SERC SPACE ENVIRONMENT RESEARCH CENTRE

Overview and Research findings of SERC Research Program 2: Orbit Determination and Predicting Behaviours of Space Objects

Robert Norman

Australian Government
Department of Industry, Innovation and Science
Business Cooperative Research Centres Programme

CRC for Space Environment Management

CRC-SEM

- Managed by the Space Environment Research Centre (SERC Limited)
- Established to build on Australian and international expertise in measurement, monitoring, analysis and management of space debris and to develop technologies to preserve the space environment
- The goal is to remote maneuver space debris using photon pressure from a ground based laser.
- Partnerships
  - –Essential: EOS, RMIT University, ANU
  - –Other: Lockheed Martin Corp., Optus, National Inst. of Info and Comms Tech [NICT]/Japan
  - –Affiliates: NASA, ESA, Japanese Space Agency [JAXA]
  - –Funding: A$60M for 5 years (cash + in-kind)

Research Programs (RPs)

RP1: Identification of Space Objects and Preservation of the Space Environment
This program is developing solutions for reliable and accurate observation and tracking of space objects, better monitoring and cataloguing of space debris, using adaptive optics and lasers.

RP2: Orbit Determination and Predicting Behaviours of Space Objects
This program is developing new tools to improve the accuracy and reliability of orbit predictions, including the development of new models for atmospheric mass density.

RP3: Space Asset Management
This program focuses on developing techniques, algorithms and databases to predict and avoid potential collisions in space. To develop a global space catalogue and distribution system having conjunction analysis and threat warnings.

RP4: Space Segment
This program will engage space objects using photon pressure with a view to establishing momentum transfer and force models for the interaction between the space objects and the propagated energy. Up to 3 dedicated satellites will be designed and launched into orbit to serve as instrument platform targets.

RP2 Work Packages (WP's)

WP1: Atmospheric mass density modelling

Dr Robert Norman, Dr Brett Carter, Dr Emma Kerr, Dr Julie Currie, Tim Kodikara, Changyong He, Andong Hu

WP2: Ray tracing – Laser

Dr Robert Norman

WP3: Precise orbit determination for controlled objects

Dr Yang Yang, Han Cai

WP4: Debris ROD using sparse observational data

Dr Yang Yang, Samantha Le May

WP5: Semi-analytic Satellite Theory (SST) for fast and accurate orbit propagation

Dr Jerome Daquin*

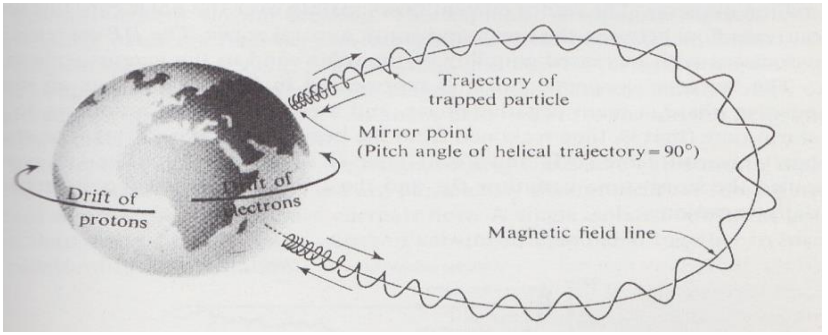
In total 45 research tasks

WP1: Atmospheric mass density modelling

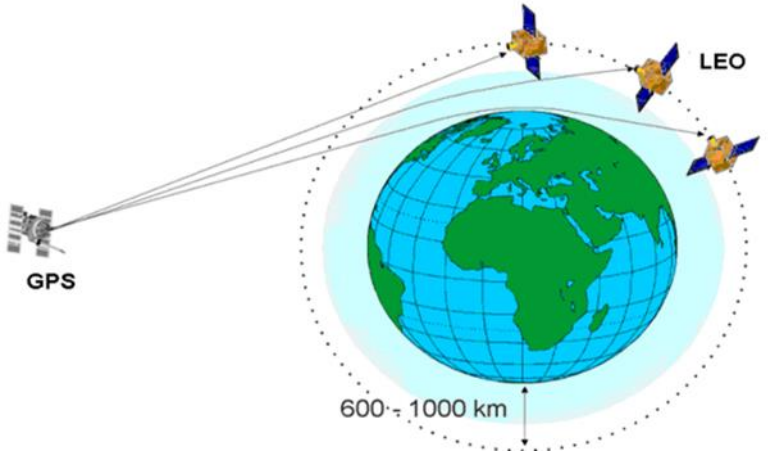
We are developing our own AMD model where we have focussed some of our attention on the ion mass density.

