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SB 503 - Avionics Technologies

4- Avionics Supporting Technologies

4-1 Federated solutions, LRUs (Arinc 600)
4-2 Modular Concept Units (Cabinets, LRM,…)
4-3 Housing, Form, Fit
4-4 Thermal Challenges & Solutions

Professor: H. GOUTELARD (Contractor ENAC/Sup'Aéro)
Thales Avionics

Content

- Packaging Definition
- Packaging Approach in Avionics
- Mechanical Design Examples
- Thermal Design Examples
- Future Cooling Techniques

What is the packaging in avionics ?

- It ensures the physical and electrical interface between the aircraft and the electronics
- It ensures the protection of the electronics in its environment (vibrations, Electromagnetic Interferences, thermal…)
- It supports the handling during aircraft manufacturing and airline maintenance

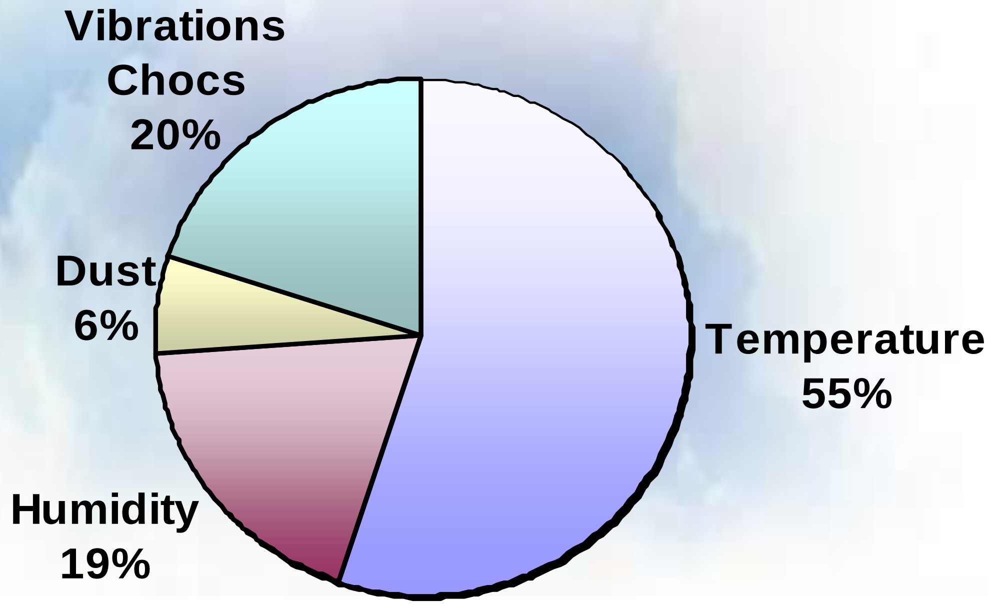
Example ARINC600 packaging

braking control system (BCS) of the A380

The packaging, is the place where most of the problems and failures originate

Why is packaging important ?

» **Major packaging failure sources**



(Source : US Air Force Avionics Integrity Program)

These major sources of failure affect the reliability of electronic equipment

Packaging major stakes

- It is absolutely crucial to develop a product which responds to the specification at a minimum cost and in one shot, it means :
  - **To be able to anticipate the behavior of the equipment regarding the environment specifications**
  - **To make the good choice for the architecture and for the technologies used in the equipment**
  - **To identify the weaknesses of the design and margins including fatigue effects**
  - **To respect the environment regulations (ROHS, Reach, CMR,..)**

The knowledge of the technologies and the use of simulation tools are the correct answer to these takes

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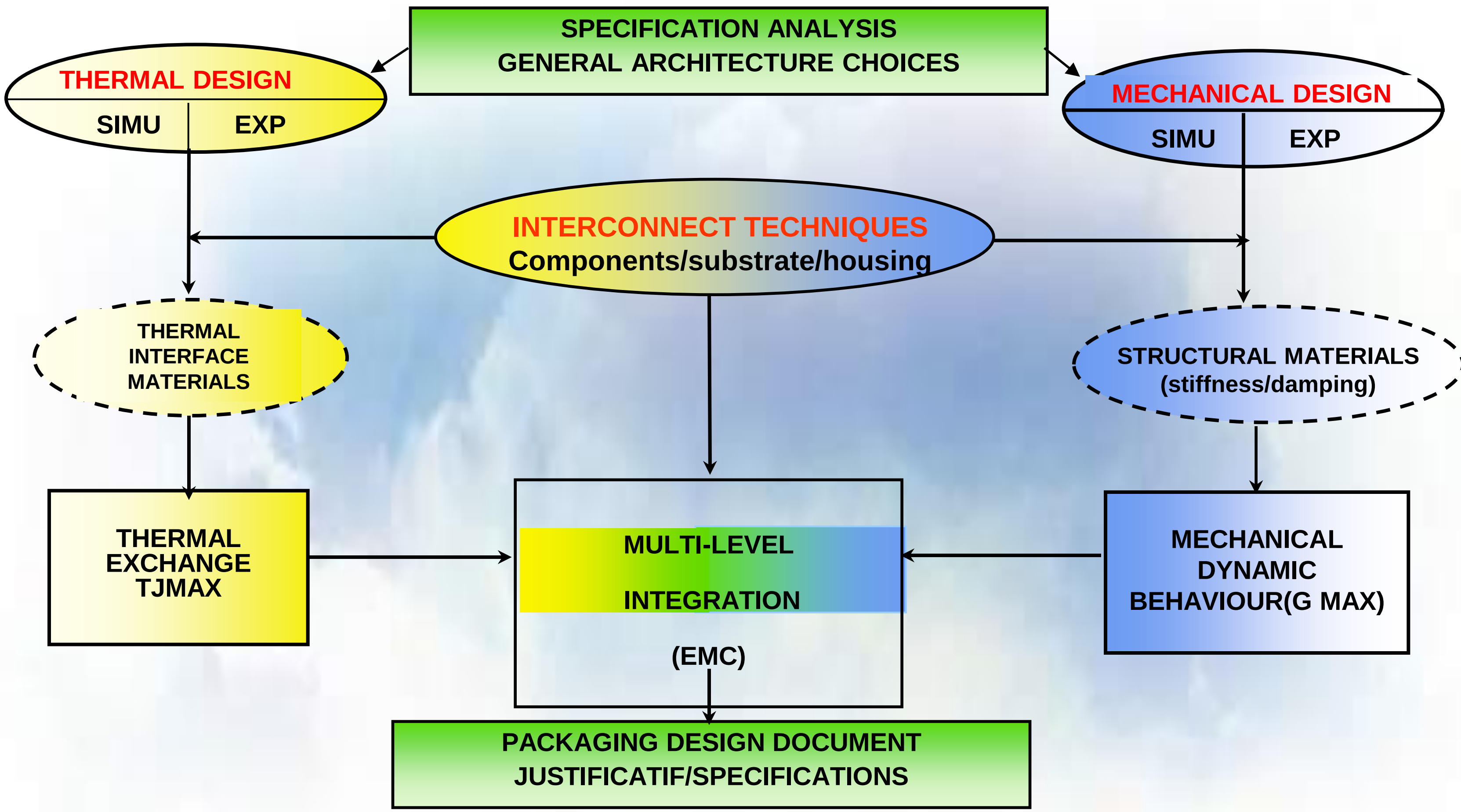
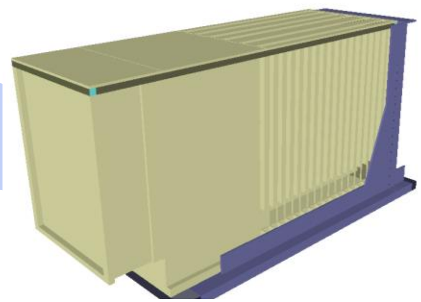
Packaging Design Approach

