SESA2024 Astronautics

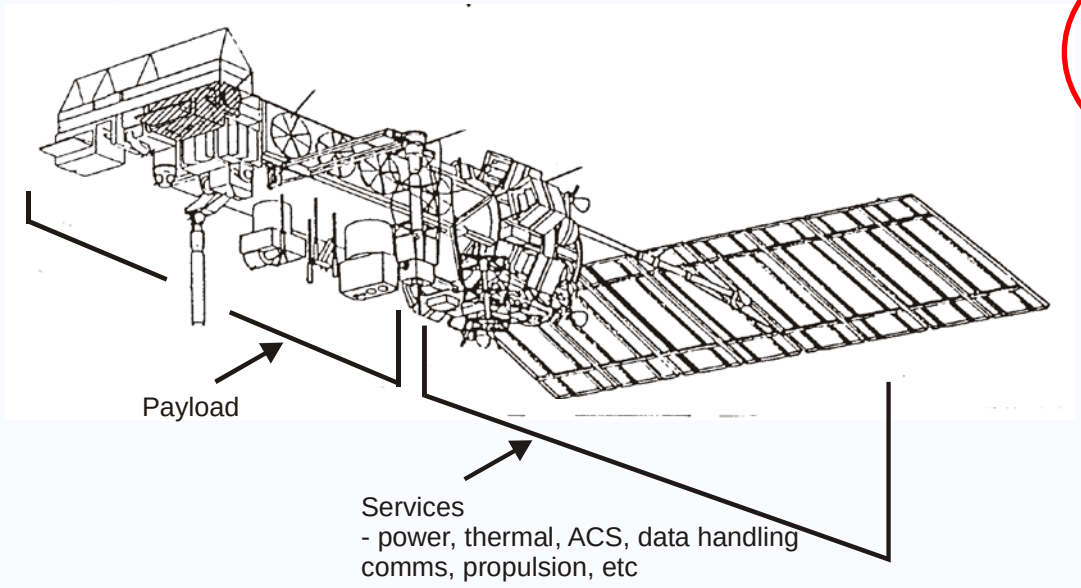
University of Southampton

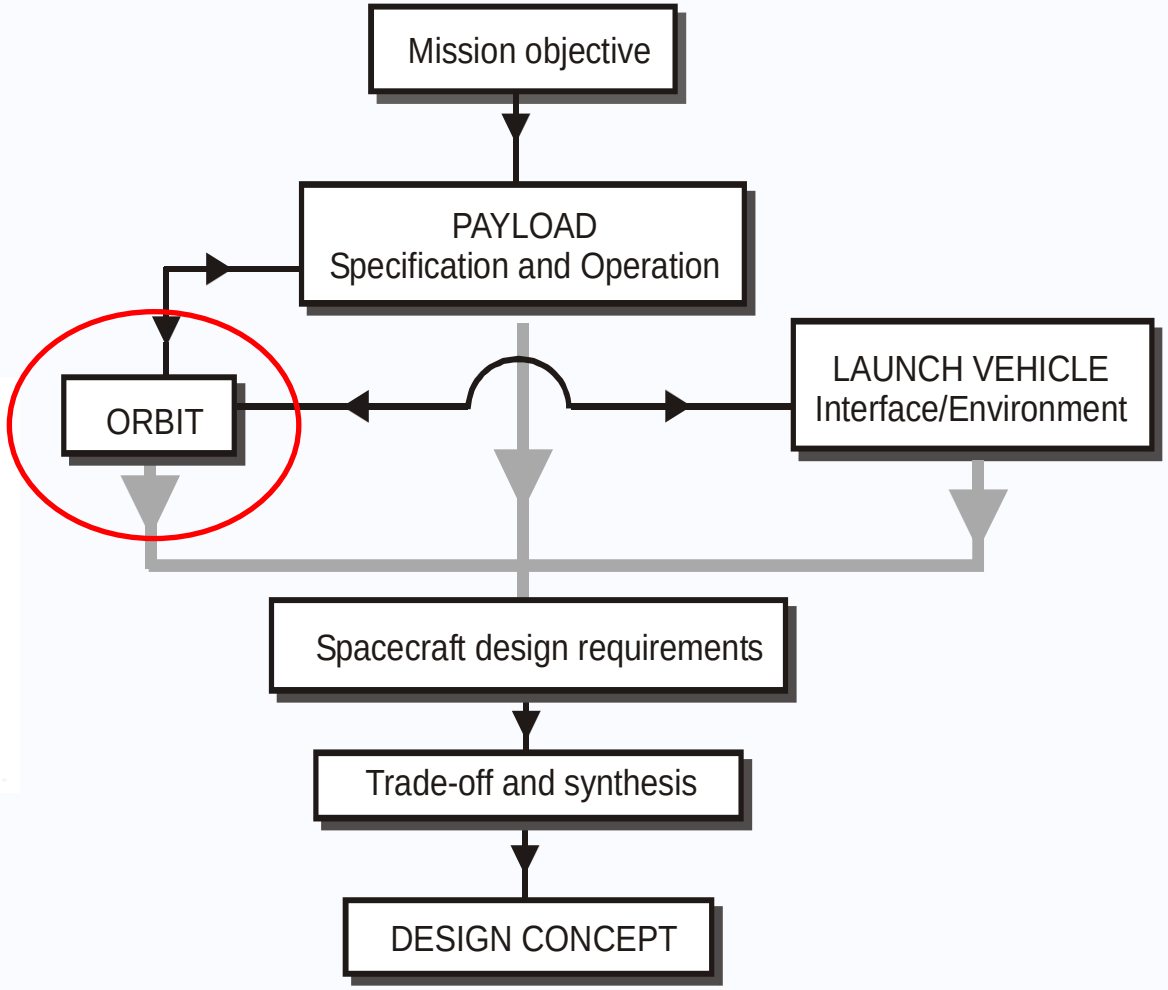
Chapter 5: Mission Analysis
Overview of Chapter 5

