SESA2024 Astronautics

University of Southampton

# Chapter 5: Mission Analysis

## Lecture 8 – Orbit visualisation activity

Professor Hugh Lewis

# Overview of lecture 8

- This lecture describes the orbit visualisation tool and a set of activities you can undertake to support your understanding of orbits and orbital elements:
  - The orbit visualisation tool is available to download from the Blackboard site (in the same folder as these lecture slides)
  - The tool is a Microsoft Excel spreadsheet, which has been tested on PCs and Macs
  - You may need to enable the Macros for the spreadsheet to function correctly (the underlying Visual Basic code is actually very simple; most of the “work” is done in the different worksheets)
  - The 3D rendering is actually achieved using a single 2D scatter plot (the orbital elements are converted to cartesian coordinates, which are subsequently projected onto a 2D “image” plane)

# Orbit visualisation

- Orbit visualisation in Microsoft Excel (available on Blackboard)

**Orbit and Visualisation Control Panel**

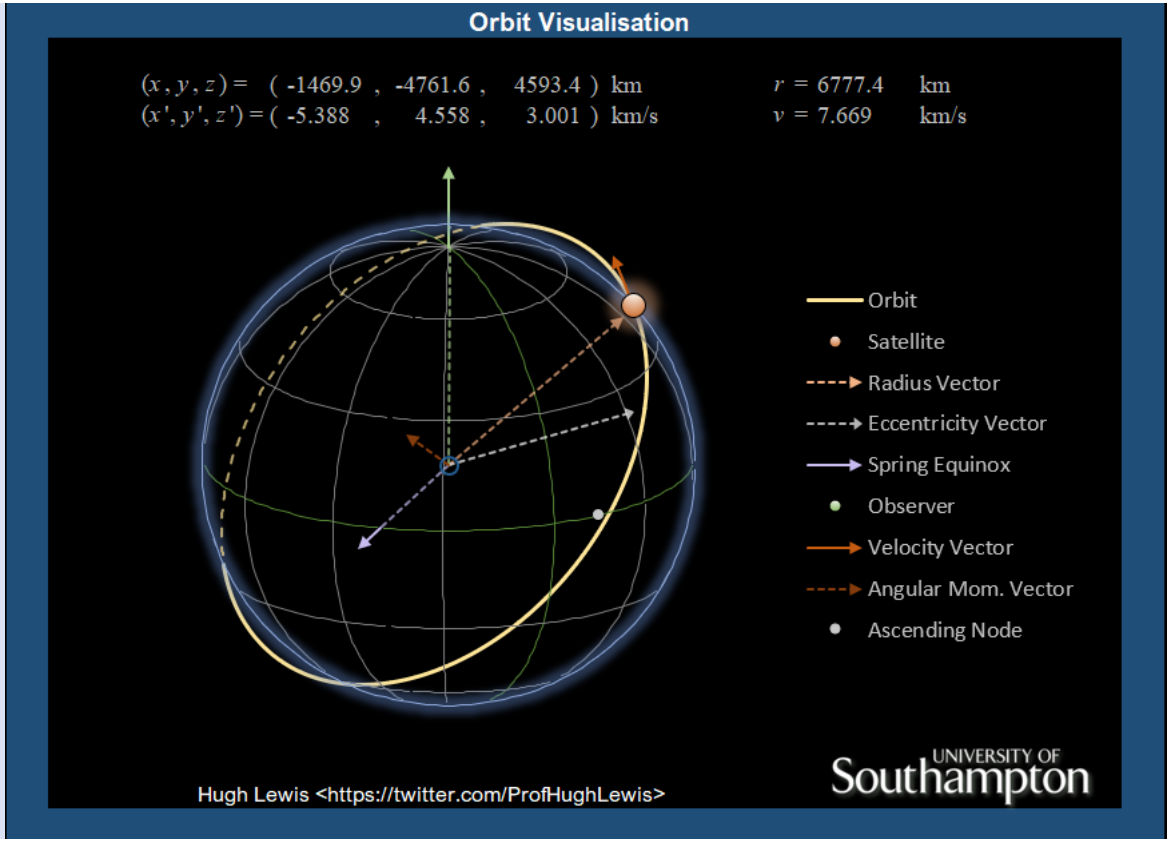
Change the orbital elements and use the view settings to visualise the orbit

