Rocket Propulsion

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Objectives

- Brief History
- Rocket Propulsion
- Advancements in Propulsion
  - Aerospike Engine
  - Nuclear Thermal Rocket
  - Ion Propulsion

What Is A Rocket?

- Reaction Engine vs. Rotational Engine
- Purpose and Use of a Rocket

The History of the Rocket

- Originally a German project in the late 30's - early 40's
- German V-2 Project
- Used ethyl alcohol and liquid oxygen as fuel
- Produced as much as 70,000 lbs. of thrust

The History of the Rocket

- German V-2 Acquired by US during WWII
- Multiple projects erupted in the 1950's to advance science
- Hermes- 3 stage booster rocket

The History of the Rocket

- Jupiter S-3D – Coalescing of many separate ballistic missile projects
- Reached height of 350 miles, range 1500 miles
- Primates flown aboard in cone shaped capsule-survived

History of the Rocket

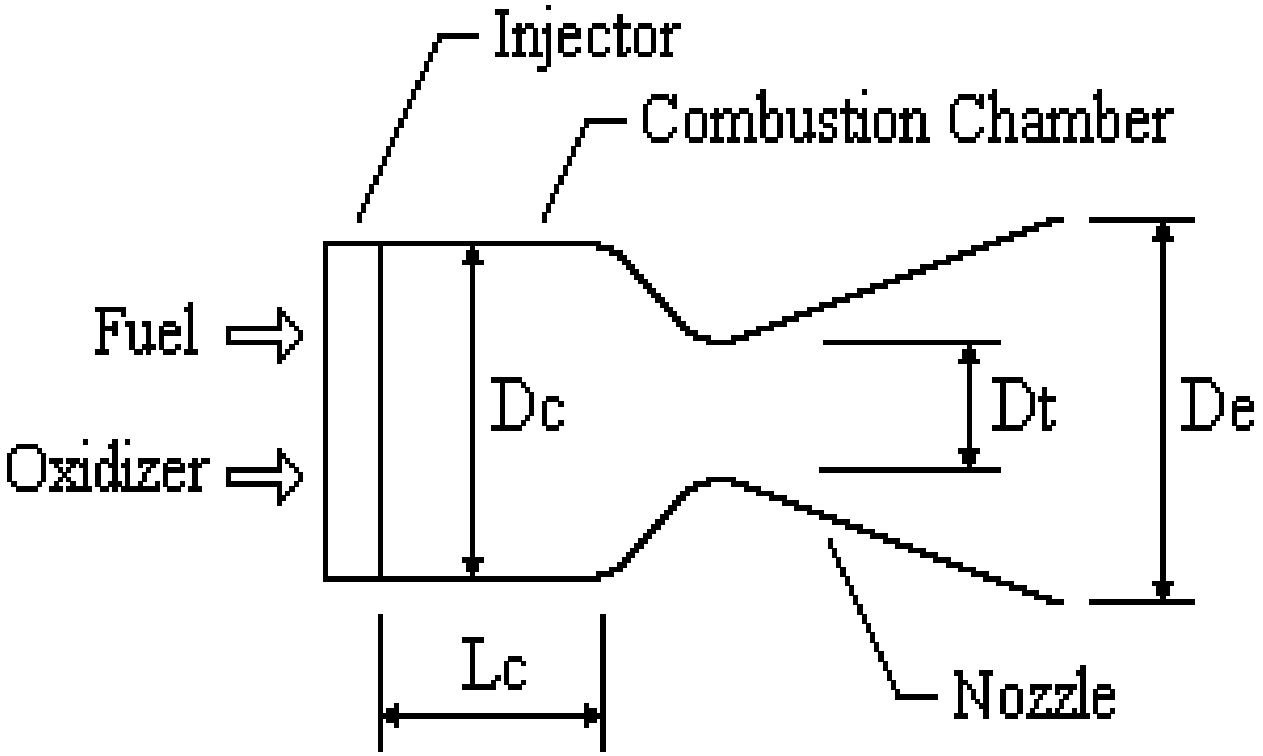
- H-1 Engine for the Saturn rocket based on Jupiter S-3D
- Clustered engines, multistage rocket – led the way to the Lunar missions
- LOX and RP-1 fuel

