

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

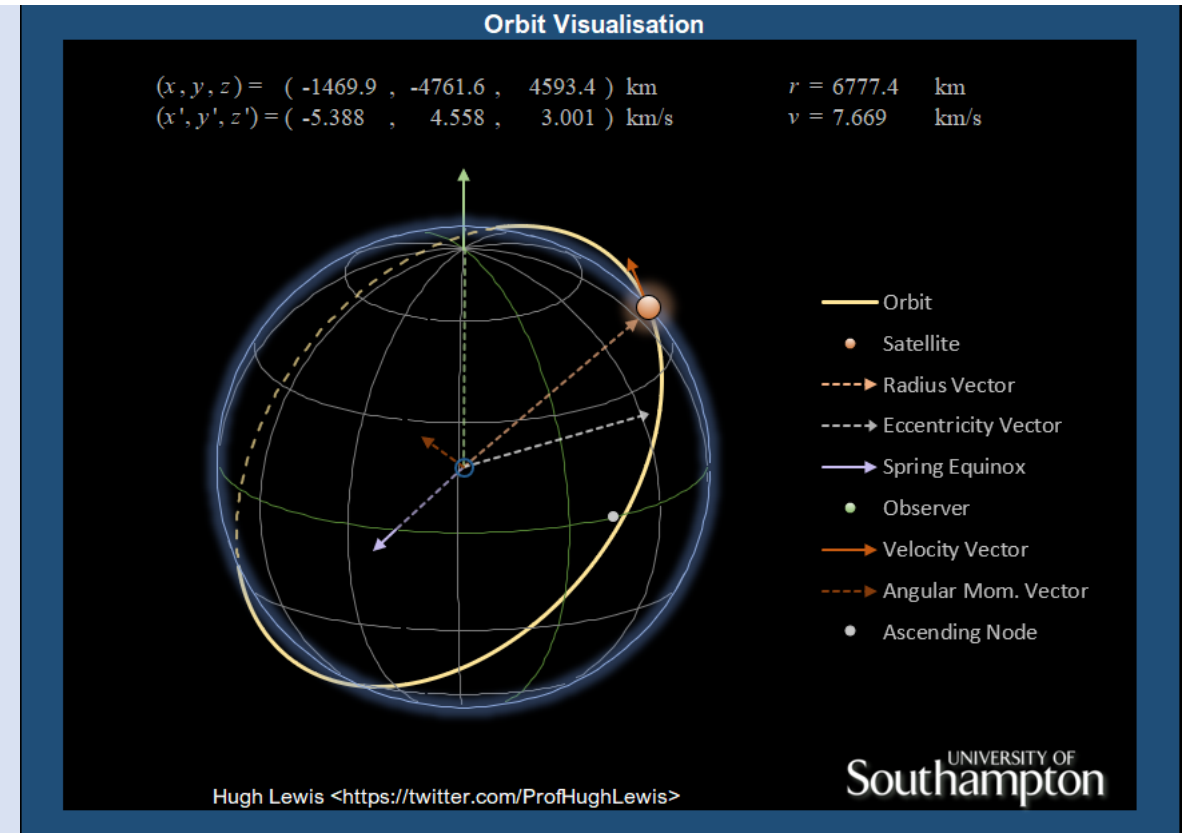
Variable	Symbol	Value	Units
Semi-major axis	a	6778 km	
Eccentricity	e	0.001	
Inclination	i	51.5 deg.	
Right ascension of ascending node	Ω	60 deg.	
Argument of perigee	ω	30 deg.	
Perigee altitude	h_p	393.2 km	
Apogee altitude	h_a	406.8 km	

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>>



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Enter the orbital elements here

