Space Exploration

Heat Shields, Structure and Controls

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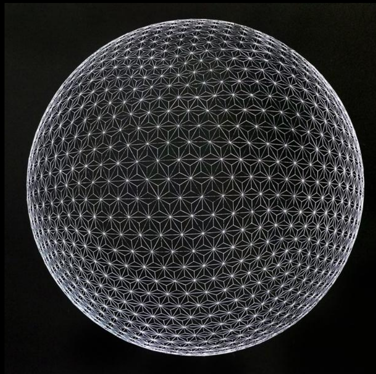
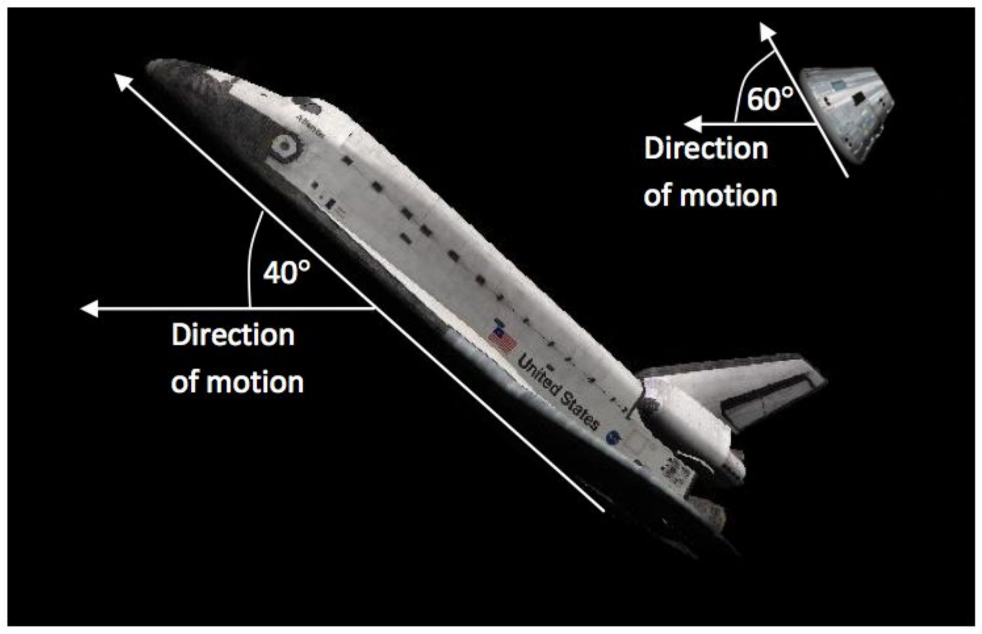
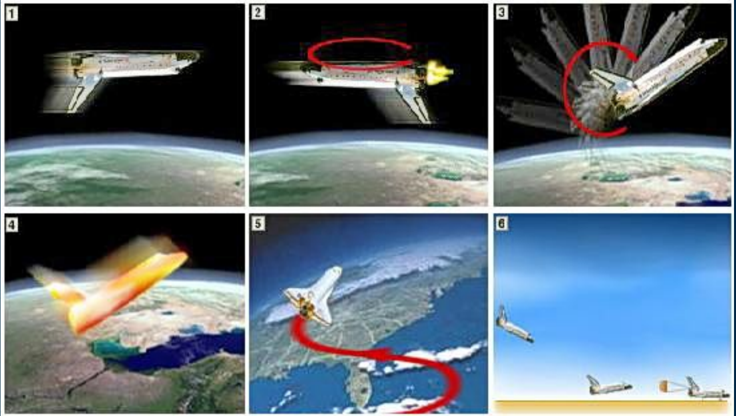


