There are many different factors which determine the detailed scheduling of an observation. All SC were assessed for their constraints on the schedule. Exceptional atmospheric conditions (e.g. seeing, low IR background) can be critical as well as the absolute timing (co-ordination with other observatories), or the dependence on earlier observations. Most importantly for VLT operations, such factors directly influence whether a programme can be carried out by means of service observations, or whether the presence of the astronomer at the telescope is required. This will still be possible in the 'classical' observing mode. Note that there might be programmes which require excellent conditions, yet are delicate enough to demand the astronomer's direct interaction. Situations like these will have to be resolved and it was one of the aims to learn how many such programmes might emerge in a realistic schedule. Another aspect of importance for the VLT operations is the data rate which will have to be handled at the observatory. Estimates of typical data volumes were derived for each SC. A related topic is the format in which data are archived. For certain observations it will be impossible to maintain all raw data and some preliminary reduction procedures will have to be applied (typically IR data will have to be combined 'on the fly'). Data storage and handling will not pose a critical problem with the possible exception of some special programmes (speckle, high-speed photometry). The current data-flow schemes should be able to cope with the amount of data delivered by the instruments. The SC provide ground examples for decisions to be taken soon. A few SC require specialised observing techniques, e.g. drift scans offer flatfield quality which may be essential for some applications.

The available VLT science cases span a wide range in project size. There are a few SC which, if implemented at the proposed scale, would take up a major fraction of the available time, while other programmes are estimated to take only a few nights for completion. Interestingly, the majority of the projects would request more than 100 hours observing time. Thus it should not be expected that observing projects at the VLT will be of smaller scale or be completed in less time than current programmes at La Silla.

Many projects are suitable for service observing, some completely depend on it to catch the excellent image quality required for the experiment. The option to make full use of co-ordinated observations, however, is not explored yet. Only few projects try to combine various observing techniques for a more complete picture of the science object.

There are certainly limitations in the current set of SC. There is an obvious bias towards observational cosmology. The large statistical samples of faint objects required for this type of research drives the demand for high multiplexing facilities at the large telescopes. Another often requested facility is outstanding imaging quality stable for very weak objects over a large wide-field of view (weak gravitational lensing, statistical lensing).

A few science areas are missing completely, e.g. there are no SC for the thermal IR or adaptive optics with IR wavefront sensor. No studies of the interstellar medium or of gas in general have been provided. High-resolution studies of stars, mapping of stellar surfaces (e.g. through Doppler mapping), stellar outflow, stellar environments, or the whole area of star formation and pre-main-sequence evolution have not yet been considered. Other stellar topics, like initial mass functions, low-metallicity stars, stars in nearby galaxies, will have to be addressed in the future. No science case for the solar system (e.g. trans-Neptunian objects) is available.

Summary

The VLT Science Cases have opened a new channel of user interaction with ESO. They were meant to have a two-way effect; first to raise the awareness within the community by stimulating European astronomers to think about the forthcoming capabilities of the VLT 8-m telescopes and entice them to prepare for the exciting opportunities they will provide. Besides this, they were meant to set elements for a concrete scientific platform for future developments in the VLT project. They also were meant to better identify what the astronomical community is expecting from ESO.

It is gratifying to see that there seem to be no major shortcomings in the VLT programme, and the instrumental resources for most planned observations will become available in due time. Yet we have identified improvements in the instrumentation plan like the massive multiplexing spectroscopy needs or the possible fiber feed boosting the multiplex capability of the high-resolution instruments (e.g. UVES).

With the experience gained from this first set of SC we now feel confident to ask interested astronomers to submit a science case to ESO. While we cannot guarantee that every pseudo-proposal can be included into our list, we do encourage all ESO astronomers to think about their plans for VLT observing, whether they submit a science case to us or not. Anybody interested in providing a VLT Science Case should contact one of the authors of this article. We are particularly interested in projects which cover research areas not represented in the current sample, and instrumental capabilities which are poorly represented in the first set of SC. These include the mid-infrared spectral range, near-infrared high resolution spectroscopy, and projects which require adaptive optics with and without artificial reference star.