Thermosphere Ionosphere Electrodynamics General Circulation model (TIEGCM)

- From our studies involving Swarm-C density data the periods of high solar and geomagnetic activity were better captured by TIEGCM than the empirical models (NRLMSISE-00 and DTM).
- Timothy Kodikara is applying data assimilation techniques to the TIEGCM model using GPS RO data. Preliminary results are encouraging.
- Dr Julie Currie and Dr Emma Kerr are developing techniques to do orbit propagation using AMD from TIEGCM.

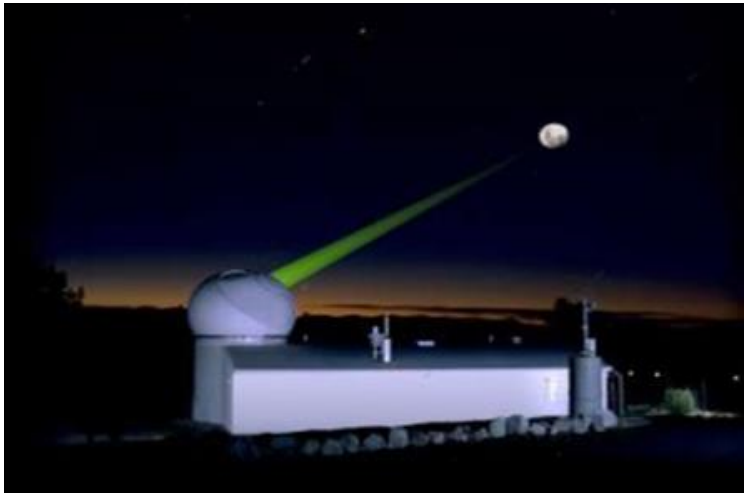


Davies, K. (1990), Ionospheric Radio, Peter Peregrinus Ltd, London UK.



WP2: Ray tracing – Signal Propagation

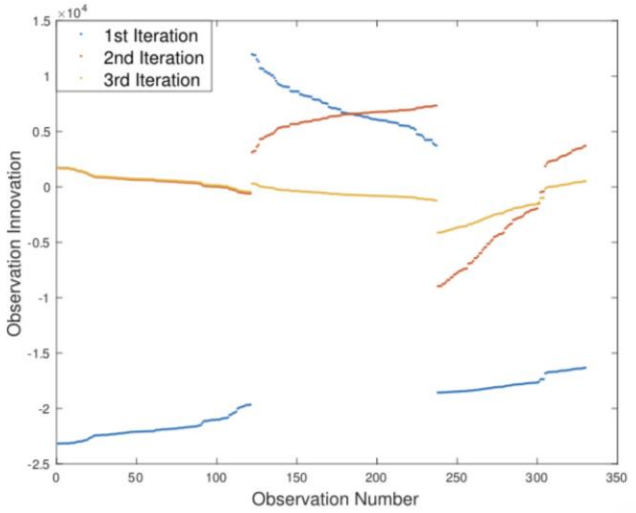
- 3-D Numerical ray tracing technique
- Involves integrating 18 differential equations simultaneously at each step along the ray path
- Traces ray tubes or finite flux tubes
- Advanced atmospheric models
- Homing-In capability
- Able to trace ray paths and determine group path, range, height, transmitted and received elevation and azimuth angles as well as the divergent/convergent signal strength.



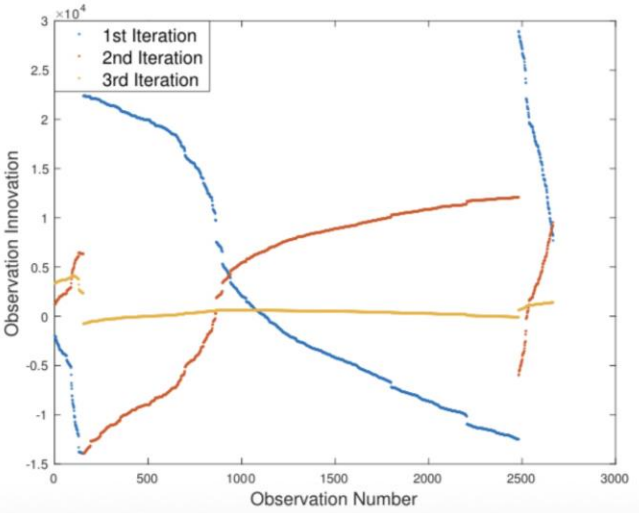
WP4: Debris ROD using sparse observational data

SLR-Only OD Solutions (LEO Objects)

