%																								
213	1.2.6.2	Design Master Layout	100%																								
214	1.2.6.3	Master Layout Designed	100%																								
215	1.2.6.4	Revise Master Layout	0%																								
216	1.2.6.5	Revise Design of Master Layout	0%																								
217	1.3	Mechanical	11%																								
218	1.3.1	Cryo-Optical Box	14%																								
219	1.3.1.1	MLI Blanket	3%																								

Project: Spartan-01-11-11
Date: Thu 1/10/02

Critical		Milestone		Rolled Up Baseline	
Critical Split		Summary Progress		Rolled Up Baseline Milestone	
Critical Progress		Summary		Rolled Up Milestone	
Task		Rolled Up Critical		External Tasks	
Split		Rolled Up Critical Split		Project Summary	
Task Progress		Rolled Up Critical Progress		External Milestone	
Baseline		Rolled Up Task		Deadline	
Baseline Split		Rolled Up Split			
Baseline Milestone		Rolled Up Task Progress	