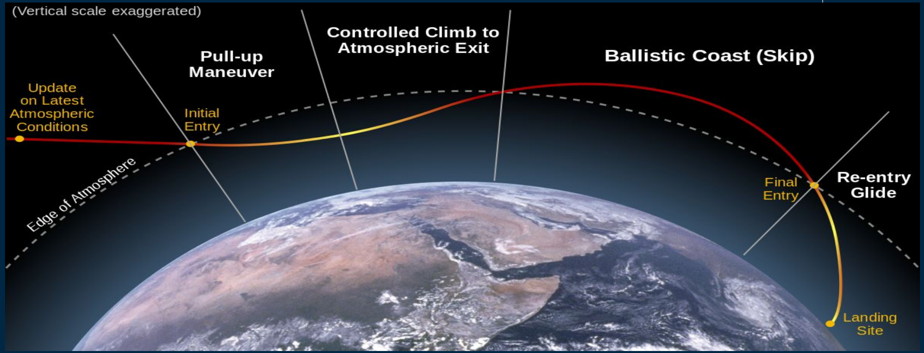
The Reentry

The re-entry maneuver

Re- entry can be a guided maneuver

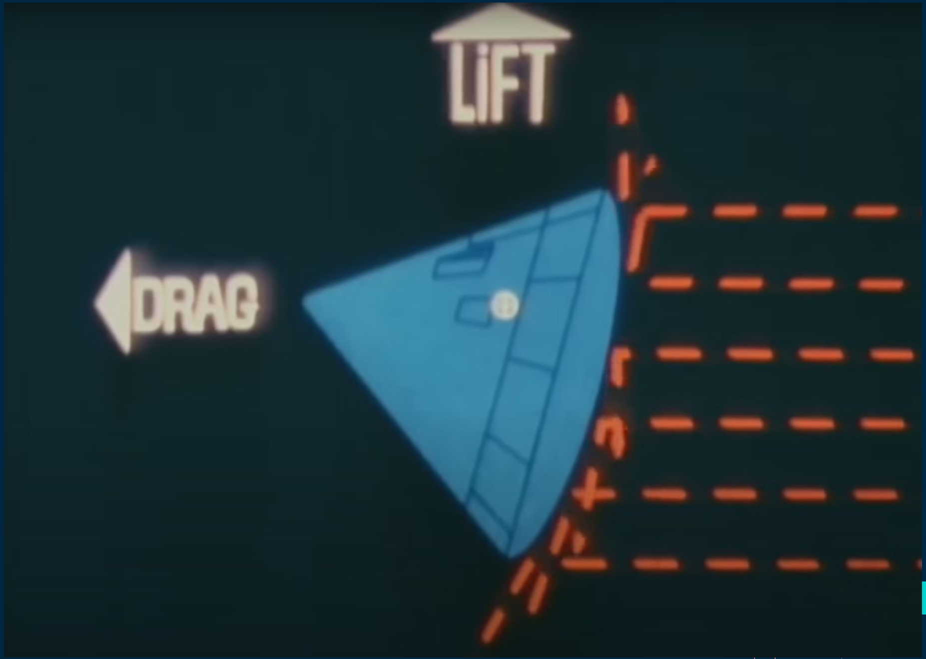






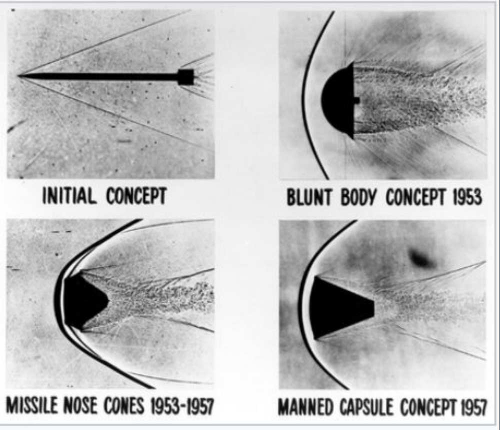
Generating lift during Reentry

- Aerodynamics associated with the Reentry Capsule
- The center of mass is offset such that the spacecraft minimises the produced G-force



