Be green, keep flying

USAIRE Student Awards 2020 – 4th laureates

AIAA Los Angeles, Celebrate Earth Day – 24/04/2021

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The presentation

- 40 minutes presentation + 10 min Q&A
- Questions ? Don't hesitate to submit them

- We will do our best for our English

Introduction

1. Who we are ?
2. What is the USAIRE Student Awards ?
3. Why did we choose to think about this topic ?

Introduction

Who we are ?

Ms. Christine LIN
Student, Mechanical Engineering Program
University of Technology of Compiegne (UTC)

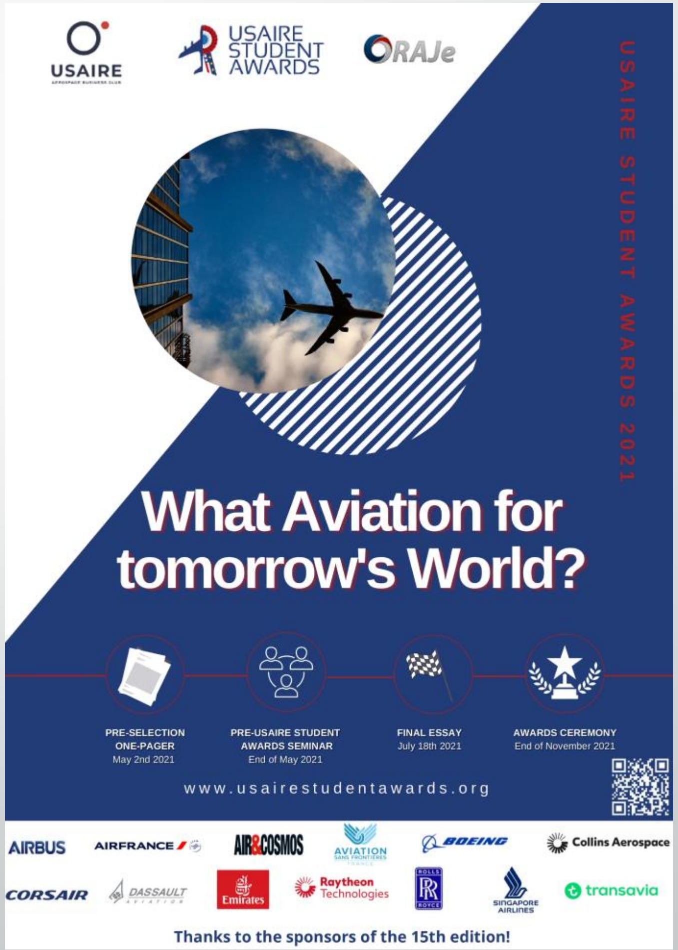
Mr. Chiu-Yüeh BLAISE
Aeronautical Engineer with a double degree from
the University of Compiegne (UTC) and Cranfield University

- Aviation enthusiast
- Several student societies
- French international air cadet
- Actual and future young professionals

Introduction

What is the USAIRE Student Awards?

- An annual international competition
- Designed by USAIRE
- Since 2006
- Give students an opportunity to
  - Awake their spirit of innovation
  - Get closer from Aerospace and Defense stakeholders.



Introduction

Why did we choose to think about this topic ?

2-3,5 %
Global CO2 emissions

4 %
Traffic growth /year

1. New technologies
2. Infrastructures and implemented measures
3. Political, social or financial changes

New technologies

1. New propulsive energy
2. Aircraft structure improvements
3. Systems

New technologies

New propulsive energy

- A decrease in :
  - Engine consumption,
  - Fuel consumption per passenger
- But
  - Less fuel in the world
  - An increasing flight demand

