SpacePlane & environmentally sustainable flight operations

Airbus – Christophe Chavagnac

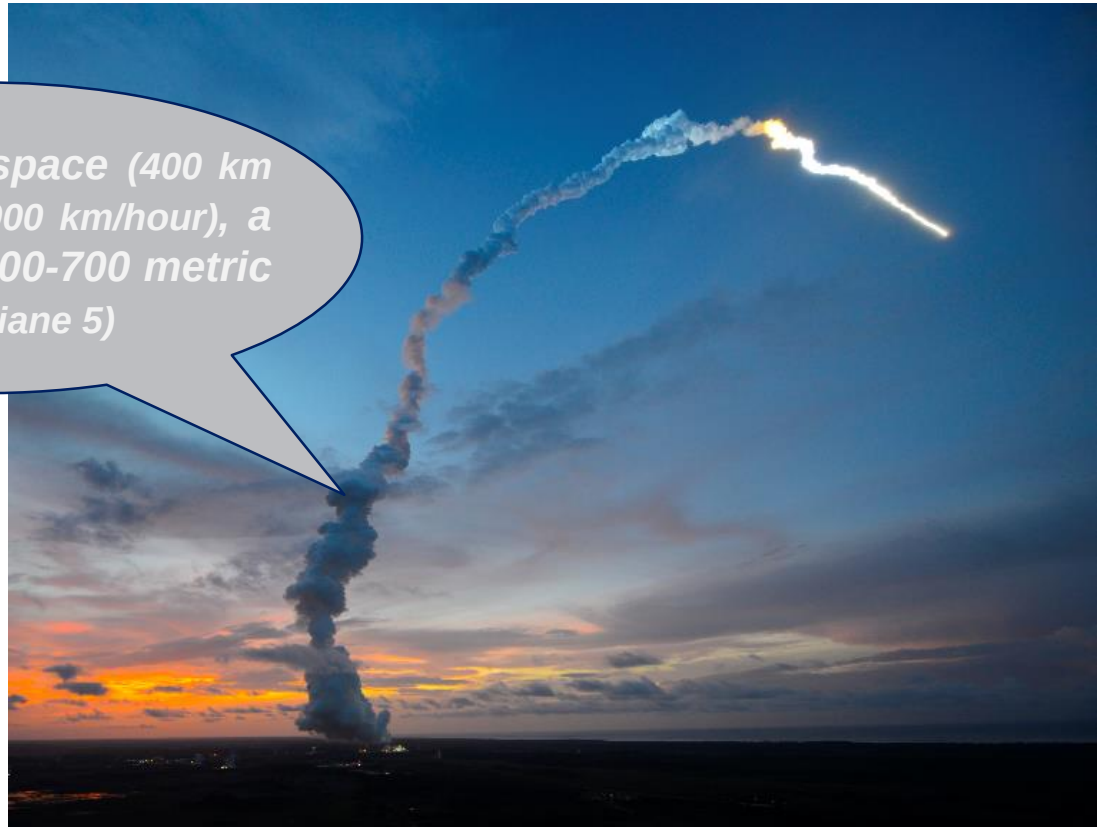
3rd ICAO / UNOOSA Aerospace Symposium

Vienna (Austria) - August, 29th to 31th 2017

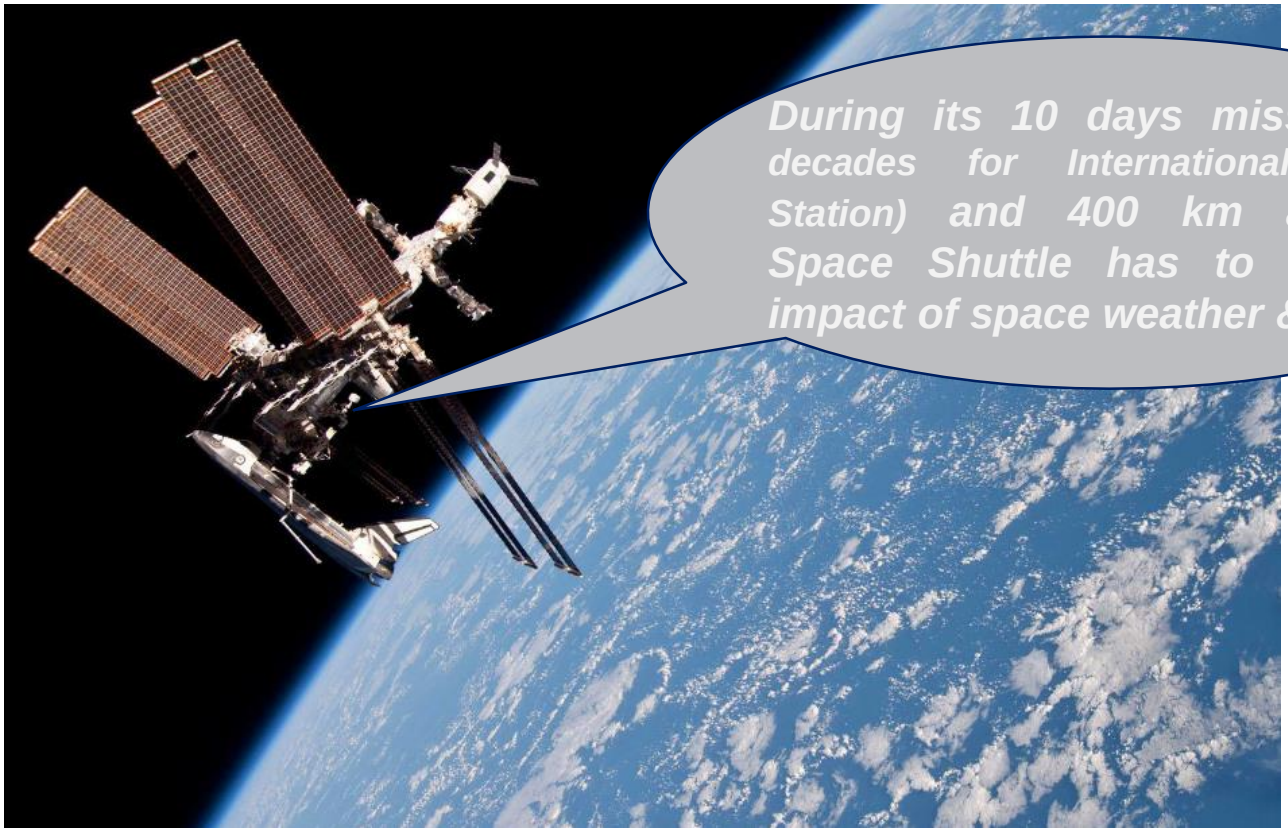
AIRBUS
DEFENCE & SPACE

Solid propulsion technology should be avoided for noise considerations

For a ride to space (400 km altitude and 28.000 km/hour), a rocket burns 600-700 metric tons of fuel (Ariane 5)



A suborbital flight (local) requires a few metric tons of fuel



Suborbital flights are far much shorter in time and lower altitude

Flight path of SpacePlane

Space phase culminating at 100 km

Space leg of the mission
(in between two red dots)
- Altitude: between 30.000 ft and 100 km
- Very limited range, if any
- 10 minutes duration

Rocket boost : reaching 60 km altitude & Mach 3 velocity

Descent & aerobraking in atmosphere

Take off & climb to 30 kft altitude

Aircraft like descent & landing back at home runway

Area for flight operations is as small as 100 × 100 km

Twin turbofans for aeronautic phases

- *State-of-the-art civil technology*

Rocket propulsion used only for acceleration to 100 km

- *Liquid technology (vs. solid)*
- *Fuel : Liquefied Natural Gas (LNG) 30% more efficient than standard jet fuel*
- *Oxidizer : Liquefied Oxygen (LOX)*

For a ride to space, SpacePlane burns ca. 9500 liters of jet fuel (translating equivalent LNG energy).

It is as the same as a flight from Paris to Vienna and a Legacy Regional Jet [1]

[1] According to computation derived from French government décret n° 2011-1336 dated October, 24th 2011

SpacePlane propulsion is optimized for minimizing fuel consumption

…..SpacePlane & environmentally sustainable flight operations…..