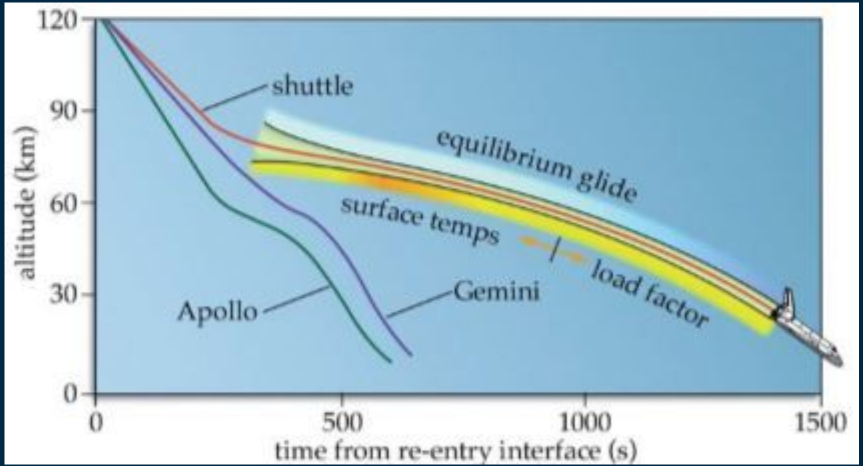
Ballistic Reentry

- Normal projectile motion
- Higher Deceleration
- Unsuitable for Human flights

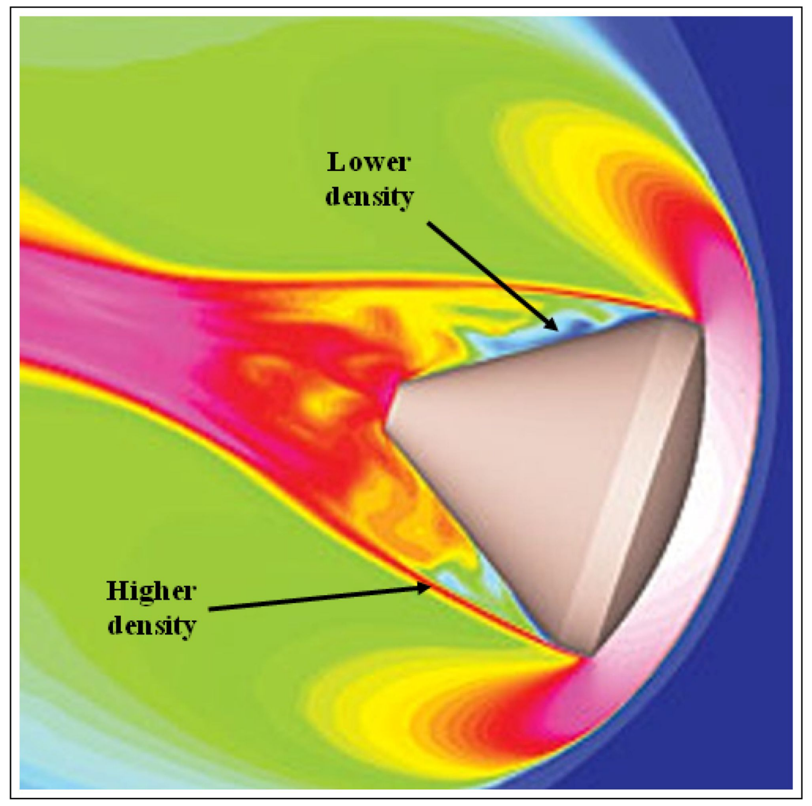


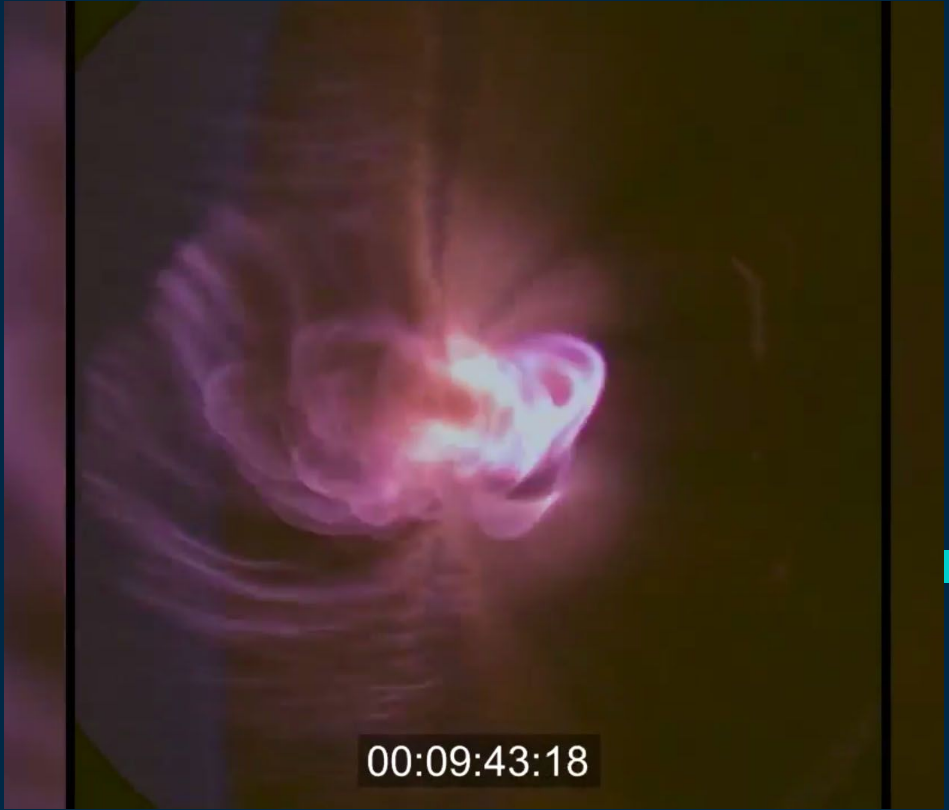
Aerodynamic Reentry

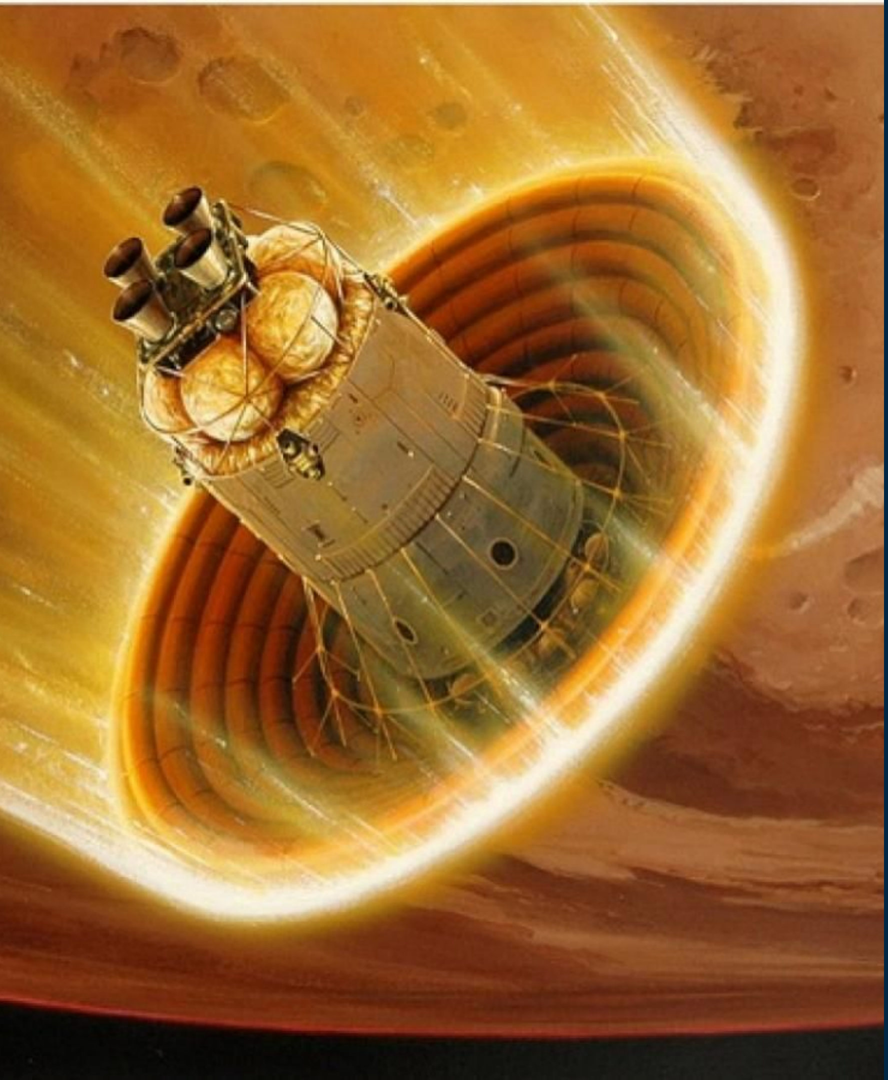
- More controlled reentry
- Lesser G-force Experienced
- More demandable design



