SAM

SAM Management
LGS-PDR and beyond

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1 Summary

The SOAR Adaptive Module SAM will be a ground-layer adaptive optics instrument mounted on the SOAR Telescope. SAM will be equipped with a Laser Guide Star (LGS) system. SAM can also work without the LGS system, using natural guide stars instead, the SAM NGS mode. The total cost of the project is estimated to be 3.7 M USD, and the project is expected to be completed by the end of 2010.

The project is being carried out in two phases. The first part of the project consists of the SAM NGS system, i.e. the SAM main module with a WFS module designed for use with Natural Guide Stars. In December 2005 the project successfully passed a PDR to review the SAM main module. The second part of the project consists of development of the SAM LGS system and it is this part that is subject to the present review. The SAM LGS system includes a laser launch telescope, beam transfer optics and a laser box, as well as a special WFS module. SAM will have a dedicated imager, SAMI, but can also feed visitor instruments, to be mounted on the visitor port of SAM.

Design and fabrication of the SAM main module is underway since July 2006, and at present, September 2007, most of the subsystems are fabricated. Design and fabrication of the LGS system will be happen in parallel to the integration and alignment of the main module, as different engineering resources are available for this effort. Commissioning of the Natural Guide Star mode is expected to start in July 2009. Commissioning of the Laser Guide Star mode is expected to start about a year after that, at the end of May 2010.

Labor and capital costs for the entire project, i.e. SAM main module, LGS system and SAMI, are presented in the Table below. The costs are split up in: 1.Costs for the conceptual and preliminary design, up to the PDR of the SAM Main Module; 2. Costs up to September 2007, the time of the LGS-PDR; and 3. Estimated costs to complete the project.

		Labor	*Capital*
Up to PDR SAM Main Module	2 December 2005	590 k USD	225 k USD
PDR Main Module – LGS-PDR	28 September 2007	890 k USD	205 k USD
LGS-PDR – completion of project	November 2010	1.3 M USD	490 k USD
	Total	2.8 M USD	920 k USD

2 Introduction

The SOAR Adaptive Module SAM is an adaptive optics instrument to be mounted on the SOAR Telescope. SAM will have a Laser Guide Star system, and the SAM main mode is a ground-layer adaptive optics system.

SAM is a NOAO Major Instrumentation Program (MIP) project, carried out at NOAO South. Nicole van der Bliek, project manager of SAM, is responsible for leading the team and maintaining cost and schedule control of the work effort. Andrei Tokovinin and Brooke Gregory share the responsibility of project scientist and systems engineer, with a commitment of Tokovinin of at least 40% and Gregory at a 10% level or less. The lead engineers in the project are Patricio Schurter and Andres Montané, mechanical engineers, Roberto Tighe, optical engineer, Eduardo Mondaca, electronics engineers, Rolando Cantarutti, software engineer and Manuel Martinéz, electronics/software engineer. The detailed mechanical design is carried out by Rossano Rivera, Alfonso Cisternas and, Hugo Ochoa, mechanical draftsmen. Instrument makers working on SAM in the CTIO workshop are Fabian Collao, Pedro Vergara, Victor Pastén, Juan Orrego, Victor Robledo, Victor Pinto and Cristian Robledo. In the area of electronics, support is given by Rodrigo Leiva, electronics draftsman, and Rodrigo Alvarez and Victor Aguirre, electronics technicians. The team receives managerial support from MIP in NOAO North.

3 Managerial aspects of the project

3.1 Phasing of the project

The main purpose the SAM project is to deliver a ground-layer adaptive optics instrument, using a laser guide star system to partially correct the seeing over a fairly large field of view. The project has been broken up into two parts to accelerate the project schedule and to decouple building of the main module from availability of funding for the laser and the science CCD.

During the first part of the project the SAM main module is designed, built and tested. The WFS will be optimized for use of natural guide stars, the NGS mode of SAM. The NGS mode is primarily meant to be an engineering and commissioning mode. At the time of the LGS PDR, the major part of the development and fabrication of the SAM Main module has been completed. Integration and alignment is expected to start in 2008.