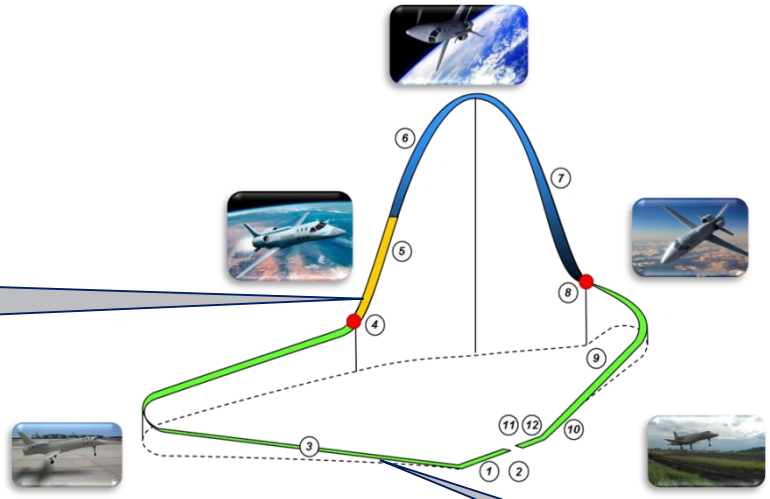
Environment impact during flight operations of SpacePlane

- Noise and propulsion
- Sonic bang sourced noise
- Emissions and propulsion
- Space weather (electromagnetic field)
- Space debris

Noise and propulsion

During space phases, rocket propulsion is ON for ca. 2 minutes only (orange line) : in between 33000 ft and 60 km altitude (Not used at take-off)

Noise generated by liquid rocket propulsion is "close" to large size turbofan

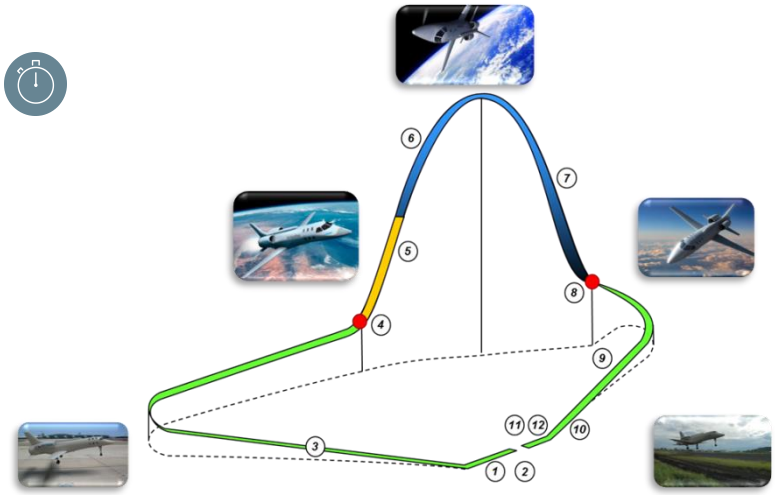


During aeronautic phases (green line) SpacePlane is powered with standard turbofans (civil state-of-the-art technology)

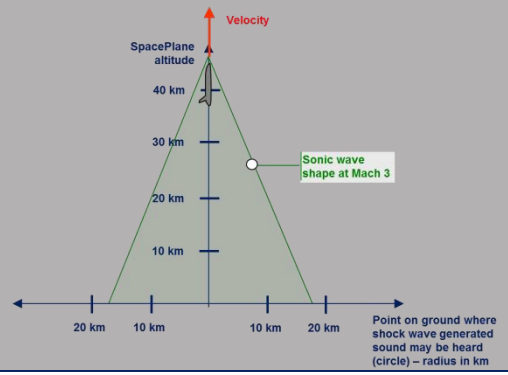
Aeronautic regulations apply. EASA CS-36 standard e.g.

Sonic bang sourced noise

SpacePlane travels at supersonic speeds during some space phases (in between red dots) : few minutes in total



According to up & down directions of "sonic" flight (close to vertical), sonic bang foot print does not exceed a circle of ca. tens kms radius decreasing with altitude and escalating vacuum conditions



…..SpacePlane & environmentally sustainable flight operations…..