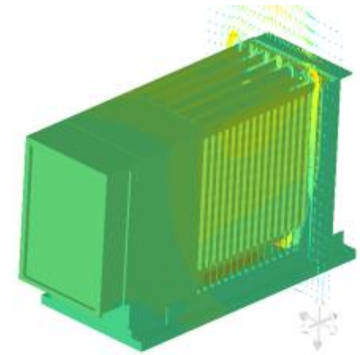


Thermal Design

- SIMULATION LEVEL 1 :

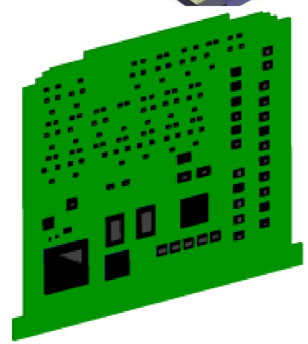
  Preliminary analysis at rack level
  Software : FLOTHERM or Excel

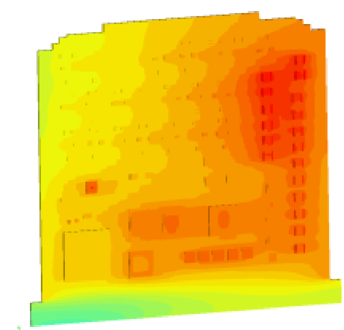




- SIMULATION LEVEL 2 :

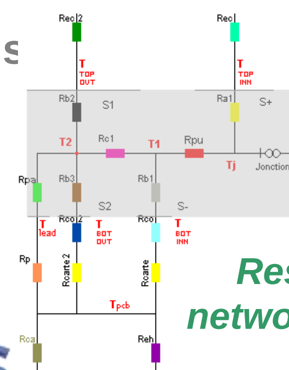
  Board Simulation / PCB level
  Software : FLOTHERM



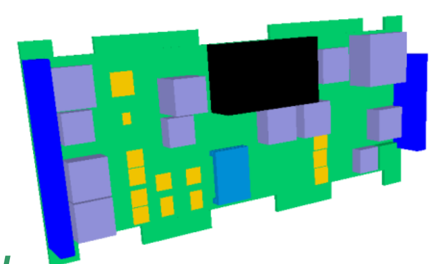


- SIMULATION LEVEL 3 :

  Board simulation with component models
  Software : WATT(In House) - FLOTHERM



Resistive network model



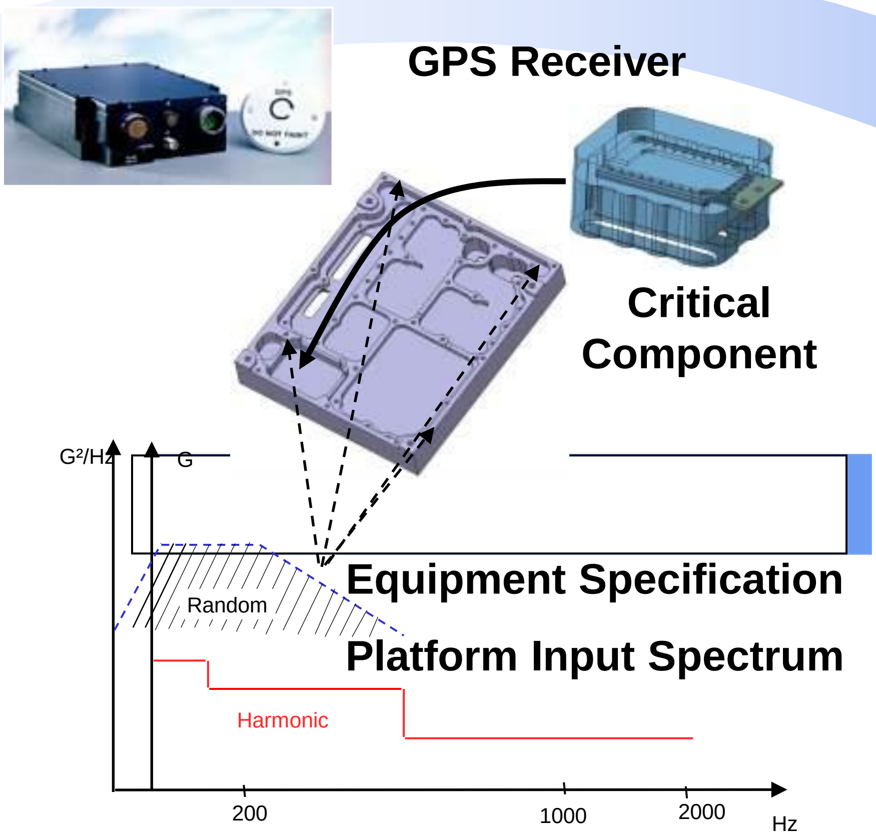
THALES AIRBUS GROUP SAFRAN

Thermal Measurement

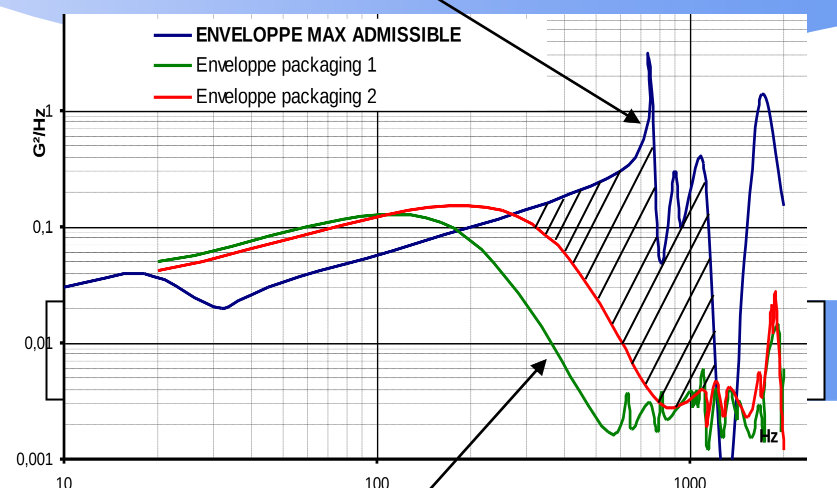
- Thermal measurement techniques
  - Thermal infrared camera (temperature mapping, hot spot identification)
  - Thermocouples
  - Air speed measurement probes
- Goal
  - Thermal model correlations
  - Location of failed components
  - Temperature gradient and thermal resistances

Mechanical Design Approach

Packaging of critical components : ex oscillators, sensors



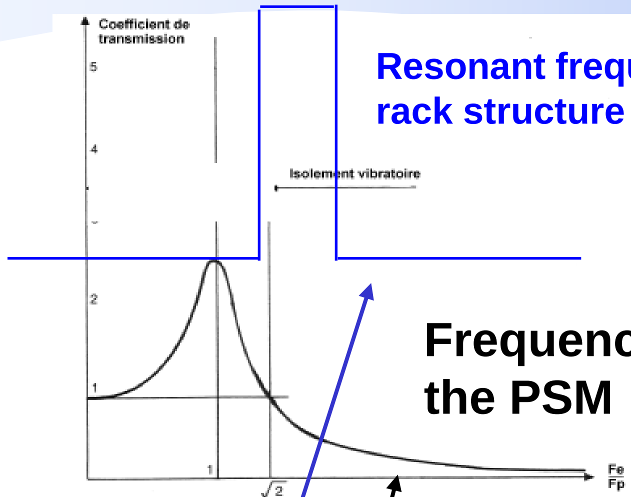
Max allowable Component G level



Level seen by the component
after mechanical treatment

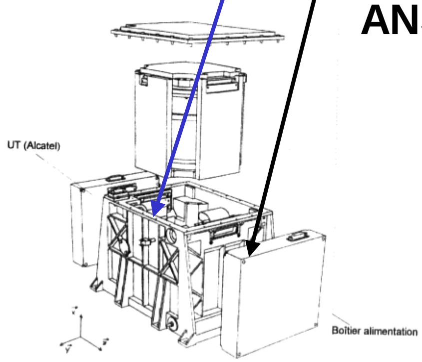
Dynamic Structural Analysis / Stiffening

