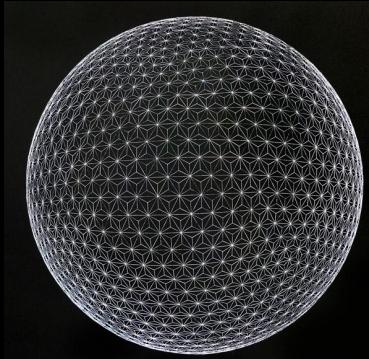


Space Exploration

Engines

- Mubashshir Uddin
- Sunny K. Bhagat
- Varun Singh



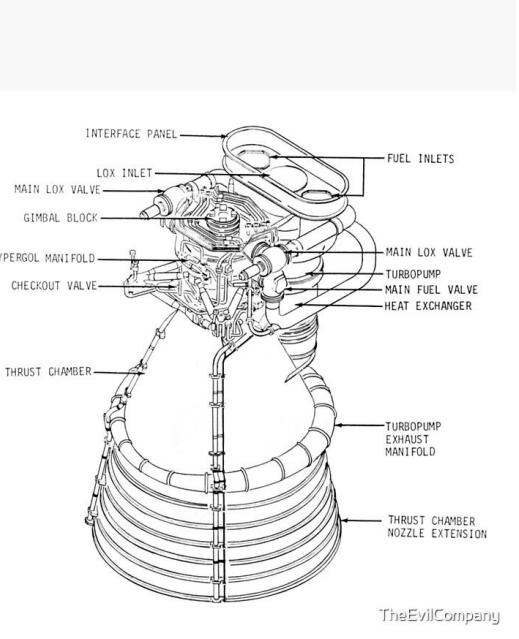
Content:

- Engine Hardware:
 - Nozzle
 - Turbopumps
 - Combustion Chamber
 - Plumbing
- Engine Considerations:
 - Gas expansion
 - Combustion Instabilities
 - Cooling

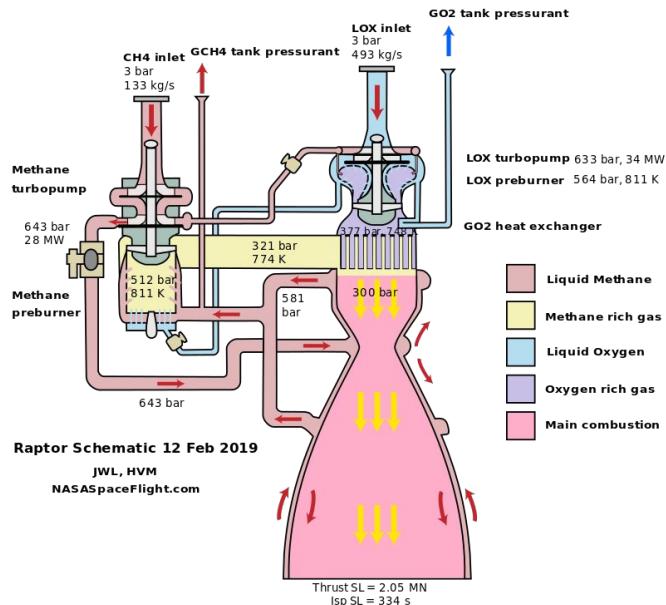


Introduction

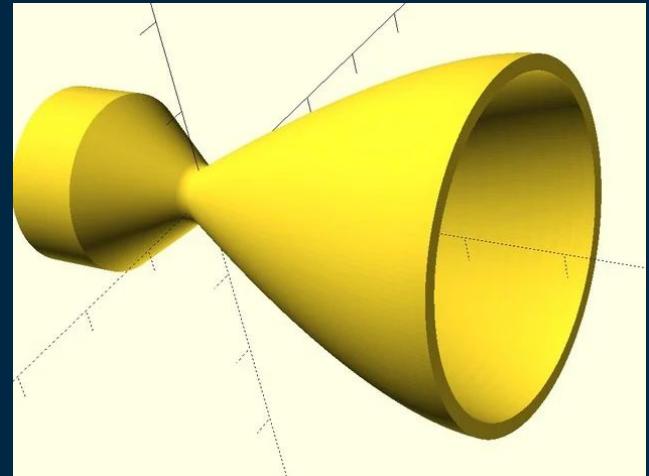
- Complicated beasts
- Gravity methods are not reliable enough for pressurizing the fuel
- Needs:
 - Plumbing
 - Cooling
 - Strength
 - Gimbaling
 - Sensing



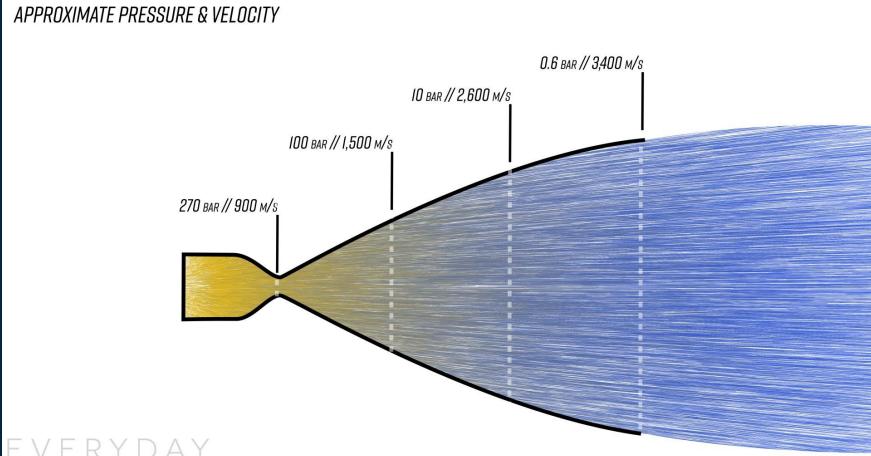
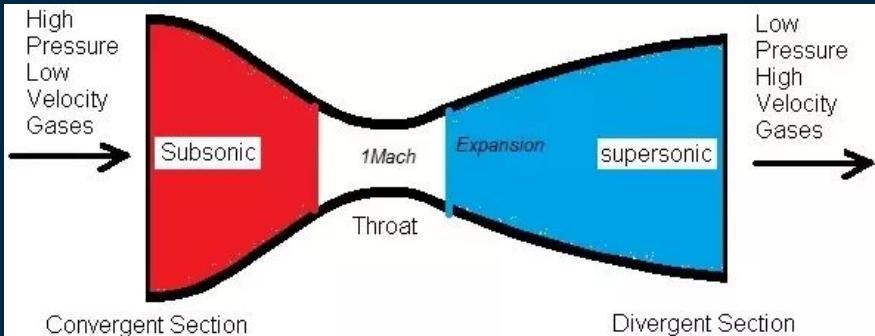
TheEvilCompany



