SOUTHERN AFRICAN LARGE TELESCOPE

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Statement of Work for SALTICAM

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(Based on the Generic Statement of Work for First Light Instruments,
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1 Introduction

This document defines the Statement of Work (SOW) for SALTICAM, the Verification Instrument, Acquisition Camera and Science Imager of SALT. It is aimed at expediting the seamless integration of SALTICAM with the telescope itself. An interface control document will be produced for SALTICAM which will cover all aspects of integration and, in particular, identify the interfaces and who is responsible for them.

The requirements on the design and fabrication of SALT instruments to deliver the capability and performance expected by the SALT consortium are demanding, particularly given the mass and volume constraints at prime focus. Although the SALT image quality requirements are not of themselves exceptional in terms of contemporary telescopes, meeting the required error budget for this telescope will be a major challenge. This is because of the nature of the segmented primary mirror array and its support structure and mechanisms, the correcting secondary optics and the complex tracker system, all of which contribute significantly to image degradation. Any instrument has to be designed to take advantage of, and not to seriously degrade, the delivered image quality of the telescope, over the entire wavelength range of its capability. Likewise, the throughput of SALTICAM will have to be excellent if it is to be competitive with other 8-10 m class telescopes. The SALT instruments need to broadly satisfy two requirements:

1. be capable of addressing the major science goals of the SALT consortium.
2. enable SALT to be competitive with other similar aperture telescopes in the southern hemisphere.

The first requirement is addressed through the canvassing of the SALT community through the partner representatives on the SALT Science Working Group (SSWG), discussion meetings, etc. Point two implies that PIs need to take cognizance of issues relating to potential niche capabilities of instruments, or novel observing modes, giving a versatility in an instrument's performance. This means targeting the science drivers for SALT as currently envisaged, plus taking account of potential future demands or requirements, to the extent that this is possible.

SALT instruments are to be funded through an allocated first-light instrument budget not less than US$4.8M, the majority of which will be 'in-kind' contributions from the PI institutions comprising the SALT partnership. Instruments will be built on a 'best-efforts' basis but applying good project management practices. Overall responsibility for an instrument project will rest with the PI, while the entire budgetary and management responsibility of the SALT Instruments sub-system, in terms of the SALT Project, is the responsibility of the SALT Project Scientist.

First-light instruments for the SALT are to be *facility* instruments, utilized primarily by the international community of astronomers comprising the SALT consortium (i.e. from the shareholding institutions of the SALT Foundation), although a small percentage of time will likely be allocated to programs outside of the SALT consortium. Unlike many similar instruments, SALT instruments will not be operated by visiting astronomers, but rather

by a dedicated SALT Operations staff, comprising SALT Operators and Astronomers. They will conduct 'service mode' queue-scheduled observations using SALT in its suite of instruments. All instruments will be serviced and maintained by the SALT Operations staff. Instrument builders will therefore need to address different aspects in respect of the dictates from several groups, namely:

- the scientific user community (i.e. astronomers from the SALT partnership).
- operations staff who will use and maintain SALTICAM and reduce the data to a certain level.
- the SALT Project Team responsible for the integration of SALTICAM on the telescope.

2 Scope of this Document

The processes and guidelines outlined in this document — coupled with the mandates in the SALT *Evaluation of First-Light Instruments Document* (EID) — aims to minimize risks and disappointments in instrument performance, delivery schedule and cost by enabling the development process to be constructively reviewed. The work summarized herein consists of designing, fabricating, testing and delivering SALTICAM to the SALT Project Office, Cape Town. This work also includes the subsequent integration of SALTICAM to the telescope, commissioning SALTICAM and associated fixtures, documentation, and other required items in accordance with this SOW and associated design, interface and software requirements (e.g. the SALT Software Standard, Interface Control Document, Safety Standard, etc).

The majority of this document is closely modeled on a similar statement of work for SOAR instruments (*Statement of Work for the SOAR XXX Instrument, GNC99-02*) written by Dr G. Cecil.

3 Executive Summary

3.1 General

(a) The SALT Project has delegated oversight responsibility for SALTICAM to the SALT Project Scientist (PS). The primary responsibility for the construction of SALTICAM rests with the Principal Investigator (PI). Certain aspects of institutional responsibility rest with the PI's home institution, and hereafter the reference to 'PI' will mean the individual PI, his/her institution or the entire instrument Project Team. The SALTICAM Principal Investigator (PI), in person, will be the direct contact person to the PS. All direction and requests for information to the PI will either originate from the PS or her/his proxy.

(b) The PI will supervise and direct all of the work involved in the construction of SALTICAM and will be solely responsible for all means, methods, techniques, sequences, choice of contractors, vendors and procedures, and for coordinating all portions of the work under this SOW.

(c) The PS and the SALT Project will determine mutually whether any deliverable items (including SALTICAM itself, documentation, training materials, and other deliverables described below) are sufficient to be deemed completed under this SOW. The SALT Project are necessarily involved because some instruments will play a critical role in telescope commissioning and scientific performance verification and/or will need to interact with various telescope sub-systems, including the Telescope Control System (TCS). In addition, the SALT Project takes responsibility for the handover of SALT, and its first-light instrument suite, to the Operations Team. Items delivered by the SALTICAM PI to the SALT Project deemed to be inadequate or not meeting the requirements or specifications of this SOW will be documented as such by the PS to the SALT Board and SSWG. It is expected that the PI will correct any deficiencies in consultation with the PS. The resolution of disputes between the PI and PS or SALT Project shall be decided by the SALT Board, under advice from the SSWG. In all cases where reviews, disputes or other activities involve the PI or PS, who are also members of the SSWG, the PI or PS will relinquish voting rights or PS authority respectively.

3.2 Management Plan

As part of the Preliminary Design requirements, the PI shall deliver to the PS a Management Plan that documents how the work specified in this SOW will be accomplished and when. This plan is the basis of managing and tracking the progress of SALTICAM development, and may be developed in stages that update and expand the level of detail for successive phases of work. The initial version of the Management Plan shall include:

(a) A work breakdown structure (WBS) that corresponds to the work;

(b) A schedule that includes milestones to at least the 2nd level of the WBS. The schedule will include start and finish dates for each WBS element, projected completion dates for each deliverable, which organization should perform the work, and the identifiable critical path or critical items with estimated allowance in the schedule for contingencies, if any. The delivery date will be coordinated with the SALT Project by the SALTICAM PI and PS;

(c) Summary of required resources for each 2nd level WBS element, broken down into total weeks of labour effort, including subcontracted activities.

(d) Capital costs, with a breakdown of major items, that will be incurred in the work; and

(e) A list of key and supporting personnel (including discipline) that have been designated to perform the work. The fraction of time committed to the work should be given as a percentage of each person's full time. The total annual cost for the labour will be included;

(f) The Management Plan shall comply with the Work Scope schedule, details of which appear in the following section.

