



SALT Board Meeting #23

§ 4.3

SSWG White Paper on Future SALT Instruments and Developments:

Science Drivers

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1. Introduction

In the initial discussion document on the instrumentation White Paper (Version 3, Jan 2008, appended), the SSWG were charged with beginning an “Aspen-like” process to determine possible future SALT science drivers that would lead to a prioritized choice for Second Generation science instruments.

Following the methodology of Gemini in mapping out the future requirements in term of instruments, it was suggested that a first approach should be to determine specific scientific “key questions”, together with the basic generic requirements in terms of new instrument/telescope capabilities. This is a bottom-up approach whereby all of the various science drivers hopefully point to a clear set of common instrument and telescope requirements. The most compelling and competitive science drivers should dictate the priorities of future instruments. The hope was that the SSWG would come up with a wide variety of science drivers which would lead to the list of instrument.

In addition we can, and should, take a top-down approach, whereby some generic science drivers, with potential benefits in many disparate fields, could lead to a different list of instrument requirement. This philosophy is what was behind the suggestion that we consider items in a few broad areas, for example:

- The current and likely future big questions in astronomy which SALT maybe relevant in helping to answer
- Science themes of interest to the consortium, or that *should* be the interest of the consortium
- What types of instruments would support these and give SALT added capability and competitiveness
- Clear and obvious future needs: e.g. spectroscopic (UV-Vis-NIR) follow-up studies from the new multi-wavelength imaging surveys.

Both approaches have their merits and the overlap of the highest priority science drivers may lead to a clear conclusion regarding the top choices for future instrument.

2. SSWG Responses

2.1 UW theme: gains from improvements to image size by adopting AO

On 11 April 2008, a group of six astronomers from the University of Wisconsin-Madison met with the author to discuss inputs into the instrumentation White Paper to be produced by the SSWG. The preference of this group was to take a more top-down approach in coming up with new instrumentation requirements, although these were still science driven. In particular, the possibilities of improving delivered image size by the telescope by utilizing low order AO was considered an important goal if preliminary investigations indicate this to be feasible. This opinion is shared by many in the South African community, and was considered the number one first priority for investigation of 2nd Gen instrument possibilities and telescope upgrades at a meeting of astronomer held in late 2007.

Science Priorities:

- Baryon life-cycle: Galaxy formation, feedback, black holes, and stellar pops
 - Evolution of Massive Black Hole (MBH) luminosities derived from stellar velocity dispersions (σ^*) in AGN host galaxies, i.e. as a function of redshift
 - AGN feedback in galaxy formation
 - Stellar Formation Rates (SFR) in E + A galaxies
 - Abundances and kinematics of stars and gas – 2D maps
 - Star-burst galaxies
 - Dwarf galaxies
 - Environment

- Low- and high-mass star formation

Required instrumentation/science capabilities:

- Spatially resolve 4Kpc structures at all redshifts (0.3 arcsec FWHM)

- 3-D spectroscopy
 - new dedicated instrument? Modify RSS? HRS?
 - at least R=30,000 with large spatial multiplex and options for spectra multiplex

- High R instruments (R = 100,000?)
 - What is the sky detection limit vs R or pixel size in a reasonable time?

- Pave the SALT focal plane (~100mm Φ) with fibres (e.g. ~10,000 x 2 arcsec fibres)
 - Versatile bench spectrograph(s), traditional/FT/SHS?
 - High (A Ω R) – 2D parameter space for stellar and diffuse sources

- Drift scan mode: spectroscopic

Instrumental constraints:

Decision tree:

- AO
 - New payload/old payload
 - What can be done with existing or slightly modifies (new detector) instruments
 - All new instrument initiatives to capture 0.1-0.2 arcsec images?
 - If we have to redo the NRS to solve IQ, is this the time to redesign the payload for AO?

- No-AO
 - High A Ω R (grasp)
 - fibre feed
 - massively parallel

- How far can we go in the IR (2 μ m? 5 μ m? More?)

