SPARES

Spartan IR Camera for the SOAR Telescope

Edwin D. Loh

Department of Physics & Astronomy
Michigan State University, East Lansing, MI 48824

Loh@pa.msu.edu 517 355–9200 x2480

18 June 2003

This note (1) identifies downtime and costs of equipment failure, (2) recommends a model for making repairs, (3) presents a recommended set of spares (for $40k), and (4) recommends purchase of a priority set (for $29k) of spares immediately.

1 Operating Model for Repairing Equipment

The goal is to minimize downtime.

The Spartan Camera is made of several units, the vacuum enclosure, the electronics box, the computer, and the rack in the insulated enclosure (Figure 1); failures in each require different action. We plan to write a procedure for diagnostics so help SOAR staff isolate the problem.

- If the failure is inside the vacuum enclosure, the minimum downtime is about a week, since repair requires first warming the instrument and breaking vacuum. The need is to have spares where the lead time for replacement is long.

- If the failure is in the computer, a replacement computer will be used. The replacement has all cards and software installed. Change of the computer requires less than an hour.

- If the failure is a part in the rack other than the computer, a spare is used, installation of which requires less than 15 minutes.

- If the failure is in the electronics, our model for recovery is this.

    - SOAR staff is responsible for determining which circuit board (PCB) or cable has failed. Diagnostics will be in the documentation.

- SOAR staff will replace the failed part with a spare for these parts: (1) Detector PCB, (2) Detector Cable, (3) Detector Controller PCB, (4) Umbilical Cable, (5) Umbilical PCB, (6) Data Card, and (7) Motor PCB. SOAR staff will repair the Motor Cabling.

- If MSU has resources and knowledgeable staff to fix the failed part, SOAR staff may send the part to MSU for repair.

There are scenarios for failure that will require a downtime of months and great cost to repair, where the cost for spares is too high. (1) If the window fails and moist air continues to enter the vacuum enclosure, the bearings in the rotation stages will be ruined. Covering the window soon after failure may save the rotation stages. We will install a software alarm to sense failure of the vacuum. (2) If the window fails catastrophically, glass may embed in the collimating mirrors.

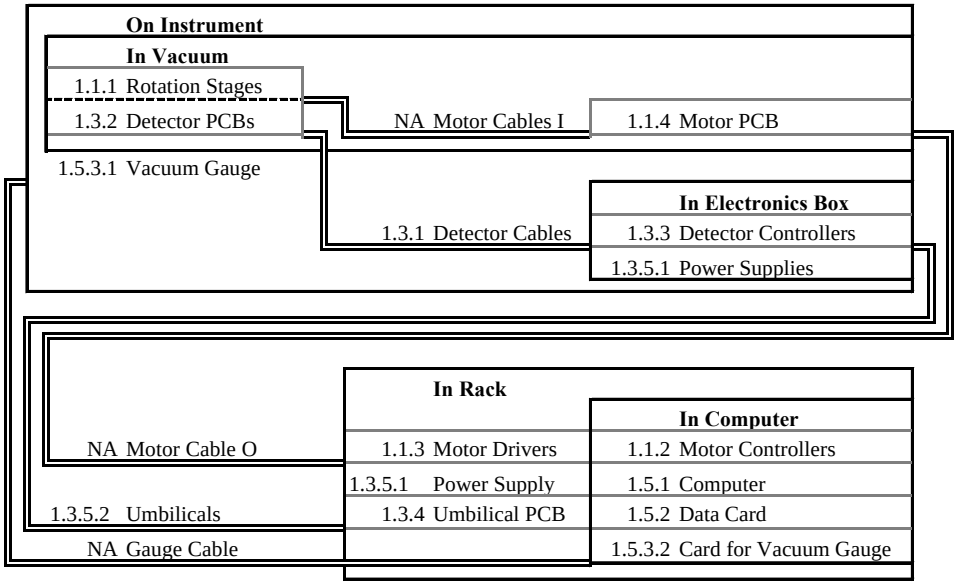

Figure 1 Diagram showing location of spare parts. The number is the WBS code. The "rack" is in the insulated enclosure supplied by the observatory.

2 Parts

We identify three lists of spare parts: a "complete" set, an "immediate" set, and a "recommended" set. (See the summary WBS in Table 1.) We need to purchase the immediate set before the staff leaves the project. Special knowledge is needed, and training new staff at a later date is not

practical. The recommended set is required to meet the requirements of the operating model. After the immediate set is done, some additional parts will be purchased at a later time to fulfill the recommended set. Finally, purchase of a window completes the complete set.