Heat During Reentry



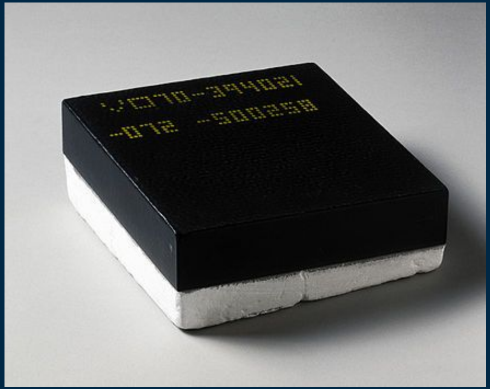




The Heat shields

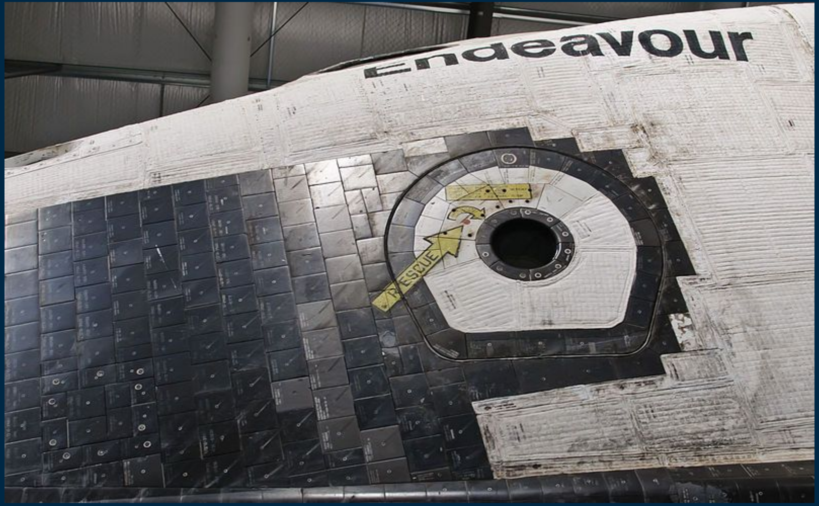
Types of heat shields

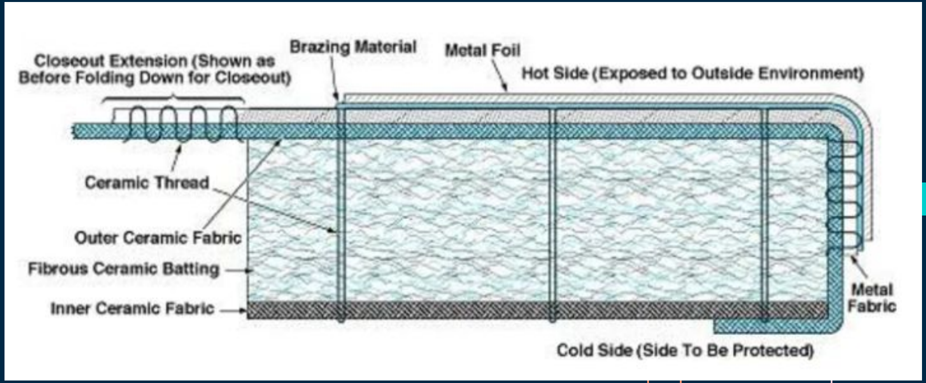
- Insulation Blankets
- Insulation tiles
- Reinforced carbon carbon
- Ablative Heat shield
- Regenerative Cooling