History of the rocket

- RL-10 Upper stage added used LOX and LH2 as fuel –major fuel advancements
- Research coincided with the SR-71
- F-1 final step to the moon, the last great engine before the shuttle main stage

Basic Rocket Configuration

- Fuel Tanks -> Combustion Chamber -> Nozzle

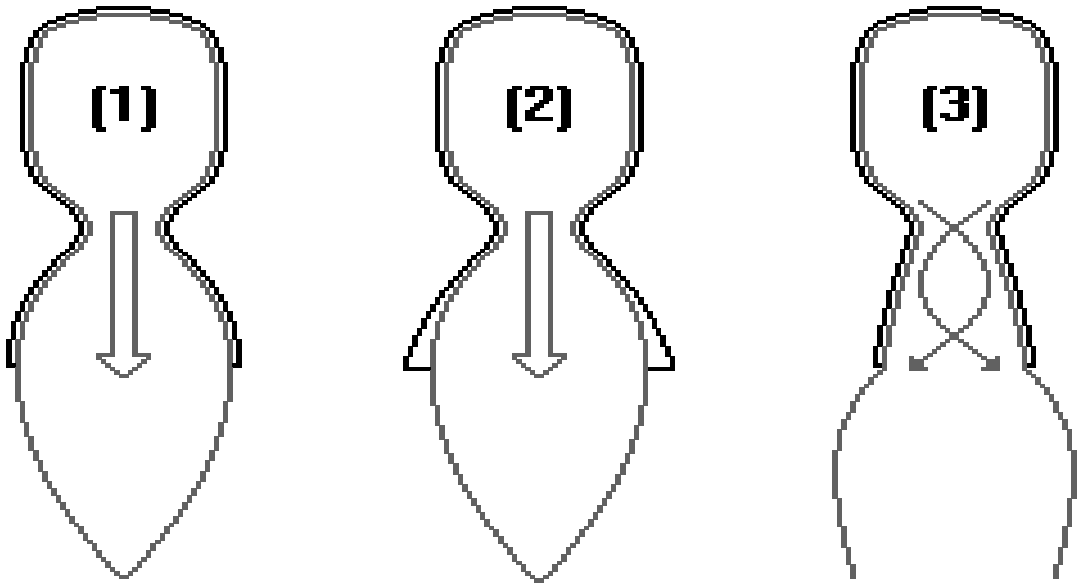


Combustion Chamber

- Turbopumps from tanks to chamber
- Over three million pounds of fuel in a couple of minutes
- Need high temperature burning fuel

Nozzle

- Optimally designed for certain altitudes
- “Acceptable performance losses”
- Smaller Nozzles in atmosphere

