

Proposed Surface Force Modelling Programme for the DORIS Satellites:

Cryosat, Jason-2, SPOT4, SPOT5, Topex-Poseidon

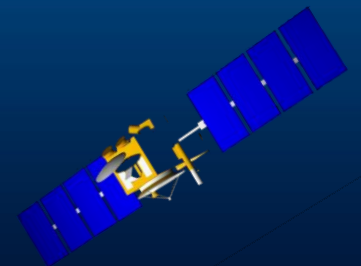
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Motivation

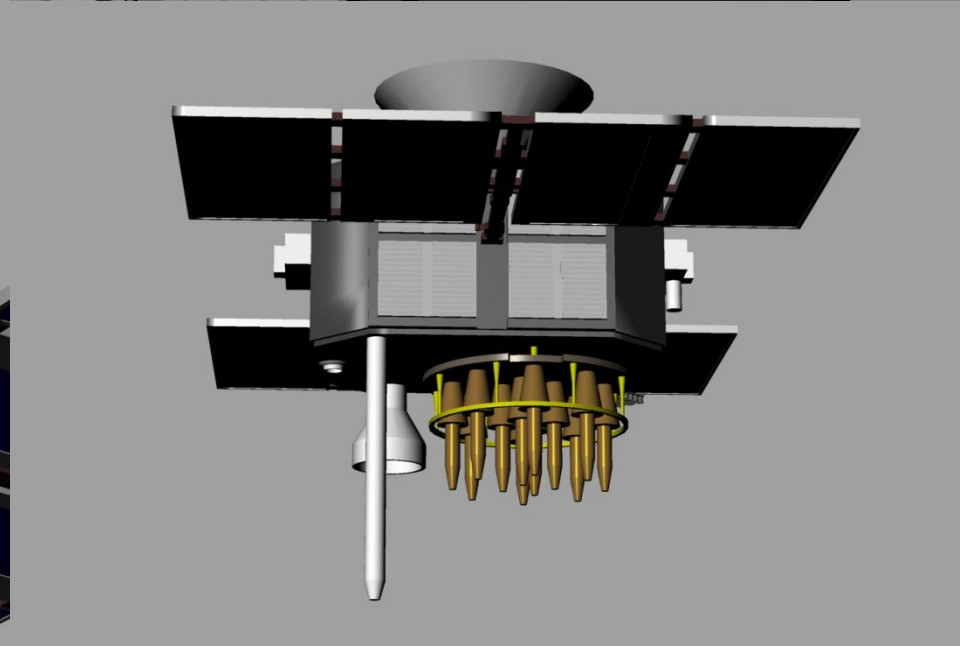
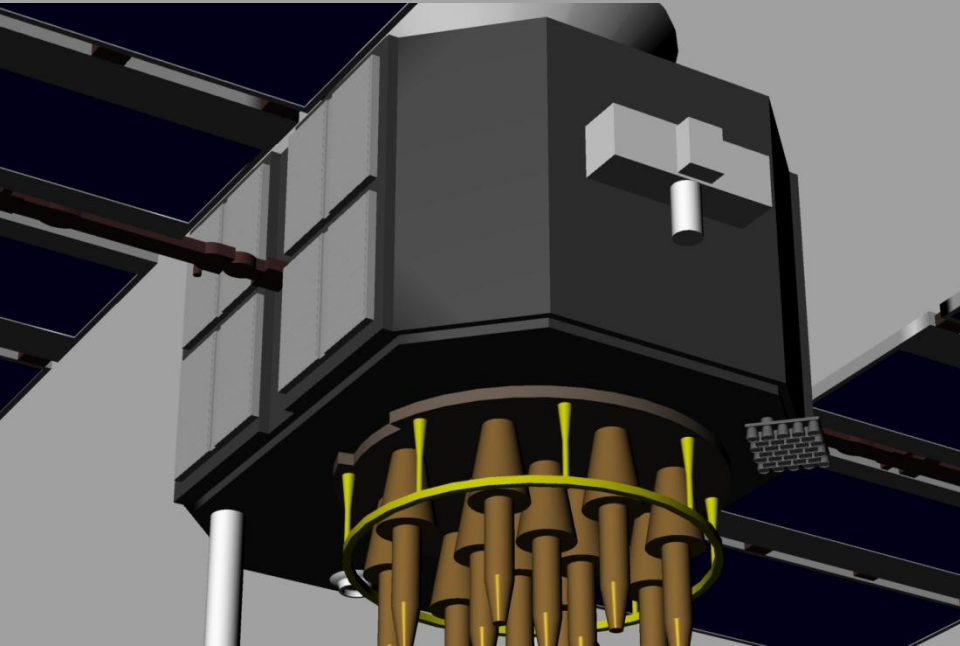
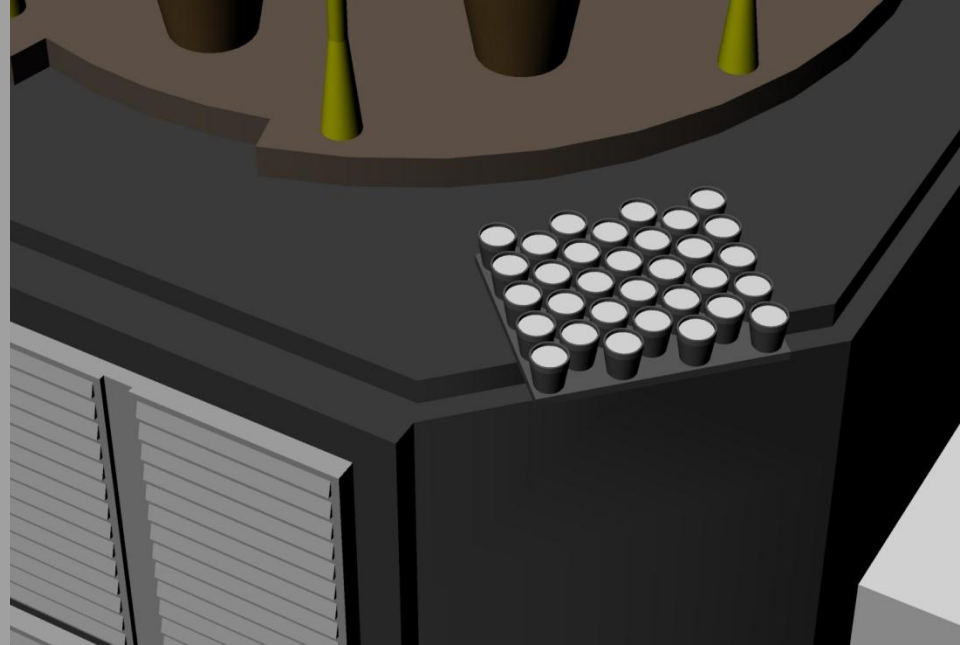
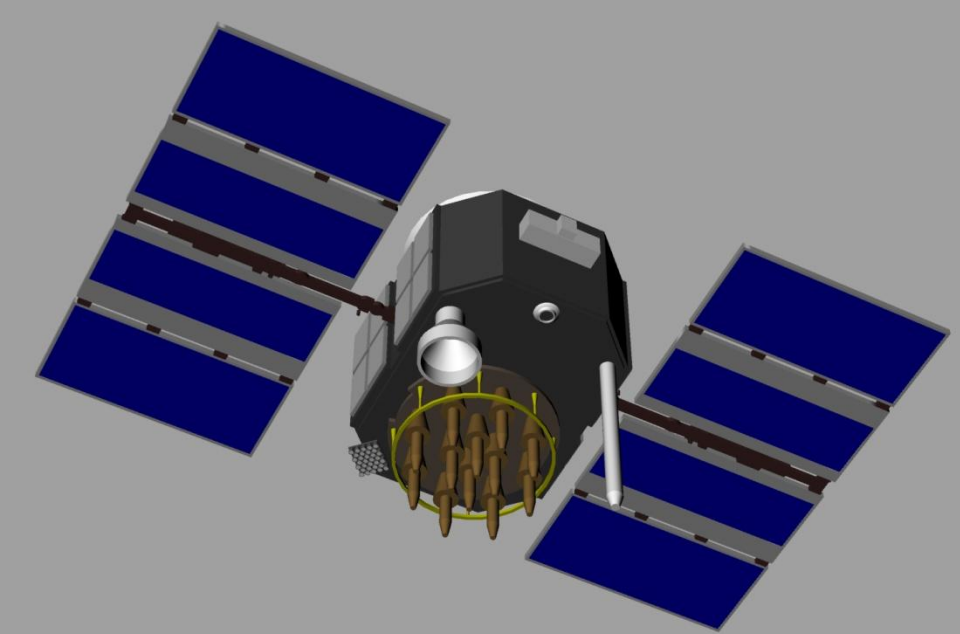
- High accuracy orbit determination of DORIS satellites is critical for earth science applications
- Requirement is for both (a) stable reference frame and (b) un-biased orbits
- In practice (a) and (b) cannot be separated
- Surface force modelling is a significant component of the error budget
- UCL SRP/TRR approach for Jason-1 has shown promise (scale factor ≈ 1.0 , improved orbit centering, reduced correlation with other parameters); GPS/GLONASS results promising