We believe it is timely to think about the capabilities of the VLT now and ask for the necessary preparatory observations with La Silla telescopes. The OPC has specifically set guidelines to devote some of the available time to preparatory programmes (cf. Call for Proposals). The work on a Science Case may also provide stimulus to check out the developments in the VLT project (see the WWW VLT page http://www.eso.org/vlt/ and the descriptions of the instruments). It certainly will prepare you for the occasions when the VLT will be 'your' telescope. On the other hand, soon real VLT proposals will take the place of SC pseudo-proposals, and some of the questions in the pseudo-proposals may be transferred to real ones, for ESO to keep active an ongoing monitoring of the needs and expectations of the community.

The ESO Imaging Survey

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1. Introduction

During 1997 (July–November), ESO plans to carry out a wide-angle, multicolour imaging survey using EMMI on the NTT, followed by a deeper, narrow-angle survey using SUSI2 and SOFI, early in 1998. A summary of the expected characteristics of the survey is shown in Table 1. This project, hereafter referred to as the ESO Imaging Survey (EIS), is meant to generate moderate-size statistical samples for a variety of astronomical applications, ranging from candidate objects at the outer edge of the Solar System all the way to galaxies and quasars at extremely high redshift. EIS data should provide a suitable database from which targets can be drawn for observations with the VLT, in its early phase of scientific operation (from the

third quarter of 1998 to approximately the end of 2000). EIS has been conceived as a service to the ESO community, with all the data becoming public immediately after its completion. Here we provide information that may help astronomers in the ESO community plan their initial VLT programmes, taking advantage of this survey.

The main motivation for EIS was the general recognition of the urgent need to prepare suitable target lists for the VLT, essential for it to soon play a leading role in ground-based optical/IR astronomy. By the year 2000, the competition will be fierce with many 8-m-class telescopes in operation. The main goal of EIS is, therefore, to foster the scientific productivity of the early VLT, and maximise its scientific impact. There was also the understanding that a co-ordinated effort was required in order to optimise the preparatory work at the La Silla telescopes as well as to guarantee the homogeneity and quality of the data. The ambitiously tight timetable and the large volume of data to be processed and analysed also implied the need for extensive collaboration between ESO and the community. Finally, there was the perception that no individual team would be able to fully exploit a survey similar to EIS in a timely fashion, were the data to remain *proprietary,* even if only for a limited period. Instead, with this *co-ordinated* effort most of the short-term survey needs will be met in a more efficient way, while the competition for VLT observing time will take place at the appropriate moment.

In order to insure the involvement of the community, a Working Group (WG) was created to design and supervise the survey. Following the recommendation of the OPC, the WG members were selected on the basis of their expertise in different research areas that could most directly benefit from the survey. The EIS Working Group has not concluded its activity with the submission of the EIS proposal and its endorsement by the OPC. It will, instead, continue to oversee all EIS activities, from the final selection of some of the survey parameters to the distribution of the data.

With the parameters listed in Table 1, the survey is expected to include ~ 150 candidate clusters with $z > 0.6$, up to 50 candidate quasars at $z > 3$ brighter than $V = 21$ and about 200 down to $I = 22.5$. These candidates will represent natural targets for follow-up work with ISAAC, FORS and UVES, as soon as they come into operation at the VLT. The deep, narrow-angle part of the survey, covering 250 square arcminutes, should contain about 10,000 objects to $I \approx 26$, with at least 30% of them being expected to lie at $z \gtrsim 1$, and at least 200 at $z > 3$. The 25 square arcminutes imaged also in the J band should lead to the identification of a similar number of galaxies with $1 \lesssim z \lesssim 2.8$. For more details and updates please check the EIS web site "http://www.eso.org/vlt/eis/".

One aspect worth emphasising is the *experimental* nature of EIS, which introduces a novel approach to large surveys. With EIS both ESO and the ESO community will gain additional experience which will be valuable for the scientific planning and operation of future surveys, such as those that are likely to take place using the ESO/MPIA 2.2-m telescope with the new wide-field camera scheduled for the second semester of 1998.

Finally, it is worth pointing out that EIS is not meant to be the only preparatory work for the VLT, nor to meet the long-term needs of the community. Other set-ups may be required for scientific goals not addressed by EIS. Other optical surveys are also likely to be needed in the future, in support of VLT research and of various space missions. The aim of EIS is just to bridge the gap between now and the early VLT era, focusing on topics that are likely to be mainstream in the time frame considered.