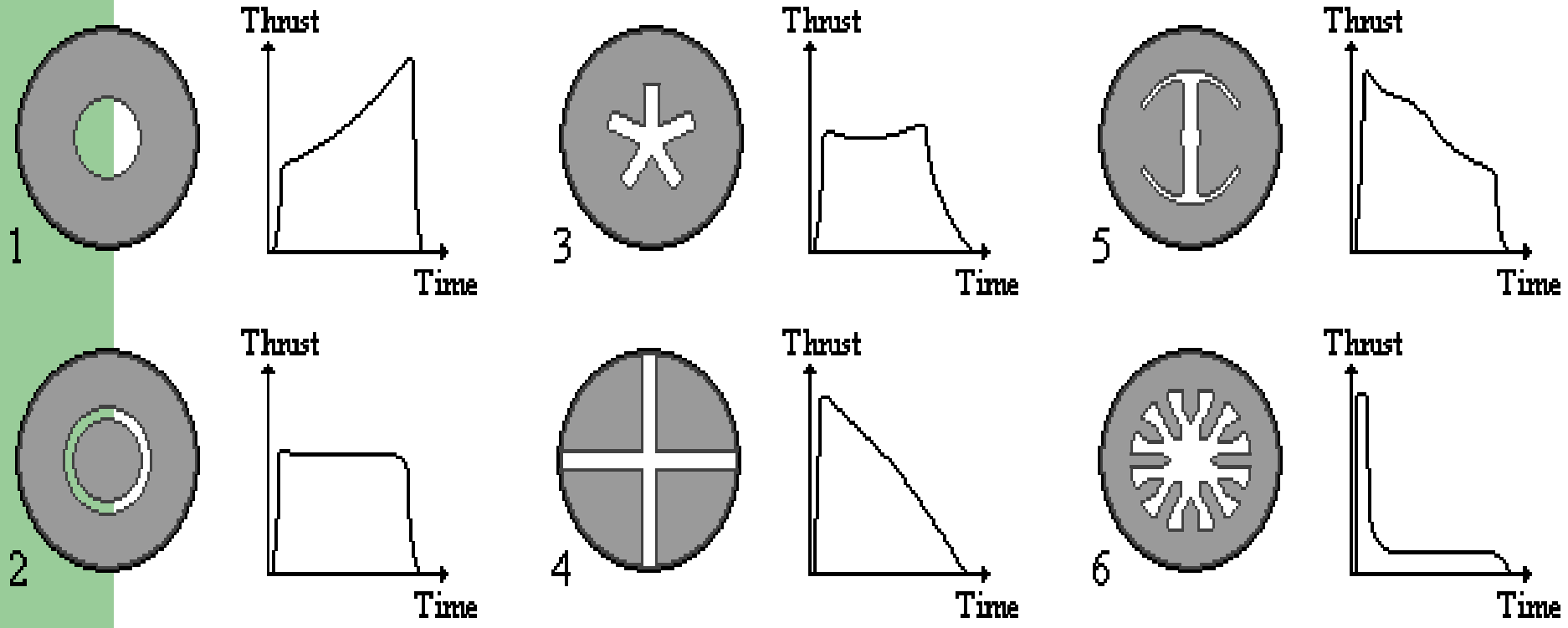


Propellants

- Two Major Types
  - Solid Fuel
  - Liquid Bipropellant

Solid Rocket Fuel

- Shape Determines Thrust Pattern



Liquid Bipropellant

- Three Categories: Petroleum, Cryogenics, Hypergolics
- High Specific Impulse low Molecular Weight
- Advantage: Throttled, stopped, restarted

The Rocket Equation

- Solution to Momentum Equation

$$L_1 + F_{ext}\Delta t = L_2$$

$$M_r V_r + F_{ext}\Delta t = (M_r - dm)(V_r + \Delta V) + dm(V_r - U_{ex})$$

The Rocket Equation

$$V_f - V_i = U_{ex} \ln(m_i/m_f) - gt_b$$

Exhaust Velocity

- Obtained by Energy Equation
- $H_c = (V_e^2/2) + H_e$

Exhaust Velocity

$$Ve = \sqrt{\frac{2 \cdot \gamma \cdot R}{\gamma - 1} \cdot Tc \cdot \left[1 - \left(\frac{Pe}{Pc} \right)^{\frac{\gamma - 1}{\gamma}} \right]}$$

Specific Impulse

- Propulsive Efficiency
- How long one pound of fuel can produce one pound of thrust
- $I_{sp} = V_e/g$ for conventional rockets

Specific Impulse

- For conventional chemical rockets Isp's between 200 and 450 can be obtained
- Propellants rated by Isp
- Hydrogen/Oxygen has highest Isp