Insulation Blankets

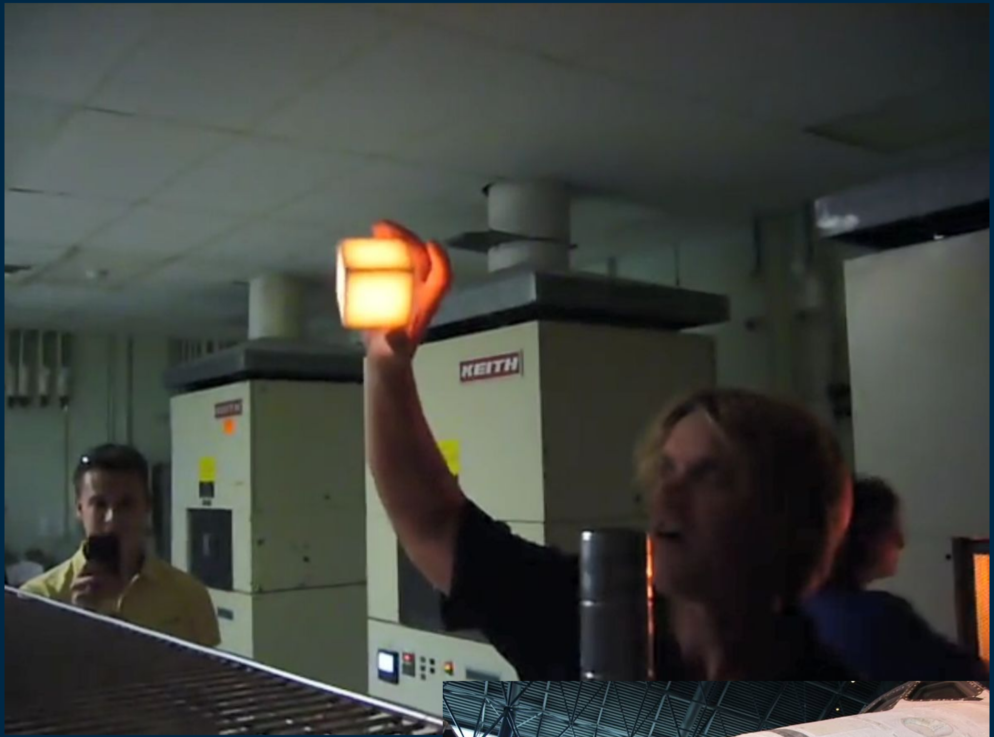
- Used where the heat of reentry is below 649 celsius
- Firmly hold on to shuttle
- Easier to maintain
- Look like Blanket

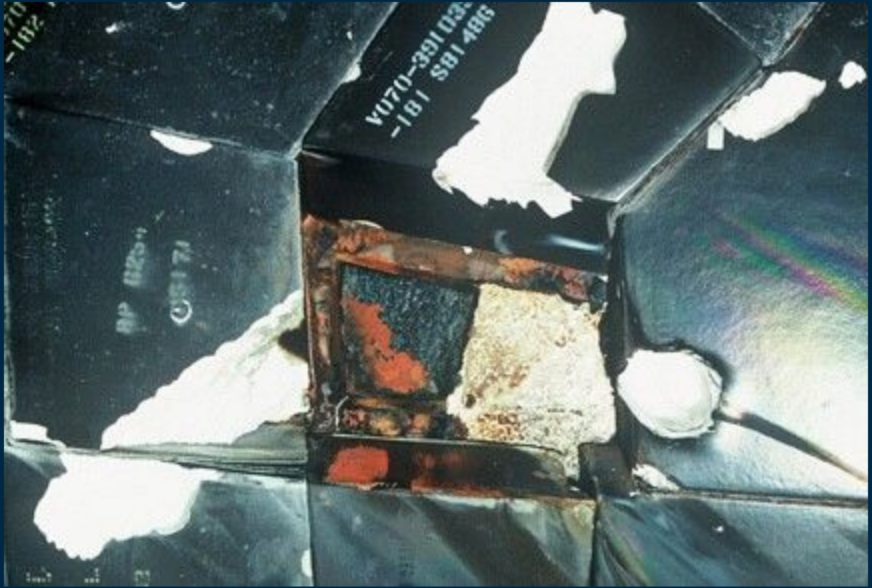




Insulation Tiles

- Made of silica ceramics
- Can withstand temperatures of 1260 C
- Very bad conductor of electricity
- Very fragile
- Has the tendency to fall off





STS-27 with metal mount
under the chipped tile

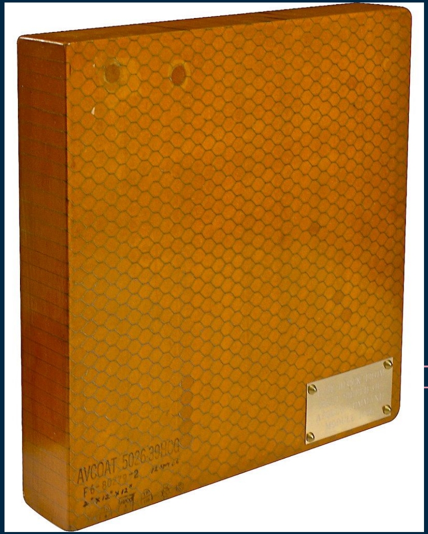
Space Shuttle Columbia debris
strike(STS107) in 2003