2. Scientific Rationale

The WG has agreed on the necessity of identifying a set of science drivers used to optimise the survey. The study of objects in the high-redshift universe has then been singled out as the field most in need of a preparatory survey. Correspondingly, the main science drivers used to optimise the survey have been identified to be the searches for: *(1) Distant Clusters of Galaxies; (2) Quasars; (3) High-Redshift Galaxies***.** With this selection, the WG has paid attention to include all classes of high-redshift objects, so as to place all research teams on a condition of parity while fostering the overall productivity of the VLT. Although the WG felt that it was essential to optimise the survey for a limited number of goals, this should not overshadow the fact that the survey will have almost countless applications in virtually every field of astronomy. In particular, it will provide a unique stellar database for studies of *Galactic structure and stellar populations***,** by detecting several hundred very low metallicity stars, M dwarfs, white dwarfs and by setting strong limits on the local density of brown dwarfs (possibly detecting some of them).

The urgency of the proposed survey comes from the necessity of providing suitable scientific targets to be observed by the VLT as early as the second semester of 1998. In designing the survey, the following timetable for the availability of VLT instruments was taken into account: ISAAC (1998/Q3); FORS (1999/Q1); CONICA (1999/Q2); UVES (1999/Q3). Adopting this specific timetable as a constraint proved to be extremely useful in designing the size of the survey which requires a balance between the need for enough targets to generate statistical samples and the availability of time to allow them to be observed with the early VLT, between 1998 (Q4) and 2000 (Q4).

While some of the targets will be immediately used in VLT observations as early as 1998, others will require further observations at the NTT or the 3.6-m to provide "clean" samples for the VLT (e.g. to confirm candidate high-redshift quasars). This lead time has to be taken into account in order to insure the *immediate* competitiveness of the VLT in some research areas in a way that it is consistent with the existing instrumentation plans for the VLT.

In order to achieve the main scientific goals and to reconcile the need for wide-angle coverage and depth, the survey will consist of two parts. A wide-angle survey to search for clusters and quasars, complemented by deep-pointed observations of a smaller area to search for high-redshift galaxies. For all the scientific goals the parameters of the survey were set to generate samples of about 200 targets each, the minimal size suitable for statistical analysis.

3. Background

In the summer of 1995, a small Panel was set up at the ESO headquarters to investigate and make recommendations about the scientific needs and the technical requirements for wide-field imaging capabilities in support of the VLT. The Panel was composed by ESO staff, visiting scientists and scientists in the Garching area, including: T. Broadhurst. S. Cristiani, L. da Costa, R. Gilmozzi, B. Leibundgut, R. Mendez, G. Monnet, A. Renzini (chair), P. Schneider and J. Villumsen. The Panel first identified a set of topics that required extensive imaging observations either in preparation for either VLT or stand-alone programmes. Among the topics considered were: search for primeval galaxies; high-redshift QSOs; distant clusters; low-surface-brightness galaxies; weak gravitational lensing by galaxies, clusters, and large-scale structures; galaxy inventory of low redshift clusters; search for high-redshift supernovae; search and study of individual objects in nearby galaxies (globular clusters, planetary nebulae, massive stars, HII regions, etc.); stellar-population studies in the Milky Way, the Magellanic Clouds and the dwarf spheroidal galaxies; and finally the search for exo-planets by gravitational microlensing. The Panel reviewed all these science cases thoroughly, as well as all the possible options for wide-field imaging. The Panel concluded that to ensure a competitive use of the VLT in several research areas required both a very wide field imager at a 2–4-m-class telescope, and a moderately-wide field imager at the VLT.

Since then, several positive develop-

Table 1. EIS General Characteristics

Science Driver	Area	t_{int}	Filters	Hours	$m_{lim}(5\sigma)$
Wide-Angle Survey					
Distant clusters	18 sq. degree	300s	*V*	96	24.7
	—	300s	*I*	96	23.8
Quasars	—	150s	*B*	48	24.5
	10 sq. degree	50s	*Gun-z*	16	22.3
Narrow-Angle Survey					
High-*z* galaxies	250 sq. arcmin.		*UGrIK*	104	26, K = 21.5
	25 sq. arcmin.		*J*	24	24
Total				384	

ments have taken place thanks to the continuous effort of ESO as well as the initiative of individual institutes in the ESO Community. The Max-Planck-Institut für Astronomie (Heidelberg, MPIA) has offered financial and technical support to equip the ESO-MPIA 2.2-m telescope with a wide-field camera ($35' \times 35'$), while the Osservatorio Astronomico di Capodimonte (Napoli) has offered financial and technical support for the development of the $8K \times 8K$ CCD detector for the same camera. While this initiative is now well underway, the Osservatorio di Capodimonte has also offered to ESO a 2.5-m telescope optimised for wide-field imaging, a proposal now under evaluation at ESO. In addition, the STC has recently approved the construction of two new, highly-competitive instruments for the VLT, the optical and near-infrared multiobject spectrographs (VMOS and NIRMOS, respectively), each with imaging cameras with a field of view $14' \times 14'$.