Nozzle

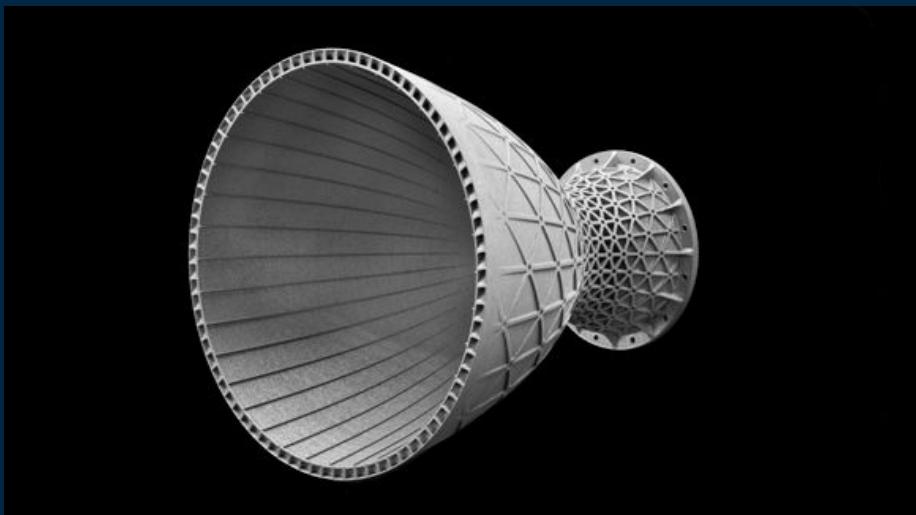


C-D Nozzle or de Laval nozzle



EVERYDAY
ASTRONAUT

Credits: Everyday Astronaut



Gas Expansion

ALTITUDE BEHAVIOR: BELL

- Low Altitude
- OVER-Expanded
 - $P_e < P_a$
 - Do not expand beyond $P_e=0.4 \text{ Pa}$
- Intermediate Altitude
 - $P_e = P_a$
- Ideally-Expanded
 - $P_e = P_a$
- High Altitude
 - $P_e > P_a$

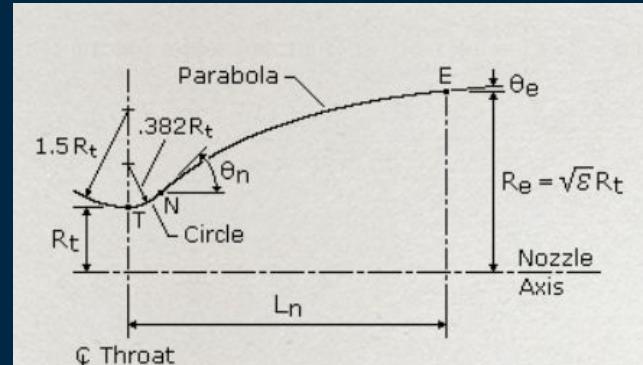
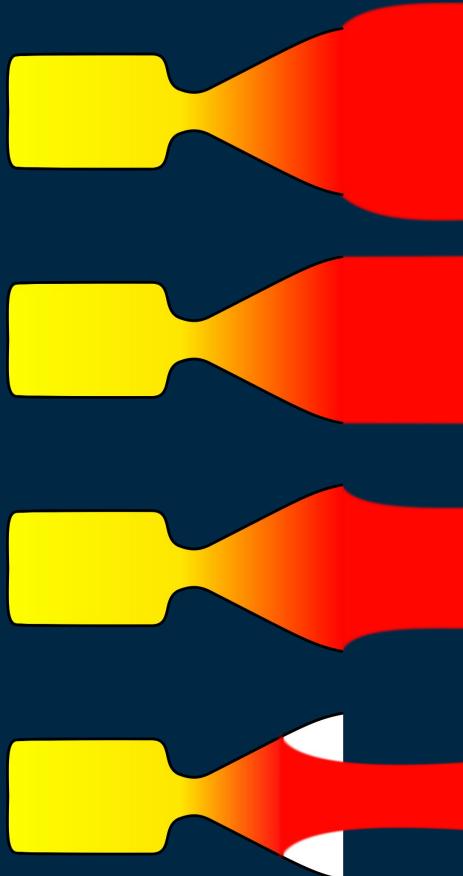
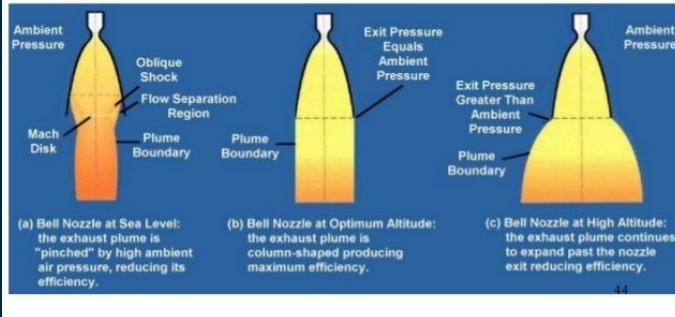
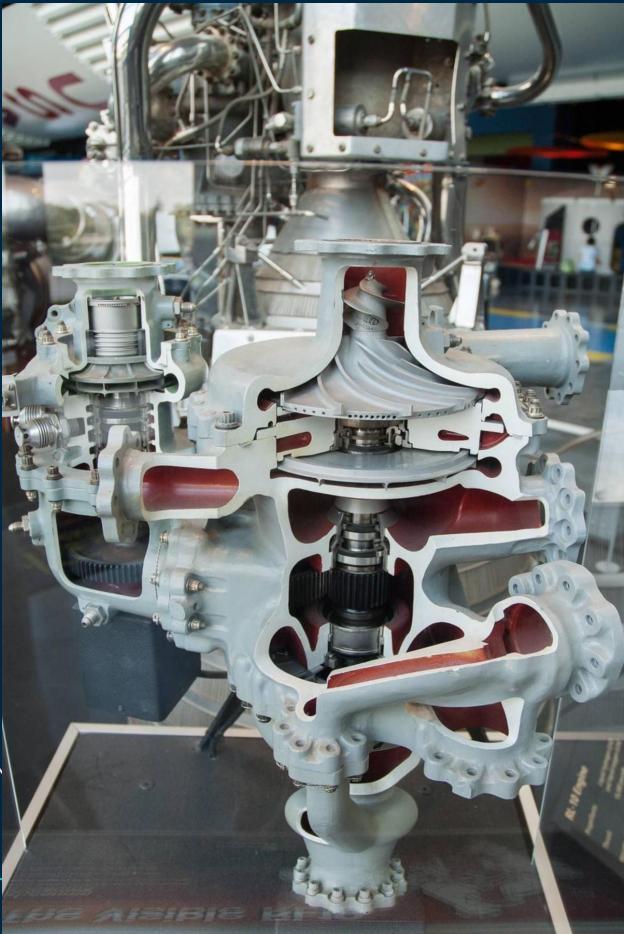
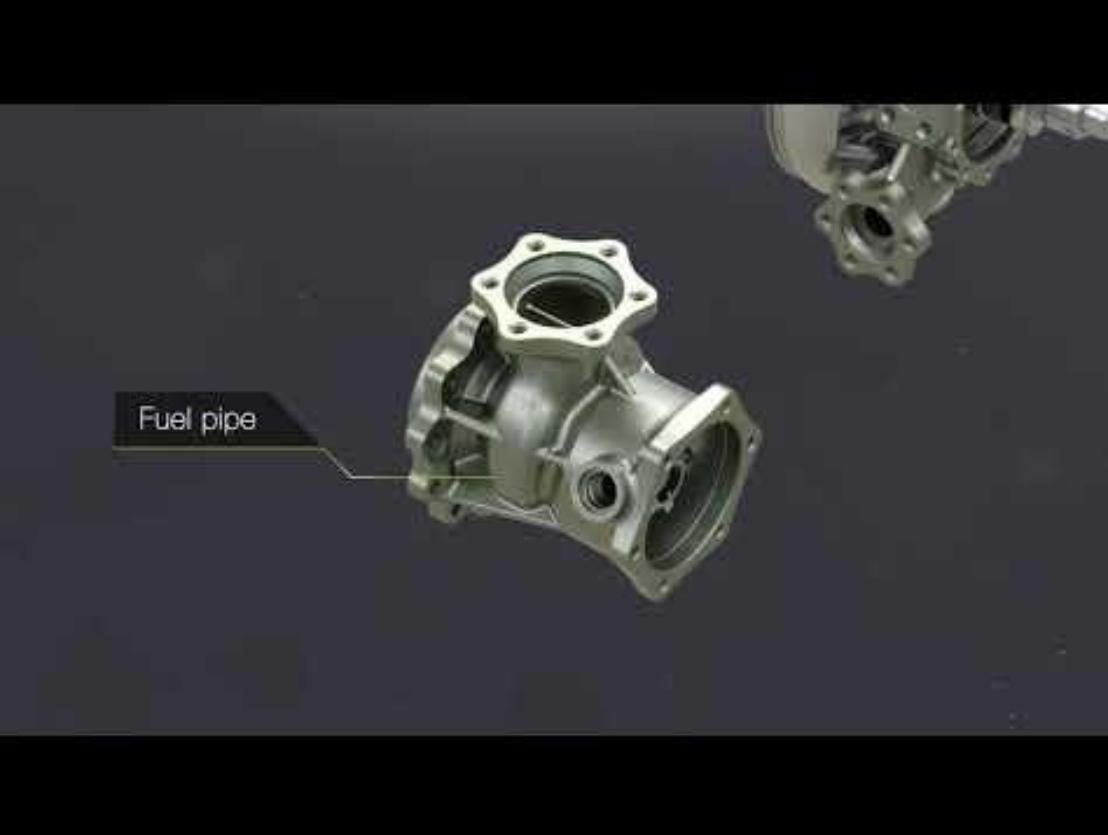


