Introduction

- We will take you through successfully launching a rocket and landing it on a different body
- This is a simplified version based on our knowledge of KSP not real life per se

Technicallities

Jargon

Orbit An object rotating around another object is said to be in orbit

Inclined An orbit that is tilted relative to the plane of the parent body

Technicallities

delta-v

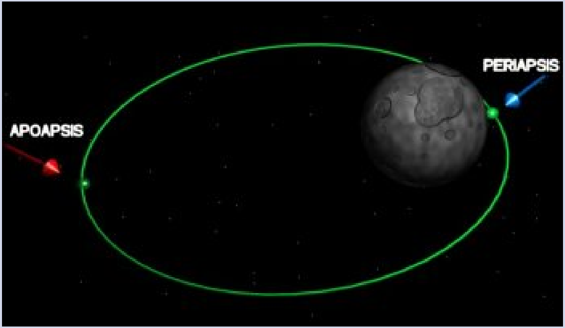
- aka: fuel budget
- how hard can i accelerate/decelerate my rocket
- dependent on:
  - fuel efficiency
  - thurst to weight ratio

Technicallities

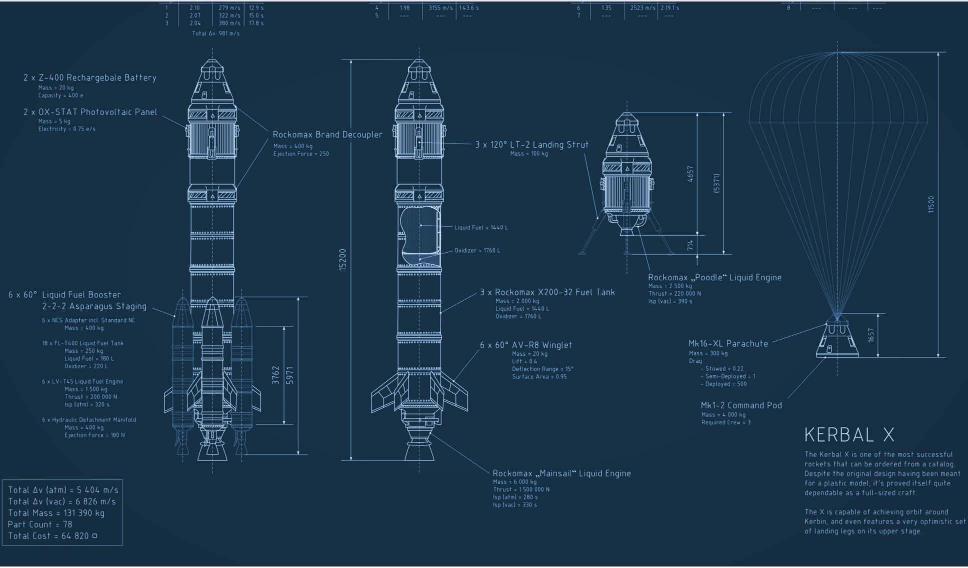
Points on orbit

apoapsis : highest point on orbit

periapsis : Lowest point on orbit

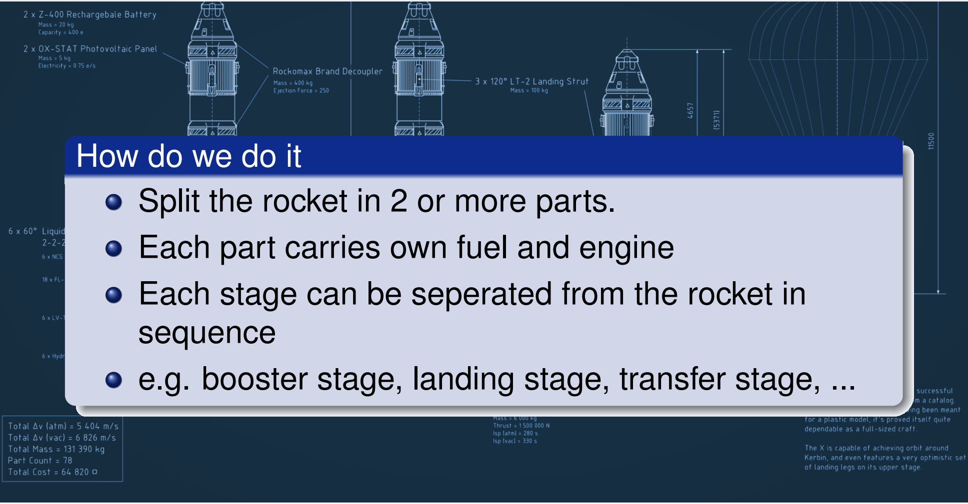


Let's prepare for launch



1 2.10 279 m/s 12.9 s
2 2.07 322 m/s 15.0 s
3 2.04 380 m/s 17.8 s
Total Δv: 981 m/s
4 1.98 3155 m/s 143.6 s
5 --- --- ---
6 1.35 2523 m/s 219.1 s
7 --- --- ---
8 --- --- ---
2 x Z-400 Rechargebale Battery
Mass = 20 kg
Capacity = 400 e
2 x OX-STAT Photovoltaic Panel
Mass = 5 kg
Electricity = 0.75 e/s
Rockomax Brand Decoupler
Mass = 400 kg
Ejection Force = 250
3 x 120° LT-2 Landing Strut
Mass = 100 kg
Liquid Fuel = 1440 L
Oxidizer = 1760 L
6 x 60° Liquid Fuel Booster
2-2-2 Asparagus Staging
6 x NCS Adapter incl. Standard NC
Mass = 400 kg
18 x FL-T400 Liquid Fuel Tank
Mass = 250 kg
Liquid Fuel = 180 L
Oxidizer = 220 L
6 x LV-T45 Liquid Fuel Engine