➢ **New propulsive energy needs to be found**

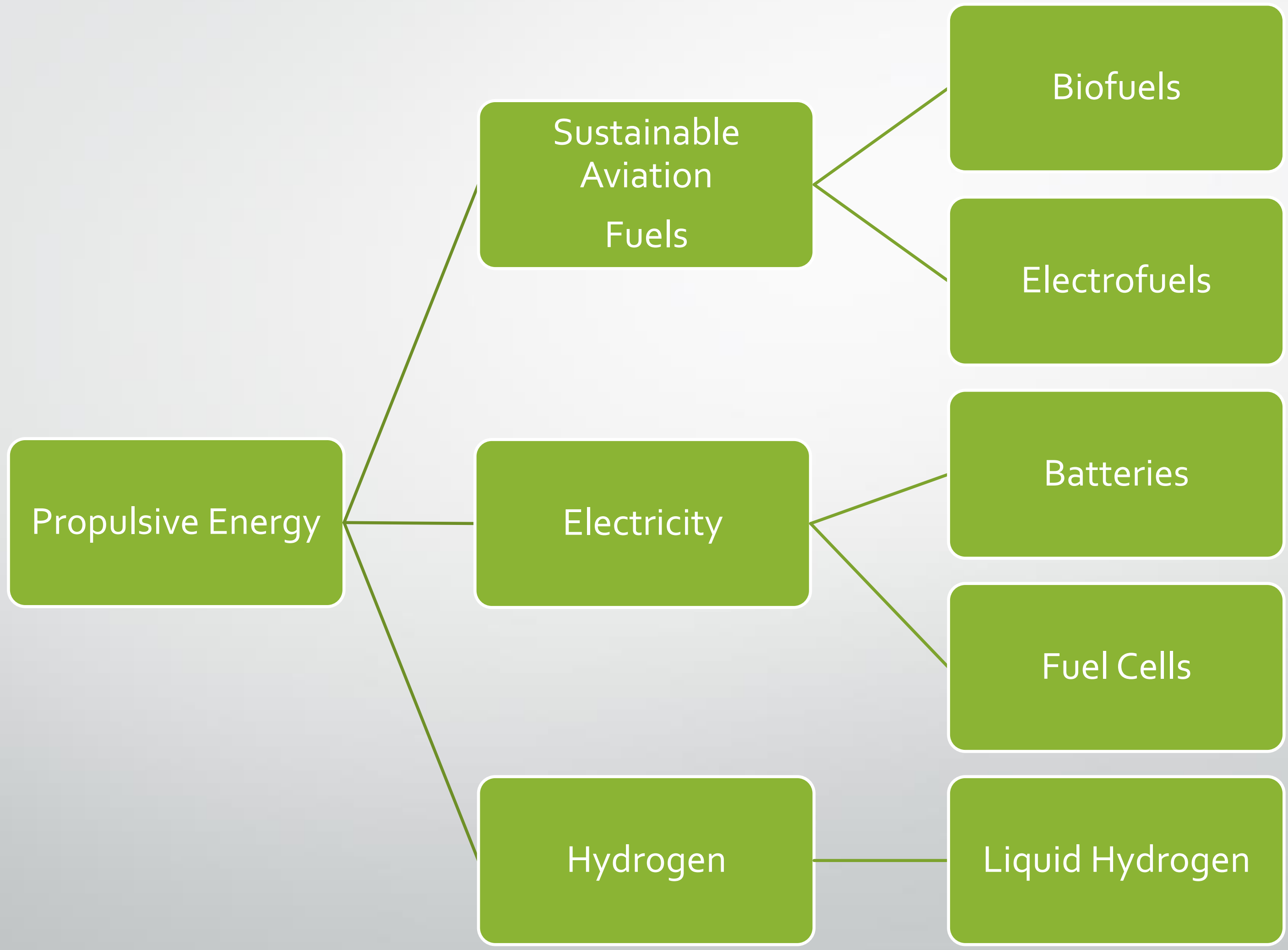
	Indicator	Units	2017	% change since 2014	% change since 2005
Traffic	Passenger kilometres flown by commercial flights(1)	billion	1,643	+20%	+60%
	Number of city pairs served most weeks by scheduled flights(1)		8,603	+11%	+43%
Noise	Number of people inside L_{den} 55 dB noise contours(2)	million	2.58	+14%	+12%
	Average noise energy per flight(3)	10^9 Joules	1.24	-1%	-14%
Emissions	Full-flight CO_2 emissions(1)	million tonnes	163	+10%	+16%
	Full-flight 'net' CO_2 emissions with ETS reductions(1)	million tonnes	136	+3%	n/a(4)
	Full-flight NO_x emissions(1)	thousand tonnes	839	+12%	+25%
	Average fuel consumption of commercial flights(1)	litres fuel per 100 passenger kilometres	3.4	-8%	-24%

(1) All departures from EU28+EFTA
(2) 47 major European airports
(3) All departures and arrivals in EU28+EFTA
(4) ETS not applicable to aviation in 2005

Source : EASA, EEA, EUROCONTROL, European Aviation Environmental Report 2019

New technologies

New propulsive energy



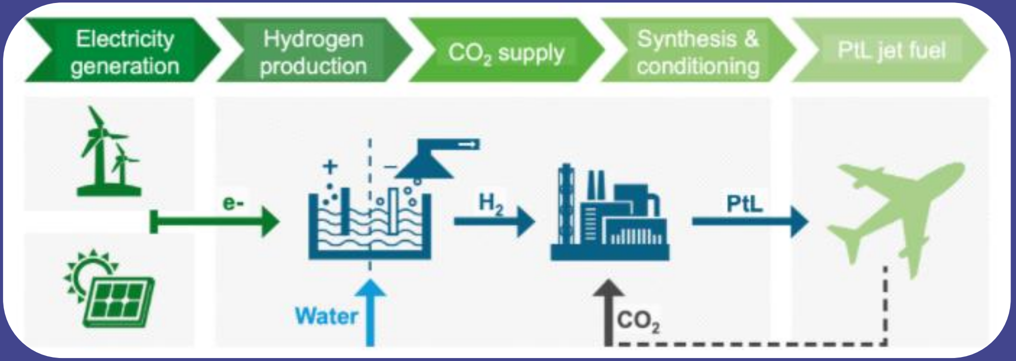
New technologies

New propulsive energy

- Propulsive Energy
  - Sustainable Aviation Fuels
    - Biofuels
    - Electrofuels
  - Electricity
    - Batteries
    - Fuel Cells
  - Hydrogen
    - Liquid Hydrogen

Biofuels

E-fuels, Power to Liquids (Fischer-Tropsch pathway)