Figure 1.5

Turbopumps





Fuel pipe

Combustion Chamber



Parts:

- Pintle Injector
- Casing

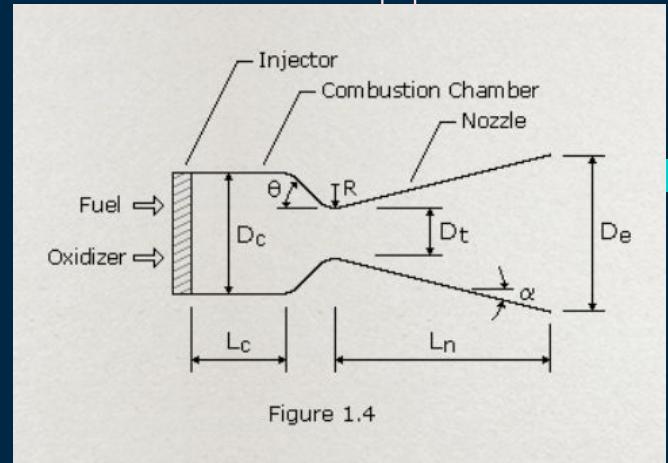
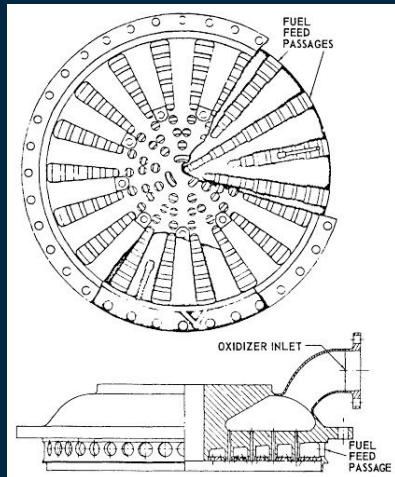


Figure 1.4

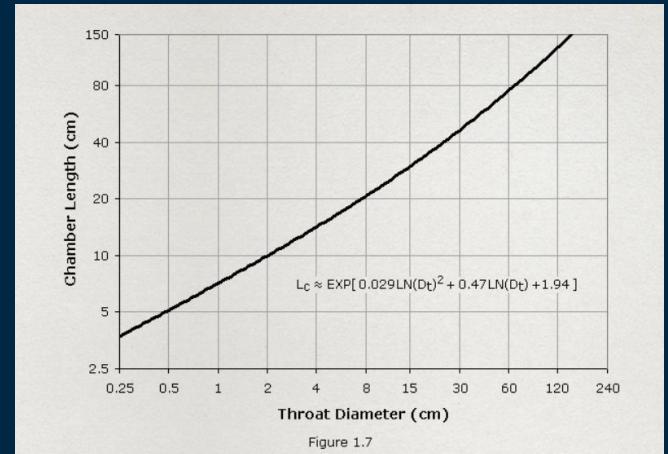
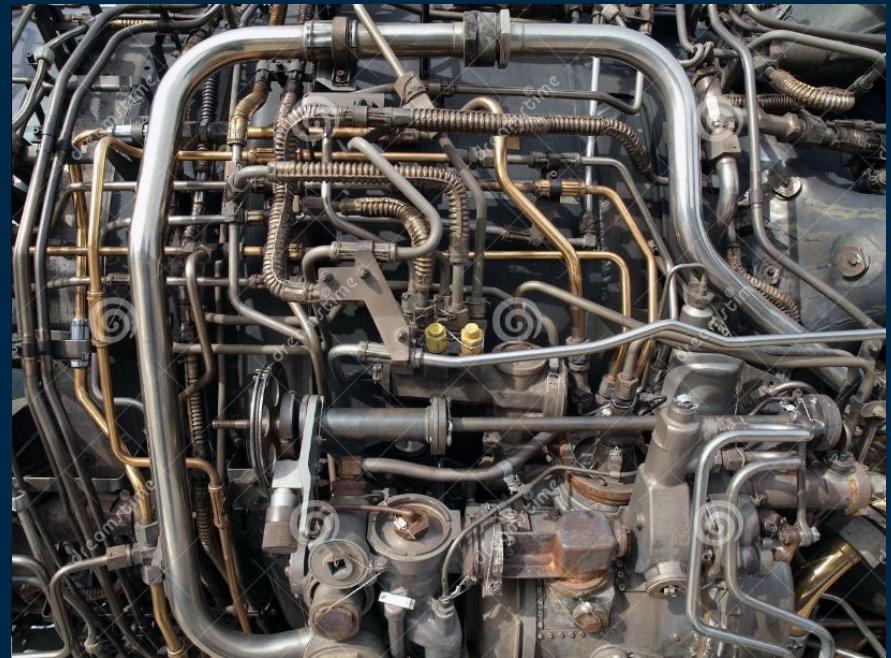