Mass = 1 500 kg
Thrust = 200 000 N
Isp (atm) = 320 s
6 x Hydraulic Detachment Manifold
Mass = 400 kg
Ejection Force = 180 N
3762
5971
15200
3 x Rockomax X200-32 Fuel Tank
Mass = 2 000 kg
Liquid Fuel = 1440 L
Oxidizer = 1760 L
6 x 60° AV-R8 Winglet
Mass = 20 kg
Lift = 0.4
Deflection Range = 15°
Surface Area = 0.95
Rockomax „Mainsail“ Liquid Engine
Mass = 6 000 kg
Thrust = 1 500 000 N
Isp (atm) = 280 s
Isp (vac) = 330 s
4657
(5371)
714
Rockomax „Poodle“ Liquid Engine
Mass = 2 500 kg
Thrust = 220 000 N
Isp (vac) = 390 s
11500
1657
Mk16-XL Parachute
Mass = 300 kg
Drag
- Stowed = 0.22
- Semi-Deployed = 1
- Deployed = 500
Mk1-2 Command Pod
Mass = 4 000 kg
Required Crew = 3
KERBAL X
The Kerbal X is one of the most successful rockets that can be ordered from a catalog. Despite the original design having been meant for a plastic model, it's proved itself quite dependable as a full-sized craft.
The X is capable of achieving orbit around Kerbin, and even features a very optimistic set of landing legs on its upper stage.
Total Δv (atm) = 5 404 m/s
Total Δv (vac) = 6 826 m/s
Total Mass = 131 390 kg
Part Count = 78
Total Cost = 64 820 ¤

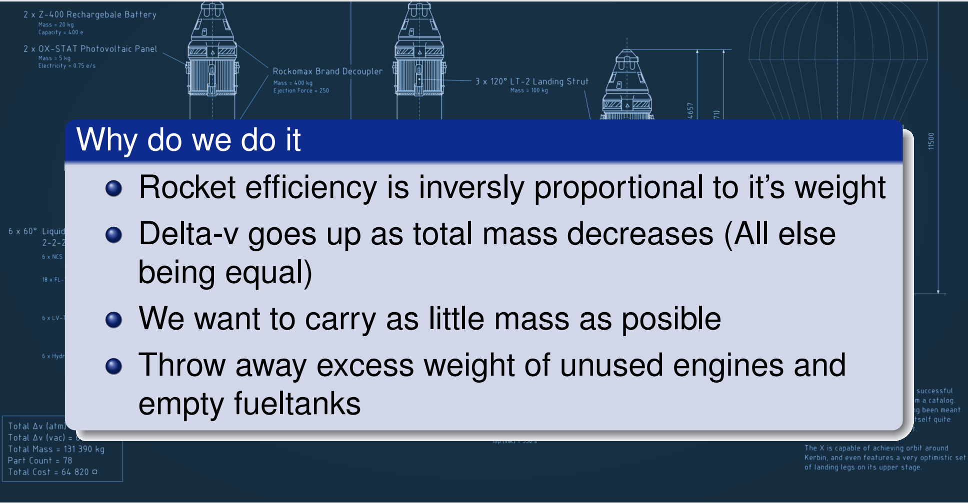
Staging



How do we do it

- Split the rocket in 2 or more parts.
- Each part carries own fuel and engine
- Each stage can be seperated from the rocket in sequence
- e.g. booster stage, landing stage, transfer stage, ...

