

Identification of a fluid for two phase fluid capillary pumped system cooling dedicated to aircraft applications

Brussels

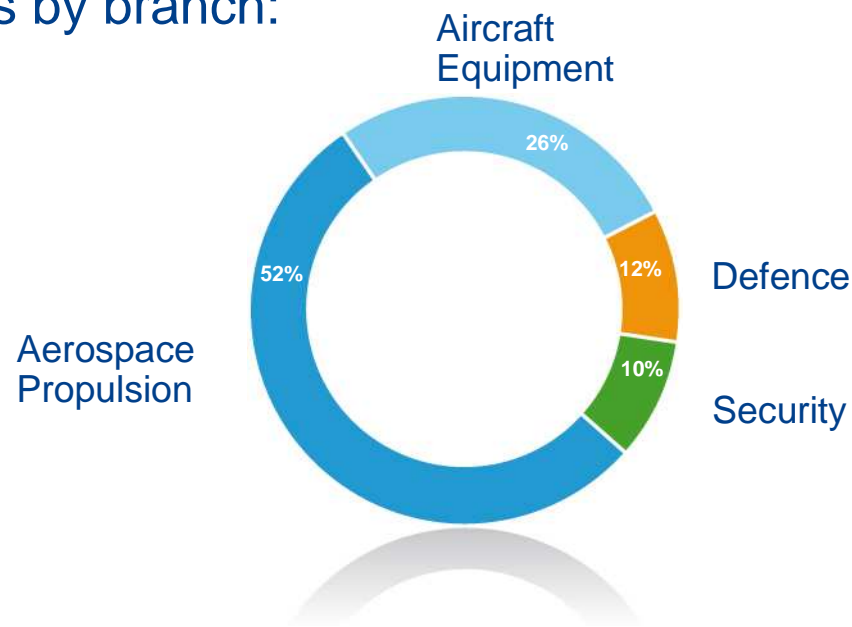
/ 19th January 2012 /

/01/

HISPANO-SUIZA at a glance

SAFRAN AT A GLANCE

- An international **high technology** group.
- Revenues of **10.8 billion euros**.
- More than **54,000 employees** in over **50 countries**.
- 2010 revenues by branch:



HISPANO-SUIZA IN THE SAFRAN GROUP

Aerospace Propulsion

- **Snecma**
- **Snecma Propulsion Solide**
- **Turbomeca – Microturbo**
- **Techspace Aero**

Aircraft Equipment

- **Aircelle**
- **Hispano-Suiza**
- **Labinal**
- **Messier-Bugatti-Dowty**

Defence & Security

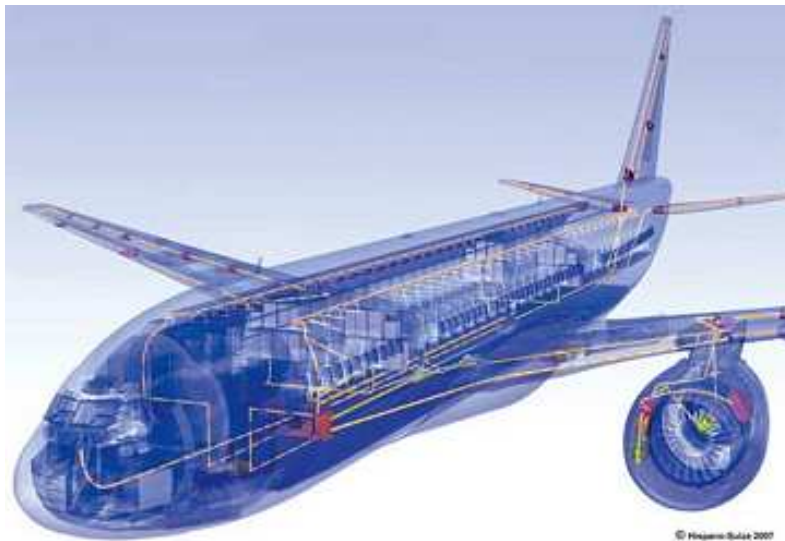
- **Sagem**
- **Morpho (formerly Sagem Sécurité)**

HISPANO-SUIZA

A major player in the airborne applications of electrical power

Specialist in the transmission and management of onboard power

→ **Power transmissions** for engines on commercial airplanes, business and regional aircraft, military aircraft and helicopters



→ **Electronic power controllers and electrical systems**

PROPULSION SYSTEM

→ A380 / NACELLE: ETRAS® (Electrical Thrust Reverser Actuation System)



Power controller



Power converter

→ The first electrical thrust reverser actuation system in the world:

- Fitted to nacelles made by Aircelle (Safran group) for the **GP7200 and Trent 900 engines offered on the A380;**
- In production, **ETRAS® has logged over 700,000 hours of operation** (as of September 2011).