Professor Hugh Lewis

Introduction to chapter 5

- Mission analysis:
  - To select orbit elements for a mission orbit, based upon derived payload requirements





Contents of chapter 5

- The contents of this chapter are divided into 14 recorded lectures & activities:

2. Kepler's Laws
3. The ellipse equation
4. Orbital motion – part 1
5. Orbital motion – part 2
6. Confirming Kepler's Laws
7. Orbital elements
8. Orbit visualisation activity
9. Orbital energy
10. Orbital energy worked example
11. Orbital transfers
12. Hohmann transfer visualisation activity
13. Hohmann transfer worked example
14. Orbit selection
15. Impacts on spacecraft & recap

We start with the work by Kepler and Newton to understand motion on elliptical orbits, then look at how we describe & define an orbit using orbital elements. Next, we use energy considerations to define an "energy equation", which enables us to calculate a key quantity that is important for mission analysis – "delta V". Finally, we apply our energy equation to solve a fundamental transfer manoeuvre: the Hohmann transfer.

How much time will I need?

Recordings:

- "Traditional" lectures
  - Kepler's Laws (04:30)
  - The ellipse equation (11:00)
  - Orbital motion – part 1 (22:30)
  - Orbital motion – part 2 (32:30)
  - Confirming Kepler's Laws (15:30)
  - Orbital elements (17:00)
  - Orbital energy (20:30)
  - Orbital transfers (25:30)
  - Orbit selection (14:30)
  - Impacts on spacecraft & recap (11:30)

  TOTAL: ~2h 55m 00s

- Worked examples
  - Orbital energy worked example (08:30)
  - Hohmann transfer worked example (14:00)

  TOTAL: ~22m 30s

- Additional activities
  - Orbit visualisation activity (14:00)
  - Hohmann transfer visualisation activity (13:00)

  TOTAL: ~27m 00s

- For all recordings: ~4h

How much time will I need?

Activities & worked examples:

- Reading
  - Chapter 4 SSE textbook (01:00:00)
  - Chapter 5 SSE textbook (01:00:00)
  - Wikipedia (ellipse) (30:00)

  TOTAL: ~2h 30m

- Worked examples
  - Orbital energy worked example (15:00)
  - Hohmann transfer worked example (20:00)

  TOTAL: ~35m

- Additional activities
  - Kepler's 3rd Law Excel (45:00)
  - Orbit visualisation activity (45:00)
  - WolframAlpha (10:00)
  - Hohmann transfer visualisation activity (20:00)

  TOTAL: ~2h

- For all activities: ~5h

Block 3 pacing

- Targets to aim for in the next two weeks:
  - By 13:00 Thursday 27th October aim to have
    - Watched lectures 2 (Kepler's Laws), 3 (Ellipse Equation), 7 (Orbital Elements) and 9 (Orbital Energy)
    - Think about any questions you'd like to ask in the drop-in session on Monday 31st October
  - By 12:00 Tuesday 1st November aim to have:
    - Watched most of the lecture recordings
    - Undertaken some of the additional learning activities & worked examples from the workshops
    - Started the problem sheet questions

Problem sheet questions

- Links to lectures and some hints:
  - Q1: Look at Lecture 5 and Lecture 9
  - Q2: Look at Lecture 9
  - Q3: Look at Lecture 11
    - We didn't derive a single formula for the total delta-V but you can write one if you understand the method (it's the sum of two differences; use some algebra and simplification and you will be able to write a formula for the total delta-V)
  - Q4: Look at Lecture 9
  - Q5: Look at Lecture 7
  - Q6: Look at Lecture 11 and Lecture 13 (the worked example)
    - Think about the important quantities that we are trying to find in Mission Analysis, whether we want these quantities to be large or small, and then how they relate to a Hohmann Transfer.
  - Q7: Look at Lecture 11 and Lecture 13 (the worked example)
  - Q8: Look at Lecture 11 and Lecture 13 (the worked example)
    - Figure 1 is trying to show you something in 3D (the parking orbit shown is circular, not elliptical)

Activity

- The orbital motion (Celestial Mechanics) topic is covered in chapter 4 of Fortescue, Stark & Swinerd:
  - Read this chapter (up to an including the "Specifying the Orbit" section; there is no need to go further) in preparation for the next few lectures & to support your learning of this topic
  - Access to the e-book is available via the Library website: https://onlinelibrary.wiley.com/doi/book/10.1002/9781119971009