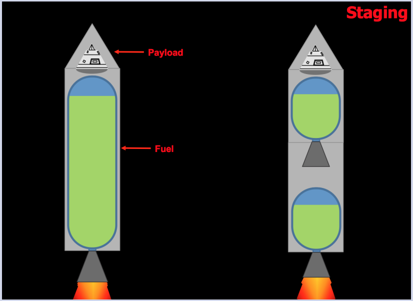
Staging



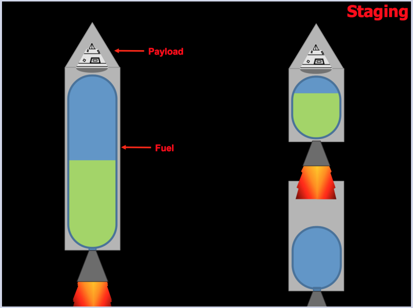
Why do we do it

- Rocket efficiency is inversly proportional to it's weight
- Delta-v goes up as total mass decreases (All else being equal)
- We want to carry as little mass as posible
- Throw away excess weight of unused engines and empty fueltanks

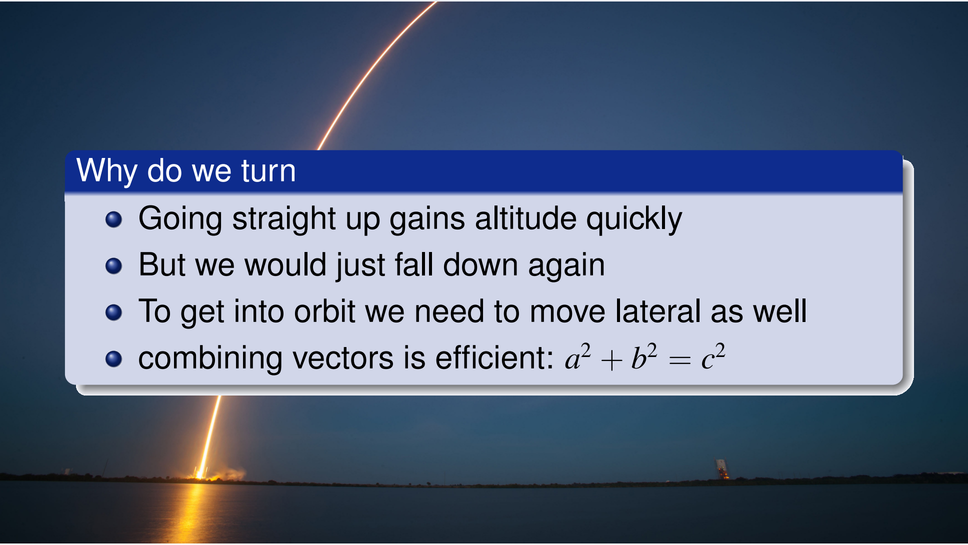
Staging



Staging



Getting into orbit



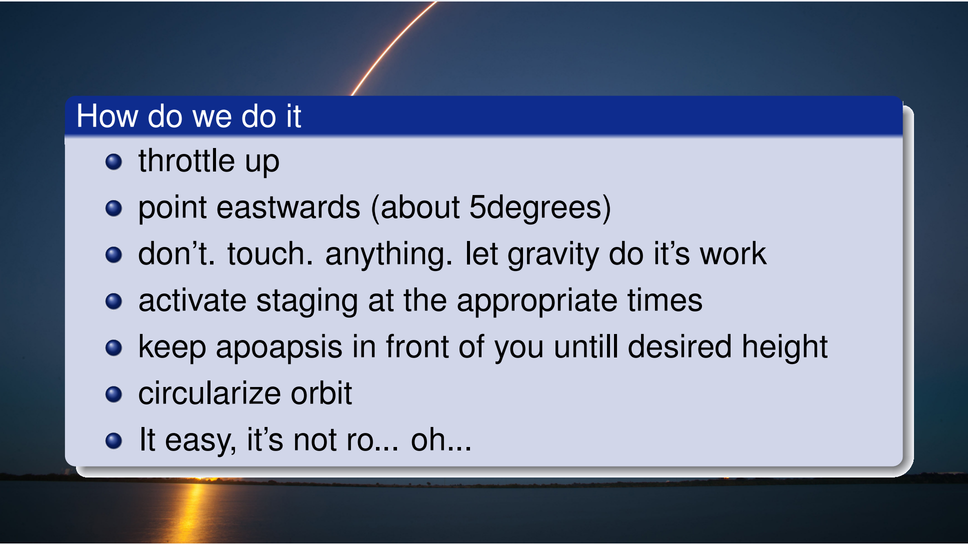
Why do we turn

- Going straight up gains altitude quickly
- But we would just fall down again
- To get into orbit we need to move lateral as well
- combining vectors is efficient: $a^2 + b^2 = c^2$

Gravity turn

- Rotation of earth is already moving us towards the east at 1.5km/h. Turning east saves precious delta-v