Aims of research

- Compute, test and implement SRP/TRR models for Jason-2, Cryosat, SPOT4, SPOT5 and Topex-Poseidon
- Extend GPS research on earth radiation pressure modelling to LEO satellites
- Develop enhanced drag and lift modelling capability
- Assess surface charge forcing effects
- Engage with DORIS analysis centres and community to share knowledge and models

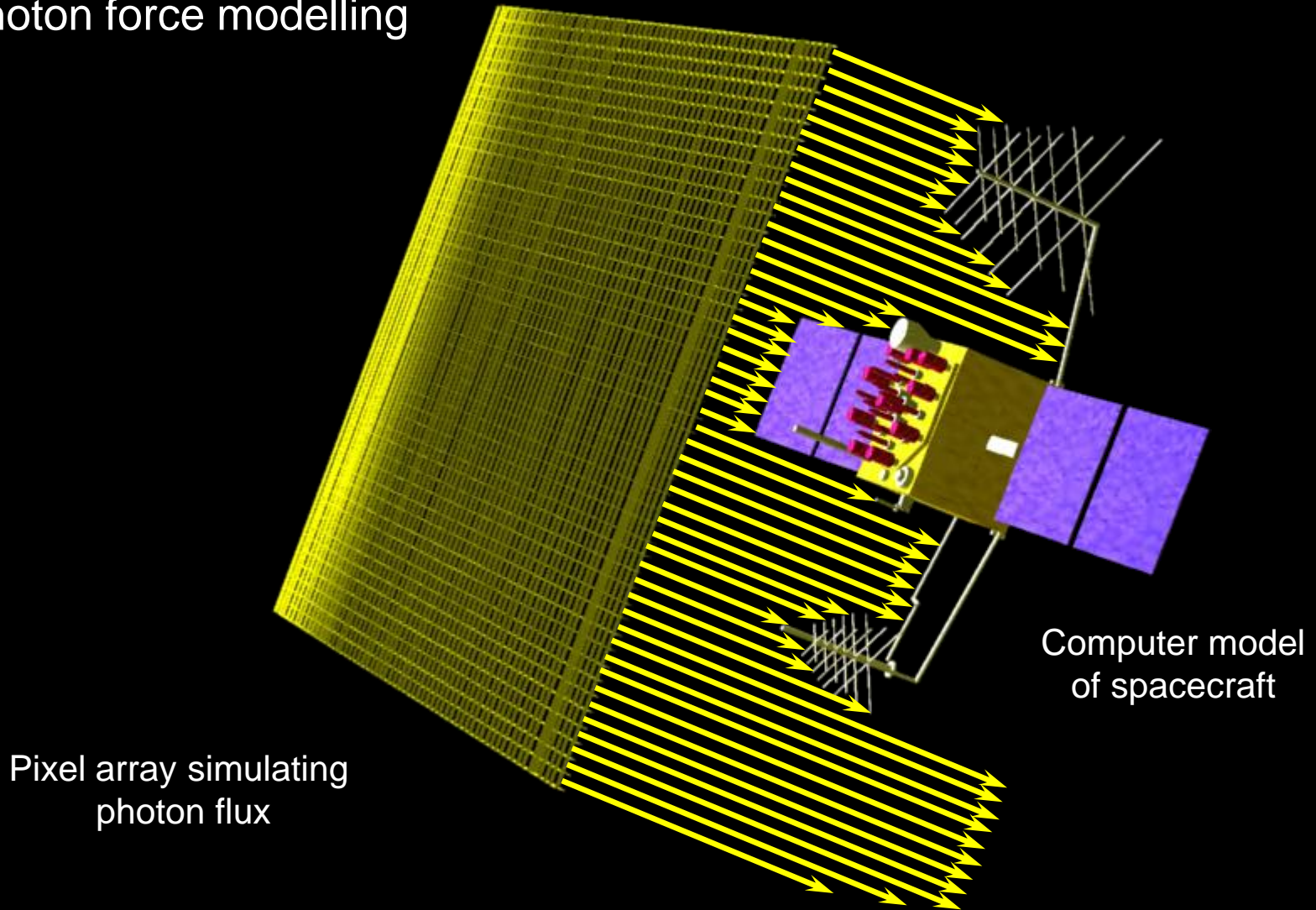