Card/ Rack Decoupling : Ex: Navigation Unit



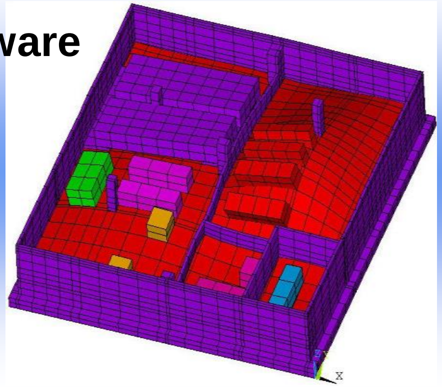
Resonant frequency of the rack structure

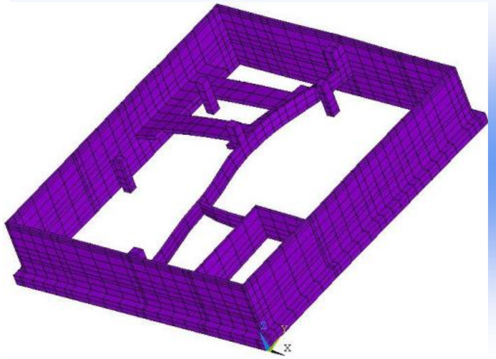
Frequency target for the PSM



ANSYS Software

Stiffener Adaptations



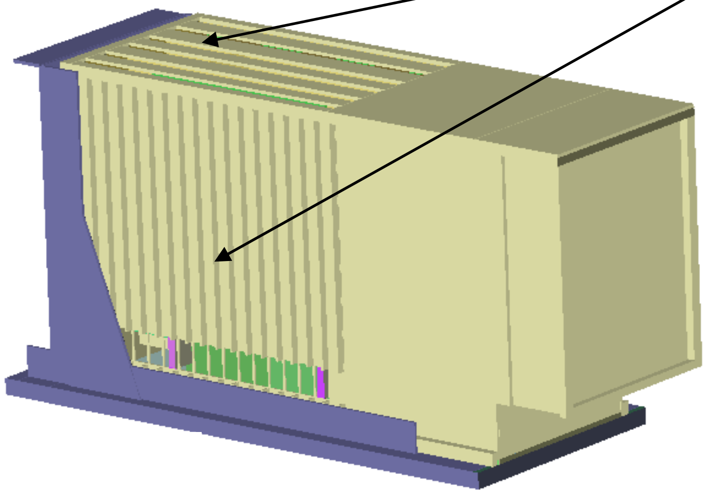


Thermal design example (1/2)

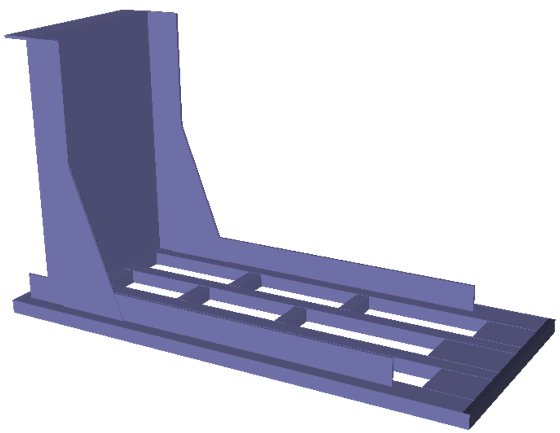
Air Inlet Optimization : Location, size

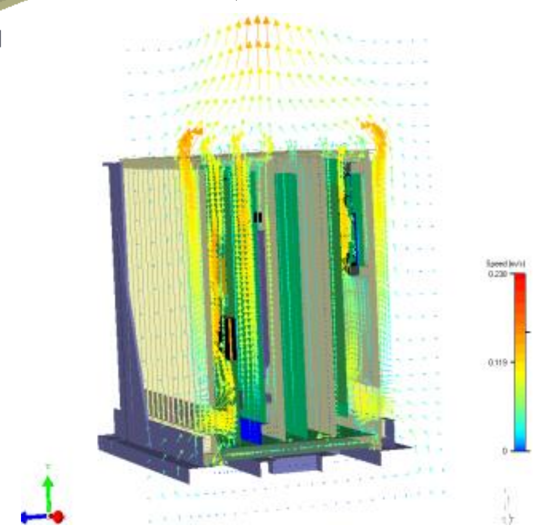
Top and lateral openings

Tray impact on the air flux



Air circulation by stiffeners porosity adjustment

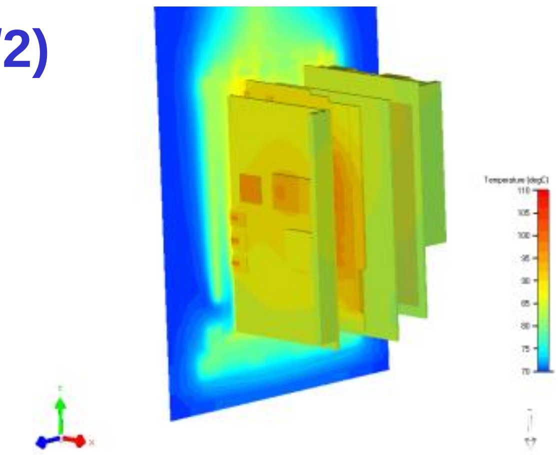




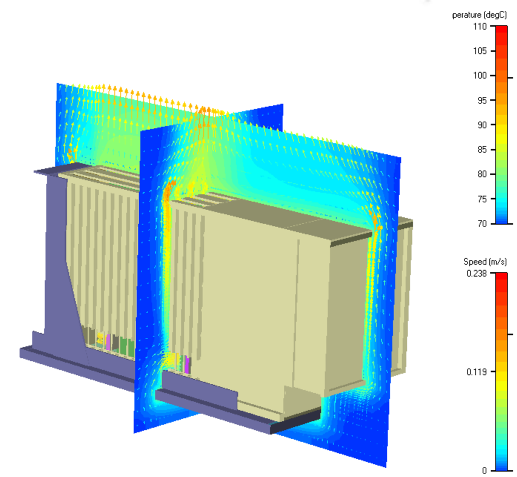
Thermal design example (2/2)

Design drivers:

- » Max Ambiant Temp 70°C
- » Typical power dissipation 30-50W
- » Free convection only
- » Max junction temperatures defined:
- » 105 °C PPC on processing
- » 105 °C Capacitors on PSM
- » 85 °C Max internal air Temp