2.3 Multiplexing gains: Multi-Object High Resolution Spectroscopy

The desire for a Multi-Object Spectroscopic capability on SALT, particularly at medium to high resolutions ($R > 10,000$) has been proposed in the past and is clearly an area worthy of exploitation. This is particularly the case for Integral Field spectroscopy of galaxies, where Matt Bershady and the author have been arguing for sometime that deployable fibre IFUs feeding medium resolution spectrograph(s) could corner a market in galaxy cluster dynamics.

In response to the current call for science drivers, Janusz Kaluzny has responded with the following list:

- population studies in the Local Group galaxies
 - chemistry & kinematics, where the term "chemistry" includes some rare abundance elements and isotopes
- spectroscopic surveys for extra-solar planets in nearby open clusters
-
- kinematics of globular clusters; kinematics of dSph satellites of the Milky Way (dark matter content).

These science drivers would be served well by a multi-object high resolution spectrograph ($R \sim 25,000$) using seeing limited (~ 1 arcsec) slits or fibres.

Clearly AO improvements (e.g. low order tip/tilt that could correct for primary mirror alignment, guiding/tracking errors and low order atmospheric effects) to the PSF size would greatly benefit spectral resolution (and the background limit) on *existing* instruments (perhaps even allowing RSS to reach $R \sim 12,000 - 20,000$). However, it also would potentially decrease the cost of 2nd Generation instruments, which could be designed for smaller PSFs if the AO improvements were realised, by decreasing their size.

2.4 A new domain: Time Resolved Astronomy

Already SALT has First Generation instrumentation that addresses the relatively unexplored territory of time-resolved astrophysics. This is continuing with the development of smaller-scale visitor-type instruments taking advantage of the auxiliary focus/port (e.g. BerkeleyCam, which will push potentially to ms resolutions or better).

I believe that the potential for future science in this area will be enhanced by the new survey projects, particularly the time variability surveys to be conducted by the LSST project, a view shared by Larry Ramsey and his colleagues at Penn State (who are partners in the LSST collaboration). Studies of optical transient behaviour of the sky is only just beginning. Potential synergies with future radio transient surveys, e.g. by MeerKAT, should also not be overlooked. Likewise, the multi-wavelength approach to variability studies utilizing observatories at higher energies (e.g. X-ray and γ -ray satellite observatories), together with SALT, should be investigated. The ground-based TeV γ -ray Cherenkov telescope in Namibia, HESS, is already doing important work on pulsars for which analogous high time resolution optical studies, possibly contemporaneous, with SALT could be extremely beneficial (e.g. the optical detection of the Vela pulsar).

Apart from the existing instrumentation, where possible we should consider the possibility of having detectors on 2nd Gen instruments that support fast readouts to enable this type of science. Investigations into the implementation of Electron Multiplication CCDs (EMCCDs), sometime also referred to as L3 (Low Light Level) CCDs, and Orthogonal Transfer CCDs (OTCCDs) should also be considered.

The benefits of the former are to improve S/N in the high-time resolution regime by virtue of turning a CCD into a virtual photon counting detector (with negligible readout noise). OTCCDs can be employed to improve image quality by performing effective atmospheric tip/tilt corrections on-chip (e.g. as prototyped in the OPTIC camera). Similar improvements in image quality by using MacKay's "lucky imaging" technique, using EMCCDs, has also been advocated by Darragh O'Donoghue.

A continuing prospect is the development of energy-resolving photon counting detectors, like the proposed Super-Conducting Tunnel Junction (STJ) devices being developed by Tone Peacock's group at ESA. These have been proto-typed in the SCAM-2 and SCAM-3 cameras on the WHT, but the full utilization of this technology in a competitive instrument is still to be realized. ESA would like to develop, at their own cost, a fibre-fed STJ camera (SCAM-5) for SALT, under a similar arrangement to BerkeleyCam. Such an instrument would not only be useful for traditional time-resolved astrophysics, but also for efficiently obtaining photometric redshifts, as has been advocated by Richard Griffiths.

