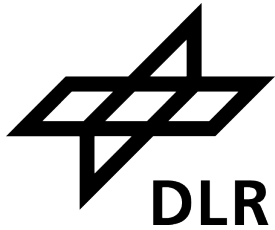


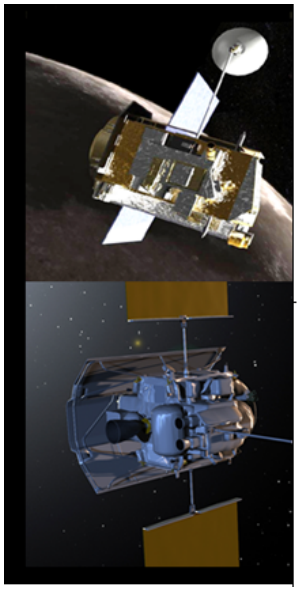



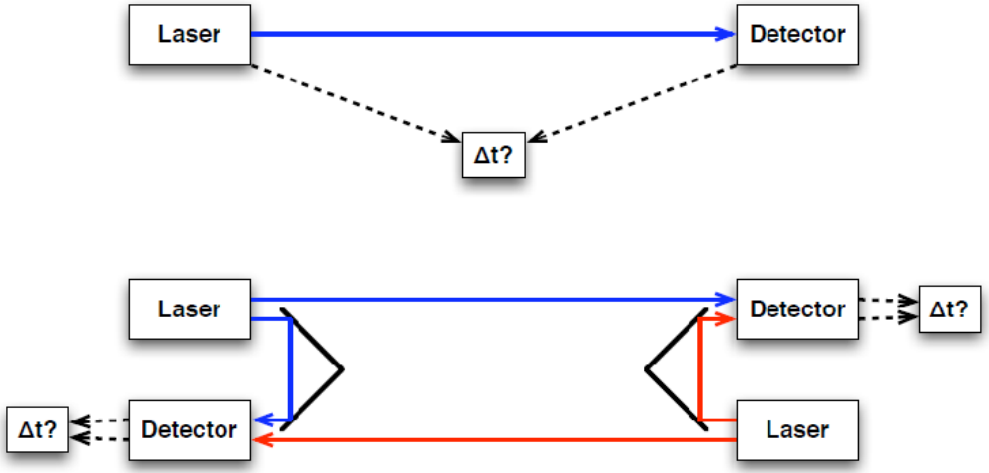
Simulated Comparative Analysis of One- and Two-Way Planetary Laser Ranging Systems

D.Dirkx, S. Bauer, R. Noomen, P.N.A.M Visser, L.L.A. Vermeersen

Planetary Laser Ranging

Available methods





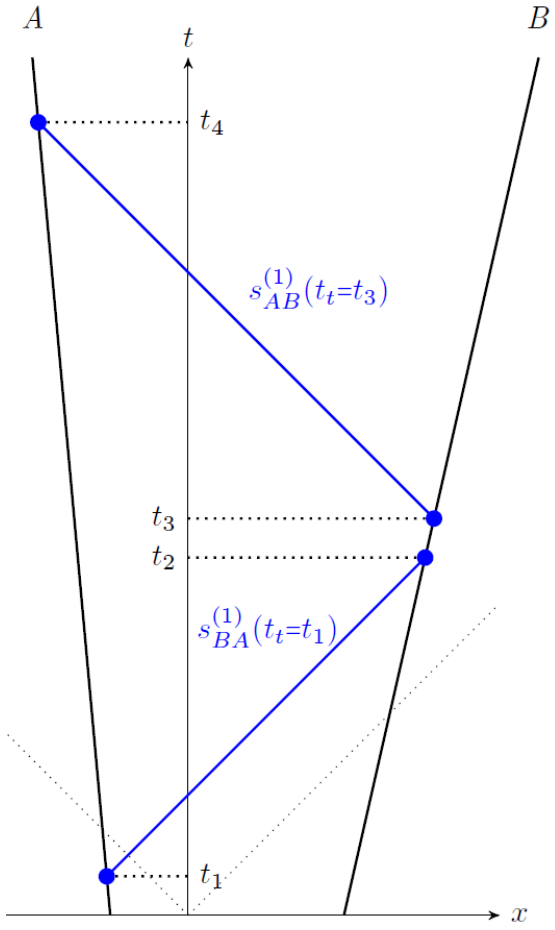
Birnbaum et al., 2010

- Active space segment required for planetary laser ranging
  - One-way system easier to operate
  - Two-way system more accurate; easier data analysis
- This study: Numerical comparative performance analysis

