EURO HEAT PIPES

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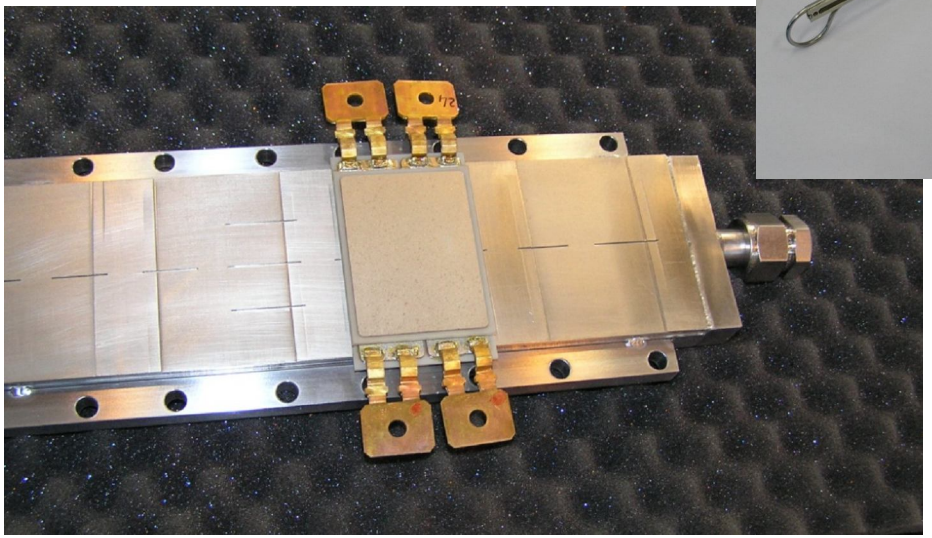
www.ehp.be

EHP : CPL / LHP Overview



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par Vincent DUPONT

Journée SFT du 3 décembre 2008

EURO HEAT PIPES PRESENTATION:

- General Company Background
- Main Partners
- Loops products (space and non space)
  - TRL definition
  - Performances overview
  - Potential market applications
- Scientific challenges

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General Company Background

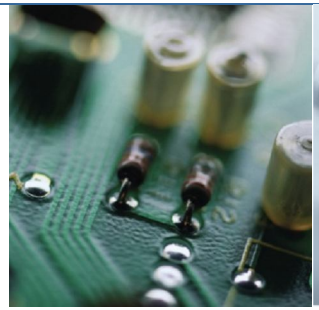
EURO HEAT PIPES:
FULLY QUALIFIED THERMAL SOLUTIONS

Euro Heat Pipes (EHP) sells **Two-Phase Heat Transfer Systems** that, thanks to their exceptional thermal performances, are **enabling the development of more powerful** and consequently more dissipative **Power Electronics**.

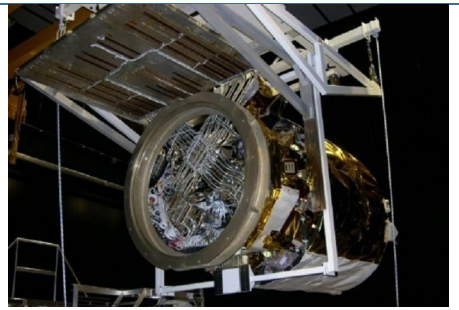
Developed for Space, now available on Earth. This 100% European technology is leading the European cooling market for Space applications and is strongly developing on Aeronautical, Defense and Terrestrial markets.

Created in 2001, by externalising the Two Phase Systems department of Sabca, EHP know-how is based on more than **30 years of heritage**.

EHP has developed full in-house capabilities (design, manufacturing, quality control and tests) and works in concurrent engineering with its customers to develop standard products and innovative thermal solutions.



EHP



EURO HEAT PIPES:
DEVELOPING NEW SOLUTIONS FROM SPACE TO EARTH

Euro Heat Pipes organisation offer **full in-house capabilities** (from breadboard up to small production series) based on a staff of 25 persons.

- Design and simulation capabilities
- Manufacturing
- Quality control
- Qualification and acceptance tests

The typical application environments are :

- Space and Aeronautic
- Defence
- Terrestrial high power electronic and electric systems.