Renewable Fuels of Non-Biological Origin

Source : LBST/BHL 2016

New technologies

New propulsive energy

- Propulsive Energy
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    - Batteries
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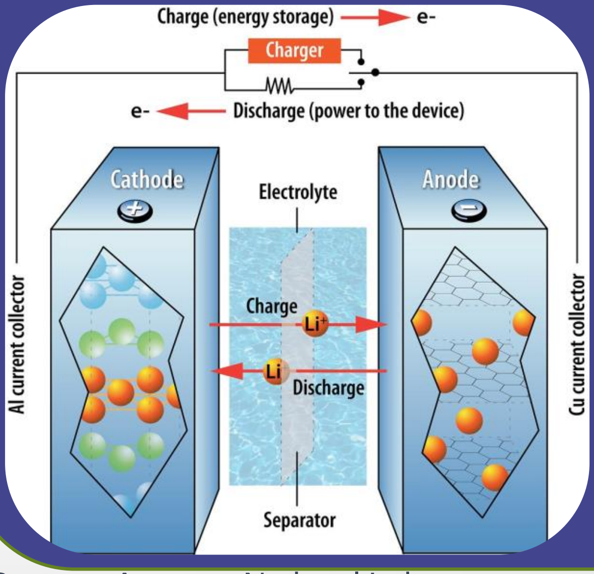
Batteries (Li-ion)



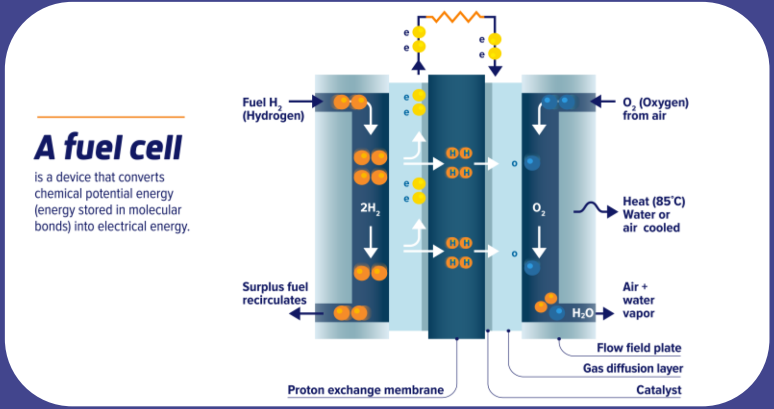
Nano-electrofuels

Li-Air

Solid States

Source : Argonne National Laboratory

Fuel Cells



Source : Wikipedia Membrane Electrode Assembly

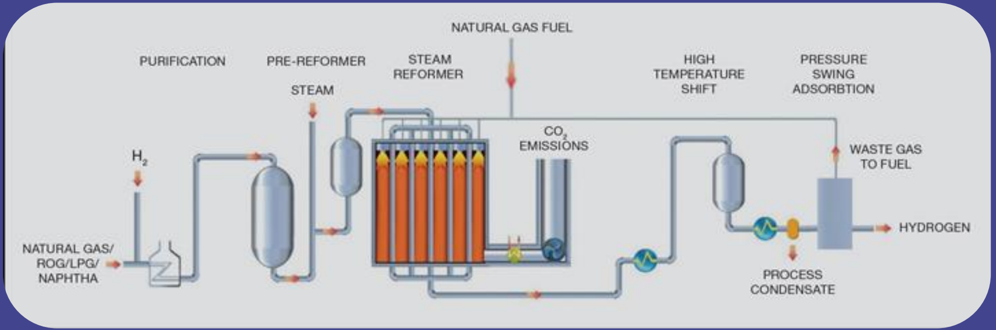
New technologies

New propulsive energy

- Propulsive Energy
  - Sustainable Aviation Fuels
    - Biofuels
    - Electrofuels
  - Electricity
    - Batteries
    - Fuel Cells
  - Hydrogen
    - Liquid Hydrogen

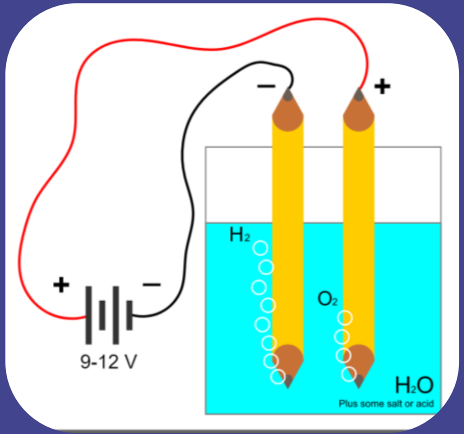
Liquid Hydrogen

Steam methane reforming $Ch_4 + H_2O \rightleftarrows CO + 3H_2$



Source : https://www.thechemicalengineer.com/

Electrolysis



New technologies

New propulsive energy

	Propulsive Energy Type					
	Jet A-1 fuel	Biofuel	Synthetic Electrofuel	Batterie	Nano Electrofuel	Liquid Hydrogen
Energy Reference	**E1**	**E2**	**E3**	**E4**	**E5**	**E6**
Energy density [MJ/kg]	46	Un-known	32	0.702	2	120

- Each energy has to be used with a proper configuration
- Energy used to produce aircraft propulsive energy need to be renewable
- On going research !