While the SAM main module was built, the LGS system, i.e. Laser Launch Telescope (LLT) and Beam Transfer Optics (BTO), has been developed, and it is the preliminary design of the LGS system that is subject to this review. Following the PDR, the LGS system will be designed in detailed and fabricated, and the laser and LLT & BTO optics will be purchased.

SAM will have a dedicated imager, the SAM Imager (SAMI). The dewar and shutter of SAMI will be copied from the SOAR Optical Imager, and the filter wheel will be a copy of the CTIO filter wheels. A separate review for SAMI is not required. Building of this imager can start as soon as resources are available. The science CCD will be purchased in coordination with a similar purchase by SOAR.

3.2 Reviews

The SAM project has passed several reviews with external review committees. These committees have given critical advice, which has helped the SAM team to develop an instrument that will have a significant impact and at the same time will be of such a scope that it is feasible to realize in a timely fashion.

SAM Co-DR & delta-CoDR
The first conceptual design of SAM was presented at a Co-DR in May 2003. In the first concept of SAM a high resolution mode, using natural guide stars, and a low resolution mode, using laser guide stars, were to be offered simultaneously. At this review it was recommended to focus on low-resolution, ground layer adaptive optics. A subsequent Co-DR (delta-CoDR) was held in January 2004 in which a simplified opto-mechanical design was presented. The focus of the project was shifted towards building an adaptive optics instrument with laser guide star system, with as an intermediate step the option to use natural guide stars. NGS mode and LGS mode will not be offered simultaneously.

SAM main module PDR-CDR
Following the delta-CoDR, the SAM project matured and on December 2, 2005 a preliminary design was presented. Parts of the design were already at a fairly advanced state and were reviewed at a CDR level. The project successfully passed this review, with as one of the important recommendations to proceed with the development of the LGS system as soon as possible, as this was viewed again as the main mode of SAM.

Internal Reviews
At the design review in December 2005, several subsystems were presented at a PDR level only. These subsystems are being reviewed in separate, internal, reviews. A list of the internal reviews is presented in Table 3.1. Reports on the subsystems can be found on SAM web pages[1].

Table 3.1 Internal Reviews
Note: Laser Selection has been included in LGS-PDR

	Lead-reviewer	***Review Date***
Completed		
VI Filter Assembly	Montané & Peréz	15.04.2006
WFS Optical Design	Hubin	01.08.2006
Housing / Optical Bench	Montané & Peréz	15.08.2006
Interface to ISB	Heathcote	25.08.2006
WFS NGS Mechanical Design	Montané	01.09.2006
To pass		
Modification of ISB Struts	Heathcote and Serrano	27.09.2007
TurSim Mechanical Design	Montané and/or Peréz	20.12.2007
Collision prevention TT Probes	Delgado and/or Schmidt	10.03.2008
WFS LGS Mechanical Design	Montané and/or Peréz	10.11.2009

[1] www.ctio.noao.edu/new/Telescopes/SOAR/Instruments/SAM/mgnt/InternalReviews/sam_internalreviews.html

3.3 Project Challenges

The two major challenges that the SAM project faces are the unavailability of resources and the lack of experience with building an adaptive optics instrument.

Resource shortages
Resource shortages continue to be a major reason for slowing down the progress of the SAM project. Team members are frequently pulled away to help out with observatory tasks, and so far this has been most notable in the progress of the mechanical work. Detailed design and drafting has been slowed down significantly and is currently defining the pace of the progress of the SAM project. Further, it is expected that once the integration and alignment of the SAM main module starts, the availability of key personnel in this area, in particular the optical engineer, will be determining the progress of the project.

Expertise and experience
This is the first Adaptive Optics instrument built at NOAO, and in particular no expertise on Ground Layer Adaptive Optics is at hand. Expertise and experience are being acquired rapidly as the project progresses, and in fact gaining experience with GLAO was one of the goals of the project.

4 Project Status, September 2007

Mechanical design & fabrication
At the time of the LGS-PDR the design and fabrication of the SAM main module is well underway. The SAM housing/optical bench will be ready for fabrication at the start of FY08, and most subsystems have been fabricated or will soon be coming out of the workshop, except for the turbulence simulator, TurSim, which will be part of the main module, and the Tip-Tilt guiders. These two subsystems are still in a preliminary design phase.