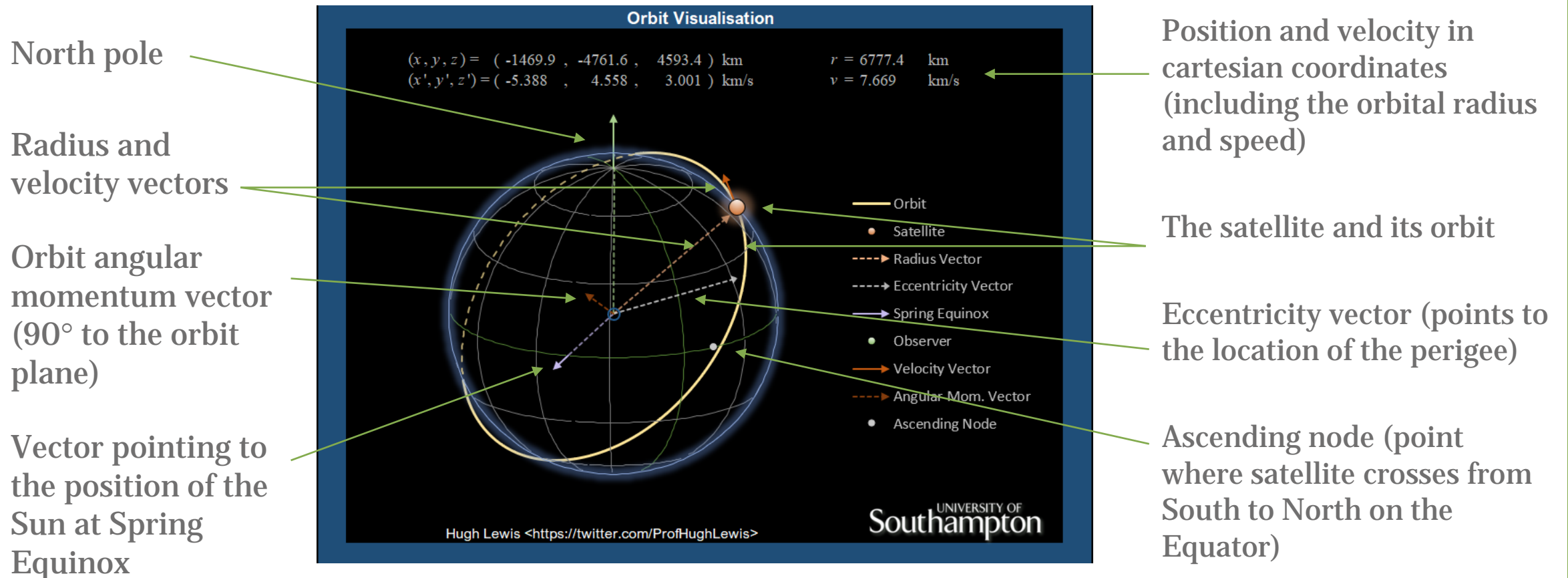
Use these buttons to change the true anomaly and move the satellite around its orbit*

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)