For **large recurring production markets** (more than 1000 systems / year), a network of qualified subcontractors is settled. Product assembly tests and quality will be managed at EHP level

EHP

EURO HEAT PIPES: STRATEGIC PARTNERS

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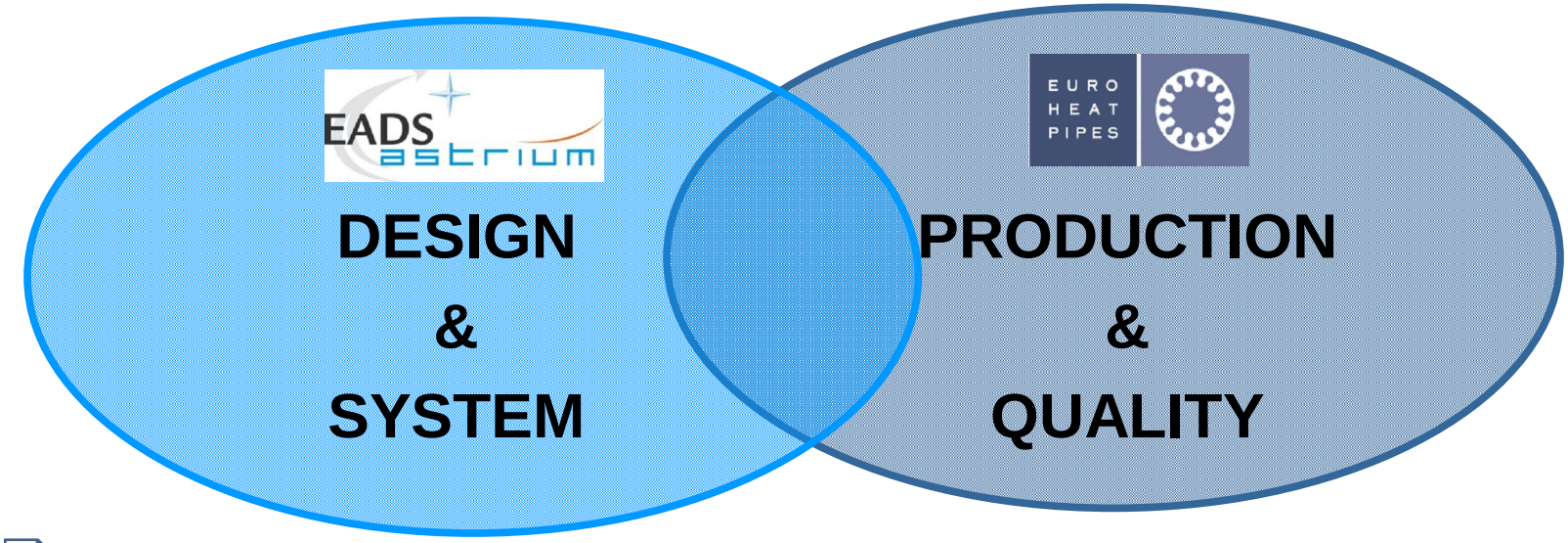
EURO HEAT PIPES and ASTRIUM integrated TEAM

- Since 2003, Astrium and EHP have established (**MOU**) a **strong and efficient integrated team** for the design / manufacturing and tests of Loop Heat Pipes
- Since 2006, a **cooperation agreement** has been signed between the 2 companies.
- In April, 2008, Astrium becomes a **16% shareholder of EHP**