3.3 Work Scope

The following Work Scope summarizes expectations regarding the completion of various tasks or delivery of particular documents:

Sect.	*Event*	*Completion Date*
§6.2	Concept Design Proposal Review (CoDR)	completed
§6.4	Preliminary Design Review (PDR)	End of February 2002
§6.7	Final Design Review (FDR)	A maximum of 6 months after PDR
§11	Pre-Delivery Acceptance Test	2 weeks before delivery
§13	Delivery at Cape Town	1 March 2003 installation
§14.1	Installation on SALT at Sutherland	SALT Project Responsibility
§14.2	Commissioning completed	TBD weeks after installation

In addition, the following milestones or document delivery deadlines will apply:

Milestone or Document	*Completion Date*
Draft Functional Performance Requirements Doc. (FPRD)	3 weeks prior to PDR
Draft Interface Control Document (ICD)	3 weeks prior to PDR
Draft Operational Concept Definition Doc. (OCDD)	3 weeks prior to PDR
Preliminary Design documents	3 weeks prior to PDR
Management Plan	3 weeks prior to PDR
Preliminary Design Review	February 2002
Completed Functional Performance Requirement Doc.	8 weeks after PDR
Completed Operational Concept Definition Document	4 weeks prior to FDR
Completed Interface Control Documents	8 weeks after PDR
Safety Review Meeting	6 weeks prior to FDR
SSWG reviews completed FPRD and OCDD	TBD before FDR
Pre-delivery Acceptance Test Plan	3 weeks prior to FDR
Commissioning Test Plan	3 weeks prior to FDR
Final Design Review	TBD
Draft Service and Maintenance Manual	1 February 2003
Draft Software Maintenance Manual	1 February 2003
Draft User's Manual	1 February 2003
Draft Calibration Manual	1 February 2003
Final versions of all manuals	Commissioning completion
As-Built Fabrication Drawings	Commissioning completion
Training of SALT operations staff	During commissioning

The suggested criteria for the design reviews, level of documentation that would be useful, and activities before and during commissioning are presented in detail in the following sections (§4 and above) of this SOW.

3.4 Meetings

The PS may call and conduct meetings of the SALT Science Working Group, or any sub-group, as s/he may deem necessary to review, discuss, present, or coordinate the work with the SALT Project. Such meeting may also include the participation of the

Project and instrument Team members, including the PI, in which case a date and location acceptable to all parties will be agreed upon.

To examine local infrastructure, the formal PDR and FDR should ideally be held at the PI's institution, or at least some provision made for assessing this (e.g. visit by the PS and possibly a member(s) of the SALT Project Team). After each review, the chair of the Review committee will draft the committee's report. The PS and PI will then generate a response to the committee report, to map a strategy for making progress. They will both sign the report, then distribute it to the chair of the Review committee, SSWG, and the SALT Board.

3.5 Progress Reports

PIs shall produce quarterly written reports to the PS summarizing the status of SALTICAM. The PS will then summarize these reports and distribute them to the SSWG and Chairperson of the SALT Board. These shall address the technical, schedule, and financial status of SALTICAM. At a minimum, such progress reports should contain:

(a) Technical status of the work, including accomplishments since the last progress report, and list of technical reports completed during the reporting period (PDF format copies should be supplied to the PS to archive at the SALT Web site);

(b) Revised WBS, schedules, and budgets including a summary of schedule changes, in particular, any change that may affect the critical path or any of the milestones;

(c) Budget details including amounts committed and spent during the quarter and itemized under the appropriate category (e.g. labour, capital purchases, consumables, project management).

(d) Problem areas related to the work;

(e) Action Items (open and closed) for the PS and PI, which shall include a summary of actions closed during the reporting period and new actions opened; and

(f) Changes in key personnel.

In addition, the PI shall on an ad hoc basis e-mail relevant status reports, minutes of meetings and other relevant material to the PS.

3.6 Interface Control Plan

a.) The PI will prepare an Interface Control Plan and submit it to the PS for review and approval by the date specified in the Work Scope. This plan will list all the Interface Control Documents required for SALTICAM, including those covering interfaces between sub-systems of SALTICAM, and whether the PI or the SALT Project is responsible for each interface. For each interface for which SALT is responsible, the document will list the person responsible for each Interface Control Document, and the date by which each Interface Control Document will

be completed. The plan will also include a listing of all interface related information that the PI will need to receive from the SALT Project, giving the date that the information must be received by the PI in order for it to complete the work on schedule.

b.) After the PS has reviewed this document, the PI will incorporate into the Interface Control Plan all changes requested by the PS and submit the revised Interface Control Plan to the PS for approval.

c.) After the PI has incorporated into the Interface Control Plan all changes requested by the PS, the latter will notify the PI in writing of the approval of the Interface Control Plan.

d.) After approval by the PS, the Interface Control Plan will be put under change control so that neither the PI nor the PS can amend or modify the Interface Control Plan without written approval for a change from both.

3.7 Applicable Documents

The latest versions of the following documents govern the work detailed in this SOW and should guide the management and design of SALTICAM:

(a) The SALT Foundation shareholders agreement
(b) Evaluation of First-Light Instruments and Scenarios for Funding Second Generation Instruments, SALT document, 12 June 2001 (EID)
(c) SALT Observatory Science Requirements, Ver. 7.1, 31 May 2000 (SOSR; SALT 1000-AS-0023)
(d) Terms of Reference for Preliminary Concept Proposals for SALT First-Light Instruments, SALT Doc. 25 April 2000 (TRCP).
(e) SALT Safety Analysis (SALT 1000-AA-0030)
(f) SALT Software Standard (SALT 1000-BS-0010)
(g) SALT Electrical Interface Control Dossier (SALT 1000-AS-0013)
(h) SALT Physical Interface Control Dossier (SALT 1000-AS-0014)
(i) SALT Data Interface Control Dossier

3.8 Cost Increases

It is the primary goal of the PI to meet all requirements in the Functional Performance and Requirements Document (FPRD) for the price detailed in the Work Scope. The PDR assessment phase should provide sufficient oversight to ensure that SALTICAM is properly defined, designed and *costed*. If, after this process, the budget cap of $0.529M + 15 per cent contingency is likely to be exceeded, the SALT Science Working Group and SALT Board must decide whether such an increase is acceptable or affordable.

4 Operational Concept

The PI shall develop an instrument operational concept model and should prepare the Operational Concepts Definition Document (OCDD) based on the SALTICAM concept

proposal, and discussions with the PS, SSWG and the SALT Project. Throughout SALTICAM's development the PI will update the OCDD to reflect the decisions mutually agreed upon by consensus of all the interested parties mentioned above. The OCDD shall address the operational concepts for SALTICAM, and specifically undertake the following:

a.) The PI will develop the SALTICAM operational concept model based on the SALTICAM Concept Proposal, SALT Science Requirements, discussions with the SSWG in relation to SALT science drivers and any feedback from instrument questionnaires and prepare an Operational Concept Definition Document (OCDD).

b.) The OCDD must present the science cases for which SALTICAM will be designed, and discuss the key functional and performance requirements that SALTICAM must meet to be able to tackle these.

c.) The OCDD will also identify and discuss the key operational scenarios of SALTICAM, especially in terms of the requirements this instrument will place on other parts of the SALT system. These scenarios should be described in sufficient detail for a technically and scientifically skilled, but non-expert, audience to understand.

d.) A draft OCDD will be prepared by the PI and submitted to the PS for the Preliminary Design Review by the date specified in the Work Scope (§3.3). This draft OCDD will have a table of contents, a first draft of all sections, and some sections in nearly final form to indicate the organization and level of detail of the document, but will not necessarily be complete. The draft OCDD will then be reviewed during PDR. The PI will incorporate into the OCDD all changes requested by the PS that would be necessary to make it consistent with the requirements.

e.) The PI will deliver the revised OCDD, incorporating changes agreed upon at PDR, to the PS by the date specified in the Work Scope (§3.3). The PS will then arrange for this revised OCDD to be reviewed by the SALT Project Team, and by the SSWG, by the dates specified in the Work Scope (§3.3). After these reviews, the PI will incorporate into the OCDD all changes agreed upon and re-submit the OCDD to the PS for final approval.

f.) After the PI has incorporated all requested changes into the final OCDD, the PS will notify the PI in writing of its approval of the OCDD.

g.) After approval the OCDD will be put under change control so that neither the PI nor PS can amend or modify the OCDD without written approval for a change from both.

h.) The PI, may at any time, submit a revised OCDD to the PS for approval. If the PS, following consultation, approves a revised OCDD, all prior OCDDs are superseded.