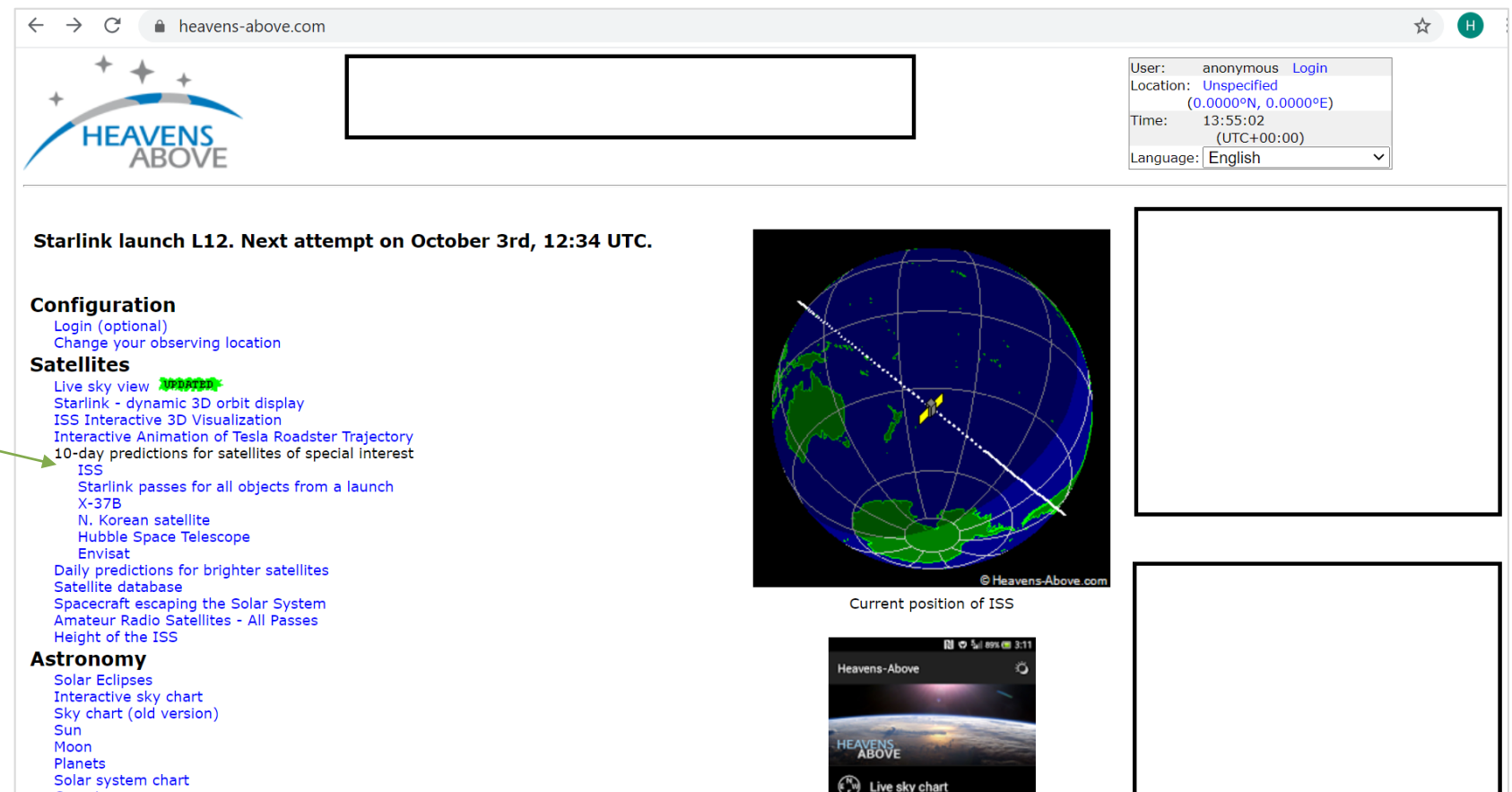
Activity

- 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



The screenshot shows the Heavens-Above website interface. At the top, there is a navigation bar with the Heavens-Above logo on the left, a search bar in the center, and user information on the right. The user information includes: User: anonymous, Location: Unspecified (0.0000°N, 0.0000°E), Time: 13:55:02 (UTC+00:00), and Language: English. Below the navigation bar, the main content area features a section titled "Starlink launch L12. Next attempt on October 3rd, 12:34 UTC." followed by a "Configuration" section with links for "Login (optional)" and "Change your observing location". The "Satellites" section is highlighted with a green arrow pointing to the "ISS" link. The "ISS" link is part of a list of satellite links including "Live sky view", "Starlink - dynamic 3D orbit display", "ISS Interactive 3D Visualization", "Interactive Animation of Tesla Roadster Trajectory", "10-day predictions for satellites of special interest", "ISS", "Starlink passes for all objects from a launch", "X-37B", "N. Korean satellite", "Hubble Space Telescope", "Envisat", "Daily predictions for brighter satellites", "Satellite database", "Spacecraft escaping the Solar System", "Amateur Radio Satellites - All Passes", and "Height of the ISS". The "Astronomy" section is also visible, containing links for "Solar Eclipses", "Interactive sky chart", "Sky chart (old version)", "Sun", "Moon", "Planets", and "Solar system chart". To the right of the "Satellites" section, there is a large globe showing the current position of the ISS, with a label "Current position of ISS" below it. Below the globe, there is a smaller image of the Heavens-Above mobile app interface with the text "Live sky chart" at the bottom.

Starlink launch L12. Next attempt on October 3rd, 12:34 UTC.

Configuration
[Login \(optional\)](#)
[Change your observing location](#)

Satellites
[Live sky view](#)
[Starlink - dynamic 3D orbit display](#)
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Astronomy
[Solar Eclipses](#)
[Interactive sky chart](#)
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[Sun](#)
[Moon](#)
[Planets](#)
[Solar system chart](#)