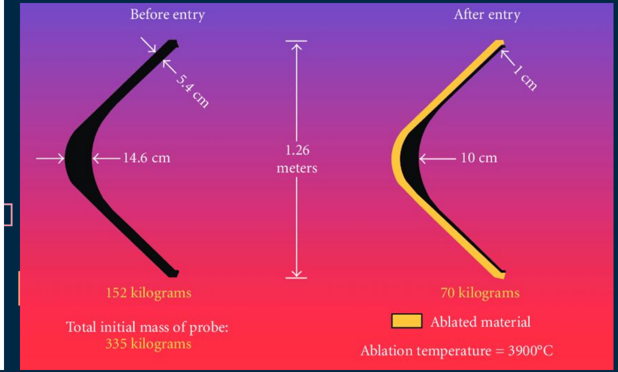
Reinforced carbon-carbon

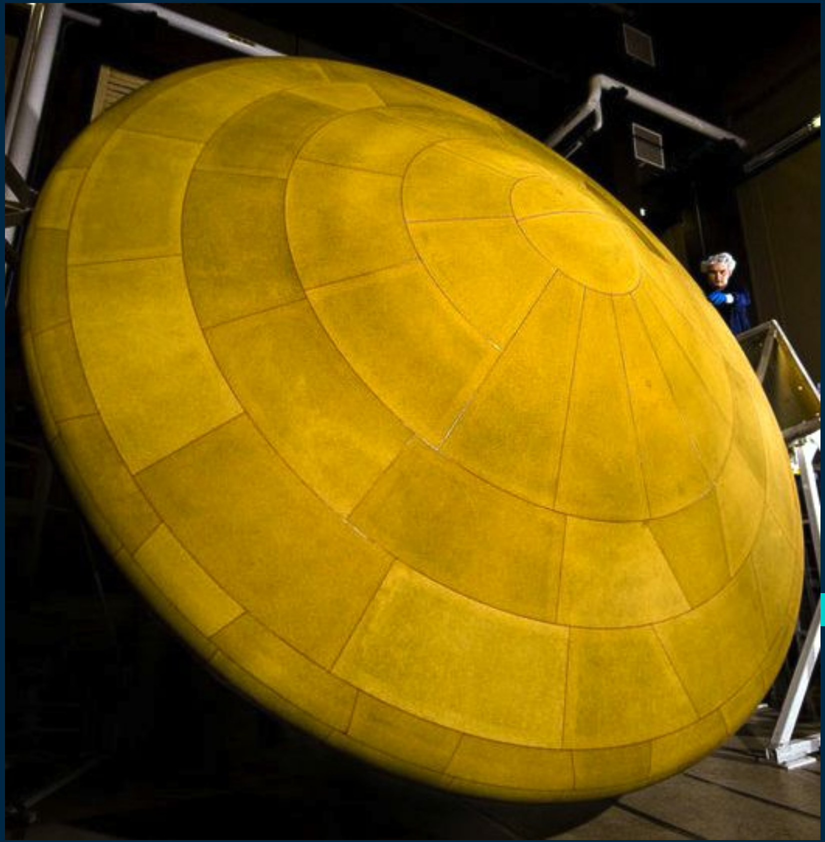
- Carbon fiber reinforcement in matrix of graphite
- Used Where temp exceeds above 1260C
- Heavy but very strong
- Usually used on the leading components of spacecraft like wing edge and nose cone

Ablative heat shields

- SLWA(super lightweight ablator)
- AVCOAT (used on Apollo missions)
- PICA (Phenol Impregnated Carbon ablator)(most modern)



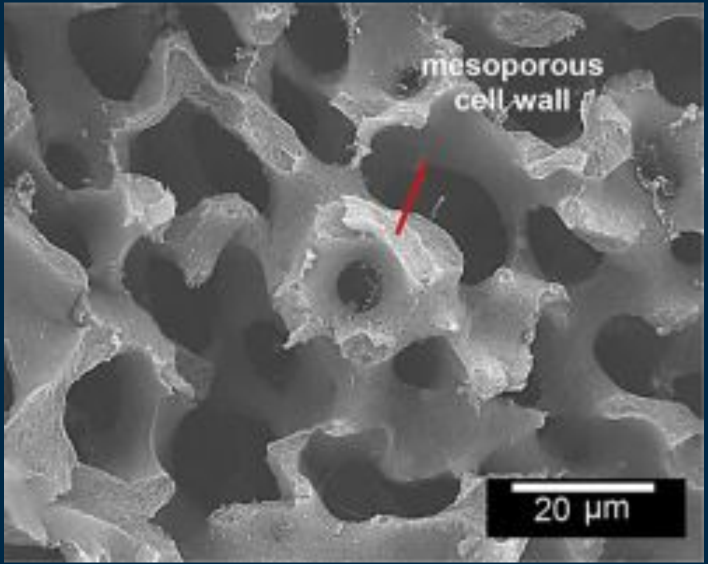




Regenerative Cooling

- To be used on more advanced rockets
- Experimental Tech
- Uses Transpiration to cool off
- Will probably use cryogenic engine Fuel

