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Topics:

Rocket Science

NOTES FOR THE LECTURER

15/07/2020

Valuable sources of information

European Space Agency:
https://www.esa.int/Education/The_rocket_principal

NASA:
https://www.grc.nasa.gov/www/k-12/rocket/TRCRocket/rocket_principles.html

Tyranny of the rocket equation:
https://www.nasa.gov/mission_pages/station/expeditions/expedition30/tryanny.html

Everyday Astronaut on rocket engines:
https://www.youtube.com/watch?v=LbH1ZDImaI8&list=PLWzKfs3icbT6yhDTpO1GyDlz9AXdWSiGr&index=2

More websites and recources are provided along the power point presentation in the comments section

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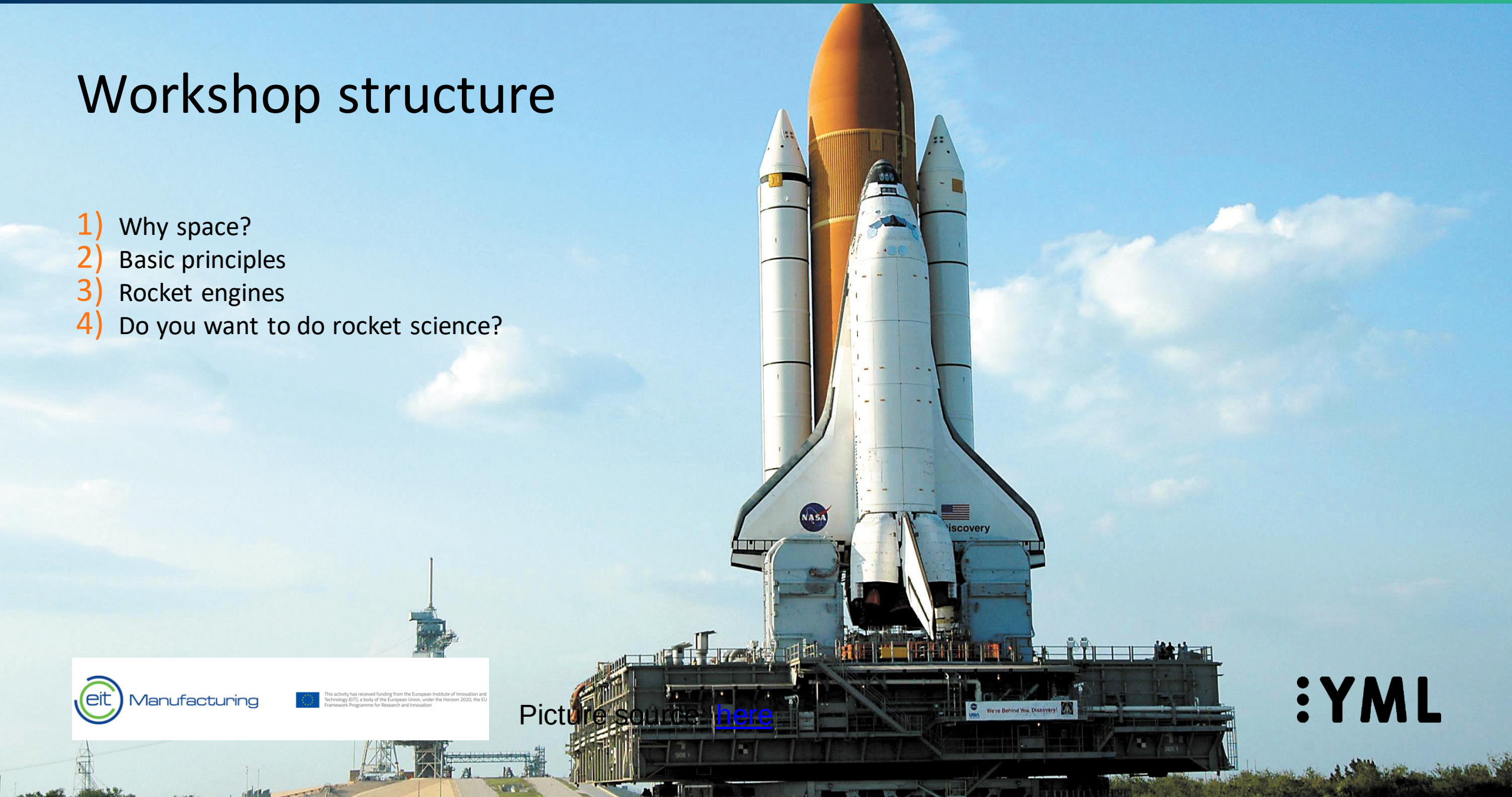
Topic:

Rocket Science

15/07/2020

Workshop structure

1) Why space?
2) Basic principles
3) Rocket engines
4) Do you want to do rocket science?