Partners within the consortium who have expressed interest to date in this type of science include South Africa, UKSC, CMU, UNC, Poland and Göttingen. Science topics include:

- Short-period cataclysmic variable star emission (QPOs, flickering, eclipses)
- Periodic optical/polarized radiation from pulsars (single and in binaries)
- M-dwarf flare phenomena
- Low mass X-ray binary & AGN black hole accretion "flickering"
- Stellar occultation of solar system planets, their satellites and asteroids
- Transits of extra-solar planets
- High precision asteroseismology
- Studies of optical transient sources (e.g. from the existing Y-STAR survey and the future LSST survey)

2.5 Exoplanets

This contribution comes from Larry Ramsey.

An exciting and unique instrument for SALT would be a 1-1.7 microns high resolution spectrograph that is focused on finding earth-mass planets in the "habitable zone" (HZ), a region where liquid water can exist, around late-type M dwarfs; the most numerous but least luminous stars in our galaxy. Of the over 250 extra-solar planets discovered to date using a variety of techniques, the vast majority have been discovered using Precision Radial Velocities (PRV) techniques which measure the tiny Doppler shift signature caused by a planetary companion. Our potential instrument would pioneer this technique into the near infrared (NIR), a realm is not currently available on 8 to 10 meter telescopes. This is fundamentally important as the NIR region of the spectrum is where the cool M-type stars, that are our primary target, emit most of their energy. The feeble emission of these objects in the visible spectrum put them at the limit or beyond the reach of current instruments.

We have tested a technical approach driven by a balance between detailed modeling and experiment. We have explored the fundamental principles that limit PRV, constructed realistic models simulating likely candidates to demonstrate the ability to recover planet signals and conducted limited experiments with a bread-board instrument to demonstrate an order of magnitude increase in the PRV sensitivity. The intersection of all these considerations leads us to a fiber fed, white pupil echelle spectrograph working in the 0.98 - 1.6 micron wavelength region at a spectral resolving power ($\lambda/\Delta\lambda$) \sim 40,000. A simultaneous emission line calibration system will allow us to achieve the \sim 2 metre/sec precision and long term stability needed to detect earth-mass planets in the habitable zone in our target stars.

The instrument is optimized to address the fundamental question of how common are extra-solar earth-like planets in an environment that could support life as well as a more general census of planets around low mass stars. In addition it will also be capable of exploring other questions ranging from star, brown dwarf and planet formation processes to the nature of the black-hole powered energy engines in the centers of active nuclei galaxies and quasars.

Finding and charactering extra-solar planets is a rapidly expanding cutting edge area of modern astronomical research that also engages intense public interest. There are few, if any, areas of science that capture the public imagination more effectively. Research results in this dynamic sub-field of Astronomy & Astrophysics are frequently in the news and are regularly listed among the top 10 or 100 science discoveries of the year, decade and even millennium. Extra-solar planet research is also the nucleus for the new science of astrobiology with its unique mixture of astronomy, atmospheric sciences, biology, chemistry and geology.

Appendix:



White Paper Discussions on Future SALT Instruments and Developments

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22 February 2008

Draft 3.0

1. Introduction

Following discussions at the 22nd meeting of the SALT Board, held in Oct 2007, the author was charged with producing a White Paper on the future SALT developments, particularly Second Generation instruments, through consultation with the SALT Science Working Group (SSWG). The timescale for the completion of the draft White Paper is before the next meeting of the Board, in May 2008. In parallel, the Strategy Committee of the Board, chaired by Matt Bershady, was to develop a second White Paper on Strategic Development, which would include technology development, funding and new partner requirements as part of its brief.

This White Paper is a necessary first step in the process of defining a set of priorities in terms of the next generation of SALT instruments and development projects for the telescope. The relative urgency in defining these has come about because of the very real possibility of additional SALT partners joining the consortium and thus bringing in new funds. Such funds would primarily be used to enhance the scientific capabilities of SALT through capital expenditures on new instruments and telescope improvements and enhancements.

Clearly having a defined prioritized list will inform the Board and the Strategy Committee on the requirements for new funding and hence the scope for admitting new partners. Some ideas of timescales of such developments will also assist in determining payment schedules and cash flow for future development projects.