New technologies

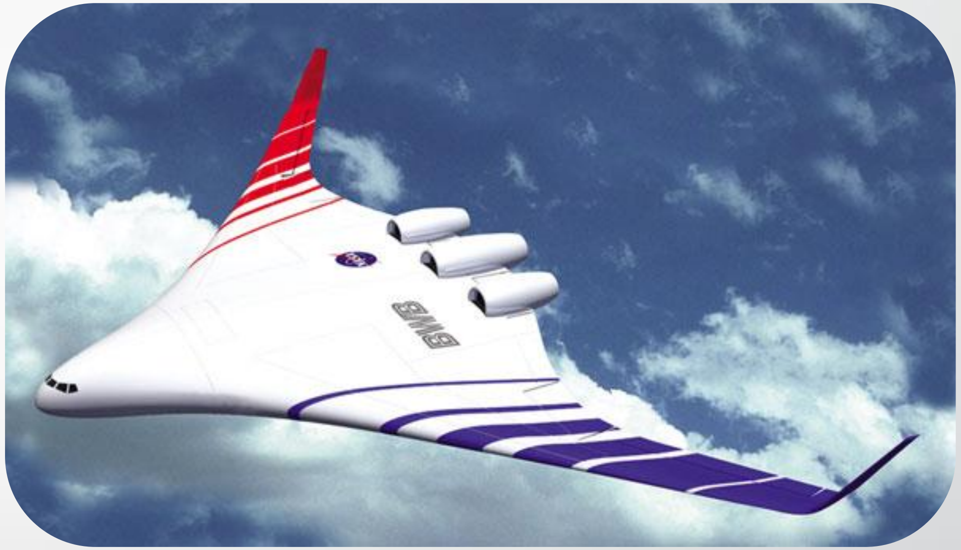
Aircraft structure improvements

Box Wing

Source : NASA/ Lockheed

Fuel Burn	lower
Takeoff Weight	lower
Operating Empty Weight	higher
Total Thrust	NC
Lift/Drag	higher

Blended Wing Body



Source : NASA

Fuel Burn	27% lower
Takeoff Weight	5% lower
Operating Empty Weight	12% lower
Total Thrust	27% lower
Lift/Drag	20% higher

Source : AIAA-98-0438, Paul O Jemitola, John P Fielding (2012) Box wing aircraft conceptual design. In: 28th Congress of International Council of the Aeronautical Sciences, 2012, September 2012