Planetary Laser Ranging

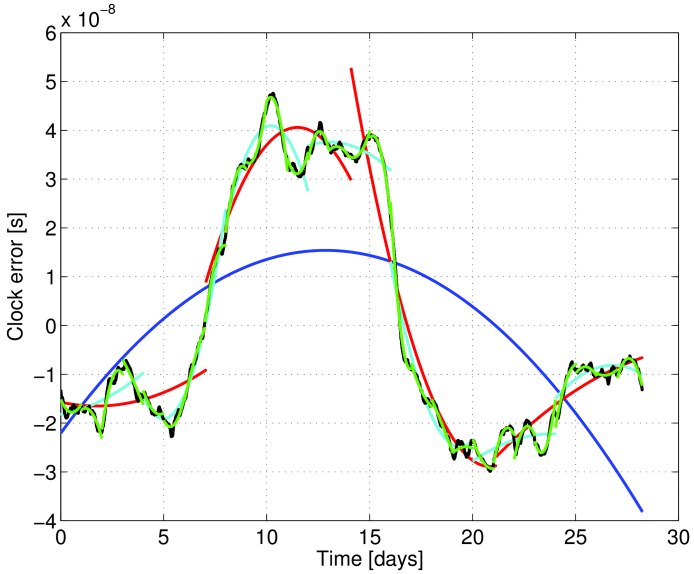
Method Difference

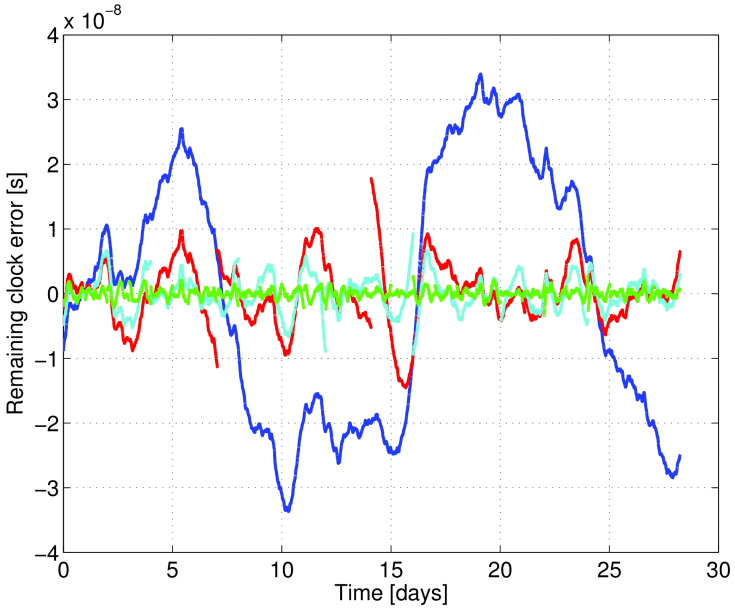
- Main difference in one- and two-way error budget
  - Influence of clock noise
- Clock noise accumulates
  - Over long time periods for one-way
  - Over light time/retransmission time for two-way



Planetary Laser Ranging

Clock noise removal





- One-way system requires clock error estimation
  - Arc length/order of estimation may be varied