Software
Most of the software has been developed, and about 80% of the actual work has been completed. Testing and debugging of the software is for the larger part awaiting delivery of the hardware and will be continuing well into the integration, alignment and commissioning phase.

Electronics & motor control
The SAM electronics for the main module have been designed and are being assembled, and/or bought. Motors and stages have been tested, and final integration of the electronics will be completed once all hardware has been received. A collision prevention system for the Tip Tilt guiders is being developed and will be presented at an internal review, before the mechanical design of the pick-off arms will be developed.

5 SAM Planning after the LGS PDR

5.1 An updated SAM Project Plan

The SAM project plan has been updated to reflect the progress made after the SAM PDR and to plan the remainder of the work, including the design and fabrication of the LGS system. The project plan was developed with a work breakdown structure and a work flow diagram.

The following considerations were taken into account when the work flow diagram was designed:

- After the LGS PDR, comments and changes will be incorporated in the design. It is expected that in January 2008, three months after the PDR, the design of the LGS system will be frozen and the laser as well as the optics for the LLT, BTO and the laser box will be ordered.
- The mechanical design of the LGS system is carried out by Andres Montané, while Patricio Schurter will be completing the design of all components of the SAM main module.
- In planning the drafting and fabrication of SAM, the assumption was made that two draftsmen and two persons in the workshop will be available to work on SAM at the same time, whenever necessary.
- The integration and alignment of the SAM main module will take place during 2008, allowing for commissioning of the SAM NGS mode at the beginning of 2009. Meanwhile the LGS system will be designed and built, so that integration and alignment of the LGS system can directly follow the completion of the commissioning of the SAM NGS system.

The detailed project plan and WBS can be found on the SAM web pages[2], both as a Microsoft Project Plan and as a PDF file. The Microsoft project file is not being used to calculate the cost of the project. Rather than duration of tasks in calendar weeks have been entered in the project file.

Two areas of the SAM project are identified as critical for overall completion of the project: completion of the mechanical design and fabrication and the integration, alignment; and commissioning of both the SAM NGS mode and the SAM LGS mode. On the SAM Planning web-site pdf files showing only tasks relevant to these two areas are posted as well as a summary file, concentrating on the major milestones for integration, alignment and commissioning of the instrument.

5.2 More about the critical path in the SAM project planning

Mechanical design & fabrication
The critical path of the SAM project is defined by the progress of the mechanical systems, up to the point that the fabrication of the SAM housing is completed. The detailed drawings of the SAM housing/optical bench are currently being reviewed and it is expected that fabrication will start at the beginning of FY08. Allowing three months for fabrication, integration & alignment of the main module will start at the beginning of 2008.

The design of two sub-systems still needs to be completed: TurSim, the turbulence simulator, which will be part of the main module, and the Tip Tilt guiders. It is anticipated that these subsystems will be ready well before the integration of the main module reaches the stage that these parts are needed.

The design of the LGS system will be carried out in parallel, and it is expected that the LGS system will be delivered well before commissioning of the NGS mode of SAM is

[2] www.ctio.noao.edu/new/Telescopes/SOAR/Instruments/SAM/ under Intranet, Management, Planning or directly www.ctio.noao.edu/new/Telescopes/SOAR/Instruments/SAM/mgnt/Planning/sam_planning.html

completed, and as such this part of the mechanical work will not be on the critical path of SAM.

Integration, alignment & commissioning
Integration, alignment and commissioning takes place at the end of the project, when all or most hardware and software have been delivered. Therefore, this part of a project naturally defines the critical path at the end of a project. This is also the case in the SAM project, with an extra caveat that one of the key players in the integration, alignment and commissioning, the optical engineer Roberto Tighe, will be absent from the project for two periods of two months each during calendar year 2008, to participate in both the shutdown of the Blanco 4-meter and the shutdown of the SOAR telescope. Ideally, integration and alignment will have come along sufficiently well that testing of the software can take place during the periods that Tighe is not available. This does require that the completion of the SAM housing is not delayed at all, and that all goes smoothly from its delivery onward. In the updated SAM plan, delays have been foreseen, and the telescope shutdowns have been incorporated into the plan. It is estimated that it will take about eight months to integrate and align the SAM main module, including testing of the software.