| Variable | Symbol | Value | Units |
|---|---|---|---|
| Semi-major axis | a | 6778 | km |
| Eccentricity | e | 0.001 | |
| Inclination | i | 51.5 | deg. |
| Right ascension of ascending node | Ω | 60 | deg. |
| Argument of perigee | ω | 30 | deg. |
| Perigee altitude | $h_p$ | 393.2 | km |
| Apogee altitude | $h_a$ | 406.8 | km |

| Observer | | |
|---|---|---|
| Latitude: | 50.9 | deg. N |
| Longitude: | 1.4 | deg. W |
| Date: | 16/09/2020 | |
| Time (UTC | 12:00:00 | |

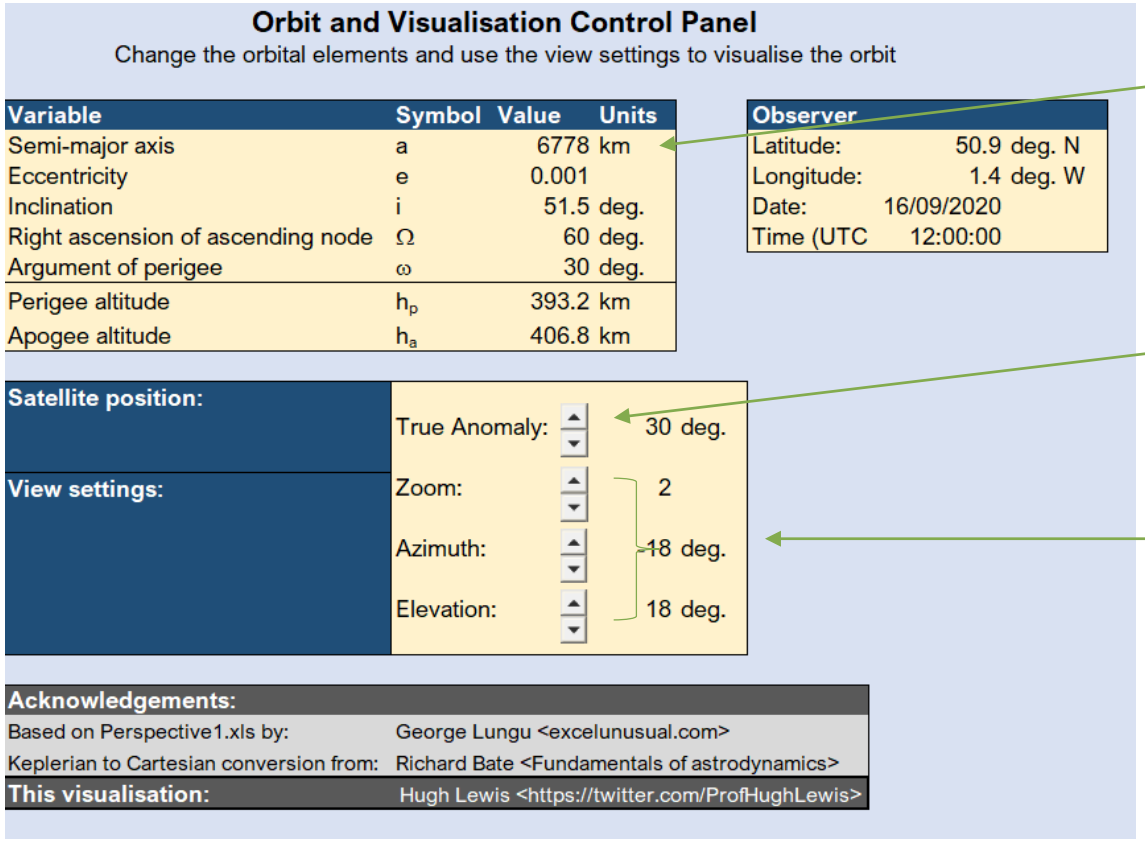
| | | |
|---|---|---|
| **Satellite position:** | True Anomaly: | 30 deg. |
| **View settings:** | Zoom: | 2 |
| | Azimuth: | -18 deg. |
| | Elevation: | 18 deg. |

| Acknowledgements: | |
|---|---|
| Based on Perspective1.xls by: | George Lungu <excelunusual.com> |
| Keplerian to Cartesian conversion from: | Richard Bate <Fundamentals of astrodynamics> |
| **This visualisation:** | Hugh Lewis <https://twitter.com/ProfHughLewis> |



# Orbit visualisation

- Orbit visualisation in Microsoft Excel (available on Blackboard)



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Enter the orbital elements here

Use these buttons to change the true anomaly and move the satellite around its orbit*

Use these buttons to adjust your point of view and to zoom in or out*

* Don't change the numbers in the cells next to these buttons except by clicking on the up and down buttons.