The good news

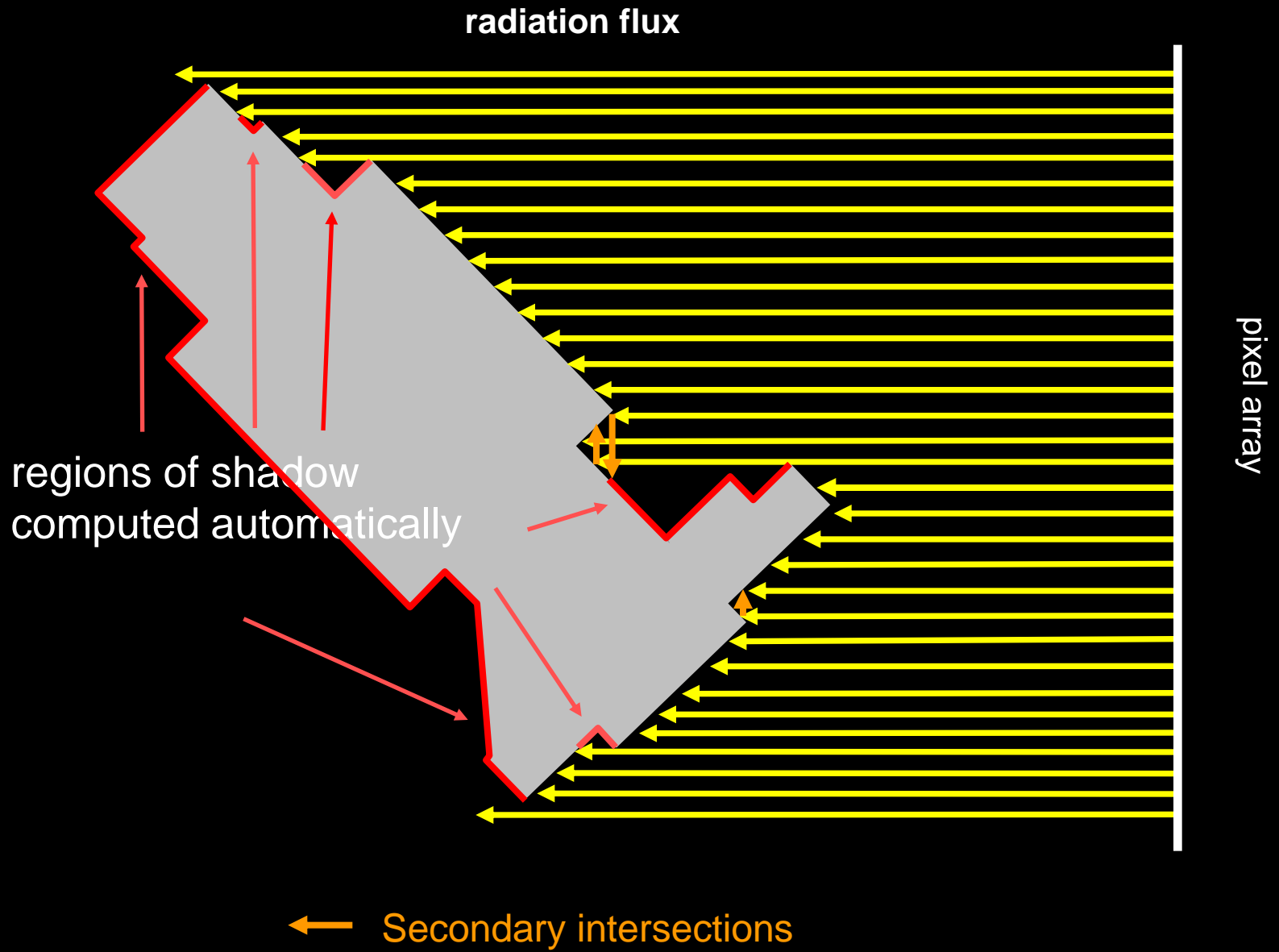
- UK research council grant has been won worth £0.72M
- Grant pays for two post-doctoral researchers for three years each
- Programme starts this September
- UCL group has 18 research staff
- Most tools are mature and tested (see later)
- Much of the structural data for the satellites has been acquired and tested (see later)