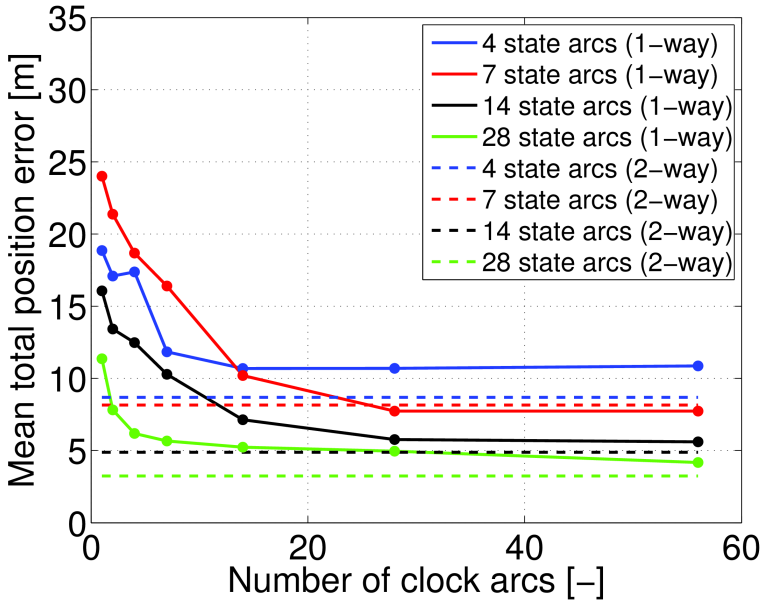
Numerical Simulations

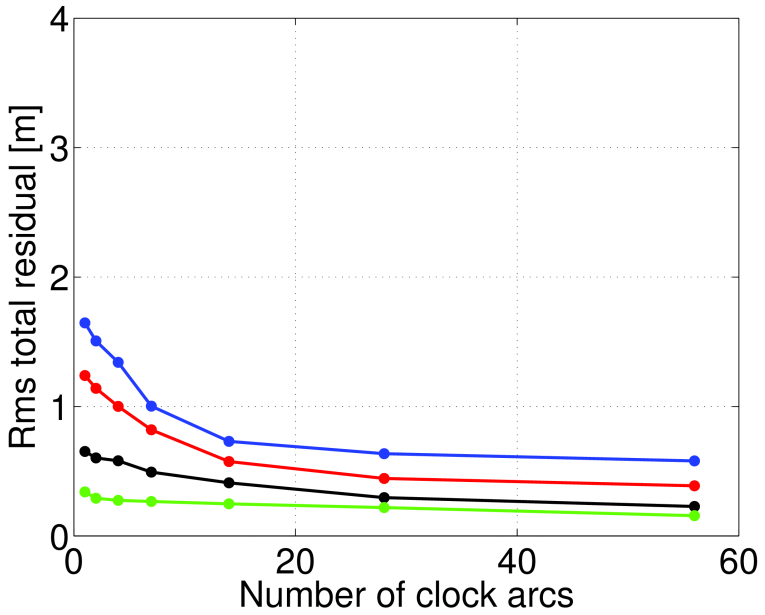
Simulation Setup

- Lunar polar orbiter (1 month)
  - Empirical model used for dynamics mismodelling
  - Radiation pressure scaling/along track emp. acc. estimated per state arc
  - No lunar physical parameters are estimated
- Phobos lander (1 year)
  - Orbit, libration amplitudes and C_{22}^{P} estimated
  - No errors in dynamical modelling assumed
- Range measurements simulated; used for estimation

Numerical Simulations

Lunar orbiter results

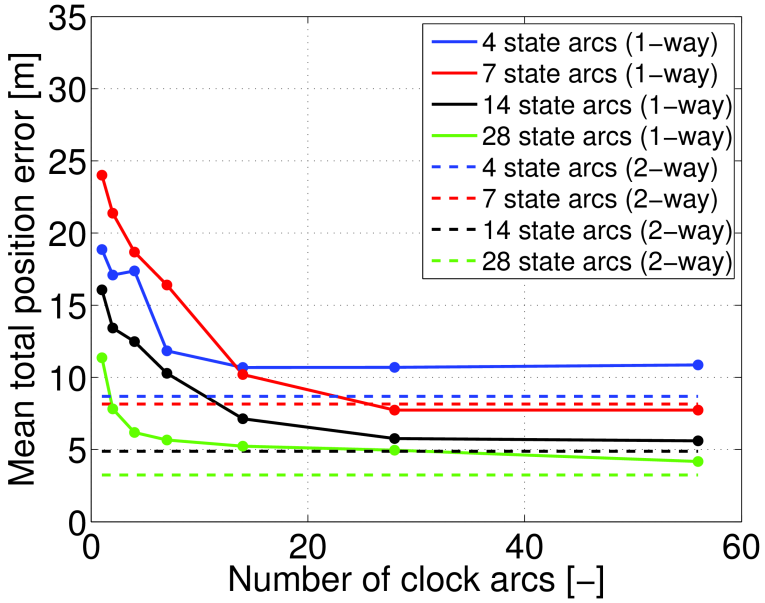




- Interchange between clock/state signal/noise
  - Correlations between parameters
  - Profile of true errors in both imperfectly modelled