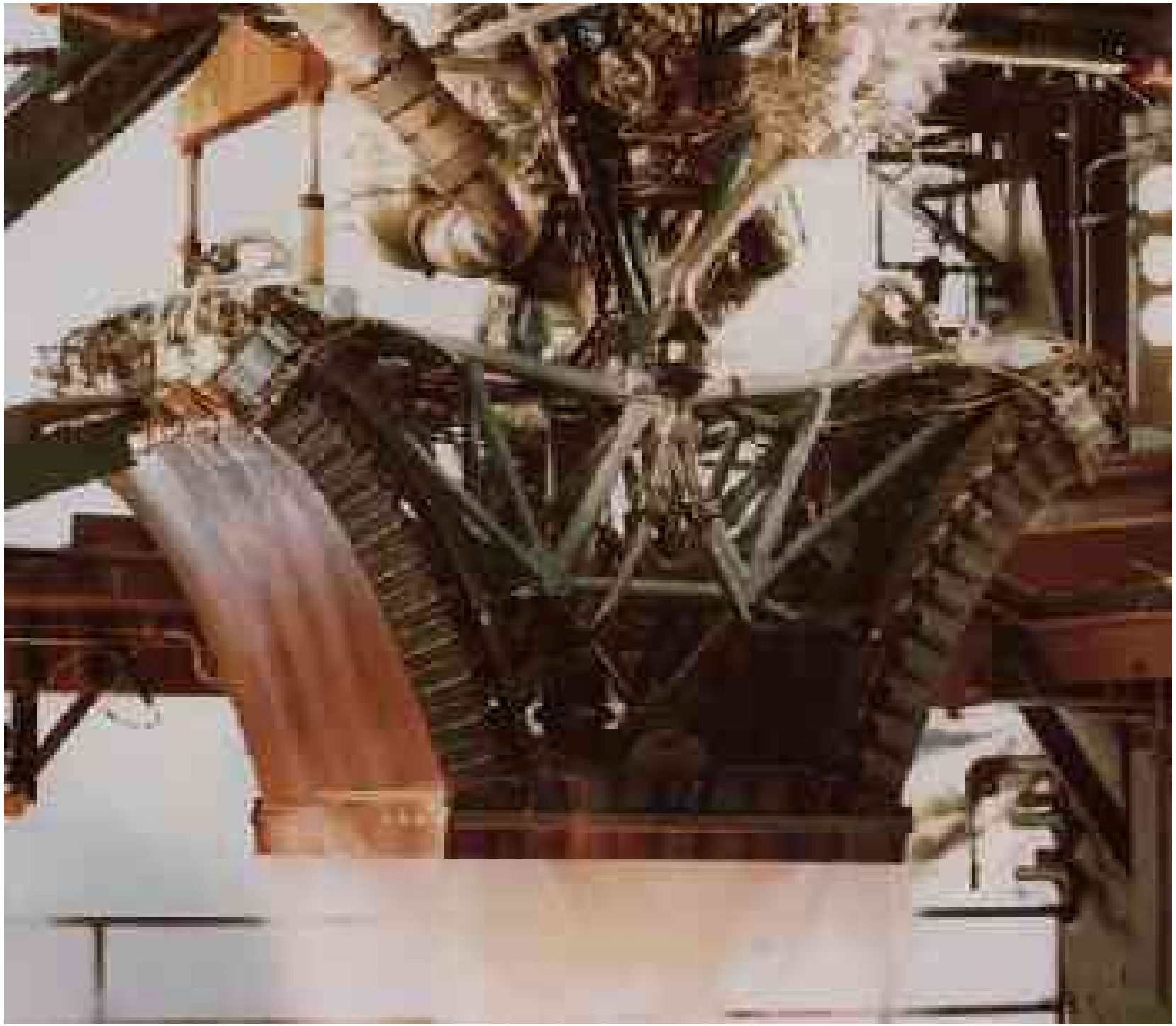
The Rocket Problem

- The fuel mass problem!!!
  - Every pound of fuel you add needs an additional amount of fuel to launch it into space.