Picture source: here

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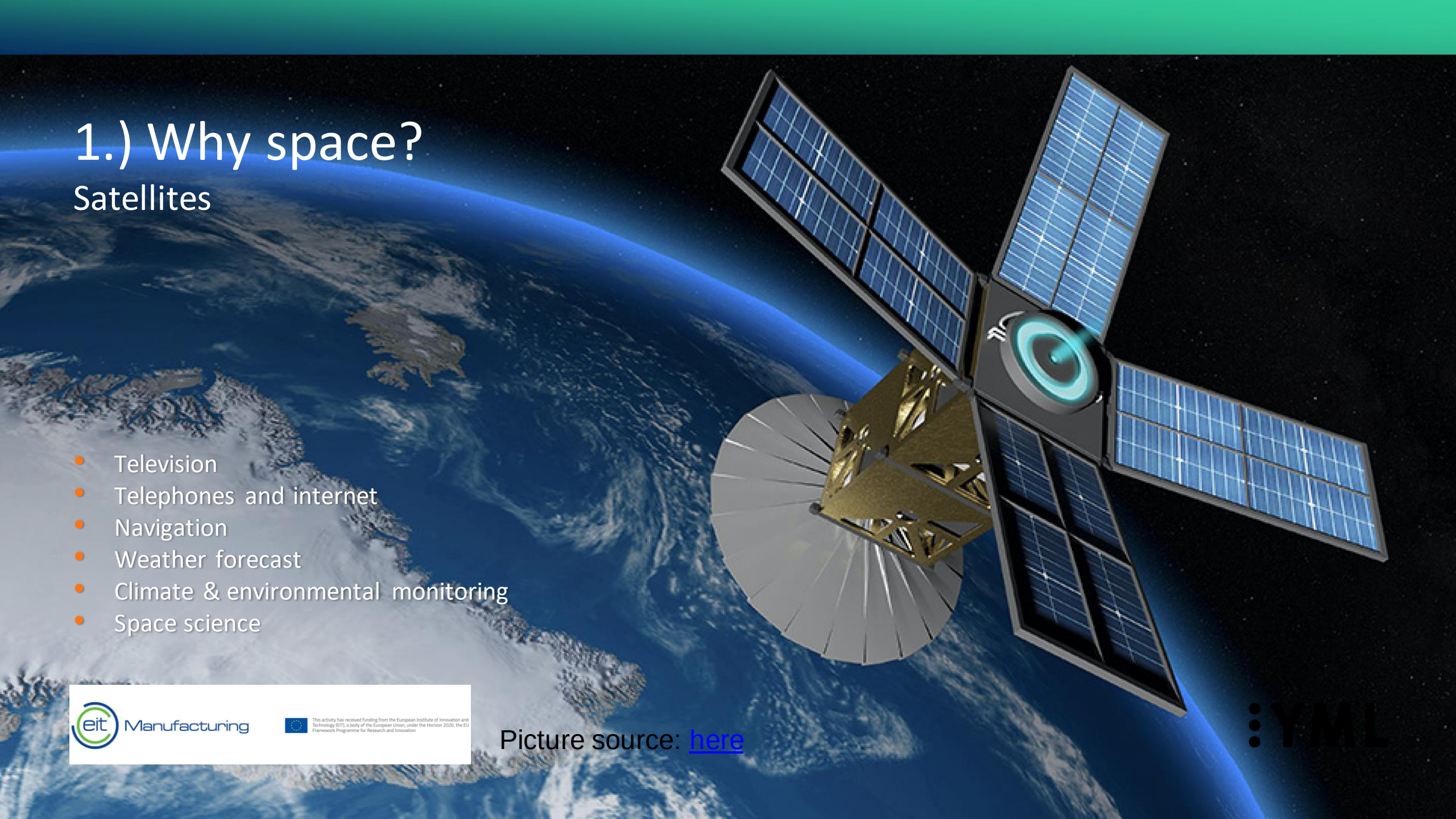
1.) Why space?

Satellites



- Television
- Telephones and internet
- Navigation
- Weather forecast
- Climate & environmental monitoring
- Space science

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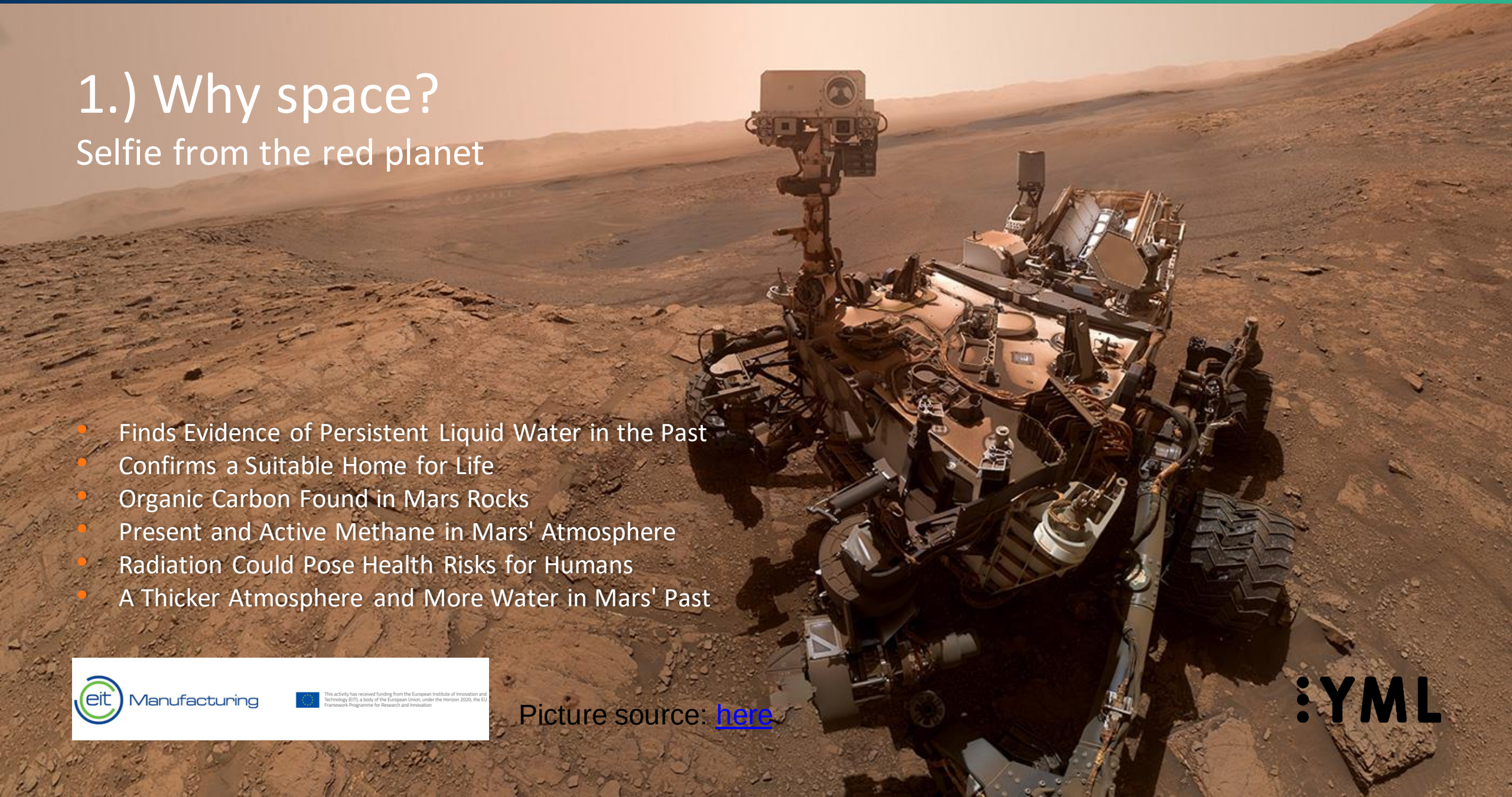
Picture source: here

1.) Why space?

