The Future of Flight

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Space Program for Inspiration

Main Asteroid Belt
MISSION: Dawn
Tech: Ion Engines

Mars
MISSION: Curiosity
Tech: EDL

Earth
Tech: Hyperloop

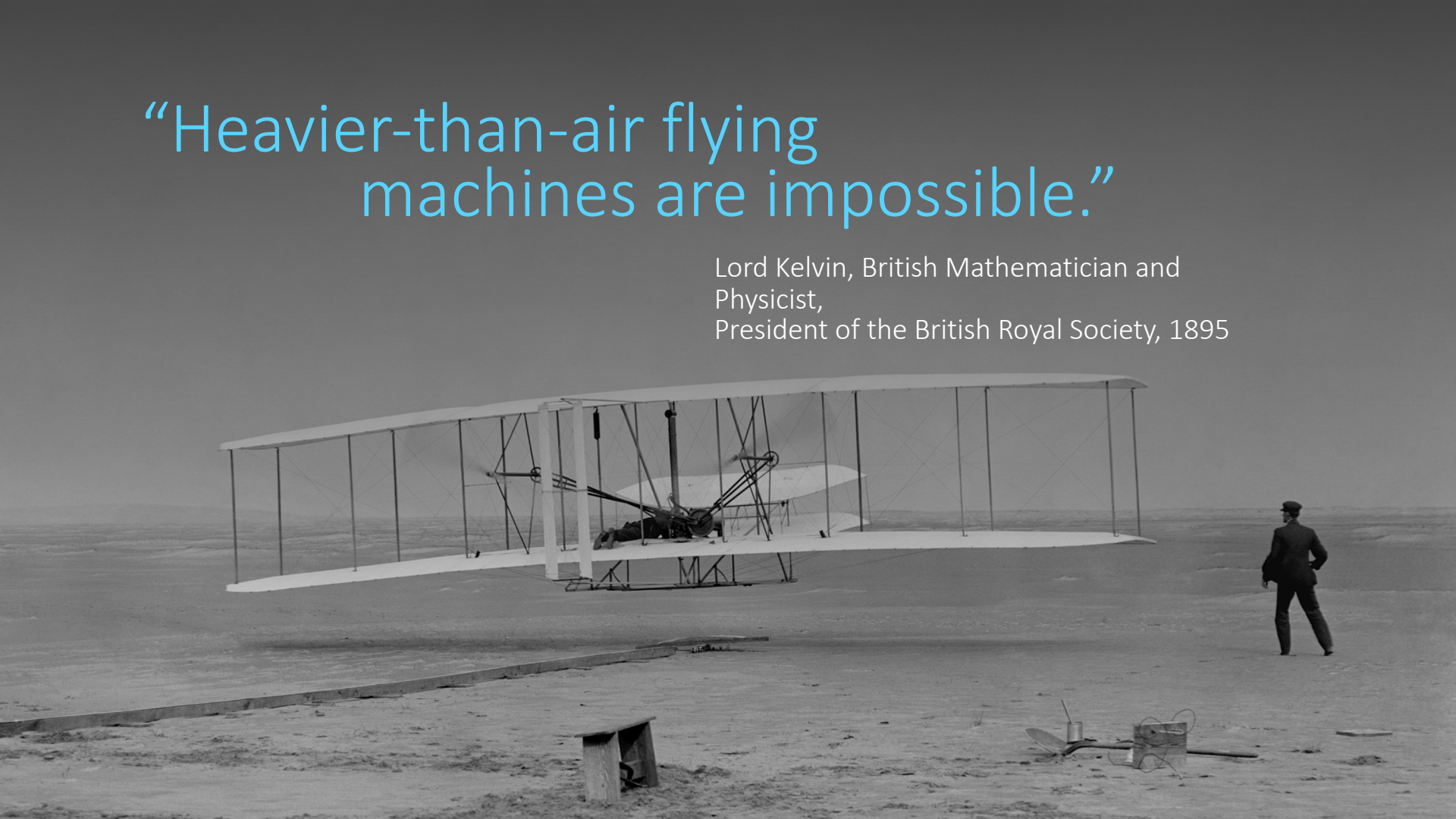
Space Program for Inspiration

Space Program for Inspiration

Climate Change at the Planetary Scale

“Heavier-than-air flying machines are impossible.”

Lord Kelvin, British Mathematician and Physicist,
President of the British Royal Society, 1895



Where We Are Headed?

Utopian Science Fiction

Where We Are Headed?

Dystopian Science Fiction?