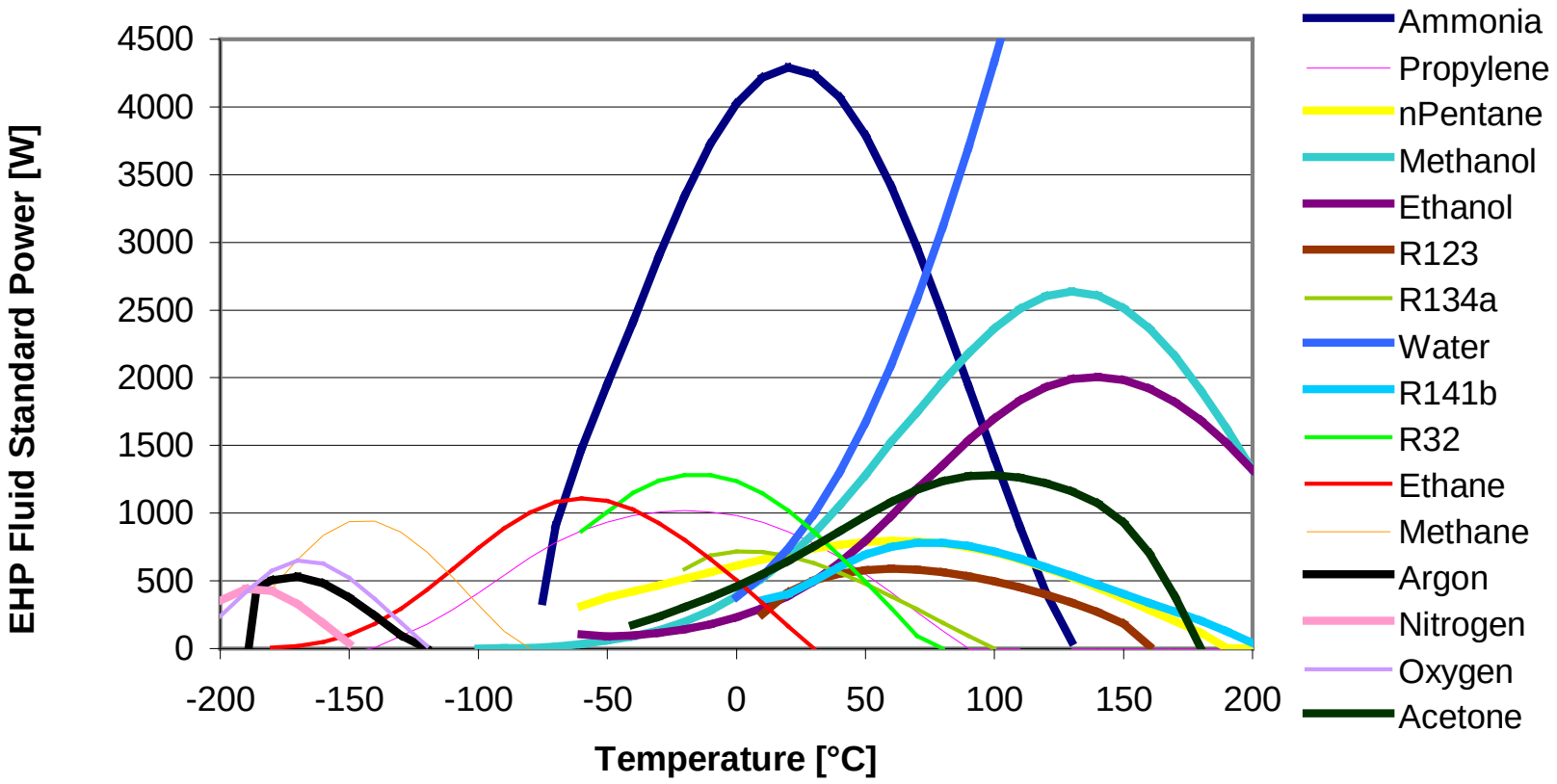


- The day-to-day average design work share is about 60% on Astrium and 40% on EHP for space market (10-90% for non-space market),
- The day-to-day average production work share is about 70% on EHP and 30% on Astrium
- EHP moves in a **new building at the end of 2008**

LHP / CPL

WORKING FLUIDS (1/2) : temperature operating range

❑ For specific operating T° range or when market safety rules are imposed, the working fluid has to be adapted



WORKING FLUIDS (2/2) safety & environmental

	NH3	*Water*	*Methanol*	*Acetone*	*Ethanol*
	Critical 	Perfect 	Critical 	Critical 	Critical 
Max concentration ***Irritant*** ***Lethal***	135 ppm 5000 ppm		1'000 ppm 65'000 ppm	500 ppm 20000ppm	3300ppm 21000ppm

	n-Pentane	*R134a*	*R123*	*R245fa*
	Critical 	Usable 	Critical 	Usable  **HCFC : ozone layer depletion**
Max concentration ***Irritant*** ***Lethal***	600 ppm tbd	tbd NA	tbd NA	tbd NA