Selfie from the red planet



- Finds Evidence of Persistent Liquid Water in the Past
- Confirms a Suitable Home for Life
- Organic Carbon Found in Mars Rocks
- Present and Active Methane in Mars' Atmosphere
- Radiation Could Pose Health Risks for Humans
- A Thicker Atmosphere and More Water in Mars' Past

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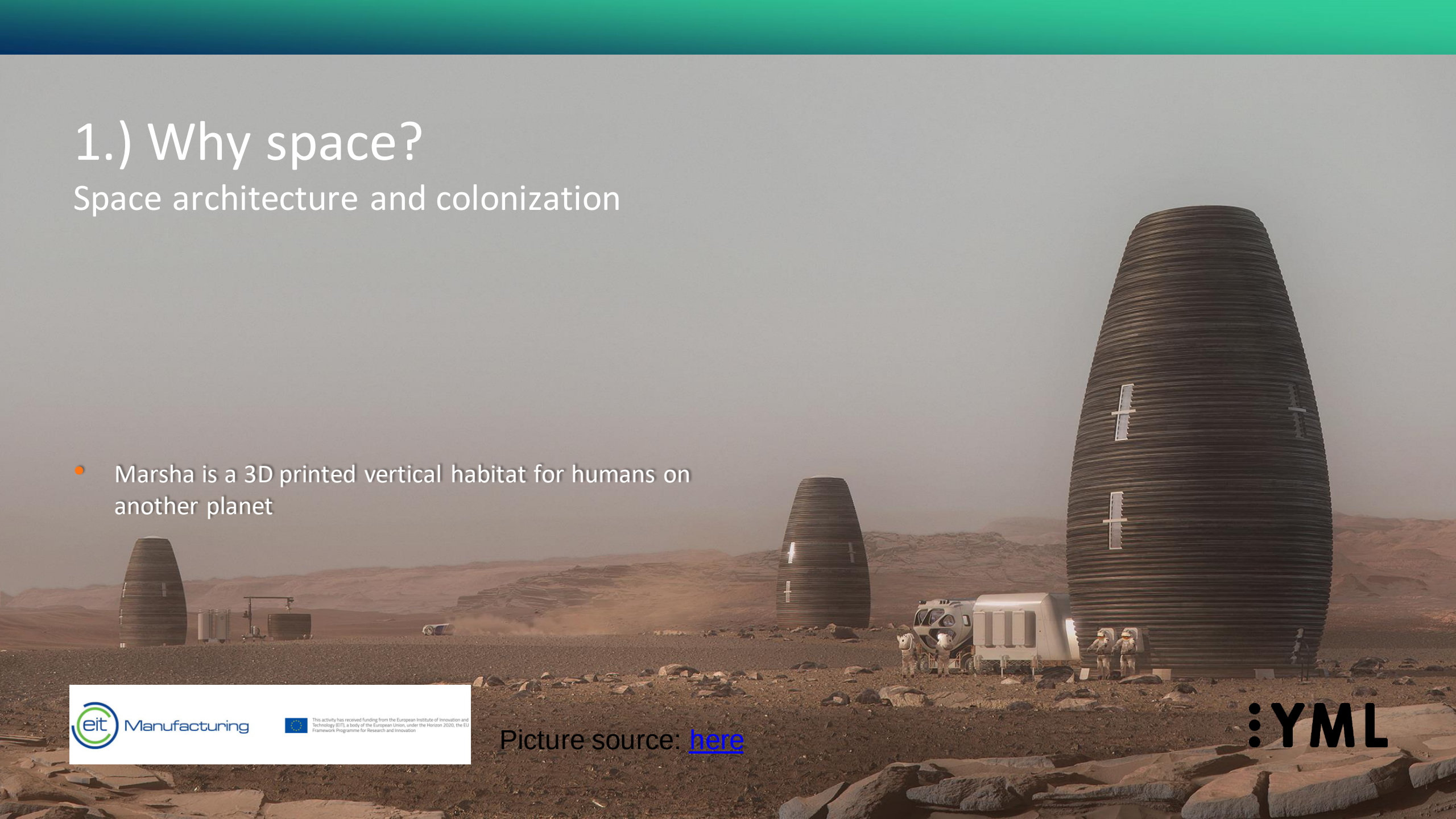
1.) Why space?

