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JETSCREEN

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Future evolution of aviation fuels – Threat or opportunity ?

Presenter: Nicolas Jeuland (Safran)

SAFRAN

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Introduction / Context

- The 3 pillars of any aircraft development (and consequently any fuel selection) are :

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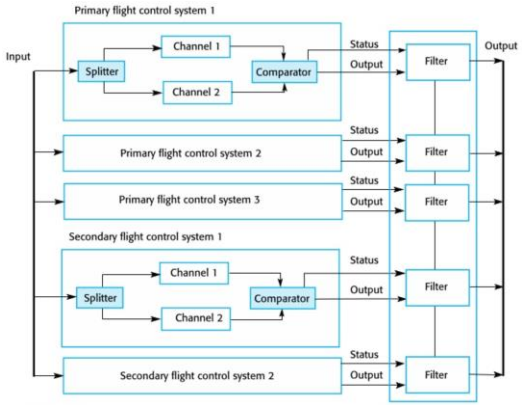
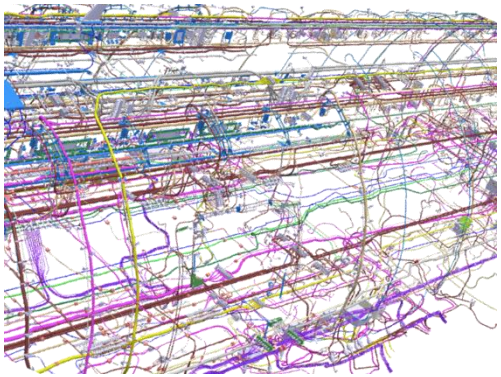
Introduction / Context

- Most of the time, safety requirements are met through redundancy (i.e. adding redundant parts for the same function until safety threshold is reached)
- Fuel is one of the rare « non-redundant » system





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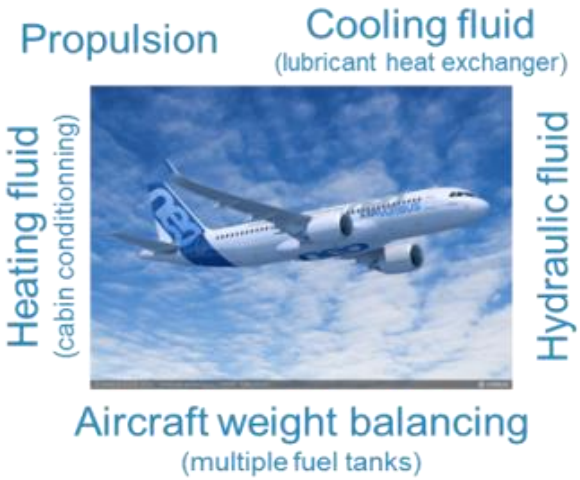
Introduction / Context

- Fuel is the swiss knife of aircraft, used for multiple functions, and having an impact on hardly any engine / fuel system parts



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Introduction / Context

- Consequence : **DO NOT PLAY WITH FUEL QUALITY !**
- Small example : Cathay Pacific Flight CX780
  - A330-342, with 322 passengers & crew
  - Double engine shut-down during descent
  - 4 minutes without any engines before the pilot managed to regain thrust in one engine
  - Landing at a speed of 231 knots (177 km/h) (typical values : 120 – 140 knots)