5 Functional and Performance Requirements (FPRD)

The PI shall develop an instrument functional and performance requirements document (FPRD) based on the SALTICAM concept proposal, the operational concepts (as discussed in the OCDD) and discussions with the PS, SSWG and the SALT Project. Throughout SALTICAM development the PI will update the FPRD to reflect the decisions mutually agreed upon by consensus of all the interested parties mentioned above. The FPRD shall address the operational concepts for SALTICAM, and specifically undertake the following:

a.) The PI will develop the functional and performance requirements that SALTICAM will have to meet in order for it to meet SALT instrument requirements, including the Operational Concept Definition Document (OCDD), and will prepare a Functional and Performance Requirements Document (FPRD).

b.) The PI will describe the origin of each functional and performance requirement described in the FPRD, so that users of the FPRD will be able to determine why each functional and performance requirement was included in the FPRD.

c.) The FPRD must clearly state the PI's assumptions regarding the characteristics or performance capabilities of the other parts of the SALT system including, but not limited to, the telescope, the acquisition system, the guiding system, the detector/controller system and the calibration system. For each of these, the FPRD must state whether the current performance of these systems support SALTICAM requirements set forth in the FPRD.

d.) A draft FPRD will be prepared by the PI and submitted to the PS for the Preliminary Design Review by the date specified in the Work Scope (§3.3). The draft FPRD shall have a complete table of contents, a first draft of all sections, and some sections in nearly final form to indicate the organization and level of detail of the document, but will not necessarily be a complete detailing of the requirements.

e.) The PI will deliver the revised FPRD, incorporating changes agreed upon at PDR, to the PS by the date specified in the Work Scope (§3.3). The PS will then arrange for this revised FPRD to be reviewed by the SALT Project Team, and by the SSWG, by the dates specified in the Work Scope (§3.3). After these reviews, the PI will incorporate into the FPRD all changes agreed upon and re-submit the FPRD to the PS for final approval.

f.) After the PI has incorporated all requested changes into the FPRD, the PS will notify the PI in writing of its approval of the FPRD.

g.) After approval the FPRD will be put under change control so that neither the PI nor the PS can amend or modify the FPRD without written approval for a change from both. Once the FPRD is approved by the PS, it replaces all other

documents as the controlling document specifying all requirements for SALTICAM.

h.) The PI may, at any time, submit a request to the PS to consider waiving one or more specific aspects of the requirements. To support this, the PI will submit a written analysis to the PS demonstrating the degree to which the requirements, or any other aspects of the use of SALTICAM, would be affected by the waiver and requesting specific changes to the requirements. After receipt of such an analysis and request from the PI, the PS may either amend the requirements as requested by the PI or refuse the waiver.

i.) The PI may at any time submit a revised FPRD to the PS for approval. If the PS approves a revised FPRD all prior FPRDs are superseded.

6 Design of SALTICAM

6.1 General

(a) The SALTICAM PI shall develop the basic concepts for the design of SALTICAM and should present the Concept Design to the PS, SSWG and the SALT Board at an appropriate venue (e.g. meeting of the SSWG and Board). Following acceptance by the SALT Board to proceed with the design development, the PI should then perform the preliminary design for SALTICAM, based upon the FPRD and inputs based on comments received from the SSWG following the presentation of the Concept Design Proposal. The PI shall prepare the Preliminary Design Documentation and shall present the design to the PS, SSWG, SALT Project Team, SALT Board and any appointed external reviewers at the Preliminary Design Review (PDR). The PI should then perform the detailed design of SALTICAM, based upon the Preliminary Design Documentation and inputs from the PS based on comments received at the Preliminary Design Review. Following a successful PDR, the PI shall continue in the design development of SALTICAM and prepare the Design Documentation to be similarly presented to the same aforementioned groups (i.e. PS, SSWG, SALT Board and Project Team, external reviewers) for review and assessment at the Final Design Review (FDR).

6.2 Concept Proposal Documentation

(a) The PI shall prepare all documentation required to develop the concept for the design of SALTICAM, based upon the Terms of Reference for Preliminary Concept Proposals.

(b) The Concept Proposal Documentation shall include all aspects of the proposed conceptual design of SALTICAM required by the SALT Science Working Group (SSWG) and Project Scientist. Aspects to be presented or addressed should include:

I. Executive Summary.
II. Introduction
III. Science Case
IV. Concept
    a. Optical layout
    b. Dispersive elements (if any)
    c. Major mechanical components

d. Description of any moving parts
e. Detectors
f. Electronics and control software

V. Telescope interfaces
VI. Acquisition and guiding
VII. Technical details and project management
VIII. Cost estimates
IX. Critical risks and mitigation

(c) The Concept Design Proposal Documentation should be placed on the SALT Science and Instrumentation web pages (restricted access) of the SALT website (www.salt.ac.za) by the date specified in the Work Scope (§3.3). The PS may provide the PI with a list of suggested changes to be made to SALTICAM concept design (consistent with the intent of this SOW) following comments from interested parties, (e.g. the SSWG). The PI may choose to incorporate such changes in the further design development and will place the revised documents online at least two weeks prior to the date specified in §3.3 above for the Concept Proposal Design Review.

6.3 Concept Proposal Design Reviews

(a) The PS will arrange for SALTICAM's Concept Proposal to be presented by the SALTICAM PI at a suitable venue, namely a meeting of the SSWG. The Concept Proposal documents will be disseminated by the PS to all members of the SSWG in time for the material to be reviewed before the meeting.

(b) The PS may request changes in the current instrument concepts, as outlined in the Concept Proposal documentation, as well as the design approach, that arise as a result of comments received at, and subsequent to, the SSWG meeting which reviewed the SALTICAM proposal.

6.4 Preliminary Design Documentation

(a) The SALTICAM PI shall prepare all documentation required to develop the preliminary design of SALTICAM based upon the FPRD, the Concept Design Proposals and any subsequent feedback from the PS, SSWG and SALT Project Team and the requirements in this section.

(b) The Preliminary Design Documentation should include all aspects of the proposed design of SALTICAM required by the PS and SALT Project Team to determine that such design will meet the requirements in the FPRD. Such aspects shall include:

I. layouts in detail sufficient to illustrate the physical configuration and principles of operation, including a detailed optical layout and optical systems performance analysis, and scaled drawings of the major subassemblies;
II. methods and results of analyses to show compliance with each of the requirements in the FPRD;
III. presentations of the concept development and engineering for SALTICAM, including electronics systems concept, conceptual thermal management scheme, software systems concept, and draft operations and maintenance concept;
IV. preliminary cryogenic performance estimate for SALTICAM;

V. identification of and specifications for the various interfaces related to SALTICAM, including at least a draft version of all applicable ICD's;
VI. the philosophy of design, fabrication, assembly, and testing;
VII. a detailed plan to complete the Design Documentation, which should include a schedule.

(c) All Preliminary Design Documentation shall:

I. have their textual documents generated in MS-Word and/or PDF format; and

(d) As a part of the Preliminary Design Documentation, the PI shall address the safety aspects of the design of SALTICAM, as it relates to safety in installation, maintenance, repair, and operation of SALTICAM.