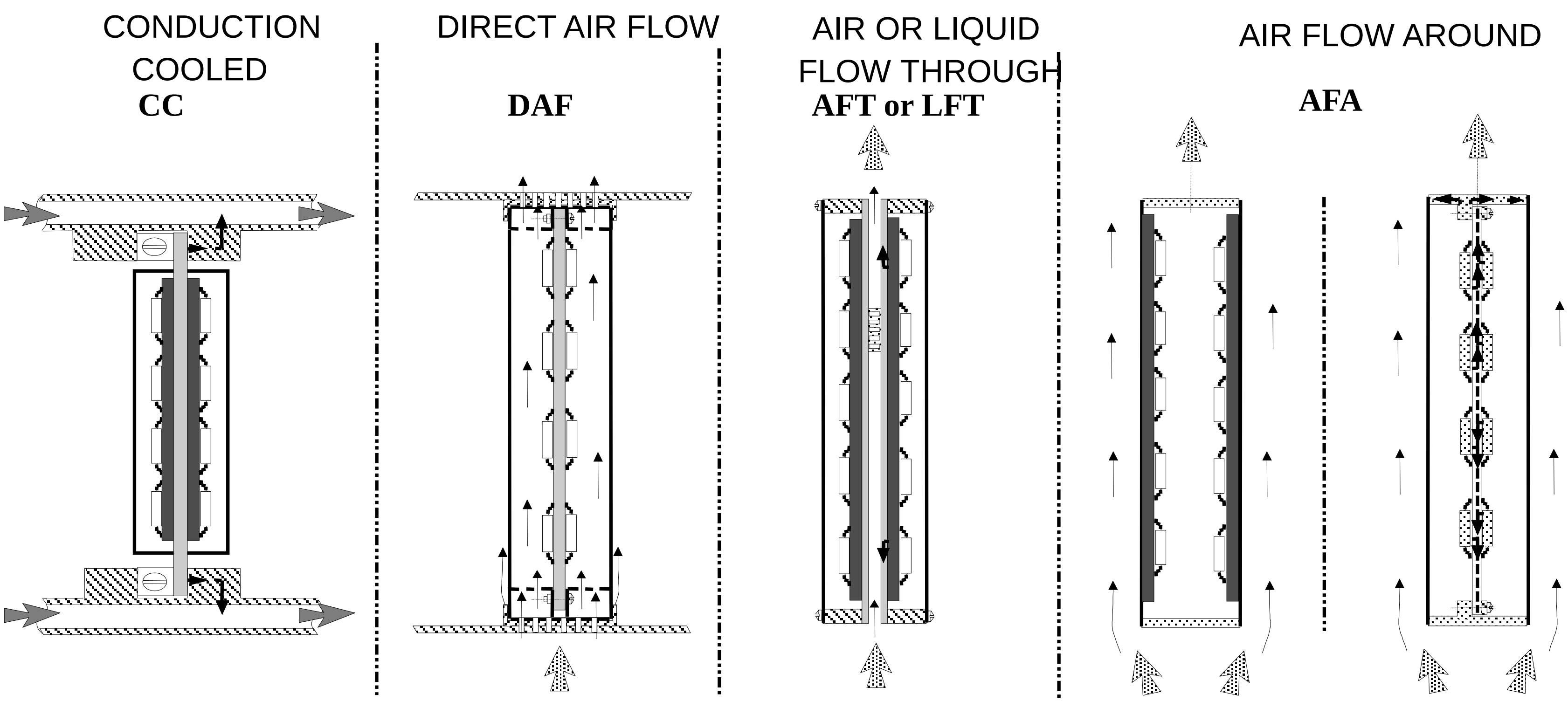
- **Design criteria:**
  - » Tjmax = (Tjmax –Tamb)*0.7 + Tamb
- **Results:**
  - » Max Components temperatures
  - » PowerPC < 100°C

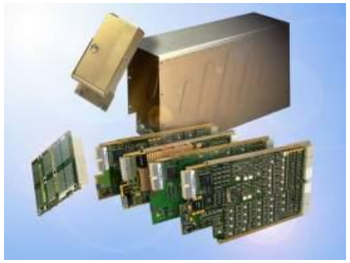


The temperature optimization has a direct impact on reliability and life

Future Cooling Techniques
“COSEE” project
(as a typical example)

