SOLUTION NOTES

Additional Topics 2001 Paper 7 Question 15 (AH)

(a) Space: Satellite hardware, signal structure [1 mark each, max 2]

Control: Tracking stations, orbital computations, data uploads, health determination [2 marks each, max 4]

User: Receivers [2 marks]

(b) Pseudo-ranges are relative measurements of range, related to real ranges by an unknown common offset which is equivalent to the receiver clock error. Two pseudo-ranges place the position on a two dimensional hyperboloid of revolution. A third pseudo-range narrows the solution to a line. The fourth reduces the possibilities to one or two points in space.

An argument that since time has to be computed along with three coordinates, four independent measurements are necessary, should gather two marks.

(c) If the satellites used for a position fix are unfortunately arranged, then a change in receiver position in some sensitive directions will only cause slight changes in the expected pseudo ranges. Conversely, small errors in the measurement of the pseudo ranges will cause the solution to have large errors in those sensitive directions. This is usually expressed as DOP – Dilution of Precision due to geometrical factors. The mean pseudo-range measurement error multiplied by the DOP gives the expected position error. Different DOPs can be computed to characterise the horizontal and vertical errors independently, know as HDOP and VDOP.

In built-up areas, satellites near the horizon are likely to be obscured by buildings, so the situation might arise where the only satellites being tracked are at high elevations. In this case, a small change in the vertical position of a receiver will affect all ranges similarly, so the pseudo ranges will hardly change, and thus this situation will not be measured accurately. This will lead to a large VDOP (perhaps 5 to 10), and large vertical errors. HDOP will be smaller (perhaps 2).

(d) If ranges were measured directly, then a change in the vertical position of a receiver would lead to similar sized changes in the ranges, so the VDOP would be 1. A change in horizontal position would make relatively little difference to the ranges, so the HDOP would be much larger (perhaps 5 to 10), and the horizontal errors would be much larger than the vertical errors. If the range measurement errors were comparable to the GPS pseudo-range measurement errors, then we would see a better vertical performance, but a degraded horizontal performance.