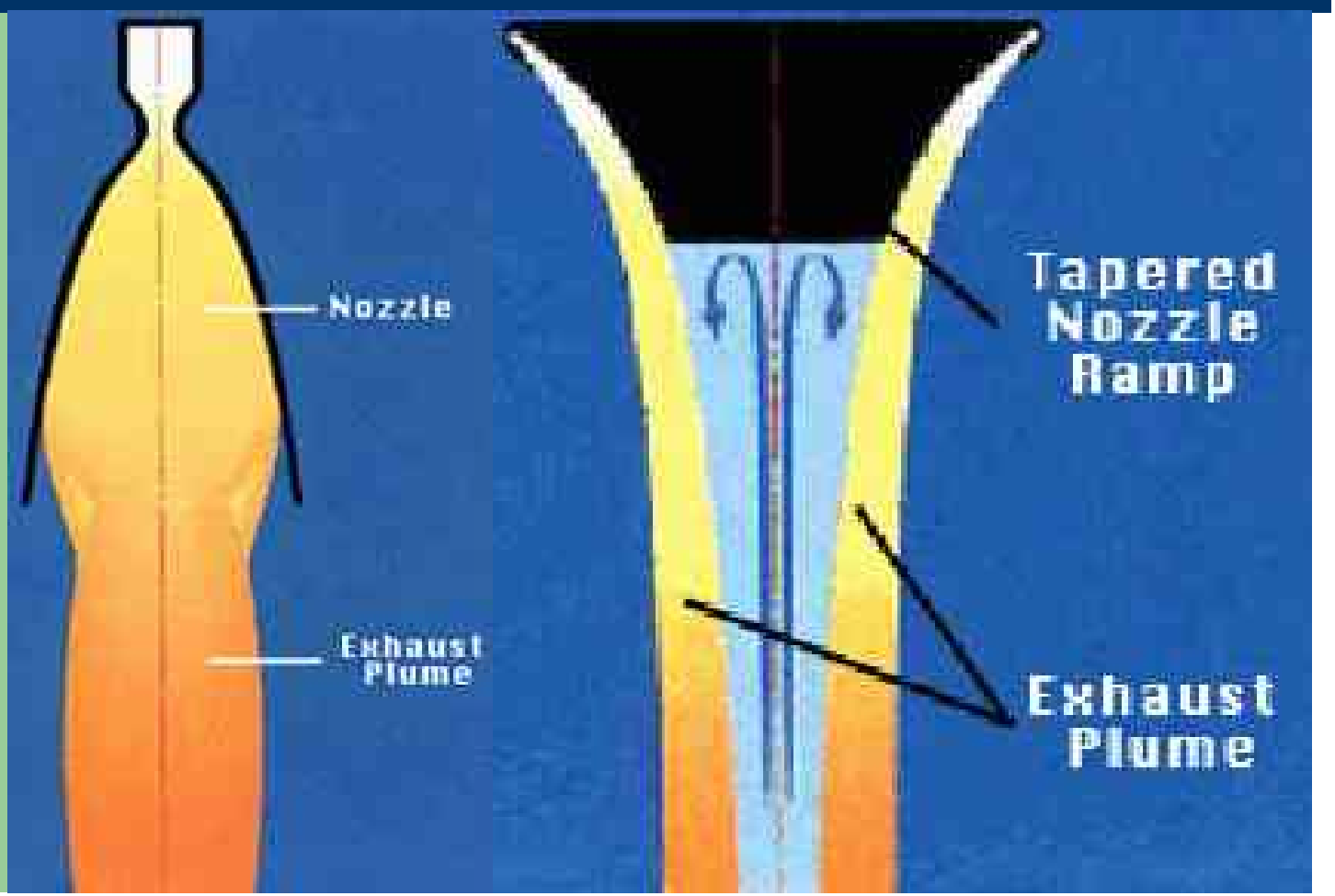
Advancements In Propulsion

Linear Aerospike Engine

- New Propulsion Method
- Nozzle Efficient at all altitudes
- Uses Atmosphere as Nozzle Wall
- Thrust Vectoring Easily Achieved