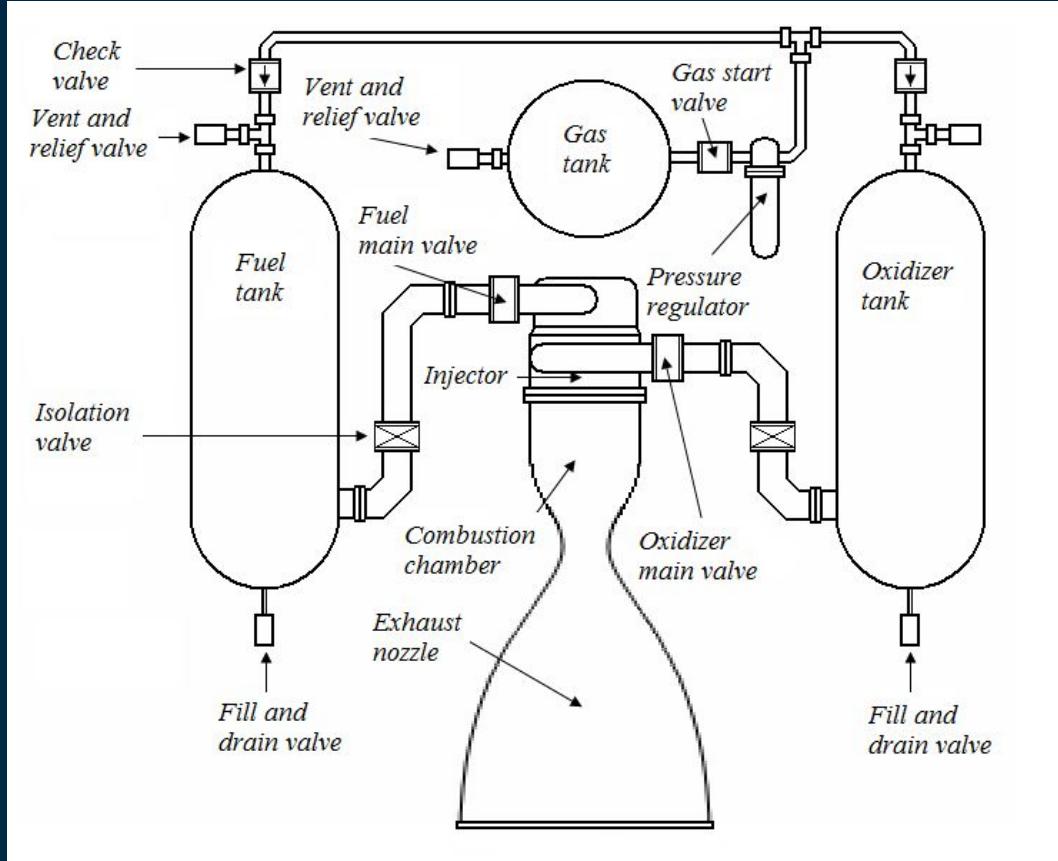
Figure 1.7

Plumbing

POWER CYCLES



Design(Pressure fed Design)

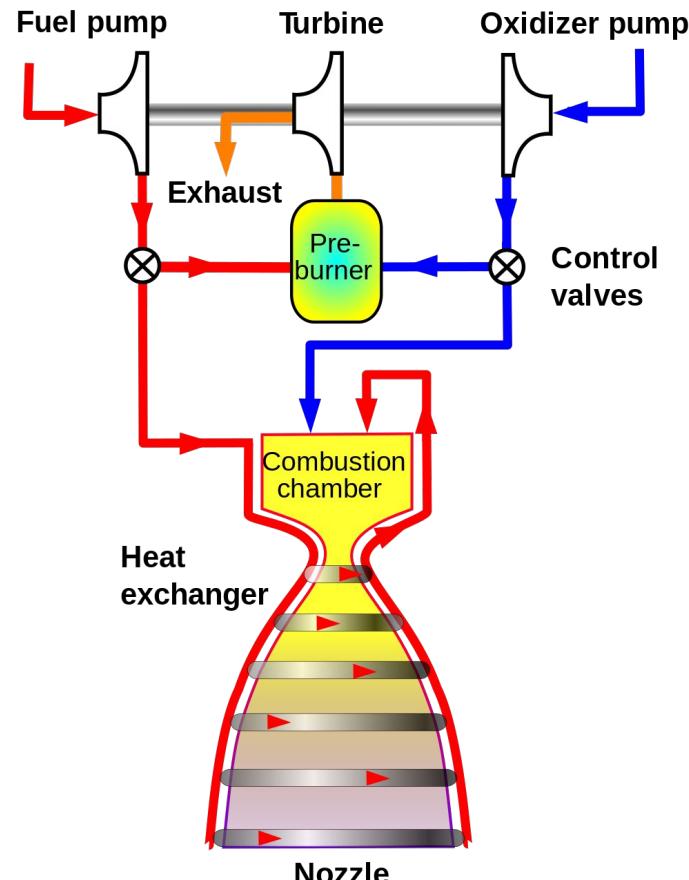


Gas-Generator Cycle

Examples:

- F1
- J2
- Vulcan

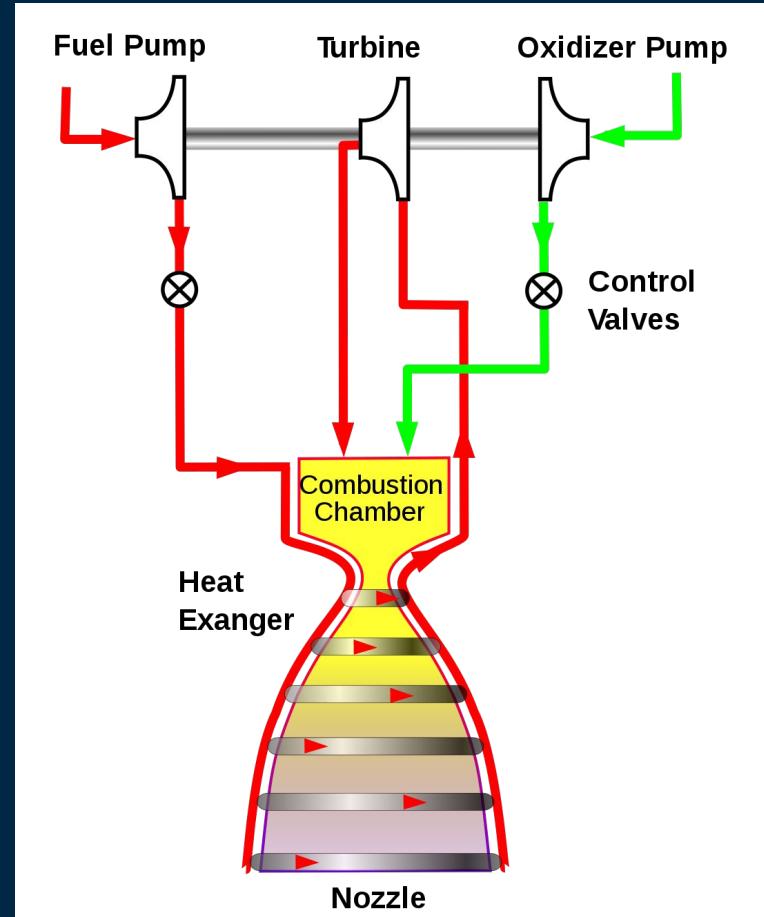
- Open Cycle engine
- Loss of efficiency due to discarded propellant
- Simple to build and operate



Expander Cycle:

Examples:

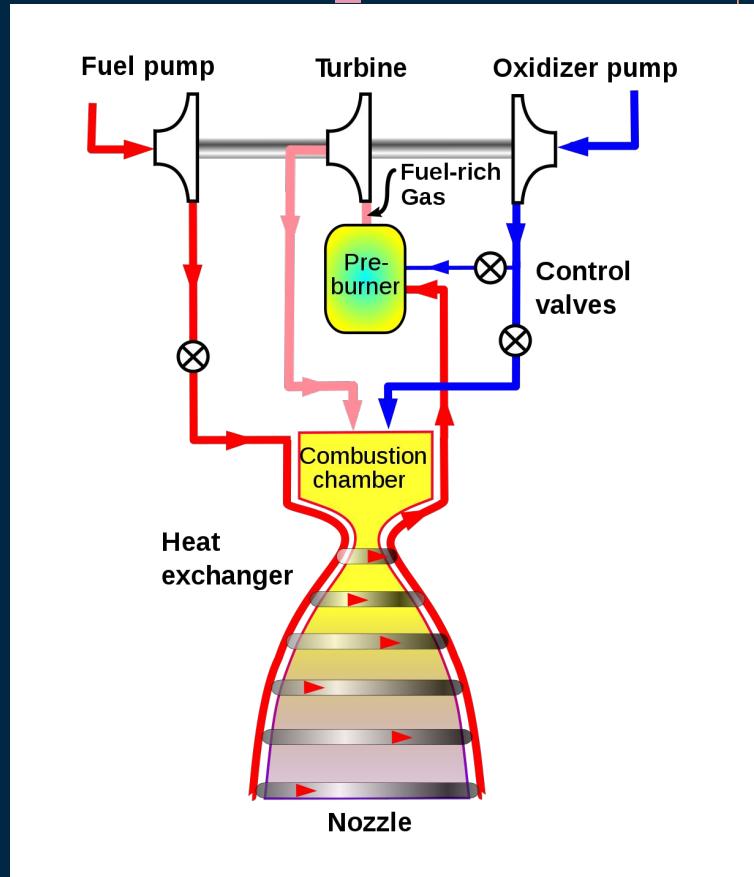
- Rocketdyne RL10
 - Vinci(Airane6)
-
- No wastage of fuel energy
 - Some modifications also available



Staged Combustion:

Examples:

- RS-25(Space shuttle)
 - RD253(Proton)
-
- Used to reduce the emission of Oxides of Nitrogen

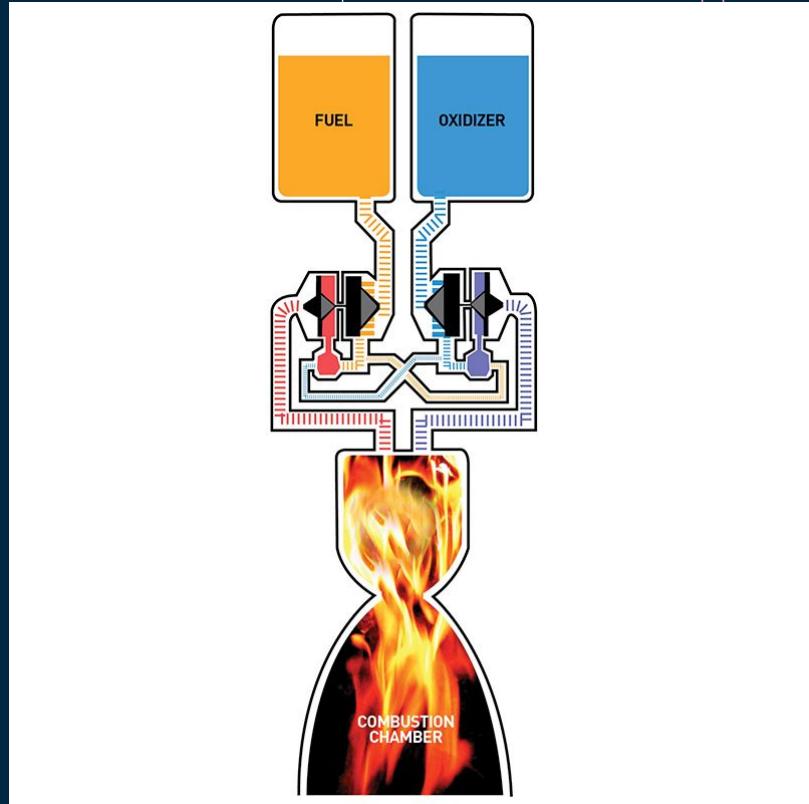
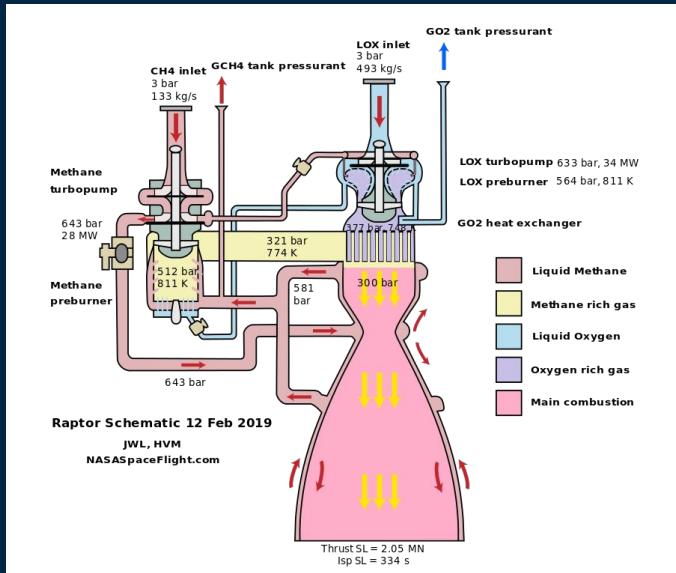