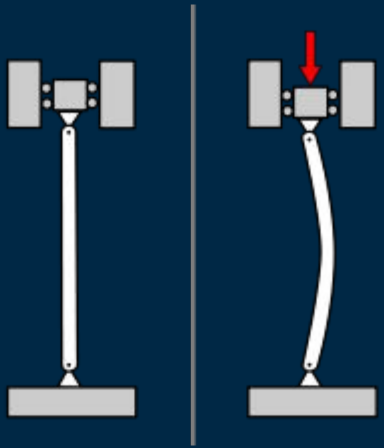
Future of Heat Shields



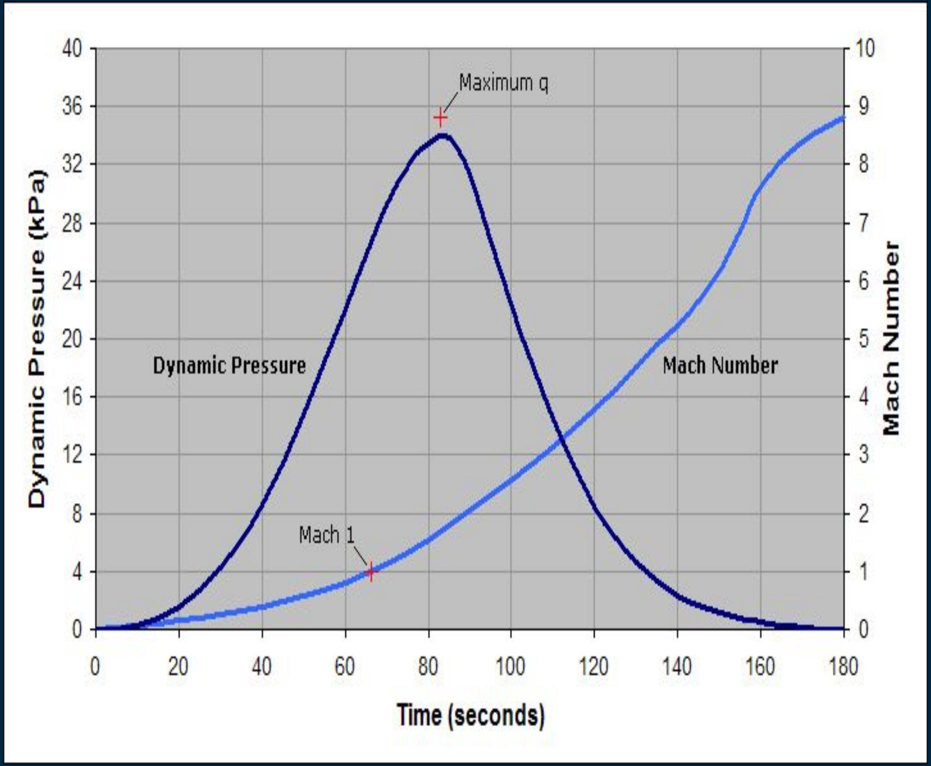
Structural System of rockets

- The structural system of a rocket includes all of the parts which make up the frame of the rocket; the cylindrical body, the fairings, and any control fins.
- The frame, is made up of **strong**, but **lightweight** materials such as aluminum or titanium.
- The performance of the rocket depends directly on the weight of the structure.
- It is coated with a **thermal protection** system, to keep out heat of air friction during the flight.
- The fins are attached to the bottom for stability during the flight.

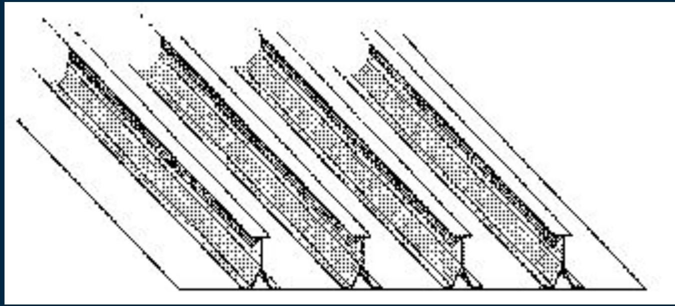
- The materials used in the construction of rocket boosters and space vehicles range from special high-density material for heat absorption to high-strength, lightweight materials to carry flight loads.
- In attempting to reduce weight, vehicle **skin thickness** must be as **low** as possible and in some cases the structure can be internally pressurized to keep the walls from buckling.