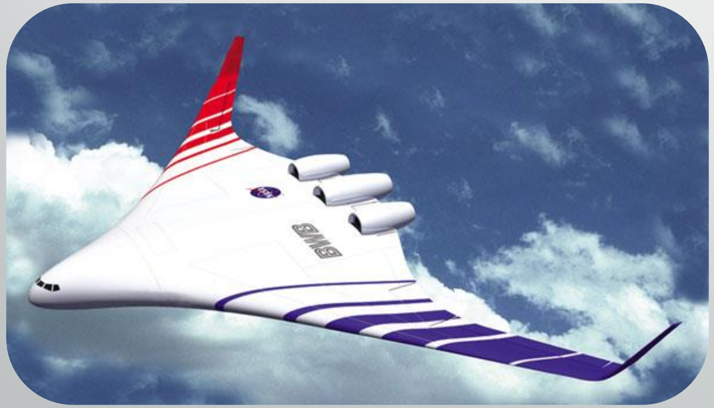
New technologies

Aircraft structure improvements

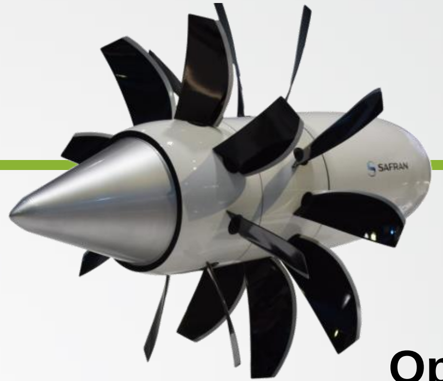
Box Wing

Source : NASA/ Lockheed

Blended Wing Body



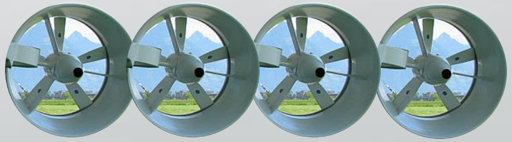
Source : NASA



Open Rotor

LH2 High by pass ratio

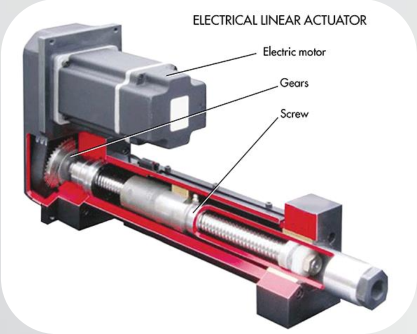
Distributed propulsion



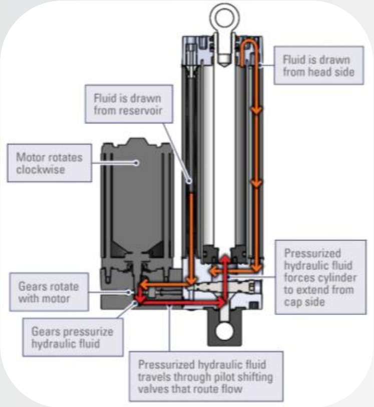
Ducted fan

New technologies
Systems

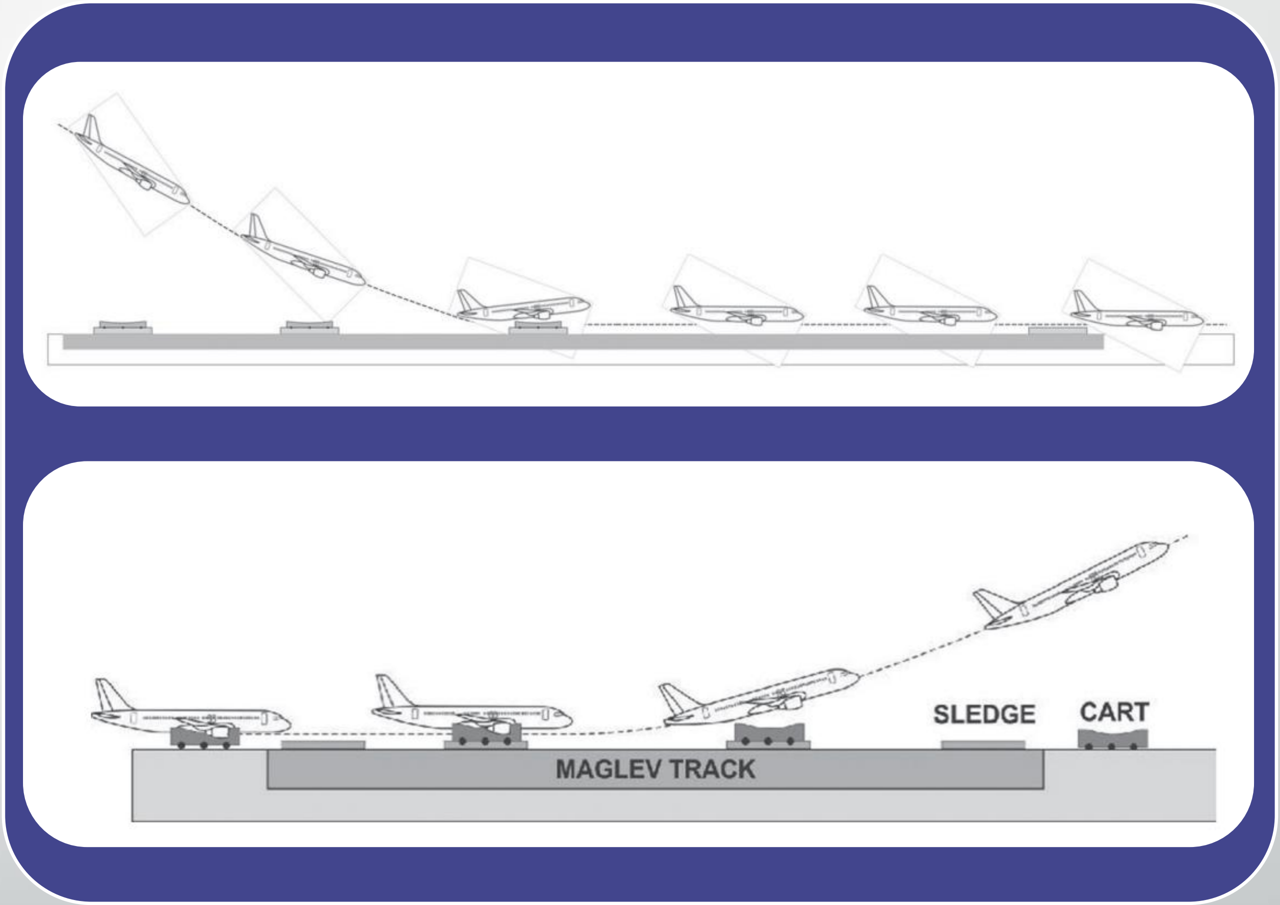
EMA



EHA



GABRIEL Project



Oled Technologies

E Taxi

Source : Journal of Marine Engineering & Technology, September 01, 2017; digitalconnectmag.com; Thomson Industries, Spike Aerospace; Safran Landing Systems

New technologies
Systems

	Propulsive Energy Type					
	Jet A-1 fuel	Biofuel	Synthetic Electrofuel	Batterie	Nano Electrofuel	Liquid Hydrogen
Energy Reference	E1	E2	E3	E4	E5	E6
Energy density [MJ/kg]	46	Un-known	32	0.702	2	120