Table 1 WBS of Spare Parts, showing cost and labor. “Complete” is the entire set. “Immediate” are parts that must be bought immediately before the staff leaves. “Recommended” are parts needed to meet the requirements of the operating model.

WBS	Task	Lead	Complete		Immediate		Recommended	
		[wk]	[$]	[hr]	[$]	[hr]	[$]	[hr]
1	Spare Parts	25	46,250	256	29,387	216	39,633	256
1.1	Mechanisms	25	21,987	64	16,514	48	21,987	64
1.2	Gaskets	2	245	0	245	0	245	0
1.3	Electronics	16.6	12,628	168	12,628	168	12,628	168
1.4	Optics	12	6,617	0	0	0	0	0
1.5	Computer	6	4,773	24	0	0	4,773	24

The remaining describes the parts in mode detail. Refer to Table 2 for the WBS.

2.1 Mechanisms (WBS 1.1)

The mechanisms consist of six rotation stages, two motor controllers (National Instruments PCI-7344) for Windows PCs, and two motor drivers (National Instruments MID-7604).

2.1.1 Rotation Stage (WBS 1.1.1)

The rotation stages are PRS-110s that have been optimized for high stiffness at low temperature. They have a long lead time. We recommend purchasing one.

2.1.2 Motor Controller & Driver (WBS 1.1.2 & 1.1.3)

The motor controllers and drivers are off-the-shelf. It is very likely that they will become obsolete during the next 10 years. Use of the exact model is required if the software is to be used without modification. (We discovered that the motor driver does not remember the position after power to the motor is shut off, and we wrote the software to compensate for that.) We recommend purchasing a set.

2.1.3 Motor PCB (WBS 1.1.4)

The motor PCB is a distribution panel with high thermal resistance.

2.2 Gaskets (WBS 1.2)

2.2.1 Filter Access (WBS 1.2.1)

The port in the vacuum enclosure for accessing the filter wheels has a copper gasket, which must be replaced each time it is opened. Opening should be very infrequent (once a semester, for example) since it requires warming the detector and breaking vacuum.

2.2.2 Other Gaskets (WBS 1.2.2 & 1.2.3)

We recommend a set of these gaskets, since they are inexpensive.

2.3 Electronics (WBS 1.3)

The immediate concern is that the electronics spares are done before the end of the project when staff is laid off. Our technician has special knowledge needed to have vendors fabricate the boards and special knowledge for testing the boards.

2.3.1 Detector Cable (WBS 1.3.1)

The detector cable, which runs from the detector board in vacuum to the controller board in air, is a set of five flexible cables potted in a vacuum bulkhead. Possible failures are a vacuum leak or a break in the trace. We recommend a spare, since the lead time is very long.

2.3.2 Other PCBs (WBS 1.3.2–1.3.4)

We recommend one spare PCB of each kind.

2.3.3 Miscellany (WBS 1.3.5)

The same power supply is used for all boards. We recommend one spare.

The umbilical is a fiber-optic cable with two fibers. We recommend one spare. This should be protected against mice.

2.4 Optics (WBS 1.4)

The window may become scratched or damaged, although the likelihood of that is difficult to estimate. SOAR may want a spare.

Failure of the optics inside the instrument is very unlikely since the parts are protected by the instrument.

2.5 Computer (WBS 1.5)

Two models for fixing failures in the computer (be it the computer itself or a card) are these:

- Replace the entire computer (cards and all) with a spare.
- Replace the computer or the card with a spare. If the computer failed, software needs to be installed.

We recommend the first model, since the difference in cost is only $3000 for the computer and an extra motor controller.

2.5.1 Computer (WBS 1.5.1)

The computer is a standard PC with 4 slots for PCI cards.

2.5.2 Cards (WBS 1.5.2–1.5.4, 1.5.5.2)

The cards are made by National Instruments.

2.5.3 Vacuum Sensor (WBS 1.5.3.1)

The vacuum sensor, made by Inificon, enables the computer to keep track of the pressure.

Table 2 Spares with high priority (1) and low priority (0). “U/S” is number used / number of spares. “Lead” is the time for fabrication and testing. “Complete” includes all spares. “Immediate” is recommended for immediate purchase.