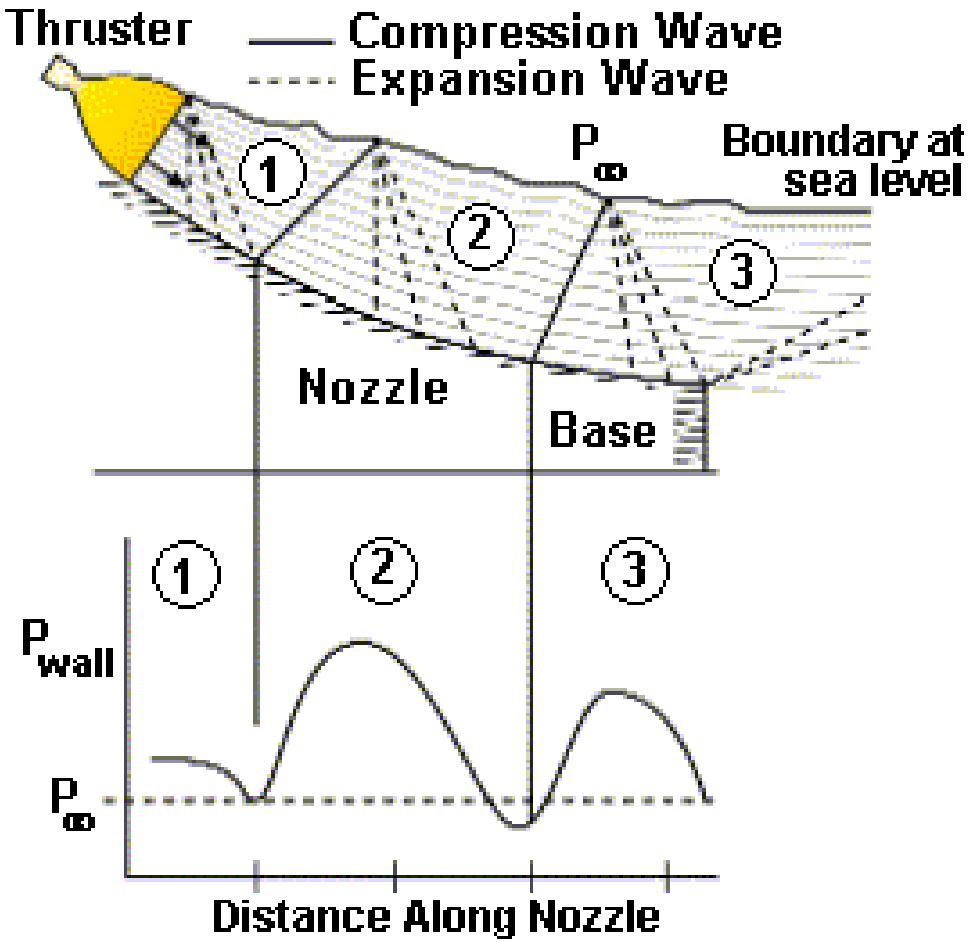


Linear Aerospike Engine



Linear Aerospike Engine

Linear Aerospike Engine



Nuclear Rockets

- Nuclear Thermal Rockets