		Energy (cf. Table 1)						Systems			
		E1	E2	E3	E4	E5	E6	EHA/EMA	OLED	E-taxi	Gabriel
References		E1	E2	E3	E4	E5	E6	S1	S2	S3	S4
Military	Unmanned	3	4	4	2	2	5	3	1	4	5
	Fighter	3	4	4	1	5	5	3	4	5	5
Commercial Aircraft	LR (HC)	3	4	4	1	1	5	3	5	2	5
	LR (LC)	3	4	4	1	1	5	3	5	2	5
	SR (HC)	3	4	4	4	4	5	3	5	2	5
	SR (LC)	3	4	4	5	5	5	3	5	2	5
Cargo Aircraft	LR	3	4	4	1	1	5	3	1	2	5
	SR	3	4	4	5	5	5	3	1	2	5

		Aircraft Structure Improvements								
		Shape		Propulsion			New technologies			
		BWB	PP	Open Rotor	LH_2 HBPR	Ducted fans	Golf Ball	Whale Tail	Demon Project	Morphing wing
References		ASI1	ASI2	ASI3	ASI4	ASI5	ASI6	ASI7	ASI8	ASI9
Military	Unmanned	5	5	2	5	2	5	5	5	5
	Fighter	4	4	2	5	2	5	5	5	5
Commercial Aircraft	LR (HC)	4	4	5	5	5	5	5	4	5
	LR (LC)	4	4	5	5	5	5	5	4	5
	SR (HC)	4	4	5	5	5	5	5	4	5
	SR (LC)	4	4	5	5	5	5	5	4	5
Cargo Aircraft	LR	5	4	5	5	5	5	5	4	5
	SR	5	4	5	5	5	5	5	4	5

- 1: Totally not suitable; 2: Feasible but not recommended; 3: Already in use; 4: Suitable, need more clarification; 5: Totally suitable