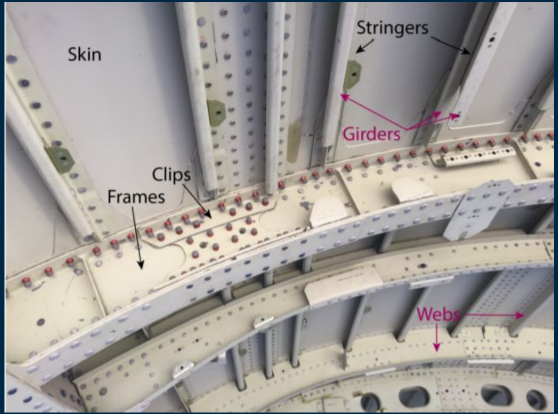


- During a launch, as the vehicle speed increases, and the atmosphere thins, there is a point of maximum aerodynamic drag called max Q. This determines the minimum aerodynamic strength of the vehicle, as the rocket must avoid buckling under these forces.
- $q = \rho v^2/2$

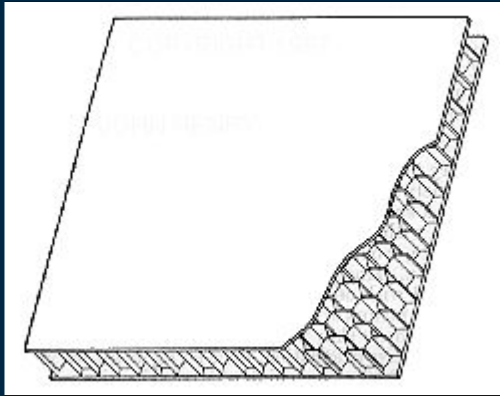


- Another method of stabilizing thin sheets is to use stringers.





- Thin sheets can also be stabilized against buckling by placing a lightweight supporting core between two sheets to form a "sandwich." The core might be in the form of honeycomb or possibly a light plastic or metal foam.
- Sandwich construction is becoming increasingly important in higher temperature applications.



- The equilibrium temperature of a space vehicle is determined principally by the nature of the structural surface. The radiation properties of this overall surface determine the relative rates of absorption of solar energy by the vehicle and the radiation of vehicle heat into space. This balance, along with the quantity of heat internally generated, determines vehicle temperature.
- Measures available to adjust this temperature balance include choice of surface color and smoothness of finish, as on Vanguard, Explorer, and Pioneer.

- New advancements in making the frame of the rocket by using materials such as beryllium and composite materials using high strength filaments.
- The best current high-temperature metals, e. g., nickel and ferrous alloys, may soon be replaced by molybdenum.
- Ceramics such as carbides have very high melting points and show much promise for high-temperature use.
- Relatively brief encounters with a hot environment can be survived by the protection method, as in the insulation of rocket nozzles and reentry nose cones.

CONTROL DURING ASCENTS

Gravity Turn →

→ A "**TRAJECTORY OPTIMIZATION**", which uses gravity as the driving force to steer the rocket into a particular trajectory.

→ TWO MAJOR **ADVANTAGES** than "Thrust" owned trajectory control :

a.) Thrust only could provide efficiency in accelerating the body rather being trajectory controller.

b) Maintenance of ZERO Angle of Attack.(*)[Minimize Aerodynamic stress]

(Can also be thought as GRAVITY SLINGSHOTS*)

(*)Angle of attack : Angle between reference line and its relative motion line from fluid.

LAUNCH

→During Rocket's initial ascent, they tries to gain both vertical speed as well as vertical altitude, during which Gravity acts just against the thrust force on rocket (trying to minimize its vertical accl^n).

→ Pitch-over Maneuver, the best way to optimize initial gravity drag, which tries to gimbal the engine slightly in such a way that rocket's thrust tilt's a bit, hence net **TORQUE** is generated.

→ **IGS*** usage for pitchover angle controls. Get it accustomed to rockets axis as soon as the pitchover is complete.

→ And here, comes the role of thrust for changing the direction in ideal gravity turn.

→ Why Pitch-over Maneuver?

→ **Deviation from it's flight path.**

→ **Correct Heading to orbit.**

*Inertial Guidance System

ROCKET's VELOCITY IS NO MORE VERTICAL!!

[So, comes back to earth again?]

Just like a ball??

(straight launch, change the direction of launch, and descend back to earth again)

Something More about Mission

→ In Context of Multi-Staged Rockets, think about firings of initial stages (utilizes some flight time for engine separation and also Not a continuous firing.)

→ Think if we fire the fuel in continuous manner. We would be running in short of fuel after a particular time XD.

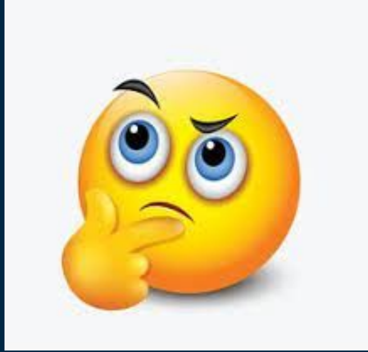
→ Launch in a planet with THICK ATMOSPHERE. Yeah Earth could be an example.

(How could you think of initial launch from Earth…..Like vertical ascent, gravity drag, pitch-over maneuver, maintenance of Zero attack angle,thrust, attainment of orbit, staging off and many more…..)

Don’t take it so lightly….YOU WILL HAVE TO ESTIMATE THE INITIAL PATH of your mission.

Connect the Logics to Mathematical Formulation & yeah then you may get your missions trajectory.

Deviation is matter of DRAG but seriously How much?



DESCENT IS ALSO NOT EASY, BRO!!

[Think, about it]

[Almost similar to ascent, so can be in assignment to explore more]

THANKS

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