THE PROBLEM

CARBON FOOTPRINT OF AVIATION IS ON THE RISE

BY 2050 AVIATION WILL BE A PRIME CONTRIBUTOR TO CO2 OUTPUT

INNOVATION IS NEEDED NOW TO MEET CLIMATE DIRECTIVES

$872B

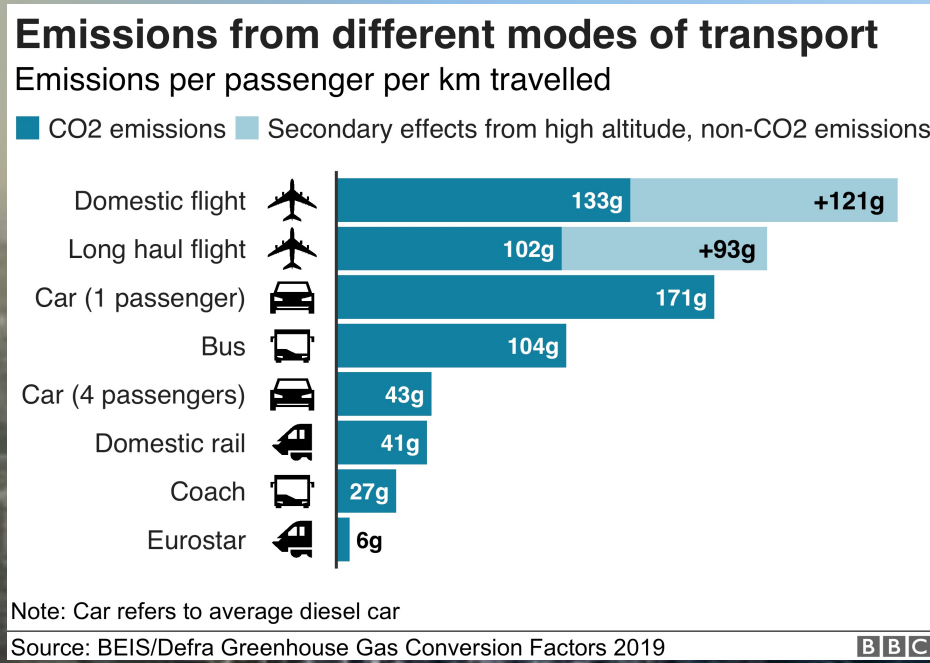
Commercial Aviation Revenue in 2020

32%

Increase in CO2 Emissions from Air travel over last 5 years

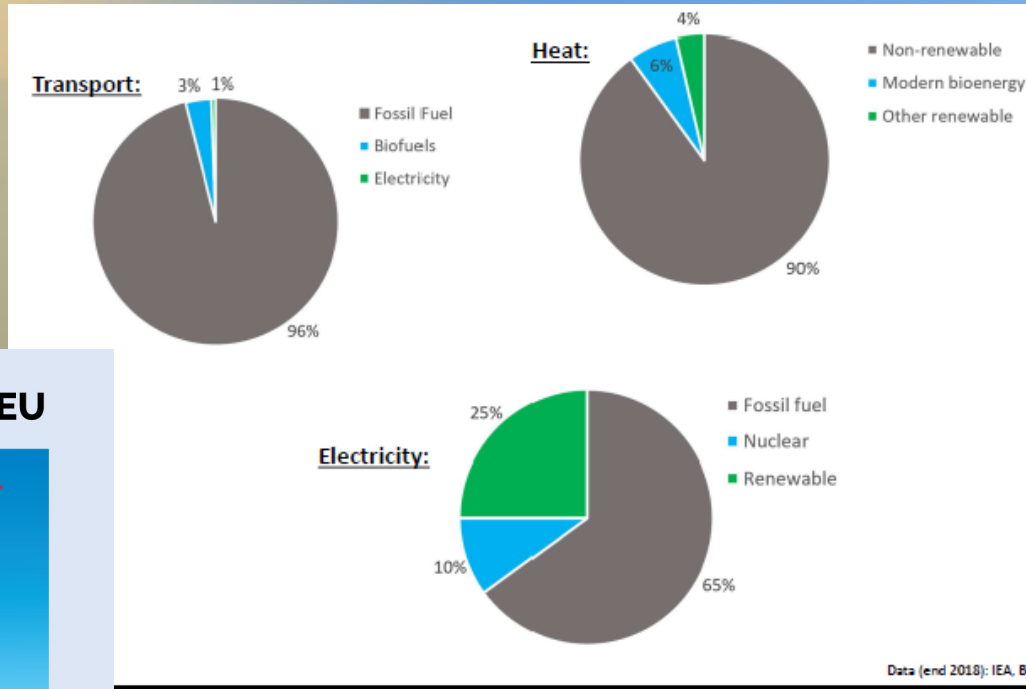
915 Mt CO_2

Major Contribution to Climate Change with secondary effects to ozone layer

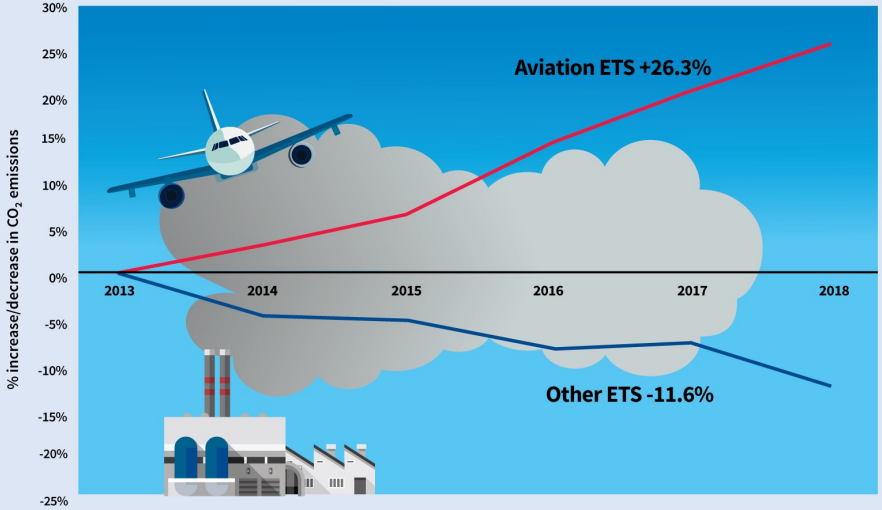


THE PROBLEM

AVIATION INNOVATION IS NEEDED NOW FOR 2050



Aviation emissions growth since 2013 in the EU



Note: For emissions that were not lodged on time, 2018 emissions have been set to 2017. For aviation, this assumption amounts to approximately 8% of the verified reported emissions.