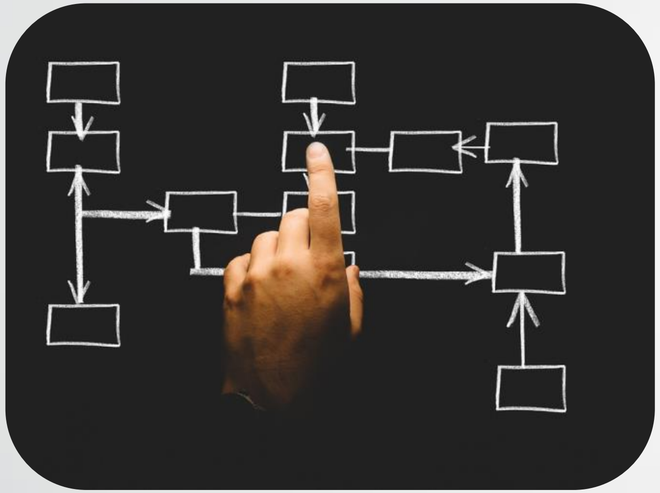
Operational changes of new aircraft

1. Flight operations
2. Airport infrastructure changes
3. Maintenance and end of life

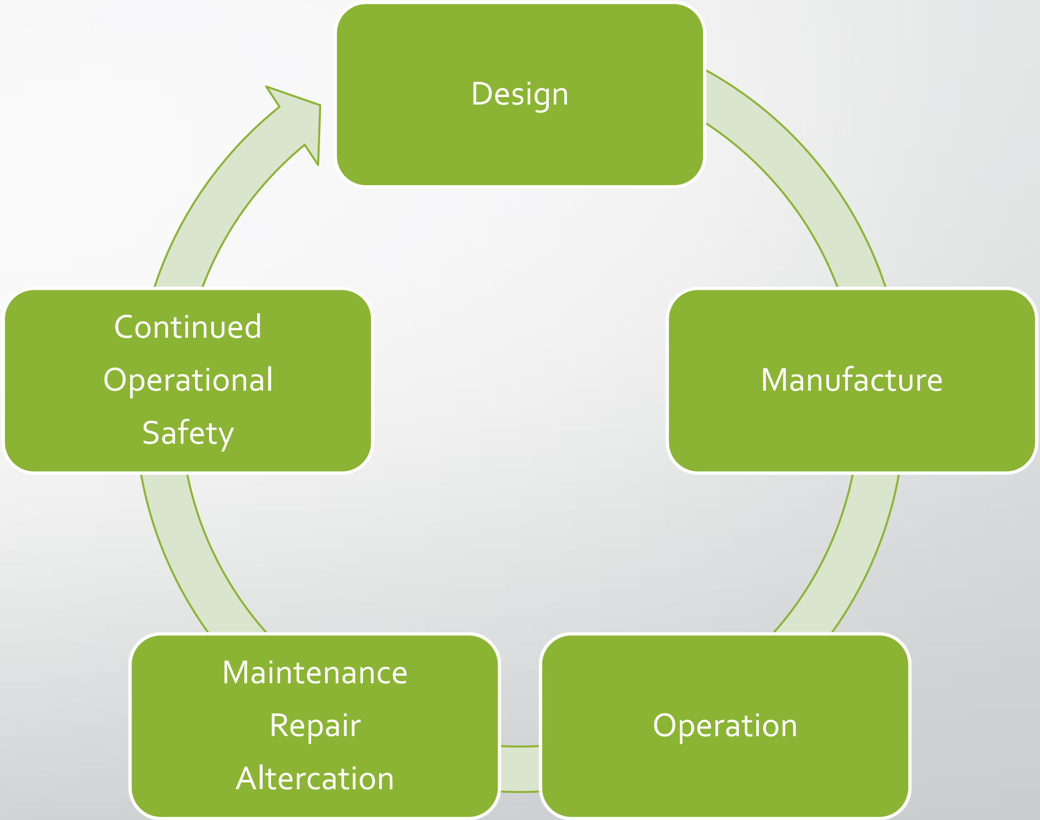
Operational changes of new aircraft

Flight operations

New Operational procedures



- Commercial operational example
  - Short range aircraft
  - Low capacity



Source : FAA

Operational changes of new aircraft

Flight operations

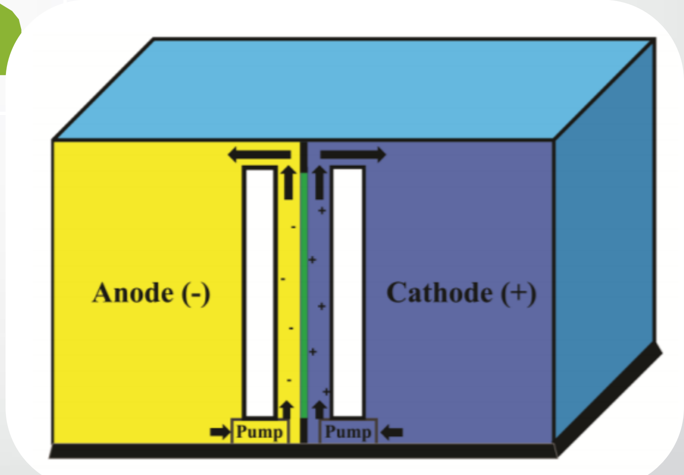
Fast charging

Source : Nasa

Hydrogen

Source : Airbus

A good way, Nano-electrofuel battery



Source : Nasa

- New Operation of flight,
- Safety of operation

Operational changes of new aircraft

Airport infrastructure changes

Source : Uniting Nation, Aug 29, 2018

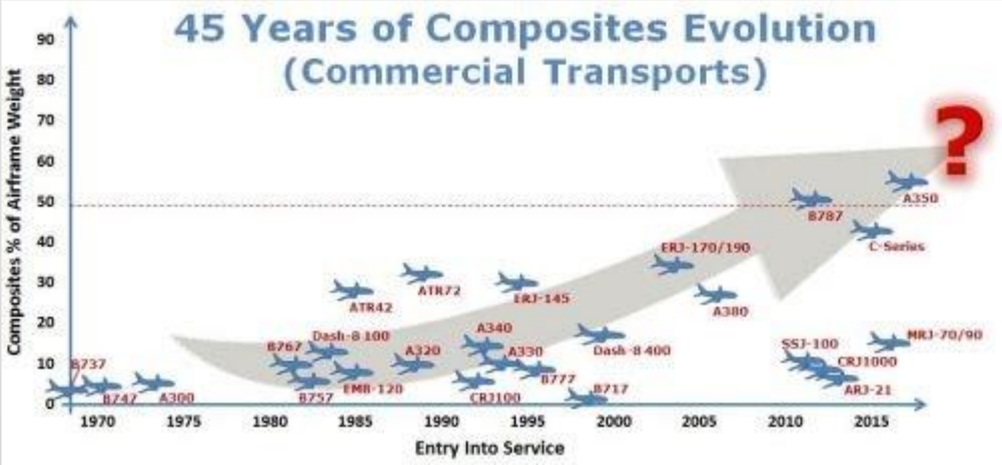
Source : AgriLife extension

- Restoration of natural resources, passengers wellbeing
- Water saving, recycled water
- Airport configuration changes with aircraft of the future

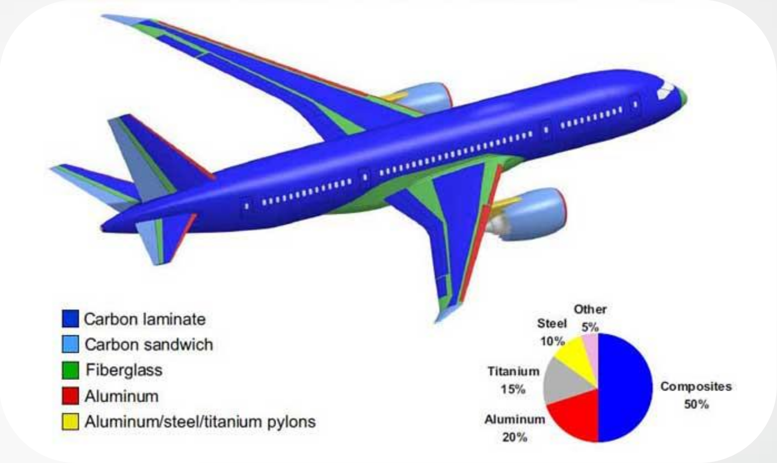
Source : Nasa

Operational changes of new aircraft

Maintenance and end of life



Source : Chris Red, Composites Forecasts and Consulting



Source : 1001crash.com, 2011

- 90% of the aircraft are valued during end of life
- The overall life cycle of an aircraft should be considered
- Process for Advanced Management of End-of-Life Aircraft (PAMELA)
  - Decommissioning
  - Disassembly
  - Smart and selective dismantling