Space architecture and colonization

- Marsha is a 3D printed vertical habitat for humans on another planet



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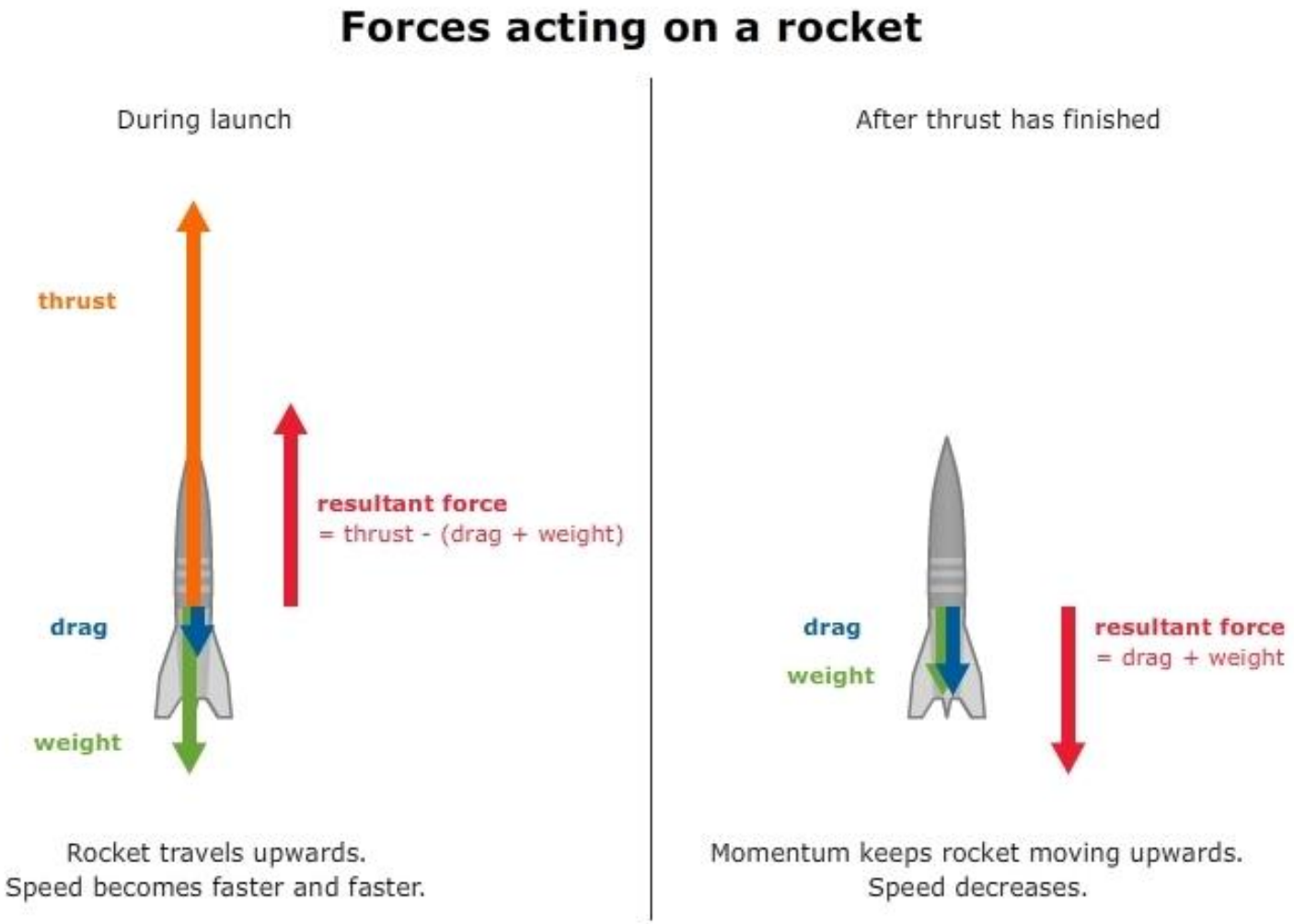
2.) Basic principles

Forces

- The rocket needs to overcome the gravitational force of its weight and the aerodynamical drag
- The resultant force is sum of all the forces acting on an object



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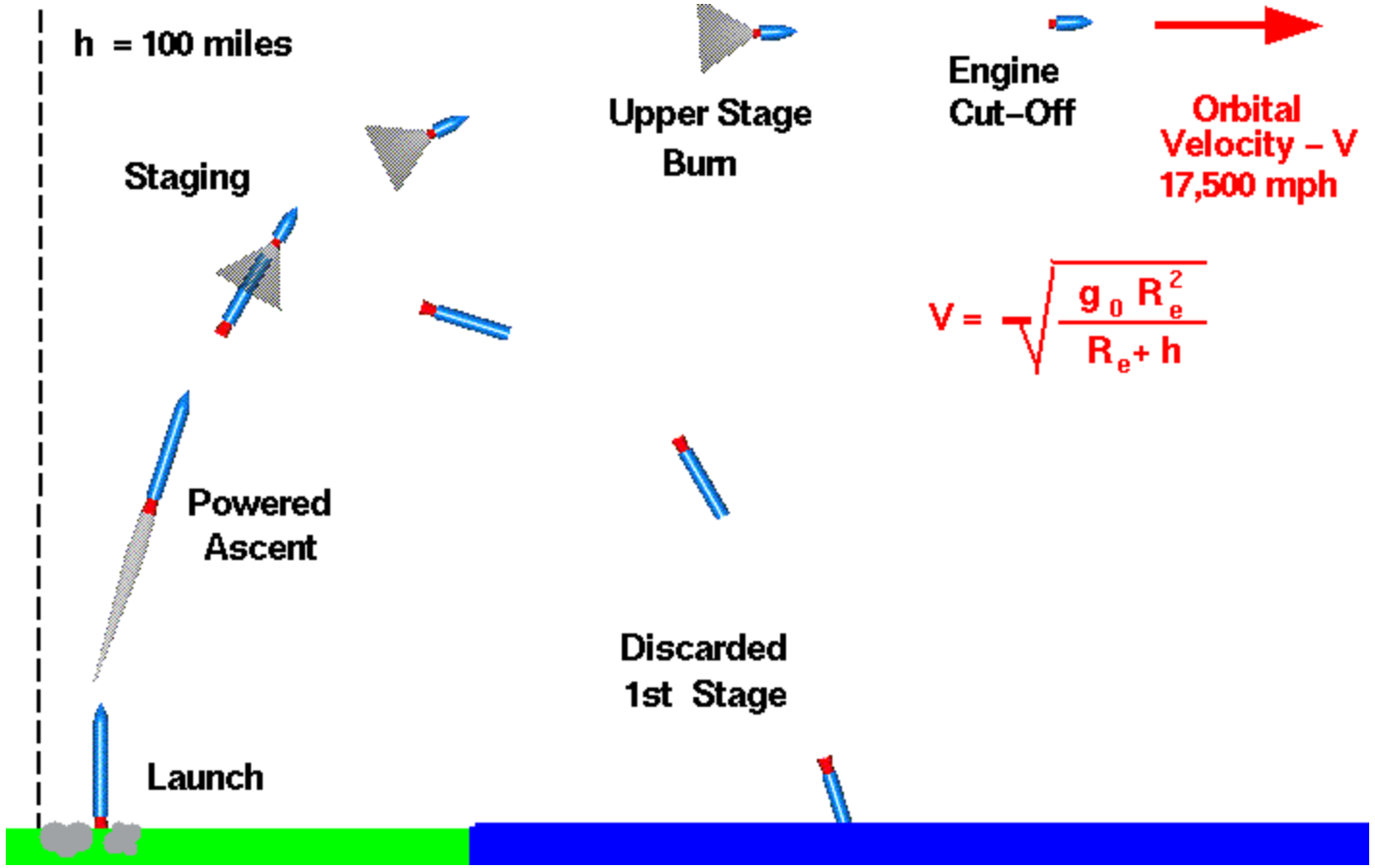
2.) Basic principles