- rotational velocity is higher around the equator that why we want to launch from Cape Canaveral

Let's Launch



How do we do it

- throttle up
- point eastwards (about 5degrees)
- don't. touch. anything. let gravity do it's work
- activate staging at the appropriate times
- keep apoapsis in front of you untill desired height
- circularize orbit
- It easy, it's not ro... oh...

About that circulizing

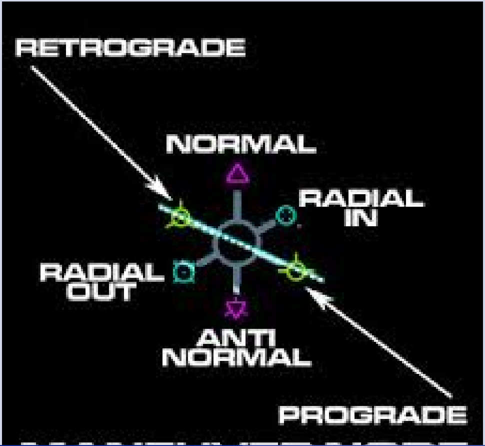
We are now almost in low earth orbit but still falling down. Our periapsis may still be within the atmosphere. So we need to learn how to manipulate our orbit while in space.

Basics

Movement on an orbit generally affects the oposite side of the orbit.

Adjusting Orbits

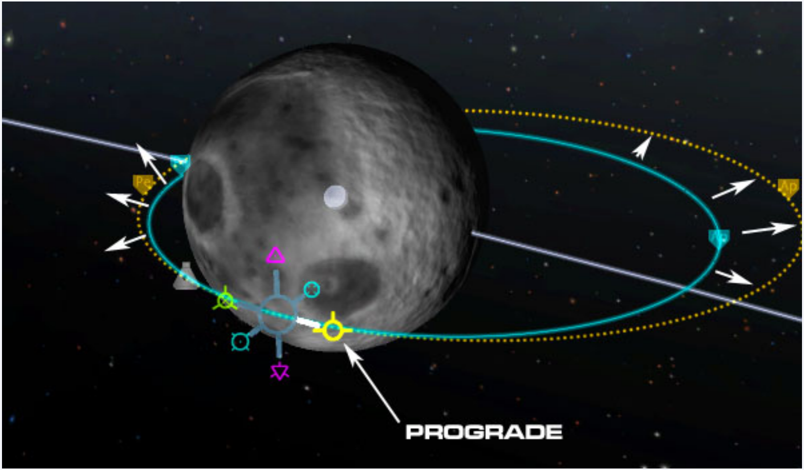
At any point on the orbit you can burn in 3 directions.
up/down, left/right, forwards/backwards