AIRBUS DEFENCE & SPACE

Emissions emanating from propulsion

During aeronautic phases, SpacePlane powered with turbofans

Aeronautic regulations apply. EASA CS-34 standard e.g.

Rocket propulsion of SpacePlane

- ***Liquid technology***
- ***Fuel : Liquefied Natural Gas (LNG) 30% more efficient than standard jet fuel***

LNG (or Methane) is the lowest Carbon species Hydrocarbon : 1 for Methane (CH_4) vs. 10 for Kerosene ($C_{10}H_{22}$) generating much lower CO_2 when burning with Liquid Oxygen [1]

SpacePlane rocket engine uses bio-LNG which was successfully tested (full scale engine) in 2016

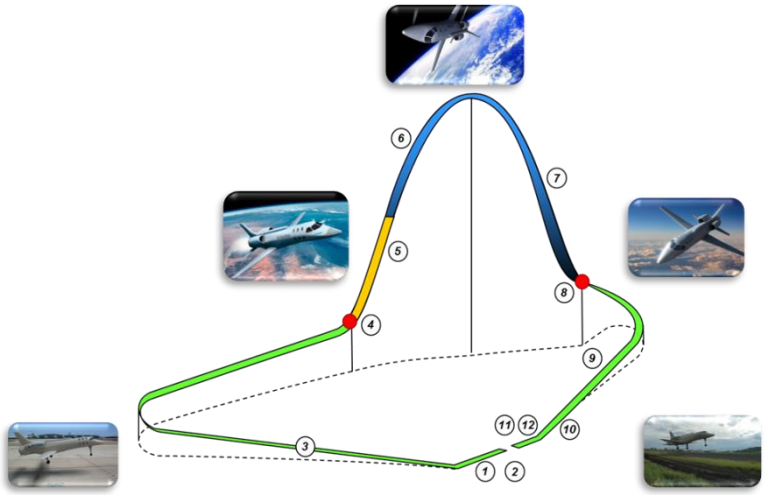
[1] Methane is known to have a strong green house effect when in gaseous state (and not liquefied)

…..SpacePlane & environmentally sustainable flight operations…..

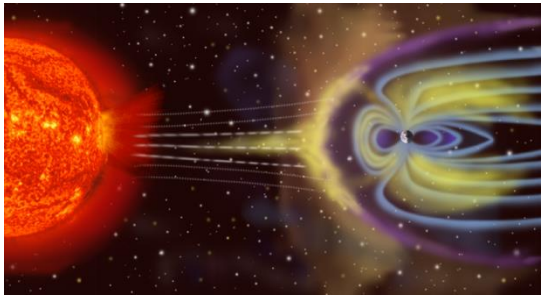
Space weather

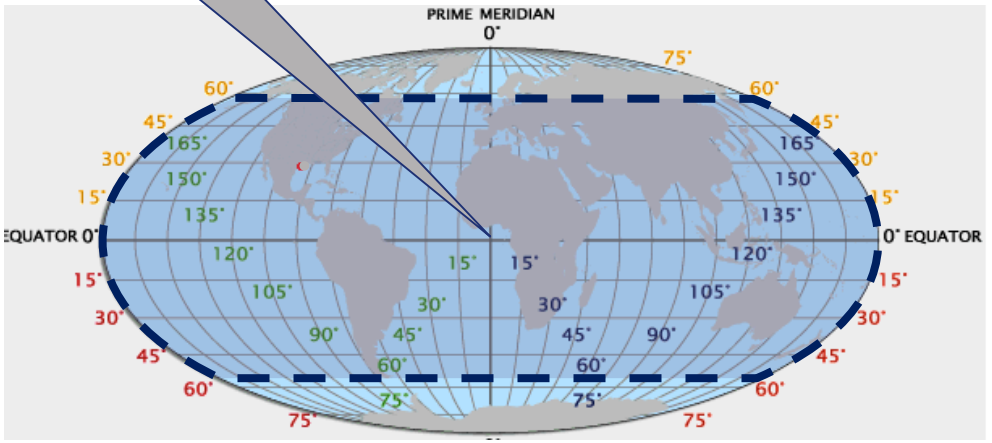
Space leg of the mission (in between two red dots)