Source: European Commission, 2019

TRANSPORT & ENVIRONMENT @transenv @transenv transportenvironment.org

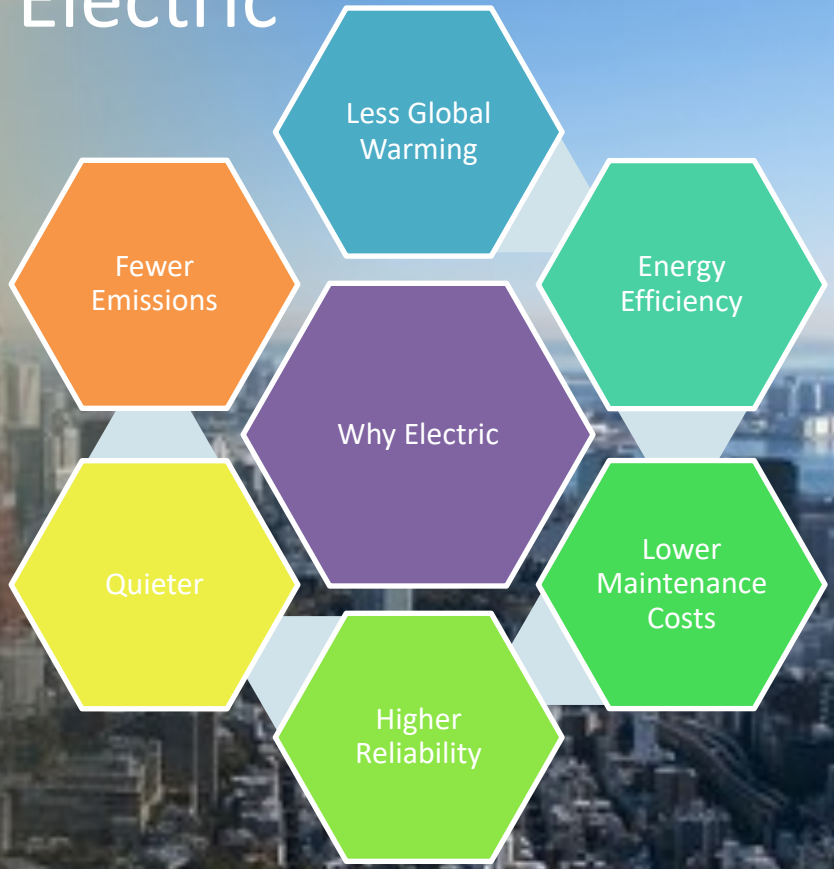
Sustainable = Electric

THE PROBLEM

BATTERIES ARE INCOMPATIBLE WITH MOST AVITAION USE CASES

BATTERY AIRCRAFT LIMITED TO LESS THAN 1 HR FLIGHT

BATTERIES DEGRADE AND HAVE LARGE CARBON FOOTPRINT



Evolutionary Use Cases for Electric Flight

Emergency Response

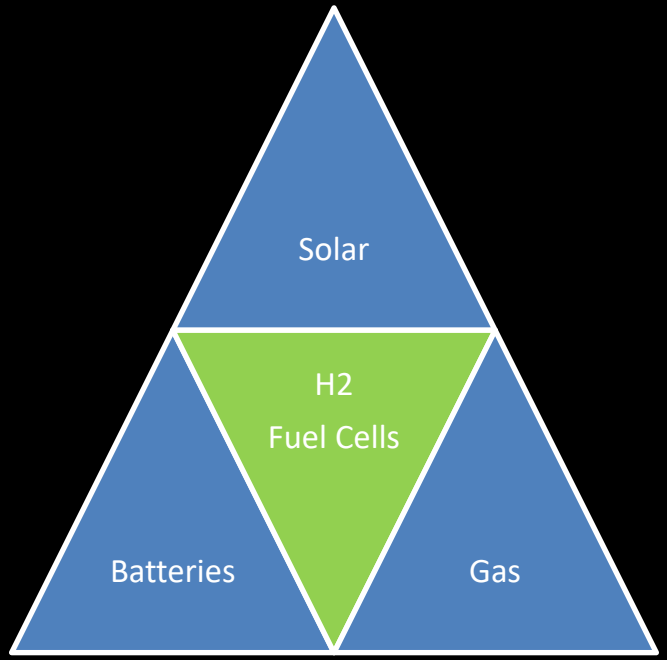
Cargo and Regional Transport

Air Taxis

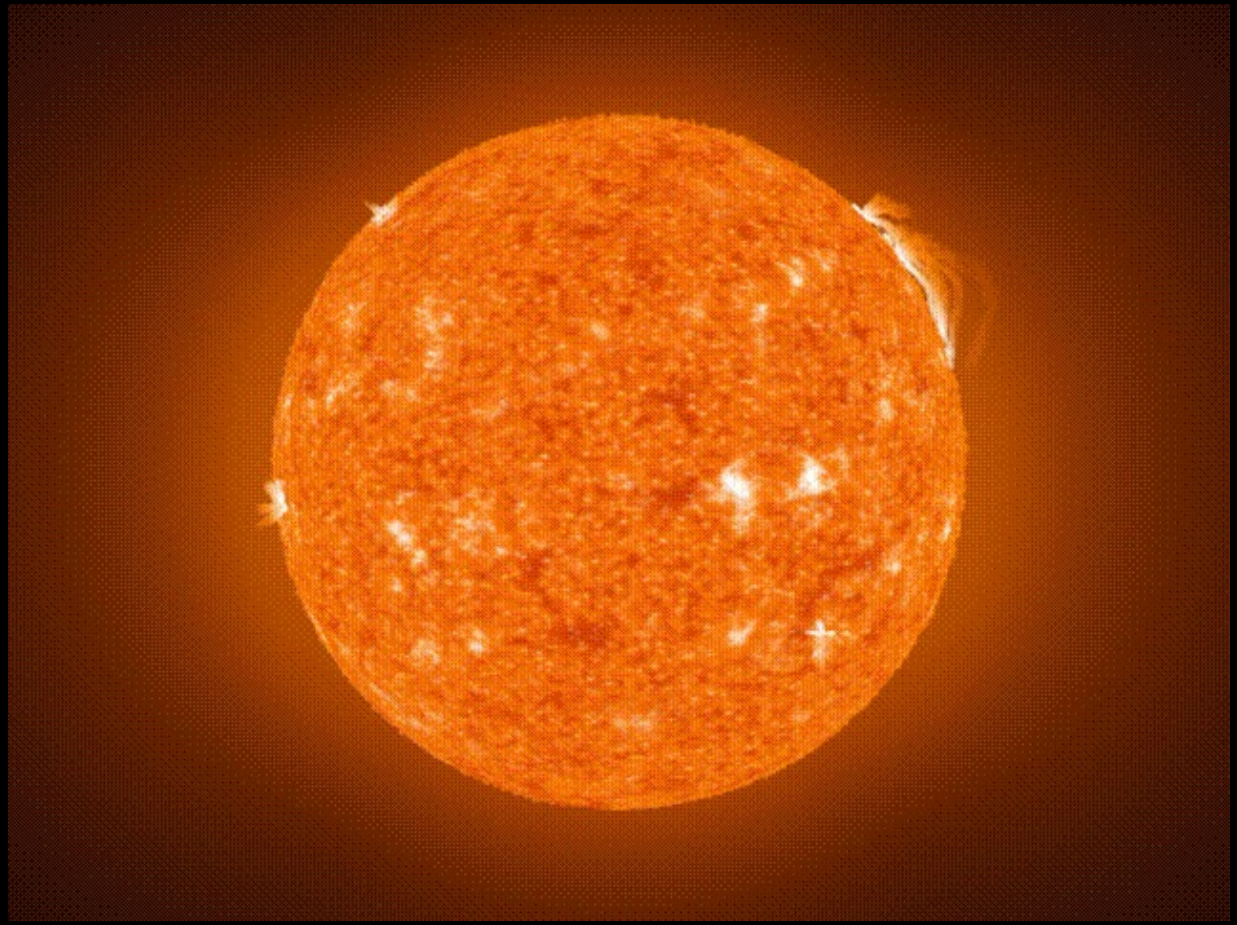
General Aviation

UAS Drones

Green Electricity to Support Energy Storage



Most Abundant Element in the Universe

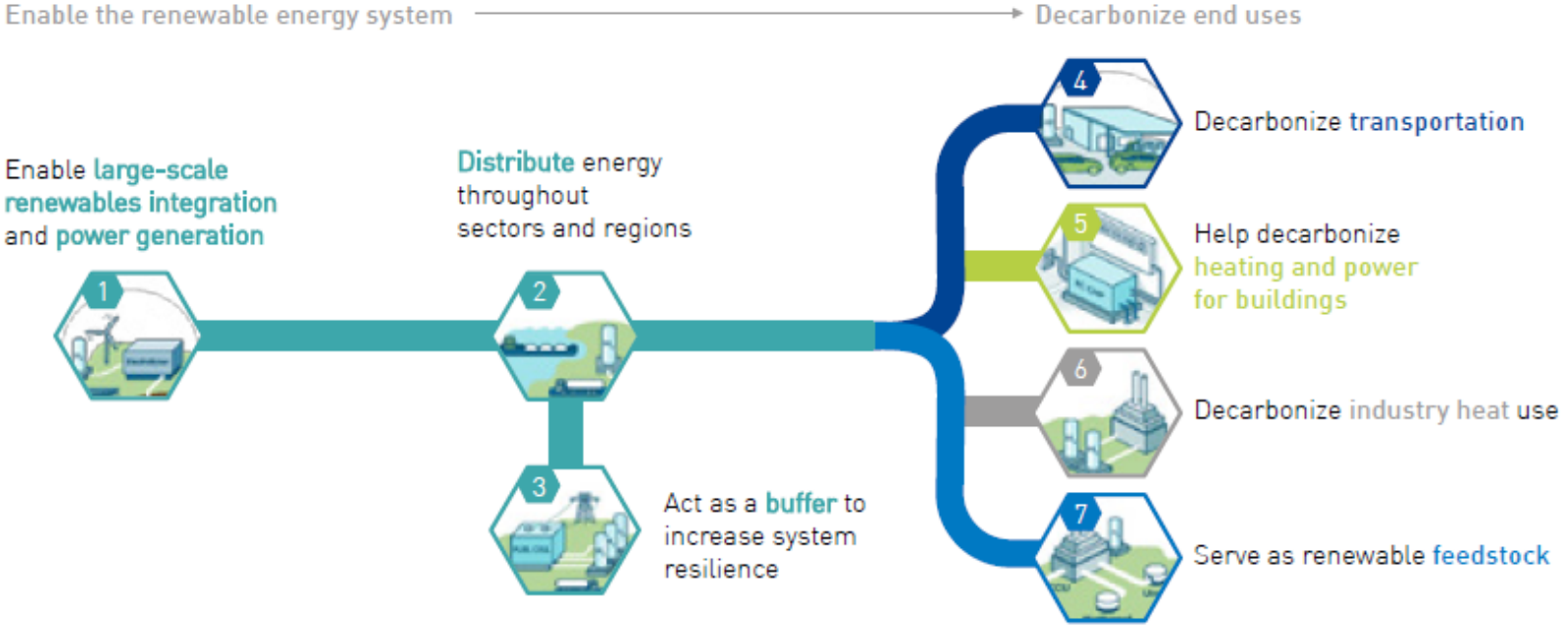


Electrolysis of Water To Make Hydrogen

Hydrogen means Water Genesis in Greek