Commissioning & engineering time at SOAR
In the SAM project plan blocks of SOAR telescope time have been scheduled to fit the needs of the SAM project. The actual scheduling of these blocks of engineering time will have to be in coordination with SOAR. As a result completion dates will probably change and this will affect the end date of the SAM project.

5.3 Major Milestones till completion

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The SAM main module is moving from the design & fabrication phase into the integration phase, whereas the LGS system is in development. This is reflected in the list of major milestones coming up in the next few years. Most of these milestones mark the completion of a part of the integration, alignment & commissioning phase, with only two major milestones marking the completion of fabrication of part of the instrument.

The first of these two milestones is the completion on the housing / optical bench of the SAM main module. This milestone also marks the start of the integration phase, even though it does not mark the end of design and fabrication of all the SAM subsystems.

The other of these two milestones marks the completion of the fabrication of the LGS system. This milestone is not foreseen to be on the critical path of SAM, as it will be reached while integration, alignment & commissioning of the SAM main module & NGS system are in full swing. Nevertheless, reaching this milestone will be an important achievement.

Table 5.3 Major Milestones till completion

WBS	*Milestone*	*Date*
1.4.3	Housing / Optical Bench Complete	11-Jan-2008
1.7.2	Integration Main Module Complete	31-Dec-2008
1.4.20	LGS Mechanical Design Complete	30-Jan-2009
1.7.6	SAM NGS Mode Commissioned	16-Sep-2009
1.7.8	First Laser Guide Star	02-Jun-2010
1.7.10	Commissioning LGS system complete	25-Aug-2010
1	Commissioning SAM, incl. SAMI, complete	03-Nov-2010

6 Project Labor and Capital Costs

6.1 Labor

In Table 6.1 the staff allocation for SAM in FTE is listed for FY08, FY09 and FY10, including October 2010, i.e. from the LGS-PDR till completion.

Table 6.1 Project staff allocation, FTE per FY & Total post-PDR

Name	***Skill Type***	***FY08***	***FY09***	***FY10***	***Totals***
van der Bliek	PM	0.50	0.40	0.33	1.23
Tokovinin	SE/Sci	0.30	0.40	0.43	1.13
Gregory	Sci	0.10	0.10	0.11	0.31
Tighe	OE	0.48	0.38	0.43	1.29
Schurter	ME	0.83	0.56	0.27	1.65
Montané	ME	0.20	0.20	0.15	0.55
Cisternas	MD	0.73	0.33	0.00	1.07
Rivera	MD	0.83	0.17	0.00	0.99
Ochoa	MD	0.08	0.29	0.05	0.43
IM's	MF	2.00	1.38	0.12	3.49
Mondaca	EE	0.19	0.13	0.20	0.52
El.Designer	ED	0.21	0.13	0.00	0.33
El.tech.	ET	0.16	0.53	0.25	0.93
Cantarutti	SE	0.90	0.42	0.66	1.98
Martinez	EE/SE	0.37	0.27	0.27	0.90
Delgado/Bonati	SE	0.00	0.20	0.16	0.36
Schmidt	EE	0.00	0.20	0.13	0.33
Poczulp	OPT	0.03	0.00	0.00	0.03
	Total per FY	7.89	6.07	3.54	17.50

Integration, alignment & commissioning
Once the project enters the integration and alignment phase, it is expected that both the project scientist, Andrei Tokovinin and the optical engineer, Roberto Tighe will spend increasingly more time on the project. Note however that Tighe will be pulled away to at least two large observatory tasks to be scheduled during calendar year 2008: a shutdown of the Blanco 4-meter telescope and a shutdown of the SOAR telescope. Each of these shutdowns is expected to take about two months of Tighe time. During commissioning also an increased involvement of the software engineer, Roland Cantarutti is expected.