TRL : Technology Readiness Level

TRL1	**Basic principles** observed and reported		**R&T**
TRL2	**Technology concept** formulated		
TRL3	Analytical and experimental **critical function proof-of-concept**		
TRL4	**Breadboard** validation in **laboratory** environment	**BB**	
TRL5	**Breadboard** validation in a **relevant environment**	**EM/DM**	**R&D**
TRL6	**Prototype** demonstration in a **relevant environment**	**QM**	
TRL7	**Prototype** demonstration in an **actual environment**	**IOV**	
TRL8	**Actual product** **"qualified"** through test and demonstration	**FM**	**Equipment**
TRL9	**Actual product** proven through **successful mission** operations	**RecFM**	

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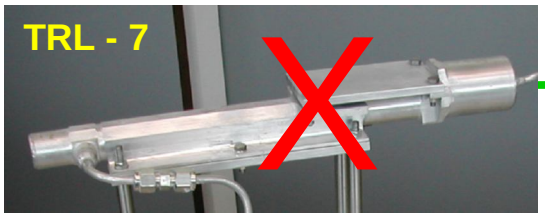
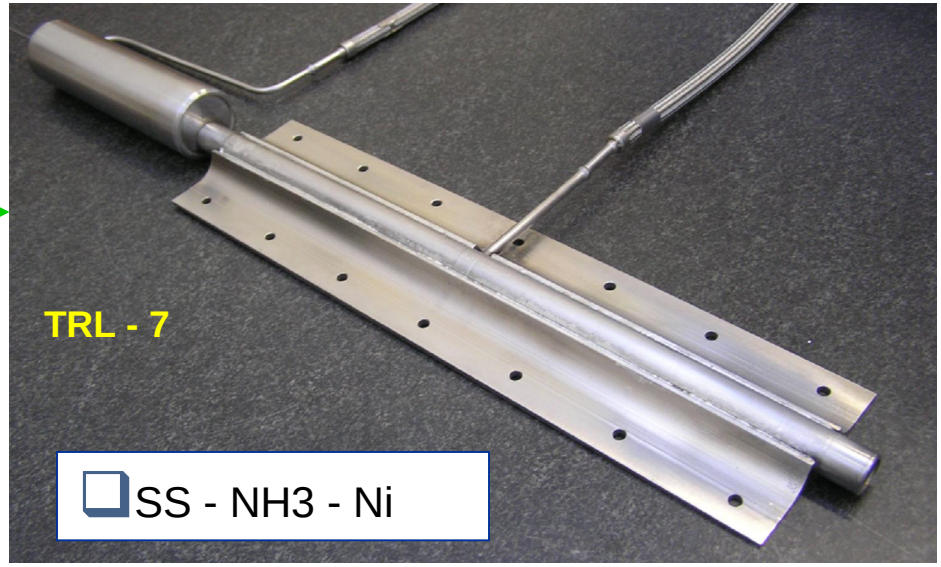
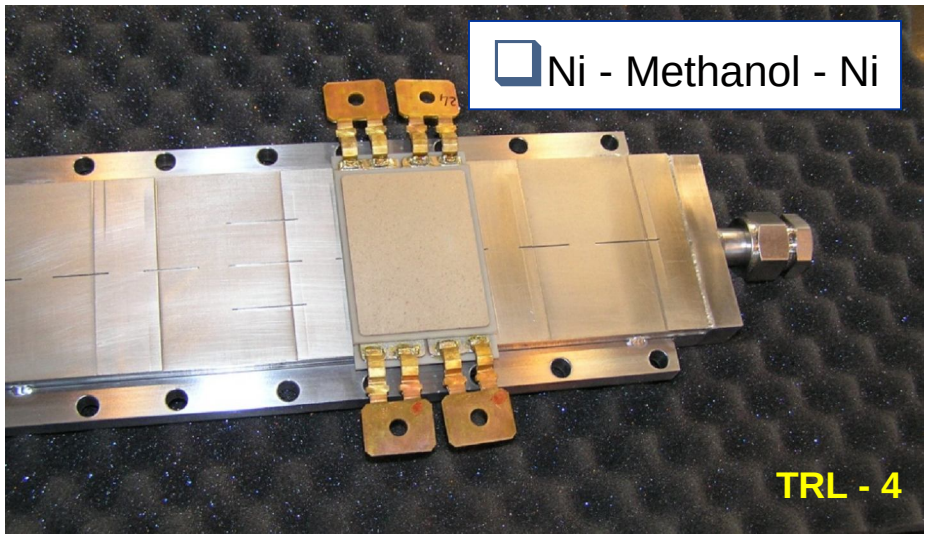
LHP & CPL : technologies (1/2)