- ***Altitude: between 30.000 ft and 100 km***
- ***10 minutes duration***



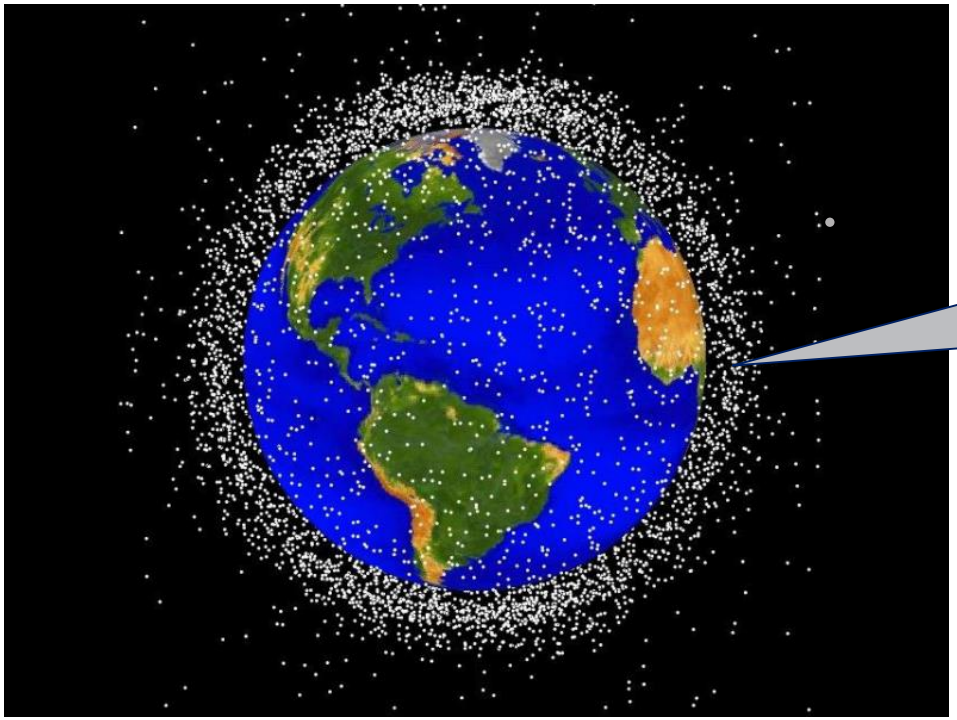
As long as location for flight ops (ca. 100 × 100 km area) remains below these latitudes, managing impact of space weather is as the same as civil aeronautics





AIRBUS DEFENCE & SPACE

Space debris



At maximum altitude of SpacePlane (100 km), space debris are "naturally" falling down to ground

According to altitude range and flight duration of SpacePlane (10 minutes for Space phases), likelihood of interaction with space debris is as low as a Paris-New York flight

SpacePlane is a kind of legacy Regional Jet in terms of environment impact

Noise & emissions from turbofans matching EASA CS-34 & CS-36

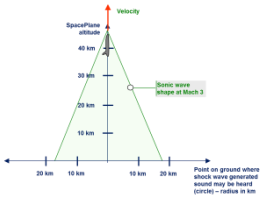
Noise from rocket engine not an issue (not used at take-off e.g.)

Effect of emissions from rocket engine (bio Liquefied Natural Gas) to be further investigated

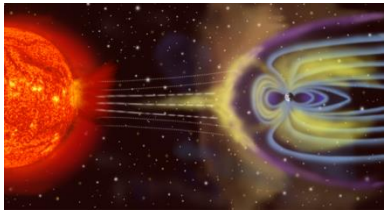
…..SpacePlane & environmentally sustainable flight operations…..

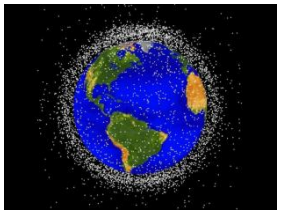
SpacePlane is a kind of legacy Regional Jet in terms of environment impact

Effect of sonic bang close to zero on ground



Impact of space environment (weather & debris) to SpacePlane is as the same as a legacy cruiser aircraft crossing Atlantic ocean





SpacePlane designed for environmentally sustainable flight operations