This White Paper is partly informed from the reports of the SALT Development Committee, which presented three reports during its tenure from 2005 until Oct 2007, when it was disbanded. In addition a number of individual scientists within the consortium have participated in discussions on future instruments and developments and these have also been on the agenda of the SALT Science Working Group meetings, at least from 2004.

As might be expected in a diverse partnership like SALT, there is a range of opinion on both the need or urgency of developing new SALT projects. There is a perhaps understandably conservative approach taken by some, which is that future developments should await the completion of the commissioning of the telescope and First Generation instruments. On the other hand, it is recognized by many, and certainly those with first-hand experience at instrument development, that the design process can take many years, and therefore

instrument projects have to begin *now* if they are realistically going to be completed in ~3 to 5 years time.

In this White Paper I will attempt to condense the opinions of the consortium members in terms of the way ahead for SALT development, and particularly the choice and prioritization of Second Generation instrument plans.

2. SALT's current status: a reason to postpone development plans?

Perhaps understandably the erstwhile SALT Development committee were concerned that developing new instruments or capabilities was maybe premature given the on-going technical problems with the telescope and its instruments. The most significant problem was, and still is at the time of writing, the poor image quality delivered by the telescope. While it is true that this issue has proven to be significant, requiring substantial resources to solve it, I believe that this fact alone should not stall future development plans.

In addition, some allusions have also been made to the complexity of the SALT's operation as a queue scheduled telescope with a range of instruments and modes, and the possibility of software related problems impacting the ability of the telescope and its instruments to perform as designed. While it is true that SALT is a software critical telescope, I believe that the effort expended on its design and implementation, adhering as it does to a systems engineering approach, has minimized the likelihood of problems of this nature. Indeed the current commissioning experience has proven the general reliability of the Telescope Control System (TCS) and has demonstrated that SALT is basically working as designed, notwithstanding the image quality problems and set-up inefficiencies. The latter are mostly a result of the incomplete integration of the TCS with the auto-guiding/auto-focussing systems, which will be completed in 2008. Likewise the Observatory Control System (OCS), which links the telescope and instruments with the scheduler and database, is beginning to be implemented and will significantly increase instrument set-up efficiencies, I therefore disagree with an opinion expressed by some that the software control of the telescope will require a large amount of resources and capital in the future, perhaps as significant as a new instrument.

My belief, which is independently supported by recent external reviews (e.g. by both Booth and Bigelow, as presented at the 21st Board meeting in May 2007), is that SALT is in a state one would expect for a telescope at this phase of its development, i.e. post inauguration commissioning. Furthermore I believe that the crucial telescope optics are *fundamentally sound*, and this is supported by the fact that sub-arcsecond images, over the *entire* science field of view, have been obtained, on occasions. I am optimistic that the image quality problems, which have been amply demonstrated by Darragh O'Donoghue et al. to arise from probable opto-mechanical deficiencies in the Spherical Aberration Corrector (SAC), are repairable and that this repair will be completed during 2008.

SALT is currently completing its commissioning phase, expected to be concluded by the end of 2008 following the return of the repaired RSS and the remedying of the image quality problem. In terms of an operational telescope, SALT has matured considerably and is now routinely and reliably being operated (time lost to technical faults is now less than the specified 3% of useable observing time). To date the major verification science conducted with SALT has been RSS long-slit spectroscopy and SALTICAM imaging, which have resulted in several publications from a variety of science programs, including galaxy dynamics and stellar astrophysics. Some of these have been discussed in the last SALTeNews items: http://www.sao.ac.za/fileadmin/files/news/SALTeNEWS/SALTNEWS-Sep2007_update.pdf and references are given in the appendix.

While these programmes have not been particularly challenging in terms of pushing the telescope and instruments to their limits, the results have demonstrated the potential of SALT and its First Generation instrument suite. Notwithstanding the low UV throughput of RSS, which has now been remedied, other aspects of this instrument have met, or even bettered, the specification. This leads us to believe that once the instrument is returned to SALT in mid-2008 that it will meet its specifications as set out in the Functional Performance Requirements Document (FPRD) and deliver excellent science.