Numerical Simulations

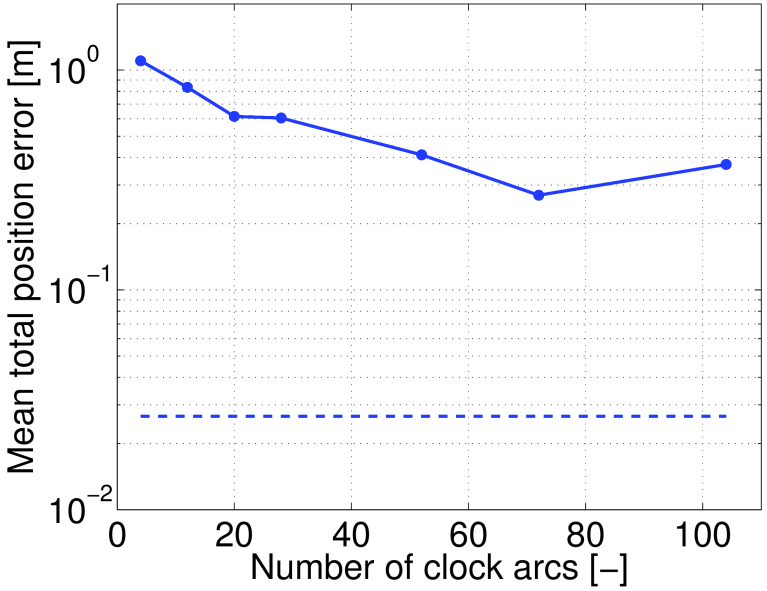
Lunar orbiter results



- Small difference between one-, two-way position error
  - Clock noise not dominant
- Two-way system more predictable
- Improvement of force modelling easier with two-way data

Numerical Simulations

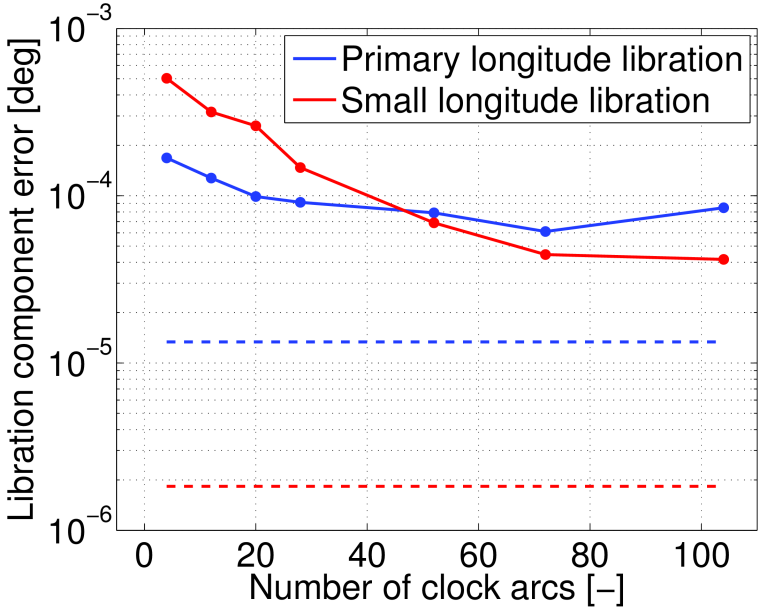
Phobos lander results



- Orders-of-magnitude improvement compared to current knowledge
  - Two-way factor ~10 better than one-way

Numerical Simulations

Phobos lander results



- Small librations estimated much better by two-way system
  - Decoupled from dynamics
- Difference for Phobos geophysics would be marginal
  - Current volume uncertainty limits interpretation

Conclusions

- One- and two-way range performance simulated for Phobos lander and lunar orbiter.
- Dynamics errors dominate lunar orbiter error budget
  - Two-way results more robust
- Two-way results for Phobos lander order of magnitude better
  - Geophysical interpretation for Phobos similar for both systems

- **Two-way system potentially superior, but analysis models must be sufficiently accurate**