FURTHER DEVELOPMENT OF THE NLRS AT ORRORAL

B.A. Greene
Division of National Mapping
PO Box 31
Belconnen ACT 2616 Australia

Telephone 062 525095
Telex 62230

ABSTRACT

The recently commissioned Natmap Laser Ranging System is described and some initial performance figures given. The development program for the system is briefly outlined. The fundamental goals of the program are to maximise precision, accuracy, and efficiency in SLR and LLR modes. From an initial capability near the state of the art, developments are outlined which will produce sub-centimetre SLE precision to any satellite within 10 seconds under even marginal meteorological conditions over the next 12 months. Preliminary considerations of multi-Gigawatt LLR lasers and multi-wavelength SLR are given.

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1. Current Status

The Natmap Laser Ranging System (NLRS) is now fully operational to LAGEOS, and is under development for Lunar ranging operations in late 1984. The principal characteristics of the NLRS can be given as:

Telescope aperture	:	1.5 metre
Pointing accuracy	:	3 arc seconds
Laser	:	QUANTEL YG402-AP
Computer System	:	HP A700
Receiver	:	RCA 31034A
Single shot precision	:	7 cm
10 second precision	:	1 cm (LAGEOS)

The NLRS is currently performing adequately to LAGEOS, obtaining 5-15000 hits/pass, depending on conditions. It has a day/night capability.

2. Short Term Developments

The random current errors of the NLRS are due to:

Laser pulse width	:	300 ps
PMT/Receiver	:	400 ps
Timing	:	200 ps

These represent the NLRS at initial configuration, which will be altered for the first 4-5 months of operation.

Commencing early in 1985, several changes will be made to the system which will improve performance. The laser pulse width selected will be reduced to 50 ps for all SLR operations. The PMT will be replaced by a new Microchannel Plate PMT with a Transit-Time jitter specification of 100 ps (max), and a rise time of 30 ps (max).

These modifications alone should reduce the single shot uncertainty to better than 4 cm, and the 10 second normal point precision to 6 mm (for LAGEOS).

Other significant improvements planned for 1985 are in the AUTOTRACK capabilities of the system. Currently, a significant proportion of the LAGEOS data is obtained without any operator assistance in guiding (i.e. absolute pointing to LAGEOS). It is expected that as the station coordinates of the site become better defined and our in-house ability to 'improve' our predictions using previously observed data improves, the dependence upon an operator will diminish significantly. The goal is to obtain 100% of LAGEOS observations without operator intervention in the long term.

The AUTOTRACK developments extend also to LLR observations. Since the mount model for the 1.5m telescope can be better than 3 arc seconds on any night (it is not stable at this level for more than 1 night), absolute pointing and guiding seems feasible, perhaps with some minimal search pattern capability added.

3. Long Term Developments

3.1 SLR Precision

The single largest error in the ranging system after the laser and receiver have been modified (above) will be the timing system (200 ps/event). An improvement in this area to 50 ps would give 2 cm single-shot precision immediately. A multi-stop, 50 ps precision timing system is under development.

If the laser is tuned to 30 ps pulse width, the system error budget becomes:

Laser	:	30 ps
Timing	:	50 ps
PMT/Receiver	:	100 ps
RSS		116 ps or 1.8 cm

Theoretical studies are currently being undertaken into the viability of using a streak camera as an additional vernier for the timing system to give 10 ps precision. Preliminary work indicates that the total random error budget for such a system could be 50 ps, resulting in sub-centimetre single shot precision.

3.2 LLR Data Density

The single most effective way of improving LLR system performance is to increase the laser power. Such a development is being considered for Orroral. The objection is to obtain 300 mJ in a single 100 ps pulse, or 800 mJ in a train of four 100 ps pulses, at 10 Hz. Alternatives to slab laser configurations are being actively pursued, and some feasible designs have been put forward which would reach the performance goal without the need for a slab. However, very significant performance improvements for Nd:YAG lasers will come from solid state pumping systems now under

development in other laboratories. If adequate performance can be maintained in the short term using the existing laser, then it is likely that further development of the laser will await developments in solid-state pumping.

3.3 Multiple Wavelength Ranging

Even preliminary examination of the two wavelength technique reveals the considerable difficulties inherent in the technique. However, if SLR ranging will be, from 1985, of 1 cm precision (normal point) for a large proportion of the ranging stations in operation, then it may be necessary for one or two stations to acquire a data base of two colour ranging data for purposes of 'calibrating' the atmospheric correction formulae. The Orroral system has some unique advantages for performing this experiment.

1. large telescope with very precise pointing and high quality Coude optics

2. extensive computing facilities on site

3. extensive optical and electronic facilities

4. colocation with a national time and frequency calibration laboratory

5. site weather characteristics much like most of the rest of the network.

For these reasons the topic is kept under review, so that when the accuracy requirement for SLR exceeds 1 cm, a decision could be made to attempt to range at more than one wavelength.

The streak camera which can operate as a 10 ps timing vernier can be adapted to determine the differential return epoch of the two returns with 10 ps (possibly even better) precision.