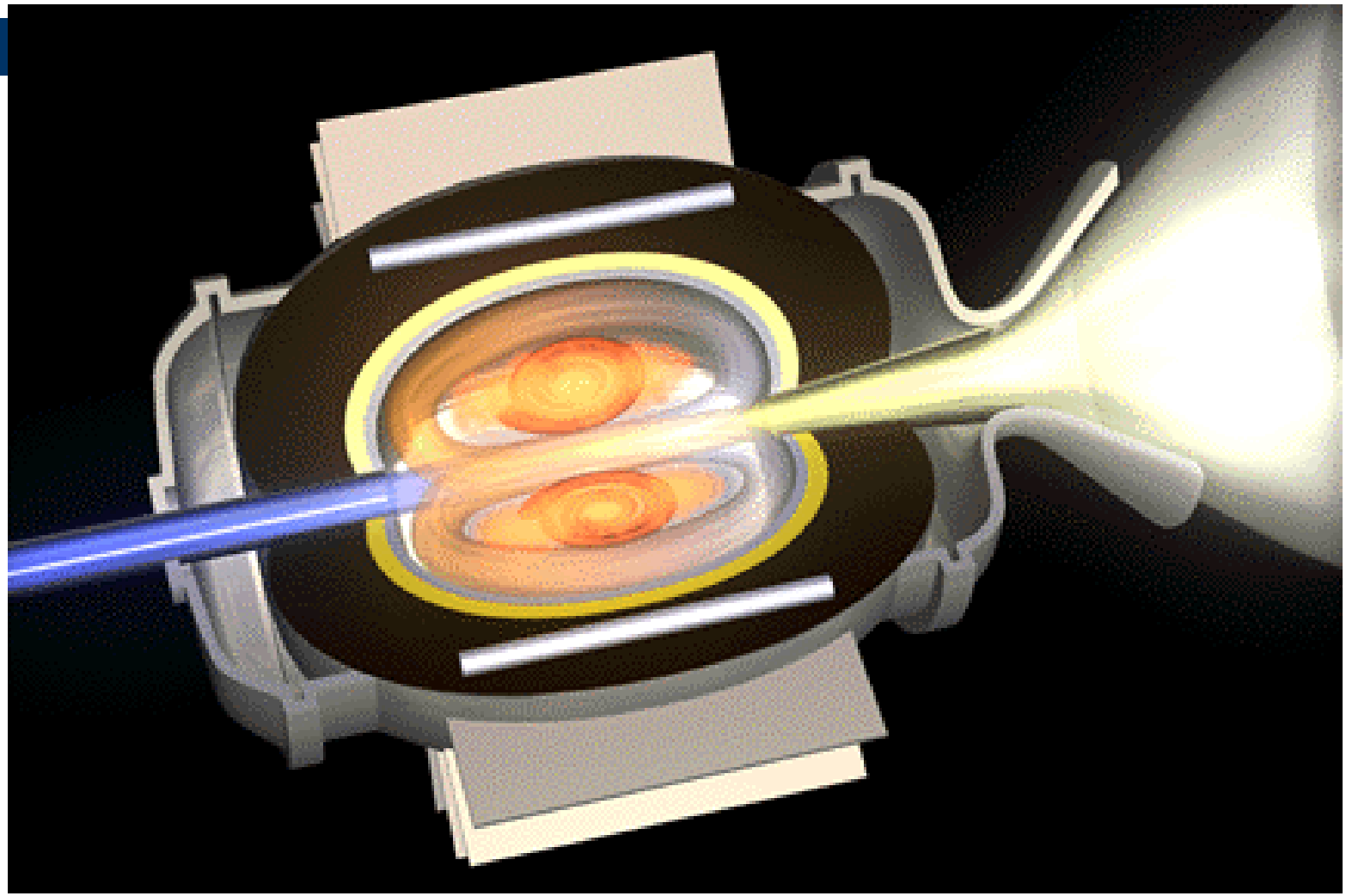
Types of Nuclear Reactions

- Fissionable Material – Uranium
- Fusion Reactions – Deuterium, He_3
- Antimatter (NASA says within 40 years!)