- Al-NH3-Ni





- SS - NH3 - PTFE



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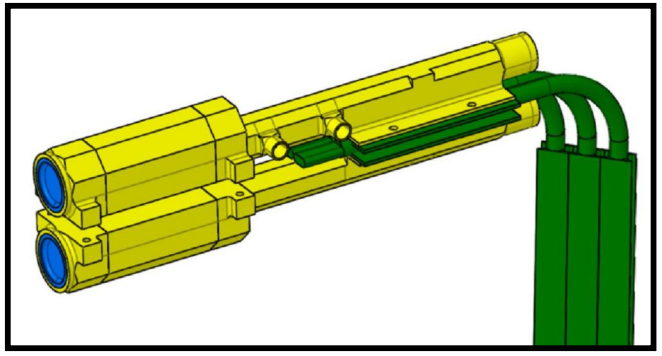
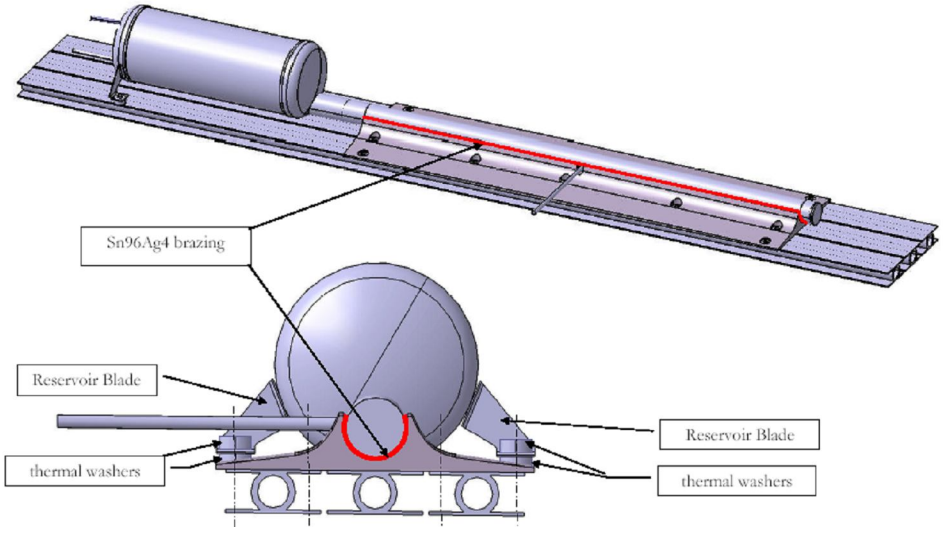
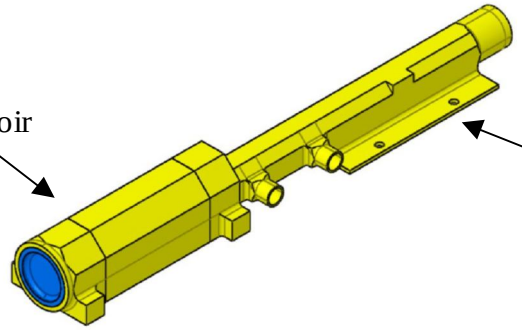
LHP & CPL : technologies (2/2)