(e) The draft Preliminary Design Documentation shall be placed on the SALT website (restricted Science & Instrumentation web pages) in MS-Word and/or PDF format at least three weeks prior to the PDR.
(f) Preliminary results in the following areas should be included in the Preliminary Design Documentation which will be elaborated upon for Final Design Review:

I. Optical Design
a.) Preliminary ray tracing of optics, including predicted encircled energy (EE50 and EE80) and/or RMS spot radii of images, both as functions of wavelength and field angle.
b.) Predicted instrument performance (including throughputs and sensitivities) for all expected observing modes (including imaging modes using all filters expected to be used, Fabry-Perot etalons, polarizing optics and any diffraction gratings, grisms or prisms with the relevant blocking filters), both before and after the detector DQE is taken into account. Slit, aperture or optical fibre losses should also be factored into throughput estimates if relevant, assuming several different seeing scenarios.
c.) Preliminary analysis of alignment tolerances for all optical elements.
d.) Draft optical mounting and alignment plan.

II. Mechanical Design
a.) Enumeration and description of all major mechanical components and sub-systems, including mass estimates where appropriate.
b.) Draft 3-D modelling for SALTICAM and major sub-systems.
c.) Identification of components or sub-systems requiring an opto-mechanical tolerance analysis and/or draft tolerance requirements.
d.) Description of the approach to flexure analysis of SALTICAM, including the structure, detector and any other crucial components
e.) Draft instrument mass estimate for each mechanism and structure, including the electronics cabinets. Indicate mass and location of any ballast needed to meet the mass and CG requirements.
f.) Draft 3-D model of the complete instrument, including detector, electronics and any ballast showing how they are mounted in a structure.
g.) A draft error budget showing the major contributors.

III. Electronics Design
  a.) System overview of SALTICAM from the electronics perspective.
  b.) Enumeration and description of all mechanisms and electronic subsystems with a described approach to each of them (e.g. commercial off-the-shelf (COTS), custom, hybrid, etc.).
  c.) Preliminary design of instrument control system.
  d.) Estimated power consumption calculation for each major electronic/electrical sub-system.
  e.) Mass estimate for each major electronics enclosure/cabinet.
  f.) Description of completed array/controller tests and those still to be carried out.

IV. Software
  a.) Review the requirements – items to be controlled, major pieces of software to be developed.
  b.) A draft software design overview, describing major functions of software, how it will be integrated with the SALT sub-systems (e.g. the TCS) and a data flow diagram.
  c.) Review the tools needed to do the development, prototyping and testing, and indicate which are already obtained and those still needing to be procured.

V. Project Management
  a.) Review the overall draft design, fabrication, assembly, integration and test schedule, including the dates for remaining project, and dates for obtaining any remaining SALT/other furnished equipment or major purchased items (e.g. cryocoolers, detector arrays, array controllers, etc.).
  b.) Show a breakdown of cost estimates for major components/sub-systems, plus expected spending profile (i.e. expected purchase dates).

6.5 Preliminary Design Review

(a) The PS will call and conduct a Preliminary Design Review (PDR) of the Preliminary Design Documentation near the date specified in the Work Scope. Such a date should not be less than three weeks after the date the Preliminary Design Documentation is submitted. The Preliminary Design Review should ideally be held at the PI's institution to allow the committee to assess the local infrastructure. If this is not possible measures must be taken by the PI, in consultation with the PS, to allow for such an assessment to be made (e.g. by prior arranged visits to the PI institution by the PS and/or an appointed representative. Appropriate representatives of the PI institution and its contractors should present the preliminary design at the review.

(b) The PS may request changes in the Preliminary Design Documentation, as well as the design approach, that arise following comments received at the Preliminary Design Review and that are consistent with the FPRD. The PI should promptly comply with all such requests deemed reasonable, and should submit the revised Preliminary Design Documentation to the PS within eight weeks of the Preliminary Design Review. The PS

will assess the risk of changes that the PI declines to make and report in writing to the SSWG and SALT Board.

(c) Sufficient information and detail shall be included in the Preliminary Design Documentation and presented at PDR to allow the reviewers to assess or answer the following points:

i. How well does SALTICAM address the science drivers/goals for SALT partners ?
ii. How realistic are the derived performance metrics (e.g. throughput/sensitivity, stability) ?
iii. How optimum is the optical and mechanical design and will it work ?
iv. Is there sufficient detail (e.g. design drawings, optical ray tracing) provided and has enough analysis (e.g. FEA, image quality) been done at this stage ?
v. Are there unexplored better alternatives (for specific components, subsystems or even the entire instrument concept) ?
vi. Have the technical risks been identified and rated ?
vii. Are the cost estimates realistic ?
viii. Are cost risks identified and rated ?
ix. Is SALTICAM well matched to the telescope parameters (e.g. focal plane scale, wavelength capability, tracking time) ?
x. Is SALTICAM capable of doing 'niche' or competitive science ?
xi. Are there trade-offs in the design which might lead to a cheaper, but still useful, instrument ?
xii. Are there development possibilities or upgrade paths for SALTICAM ?
xiii. Will SALTICAM operation be easily accommodated by the SALT queue-schedule approach ?
xiv. Are there any issues relating to interfacing to the telescope which have not been addressed ?
xv. Has sufficient thought been given to calibrations, how they'll be done and the associated problems inherent in SALT's design ?
xvi. Is there a clear plan for SALTICAM control and software development ?
xvii. Is there a plan for how SALTICAM will be designed, built, integrated, tested, installed and commissioned ?
xviii. Has sufficient thought been given as to how SALTICAM will be transported, lifted, stored and installed ?
xix. Does the project plan look feasible and is the resource allocation adequate ?
xx. Do the labour cost estimates look reasonable ?
xxi. Are overhead costs reasonable ?
xxii. Are the qualifications and experience of the personnel involved in the project sufficient for the task ?
xxiii. Is the schedule realistic ?
xxiv. Are any contingencies included on cost estimates ?

6.6 Final Design Documentation

(a) The PI shall prepare all documentation required to complete the detailed design of SALTICAM based upon the FPRD, the OCDD, the Preliminary Design Documentation, and the requirements of this SOW.

(b) The completed Final Design Documentation placed on the SALT Project website shall contain all aspects included in the Preliminary Design Documentation, modified as a result of the Preliminary Design Review and additional design efforts, and should also contain:

I. SALTICAM performance predictions;
II. a review of SALTICAM safety aspects;
III. a schedule for fabrication, assembly, test, and delivery of SALTICAM;
IV. scaled drawings showing each and every item, component, subassembly, assembly, item of equipment, and subsystem of SALTICAM in the “as finished” condition with all applicable dimensions, material designations, and specifications;
V. engineering calculations and analyses adequate to demonstrate that all requirements of the FPRD will be met;
VI. models of SALTICAM adequate to demonstrate that all requirements of the FPRD will be met;
VII. a means for handling SALTICAM while it is not mounted on the telescope; and
VIII. final versions of all ICD’s.
IX. finite element analyses (FEA) of critical parts of SALTICAM (e.g. supporting structures. Any FEA models should be compatible with a finite element package mutually agreeable to the SALT Project, PS and PI. In the event that the SALT Project considers calculations and analyses to be inadequate, the PS may request that the PI perform further calculations and analyses to ensure that the requirements in the FPRD are met. The PS will assess the risk if the PI declines to pursue these analyses and report in writing to the SSWG and SALT Board.