PROPULSION SYSTEM

→ C919 / NACELLE: TRCU (Thrust Reverser Control Unit)



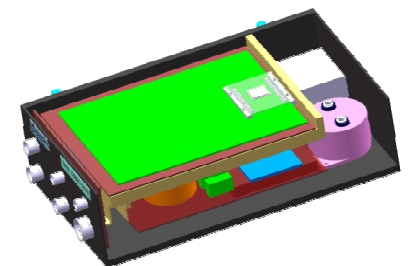
→ TRCU: an innovative electronic power converter

- Controls the thrust reverser actuation system of the **COMAC C919** Nacelle developed by Nexcelle (an Aircelle/GE Joint Venture)

→ Based on experience with the ETRAS® system for the A380.

→ A work in synergy with fellow Safran companies for Aircelle:

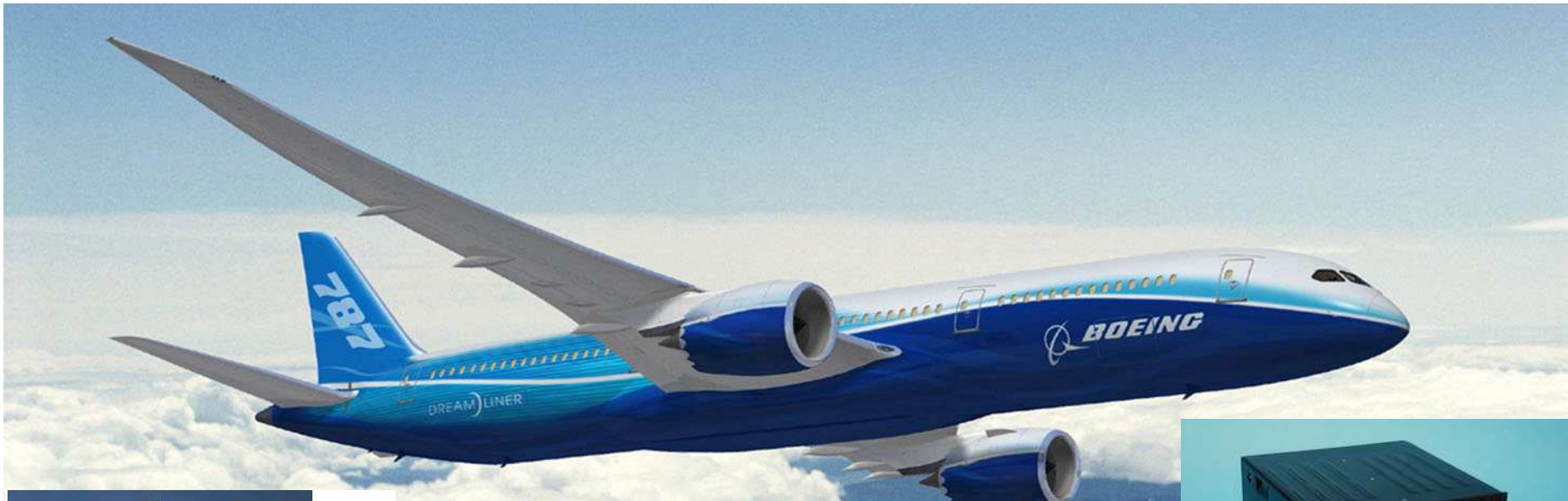
- **Aircelle**: Architecture and equipment integration in the nacelle;
- **Sagem (Safran Electronics)**: Reverser actuation system;
- **Hispano-Suiza (Safran Power)**: TRCU (Thrust Reverser Control Unit).



