UNIVERSAL TRANSPORT SYSTEMS

UTS Technical Arguments

Why we do what we do

Why SSTO?

- Our primary market cannot afford large infrastructure investments, drives towards SSTO
- Difficult to manage multiple stages with a small team
- Lower cost and difficulty, assuming mass fraction requirements can be met

“Any SSTO vehicle can be placed on top of a first stage, and increase the payload ratio” - True but irrelevant. The 747 does not use drop tanks

How SSTO?

LOX / LH

9000 m/s delta -v

non-fuel fraction:13%

Rough requirements:

- 1% Engine
- 10% Tank
- 1.5% Heat Shield
- 3% Landing Gear

Total non-propellant:

15.5% of GLOW

Payload: -19% of dry mass

Payload would be tiny fraction of dry mass after astronomical levels of optimization

LOX / RP-1

9000 m/s delta -v

non-fuel fraction:7%

Rough requirements:

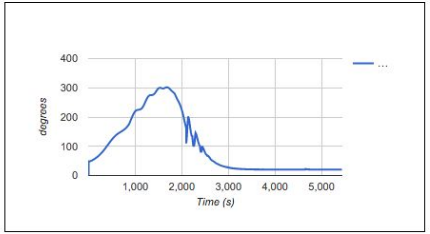
- 1% Engine
- 2% Tank
- 1.5% Heat Shield
- 3% Landing Gear

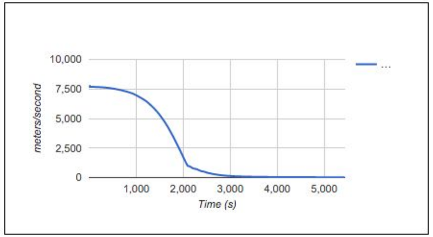
Total non-propellant:

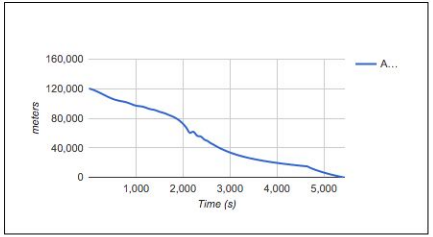
7.5% of GLOW

Payload: -7% of dry mass

Payload would be small fraction of dry mass after heroic levels of optimization







Fluffy Bunny

9000 m/s delta -v

non-fuel fraction:2%

Current status:

- 0.8% Engine (projected 80 kg)
    a. Goal: 0.4%
- 0.9% Vehicle (measured 86kg)
    a. Goal: 0.6%

Total non-propellant:

1.7% of GLOW

Payload: 15% of dry mass

Payload is already a reasonable fraction of dry mass before any optimization!

Why Solid?

- Solid rocket propellant is difficult to ignite outside of the engine
- It is not detonatable
- Bullet impact testing shows no ignition or adverse effect
- Propellant will not flow away from spills / storage areas
- Propellant not pressurized outside of engine, so no dispersion of propellants during emergency events
- Solid rocket engines are cheaper to develop / produce
  - (Space shuttle solid engines added to save program when they ran out of money)
- Solid rocket engines are more reliable
  - (Soyuz uses solid rockets to slow descent during landing - liquids could not be reliable enough)
- Our engine is throttleable, stoppable, and in flight restartable

Why Pressure Stabilization?

- SSTO leads to high mass fractions being critically important
- Atlas “balloon” tanks were some of the lightest tanks/structures ever made
- All rockets use pressure stabilization to some extent
- By taking this further and making the structure collapsable without damage, we avoid the handling requirements of the Atlas rockets and achieve an even higher mass fraction by using more modern materials
- Lowers operational difficulties and costs
- Far easier to manufacture

Reentry Heating

- Many others have done inflatable reentry vehicles
  - (NASA IRVE, NASA HIAD, Russian IRDT)
- Most common formula is

$$\dot{q} \cong 1.83 \times 10^{-4}\ V^3 \sqrt{\frac{\rho}{r_{nose}}}$$

  - This is an approximation that cannot be applied to "fluffy" objects; ie when the ballistic coefficient is low
  - Vehicle mass is not present in the formula, while the vehicle mass presents a physical maximum on the energy available
  - Deceleration at higher altitude is better, as this formula shows - Fluffy Bunny slows/flies much higher than more typical reentry vehicles
  - We are currently using simulations, and assuming a certain percentage of the energy is rejected to space as our best estimate of heating (kinetic energy change divided by radiator area) - this needs more research, but looks manageable in simulations
- Lifting reentry decreases peak heating while increasing heating duration
- Paper survives reentry!
  - "relatively fire resistant" paper survived the Columbia shuttle breakup and reentry in good condition
  - In 2009, JAXA scientists tested paper airplanes at hypersonic conditions (oriplane)

Slow Flight

- Slowing atmospheric flight during flight increases gravity losses
- Lifting body design counters this loss, by effectively increasing vehicle Isp by the lift to drag ratio
- This is not enough to eliminate the loss, but enough to make the tradeoff possible
- Slow atmospheric flight allows for a lighter vehicle, and simpler design
    - The Fluffy Bunny stays subsonic while in the appreciable atmosphere
    - Very low max Q values