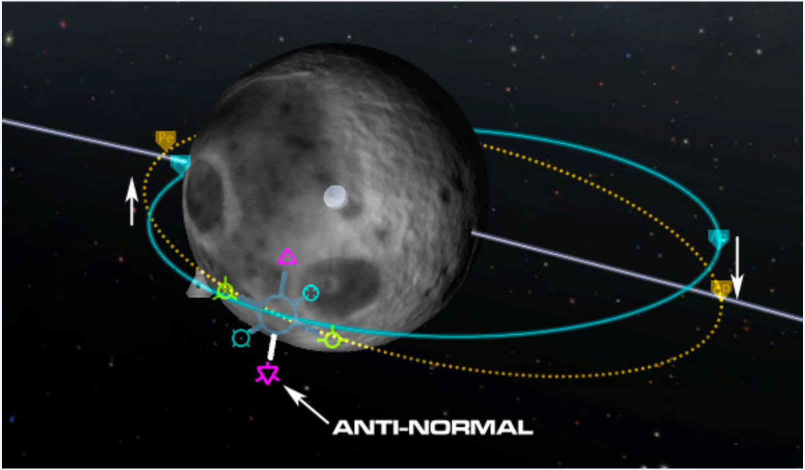
Maveuvering in space

prograde	Along your movement vector, used to increase orbit altitude
retrograde	Oposite your movement vector, used to decrease orbit altitude
normal	Perpendicular to orbit, used to increase/decrease inclination
anti-normal	perpendiculat to orbit, used to increase/decrease inclination
radial	Towards parent body, Used to shift orbit around
anti-radial	Away from parent body, used to shift orbit around

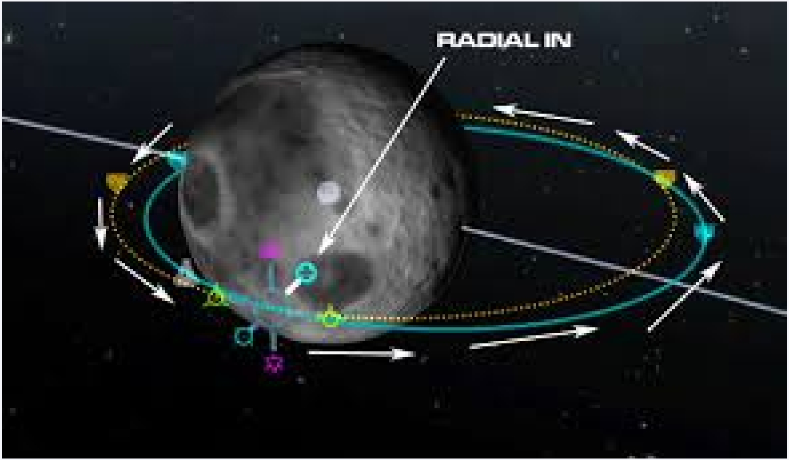
Prograde



Normal



Radial



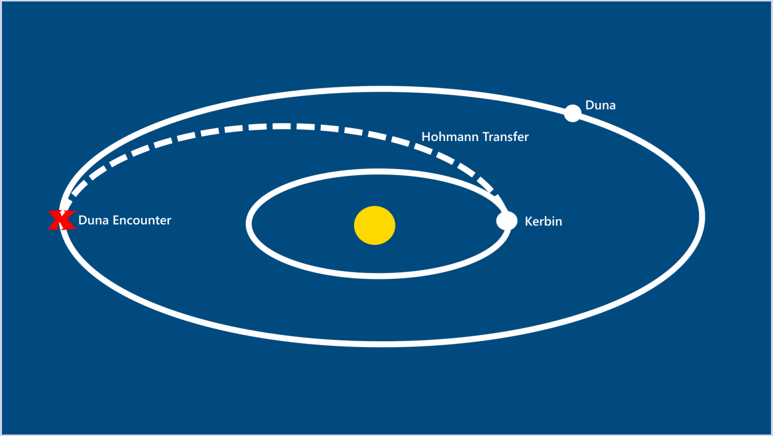
Planning Transfe

Finally achieved a stable low earth orbit. We need to plan our tranfer to our target body


Jupiter
Europa
Ganymede
Io
Callisto
Deimos
Mars
Phobos
Titan
Saturn
Venus
Uranus
Mercury
Neptune
Earth Intercept
Moon
Geostationary Orbit
Low Earth Orbit
Low Orbit
Intercept
45000
17200
3360
1480
580
8890
1970
790
6700
1850
730
10320
70
1760
5140
4
2
990
3800
1440
1060
1280
8
3
660
7600
3060
10230
30000
4500
27000
2940
640
6120
18000
5280
3060
1220
8650
6750
19000
5390
1730
680
3260
3210
3910

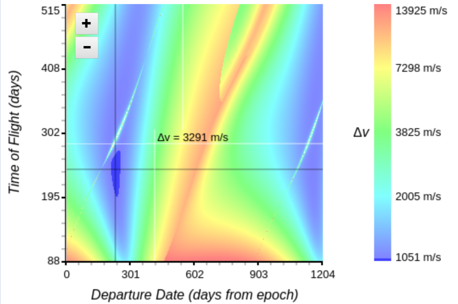
Hohmann transfer

Now that we now our target and know the delta-v required to get there we need to plan the encounter