Catia view of the C919 Thrust Reverser Control Unit

LANDING AND BRAKING SYSTEMS

→ BOEING 787 / BRAKING: EBAC (Electrical Braking Actuation Controller)



Messier-Bugatti-Dowty
electric brake
for the Boeing 787

→ The first electrical braking system in the world developed for civil application. Safran Power provides the EBAC electronic control unit:

- EBAC is used with Messier-Bugatti-Dowty **electric brakes for the Boeing 787**;
- 4 EBAC units control braking on the main gear's 8 wheels.



EBAC (Electrical Braking
Actuation Controller)

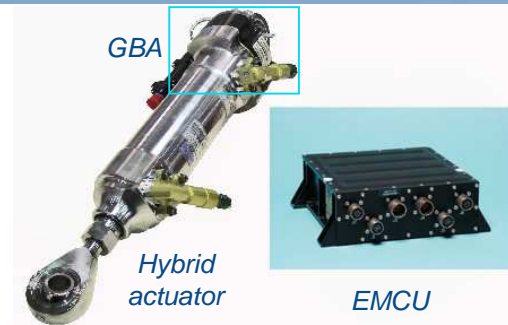
LANDING AND BRAKING SYSTEMS

→ A400M / LANDING: EBMA (Electrical Back-up Mechanical Actuator)



→ An electro-hydraulic assembly developed by Messier-Bugatti-Dowty:

- The EBMA handles **the opening and closing, in backup mode, of the landing gear doors on the A400M;**
- **Hispano-Suiza supplies the electrical drive for the EBMA**, comprising an EMCU (electric motor control unit) and GBA (gearbox assembly) reduction gearbox.



ELECTRICAL SYSTEM

→ KC390 / EEPGS (Emergency Electric Power Generation System)



- Emergency electric power generation system (ATA 24),
- The system will convert air stream in electric power for the loads that are essential for continued safe flight and landing in case of emergency.