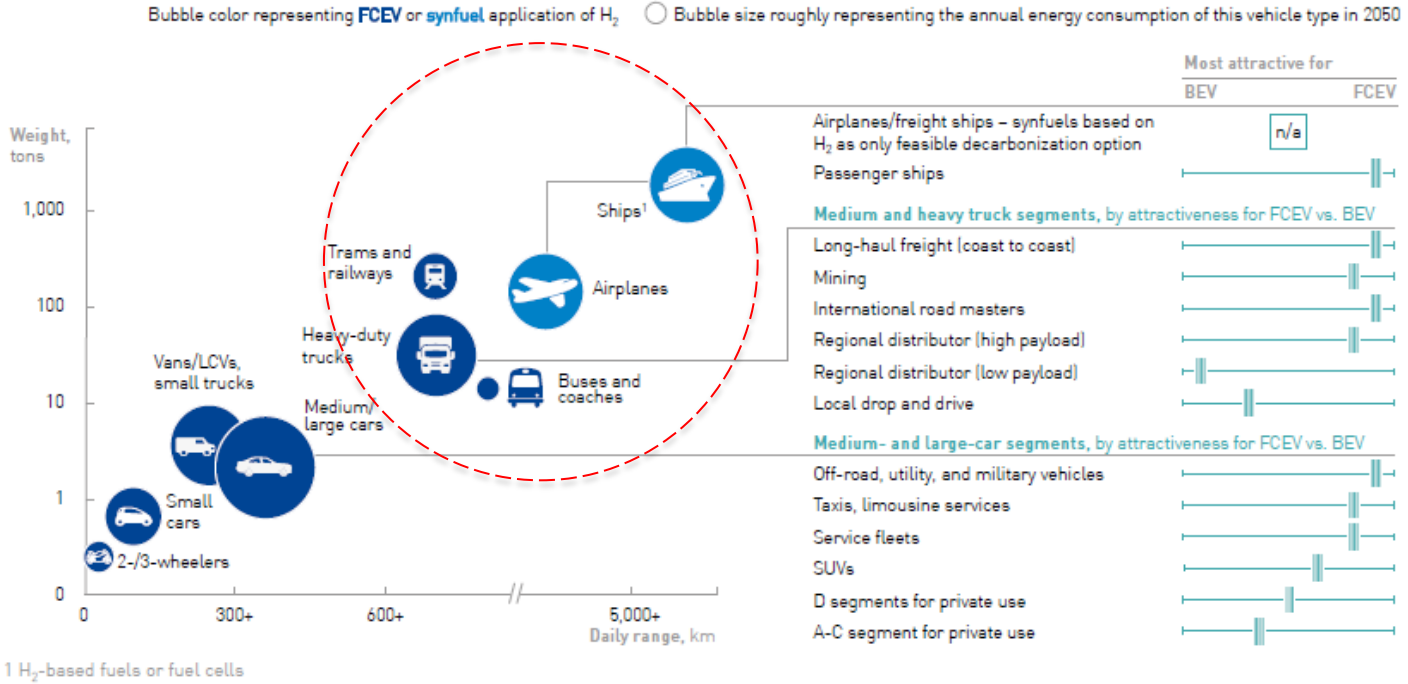
EU INVESTMENT IN HYDROGEN AS ENERGY ENABLER

EXHIBIT 4: HYDROGEN AS ENABLER OF THE ENERGY TRANSITION IN EUROPE



EU INVESTMENT IN HYDROGEN AS ENERGY ENABLER

EXHIBIT 10: COMPARISON OF RANGE, PAYLOAD, AND PREFERRED TECHNOLOGY



1 H_2-based fuels or fuel cells

THE HYDROGEN FUEL CELL ECONOMY

Aviation Auxiliary Power Unit (APU)

- Jet aircraft APU
- Global Hawk APU

UAS

- Cargo drone or surveillance drone electric propulsion
- Range extension for all UAS

Marine

- Electric Propulsion
- Diesel generator replacement
- Water supply

Automotive

- Buses
- SUVs
- Trucks

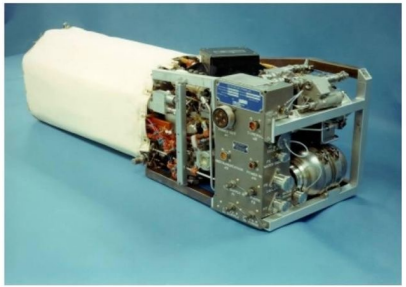
Space/ Hyperloop

- Passenger pod power
- Pod side propulsion
- Satellite Power
- Human Space Exploration