(c) All Design Documentation shall:

I. have drawings generated in (or be transferable to) AUTOCAD Release 14, or a similar mutually agreeable format, or later in native (DWG) file format;
II. have their drawings organized by subsystem, so that drawings related to each subsystem are grouped together to assist in maintenance and operation of SALTICAM;
III. have their textual documents generated in MS-Word and/or PDF format; and
IV. have a prominent space within the title block on each drawing for a unique drawing number to be assigned by the SALT Project, which should be placed on each such drawing by PI as directed by PS near the completion of the Design Documentation effort.

(d) The PI shall conduct a safety review of the design of SALTICAM, as it relates to safety in installation, maintenance, repair, and operation of SALTICAM, on a date to be specified by the PS. This safety review of the Design Documentation should determine compliance with all appropriate safety regulations then in effect at SITE. The SALT Project will assist the PI in determining what safety regulations are in effect at SITE. The review should include assessing risk to personnel and hardware during normal operations, maintenance operations, transportation, handling, and while being subjected to the environments specified in the FPRD. Subsequent to the review, the PI shall prepare a written report detailing any safety problems inherent in the designs as represented in the Design Documentation, and this report shall be presented to the PS

at the Final Design Review. In the event that the SALT Project determines that any of the Design Documentation is inadequate with respect to safety issues, the PS may require the PI to promptly revise such Design Documentation.

(e) The Final Design Documentation shall be completed and placed on the SALT Project website by the date specified in the Work Scope. The PS may provide the PI with a list of suggested changes to be made to the Design Documentation (consistent with the intent of this SOW) within two weeks after this date. The PI should incorporate changes that it agrees to in the Final Design Documentation, and place the revised documents on the SALT Project website at least two weeks prior to the date specified by the Work Scope for the Final Design Review. The PS will assess the risk if the PI declines to make some changes and report in writing to the SALT Board and SSWG.

6.7 Final Design Review

(a) The PS will call and conduct a Final Design Review of the Final Design Documentation near the date specified in the Work Scope. Such date should not be less than three weeks after the date the Design Documentation is submitted. The Final Design Review should ideally be held at the PI's institution. Appropriate representatives of the PI and its contractors should present the design at the review.

(b) The PS may request changes in the Design Documentation, as well as the design approach, that arise following comments received at the Final Design Review and that are consistent with the FPRD. Changes declined by the PI will be noted by the PS and duly reported to the SALT Board and SSWG, along with an assessment by the PS of the likely impact on instrument scientific and operational performance, and on the likely delivery date. The PS will work with the PI to ensure that this report will present all viewpoints.

(c) The following items must be addressed in the Design Documentation for the Final Design Review:

I. Safety Review
   a.) Measures for avoidance of electrical shock, explosions, body parts getting pinched by moving parts on the outside of SALTICAM, handling fixtures, vacuum.

II. Optical Design
   a.) Ray trace of all optics, showing spot diagrams against the pixel box or Airy disk for different field angles.
   b.) Predicted encircled energy (EE50 and EE80) and RMS spot radii of images, both as functions of wavelength and field angle. The effects of tolerancing errors in positioning of optical elements on these results should be discussed.
   c.) Predicted instrumental throughputs for all expected observing modes (including imaging modes using all filters expected to be used, and any grisms or prisms with the relevant blocking filters), both before and after the detector DQE is taken into account.
   d.) Stray and scattered light analysis in all modes. Indicate through use of appropriate modeling, or other software tools, for a given ensemble of rays

entering SALTICAM, where the light ends up and where the major problems are.

e.) Complete baffling design to reduce stray light.
f.) Alignment tolerances for all optical elements.
g.) Opto-mechanical tolerances for all mechanisms in all modes.
h.) Discuss any mitigation against optics being exposed to a hostile environment (e.g. dust, moisture, glycol leaks, etc).
i.) Optical mounting and alignment plan.
j.) Assessment of manufacturing risks arising from discussions with potential vendors.

III. Mechanical Design

a.) Enumeration and description of all major components and/or sub-systems, including mass estimates where appropriate.
b.) Assessment of the opto-mechanical tolerances (in previous section) given by the optical designer and any derived mechanical requirements that they imply (e.g. tolerances on lens cells).
c.) Assembly drawings of all mechanisms, and analysis to show they meet the opto-mechanical tolerances.
d.) Flexure analysis of SALTICAM as a whole, and major sub-systems (including the detector/dewar with respect to focal plane) with electronics cabinets and balance or dummy masses in place.
e.) For cryogenic components, thermal cold strap design for distributing cooler capacity to mechanisms and optics.
f.) For cryogenic components, steady-state FEA thermal analysis showing temperature distribution at the end of the cool-down cycle; include all shields, all strapping in the final design, and lump masses for mechanisms.
g.) For cryogenic components, cool-down prediction incorporating the cooler capacity as a function of temperature, strap capacity, shields, and other items. The model should be adequately detailed to give the prediction a maximum error of 10%.
h.) All fabrication drawings complete to a standard TBD.
i.) Detailed instrument mass estimate for each mechanism and structure, including the electronics cabinets. Indicate mass and location of any ballast needed to meet the mass and CG requirements.
j.) Show the complete instrument, with electronics and ballast mounted in some sort of structure.
k.) As an Appendix, generate an error budget showing how opto-mechanical errors are distributed across SALTICAM and lead to a value that is within the overall error budget allocation for SALTICAM in the SALT environment.
l.) As an Appendix, or a separate document, fabrication drawings of every part and a drawing tree showing the hierarchy of drawings. This does not necessarily have to be duplicated for all reviewers, but should be available for general perusal at FDR. All drawings shall have SALT-approved drawing numbers in each title block.

IV. Electronics Design

a.) System overview of SALTICAM from the electronics perspective.

b.) Enumeration of all mechanisms and electronic subsystems with a described approach to each of them (e.g. commercial off-the-shelf (COTS), custom, hybrid, etc.)
c.) Details of each major subsystem. For modification of existing electronics, list each modification to be made.
d.) Listing of all specification sheets for COTS equipment and components, which shall be gathered together in an Appendix.
e.) Include, as an Appendix, detailed circuit schematics for all custom hardware.
f.) Layouts of the electronics cabinets showing where each piece of electronics will go. All details should be provided: including power supplies and SALT-furnished LAN hubs and other equipment. Show every board in each major subsystem, so the review committee can verify that all the interface boards are accounted for.
g.) Detailed power consumption calculation for each cabinet, including power for each board, if possible.
h.) Detailed mass estimate for each cabinet, listing at least every rack-panel piece of equipment, and more detail if it exists.

V. Software
a.) Review the requirements – items to be controlled, major pieces of software to be developed.
b.) Overall description of how the approach meets the SALT Software Requirements, TCS architecture and software design philosophy. Address whether LabVIEW will be SALTICAM control software, and if not, a description of the how the software will meet the requirements.
c.) Software design overview, giving each major item of software and how it fits into the grand scheme of things (e.g. a data flow diagram, hierarchical chart, LabVIEW Virtual Instrument (VI), or some other graphical representation) and interfaces with other telescope sub-systems (e.g. the TCS).
d.) Describe for each VI, the function it performs, total lines of code, or equivalent, to develop, and degree of difficulty of the code (give % of LabVIEW code, % of C code in DLL/shared libraries, etc.).
e.) Review the tools needed to do the development, prototyping and testing, and indicate which are already obtained and those still needing to be procured.
f.) As an Appendix, include a compliance list with all software requirements (e.g. SALT Software Standard).