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Introduction / Context

- Consequence : **DO NOT PLAY WITH FUEL QUALITY !**
- Small example : Cathay Pacific Flight CX780
  - A
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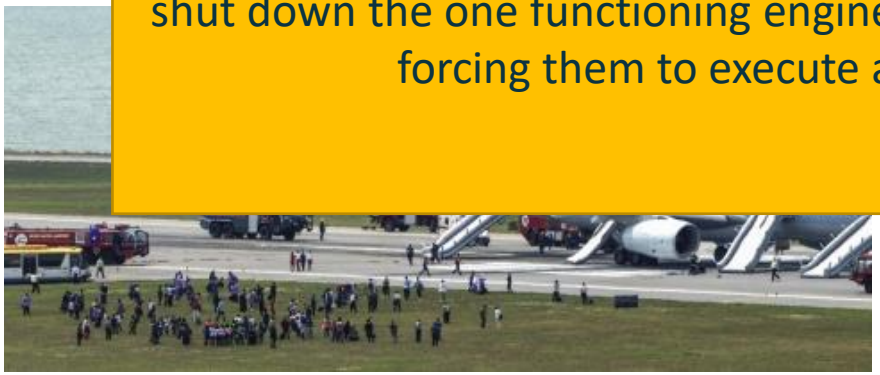
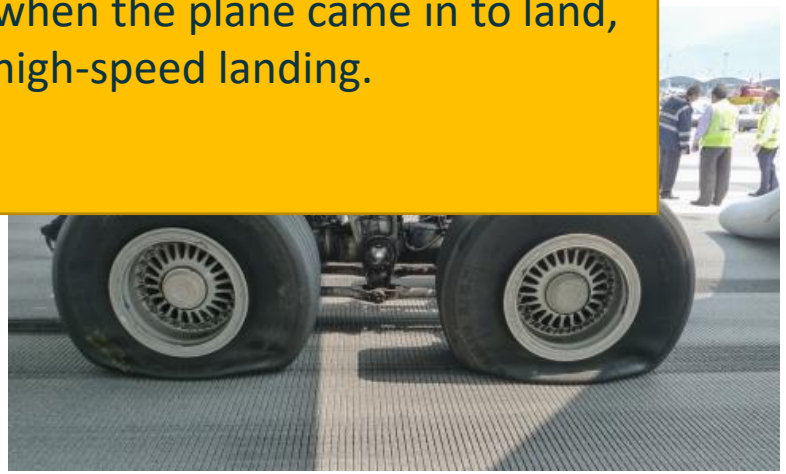
Investigations found the 24,400kg of aviation fuel uploaded at Surabaya was contaminated with SAP (Super Absorbant Polymer), which caused engine pressure fluctuations and later near-catastrophic engine failure. The SAP damaged filter monitors, which meant the pilots were unable to shut down the one functioning engine when the plane came in to land, forcing them to execute a high-speed landing.





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Introduction / Context

- The high safety level of aviation fuels is based on :
  - Worldwide accepted specifications
  - Worldwide defined monitoring procedures
  - Worldwide followed refuelling procedures
- As a consequence, aviation fuel specifications can be seen as conservative, as they are the results of all these constraints

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End of the story

Thank you for your attention

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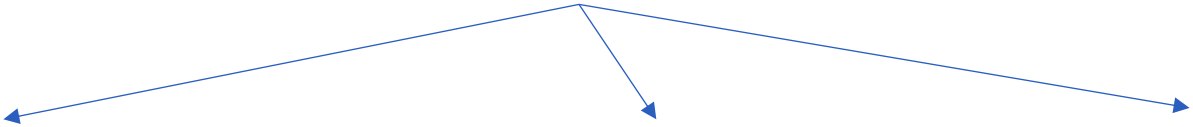
Not at all the end of the story…
Fuel evolution seems compulsory…

- Environmental constraints will have a massive impact on the future of aviation



- Need for accelerated efficiency gains (« Skip one generation »)
  - New aircrafts architectures, new fuel constraints (oxydation stability…)
- Need for massif SAF incorporation
  - Overcome the current 50% limit
- Need for long term disruptive technologies (carbon neutral)
  - New fuel technologies / chemical compositions ?

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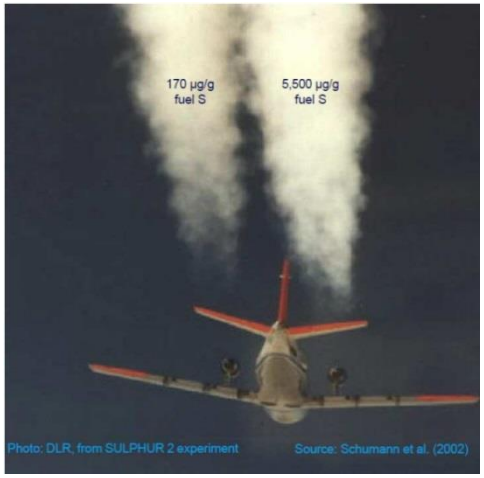
Not at all the end of the story…
Constraint or opportunity ?