Hydrogen Fuel Cells In Space Program

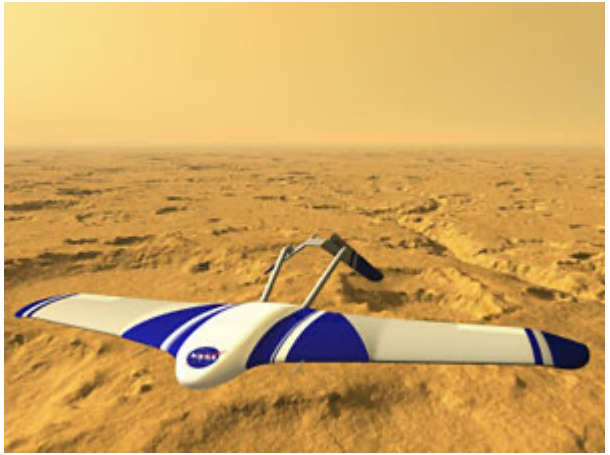
H2 -training
www.h2training.eu

Fuel cells for NASA space programme

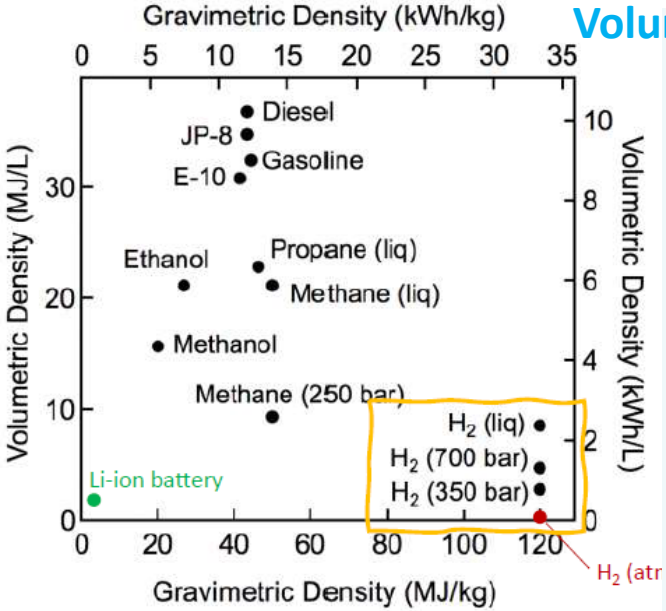


Nasa Space Shuttle Orbiter fuel cell. One of three fuel cells aboard the Space Shuttle. These fuel cells provide all of the electricity as well as drinking water when Space Shuttle is in flight. It produces 12 kilowatts electricity adn occupies 154 litres (Source: NASA).

B

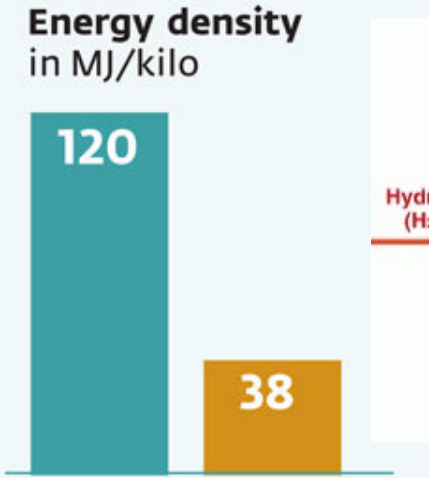


Making Electricity from Hydrogen: Opportunity and Challenges

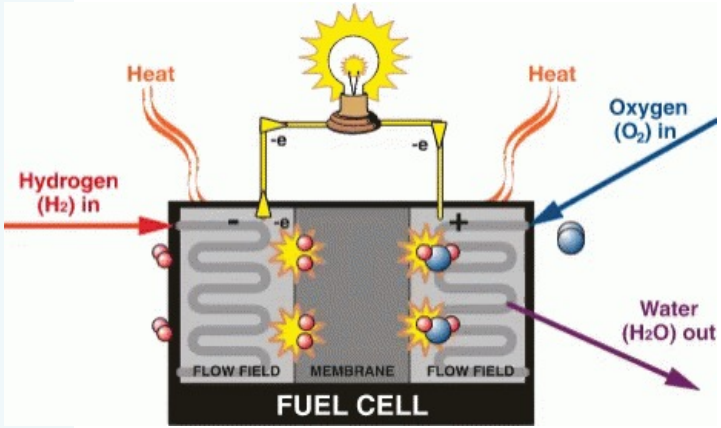


Mass

Volume



Electrical Efficiency



Water Exhaust

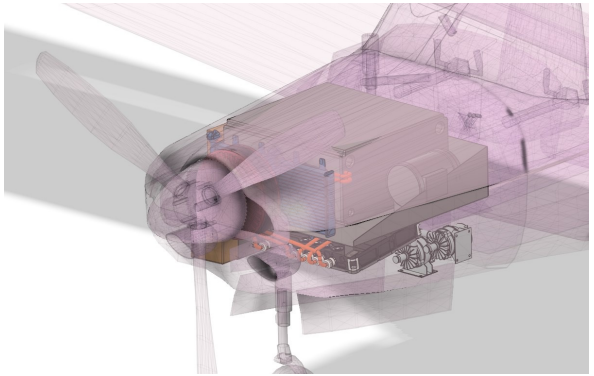
HYDROPLANE

THE FLIGHT PLAN TO EMISSION FREE AVIATION:

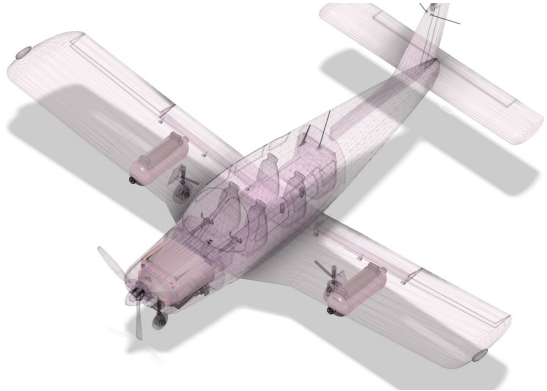
HYDROGEN FUEL CELL POWERPLANT FOR AVIATION

OUR FLIGHT PLAN

- ✓ Obtain Government Customer and Funding
- ✓ Design Aviation Specific Modular Hydrogen Fuel Cell Powerplant (up to 1 MW)
- ✓ Conduct Test Flights
- ❑ Humanitarian Aid Disaster Relief Operations
- ❑ Powerplant Production and Sales to OEMs