Despite these important developments, none of these facilities will be available before the VLT is offered to the community. In order to cope with the short-term needs, a group of ESO astronomers was set up (L. da Costa (chair), A. Baker, J. Beletic, D. Clements, S. Coté, W. Freudling, E. Huizinga, R. Mendez, and J. Ronnback) to investigate other alternatives. During several months, this group investigated the possibility of conducting an imaging survey at the NTT during the second semester of 1997 (about one year before the beginning of the VLT scientific operations) and making the data available to the ESO community. On 12 May 1996, the Group released its final document describing the conclusions of this feasibility study, which included a careful analysis of the science drivers of the survey and its technical, observational, and operational aspects. The document also included contributions on specific topics by H. Böringer, S. Cristiani, P. Schneider, and J. Villumsen.

On 31 May 1996, the ESO Director General and the VLT Programme Scientist illustrated to the OPC the benefits that an imaging survey would have for the early VLT observations. The OPC fully endorsed the notion, and recommended the formation of a Working Group to elaborate a formal proposal for the imaging survey to be discussed at the following meeting of the OPC on 29 November 1996. Being recognised as an integral part of the VLT Programme, the VLT Programme Scientist was asked to organise and chair the Working Group. On 10/11 July 1996, the WG had its first meeting in Garching, with the presence of G. Chincarini, S. Cristiani, J. Krautter, K. Kuijken, Y. Mellier, D. Mera, H. Röttgering and P. Schneider. From ESO, besides the authors of the present article, several other astronomers attended the meeting, including J. Bergeron, S. D'Odorico, W. Freudling and R. Gilmozzi. As the starting point of the discussions, the WG adopted the da Costa et al. document, complemented by additional input from S. D'Odorico on the deep observations. The WG soon endorsed the concept, goals, and general design of the proposed survey. This was followed by a very productive discussion about the various trade-offs, such as depth versus sky coverage, length versus width and filter selection, among others. As a result of the discussion, important improvements were made to the original design, and the ESO astronomers were requested to prepare a revised and more concise proposal to be circulated in advance of the next meeting.

The draft of the EIS proposal was distributed to the WG members in September 1996, and on 4 October 1996 the WG met again, this time with the presence of S. Charlot and R. Saglia, and thoroughly discussed the proposal. While the wide-angle part of the EIS proposal was unanimously endorsed by all the WG members, a few among them expressed some reservation concerning the pointed observations. Although fully acknowledging the outstanding scientific value of this part of the proposal, some argued that individual teams from the community could have submitted a regular proposal on their own to conduct the corresponding observations, while maintaining proprietary data rights for some time. The WG finally endorsed both parts of the survey, and issued a set of recommendations to the OPC ("http://www.eso.org/vlt/eis/eis_wgr.html").

An additional and independent endorsement to EIS came from the ESO VLT Key Programme Working Group in Extragalactic Astronomy that stated in its final report: "The working group strongly endorses the OPC policy to reserve substantial amounts of NTT time for programmes that are preparatory to VLT programmes. In particular, the working group expresses very strong support for the important initiative of the ESO Imaging Survey on the NTT as a vital preparation for the first few years of the VLT".

In the letter to the OPC accompanying the EIS proposal and the WG recommendations, the VLT Programme Scientist stressed the following additional point:

"The ESO scientists appearing as PI and Co-I of the EIS proposal commit themselves to avoid any personal use of the survey data before they become public. If appropriate, the time limit of this commitment can be extended at the discretion of the OPC. A similar commitment will be asked to all those members of the community that may come to ESO to handle the data."

The EIS proposal was formally submitted to the OPC on 31 October 1996 as planned, with the VLT Programme Scientist as PI, and L. da Costa, W. Freudling, S. D'Odorico, P. Quinn, J. Spyromilio, and J. Beletic as Co-Is. Since the proposal was not intended to provide data rights to the team, the team composition reflected exclusively the functional aspects of the Survey. In practice, a much larger number of people has been and will be directly or indirectly involved in the EIS project.