# Orbit visualisation

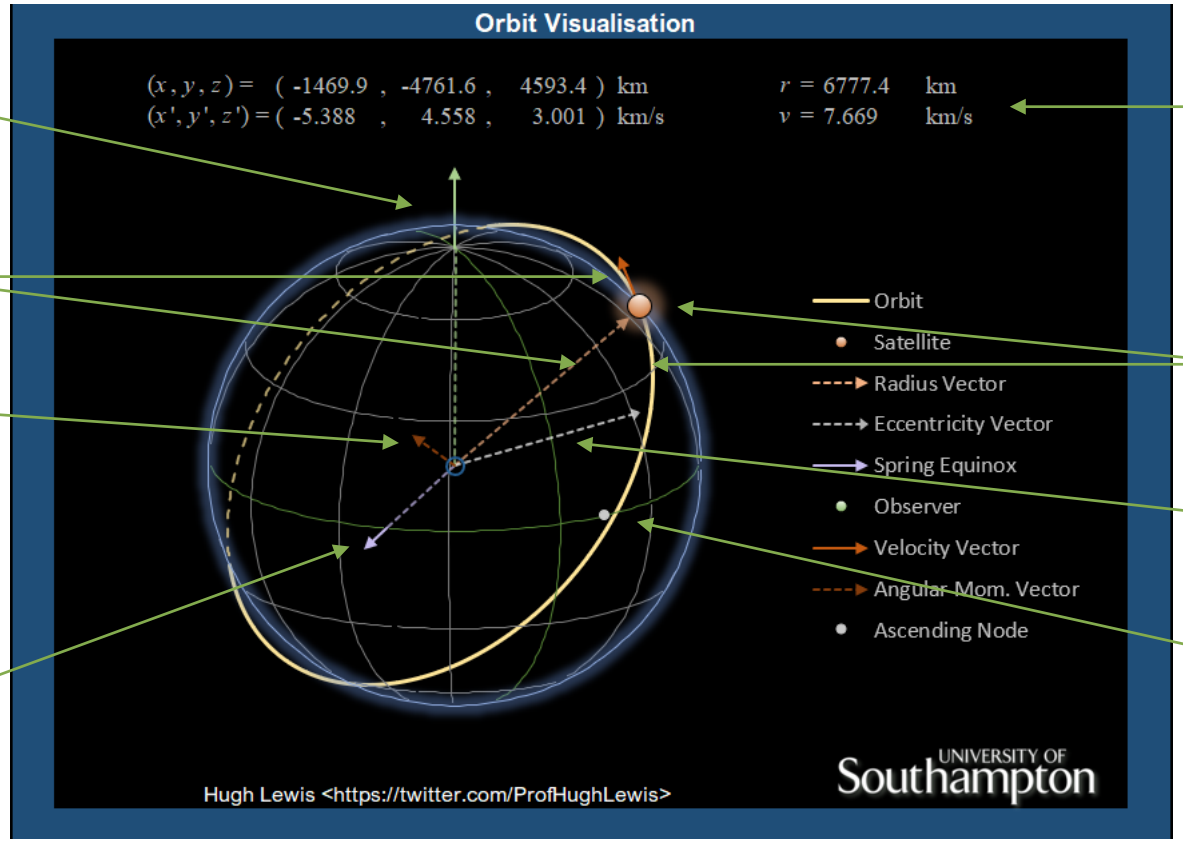
- Orbit visualisation in Microsoft Excel (available on Blackboard)

North pole

Radius and velocity vectors

Orbit angular momentum vector (90° to the orbit plane)

Vector pointing to the position of the Sun at Spring Equinox




Position and velocity in cartesian coordinates (including the orbital radius and speed)

The satellite and its orbit

Eccentricity vector (points to the location of the perigee)

Ascending node (point where satellite crosses from South to North on the Equator)