HYDROPLANE: PROTIUM AIRCRAFT



Range: 1000 km

Cruising speed: 210 kph

Aircraft Type: Single Engine Land

Mission: HADR / Air Taxi

Payload: 350 kg

Pilot: Commercial SEL

Power System: H_2 Fuel Cell Electric Propulsion

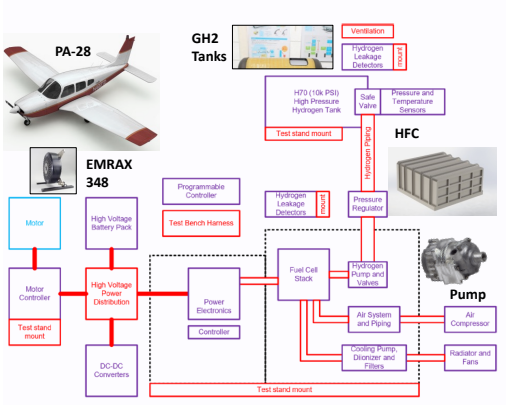
Platform	Urban	Rural	Regional
HYDROPLANE	✓	✓	✓
Jet	✗	✗	✓
eVTOL	✓	✗	✗

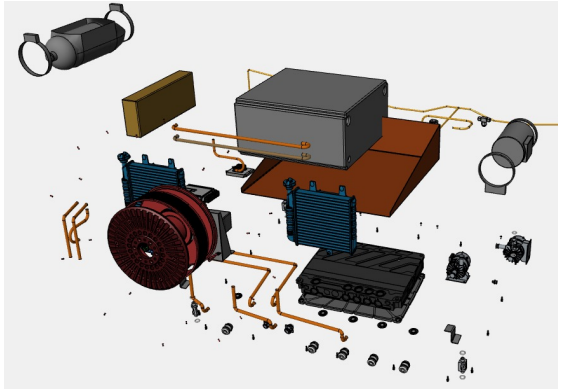
EMISSION FREEE | REGIONAL RANGE | RAPID CERTIFICATION

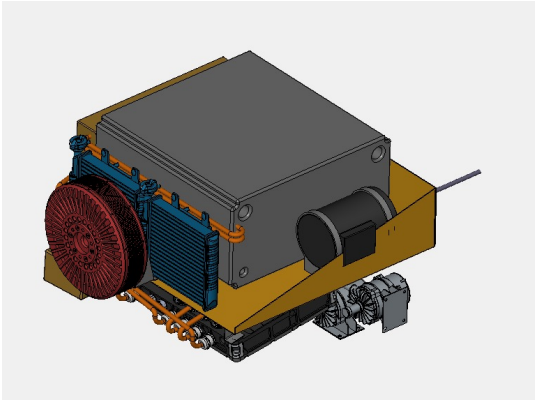
Prototype 2021 → **Demonstrator 2022** → **Production 2023**

TRL3 POC | TRL4 Lab Demo | TRL5 Iron Bird | TRL6 Flight | TRL8 Cert | TRL9 Operational

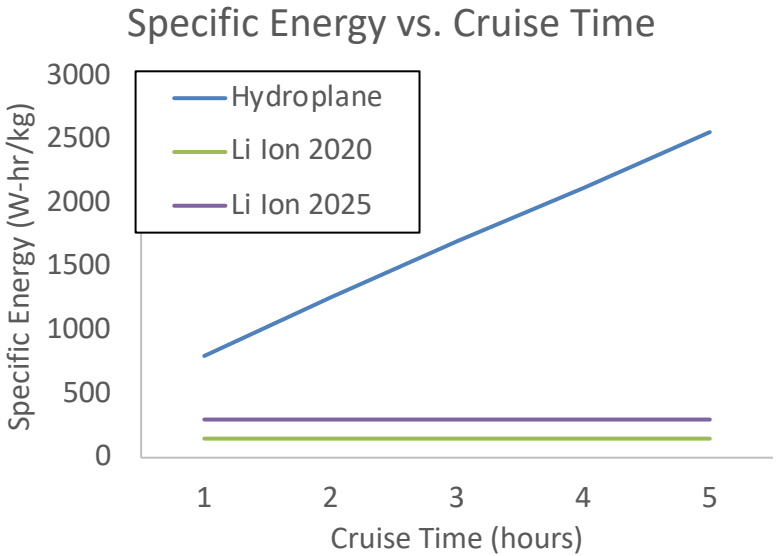
HYDROPLANE: R&D Facility at Fox Field (Los Angeles North Desert)