On 29 November 1996, the OPC reviewed the EIS proposal and as of February 1997, the wide-angle section of the survey has been scheduled for period 59. Funds have been allocated to the project and a visitors programme has been established to sponsor short- and long-term visits of scientists from the community that can contribute with specific skills to the preparation and execution of the survey. The survey has also received high priority within all other ESO divisions, thus securing the necessary support.

4. Recent Developments and Future Work

In early February 1997, it became apparent that a FIERA controller could not be implemented on EMMI in time for

the survey to use this facility. This has led to the decision to abandon the drift-scan mode of observations, that was originally recommended by the WG, in favour of the shift-stare mode with the EMMI-ACE system. Using recent estimates of the readout time, we expect an overhead of about 100 seconds per exposure which will imply an efficiency of $\sim$ 60% relative to that expected for the drift-scan. This has already been taken into account in Table 1. The implication is a reduction of the area covered during the Chilean winter-spring period, unless more time is allocated to the project. On the positive side, the EMMI-ACE system will be fully tested by the time EIS observations get underway. The system is also VLT-compliant, and as so EIS will serve as a prototype for the service-mode observations and the development of the archive research environment. Another advantage of the shift-stare mode is that it gives more flexibility in the choice of the survey regions.

Given these changes, the WG is currently evaluating the possibility of still covering a wide range of right ascensions, thus allowing for an even distribution of VLT targets. For example, the survey may be conducted in 3 patches of about 6 square degrees each, separated by 3^h and spread over the right ascension range 21^h to 3^h. The exact pointings and the format of each patch (e.g., $1^\circ \times 6^\circ$ or $0.5^\circ \times 12^\circ$) are still under consideration. The EIS home page will be updated as soon as the WG makes its final recommendation.

Since receiving the endorsement of the OPC, the EIS team has initiated its work on several fronts:

• Preparation and distribution of the Announcement of Opportunities for the EIS visitor programme.

• The preparation of the EIS home page ("http://www.eso.org/vlt/eis/") which so far has been accessed over 1000 times.

• Orders have been placed for a set of wide-band filters and computer hardware.

• ESO fellows are already at work in a variety of tasks related to the survey.

• Interviews are being conducted to select the first group of visitors who will work on the development of the data-processing pipeline.

• The general plan for EIS is being elaborated in collaboration with other ESO Divisions to establish the necessary interfaces between EIS and the User Support Group, the NTT team, the Data Management Division and the ECF.

Some of the main tasks of the EIS team are:

• Selection of the survey regions to be presented to the WG for final approval.

• Phase II Proposal Preparation (P2PP) and production of the Observational Blocks.

• Implementation of data-processing pipeline.

• Implementation of EIS database, data archive, and procedures for data distribution.

• Development of algorithms for the production of catalogues of candidate clusters, quasars, high-redshift galaxies and galactic objects.

The EIS team is also following closely the progress of SUSI2 and SOFI, with which the deep observations will be conducted.

Given the large amount of work ahead and the ambitious timetable of the survey the involvement of the community in EIS is an essential ingredient for its success.

5. Participation of the Community

The involvement of the ESO community is essential for two reasons. First, it is appropriate that this "service to the community" is carried out with the direct control and participation of the community itself. Second, the tight timetable of the survey and the fact that the ESO staff already have other commitments make it necessary to rely on the participation of scientists from the community. ESO is committed to provide the necessary support to make this participation possible.

The involvement of the community is already present through the EIS Working Group. However, to expand this participation, we urge interested scientists to interact either directly with the EIS team at ESO or with the members of the EIS Working Group which will remain active until the completion of the survey.

ESO also envisions a more active participation of the community via the direct involvement of scientists and students in the observations, data reduction and analysis. For this purpose a special ("http://www.eso.org/adm/personnel/ann/eis.html") visitors programme has been established to sponsor short- and long-term visits of scientists/programmers/data assistants willing to contribute to EIS. As EIS will operate in a very tight schedule, the priority will be determined by the most pressing needs of the survey which will evolve in time.

So far we have received over 70 applications for the visitors programme from all over Europe and abroad. We are currently selecting visitors who will help us implement the data reduction pipeline.

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