State of the Art in Avionics Cooling Techniques





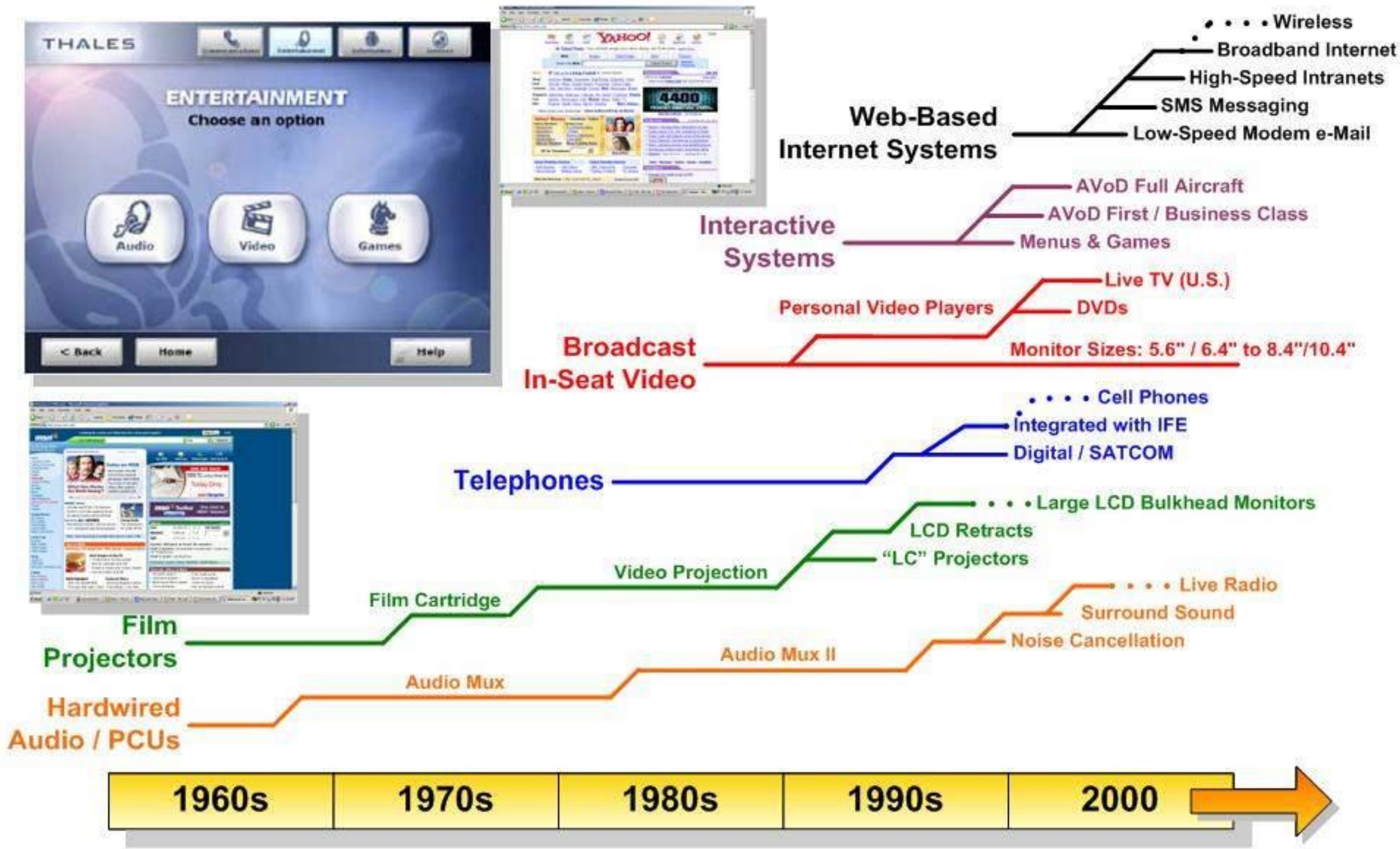
- Airbus A340 / A380

Thales Avionics civil Needs : Computers

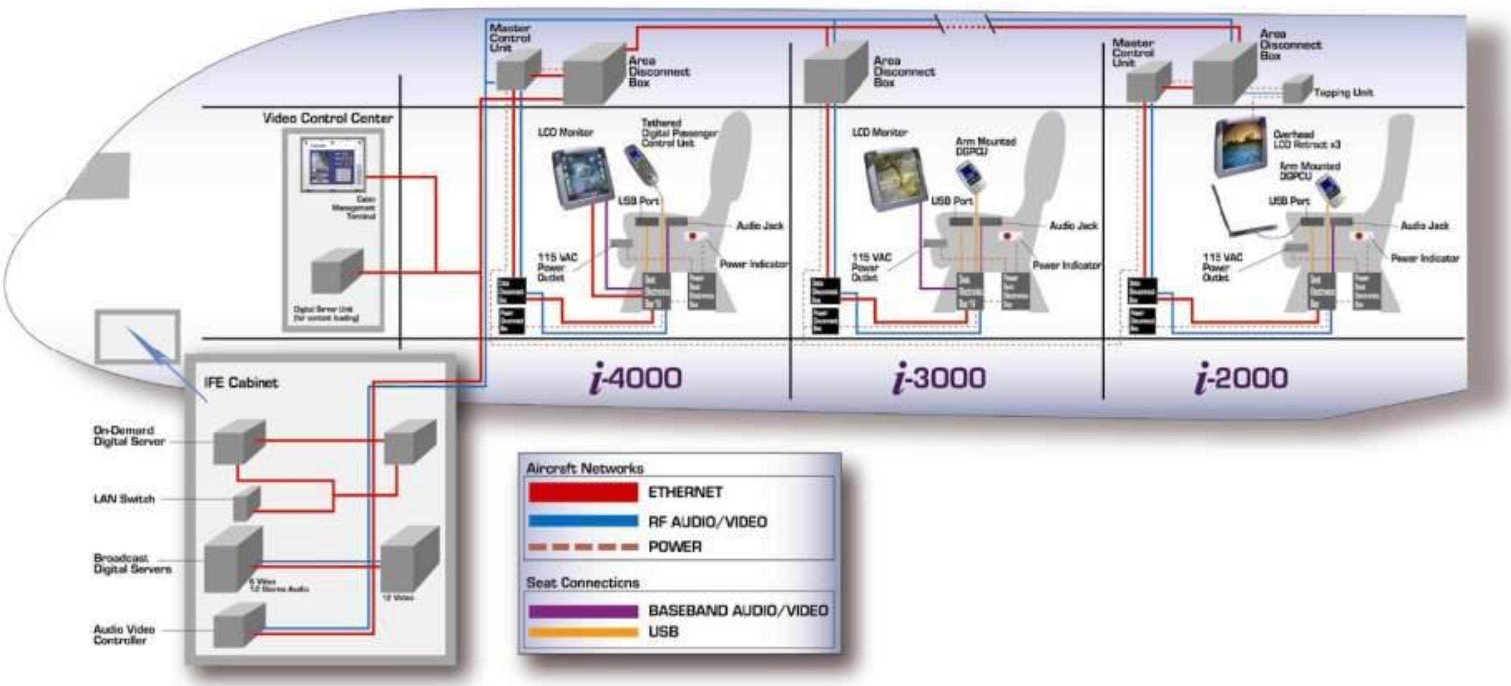
- Most of the avionics equipments are forced air cooled and compatible with ARINC 600 standards in the Electronic Bay : Airflux 220 kg/h/kw
- With increased hot spots dissipation, phase change systems have been identified as possible options

	Power Dissipated		card/mod. size		Programs
	Card/modules	Hot Spots	Length/height	Width	
cards	8/12w	4/5 w	240x160	<1"	A340
	15/17w	4/5 w	300x160	1"	IMA - A380
Existing Modules	20/30 w	4/5w	300x160	1"	RRJ
Future Modules	60 w	30w ou 2x17w			Future programs (Boeing, Airbus)

History and Trends of In Flight Entertainment



Aircraft « Cabin Install » overview



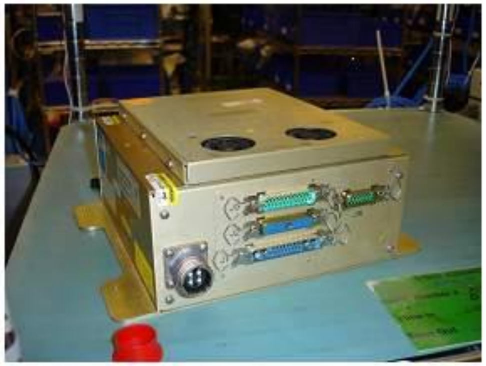
- Over 2,000 LRUs per aircraft
- Over 3 million lines of software code
- Multiple configurations per aircraft type

Non EE-Bay cooled LRUs example

Seat Electronics Box: SEB-106

Seat Data Box: SDB (i8000)

Seat Power Box: SPB (i8000)



Area Distribution Box: ADB (i5000)

Synthesis / COSEE Project

- New generations of IFE are required to provide more services (audio, internet, phone…)
- These systems may be buried in small enclosed zones. When forced convection, provided by the aircraft is not available two existing techniques remain :

  Natural convection with limited power dissipation

  Integrated fans

  - Extra cost when multiplied by the seat number
  - Reliability and maintenance concern risks of blocking by passengers

- Heat pipes and phase change systems adequately integrated into the seat or the cabin structure have been identified as a reliable efficient alternative to fan cooling

The COSEE European project has been launched to evaluate the new technology

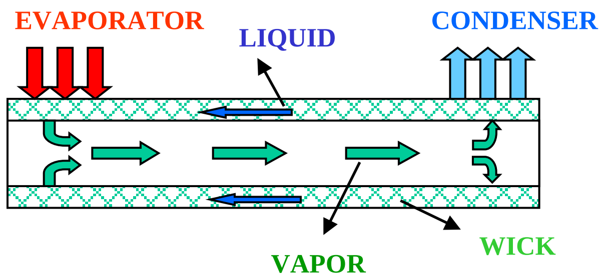
COSEE QUANTIFIED OBJECTIVES

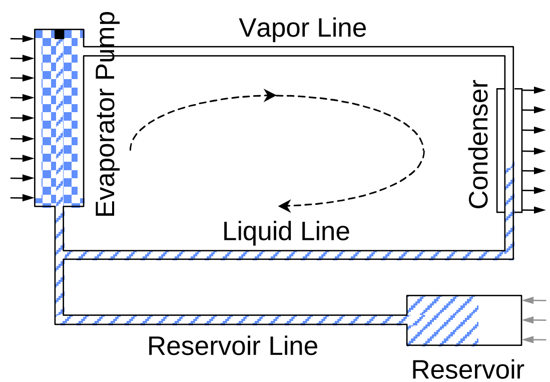
- Transfer capacity up to 100W
- Thermal conductivity at least 800 W/m°K
- Heat transportation distance 500 mm (max)
- Resistance to aircraft cabin environment (vibration, acceleration, shocks, airbus specifications)
- Minimum volume and low weight
- Ease maintainability
- Affordability cost target ≤ cost of a fan system