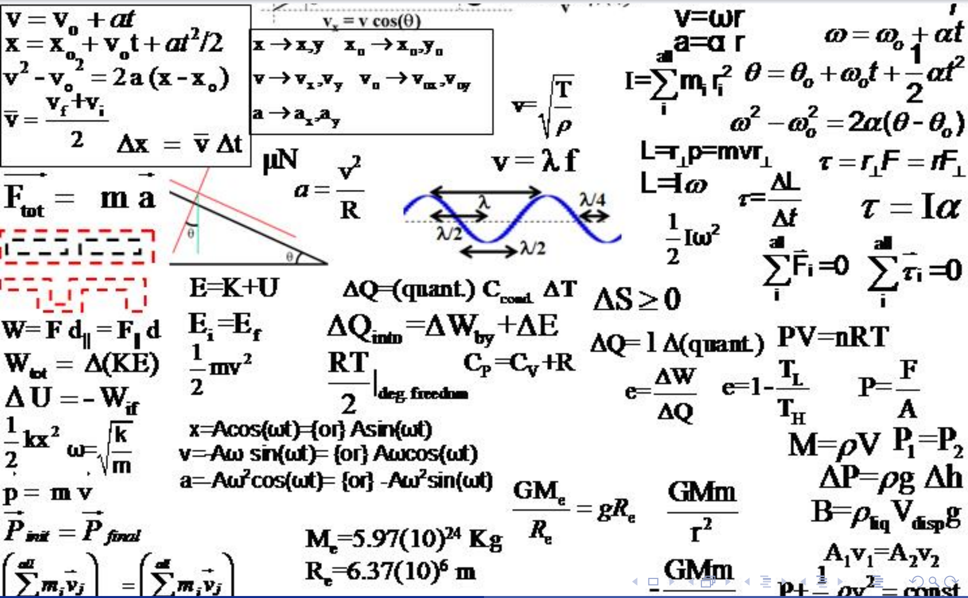


Hohmann transfer window

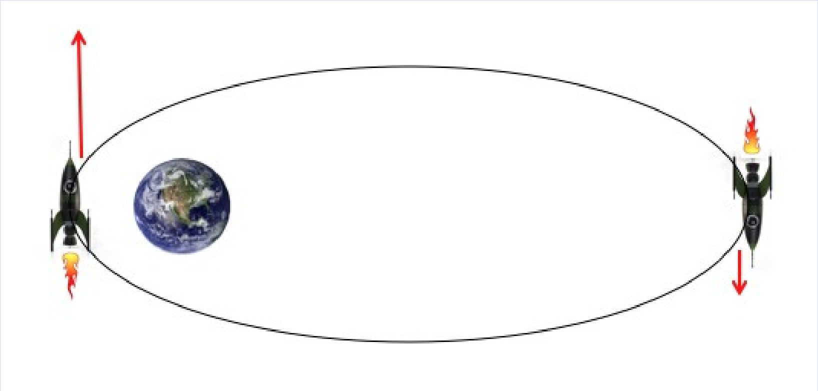
To be able to transfer with the least amount of delta-v as possible we need to launch when the target body is at an exact position relative to us. If we are on a strict delta-v budget we need to wait for a good window



Oberth Effect



JK, Oberth Effect



Oberth Effect explained

- things that go fast have higher energy
- $KE = 0.5 * m * v^2$

- mass is a form of energy
- $E = MC^2$

- Newton's third law
- $F_a = -F_b$

Dumping mass (fuel) while going fast(Deep in the gravity well) gives more kinetic energy to the ship

Escape

Now that we can make optimal use of the Oberth effect we can begin our escape burn and start our tranfer orbit

- descelarate to drop periapsis deeper into the gravity well
- wait for periapsis (to make maximal use of Oberth effect)
- make transfer burn and coast to encounter

Introduction

- We will take you through successfully launching a rocket and landing it on a different body
- This is a simplified version based on our vast KSP knowledge

Introduction

- We will take you through successfully launching a rocket and landing it on a different body
- This is a simplified version based on our vast KSP knowledge

Introduction

- We will take you through successfully launching a rocket and landing it on a different body
- This is a simplified version based on our vast KSP knowledge