I am therefore of the opinion that immediate future of SALT looks bright and that by the end of 2008 we will have matured to a fully functional telescope capable of addressing the varied science needs of the SALT community. In addition, with the SALTHRS construction phase beginning in 2007, and the completion of the conceptual design phase of the Near IR arm of RSS the same year, we are already well on the way to seeing new instrument capabilities added, from late-2009/early-2010 (for SALTHRS). At least the former is fully budgeted, and we are anticipating funding in the near future (during 2008) to support the construction of the RSS NIR arm.

However, I reiterate that both these developments can be seen as a continuation of First Generation instruments (or maybe Generation 1.5 in the case of RSS NIR), since at least SALTHRS was originally anticipated as a First Light instrument, while the RSS NIR was always considered a desirable upgrade of RSS and was subsequently voted as the number one priority instrument to be developed following completion of SALTICAM, RSS (UV-Visible beam) and SALTHRS.

In light of the timescales involved in the development of instruments (typically 2-5 years), I believe that it is *crucial* for the SALT community to begin planning for new telescope and instrument developments. Specifically I believe it is time to develop a prioritized list of Second Generation instruments for which investment in design studies can begin. This list should be informed by the SALT community, through its SALT Science Working Group representatives. Such a list can then be used by the SALT Board to decide on funding objectives in terms of generating new capital from existing or future SALT partners.

3. Response to Development Committee questions

In its final report to the Board (Oct 2007), several questions were put to the SALT Board. Whereas most of these have been discussed at the 22nd meeting of the Board (Oct 2007), it is probably useful to discuss these so that they are finally “put to bed”. These are my considered responses to these questions:

1. *Is the expenditure of \$3.2M+ for the construction of a PFIS/NIR are really good use of capital finds? Is the 0.9 – 1.4 micron wavelength region that important?*

I believe that the answer to these two questions is a resounding yes. This has subsequently been discussed at both SSWG and Board level, where the competitiveness of RSS NIR beam was amply demonstrated. The question is now moot since the Board approved funding of the RSS NIR development through to its Preliminary Design Review.

2. *What is the decision tree for the SALT Board to take re. new instruments (and additional questions relating to potential underperformance of existing instruments)?*

Most of these questions revolve around the “what if” scenarios of RSS, SALTICAM or SALT not reaching their design goals. I have already stated in section 2 my reasons for believing that these considerations should not mean the postponing of Second Generation instrument plans.

In answer to the primary question, the Board has charged us to produce a draft White Paper on future developments, and specifically the next generation of SALT instruments. The process will be consultative and will, as in the past, be governed by the following principles:

- a) Science drivers for new instruments, particularly demonstrating the relative competitiveness and relevance.
- b) That there exist a “champion(s)” for the instrument who is technically competent to lead its development as a Principal Investigator
- c) Support for the development of the instrument by the SALT community
- d) Logistics and funding, although this is within the purview of the Strategic Development Committee’s White Paper.

While SALT was designed as a seeing limited telescope, even in the era of Adaptive Optics (A-O), one should not lose sight of the importance of a seeing-limited imager on a large telescope that can deliver a reasonable field (~10 arcmins). This is particularly the case in the UV-Visible region where it will be sometime before A-O has overcome the inherent technical challenges. The very real possibility of employing some sort of A-O system on SALT (e.g. GLAO) should not be overlooked, and indeed there is already a SALT AO Working Group which has begun to investigate such possibilities.

3. *The idea of SALT II is very attractive to many but might remain under funded until the astronomy community sees excellent science from SALT I.*

This is a valid point and is also a somewhat different proposition to “just” developing the next generation of SALT instruments or telescope upgrades. The possibilities of a “SALT II” will be discussed in the separate White Paper from the Strategic Planning Committee, so is likely to take somewhat of a back seat compared to the other developments discussed in this White Paper.