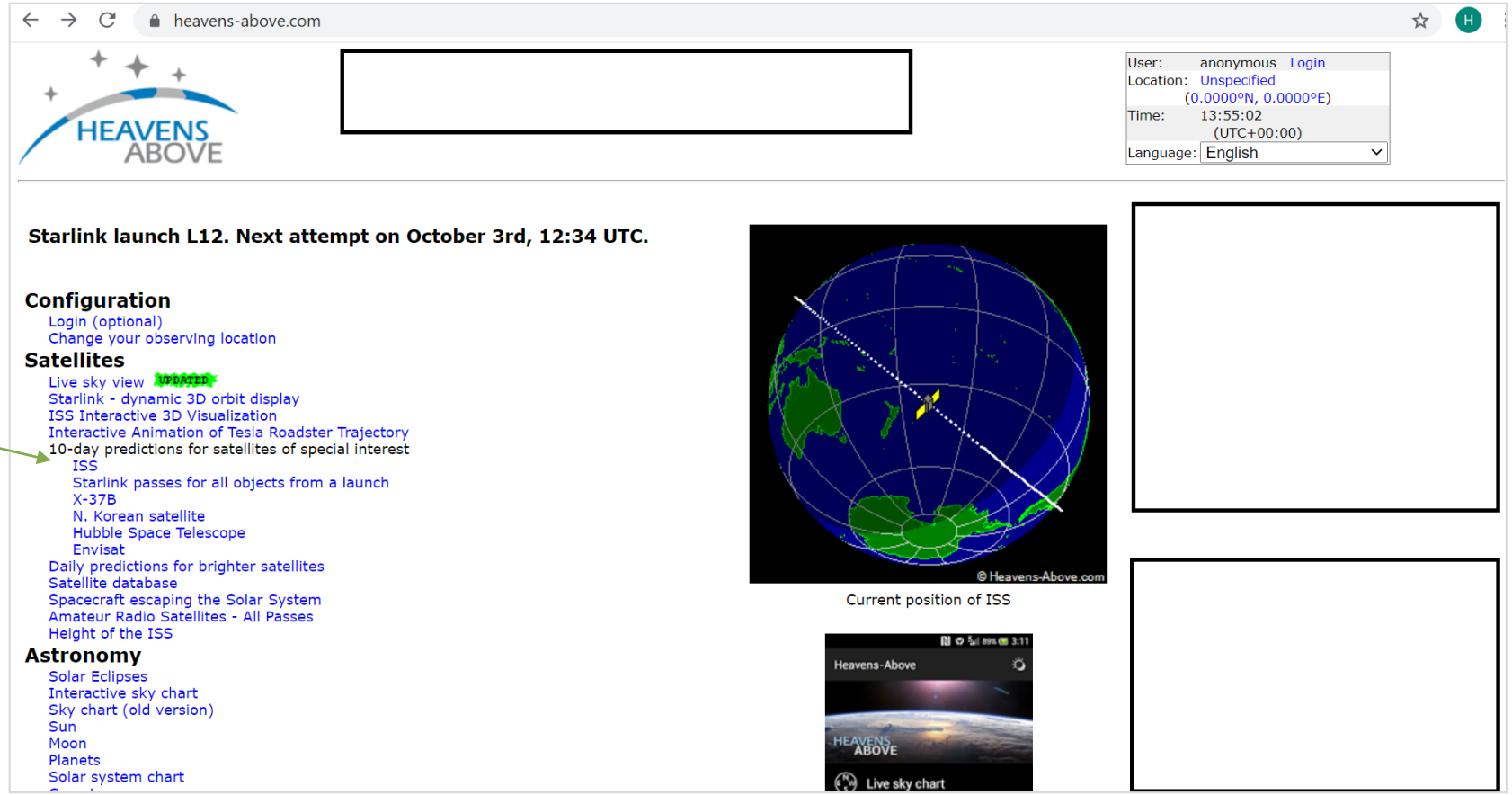
# Activity

- Activity using the orbit visualisation tool:
  1. Visit “Heavens Above” (information on the next few slides) to find the orbital elements of the following satellites:
     - The International Space Station (ISS)
     - The Hubble Space Telescope (HST)
     - Envisat
  2. Enter the orbital elements into the orbit visualisation tool
  3. Change the view settings to match the images provided on the “Heavens Above” website
  4. Find the ascending and descending nodes, and the closest approach to the Earth (perigee)

