Multi-Stage Dual Payload Engines

Designing a multi-stage launch vehicle capable of delivering payloads to both **Low Earth Orbit (LEO)** and **Geostationary Transfer Orbit (GTO).** The rocket will consist of a **core stage, liquid rocket boosters (LRBs),** and an **upper stage**, with staging planned to occur first at **LEO** and again midway between **LEO and GTO.**

Engines for consideration in the core stage of the launch are: RS-25 (propellent - LH2), SpaceX Raptor (propellent – LCH4). Both these engines have a success rate of over 90% (although Raptor is still in testing). The RS-25 was used in the Space Shuttle and the SLS.

* SpaceX Raptor
  + ISP(vacuum) – 380s
  + ISP(Sea level) – 327s
  + Thrust – 2.5MN
  + Dry Mass – 1630kg
  + Burn time – 2127s
* RS-25
  + ISP(vacuum) – 452.3s
  + ISP(Sea level) – 366s
  + Thrust – 2279kN
  + Dry mass – 3177kg
  + Burn time – 510s

Secondary engines using LRBs for a potential secondary core stage are: RD-171 and the Merlin 1D both of which use the propellent RP1 (refined Kerosene)/LOX. Both engines have a success rate of between 9%-98% with 100s of flights. The RD-171 was used in the Zenit rocket and the Merlin 1D was used in the falcon 9.

* RD-171
  + ISP (vacuum) – 338s
  + ISP (Sea level) – 309s
  + Thrust – 7887kN
  + Mass – 9750kg
  + Burn time – 140s
* Merlin 1D
  + ISP (vacuum) – 348s
  + ISP (sea level) – 283s
  + Thrust – 900kN
  + Mass – 630kg
  + Burn time – 180s

Potential engines to be used in the upper stage of flight (LEO – GTO) are: RL10 (propellant – LH2/LOX), Raptor Vacuum (propellant – LCH4/LOX). The RL10 engine has a perfect success rate with no engine failures. The other 2 engines are still in the testing phase. The RL10 is used in the Centaur, Delta IV and SLS upper stage. The raptor vacuum is being used and tested in the Starship.

* RL10
  + ISP (vacuum) – 410s
  + ISP (sea level) – 10s
  + Thrust – 66.7kN
  + Dry Mass – 131kg
  + Burn time – 482s
* Raptor vacuum
  + ISP (vacuum) – 380s
  + Thrust – 2MN
  + Mass – 1500kg
  + Burn time – 2127.7s