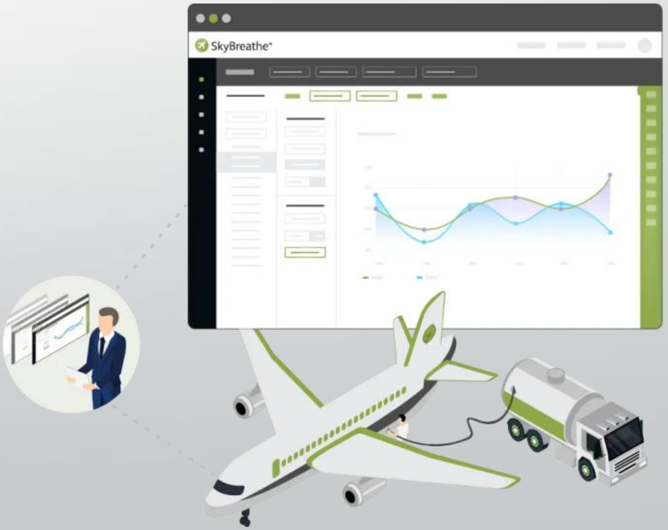
Flying in the future, a human challenge

1. Immediate improvements, an economical motivation
2. Keep flying, social and political choices
3. Future of transportation

Flying in the future, a human challenge

Immediate improvements, an economical motivation

- Flight road optimisation
- Electrification improvements
- Circular economy, 3R actions



Sustainability can drive benefits

Source : OpenAirlines

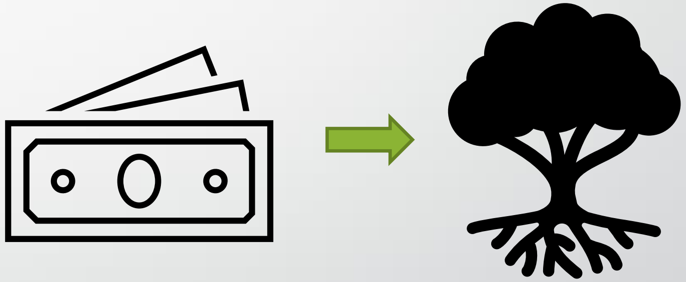
Flying in the future, a human challenge

Keep flying, social and political choices

- Sustainability :
  - a state of mind,
  - a way of life,
  - a political direction.

“flygskam” “Aeronautic shaming”

- Additional green increased price ticket
  - a factor of gender, flight range and gas reductions



- Working together
  - International Thermonuclear Experimental Reactor (ITER)
  - “Airbus of Batteries”

Flying in the future, a human challenge

Future of transportation

E-VTOL

Source : Embraer

Hyperloop

Source : Hyperloop

Airship

Source : Flying Whales

Supersonic

Source : Boom

- Electrical Vertical Take-Off and Landing (e-VTOL)
- Hyperloop
  - speed : up to 760 miles per hour in a low pressure tube
- Airship
  - Heavy transportation capacity

10% of the CO_2 emissions of a commercial aircraft

Conclusion

1. Stakeholders are involved to fight global warming.
2. Propulsive Energy, a constraint.
3. Political decisions, a game changer.
4. A mix of energy until a final sustainable solution.

Be green, keep flying

Conclusion

Transports	Previsions												Application	
	2030			2050			2065			2100			Freight	Pax
	Trend	%	Social	Trend	%	Social	Trend	%	Social	Trend	%	Social		
Rail	→	44,6	Average	→	44,6	High Income	↓	43,725	High Income	↑	43,8	Low Income	Yes	Yes
High Speed Train	→	5,15	Average	→	5,15	High Income	↓	4,6	High Income	↓	4	Average	Yes	Yes
Hyperloop	↑	0,1	High Income	↑	1	High Income	↑	1,3	High Income	↑	7,5	High Income	Yes	Yes
E-VTOL	↑	0,05	High Income	↑	0,20	High Income	↑	0,28	High Income	↑	5	Average	Yes	No
BWB	↑	0,1	Average	↑	0,84	Average	↑	2,3	High Income	↑	8	Average	Yes	Yes
PP	↑	0	Average	↑	1	Average	↑	1,65	High Income	↑	4,5	Average	Yes	Yes
Conventional aircraft	↓	7	Average	↓	6,5	Average	↓	6,3	Average	↓	5,5	High Income	Yes	Yes
Car	↓	36,44	Average	↓	34,5	Average	↓	34	Average	↑	34,9	Average	No	Yes
Bus	↓	4,7	Average	↓	4,35	Average	↓	4	Average	↑	4,6	Average	No	Yes
Boat	↓	1,9	Average	↓	1,5	Average	↓	1,35	Average	↑	1,5	Average	Yes	Yes
Airship	↑	0,1	Average	↑	0,3	Average	↑	0,42	Average	↑	0,6	Low Income	Yes	Yes
Supersonic	↑	0,01	High Income	↑	0,06	High Income	↑	0,075	High Income	↑	0,1	High Income	No	Yes
Energy used	Oil, Gas, Synthetic Electro fuel, Electric, Hydrogen									Hydrogen, Electric, Nano-Electro fuel				