Section 5: Small Telescopes or Internet Access?

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The Choice of Small Telescopes

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Abstract. Small telescopes can be powerful tools for astronomical research. Many are being used by professional and amateur astronomers to do important, even frontier, research. They are also extremely valuable tools for education. This paper discusses the characteristics of such telescopes, and it makes recommendations about items such as field of view, focal length, and so on. It also discusses a few small telescopes representative of what is currently being done. Astronomy needs such facilities as much as it needs the giant telescopes. They complement each other very well.

1. Introduction

New-generation small telescopes, ones using modern CCD imaging detectors and taking full advantage of computer control and of communication networking, are truly frontier instruments for astronomical research and for education. These new-generation aspects apply just as much to small telescopes as they do to the much larger (and much more expensive) ones. It is a fact that the automatic and networked use of such small telescopes could provide many more quality observing hours to the astronomical community worldwide. A non-profit organization, GNAT, Inc., has been created with the goals of developing and operating such a global network of astronomical telescopes and in being a catalyst for all those interested in the effective use of small telescopes for research and for education. GNAT will be a relatively low-cost operation, with low overhead and a small staff, but with many members, allies, and partners. We believe that the program has very little risk, but with nearly unlimited upside potential. This paper can only summarize some of the problems and potentials.

2. Special Problems for Developing Countries

1 *Hardware and other facilities.* These often do not exist in developing countries and, if they do, may be outmoded or poorly maintained. It is difficult to build, to operate and to maintain facilities with low funding and few trained staff. In general, of course, the staff are more interested in do-

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ing research, or education, than in developing and maintaining a viable facility.

2 *Bureaucracy and other issues.* Unfortunately many developing countries suffer from these problems as much as, or even more than, do the more technically advanced countries.

3 *Poor communications.* These are a big problem in almost all developing countries. Astronomers in such countries need a great deal of help with the Internet and staying in touch.

4 *Exchange of people.* This is needed for interaction and cultivating allies, but is often a problem for developing countries.

3. Research and Education Drivers

In all countries, there are good people and there are good ideas. We have heard here at this meeting of many potentials for research and education, and of many places where realization of these potentials is possible, and much needed. The people in these places want to do good things, interesting and useful research, and to use astronomy as an educational tool for students. There are many other examples that we have not heard about here. Valuable techniques with small telescopes include: imaging, photometry, spectroscopy, and others. There is a growing array of good instrumentation at lower costs than in previous years. Small telescopes complement very well the research being done with large telescopes and with space facilities. Just like the operator of a fleet of trucks, we need resources of all sizes. The small ones cost much less than the large ones; both are much needed tools. There is, of course, other needed infra-structure, such as libraries, technical facilities and help, and allies and mentors. Finally, we note that it is essential to fit the local situations and potentials. All countries are different. Viable solutions must take that fact into account.

4. Telescopes and Instrumentation Issues: Types, Specifications and Sources

There are three ways to obtain access to these tools. Astronomers can develop and operate an observatory within their own country (perhaps of particular interest for those countries with good observing conditions), or they can become involved in the operation of a remote observatory, located elsewhere in excellent observing conditions, or they can "observe" by accessing existing data bases. We will discuss these options below. But wherever telescopes are located, some items are in common. First, what type of telescope? What mounting, size and instrumentation? For a number of reasons, we will consider here only "small telescopes." By these, we mean ones with an aperture of 0.5 m to 1.0 m. Instruments in this size range are of relatively low cost, easier to construct, to ship, to install, to operate, to maintain. These modest-aperture telescopes, if quality ones, can be used for very viable and exciting research, at the frontier of many scientific problems. Any type of mounting will be acceptable, and many of the problems of design are much simpler than for larger telescopes. However, the telescopes should be good ones, of high quality. What about design specifications? GNAT has published the following specifications, after much thought about needs and current and past designs, and after a much discussion with observers and with telescope makers:

1 Imaging and photometry will be the main roles for a small telescope, although spectroscopy and other techniques could be used.