Orbit

- Once the rocket reaches the orbit it needs to be moving at orbital velocity
- Otherwise it would fall back to the Earth
- The thrusters are deployed in several stages in order to save mass in the higher altitudes



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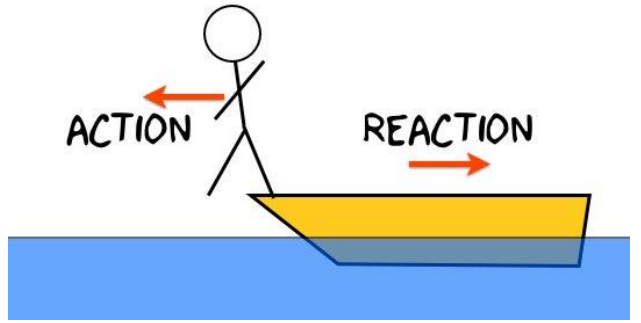
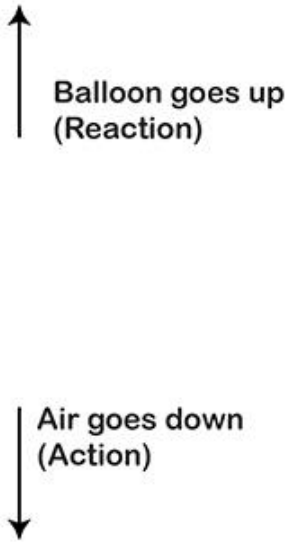
2.) Basic principles

Newton's 3rd law



- Newtons 3rd law enables sending objects to space
- Rockets are pushing hot gas at high velocities just like balloons are blowing air which moves them forward



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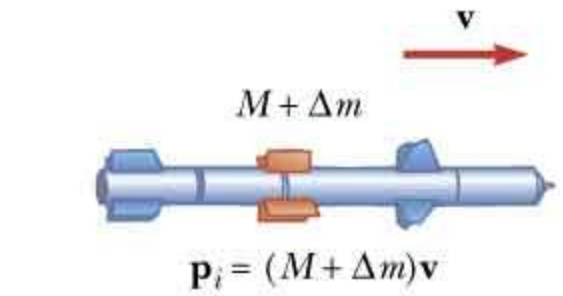
2.) Basic principles

Conservation of momentum

- The basic concept of conservation of momentum allows us to derive the famous ROCKET EQUATION
- The terminal velocity is dependent on the exhaust velocity from the rocket nozzle and on the initial mass of the rocket including the fuel

$$v(t) = v_0 + v_e \ln \frac{M_0}{M(t)}$$



Picture source: here

2.) Basic principles

Means of transportation

- Energy density of fuel options dictates how much payload we can get from the surface of the Earth
- Our daily commute is considerably more efficient than any rocket launch ☺

Implications to Design

	Percent Propellant	Percent Payload	
Queen Mary	3	30-60	Surface
My Pickup	4		
Locomotive	7		
Fighter Jet	30	20-40	Air
Cargo Jet	40		
Rocket	85	2	Space
Molotov Cocktail	54	-	Explosive

Rocket Equation

Results for Earth Orbit

Propellant	Mass Percent Propellant	Percent Payload
Solid Rocket	96	
Kerosene-O_2	94	
Hypergols	93	
Hydrogen-O_2	83	
Saturn V	85	4
Shuttle	85	1
Soyuz	91	2

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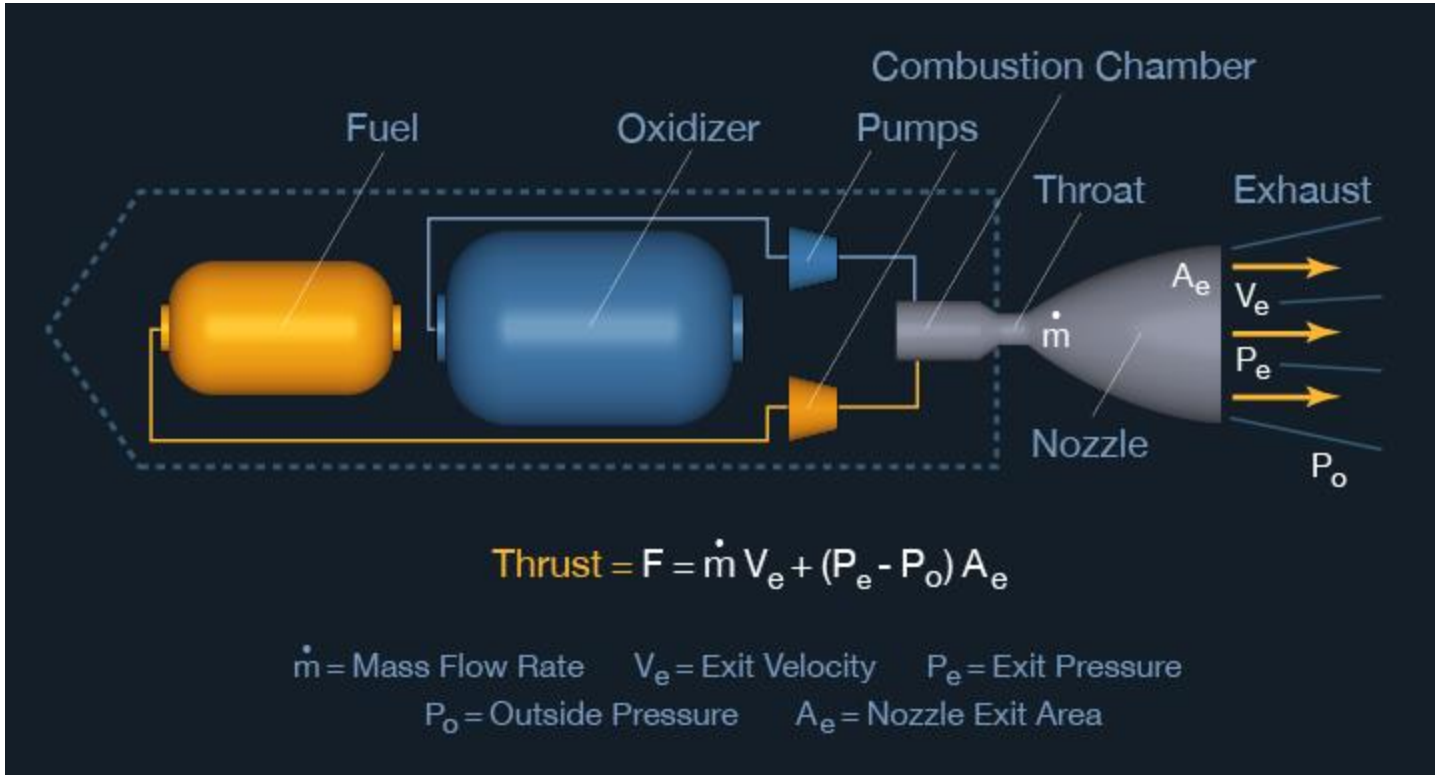
3.) Rocket Engines