Example 1: TIROS 10 (NORAD ID 1430)
Obs arc: 330 epochs in 3 days
Prediction: 1/3 day(s)
Innovation: 322.080m/5639.638m



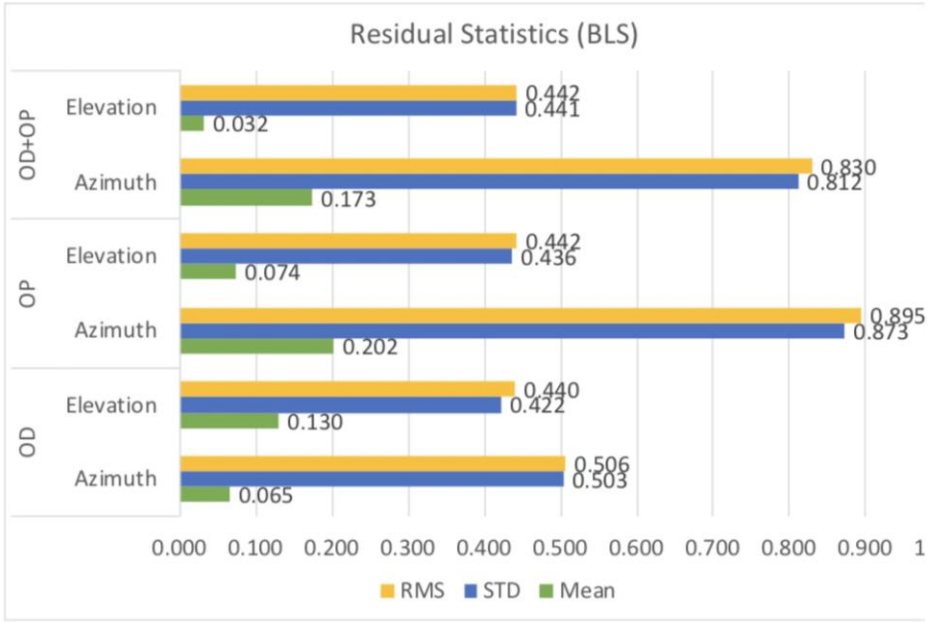
Example 2: Rocket Body (NORAD ID 2621)
Obs arc: 2666 epochs in 3 days
Prediction: 2 days
Innovation: -189.863m



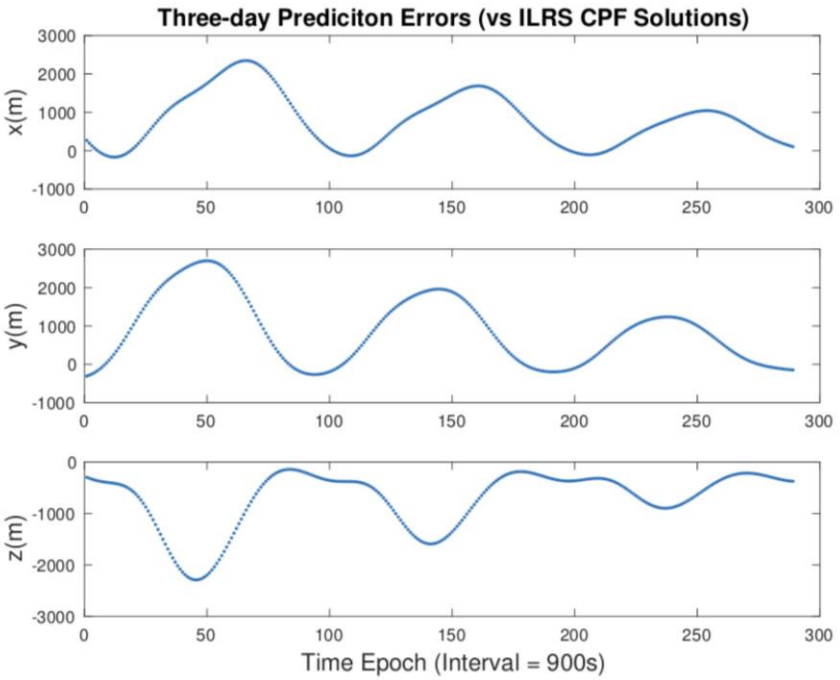
WP4: Debris ROD using sparse observational data

Angles-Only OD Solutions (GEO: QZS1 (Cont.))

Precision



Accuracy



Filters implemented: BLS, UKF, AUKF and GMUKF

Conclusion

- RP2 is going well and we have met the project milestone deadlines
- We are on track to meet all the timelines for the project deliverables
- Project deliverables: AMD model, Fast and accurate orbit propagator, GNSS-POD, ROD and 3-D RT.

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