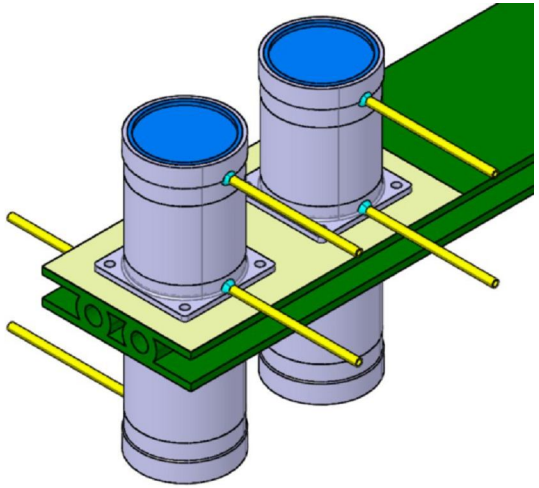


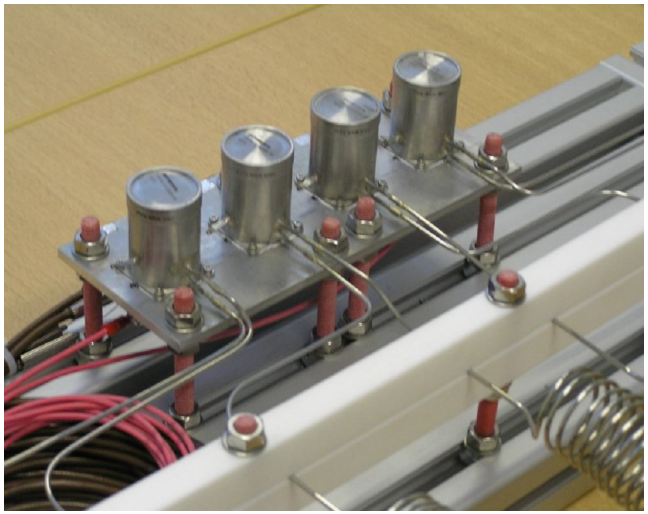


Reservoir



Evaporator saddle