# "Heavens Above"

- Go to https://www.heavens-above.com/

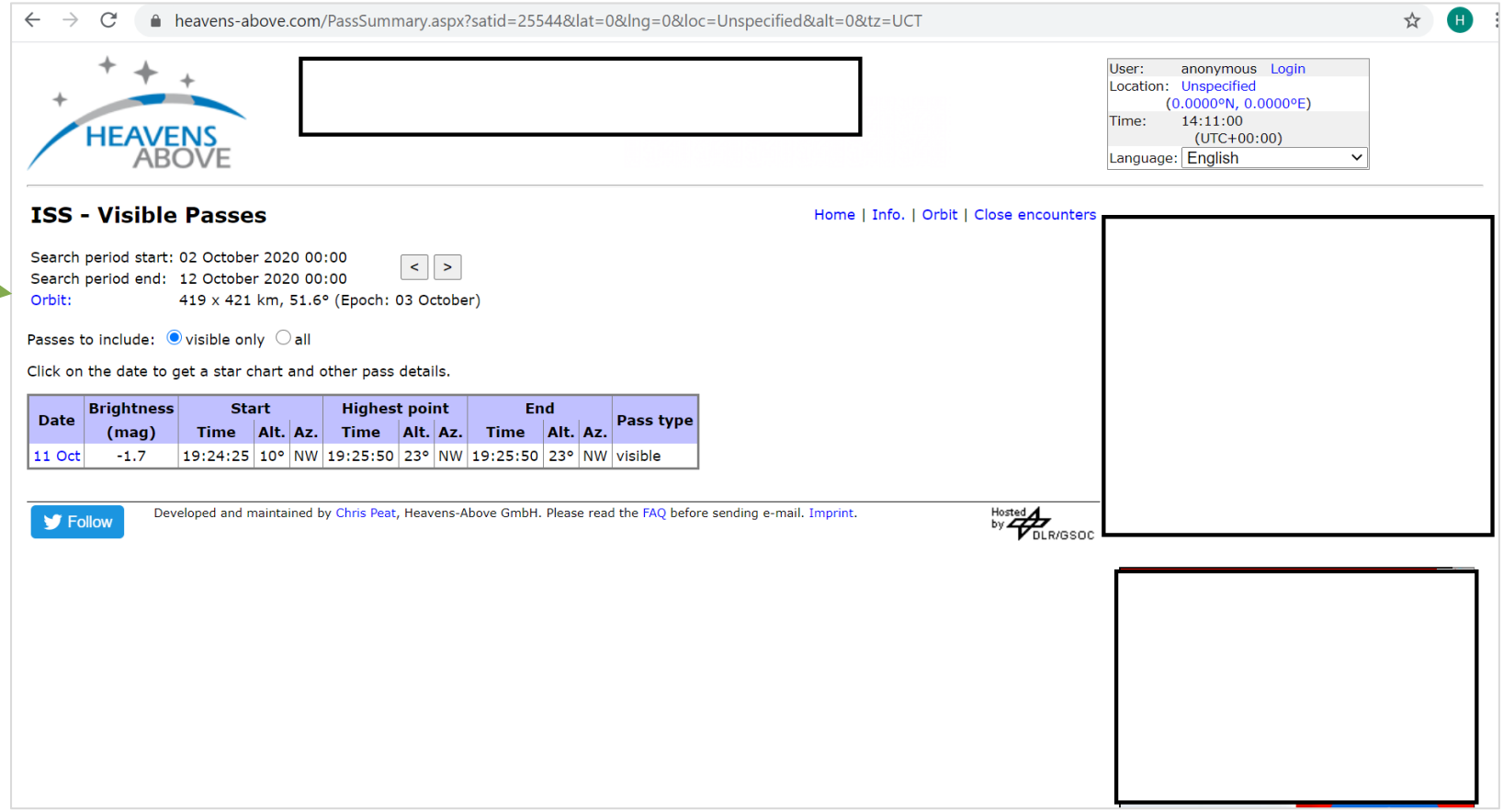
Click on "ISS" to view information related to the ISS