4. *What about SALT software development? Is this part of the operations or should SALT spend some capital funds to cover reduction and data archive development?*

I have argued earlier that the operational software for SALT and its instruments form part of the original design that was initially funded from the construction budget and continues to be funded by the operations budget. While I have stated that the basic telescope/instrument operational software is in hand, and I expect it to transition to a steady-state from later in 2008, the development of a comprehensive data reduction pipeline was not budgeted as part of the original construction.

Discussions on the scope and nature of the SALT data reduction pipeline go back at least to 2004 where it was discussed extensively at the Dartmouth SSWG meeting. The driver at that time was to provide reduction software for the various RSS modes, initially as an aid to the SALT Astronomy Operations in order to provide a ‘quick-look’ analysis for quality assessment, at the telescope. The suggestion by the RSS instrument PI, Ken Nordsieck, was to adopt Pyraf as the basic reduction scheme, supplemented, where required, with purpose-written software (e.g. for Fabry-Perot modes). This approach was endorsed by the SSWG and has subsequently been expanded through the strong desire of SAAO Director, Phil Charles, to provide a robust and comprehensive suite of pipeline software, both for the benefit of SALT Operations and, eventually, for the wider SALT community. This is seen as particularly pertinent for the full exploitation of SALT by the South African community, which is why additional SAAO resources have been allocated to this task.

The philosophy for the SALT pipeline has evolved to adopt Python as the general language in which data reductions will be written, and Pyraf specifically for those reductions that can be undertaken with existing IRAF tasks. This is seen as a scaleable and modern approach, which has indeed been adopted by the STScI for the HST. The laudable aims of the pipeline development is to eventually provide the SALT user with pipeline-reduced software of sufficient quality that for the vast majority of SALT observations an individual investigator could not improve on the results from the pipeline. The advantage of such an approach is the immense added value of the data supplied to the PI, who in most cases will be able to start analysing the data much sooner. This will lead to a quicker turnaround from data acquisition to analysis and final results, hugely increasing the scientific productivity of SALT.

The SALT pipeline development has been led within the SALT Astronomy Operations, with the first version of the Pyraf pipeline written by Martin Still. Since he left employment at SALT, the management of the pipeline development has been taken over by Steve Crawford. While some pipeline development work was always envisaged as part of SALT Astronomy Operations, its expansion into a fully supported project made available to the wider SALT community was never budgeted for, either in terms of personnel or capital expenditure. Thus the current beginnings of the SALT data pipeline reduction development and data archiving has involved significant additional expenses, some of which have been born to date by SAAO

(e.g. the current position of Steve Crawford as SALT Data Manager is currently a 100% SAAO position). Similarly new capital expenditure to support the SALT data storage system and related computer servers have initially been funded by SAAO, but more recently supported by contributions from SALT. It is therefore likely that given the investment needed in the pipeline development and the demonstrable advantage to the SALT community in having this, that additional future funding will be required from SALT. However, rather than treat this as a pseudo-instrument project, I believe that it is more appropriate to include this as an additional expense to SALT operations, mostly in the form of FTE costs once the capital has been expended for servers and data storage. A wider participation in the pipeline development by interested parties within the SALT community is also envisaged and will be encouraged. This is maybe something more relevant in the deliberations of the Strategic Planning Committee.

4. SALT Science Drivers for Future Instruments and Developments

Future SALT developments and new instrumentation must be informed by a clear set of science drivers based upon the perceived major science questions which SALT should be addressing in ~5-10 years time (a typical timescale of major instrument development). This is a process that must be driven by the SALT Science Working Group (SSWG). The choice of First Generation instruments for SALT came partly from the science drivers as conceived by the early SALT partnership, which came together for a workshop in March 1998. This in turn led to the choice of the first instrument suite for SALT by 2000/2001.

A similar process should now be followed to inform the choices for the next generation of SALT instruments and potential enhancements to the telescope. Ideas have already been aired on this subject by various individuals within the partnership, with some being presented at the last SALT workshop, in 2003. It is now time to gather together all of the suggestions and call on the community, as a whole, to contribute through the SSWG to this process of defining the future directions. This will be the SALT equivalent of the 2003 Gemini "Aspen Process" (see http://www.gemini.edu/files/docman/science/aspens_report.pdf), although on a much less grander scale. It will no doubt require us to formulate this White Paper over an extended period of many months and in addition may require some face-to-face meetings outside of the normal SSWG business.