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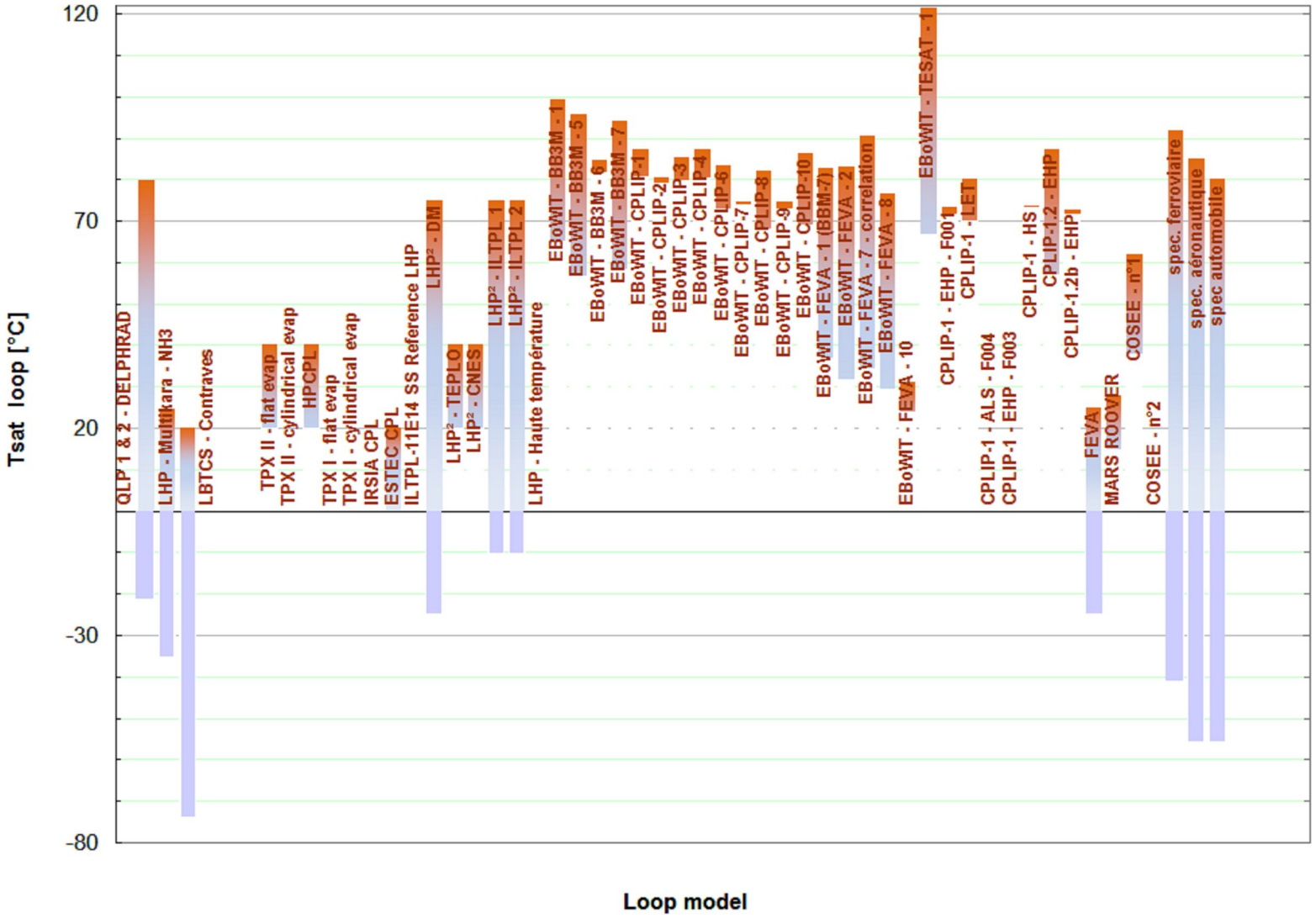