WBS	Task	Priority		U/S	Lead	Complete		Immediate	
					[wk]	[$]	[hr]	[$]	[hr]
1	Spare Parts	1			25	46,250	256	29,387	216
1.1	Mechanisms	1			25	21,987	64	16,514	48
1.1.1	Rotation Stage	1	Long lead		25	16,220	40	16,220	40
1.1.1.1	Vendor Fab Rotation Stage	1		6/1	24	15,500	0	15,500	0
1.1.1.2	Test Rotation Stage	1		6/1	1	720	40	720	40
1.1.2	Motor Controller	0	Low risk		2.2	3,134	8	0	0
1.1.2.1	Vendor Fab Motor Controller	0		2/2	2	2,990	0	0	0
1.1.2.2	Test Motor Controller	0		2/2	0.2	144	8	0	0
1.1.3	Motor Driver	0	Low risk		2.2	2,339	8	0	0
1.1.3.1	Vendor Fab Motor Driver	0		2/1	2	2,195	0	0	0
1.1.3.2	Test Motor Driver	0		2/1	0.2	144	8	0	0
1.1.4	Motor PCB	1			2.2	294	8	294	8
1.1.4.4	Vendor Fab Motor PCB	1		1/1	2	125	0	125	0
1.1.4.1	Assemble & Test Motor PCB	1		1/1	0.2	169	8	169	8
1.2	Gaskets	1	Low cost		2	245	0	245	0
1.2.1	Filter Access	1	Change w/ each access		2	30	0	30	0
1.2.1.1	Vendor Delivers Gasket for Filter Acces	1		1/10	2	30	0	30	0
1.2.2	Nitrogen Plumbing	1			2	150	0	150	0
1.2.2.1	Vendor Delivers Gaskets for N2 Plumbi	1		1/3	2	150	0	150	0
1.2.3	Vacuum Plumbing	1			2	65	0	65	0
1.2.3.1	Vendor Delivers Gasket for Motor & Nit	1		1/0	2	30	0	30	0
1.2.3.2	Vendor Delivers Gaskets for Pump Port	1		6/10	2	15	0	15	0
1.2.3.3	Vendor Delivers Gaskets for Right-angle	1			0.2	0	0	0	0
1.2.3.4	Vendor Delivers 62-in Custom O-ring	1			0.2	20	0	20	0
1.3	Electronics	1			16.6	12,628	168	12,628	168
1.3.1	Detector Cable	1	Long delivery		16.6	4,709	24	4,709	24
1.3.1.1	Vendor Fab Flex Cable	1		2/1	4	2,543	0	2,543	0
1.3.1.2	Test Flex Cable	1		2/1	0.2	144	8	144	8
1.3.1.3	Vendor Pots Cable in Vacuum Connecto	1		2/1	12	1,734	0	1,734	0
1.3.1.4	Test Cable Assembly	1		2/1	0.4	288	16	288	16
1.3.2	Detector PCB	1	Special knowledge		4.6	1,145	24	1,145	24
1.3.2.1	Vendor Fab Detector PCB	1		2/1	4	713	0	713	0
1.3.2.2	Assemble & Test Detector PCB	1		2/1	0.6	432	24	432	24
1.3.3	Detector Controller PCB	1	Special knowledge		6	4,240	80	4,240	80
1.3.3.1	Vendor Fab Detector Controller	1		2/1	4	2,800	0	2,800	0
1.3.3.2	Assemble & Test Detector PCB	1		2/1	2	1,440	80	1,440	80
1.3.4	Umbilical PCB	1	Special knowledge		5	2,340	40	2,340	40
1.3.4.1	Vendor Fab Umbilical PCB	1		1/1	4	1,620	0	1,620	0
1.3.4.2	Assemble & Test Umbilical PCB	1		1/1	1	720	40	720	40
1.3.5	Misc	1			2	194	0	194	0
1.3.5.1	Vendor Delivers Power Supplies	1		3/1	2	97	0	97	0
1.3.5.2	Vendor Delivers Fiber-optic Cable	1		2/1	2	97	0	97	0
1.4	Optics	0			12	6,617	0	0	0
1.4.1	CaF2 Window	0	Low risk		12	6,617	0	0	0
1.4.1.1	Vendor Fab CaF2 Window	0		1/1	12	6,617	0	0	0
1.5	Computer	0			6	4,773	24	0	0
1.5.1	Computer	0	Low risk		1.6	1,523	24	0	0
1.5.1.1	Vendor Delivers Computer	0		1/1	1	1,091	0	0	0
1.5.1.2	Install Software & Hardware	0		1/1	0.6	432	24	0	0
1.5.2	Data Card	0	Low risk		1	995	0	0	0
1.5.2.1	Vendor Delivers Data Card	0		1/1	1	995	0	0	0
1.5.3	Vacuum Sensor	0	Not critical		6	2,255	0	0	0
1.5.3.1	Vendor Delivers Vacuum Sensor	0		1/1	6	1,260	0	0	0
1.5.3.2	Vendor Delivers Interface Card for Vacu	0		1/1	1	995	0	0	0