LGS system – mechanical work
The mechanical design & fabrication of the LGS system will start within a few months after the LGS-PDR, allowing time to incorporate changes suggested by the review committee. The mechanical design will be carried out by Andres Montané, mechnical engineer, and detailing and drafting will be carried out by Alfonso Cisternas & Hugo Ochoa, mechanical draftsmen. Montané, who is also head of the mechanical group, will only be available at a 20-30% level. This has been accounted for in the planning of the work on the LGS system. Note, that the Blanco shutdown also impacts the timeline for the LGS system: Montané will be fully occupied during that time as will the workshop.

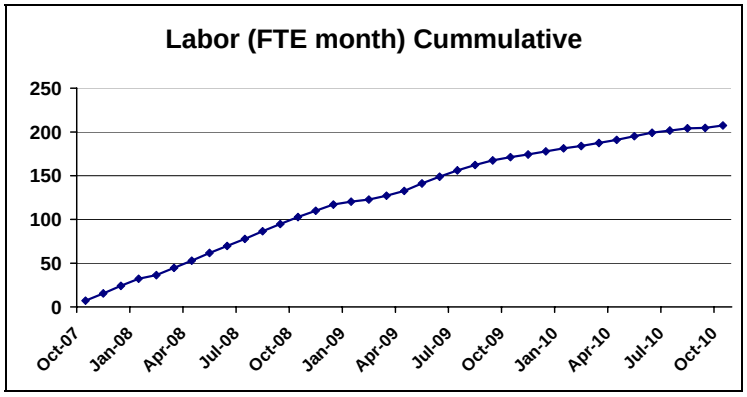
LGS system – software & electronics
The real-time software development of the LGS system is an integral part of the overall software effort and as such has not been separated out in the WBS of the project plan. The development of the software for motion control and the LGS main GUI are planned to start in 2009. Electronics/software engineer Manuel Martinéz will develop the motion control system for the LGS, both the electronics and the software. The LGS GUI will be developed by software engineer Rolando Cantarutti, in close collaboration with Martinéz. The electronics for the fast shutter is already in hand and has been tested. The laser control electronics will be purchased with the laser and a significant time for testing is planned for to be carried out by Eduardo Mondaca, electronics engineer.

Interfaces to SOAR
Work on the interfaces to SOAR and the SOAR Instrument Box (ISB) has been planned for. However, particularly the work on the interface to SOAR will probably have to be "re-planned" nearer to data, in close coordination with the SOAR team. Accommodating the ISB to fit SAM and several other instruments is expected to happen during the SOAR shutdown, in October 2008. The design for these modifications is ready for review by the various instrument teams and will be detailed within the next few months. Modifications of the trusses of the ISB will be reviewed by Heathcote & Serrano on September 27, 2007, and the modified trusses are expected to be put in at the beginning of 2008, at the same time as the fit-test of the empty SAM main module at the telescope.

SAMI software
The software for the SAM Imager will be written by Francisco Delgado or Marco Bonati. Ricardo Schmidt will develop the controller software and test the science CCD. This effort will include testing the controller, and integrating the controller software into the LabView environment.

Staff allocation changes – FY09 & FY10
In FY09 fewer staff will be working on SAM, assuming that the SAM main module is integrated and ready to be commissioned and that the LGS system has been designed and fabricated. In FY10 staff working on SAM will be involved in the commissioning of the LGS and the integration & commissioning of SAMI. These staffing changes are reflected in Table 6.1. Figure 6.1 shows the cumulative labor, expressed in FTE by month, from the LGS-PDR till completion of the project.

Figure 6.1 Cumulative Labor, FTE by month



6.2 Capital Cost

The total capital budget for SAM is 920 k USD. This includes the 78 k USD spent in the concept development phase up to and including the delta-CoDR. The costs for the SAM main module, including the elements for the WFS LGS module are about 430 k USD. The SAM Imager is budgeted to cost about 200 k USD, where the major expense will be the science CCD. The capital budget for the LGS system is 215 k USD and Table 6.2 shows details for the budget of the LGS system. The detailed budget for the entire project, from the delta-CoDR up to completion can be found on the SAM web pages[3].