Reduction of aromatic content

- Strong positive impact on particle emissions (and, as a side effect positive impact on furtivity / infrared signature for military application
- Impact on air quality (Benzene, PAH…)
- Positive impact on deposits / cokefaction
- Increase of H/C ratio ➔ positive impact on combustion CO2 Emissions



Reduction of sulfur content

- Reduction of particle mass
- Reduction of corrosion
- Positive impact on deposits / cokefaction
- Impact on air quality (Sulfurized compounds)

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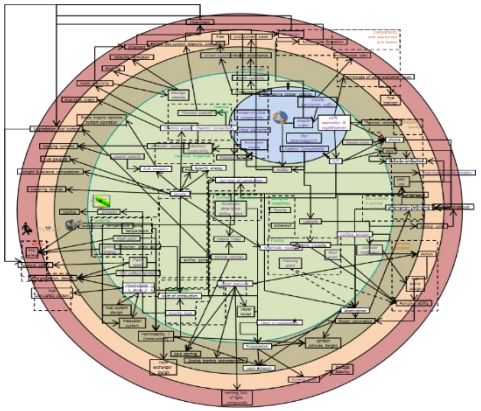
But the situation is (as usual) not so simple

Example 1 :
Impact of reducing sulfur level

- Corrosion
  - In the fuel logistic (see mercaptans)
  - At the exhaust of the turbine (acid emissions)
  - In the combustor
    - Corrosion of nimonic alloys
    - Sulphidation (for very high sulfur contents)



- Deposit formation
  - decrease of particle mass ➔ potential decrease of deposits
  - Impact on fuel line wall roughness (corrosion) ➔ decrease deposits « sticking »
- Lubricity of the fuel
  - The sulfur removal processes induce a reduction of fuel lubricity.
- Impact on polymers (seals…)
  - Some sulfur compounds are known to decrease peroxide content. Potential increase on peroxide content may consequently lead to negative impact on seals
  - Severe HDS may slightly reduce (poly)aromatic content
- HDS may lead to a slight reduction of fuel conductivity (removal of polar compounds)
- Impact on fuel stability
  - Sulfur compounds are known for their antioxydant effect, reducing the peroxide formation
  - On the other side, HDS process may remove organic acids, known to decrease fuel oxydation stability

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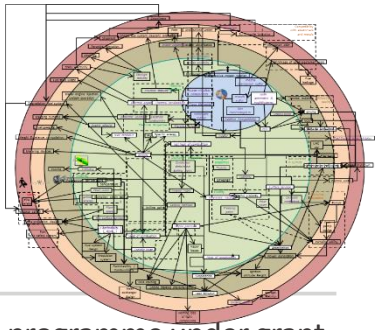
But the situation is (as usual) not so simple

Example 2 :
Impact of reducing aromatic level

- Aromatics tend to increase particle emissions
  - Question remaining : polyaromatics >> aromatics / naphtheno-aromatics >> naphthenic compounds ➔ selective reduction ?
- Reduction of exhaust aromatics, especially benzene ➔ positive impact on local air quality
- Increase of H/C ratio
  - increase of energetic content and decrease of CO_2 emissions
  - But decrease of density ➔ fuel consumption impact depending on the mission
- Reduction of deposit formation (injector cokefaction, exhaust of the turbine)
- Reduction of infra-red signature (military aircrafts)
- Impact on seals and elastomers
  - Aromatic content reduction may have a negative impact on some elastomers ➔ which acceptable level ? Impact of aromatic type ? Impact of naphthenes ?
- Effect on combustion
  - Decreased auto-ignition delay (aka cetane)
    - Impact on flame stabilization point ?
    - Impact on altitude relight ?
    - Impact on combustion stability ?