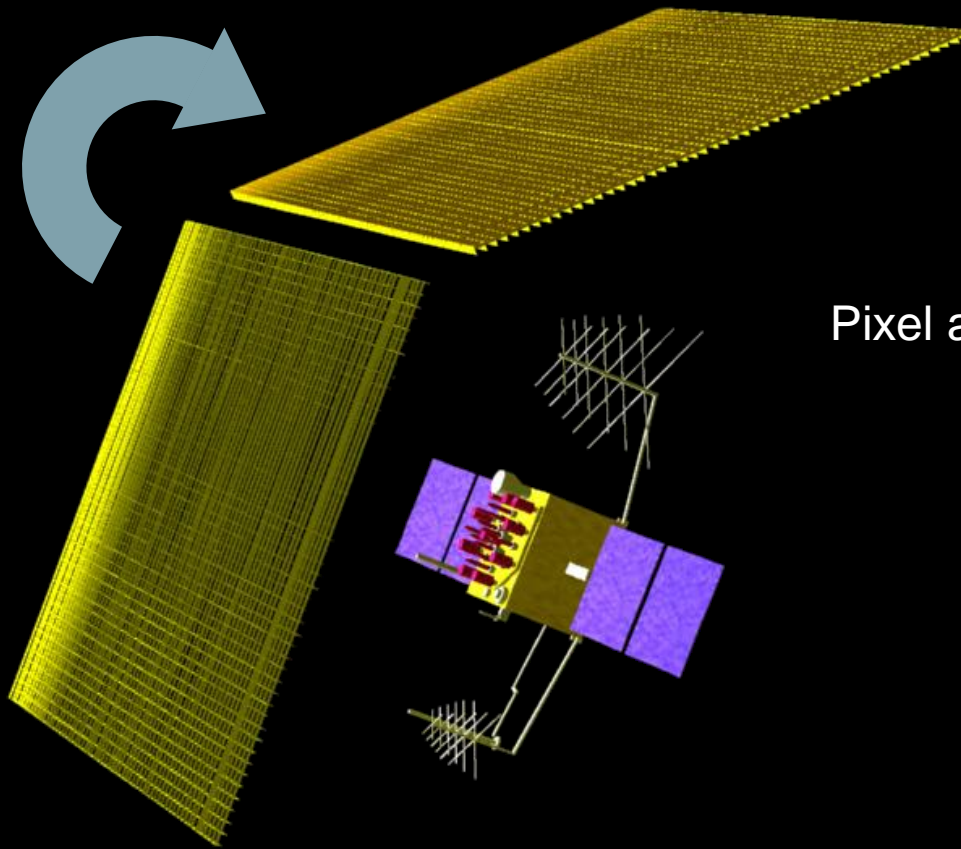


We develop a detailed structural computer model of the spacecraft

Photon force modelling







Pixel array rotated around spacecraft,
solar panels adjusted

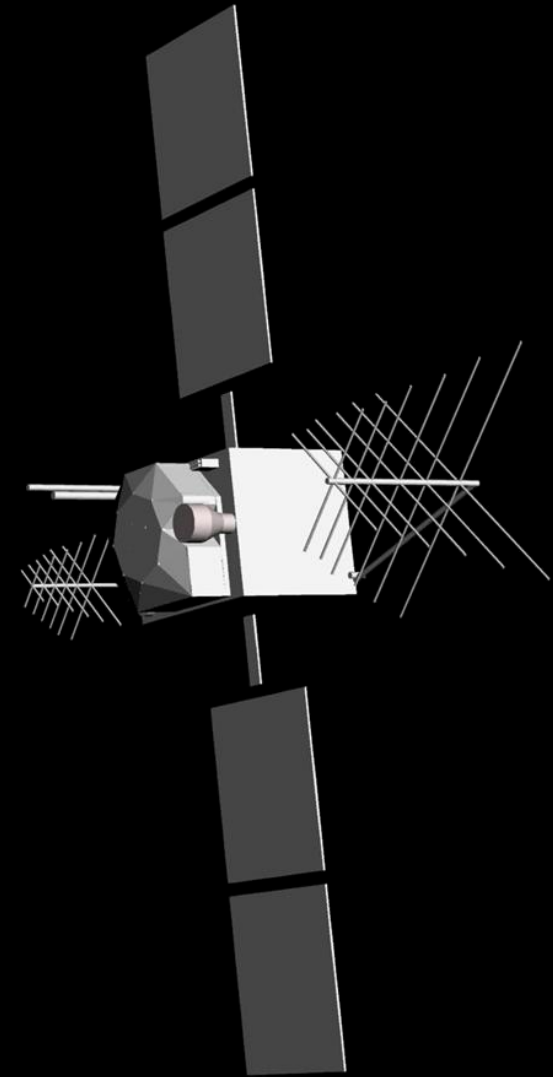
Publications:

Ziebart, M., (2004) Generalised Analytical Solar Radiation Pressure Modelling Algorithm for Spacecraft of Complex Shape, Journal of Spacecraft and Rockets, Vol.41, No.5, pp 840-848(9)

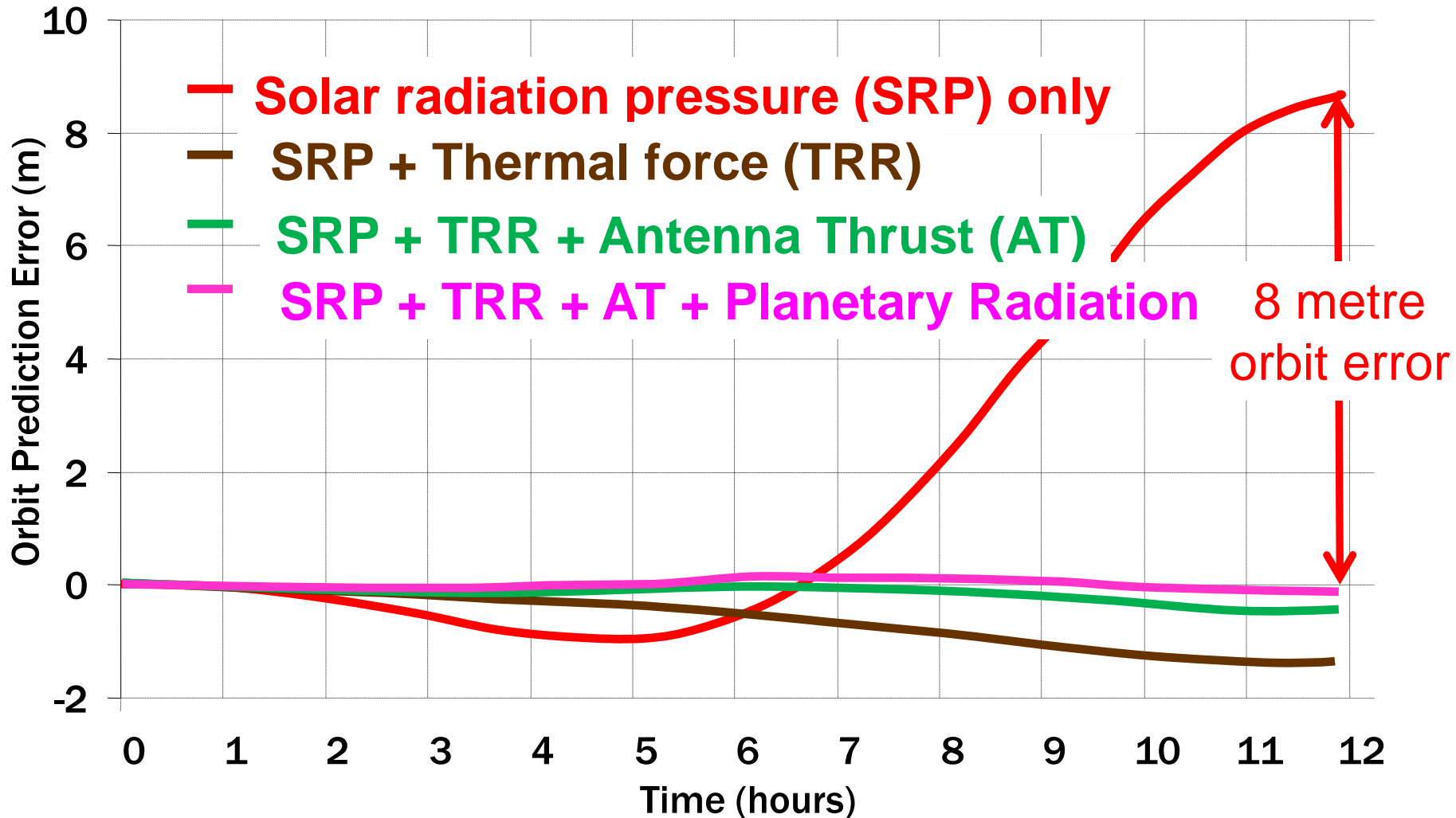
Ziebart, M., Adhya, S., Sibthorpe, A., and Cross, P., (2003) GPS Block IIR Non-conservative Force Modelling: Computation and Implications, Proceedings of ION GPS/GNSS 2003, Portland, Oregon, US (*winner of best paper award*, Science/timing application session)