Nuclear Thermal Rockets

- Three possible types: solid, liquid, gas
- Current research into toroidal centrifugal liquid fission core
- Gas goes through center of core and heats up

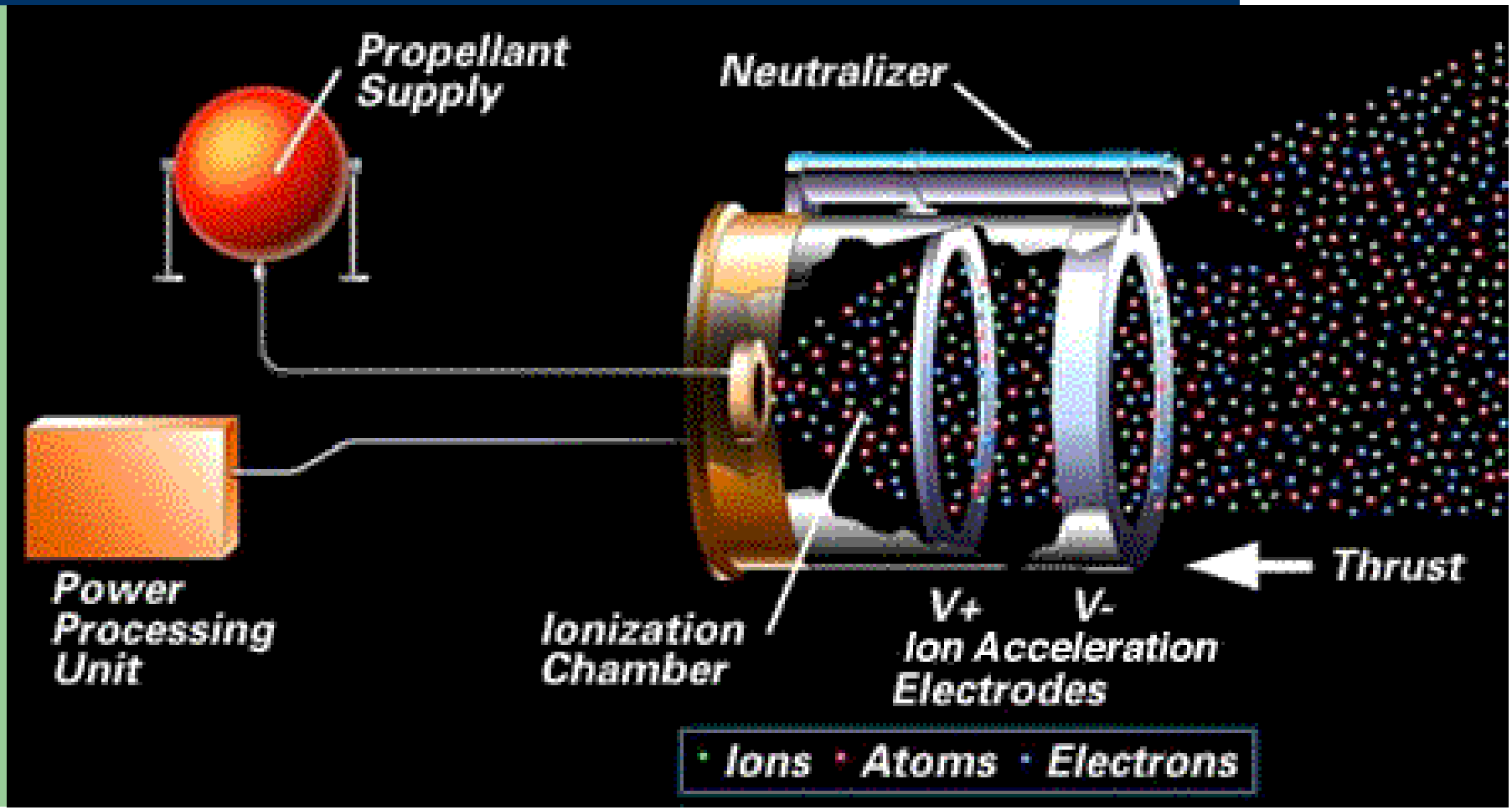
Nuclear Thermal Rocket



Nuclear Thermal Rockets

- Fusion a possible solution- current status is at break even point
- Helium-3 best fuel supply, not enough on Earth
- Antimatter- Anti Hydrogen has been made

Ion Propulsion



Thank You! Questions!