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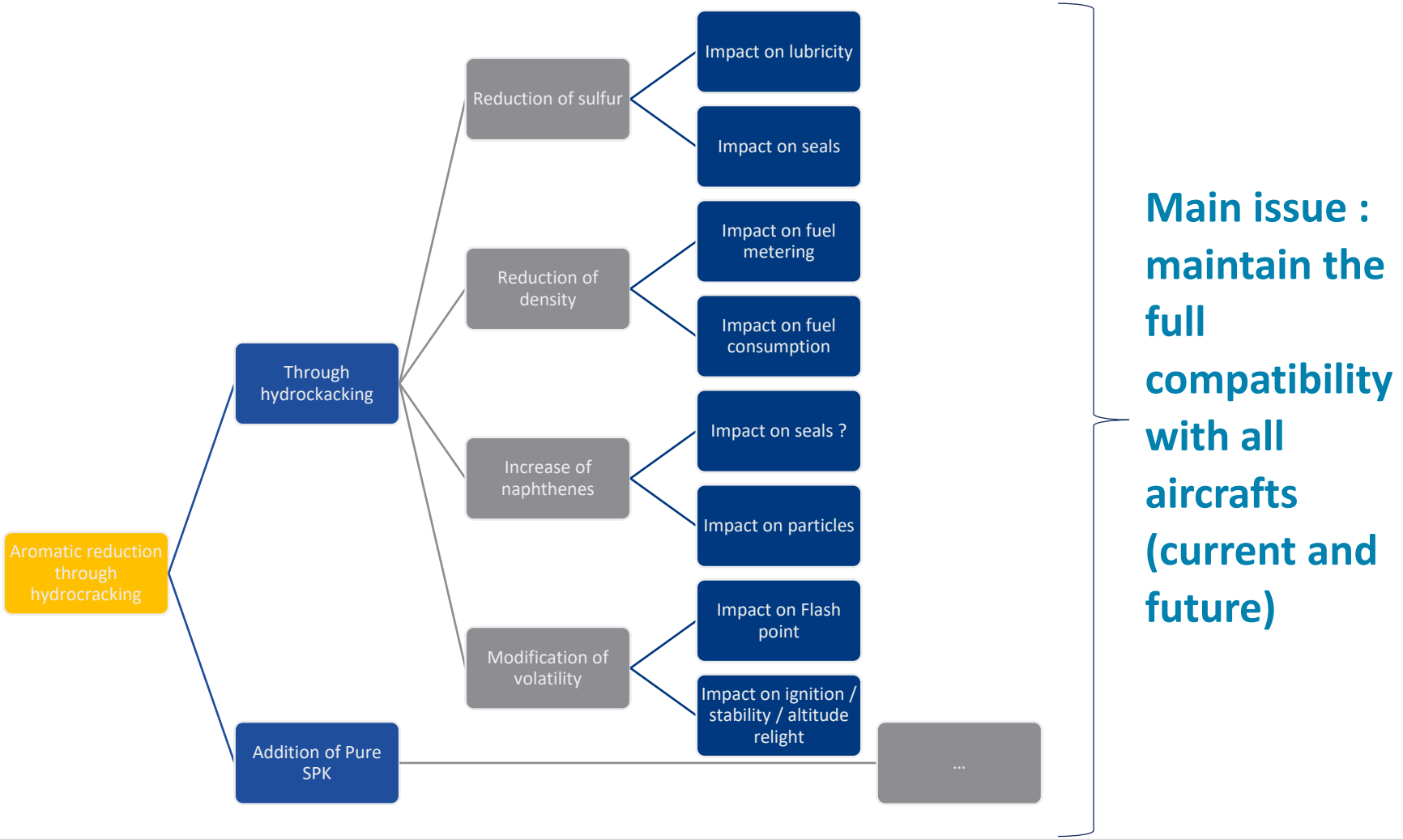
all parameters are linked



Main issue : maintain the full compatibility with all aircrafts (current and future)

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Fuel R&T roadmap

- Jetscreen project has set the ground for better understanding of fuel / aircraft interactions, allowing to understand the phenomena ➔ Very interesting work, to be continued
- Following step : Explore the limits of drop-in concept, while
  - Ensuring full compatibility with existing aircrafts
  - Ensuring full compatibility with future aircrafts
- Develop strategies in order to allow raising the acceptable SAF level up to 100%
  - Through fuel formulation
  - Through assessement of full impact on existing aircrafts (combustion, material compatibility, safety…)
  - Through development of compatible materials (pumps, sensors…)
  - Through the exploration of the potential of aircraft / fuel coupled optimization (fuel « sensor »)

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