Force modelling on GPS satellites

- Computer codes adapted to run on supercomputers
- Contract research for US Air Force/JPL
- Won several international awards
- Orbit determination accuracy of 2cm achieved
- Earth radiation pressure modelling adopted as international standard (IGS)
- Commercial contract to develop orbit prediction and orbit determination code for one of the world's largest providers of GPS positioning services
- Ziebart now serving on the governing board of the IGS, running a working group on orbit dynamics

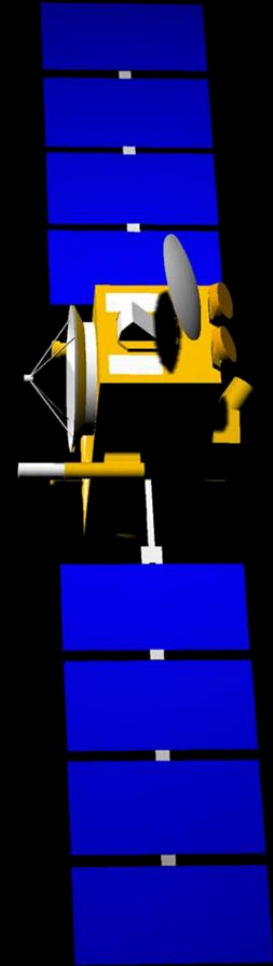


Along-track orbit prediction errors over 12 hours for one GPS satellite with different photon-based force models



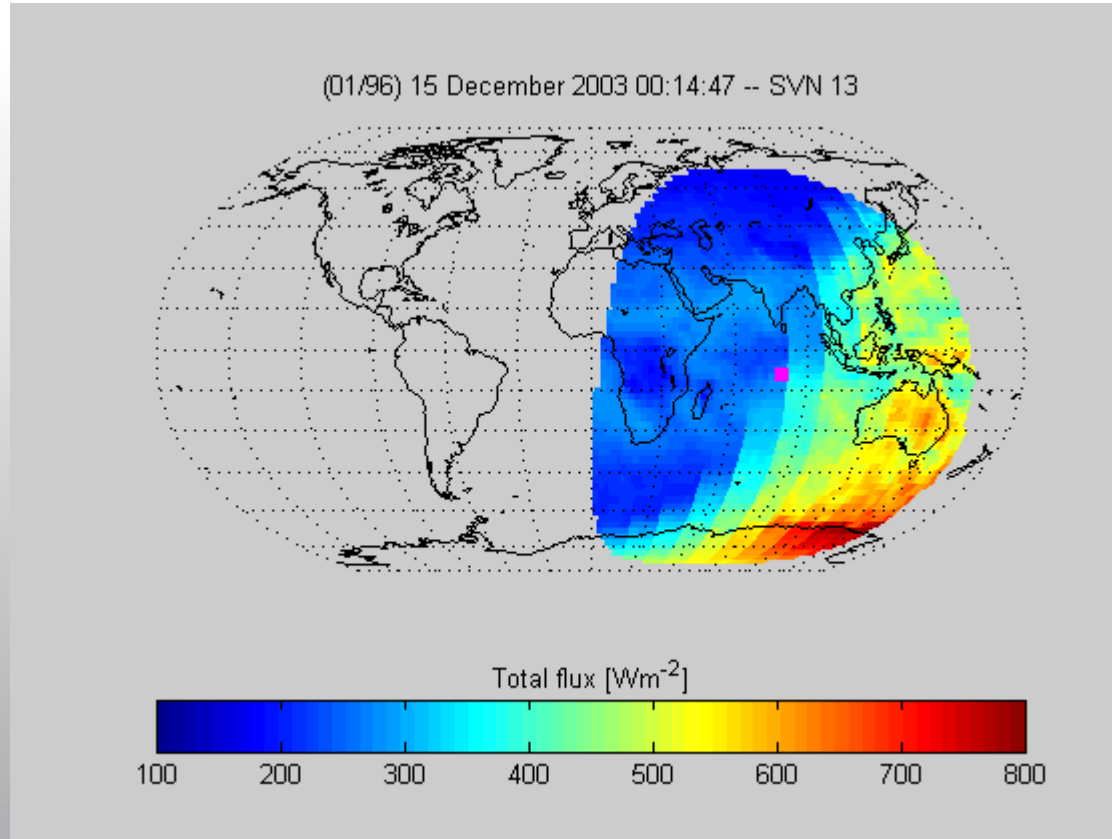
Jason-1 modelling (SRP and TRR)