VI. Project Management
a.) Review the overall design, fabrication, assembly, integration and test schedule, including the dates for remaining project milestones listed in the SOW and contracts, and dates for obtaining any remaining SALT/other furnished equipment or major purchased items (e.g. cryocoolers, detector arrays, array controllers, etc.).
b.) Show, as an Appendix, a complete bottom-up schedule that includes all the remaining tasks discussed in the earlier presentations. For example, each major piece of software should be listed, each electronics custom board, each major mechanical assembly, optics fabrication and testing, etc.

c.) Show a detailed bottom-up cost estimate based on the above detailed schedule.
d.) Supply a complete list of recommended spares.

6.8 Final Design Approval

The PI shall revise and place on the SALT Project website, within eight weeks after the date of the Final Design Review, the Final Design Documentation, quality assurance plan, and Pre-delivery Acceptance Test Plan, with all revisions arising from the Final Design Review incorporated therein.

6.9 Errors, Inconsistencies and Omissions

The PI shall study carefully and compare the various applicable documents (e.g. EID, ICD, SSRD, FPRD, and the approved Design Documentation and Pre-delivery Acceptance Test Plan and shall promptly report to the PS any error, inconsistency, or omission therein, or with this SOW. The PI, PS and the SALT Project shall coordinate to eliminate such errors, inconsistencies, or omissions.

7 Fabrication Documentation

7.1 Fabrication Drawings and Fabrication Specifications

(a) The PI shall place on the SALT Project website, by the date specified in the Work Scope (§3.3), a complete set of as-built Fabrication Drawings and Fabrication Specifications for SALTICAM, which should be consistent in all respects with the approved Design Documentation and the requirements of this SOW. These drawings and specifications will become part of the documentation of SALTICAM.

(b) The Fabrication Drawings and Fabrication Specifications shall:

I. establish all of the fabrication requirements in detail including machining processes, coating and plating processes, and all other shop drawings and working drawings, processes reasonably required to fabricate all of the components and equipment comprising SALTICAM;
II. be consistent with the approved Design Documentation;
III. comply with all requirements of this SOW; and
IV. conform to the PI institution's drawing and documentation standards used for instruments of similar function and complexity. The Fabrication Drawings shall be adequate for their intended use of guiding the complete fabrication, pre-assembly, and installation of SALTICAM.

(c) Fabrication Specifications shall be in MS-Word and/or PDF format. All Fabrication Drawings should be generated in (or be transferable to) AUTOCAD Release 14, or a similar mutually agreeable format, or later, in native (DWG) file format.

7.2 Errors, Inconsistencies and Omissions

The PI shall carefully study and compare the Fabrication Drawings and Fabrication Specifications and should promptly report to the PS any error, inconsistency, or omission discovered therein, or with the Design Documentation or this SOW. The PI, the PS, and

the SALT Project shall coordinate to eliminate any such errors, inconsistencies, or omissions.

8 Materials, Fabrication and Workmanship

8.1 Materials

All materials incorporated into the work shall:

a.) be new and of high grade commercial quality;
b.) be able to withstand the environmental conditions listed in the FPRD; and

8.2 Fabrication

a.) The PI shall fabricate all parts, equipment, components and materials related to SALTICAM in accordance with the requirements set forth in the FPRD and the other provisions of this SOW.
b.) Subsequent to fabrication, but prior to packaging and delivery of SALTICAM, the PI shall store all components, materials and equipment related to SALTICAM in a manner that will reasonably protect such components, materials and equipment against loss or damage.

8.3 Workmanship

All work involved in the fabrication of SALTICAM shall be performed to high standards commensurate with the function of SALTICAM, and should be adequate to achieve the accuracies and surface finishes required by this SOW and the Fabrication Documentation.

9 Spares

The PI shall prepare a list of recommended spares for the PS's review by the date specified in §3.3 for the draft version of the Service and Calibration Manual. The Spares List shall include all components of SALTICAM whose function and useful lives require occasional replacement to prevent interruptions in operation of SALTICAM. The SALT Observatory will purchase all spares that it desires at its sole expense.

10 Assembly

10.1 General

Subsequent to fabrication, but prior to packaging and delivery of SALTICAM, the PI should fully assemble SALTICAM at the PI's facility to ensure proper form, fit, and operation of every component part of SALTICAM. The assembly of SALTICAM should not be deemed completed until the PI has conducted sufficient tests to ensure that the assembled instrument is fully functional and conforms to the FPDD and OCDD, to the extent that this is possible without SALTICAM being in place on the telescope.

10.2 Other Assembly Requirements

a. The PI shall provide all parts, equipment and facilities required or deemed to be desirable, to complete the assembly and testing of SALTICAM, including all required fixtures, handling equipment, supports, and all other items required to

facilitate the assembly and testing of SALTICAM. All materials, components, and equipment that are incorporated in, or connected to, or otherwise required to support and maintain the assembled instrument shall be packaged and delivered to the SALT Project along with SALTICAM.

b. The SALT Project will provide cranes, lifting gear and other necessary equipment for the sole purpose of installing SALTICAM in its final mounting fixture/position.

c. The PI shall remain solely responsible for the successful and timely assembly and completion of SALTICAM.

10.3 Assembly Procedures

The PI shall prepare complete documentation of the procedures for assembling SALTICAM. Sections of the Service and Calibration Manual may be used for this purpose. The PI should verify the procedures during assembly and integration with the telescope. The PI should deliver a draft version of the assembly procedures at the same time as given in §3.3 for the Service and Calibration Manual and a final version along with the final versions of the manuals on the date given in §3.3 above.

11 Pre-delivery Acceptance Testing

11.1 Pre-delivery Acceptance Test Plan

The PI shall prepare and submit to the PS the Pre-delivery Acceptance Test Plan.

11.2 Pre-delivery Acceptance Tests and Inspections

Notwithstanding any other provision of this SOW to the contrary, the Pre-delivery Acceptance Test Plan shall provide for inspections and tests which adequately ensure that SALTICAM complies with all requirements of the FPRD, OCDD and this SOW, as far as can be ascertained with SALTICAM not mounted on the telescope.

11.3 Pre-delivery Acceptance Testing

a. The PI shall perform all tests, and facilitate all inspections by the PS leading to Pre-delivery Acceptance, as provided in this SOW and the Pre-delivery Acceptance Test Plan.

b. All costs associated with repair, re-work, re-inspection and re-testing that arise from failure of SALTICAM to successfully complete the tests and inspections specified in the Pre-delivery Acceptance Test Plan shall be borne by the PI.

c. The assembled instrument will be assessed by the PS to ensure proper form, fit, and operation of every component part of SALTICAM, to the extent this is possible off-telescope. Acceptance testing of SALTICAM shall not be deemed complete until the PI has conducted sufficient tests to reasonably ensure that SALTICAM is fully functional and conforms to the FPRD, OCDD and this SOW, as far as this can be assessed.

d. Where appropriate the SALT Project will provide software and/or hardware simulators capable of simulating certain interfaces between SALTICAM and the telescope. It is the responsibility of the SALT Project to provide these in time for SALTICAM Pre-delivery acceptance testing.