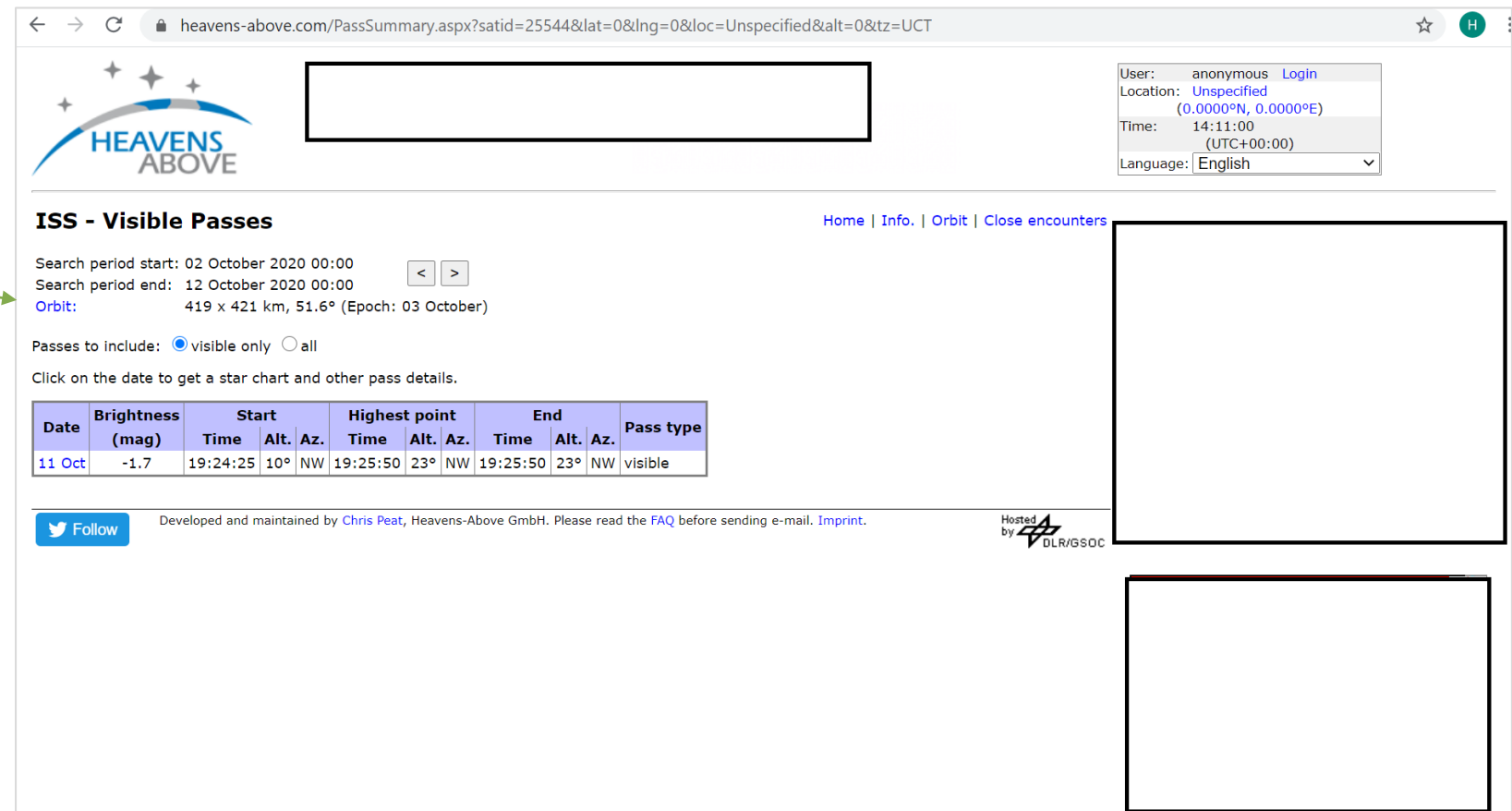
Current position of ISS

Live sky chart

“Heavens Above”

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

Click on “Orbit” to
view the orbital
elements for the
ISS



heavens-above.com/PassSummary.aspx?satid=25544&lat=0&lng=0&loc=Unspecified&alt=0&tz=UCT

HEAVENS ABOVE

User: anonymous [Login](#)
Location: Unspecified (0.0000°N, 0.0000°E)
Time: 14:11:00 (UTC+00:00)
Language: English

ISS - Visible Passes [Home](#) | [Info](#) | [Orbit](#) | [Close encounters](#)

Search period start: 02 October 2020 00:00
Search period end: 12 October 2020 00:00
[Orbit](#): 419 x 421 km, 51.6° (Epoch: 03 October)

Passes to include: ☒ visible only ☐ all

Click on the date to get a star chart and other pass details.

Date	Brightness (mag)	Start			Highest point			End			Pass type
		Time	Alt.	Az.	Time	Alt.	Az.	Time	Alt.	Az.	
11 Oct	-1.7	19:24:25	10°	NW	19:25:50	23°	NW	19:25:50	23°	NW	visible

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Developed and maintained by [Chris Peat](#), Heavens-Above GmbH. Please read the [FAQ](#) before sending e-mail. [Imprint](#).

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“Heavens Above”

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

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

The screenshot shows the Heavens Above website interface. At the top, there is a search bar and a user login section with fields for User (anonymous), Location (Unspecified), Time (14:16:30), and Language (English). Below the search bar, the title "ISS - Orbit" is displayed. To the right of the title are links for Home, Info, Passes, and Close encounters. The main content area features three orbital visualizations: "View from above orbital plane" (a top-down view of the Earth with the ISS orbit as a white circle), "View from above satellite" (a view from the ISS looking down at the Earth), and a large world map showing the ISS's ground track as a white line. A green arrow points from the text "Try to replicate these views using the MS Excel orbit visualisation tool" to the "View from above orbital plane" image. To the right of the visualizations, the text "Scroll down to see the orbital elements" is accompanied by a large blue downward-pointing arrow. Two empty rectangular boxes are positioned to the right of the arrow, likely for additional information or instructions.

“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