Video source: here

3.) Rocket Engines

Thrust in liquid engines

- Fuel and Oxidizer are pumped to the combustion chamber at the highest rate possible
- They react together and expand rapidly towards the nozzle
- The tremendous flow of hot gas is accelerated in the throat



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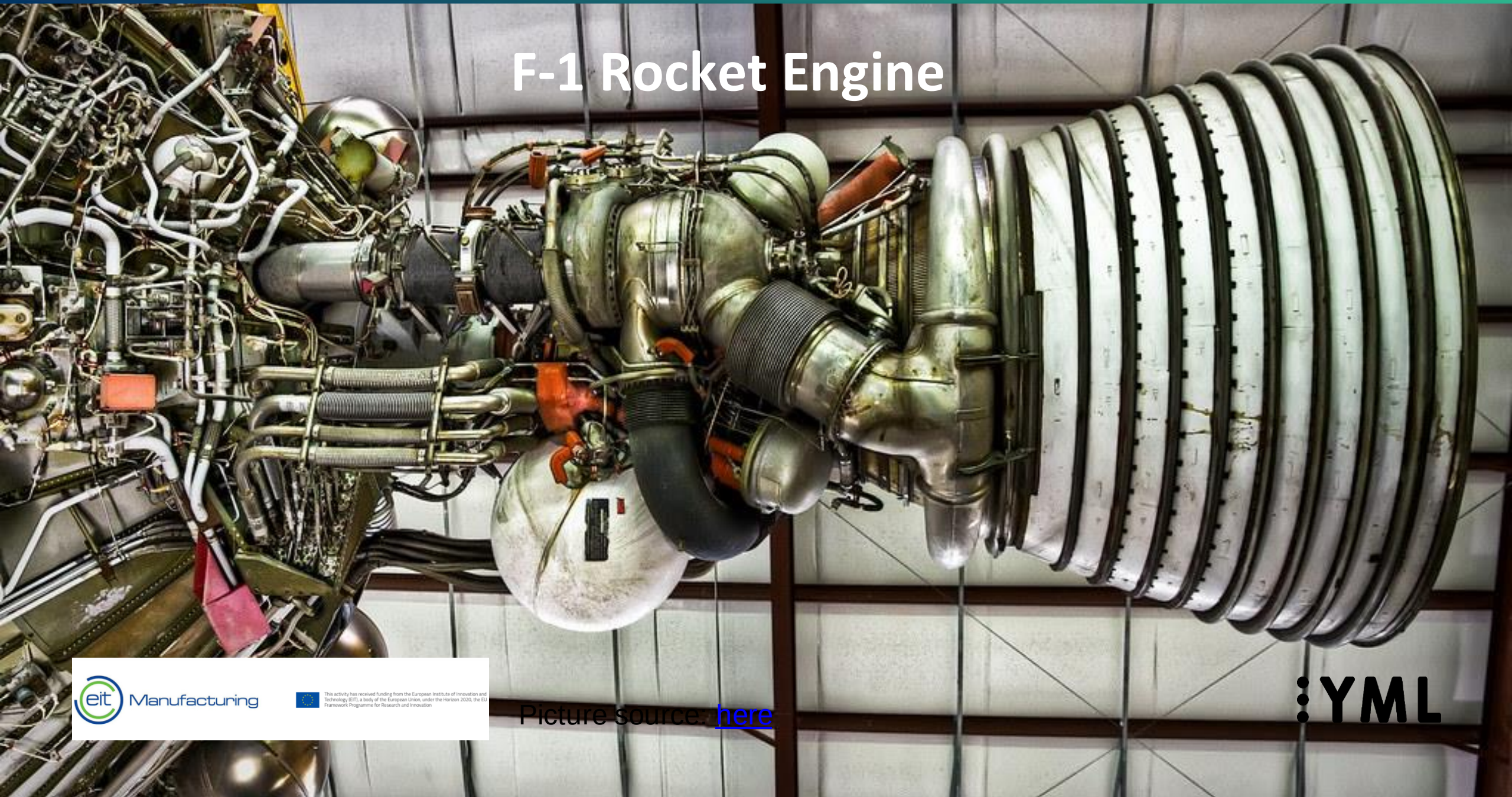
Picture source: here