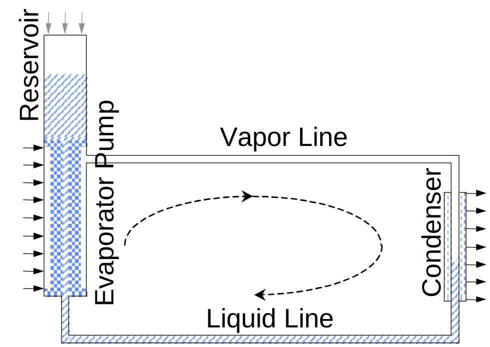
Heat Pipe Technology

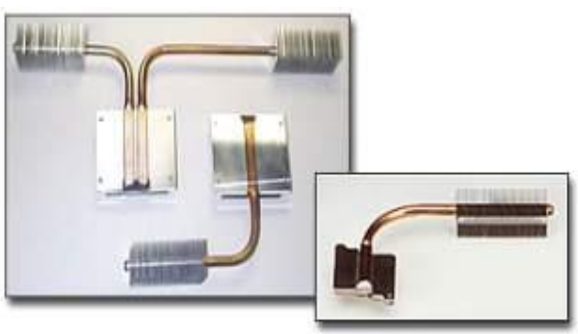
2 Phase capillary pumped systems

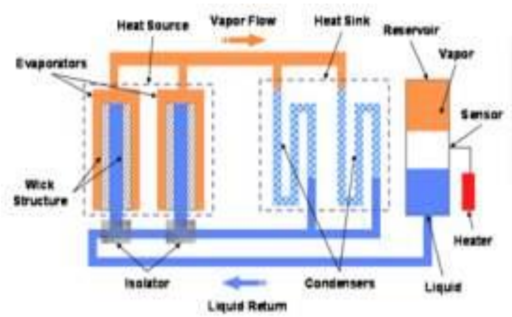
HP	CPL	LHP

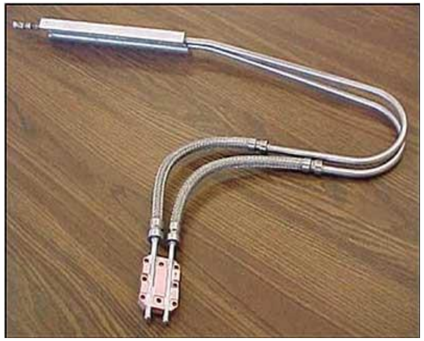








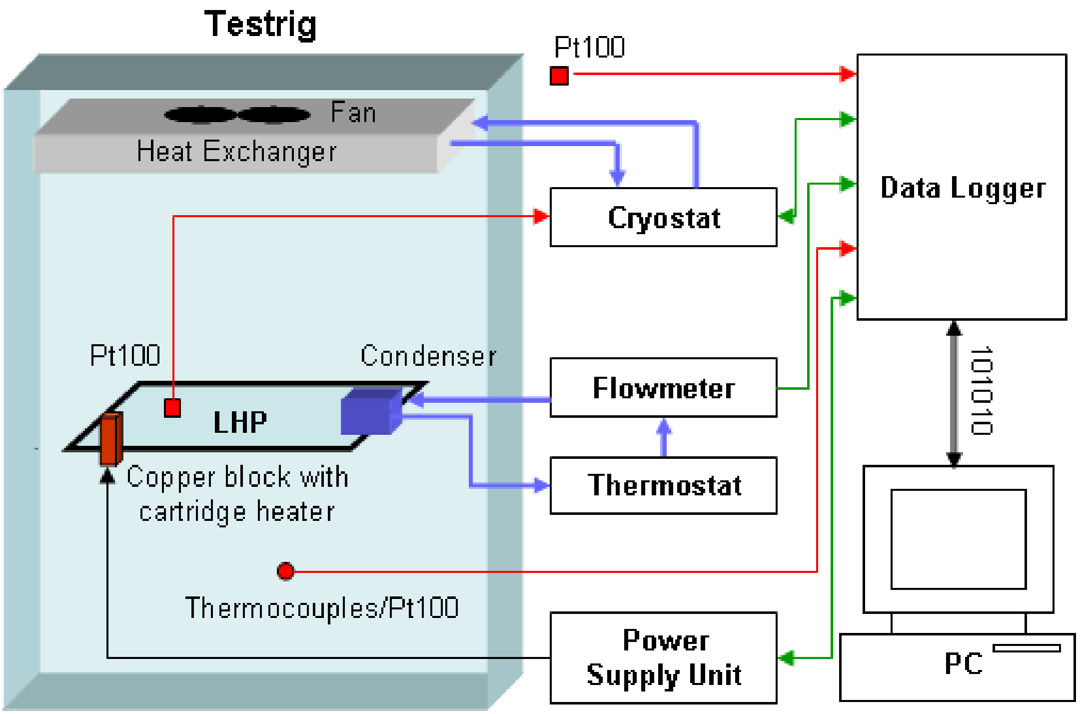




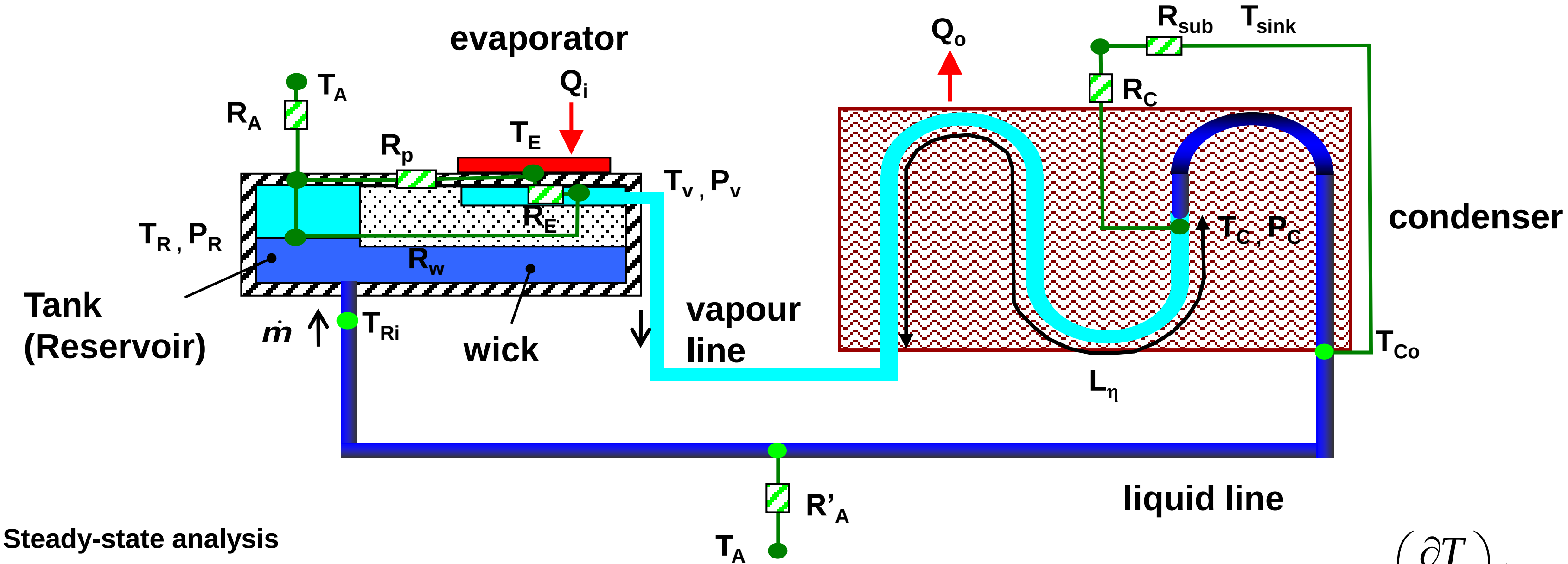
Test rigs and measurement setup

Test rig No. 1

Test rig No. 2



LHP Thermal Model



- Steady-state analysis
- Nodal method
- Heat exchanges with ambient along the liquid line and at the tank / reservoir
- Negligible temperature variation in the vapour grooves and vapour line
- Negligible vapour desuperheating length in the condenser
- Two-phase fluid in the reservoir
- Existence of a transversal heat leak (through the wick) and a longitudinal heat leak (through the wall)
- Variation of the fluid thermophysical properties with the temperature
- Laminar or turbulent flows
- Isobaric phase change process in the condenser

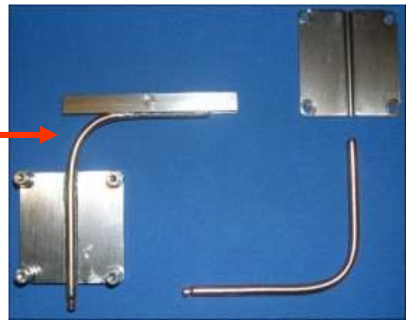
$$T_v - T_C = \left(\frac{\partial T}{\partial P}\right)\Delta P_v$$

$$\Delta P_{cap} = \Delta P_{vl} + \Delta P_{ll} + \Delta P_{porous} + \Delta P_{gravity}$$

$$T_C - T_R = \left(\frac{\partial T}{\partial P}\right)\left(\Delta P_l + \Delta P_g\right)$$

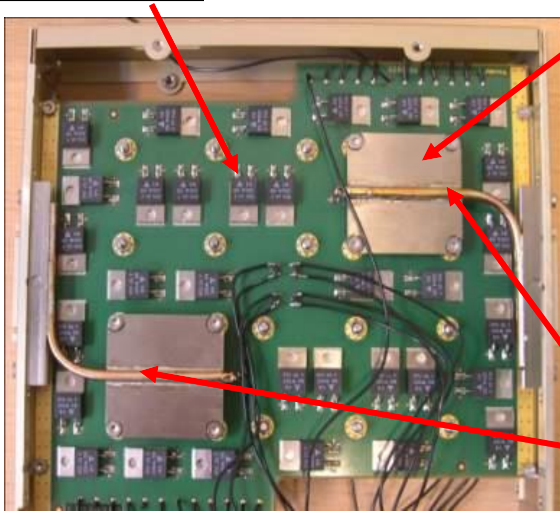
Equipment Set-Up w/ suitable adaptations

