Creating a Consolidated Laser Ranging Prediction Format

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Introduction

- LLR, SLR, Transponder ranging experiments have used different prediction techniques
- Anticipated placement of transponders on the moon, Mars, and elsewhere make long-distance ranging accessible to the average station
- This and limitations to the current formats argue for a consolidated prediction format

Artificial Satellites (SLR)

- Widely-used format and sample integrator code has existed for about 20 years
- Includes date/time, SIC, Earth orientation and state vector
- In pseudo-body-fixed reference system of date
- Entire prediction solution performed in geocentric system

Lunar Laser Ranging (LLR)

- Prediction code passed from station to station
- Based on JPL DE-4xx, MIT PEP, or other solar system ephemerides
- Rigorous light-time iterations with relativistic and stellar aberration (for point angles) effects required, with separate in- and out-bound computations
- Interpolation in solar system barycentric reference frame

Laser Transponders

- Synchronous
  - Similar to lunar ranging
  - Need to correct for latency in transponder between receive and transmit
- Asynchronous
  - Similar to lunar ranging in terms of rigorous iteration of light time, relativistic corrections
  - Also requires precise knowledge of pulse repetition rate, range rate, oscillator offset and drift
  - Will require centralized processing of results, as some information is required from spacecraft

Format Characteristics

- Tabular (grid) format (interpolation, not integration)
- State vectors spaced as required (fixed or variable)
- True body-fixed geocentric coordinates of date (EOP included)
- Multiple header and ephemeris record types
- Special record types to handle features of particular target classes
- Records short enough for e-mail
- Non-header records are free format (with restrictions)
- Removes need for drag messages
- Allows for integration beyond last record of the file

Format Headers

- Date/Time, start and end
- Step size
- Satellite info: SIC, COSPAR ID, target type
- Expected accuracy
- Transponder information: latency, oscillator UTC offset and drift, and pulse repetition rate
- Tracking restrictions

Format Body

- Positions (in-bound and out-bound)
- Relativistic and stellar aberration corrections for objects computed from solar system ephemeris
- Relativistic spacecraft oscillator corrections for transponders

Sample Code

- Interpolates in geocentric reference frame
- Translates from geocenter to topocenter
- Applies relativistic and stellar aberration corrections
- Computes point angles, ranges, and range rates
- Simpler than current code using integrator

Interpolation Step Sizes

Satellite	Interval (min)	
	Degree 7	Degree 9
CHAMP (LEO)	2	3
GFO-1	3	4
TOPEX	4	5
LAGEOS	5	10
GPS	15	30
Moon	30	60
MGS at Mars	0.3	

Status

- Lunar tests complete
- Transponder tests almost complete
- Interpolator tests almost complete
- Preliminary format ready for laser community comment
- Sample code in development (FORTRAN, c)
- Field tests to commence when code is more mature

Conclusion

- Consolidated prediction format includes 4 different target types in one prediction format and sample software set
- Opens up opportunities for most stations to range a wider variety of targets
- Naturally solves several difficulties in current SLR predictions
- Will come at the expense of larger file transfers