2 An imaging CCD photometer is the main instrument, but others could be used.

3 *Value per cost* is a key element.

4 The use of a common design for many telescopes results in the sharing of design and fabrication costs by many users, thus maximizing *value per cost.*

5 Users working together can help to improve quality and to lower costs.

6 Reliability of the instrument is critical: low operating costs are as important as low capital costs.

7 The primary focal ratio should be in the range 1.5 to 2.0; the secondary focal ratio in the range 6 to 9.

8 The field of view should be designed to handle a 2000 square CCD chip, although telescopes could operate with smaller chips. The are potential uses for telescopes with larger fields of view but these would cost considerably more.

9 Pixel size, seeing and field of view should all be matched but some compromise will probably be necessary. Note: in this area small telescopes are better than larger ones.

10 Image quality should be between 0.6 and 0.8 arc-sec at full-width half-maximum (FWHM).

11 Pointing accuracy should be approximately 10 arcsec (open loop) or 1 arcsec (closed loop)

12 Tracking should be accurate to within about 0.1 arcsec over several minutes.

13 The telescope control system should offer the possibility of fully automatic and remote operation.

14 Communication to the telescope to be via ATIS (Automatic Telescope Instruction Set).

15 Telescope scheduling must take account of the needs of many users of many telescopes at many sites.

16 Good documentation is critical.

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17 The housing and site of the telescope are dictated by local considerations and are not in the standardized design.

18 Sites should be of high quality with good seeing and many clear hours, but it is not essential to have the site of highest quality if developing it would be too costly.

4.1. On-site facilities in one's own country

How does one go about buiding an observatory? Among the issues to be considered are funding, observing conditions in the country concerned, technical issues (avaiability of electric power etc.), capital costs, operating costs, maintenance issues and upgrading: all are important and all need very careful consideration. It is often easier to get the capital costs covered than to obtain the operating costs. Many examples exist of real problems due to lack of operating funds, even in developed countries.

What is "On site"? Pride of ownership is not enough. Remember that even a site within the country is remote for most users.

4.2. Remote facilities

Do astronomers in a coountry set up a remote observatory as a single group or join in a consortium? Several possibilities exist; the choice will depend on circumstances. Similar technical considerations to those already mentioned must be taken into account. There are again many possibilities for doing the research. Scientists can work as individuals, as members of a team or on observatory projects. There are also many ways to be involved in the technical development of hardware and software. Access to the telescope can be by Internet or even by mail. GNAT for example is not a real-time operation, but nearly 100 percent queue scheduling. Pluses and minuses need to be thoroughly understood and discussed, in each individual case. Most remote operations can and will be very adaptable to individual needs and constraints. Overall operational costs can and should be relatively low.

4.3. Observing data bases

Problems and potentials of access are the same as in remote observing. Solving the access problem, whether by Internet access or otherwise, will be one of the first things that must be successfully addressed by any country. Other papers at this meeting have discussed this issue. The potential is great for anyone and any country. But note that the data in the database must be of high quality, and anyone (observatory or individual) inputting data must ensure that they are only high-quality data. One must understand what makes for high-quality data. Unfortunately, too many examples exist of low-quality data.

5. Can a Remote-Observatory Concept Work?

Of course. The needs and the potential are there, and the technology is ripe. The implementation of a successful project will need help from many individuals, from many countries. It can happen. It will. The only questions are "When?" and "How?" and "How Cost Effective?" The key elements and needs are:

i Funding. Note that not only can the observatory be distributed globally but so can the funding sources.

ii People, in the countries concerned and partners.

iii The facilities themselves, both in the home country and the remote site.

iv Education, in the home country, of those involved in research and technology, and of teachers and students. Some edication can be abroad, through partners, and "meetings."

v Travel funds.