F-1 Rocket Engine



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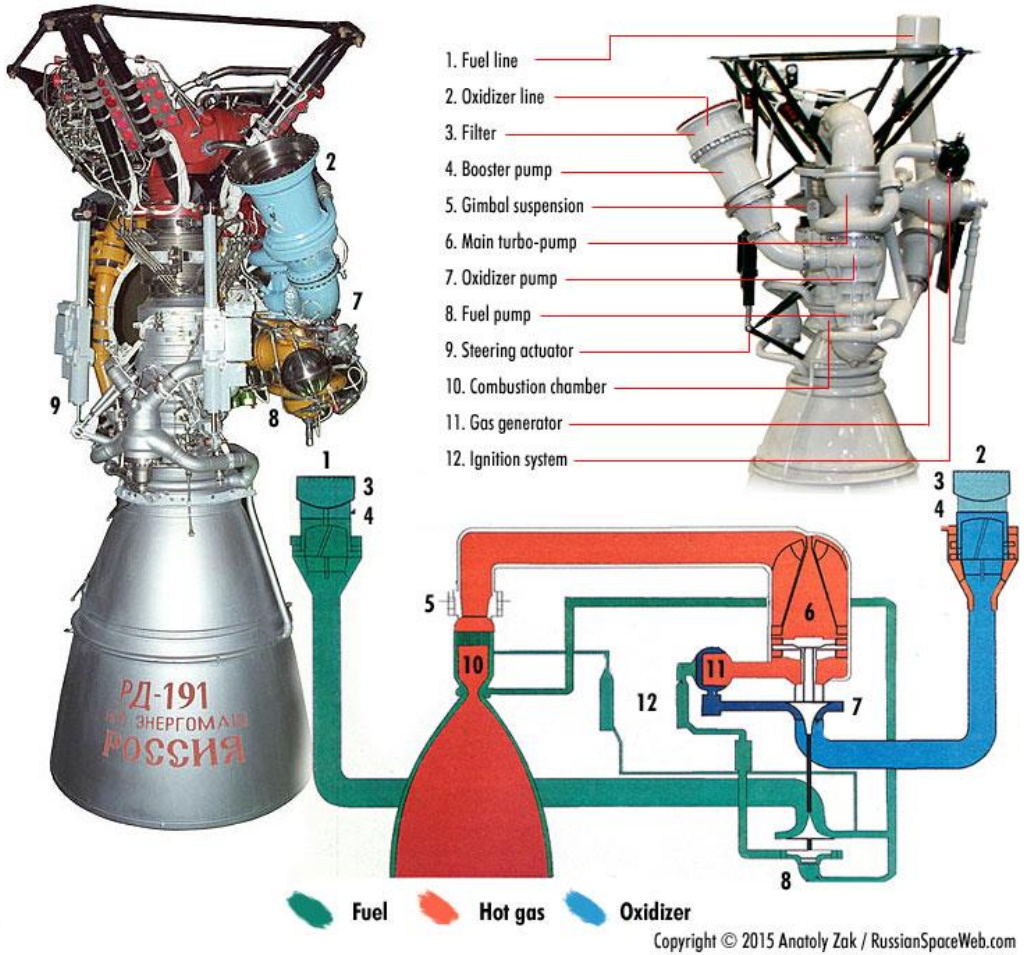
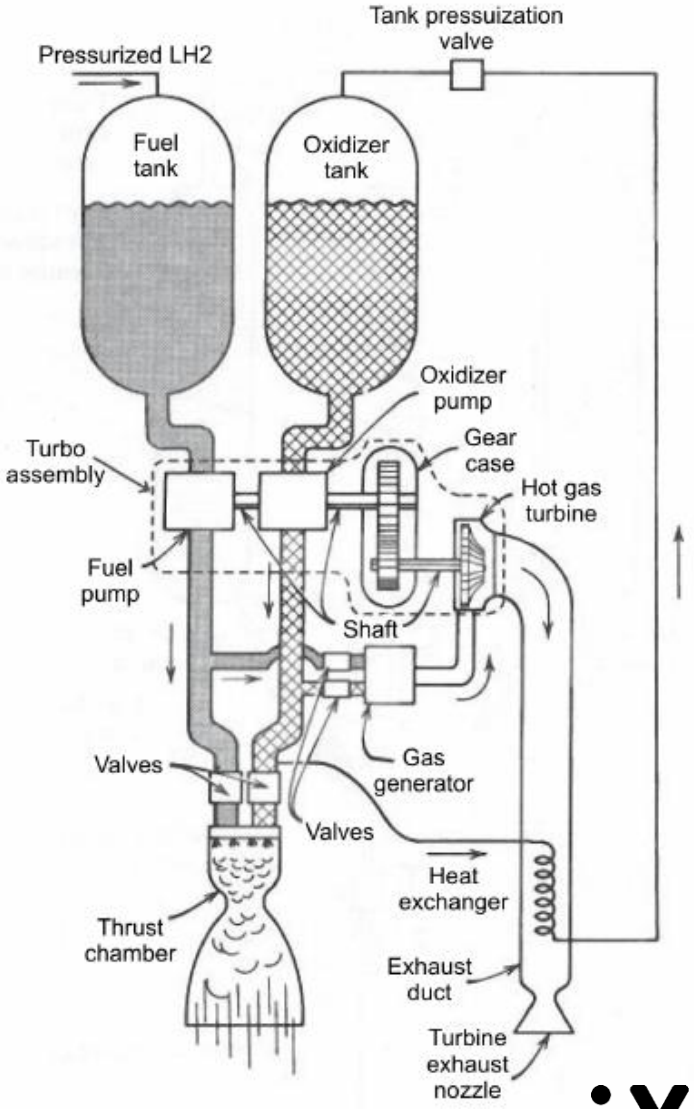
3.) Rocket Engines