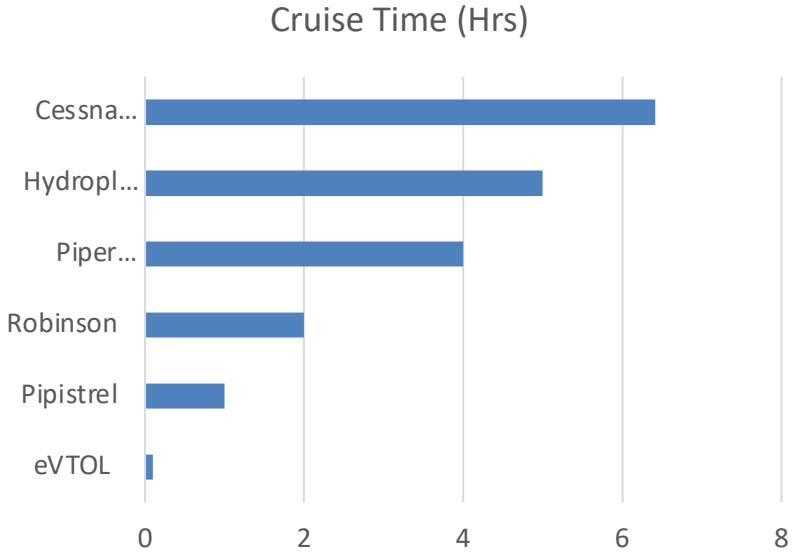






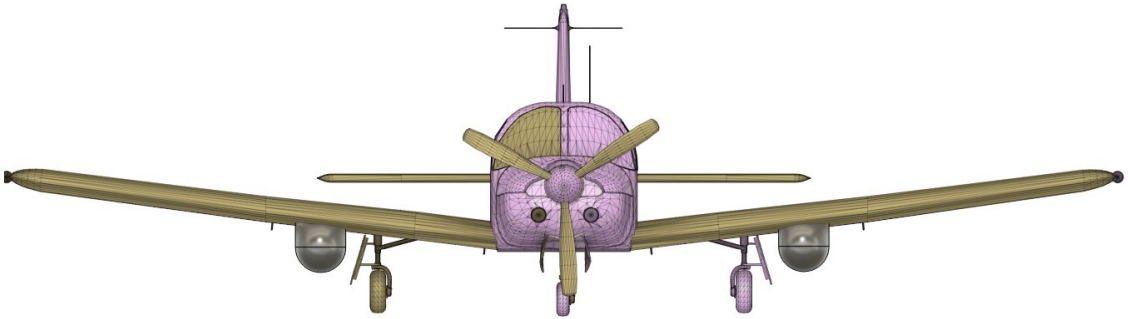
ELECTIC AIRCRAFT WITH AVGAS RANGE

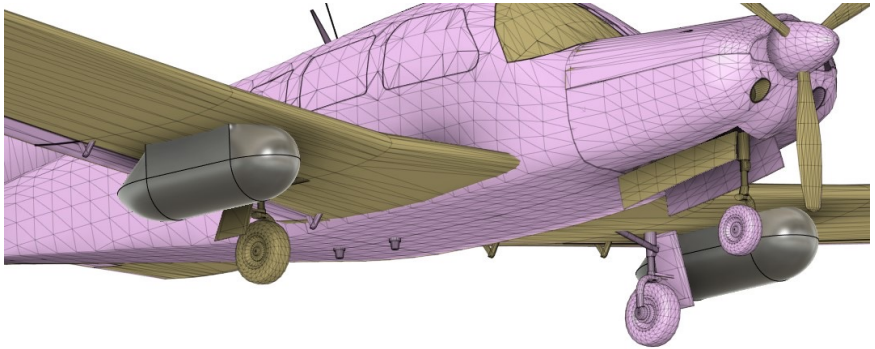




HYDROPLANE

CURRENT GOAL: Hydrogen Powered Aircraft for Humanitarian Aid and Transport





HYDROPLANE

NEXT GOAL: Hydrogen Powered Jet, Hydrogen Container Ships

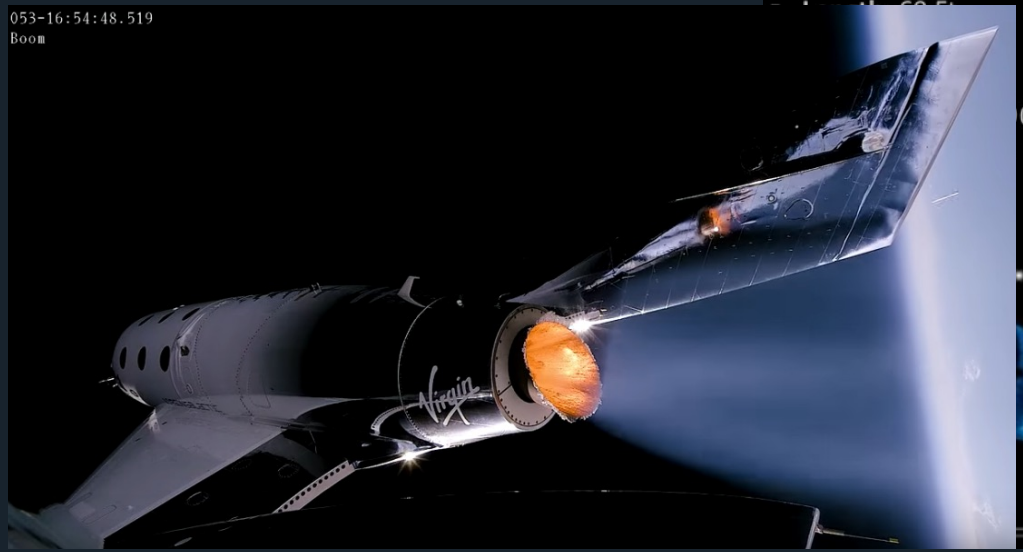
HYDROPLANE

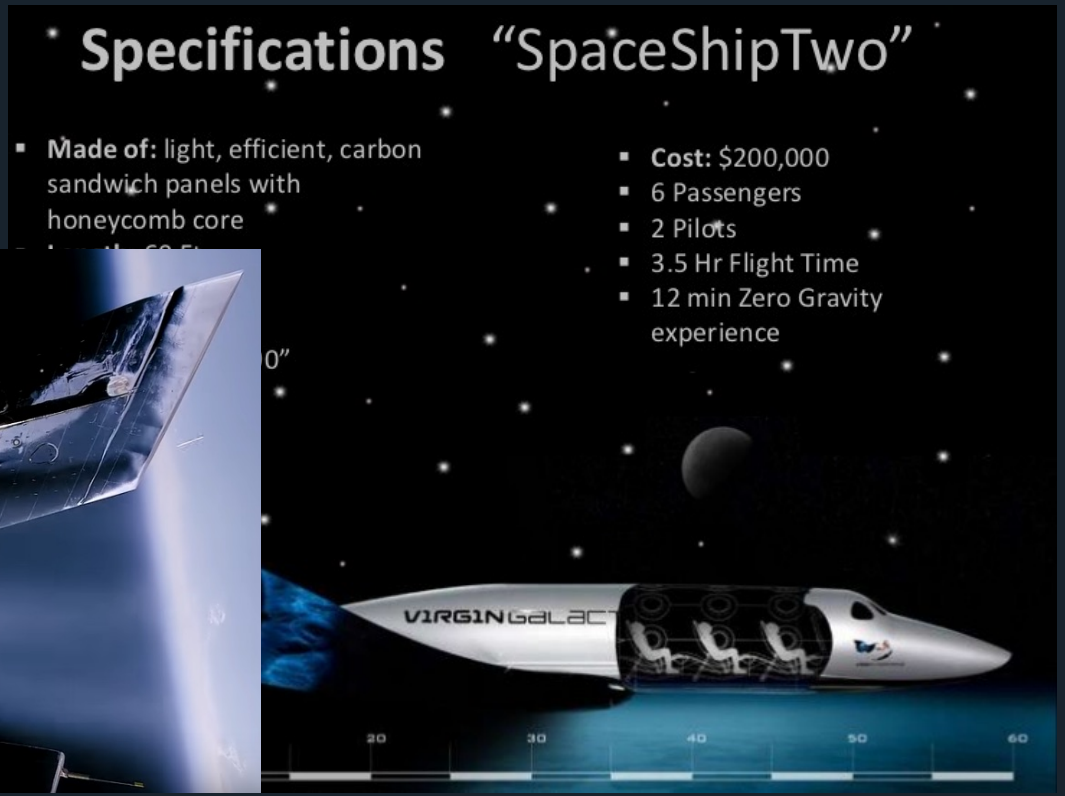
FUTURE GOAL: Fuel Cells for Human Mars Base