# "Heavens Above"

- Go to https://www.heavens-above.com/

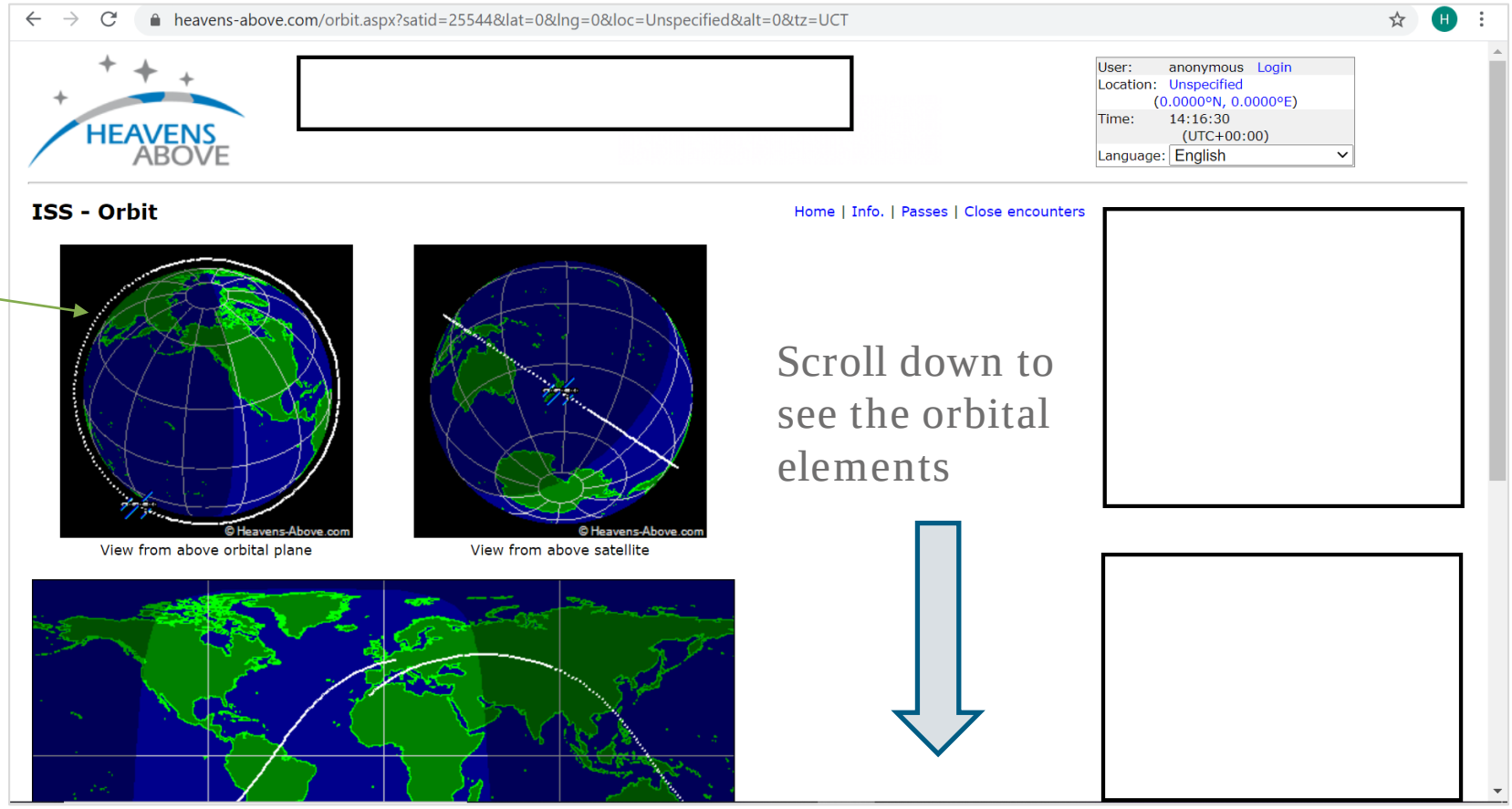
Click on "Orbit" to view the orbital elements for the ISS



# "Heavens Above"

- Go to https://www.heavens-above.com/

Try to replicate these views using the MS Excel orbit visualisation tool



# "Heavens Above"

- Go to https://www.heavens-above.com/

Orbital elements are here. Using Kepler's 3rd law, you can convert the "revolutions per day" to a semi-major axis, or you can use the perigee and apogee heights