11.4 Pre-delivery Acceptance Test Deficiencies and Non-conformances

As a result of pre-delivery acceptance test inspections, the PS may deliver to the PI a list of deficiencies and non-conformances that are observed during such inspections (the "Pre-delivery Acceptance Test Non-conformance List"). The PI shall promptly correct all such deficiencies and non-conformances noted. Within a TBD time of the PI's receipt of this non-conformance List the PI shall provide the PS with a list, in the same format as the Pre-delivery Acceptance Test Non-conformance List, specifying the corrective action taken, if any, and the date such action was completed with respect to each of the deficiencies and non-conformances. In any event, the PI shall provide the PS with a complete list of all such corrections upon completion of the last of all such corrections. The descriptions of corrective action taken shall correspond directly with each individual deficiency and non-conformance noted in the non-conformance list. SALTICAM shall not be deemed to have passed Pre-delivery Acceptance Tests until all such deficiencies and non-conformances have been corrected by the PI in a manner deemed adequate by the PS.

12 Packaging

12.1 General

The PI shall utilize equipment, packaging materials, shipping containers, and methods mutually acceptable to the SALT Project and the PI. In addition the PI shall provide shipping containers for all components, materials and equipment related to SALTICAM that provide adequate protection from loss or damage to such components, materials and equipment in transit and storage

12.2 Packaging

a.) The PI shall ensure that all shipping containers required to transport SALTICAM provide sufficient support and protection of all components, including measures to prevent corrosion or damage to unpainted surfaces. All packaging of electrical and electronic equipment and components will include an adequate de-humidifying agent or desiccant to eliminate condensation-caused damage during transportation and storage.

b.) The PI shall ensure proper and complete identification of all packaging such that the SALT Project can quickly and accurately identify and locate each component, material, and equipment item of SALTICAM.

13 Delivery

Delivery shall take place to the SALT Project Office in Cape Town.

14 Commissioning and Final Acceptance Testing

14.1 Arrival at SITE

Upon arrival of SALTICAM at the SITE, the PI, or his/her representative, should inspect SALTICAM to ensure that no damage has been sustained by the instrument during shipment to the SITE. SALTICAM shall not be deemed free of damage until the PI has conducted sufficient tests to reasonably ensure that SALTICAM is fully functional and conforms to the FPRD, OCDD and this SOW, as far as this can be assessed. Any damage sustained during transport to SITE shall be made good by the PI but at the sole cost of the SALT Project.

14.2 Re-assembly Deficiencies and Non-conformances

The PS shall also inspect SALTICAM at the SITE. As a result of such inspections, the PS may deliver to the PI a list of deficiencies and non-conformances that are observed during such inspections (the "Re-assembly Non-conformance List"). Any damage sustained during transport to SITE shall be made good by the PI but at the sole cost of the SALT Project.

14.3 Installation on Telescope

14.3.1 Mounting on Telescope

a. Before SALTICAM is mounted on the telescope, all mounting points, interfaces will be inspected by the PI and PS to ensure that they conform to the expected form, fit and function.

b. Installation of SALTICAM on the telescope shall not be deemed complete until such time as the PI has conducted sufficient tests to reasonably ensure that SALTICAM is fully functional and conforms to the FPRD and OCDD. Often installation will consist simply of bolting SALTICAM to its support frame, reconnecting electronic cables, optical LAN fibre, and cryogenic lines, and adjusting trim weights. A rack-mounted PC may be moved from SALTICAM preparation room to the Observatory computer room.

c. The PI shall supervise all installation and removal of SALTICAM on and from the telescope as requested by the PS to accomplish the commissioning of SALTICAM. The PI may have use of the handling and lifting equipment at the SITE in such installation and removal and can expect assistance in this regard from the SALT Project staff. The SALT Project, the PS, and the PI should cooperate to accomplish all installation and removal operations in a manner that will prevent risk of harm or damage to persons and property, and that will not interfere with other operations being conducted at the SITE.

14.4 Commissioning

14.4.1 General

The PI shall perform all functions required to ensure that SALTICAM meets all requirements in the FPRD and OCDD during its actual operation as a part of the SALT Observatory. Such functions shall include:

(a) proper integration of SALTICAM with other interfacing components and subassemblies of the SITE;
(b) trouble-shooting problems related to operation and maintenance of SALTICAM;
(c) developing and revising operational and maintenance procedures to ensure adequate instrument performance; and
(d) any other function to ensure the proper operation and maintenance of SALTICAM.

In addition, it is intended that the first-light instruments shall play critical roles in optimizing the performance and capabilities of the SALT. To this end, the SALTICAM PI will work with the PS and SALT Project to determine a reasonable set of activities related to telescope commissioning that can be supported by SALTICAM. These activities will utilize commissioned aspects of SALTICAM, and will not involve undocumented or unsupported functionality beyond the scope of the performance outlines in the FPRD and OCDD. Costs associated with these additional activities that are not directly related to commissioning aspects of SALTICAM will be borne solely by the SALT Observatory.

14.4.2 Commissioning Team

(a) The PI, in consultation with the PS, shall appoint a commissioning team to be present at the SITE during reassembly, installation, and commissioning of SALTICAM.

(b) The Commissioning Team shall be comprised of some persons who were intimately involved in the design, fabrication, assembly, and testing of SALTICAM. The members of the Commissioning Team should:

I. be selected by the PI, with the concurrence of the PS; and
II. have qualifications and experience adequate to install and conduct the commissioning of SALTICAM.

(c) The Commissioning Team should be available to serve at the SITE at the discretion of the PS for a period not to exceed 6 months following installation of SALTICAM on the telescope. The exact dates of commissioning will be specified by the PS near the completion of shipment of SALTICAM to SITE.

(d) All expenses incurred by the PI related to reassembly, installation, and commissioning at SITE shall be borne solely by the PI.

14.5 Commissioning Testing Program

14.5.1 Commissioning Test Plan

The PI shall prepare and submit to the PS the Commissioning Test Plan. The PS will ask that the Plan be revised if s/he feels that it inadequately certifies the various functional modes of the instrument or fails to exercise agreed upon telescope/observatory commissioning functions. Modes that are not certified will not be supported by Observatory staff, nor allowed to operate if they might endanger personnel, the telescope or hamper Observatory operations. The PS, or his/her proxy, will be the sole judge of any such danger.

The PI, in consultation with the PS, may develop a staged approach of commissioning SALTICAM, which may involve several commissioning runs during which different operational modes of SALTICAM are tested and commissioned.

14.5.2 Commissioning Tests and Inspections

(a) The Commissioning Test Plan shall provide for inspections and tests adequate to ensure that SALTICAM complies with all requirements in the FPRD and OCDD.

(b) All costs associated with repair, re-work, re-inspection, and re-testing that arise from failure of SALTICAM to successfully complete the tests and inspections specified in the Commissioning Test Plan shall be borne by the PI.

15 Coordination with Other Suppliers

Some work described in this SOW depends on the supply of equipment or completion of work by SALT Project contractors. Schedules showing the dates of equipment delivery and completion of such work should be provided with adequate notice to the PI. The PI shall report to the PS as early as possible any delays of which s/he is aware that could affect the work schedule. The cost to the PI of delays caused by the failure of SALTICAM sub-contractors to deliver or complete will be covered by the PI. The cost to the PI of delays caused by the failure of telescope sub-contractors to deliver or complete will be reimbursed by the SALT Project. The SALT Project and the PS will determine the validity of each claim. The PI shall have the right of appeal to the SALT Board in the case of any disputes. To obtain such reimbursement, the PI must notify the PS as soon as possible after the PI is aware of the failure of others to deliver or complete, and must receive direction from the PS on how to handle the delay.