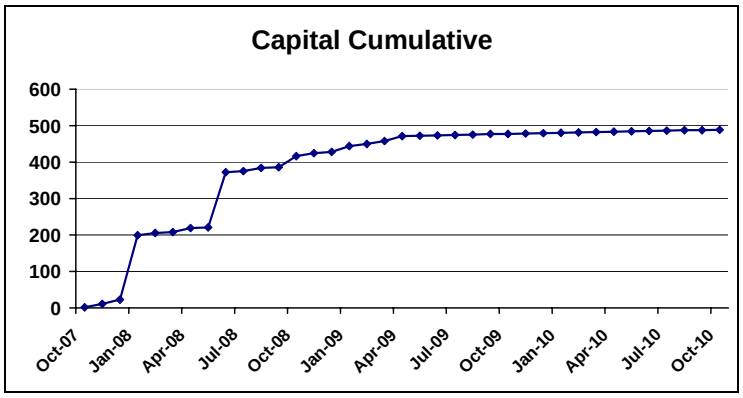
Table 6.2 SAM LGS System Capital Budget (in k USD)

BTO & LLT	***215***
Laser	115
LLT Optics M1	50
LLT Optics M2 & M3	5
Beam Transport Optics M4	3
Beam Expander	3
Laser Box Additional Optics	5
Beam profiling CCD	5
Alignment & testing tools	5
Materials	5
Motors (5+1 spare)	14
Connectors, cables, electronic box	5

Figure 6.2 shows the cumulative capital to be spent per month. The jumps in the graph show when major expenses are to be made:

- January 2008: BTO & LLT Optics and Laser
- June 2008: Science CCD
- October 2008: SAMI SDSU-III Controller

Figure 6.2 Cumulative Capital per Month



[3] www.ctio.noao.edu/new/Telescopes/SOAR/Instruments/SAM/mgnt/Planning/sam_planning.html, Capital Estimates, September 21 2007

7 Recognition of Risk & Risk Mitigation Activities

7.1 Risks factors

There are various areas within the SAM project which bear risks affecting the planning and budget of the project.

Resources – unavailability of key people

The major factor affecting the SAM project planning is the availability of key people. There is one optical engineer involved in the project, at a 30% level. This is the only optical engineer at CTIO, and any observatory tasks involving optics, the optical engineer is pulled away from SAM. This has affected the progress of the preliminary design of the SAM main module as well as the SAM LGS system. It is foreseen that it will also affect the progress in the integration, alignment and commissioning phase. Some contingency has been built into the project plan to account for this, but more might be necessary.

Unplanned rework

If parts of the instrument do not meet the specifications, these parts will have to be adjusted and/or remade. This will impact both schedule and budget, and monitoring closely that requirements are met, is therefore of vital importance. There is no slack in the schedule to account for such rework.

Problems with optics or other purchased items

Other risk factors are possible problems with the optics, such as poor performance, or even manufacturer's failure to produce. Failures of this kind are much more difficult to plan for and to absorb and such will have a significant affect on both schedule and cost.

First NOAO-built AO instrument & LGS

The relative inexperience with building and operating AO instruments and in particular ground-layer AO, with a Laser Guide Star system, is one of the most challenging parts of the project. For this reason there is about one year between commissioning of the NGS mode and commissioning of the LGS mode. It might be necessary to continue testing and commissioning of the LGS system after the projected end date of the project.

7.2 Risk Mitigation Activities

Prototyping

All the way through the development and manufacturing of the instrument, prototyping of the instrument is taking place with the lab test set-ups and eventually with the actual subsystems. In this way it can be verified at an early stage that all subsystems delivered meet the requirements.

Phasing the project

SAM is built and commissioned in two phases: first the NGS mode and then the LGS mode. This enables the team to obtain experience with operating the SAM main module before moving into the next phase. Launching a laser to obtain a laser guide star and commissioning and testing of the LGS mode will take place about a year later, allowing for improvements and changes based on the experience obtained with the NGS mode.

Progress meetings & reports

To monitor progress in all areas of the project, weekly meetings are held with the key team members. In these meetings work done in the past week and work planned for the coming week are discussed. The project manager reports weekly to the Associate Director of MIP, Dr. David Sprayberry. And, at the end of each fiscal year the project manager provides a written progress report[4].

[4] www.ctio.noao.edu/new/Telescopes/SOAR/Instruments/SAM/mgnt/Reports/sam_reports.html