Astrodynamics and Space Geodesy for Space Domain Awareness and Sustainability

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Space Geodesy & Navigation Laboratory

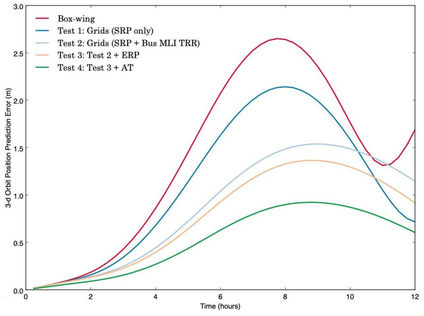
Spacecraft and Space Debris

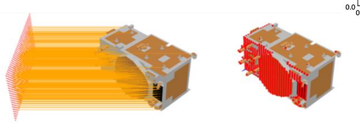
Precision Orbit Determination and Prediction

An important area of expertise in the group lies within our capability to produce high fidelity models of non-conservative forces.
Accurate modelling of these forces has allowed for sub-metre precision when applied to the GPS constellation.

These high-precision force models include:

- Solar Radiation Pressure (Ray-tracing)
- Thermal and Planetary radiation
- Antenna thrust effects



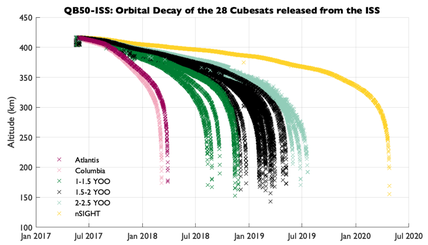


High precision radiation force modelling allows for predicting the position of a GPS satellite at the sub-metre level after 1 orbit (~80,000Km).

QB50 constellation studies

The group is currently collaborating with UCL Physics and Astronomy and Mullard Space Science Laboratory (MSSL) to investigate atmospheric mass density in the 400-150 Km altitude range with the help of the Ion and Neutral Mass Spectrometer (INMS).

By studying the orbital decay of the QB50-ISS constellation, the group is attempting to infer properties of the environment it is flying through. The use of the INMS will serve as a way to validate these inferences.



In addition, the group is looking to use all-sky camera data as a source of data in this study.

The streak in this all-sky camera image with variations in brightness indicates the possible presence of a tumbling object on orbit. (Image Credit: Svalbard KHO Observatory)

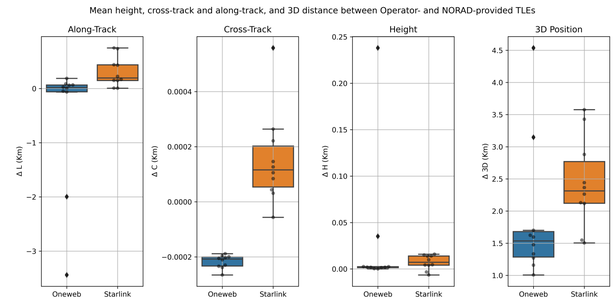
Constellation Analysis

Characterizing Orbit Consistency

Force modelling at the constellation level allows for a more comprehensive study of space weather than single missions offer. It also allows the study of constellation wide effects, tying in to space traffic management practices.

The explosion in SSA-related businesses is a testament to the strength of the need for improved orbit prediction, which is predicated on a precise modelling of the physical environment.

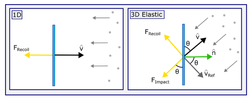
The group has recently been characterizing the quality of the commonly used Two Line Elements provided by the North American Aerospace Defense Command (NORAD) on an inter- and intra-constellation basis.



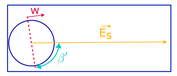
Space Surveillance Network vs Operator-based TLE generated orbits.(For 3D position: OneWeb: Mean of 1.9Km, Std.Dev: 1.0Km; Starlink: Mean of 2.4Km, Std.Dev: 0.67kM)

Impact of Aerodynamic Force Models on Constellation Orbit Propagation

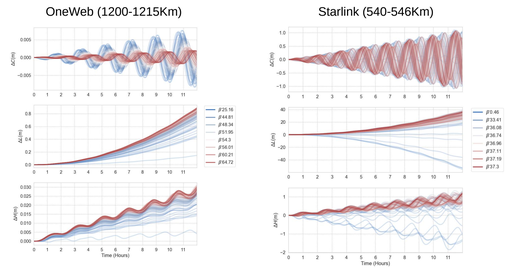
Improving orbit propagation and determination has important scientific and engineering applications (e.g. study of space weather and increase in fuel use efficiency). A recent study has investigated the impact of increasing aerodynamic force model fidelity on the the Oneweb and Starlink constellations.



'1D' is the most widely used drag model. '3D Elastic' represents a computationally inexpensive increment in physical fidelity.



β' is the angle between the orbit normal and the Earth-Sun vector.



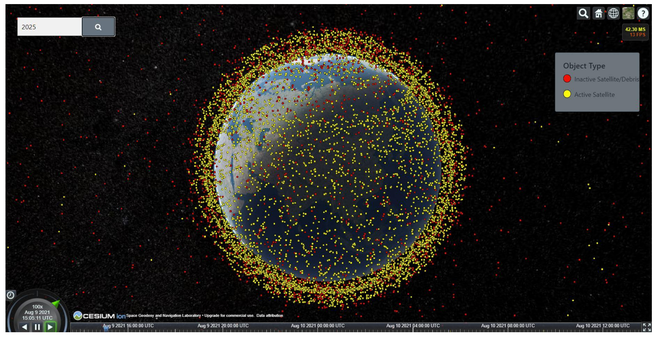
After 6 hours, improvements in the physical fidelity of drag models impacted positioning on the decimetre scale for the Starlink constellation, and at the sub-meter level for OneWeb. A clear link is visible between β' angle and positional divergence.

Environmental Prediction

Future Space Populations

The UCL FSP Model is a detailed computational model of the future population of artificial resident space objects (RSOs), including information individual RSO locations, individual trajectories and object metadata.

We are currently using this model to simulate multiple future scenarios to deepen our understanding of potential consequences in order to inform Space Policy. We hope that our findings will be used to continue our discussions around space sustainability, both within the public and private sectors.

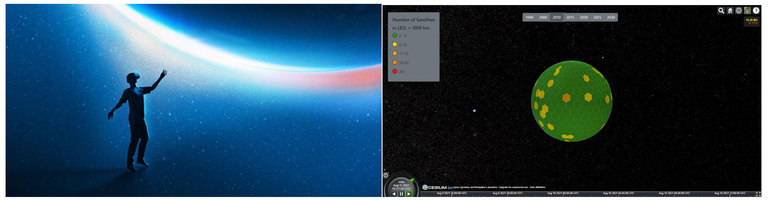


FSP: Predicted LEO Population in 2025

Democratising Space through Data Visualisations

There is a clear need to democratise the complex data for the general public. Space should be a domain that is for all, and for true change to occur, the public should be aware of how this could effects them. This is especially important for when new policy and regulations are put into place.

Therefore, we are researching new methods of using technology to better communicate this problem to the general public. Current efforts are looking into using Virtual Reality and new data visualisation techniques, including 4D real-time hotspot mapping.



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