16 Completion Requirements

16.1 General

The work associated with the successful design, construction and commissioning of SALTICAM shall not be deemed complete, and final payment shall not be made, until the PI has:

a.) completed all of the work specified in this SOW;
b.) completed and submitted all Record Documents;
c.) completed and submitted all the Manuals; and

d.) submitted the documents specified below.

16.2 Record Documents

16.2.1 General

a.) The "Record Documents" for SALTICAM include the Design Documentation, and drawings/documents as required to accurately depict the as-assembled instrument. Included in this are each and every item, part, component, article of equipment, subassembly, assembly, and subsystem comprising SALTICAM. Also to be included are Fabrication Drawings, and the Fabrication Specifications for SALTICAM, including any subsequent modification up to commissioning. The Design Documentation and Fabrication Documentation that become Record Documents should accurately depict the final as-assembled condition of each and every item, component, subassembly, assembly, item of equipment, and subsystem of SALTICAM, with all applicable dimensions, material designations, and notes.

b.) All Record Documents shall:

I. be generated in (or be readily transferable to) AUTOCAD Release 14, or a similar mutually agreeable format, or later in nature (DWG) file format;
II. have their drawings organized by key subsystem of SALTICAM, so that drawings related to each key subsystem are grouped together to assist in maintenance and operation of SALTICAM;
III. have their textual documents generated in MS-Word and/or PDF format; and
IV. have a prominent space within the title block on each drawing for a unique drawing number to be assigned by the SALT Project, which shall be placed on each such drawing by the PI as directed by the PS near the completion of the Fabrication Documentation effort.

16.2.2 Installation Modifications

a.) The PI shall modify all Design Documentation and Fabrication Documentation to accurately depict the as-installed condition of each and every item, component, subassembly, assembly, item of equipment, and subsystem of SALTICAM, with all applicable dimensions, material designations, and notes, as required. The record Design Documentation and Fabrication Documentation shall include all addenda, Change Orders, and similar modifications thereto that are issued in printed form during fabrication and assembly of SALTICAM, as well as marked-up variations (of substance) reflecting differences in actual work, as compared with the text of the Design Documentation and Fabrication Documentation and modifications, as issued.

b.) When any of the work related to product data varies from that specified previously, the PI shall note such variations, either on or as an addendum to, such record drawing or document. Notations should include variations in the product, as delivered and incorporated into the work, and variations from the manufacturer's instructions and recommendations for installation. The PI should also note related modifications of record Design Documentation and Fabrication Drawings.

16.2.3 Submittal of Record Documents
Upon completion of the work, the PI shall deliver to the PS one set of each of the Record plus one set of all record Design Documentation and Fabrication Drawings in AutoCAD 14 format. These shall be delivered on a standard format CD-ROM or DVD-ROM.

16.3 Installation, Operation, and Maintenance Instruction
Upon completion of installation of SALTICAM, the PI, or appointed representative, shall arrange to meet with the SALT Observatory personnel at the SITE to provide basic instructions needed for proper installation, operation, and maintenance of SALTICAM.

The PI shall train designated representatives from the SALT Observatory in all pertinent aspects of operation and maintenance of SALTICAM, including:

a.) assembly/disassembly procedures;
b.) insertion of removable components (e.g. slit masks, filter jukeboxes, gratings, etc.)
c.) cool-down and warm-up procedures; and
d.) all operations and maintenance procedures.

Such training shall be in accordance with the Work Scope and this SOW, and should be provided at the SALT Project or SAAO Cape Town Offices near the time of Commissioning and at SITE after SALTICAM has been commissioned at the telescope. SALT Observatory personnel will be responsible for disseminating instrument capabilities, calibration procedures, and observing procedures to the scientific community.

The PI shall review the Manuals, Record Documents, tools, spare parts and materials, lubricants, identification system, control sequences, hazards, cleaning, preventive maintenance schedules, and similar procedures and facilities with SALT Observatory personnel.

The PI shall also review maintenance and operations in relation to the TBD warranty period and similar continuing commitments.

16.4 Manuals
a.) The PI shall prepare and submit to the PS by the date specified in §3.3 draft versions of manuals, a complete set of maintenance and operation data in the form of draft or final manuals, which shall comply with the requirements specified in this SOW and the Work Scope. The PS may request changes to the proposed table of contents that are consistent with the intent and requirements of this SOW. The PI should promptly comply with all such requests, and should complete such changes within a reasonable time.

b.) The manuals shall contain all data related to maintenance and operation of SALTICAM, so that the information in the manuals will be adequate to enable SALT Observatory personnel to perform the full range of expected operating and regular maintenance functions related to SALTICAM without the need to seek information

from a source other than the manuals. Such information shall include all information related to normal operations and procedures, emergency operations and procedures, normal maintenance and procedures, emergency maintenance and procedures, spare parts, warranties, wiring diagrams, inspection procedures, performance curves, shop drawings, product data, and similar applicable information. Each major component and item of equipment comprising SALTICAM shall have a separate section in the manuals devoted specifically to such component or item of equipment describing the operation and maintenance thereof. The manuals shall also include pertinent information for future maintenance, including the name, address, and telephone number of the PI.

c.) The PI shall certify, by appropriate endorsement thereon, that each manual is complete and accurate. The PI shall provide the PS with one copy of each manual in MS-Word and/or PDF format, suitably indexed for hyperlinked Web browsing.

16.5 Completion Submittals

In addition to the other requirements of this SOW, and prior to Final Acceptance by the PS, the PI shall submit to the PS, in a form acceptable to the PS, assurance adequate to the PS that all other conditions under this SOW have been fulfilled by the PI.

17 Instrument Control System Software

The PI shall develop LabVIEW Virtual Instruments (VI's) and/or provide such other software and control systems support as is required to deliver an instrument control package that meets all SALT requirements in accordance with the SALT Software Standard. SALT will provide Labview VI's for communicating with the TCS and other SALT subsystems and a TCS Simulator, which will provide a communications interface to the PFIS, simulating the other subsystems. Communication of scientific data for storage and retrieval will not be simulated.

The PI shall also provide a means of testing its software without reliance on software from the SALT Project, such as by building diagnostic tools into its instrument control subsystem.

Included in the deliverables are:

1. Complete and robust instrument control system. GUI's for instrument control to be run on the SALT Astronomer’s display (i.e. this will run on the TCS SA MMI computer).
2. Primary data products, with correct and sufficient FITS header keywords, etc.
3. Software and procedures sufficient to reduce and analyze instrument commissioning observations.
4. Basic pipeline reduction software in support of the major (i.e. commissioned) modes of SALTICAM.
5. Instrument control software for the 'minor' (potentially user commissioned) modes, at some later date (i.e. during commissioning or not long after post-commissioning).

6. Concepts for more rigorous data reduction of major & minor modes.

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The author thanks Gerald Cecil for providing the SOW document on which this document is based.

APPENDIX 1 **GLOSSARY OF ACRONYMS AND TERMS**

FDR	Final Design Review
CoDR	Concept Design Review
EID	Evaluation of First-Light Instruments Document
FPRD	Functional Performance Requirements Document
ICD	Interface Control Dossiers
INSTRUMENT	A generic SALT facility instrument
OCDD	Operational Concept Definition Document
PI	Instrument Principal Investigator or his/her institution
PS	SALT Project Scientist
PDR	Preliminary Design Review
SAAO	South African Astronomical Observatory
SALT	Southern African Large Telescope
SDSU	San Diego State University
SOW	Statement of Work
SSWG	SALT Science Working Group
TBD	To be determined
TRCP	Terms of Reference for Concept Proposals