Problem 2:

a)

b)

**Table 1: Payload mass fractions for a generic two-probe satellite.**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  |  |  |  |  |
|  |  | Level 2 |  | Level 1 |
|  | CBE | Cont. | Allocated |  |
| 1.0 Payload |  |  |  | 500.0 kg |
| 1.1 Probes | -- | -- | 450.0 kg |  |
| 1.1.1 Probe 1 |  |  | 250.0 kg |  |
| 1.1.2 Probe 2 |  |  | 200.0 kg |  |
| 1.2 Probe Mounting Hardware | -- | -- | 50.0 kg |  |
| 2.0 Spacecraft Bus (dry) |  |  |  | 1161.5 kg |
| 2.1 Propellant Tanks | 56.0 kg | 5.6 kg | 61.5 kg |  |
| 2.2 All other subsystems | 1000.0 kg | 100.0 kg | 1100.0 kg |  |
| 3.0 Spacecraft Dry Mass |  |  |  | 1661.5 kg |
| 4.0 Consumables |  |  |  | 0.0 kg |
| 5.0 Propellant |  |  |  | 559.5 kg |
| 5.1 Propellant for first burn | -- | -- | 227.6 kg |  |
| 5.2 Propellant for second burn | -- | -- | 129.6 kg |  |
| 5.3 Propellant for third burn | -- | -- | 202.3 kg |  |
| 6.0 Loaded Mass |  |  |  | 2221.1 kg |
| 7.0 Kick Stage |  |  |  | 0.0 kg |
| 8.0 Injected Mass |  |  |  | 2221.1 kg |
| 9.0 Launch Vehicle Adapter |  |  |  | 75.0 kg |
| 10.0 Boosted Mass |  |  |  | 2296.1 kg |
| 11.0 Margin |  |  |  | 703.9 kg |
| 12.0 Total Launch Vehicle Capacity |  |  |  | 3000.0 kg |
|  |  |  |  |  |

c)

This percentage is just about right because this analysis is a quick pre-phase A calculation which should be between 25%-35% margin for the mass.

d) Adding 50 kg to probe 1 indirectly increases the mass of the spacecraft by 56.6 kg. If the specifications changed to instead add 50 kg to probe 2, the indirect mass increase is more like 61.8kg. The main reason for the extra costs associated with adding mass, is the fuel it will take to move the extra mass. The difference between the two cases comes with when the probes are released, in the first case, the spacecraft needs to carry the extra weight for one less burn period than the second case.

Problem 3:

a)

**Table 2: Delta V budget for weather satellite.**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  |  |  |  |  |
|  | CBE | Cont. | Allocated | Level 1 |
| Allocated dV |  |  |  | 330.0 m/s |
| Orbital Maneuvering | 200.0 m/s | 20.0 m/s | 220.0 m/s |  |
| Station Keeping | 100.0 m/s | 10.0 m/s | 110.0 m/s |  |
| Margin(30%) |  |  |  | 99.0 m/s |
| Total dV |  |  |  | 429.0 m/s |
|  |  |  |  |  |

b)

**Table 3: Payload mass fractions for weather satellite.**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  |  |  |  |  |
|  | CBE | Cont. | Allocated | Level 1 |
| 1.0 Payload |  |  |  | 325.0 kg |
| 1.1 Payload | 250.0 kg | 75.0 kg | 325.0 kg |  |
| 2.0 Spacecraft Bus (dry) |  |  |  | 862.5 kg |
| 2.1 Propulsion | 68.2 kg | 6.8 kg | 75.0 kg |  |
| 2.2 ADCS | 90.9 kg | 9.1 kg | 100.0 kg |  |
| 2.3 Communications | 85.2 kg | 8.5 kg | 93.8 kg |  |
| 2.4 C&DH | 51.1 kg | 5.1 kg | 56.3 kg |  |
| 2.5 Power | 159.1 kg | 15.9 kg | 250.0 kg |  |
| 2.6 Structure | 352.3 kg | 35.2 kg | 200.0 kg |  |
| 2.7 Thermal Control System | 79.5 kg | 8.0 kg | 87.5 kg |  |
| 3.0 Spacecraft Dry Mass |  |  |  | 1187.5 kg |
| 4.0 Consumables |  |  |  | 0.0 kg |
| 5.0 Propellant |  |  |  | 171.0 kg |
| 6.0 Loaded Mass |  |  |  | 1358.5 kg |
| 7.0 Kick Stage |  |  |  | 1114.9 kg |
| 7.1 Kick Stage Structure | -- | -- | 101.4 kg |  |
| 7.2 Kick Stage Propellant | -- | -- | 1013.6 kg |  |
| 8.0 Injected Mass |  |  |  | 2473.5 kg |
| 9.0 Launch Vehicle Adapter |  |  |  | 65.0 kg |
| 10.0 Boosted Mass |  |  |  | 2538.5 kg |
| 11.0 Margin |  |  |  | 961.5 kg |
| 12.0 Total Launch Vehicle Capacity |  |  |  | 3500.0 kg |
|  |  |  |  |  |

c) The required CBE orbital maneuvering delta V for a mass margin of 30% is 334.5 m/s.

**Figure 1: Orbital Maneuvering Delta V vs. Boosted Mass for weather satellite.**

**Figure 2: Orbital Maneuvering delta V vs. Mass Margin for weather satellite.**