- Extensive tests carried out at JPL
- Dynamic orbit improvements in cross overs, SLR residuals, orbit overlaps and scale factors
- Model subsequently tested by Goddard Space Flight Centre
- North hemisphere – South hemisphere mass transfer anomaly resolved
- Anomalous 60 day period signature reduced
- Model adopted by GSFC/JPL as POD standard



Additional techniques

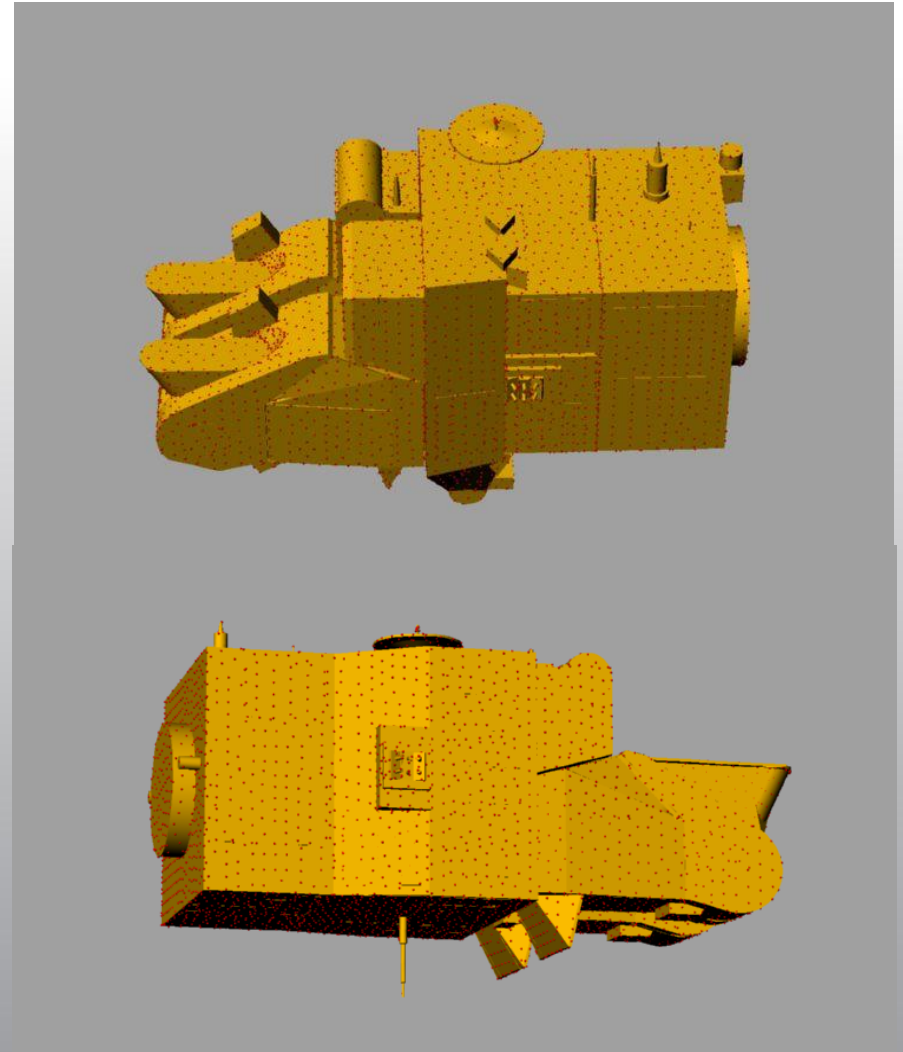
- Thermal imbalance force (solar panels), power draw
- Thermal imbalance force (thermal blankets)
- Earth radiation pressure (IR and visible, emitted and reflected)
- Penumbra flux scaling
- Antenna thrust
- Eclipse transition prediction based on ellipsoidal earth model



Earth radiation flux on GPS satellite SVN13
24 hours of modelling

SPOT4/SPOT5

- Structural models complete and tested
- Open questions about surface material properties, power draw
- Open questions about attitude models



Model formats/languages

- Preferred format is a grid file modelling acceleration along a given spacecraft body-fixed axis as a function of the radiation source latitude/longitude
- Interface for this approach coded and tested in GIPSY and Geodyne
- Code in either Fortran or C++
- Other model formats exist (Fourier series, spherical harmonics)

Conclusions

- Initial research builds SRP/TRR models for Jason-2, Cryosat, SPOT4 and SPOT5
- Experimental/developmental work on: earth radiation pressure; ram profiling/lift; surface charging effects
- Aim is to support Jason-2/Cryosat POD and reference frame but also long term reprocessing
- Funding for three years
- I welcome feedback, and hope for a good engagement with the DORIS community



Discussion?