What Comes Next

Suborbital Flight: Hydrogen Powered

Suborbital Flight: Not Hydrogen Powered





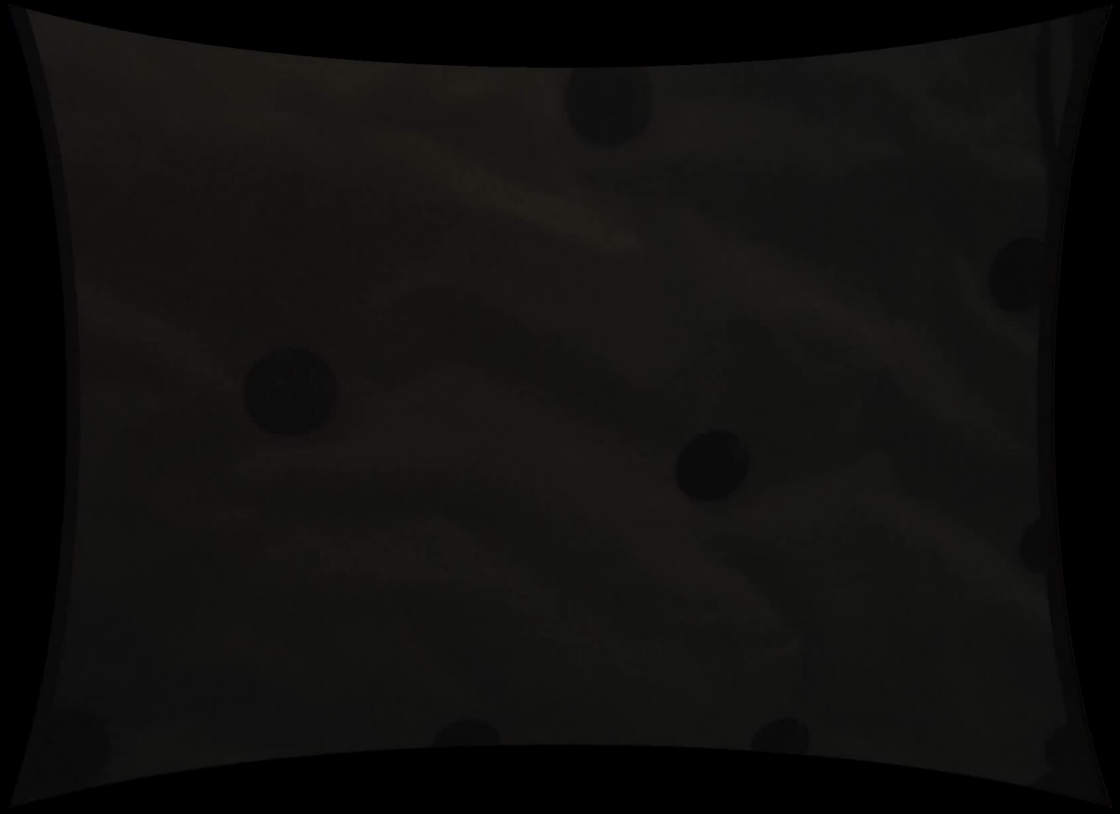
Low Earth Orbit: Can be Hydrogen Po

Interplanetary Cruise

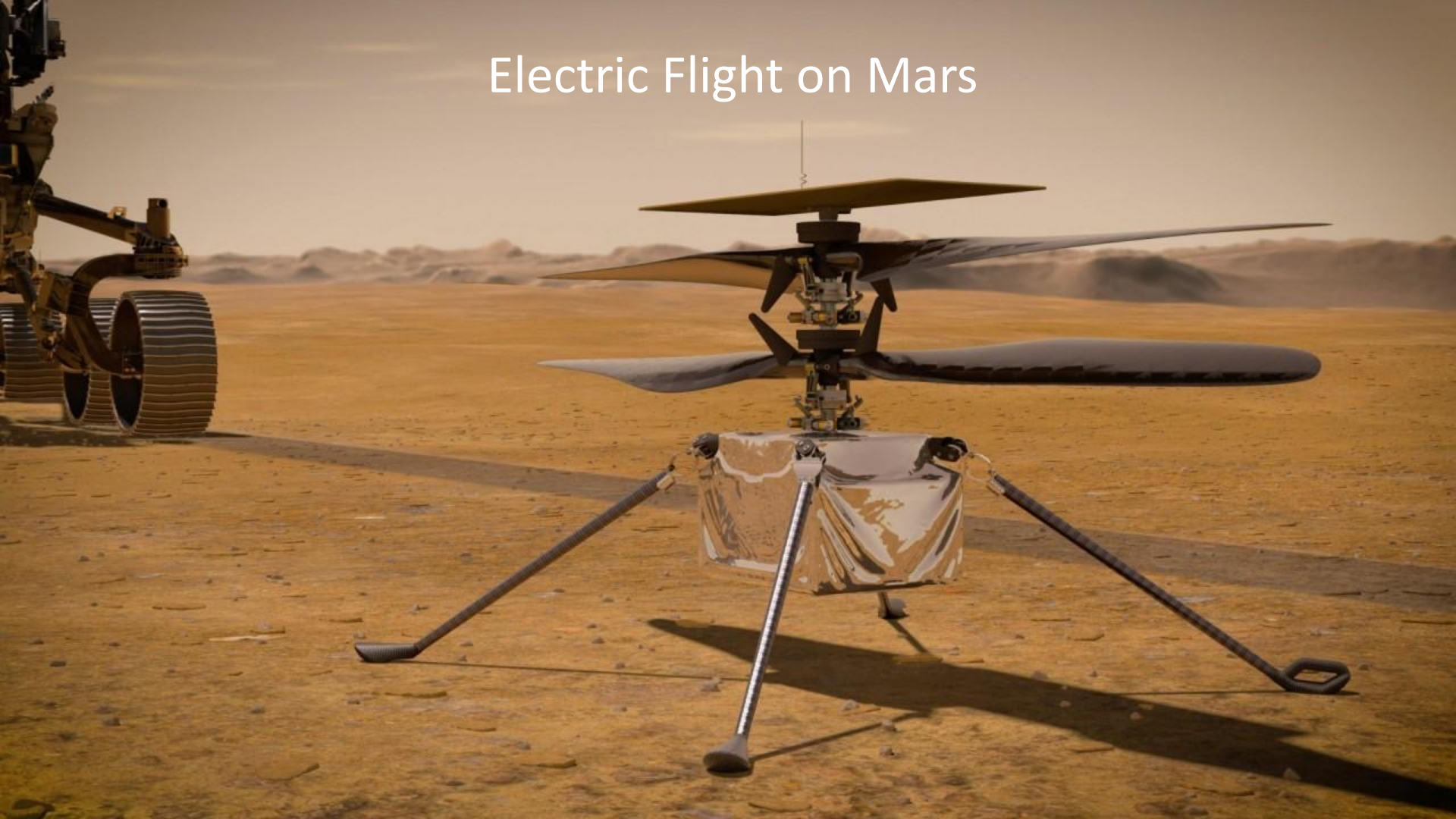
Space Flight To and On Other Planets

Flight on Mars

Actual Flight on Mars



Electric Flight on Mars



Electric Flight on Titan

Return to the Moon

Green Technologies to Connect the World

QUESTIONS

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