Full flow Staged Combustion

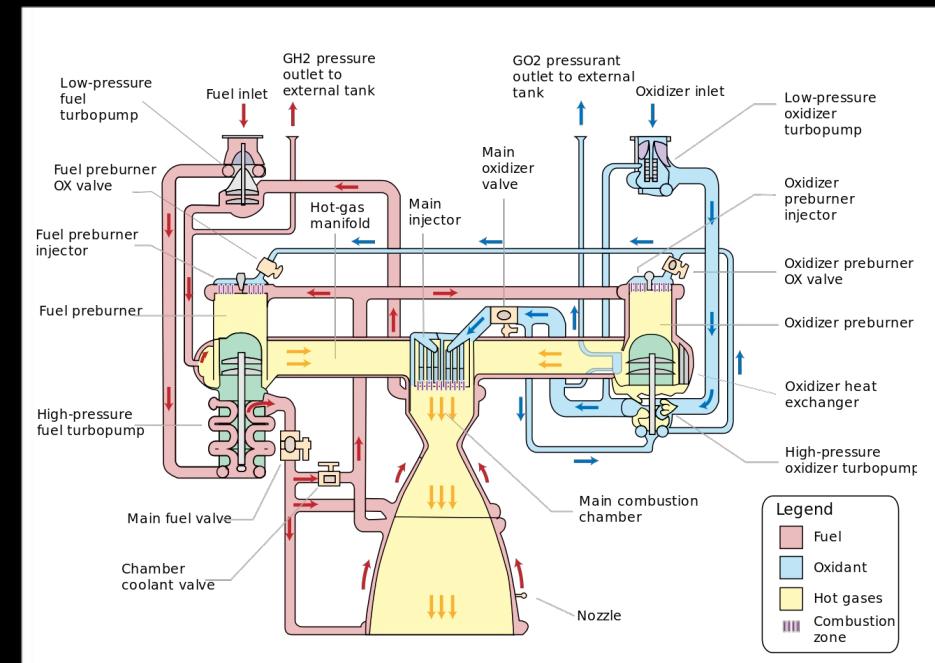
Examples:

- Raptor
- RD270

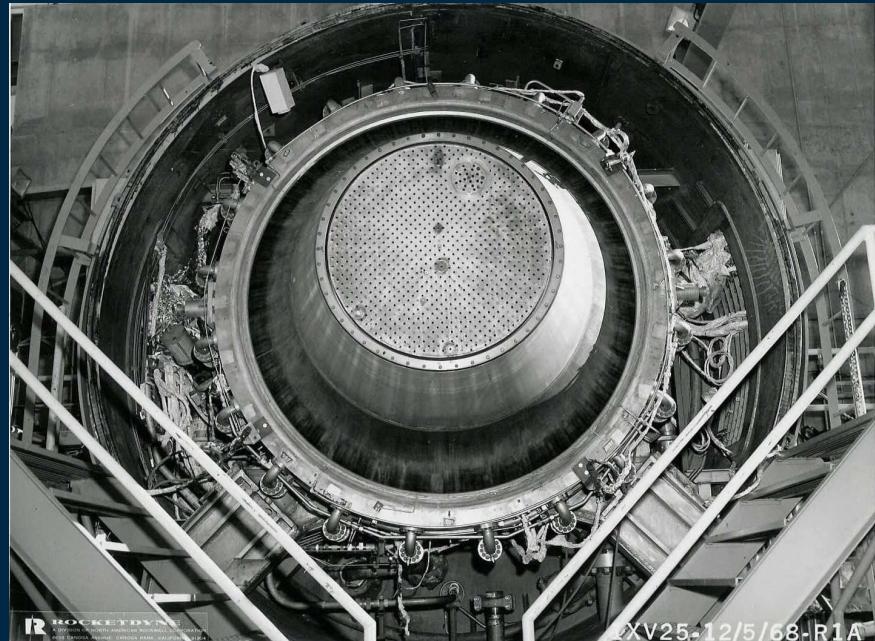
- Along with all the advantages of Staged combustion
- This is the best engine in terms of efficiency



The RS25 engine:



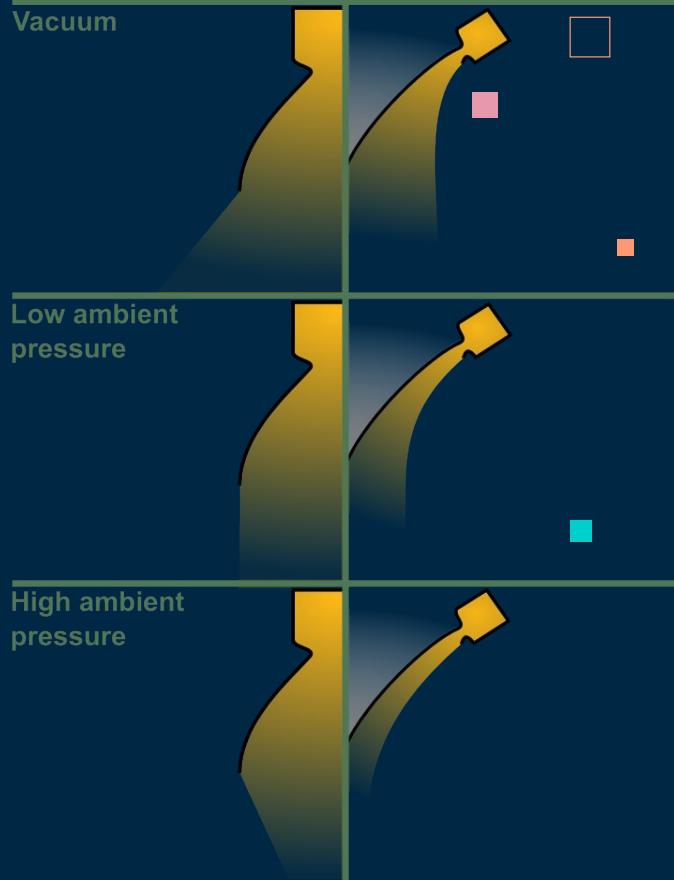
AeroSpike

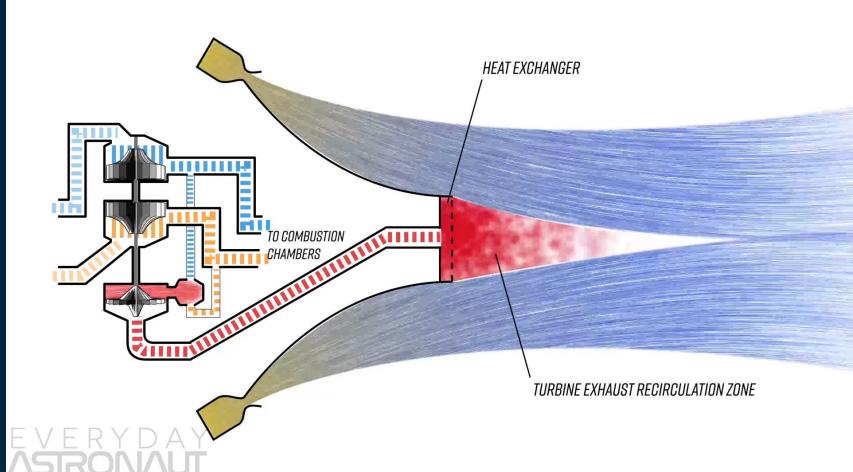


XV25-12/5/68-R1A



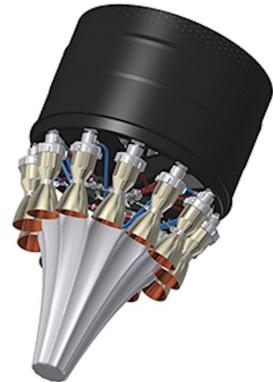
Instead of a CD nozzle they are engines with no nozzle



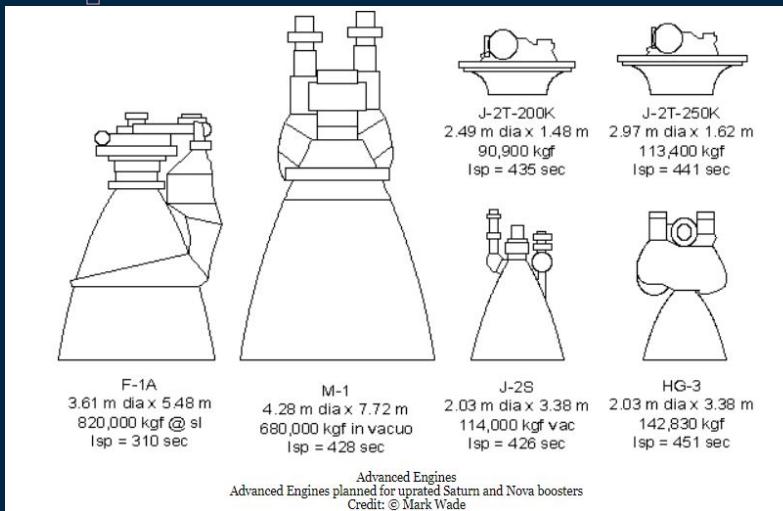


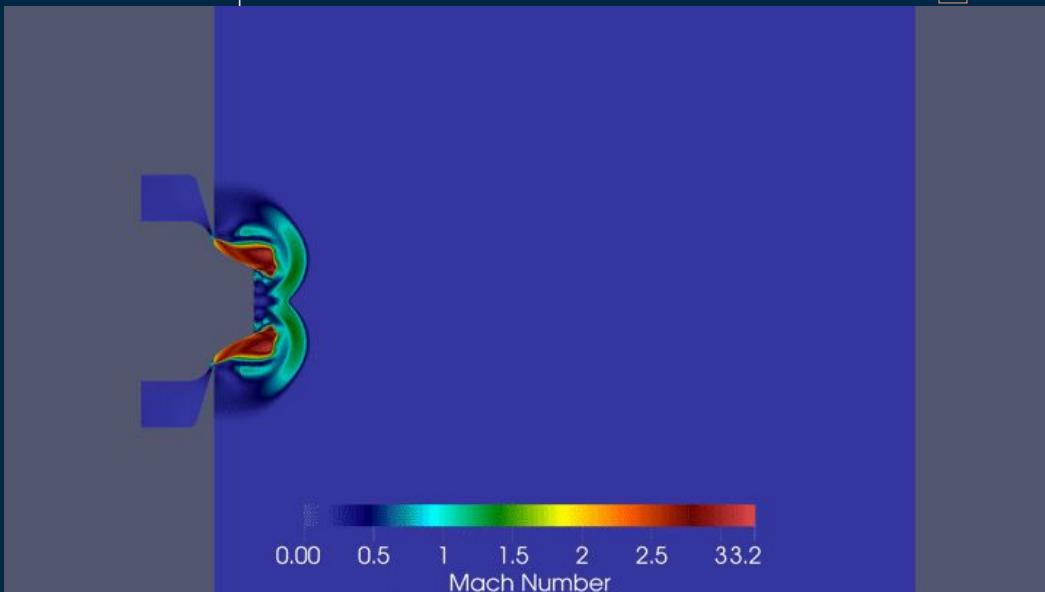
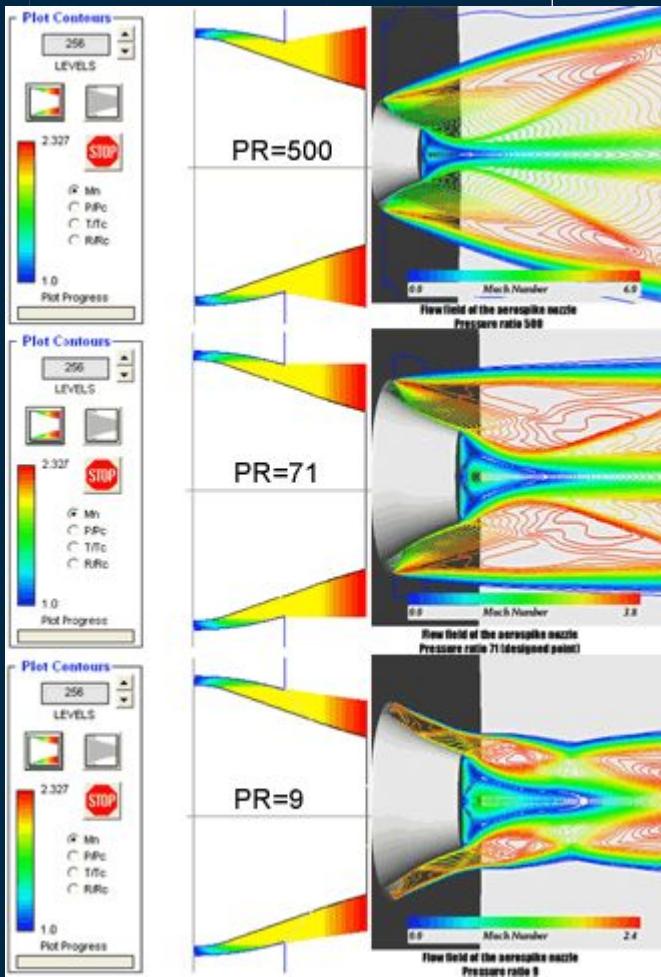
EVERYDAY
ASTRONAUT