One example of the many with potentials is GNAT. GNAT's Goal is to develop and operate a global network of small telescopes. At least two 0.8-m aperture telescopes at a minimum of each of six worldwide quality sites, three in the northern hemisphere and three in the south. In addition, there would be a home base, to be the catalyst of the operation and the communications center. Besides the 0.8-meter (and larger apertures ones in the future), at the same sites, GNAT will develop and implement "three-shooter telescopes." These are small-aperture instruments, on the same mounting, directed at a fixed altitude and azimuth for months at a time. They operate in a drift-scan mode and scan the sky in a strip of 48 arcminutes wide at a particular declination. Comparison of the images from night to night will permit the recognition of slow moving objects and of variable brightness objects.

Access to GNAT should be possible by almost anyone, anywhere. Usage of the facility can be via observatory programs, consortia programs, or individual research projects. Many types of programs are possible, ranging from variable stars through the search for extra-solar planetary occultations. The data will be accessible to all via on-line data bases. GNAT is really an electronic, distributed, world-wide observatory, in facilities and in staff. To be successful, it needs funding, of course, and the involvement of many individuals, as unpaid, part-time staff members and as observers.

GNAT is now operating a prototype 0.5-m telescope, in a fully automatic and efficient mode, in the Tucson, Arizona, area, every clear night. We are using a 1000 square pixel CCD imaging photometer and ATIS communication software. The telescope control software, by Don Epand, is working very well. The telescope has been obtained from SciTech, a California company. There are other suppliers, but we have been dealing only with SciTech. Some of the suppliers come and go, and some seem to deal mostly with "virtual telescopes," not really yet having quality operating telescopes. We will be negotiating a lease/option arrangement for the first 0.8-m telescope later this year. It will be located in the San Diego area, and allow linked operation between the two telescopes, both operated remotely and automatically.

GNAT will operate many of its programs through Working Groups, whose job will be to develop and implement the observing programs. The first such, for Photometric Systems and Standards, is now being formed. Both BVRI and Strömgren standard systems will be in operation on the 0.5-m telescope later this year, with a program of observing standard stars on a regular basis. A second working group, on Open Cluster Photometry, will be operating shortly. Others will follow next calendar year.

A prototype of the "three-shooter" is now being operated to verify system operation and performance. Work has begun on the first full-sized system, and software development is well underway. Costs of such a "three-shooter" facility will be remarkably low, and the data output rate remarkably high.

6. Conclusions

There is a real need for a networked remote observatory of small telescopes. It is a very viable, cost effective concept, one that can supply a lot of good-quality photometric data to the astronomical community, world-wide. For example, with GNAT, astronomers do research and GNAT takes care of the rest: development, implementation, operation, liabilities, and all the non-research aspects of owning and operating a major observatory. All "members" can and would be active partners in the efforts. It has a very high *value per cost* ratio. There are other similar proposed networked facilities. Such facilities will be of great benefit to astronomical research and education worldwide in the coming years. Small telescopes will remain a needed and valuable resource to the worldwide astronomy indefinitely.

Discussion

Hearnshaw thought GNAT a great concept but pointed out that Crawford had been advocating it for many years. Why was it taking so long to get started? Crawford replied that the start was bound to be slow in the absence of funding and permanent staff, but progress is being made and the protoype telescope is performing very well. Rijsdijk asked if existing small telescopes at "mothballed" observatories could be incorporated into GNAT. Crawford thought not, in general, since GNAT is based on having "new-generation" telescopes. Other organizations have tried taking over the telescopes to which Rijsdijk referred, with mixed success. Hingley drew attention to the New Zealand conference in 1985 in which Warner analyzed "numbers of research papers per megabuck" which favoured small apertures. Warner also spoke of "aperturism" in astronomy – which kills telescopes. Crawford said that many astronomers catch the disease of "Aperture fever". Metaxa appealed for all astronomers to fight light pollution and similar problems in other parts of the electromagnetic spectrum, before we lose the night sky.