Turbo pumps





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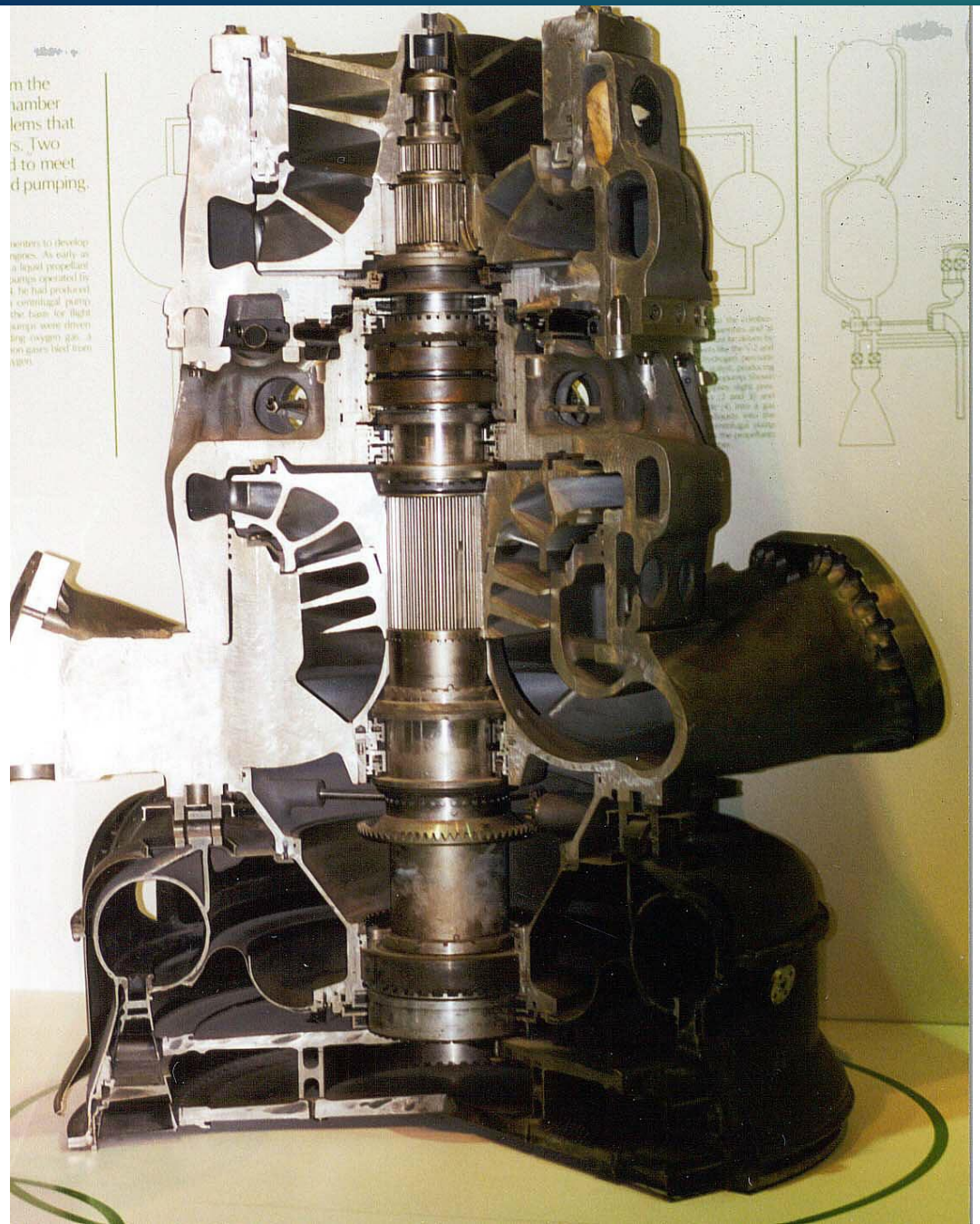

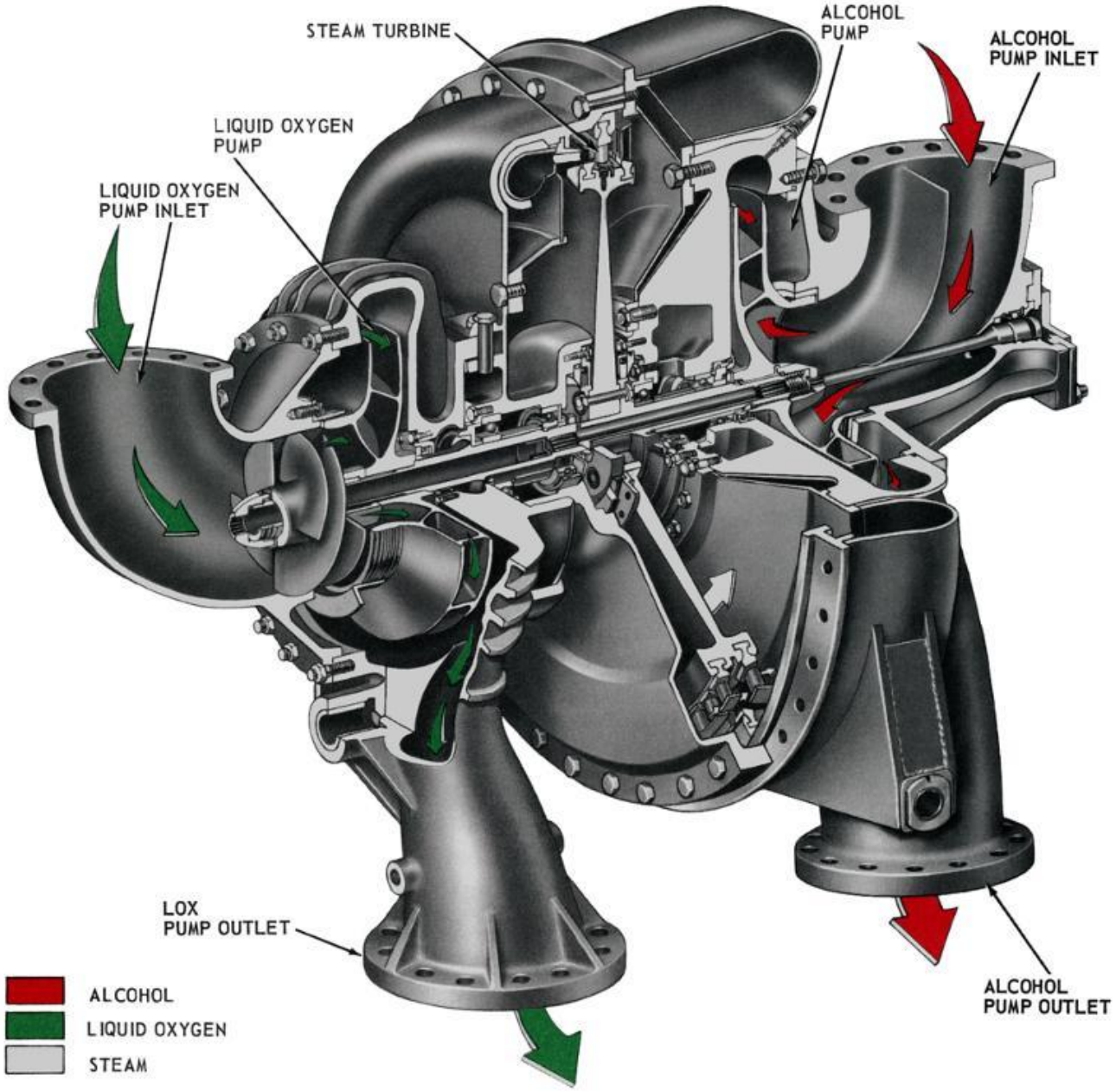

Figure V-4 – Operation of the Turbopump

Video source: here

4.) Do you want to do Rocket Science?

There is a great number of space agencies and private companies working in this field

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