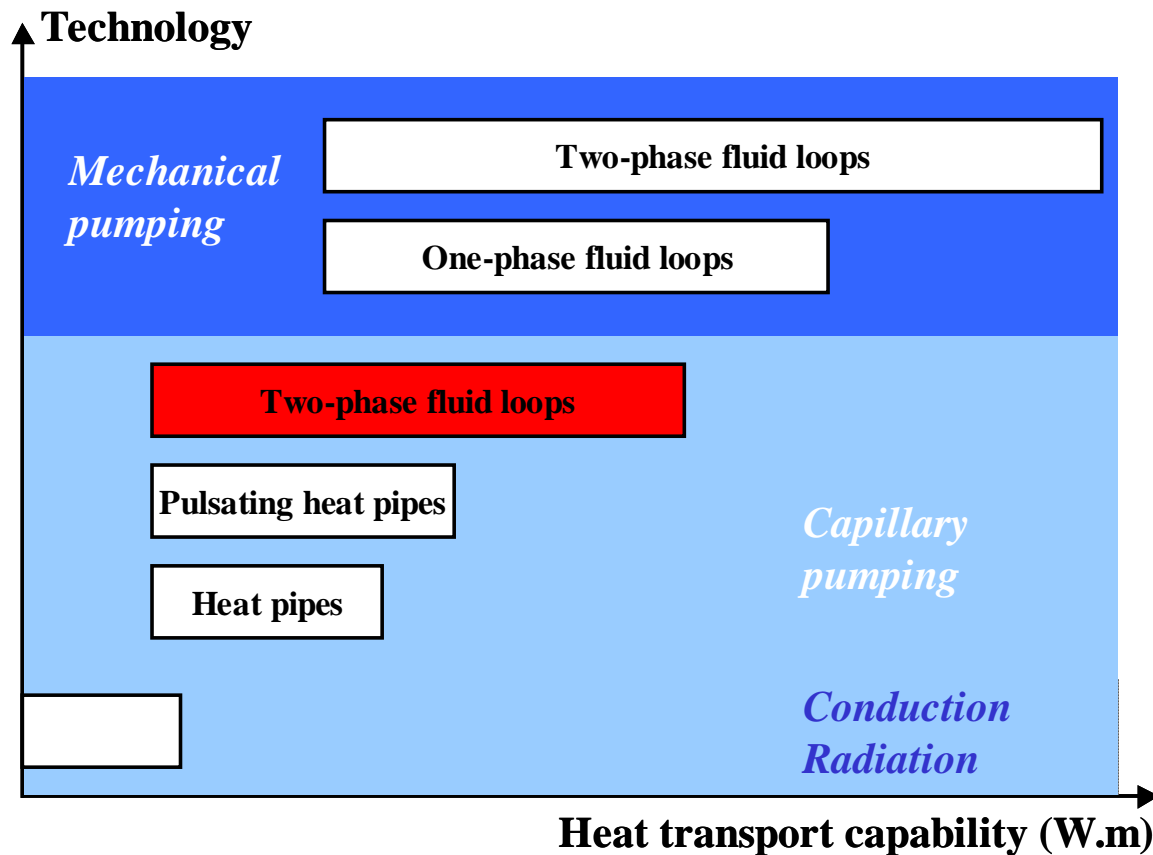
/02/

Thermal management of power electronics

Thermal management in More Electrical Aircraft at equipment level

→ High heat power density => efficient heat transfer systems

- Capillary pumped two-phase fluid loop



- More efficient than Heat pipes
- As efficient as One-phase fluid loops:
 - 10-10000 W.m
 - Up to 100 W/cm²
- **Passive system: no mechanical pumping**

Key Design Drivers

$$P_{cap,max} \geq \Delta P_{liq}(f(Q,l)) + \Delta P_{vap}(f(Q,l)) + \Delta P_{grav}$$

Capillary pressure pumping capability *Liquid flow pressure drop* *Vapor flow pressure drop* *Hydrostatic pressure drop*

- **Capillary pumping capability** : surface tension
- **Liquid / vapor pressure drop** : dynamic viscosity and density
- **Hydrostatic pressure drop** : density
- **Mass flow rate** : Latent heat of vaporization

/03/

Fluid specification

Generality

→ Commonly used fluid in capillary pumped two-phase systems:

- List:
 - Water
 - Ammonia
 - Methanol
 - Ethanol
 - Acetone
 - ...
- Only partially compliant with all aerospace application requirements

→ New fluid is required:

- Performances similar to classical fluids ones
- Compatible with aerospace environmental requirements

- Water that freeze below -55 °C !!!

Environmental requirements

→ **REACH compliant**

→ **Fireproof fluid:**

- Not flammable
- Auto-ignition temperature > 400°C
- Auto-extinguishing under this temperature

→ **Temperature range: [-55°C;150°C]**

→ **Fungus proof**

→ **Compatible with fluid commonly used in aircrafts (see DO160-G)**

→ **Compatible with common metals**

→ **Dielectric fluid preferred**

Thermal physical properties requirements

→ Main typical properties:

- Latent heat of vaporization as high as possible: at least higher than **500 kJ/kg**
- Dynamic viscosity of vapor as low as possible: at least lower than **$140 \cdot 10^{-7}$ kg/m/s**
- Surface tension as high as possible: at least higher than **$11 \cdot 10^{-3}$ N/m**
- Vapor density at least higher than **1 kg/m^3** at 80°C

→ Other properties required :

- Dynamic viscosity of liquid as low as possible: at least lower than **$0.12 \cdot 10^{-3}$ kg/m/s**.
- Specific heat of liquid as high as possible: at least higher than **2000 W/kg/K**.
- Specific heat of vapour as high as possible: at least higher than **1300 W/m/K**.
- Thermal conductivity of liquid as high as possible: at least higher than **0.150 W/m/K**.
- Thermal conductivity of vapour as high as possible: at least higher than **0.015 W/m/K**.
- Density of liquid as high as possible: at least higher than **700 kg/m^3** .
- Saturation vapor pressure must be lower than **7 Bars** over the temperature range.

→ Requirements over the whole temperature range

/04/

Schedule of work

Schedule and major deliverables

→ Review of existing fluids

- To identify fluid kinds which are the most adequate
- Deliverable is expected within 2 months

→ Synthesis of new fluid

- First, in silico
- Then, Experimental synthesis
- Deliverable is expected within 6 months (TBC)

→ Experimental characterization of the synthesized fluid:

- Evaluation of thermal physical properties to check compliancy with requirements
- Deliverable expected at the project end