Source: Firefly



EVERYDAY
ASTRONAUT

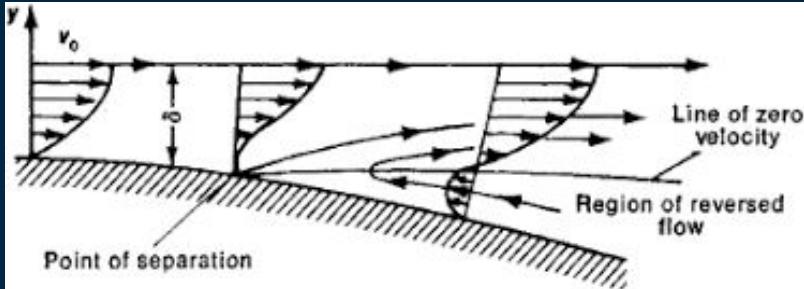




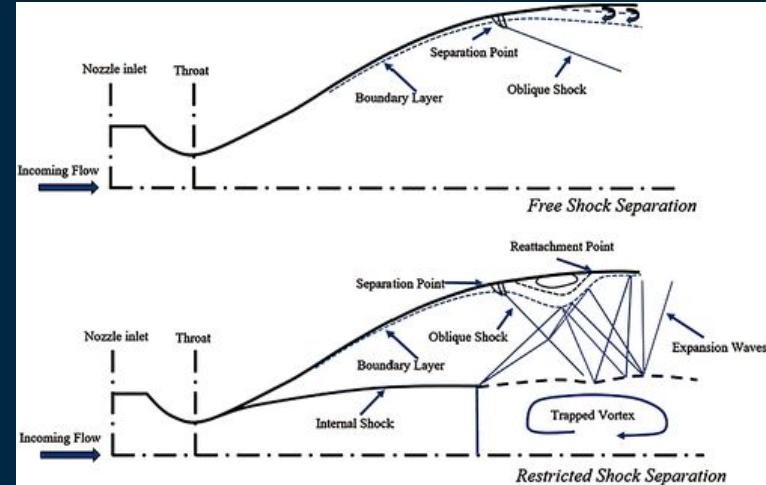
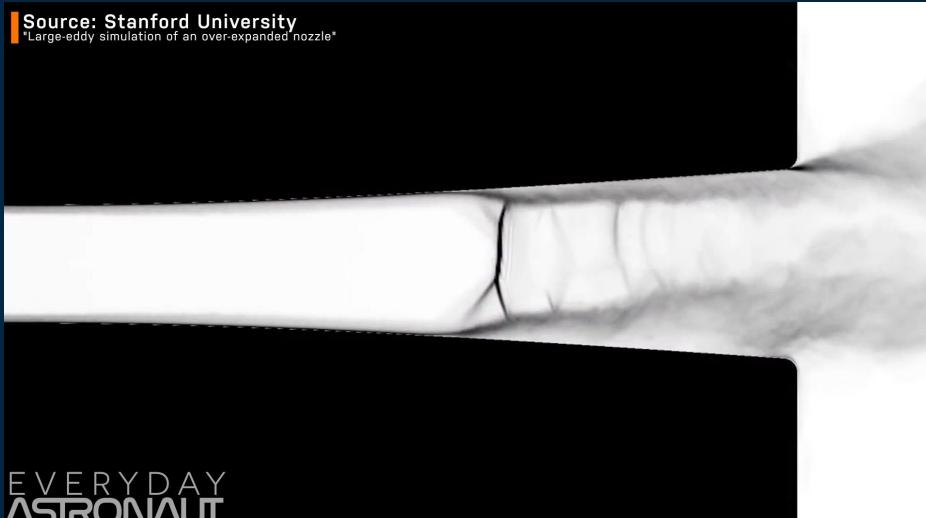
Engine Instabilities



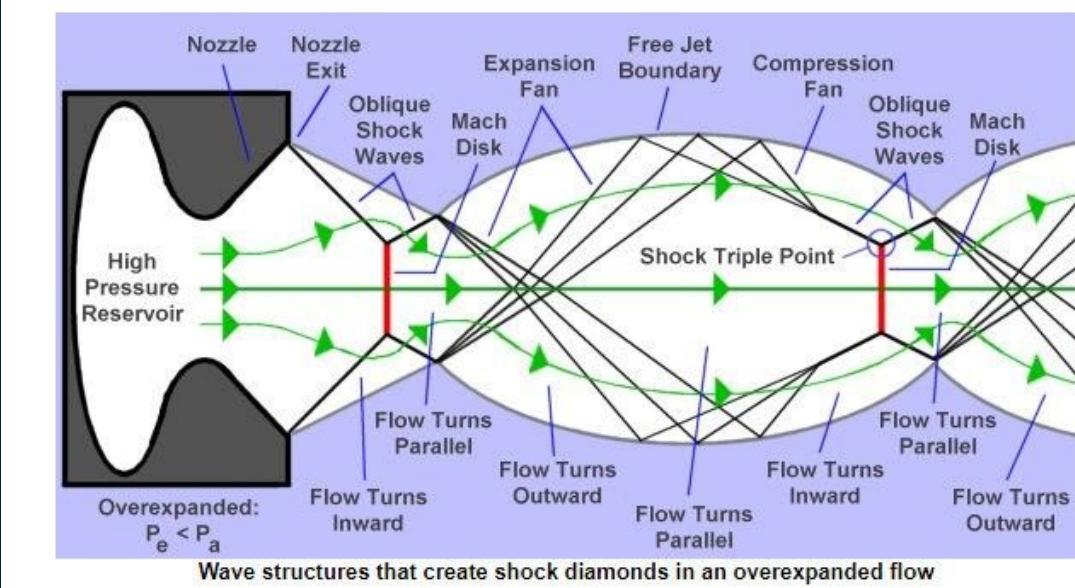
Cause of Separation



Source: Stanford University
"Large-eddy simulation of an over-expanded nozzle"



Shock Diamonds





THANKS

LET'S CONTINUE LATER WITH MORE INTERESTING STUFFS AND FEW
MORE CALCULATIONS.