Heat pipe brazed



Lateral clamping

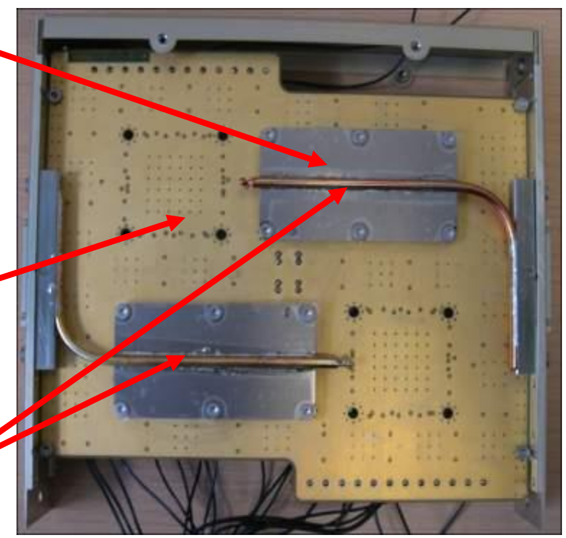
RTO20 Resistors



Metallic clamping plates

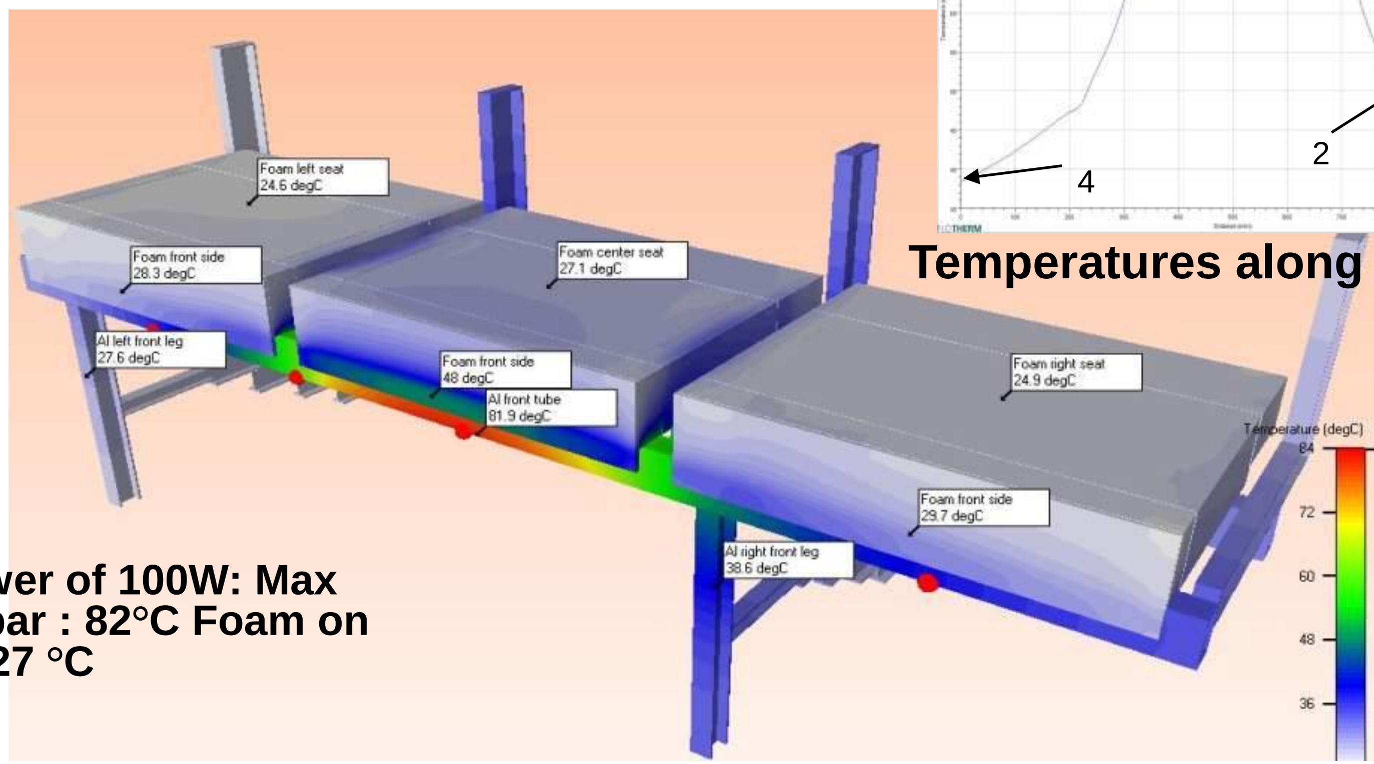
Copper mass plan

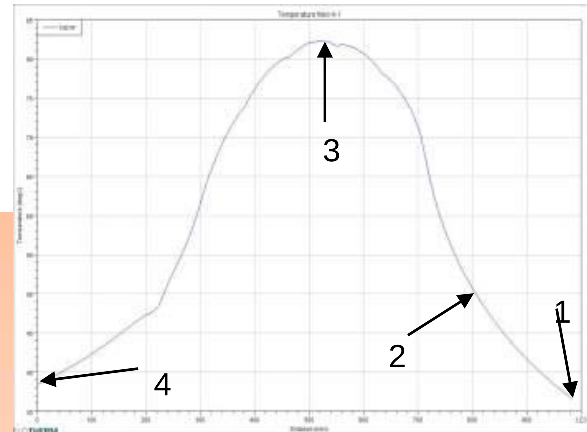
Heat pipes



Seat with LHP Modelisation

- **Simulation: 2 × 50 W**



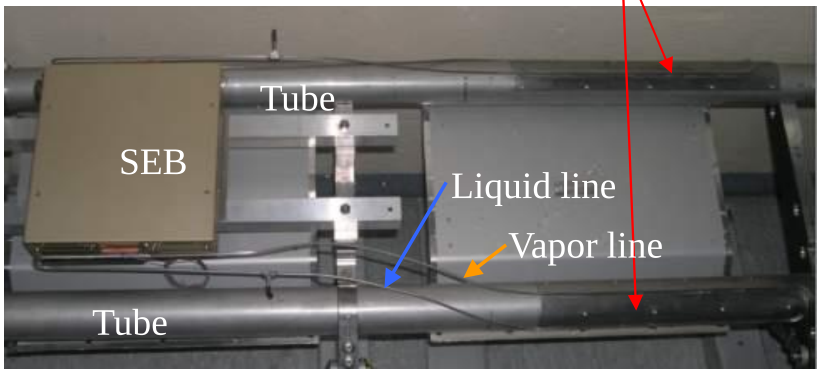


Temperatures along the bar

With a power of 100W: Max temp hot bar : 82°C Foam on the seat : 27 °C

Mounting of the Loop Heat Pipe on the seat

Condensers of the LHPs

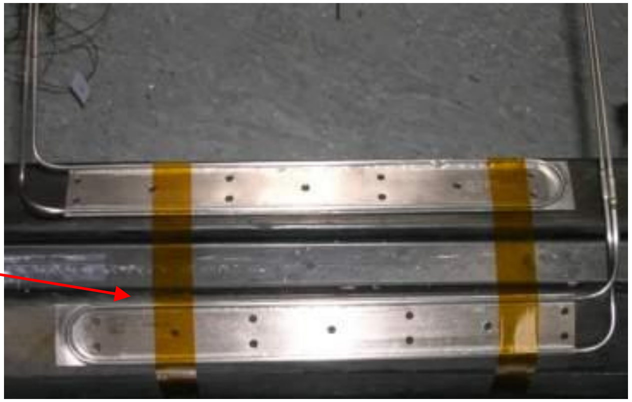


EHP Loop Heat Pipe (SS-R245fa) on the seat A

ITP Loop Heat Pipe (Ni-SS R141b) on the seat B

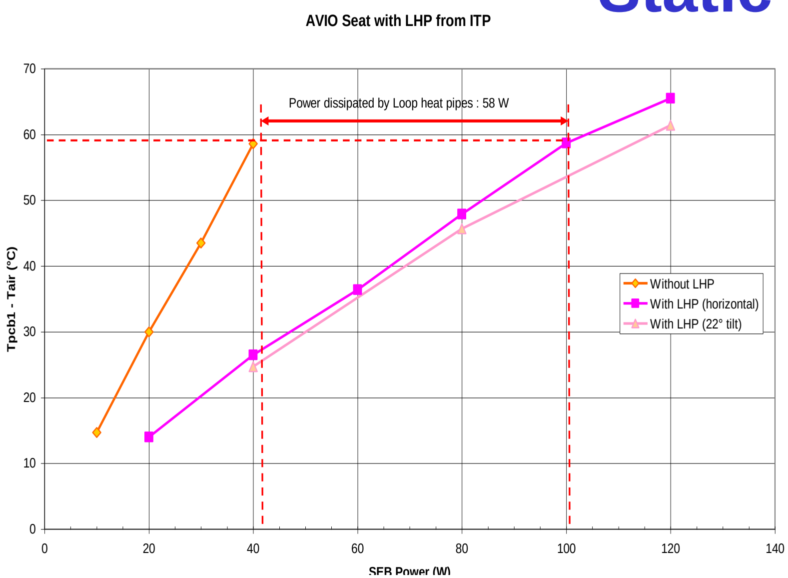
Evaporator of the LHP

Condensor of the LHP2

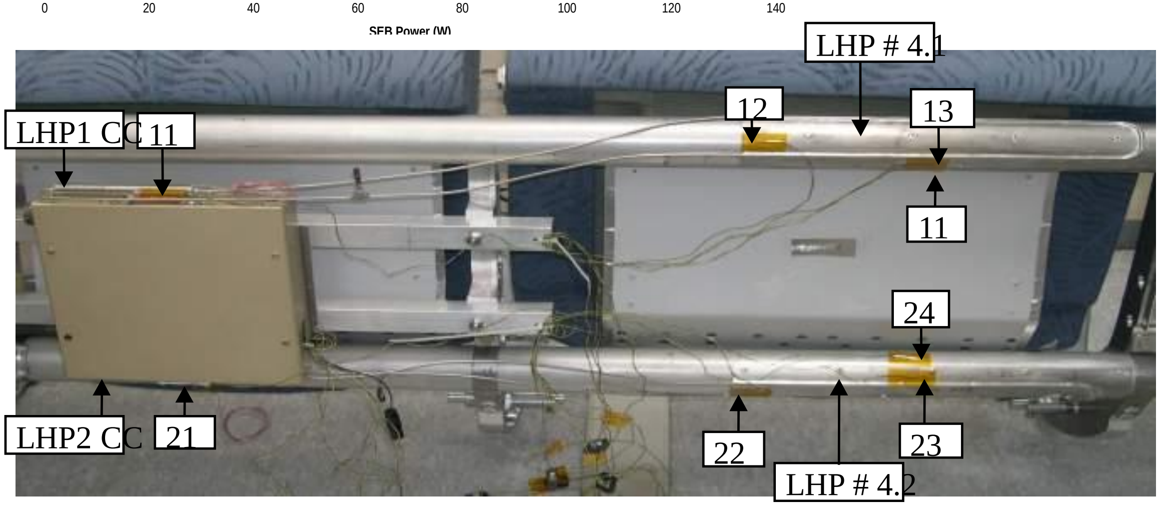


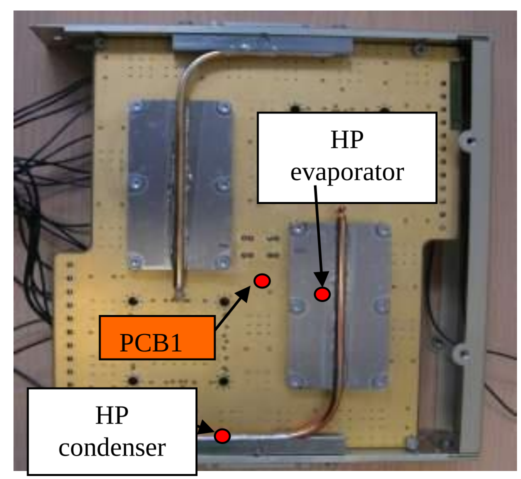
Static ambient performances

Avio seat with ITP Loop Heat Pipe



- Increase of 150% of the heat dissipation capability 40W to 100W with a constant PCB temperature)
- For a same dissipated power 40W the use of HP and LHP allow 32°C decrease on the PCB temperature without the use of fan





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Linear acceleration on Avio seat

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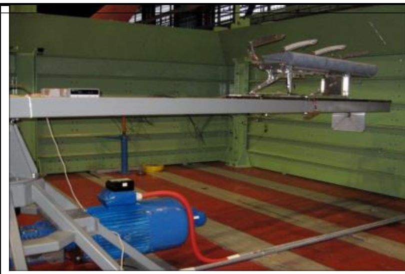
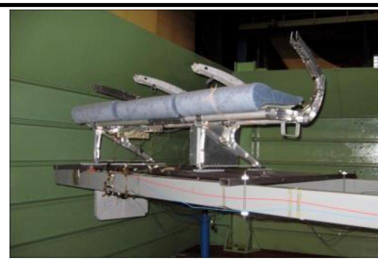