To kick-start the current discussions, I would suggest that we consider items in the following broad areas:

- The current and likely future big questions in astronomy which SALT maybe relevant in helping to answer
- Science themes of interest to the consortium, or that *should* be the interest of the consortium
- What types of instruments would support these and give SALT added capability and competitiveness
- Clear and obvious future needs: e.g. spectroscopic (UV-Vis-NIR) follow-up studies from the new multi-wavelength imaging surveys

The issues regarding funding strategies, technology development, potential instrument builders, new partner requirements, finances and politics is the brief of the Strategic Planning Committee's (Chair: Matt Bershady) White Paper. This is to be developed in parallel with the Instrument and Development White Paper, being produced by the SSWG, but also to a degree being informed by its conclusions and recommendations.

The science drivers will be used to define the specific instrument and telescope capabilities required to address them. Where there is either no existing capability, or a reduced competitive ability, this will indicate the required generic instrument or telescope development directions.

Following the methodology of Gemini in mapping out the future requirements in term of instruments, I would suggest that specific scientific "key questions" be proposed, together with the basic generic requirements in terms of new instrument/telescope capabilities. So generically, something like the following:

Key Question:

SALT should investigate the nature of <some observable> in the <some class> of objects.

Generic Requirements:

Field of view; image size; number of apertures (slits/fibres); spectral coverage; spectral resolution

Instrumentation and Observations:

This clearly needs an <acme> type of instrument and the telescope needs to be capable of performing <foo> tasks. Observations would be done using a <specific> strategy involving <X # of targets; Y # of visits, Z # of configurations>.

5. Potential Development Paths

This section lays out the scope and possible development options for SALT in three generic temporal categories, but with some specific examples that have already been suggested.

- 1) Near Term Developments (completed in 1-3 years)
 - a) Essential upgrades
 - Inductive edge sensor developments (begun)
 - Potential telescope enhancements (e.g. implementation of a wave-front camera)
 - Implementation of small science instruments for the Auxiliary Port (e.g. Berkeleycam; GASP; SHS) on small budget (<\$0.5M)
 - b) Potential instrument/telescope upgrades (modest budgets of <0.25M)
 - New gratings for RSS
 - New etalons/filters for RSS
 - Recoating of SAC mirrors
- 2) Intermediate Term Developments (completed in 3-6 years; budgets of ~\$5M)
 - a) Second Generation instruments
 - IFU / multiplex Medium Resolution Spectrograph
 - EMCCD (= L3 CCD) based imager
 - Possible SALTICAM upgrade (single 4k x 4k CCD)
 - Multi-Object Fibre Feed system
 - b) Concepts for A-O instrumentation (potentially larger budget?)
- 3) Long Term Developments (completed in 5-10 years)
 - a) Design of a wide field SAC and associated instrumentation
 - Possible synergies/sharing with other facilities (e.g. HET)
 - b) Implementation of multi-layer sputtering facility for primary mirror segments
 - c) Implementation of an A-O system on SALT
 - Redesign of the Payload
 - Concepts for A-O supported instruments
 - Photonic device based instruments
 - Novel focal plane assignment in the era of a wide field corrector (a la HST)
 - Central region for RSS
 - Outer annulus for massive fibre feed to many spectrographs (e.g. Virus)
 - d) Concept for a 10-m "SALT II"
 - More the purview of the Strategic Development Committee?
 - e) Concept for an ELT version of SALT
 - More the purview of the Strategic Development Committee?

The above list encapsulates the current suggestions that have been made by the community to date, but are not necessarily complete. I expect this draft White Paper to evolve as new initiatives are suggested.

While items above have clearly been informed from science drivers presented by their proposers, it is clearly important not to put the cart before the horse, and therefore we should develop these science drivers *before* getting too far along the track of considering specific instrument developments.