SESA3041 and SESA6079

Problem sheet 1: Mission Selection, Payload Selection and Remote Sensing

1. Choose a current spacecraft in the NASA New Frontiers Program and explain how it meets the key Program objective.
   [5 marks]

2. Explain the function of a Mission Assessment Group in the selection of a mission for ESA's Earth Explorer Programme.
   [4 marks]

3. What are the differences between ESA's Earth Explorer Programme and ESA's Earth Watch Programme? Comment on how these differences might affect the types of mission and design of the spacecraft that are funded.
   [6 marks]

4. Identify four microwave remote sensing techniques that can be used by instruments on an Earth-orbiting satellite and explain the possible impacts of each instrument on the power and attitude control sub-systems.
   [8 marks]

5. Describe the operation of the main SIRAL instrument on the Cryosat-2 spacecraft and explain how the choice of this instrument led to the selection of the spacecraft's attitude sensors.
   [9 marks]

6. A satellite in a dawn dusk Sun-synchronous 720 km circular orbit is to be used to measure the extent and characteristics of ice extent over the poles. Propose a suitable payload for this orbit and application and give reasons for your choice.
   [8 marks]

7. A satellite in a circular orbit at an altitude of 616 km uses a single waveband (panchromatic) instrument with a focal length f = 4 m to provide imagery of the Earth' surface. Images are built-up line-by-line using a push-broom scanning method, the instrument has a linear CCD sensor with N = 8000 pixels and an inter-detector spacing w = 13 μm. Each pixel is encoded using Q = 8 bits. Use the information above and formulae below:

   a. How many discrete Digital Numbers can be used to represent the reflectance of each pixel?
   b. What is the spatial resolution of the instrument in the cross track direction (defined by the Ground-projected Sample Interval)?
   c. What speed does the sub-satellite point travel over the Earth's surface?
   d. What is the approximate swath width of the instrument?
   e. If the spatial resolution of the instrument in the in-track direction is the same as the spatial resolution in the cross-track direction, at what rate does the CCD array need to be sampled?
   f. What is the uncompressed data rate of the instrument in bits per second?

   [16 marks]

Formulae are provided on the next page.

Ground-projected Sample Interval: $\mathrm{GSI} = w \times \frac{H}{f}$

Instantaneous Field of View: $\mathrm{IFOV} = 2\tan^{-1}\left(\frac{w}{2f}\right)$

Field of View: $\mathrm{FOV} \cong N \times \mathrm{IFOV}$

Swath width/Ground-projected Field of View (GFOV): $\mathrm{GFOV} = 2H\tan\left(\frac{\mathrm{FOV}}{2}\right)$

Data rate: $R_b = \frac{N \times Q}{t_s}$ where t_s is the pixel sample time and 1 Mbit = 10^6 bits.

Ground speed of satellite: $V_{gd} = V_{orb}\frac{R_E}{r_{orb}}$ where the radius of the Earth $R_E = 6378$ km, the orbit radius $r_{orb} = R_E + H$, and $V_{orb} = \sqrt{\frac{\mu}{r_{orb}}}$

For μ = 398600 km^3/s^2