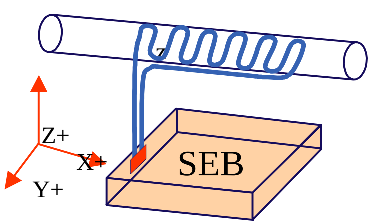
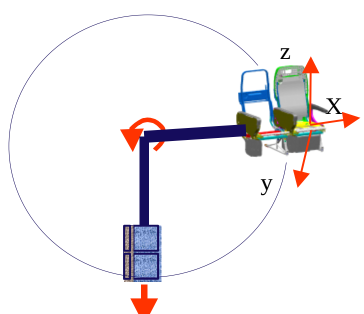
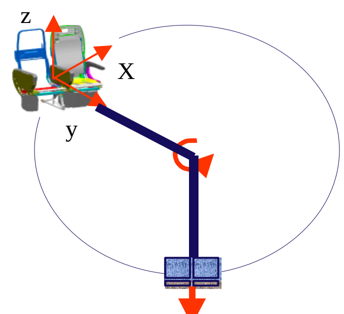
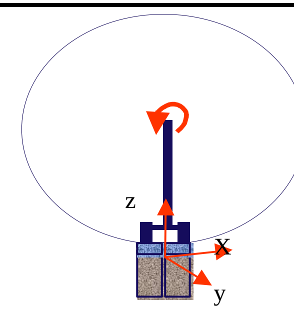
<tr><td>AXIS +</td><td></td><td></td><td></td></tr>
<tr><td>AXIS -</td><td></td><td></td><td></td></tr>
<tr><td>
</td><td>
</td><td>
</td><td>
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Results of other tests

- Climatic test OK
- Thermal shocks OK
- Temperature cycling OK
- Vibrations OK

- The HP and LHPs on the two types of seats have a good behavior.
- The thermal performances are about the same range after all the tests

COSEE: Results and conclusions

- Two LHP cooling techniques have been developed with the combination of heat pipes in the electronic box and loop heat pipe for the long distance heat transportation.
- The performance achieved with a conductivity of 80000 W/m°K is equivalent to 200 times the bare copper capability. The 3 mm tubes would be equivalent to a copper rod of 80mm in diameter.
- Simulation tools and measurement techniques have been developed.
- The environment tests corresponding to civil aircraft applications have been passed successfully
- The industrial development has to be continued for cost competitiveness

The COSEE European project has demonstrated the feasibility of this technique for future avionic application