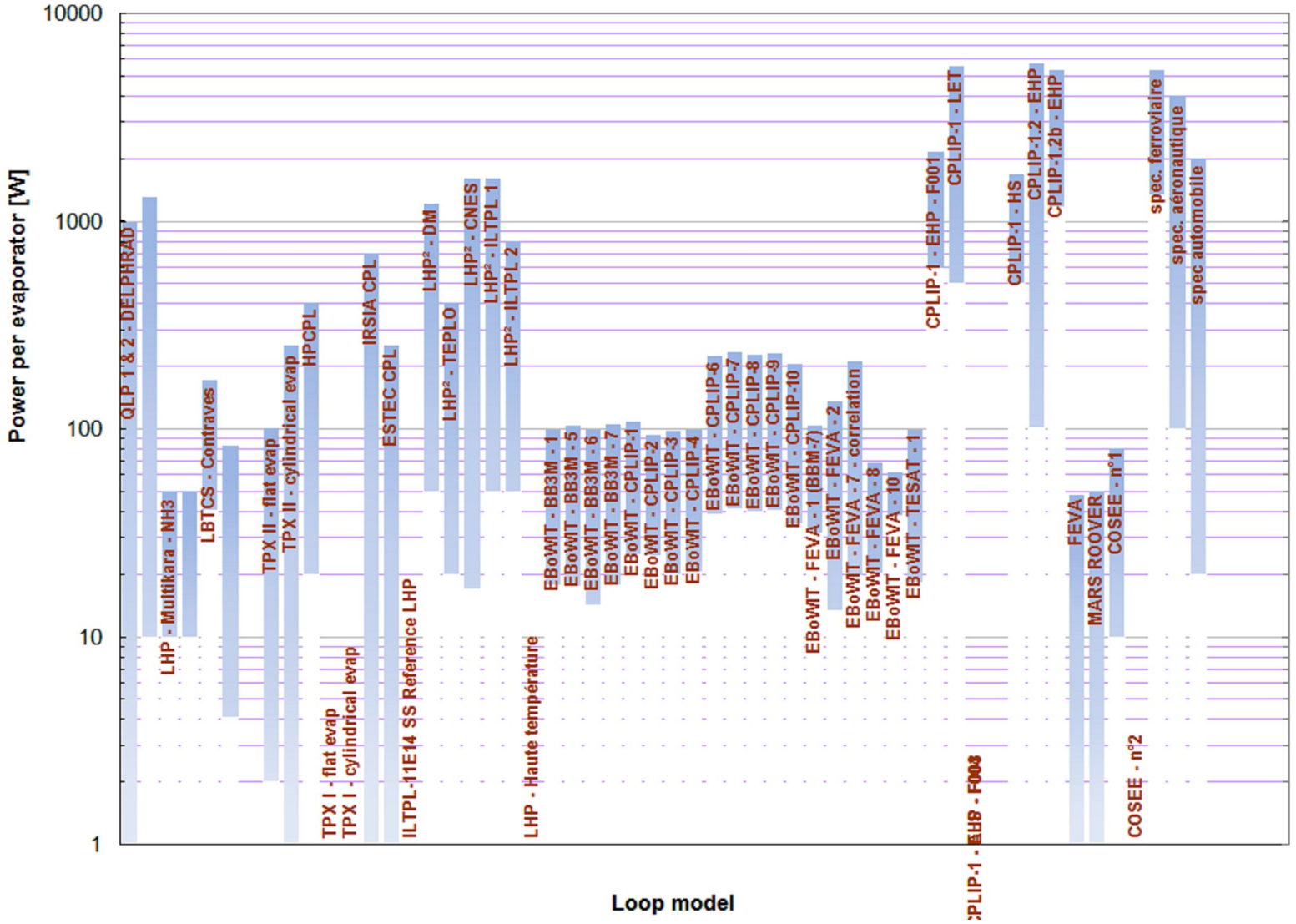
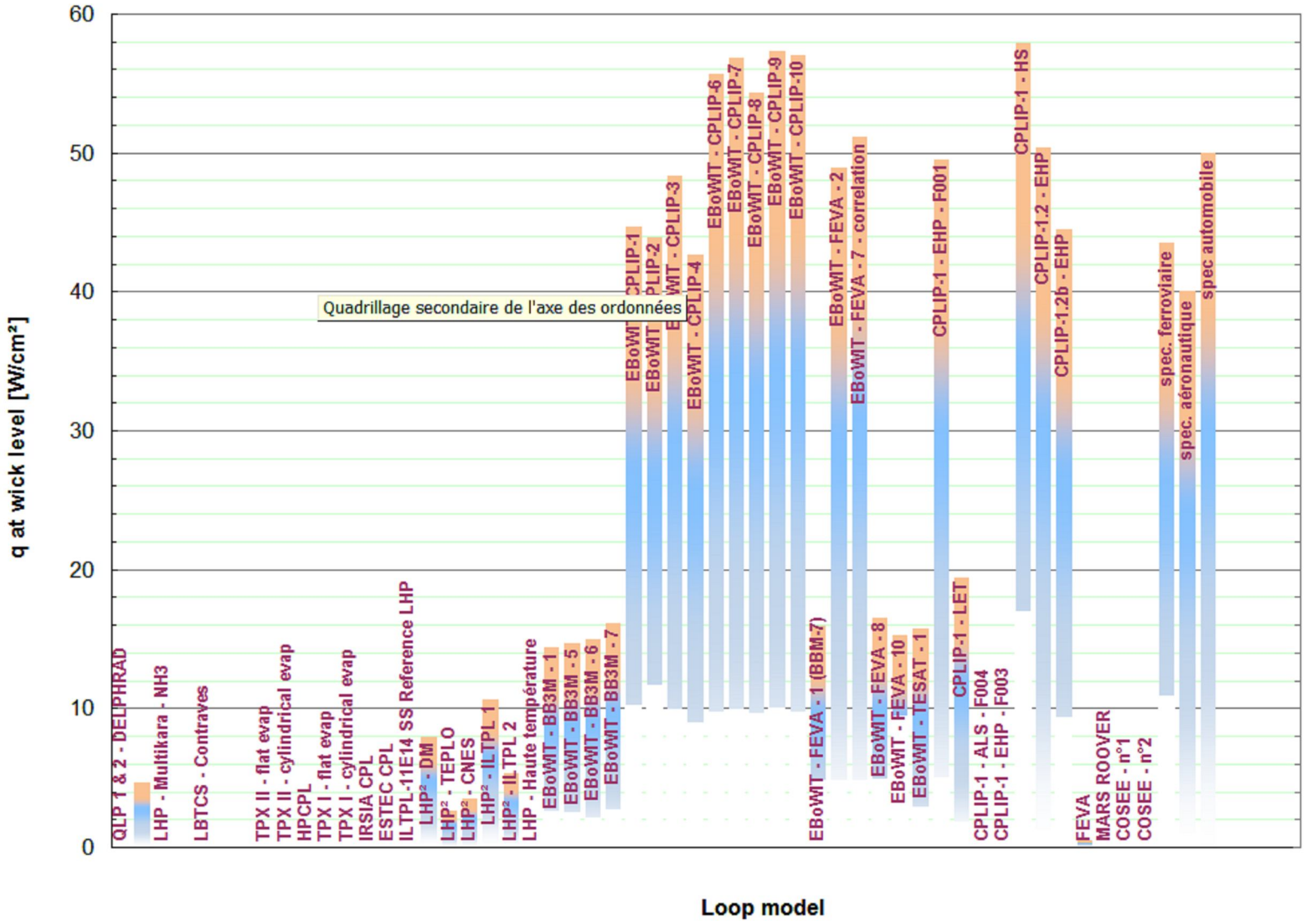
Loop overview – Operating Temperature



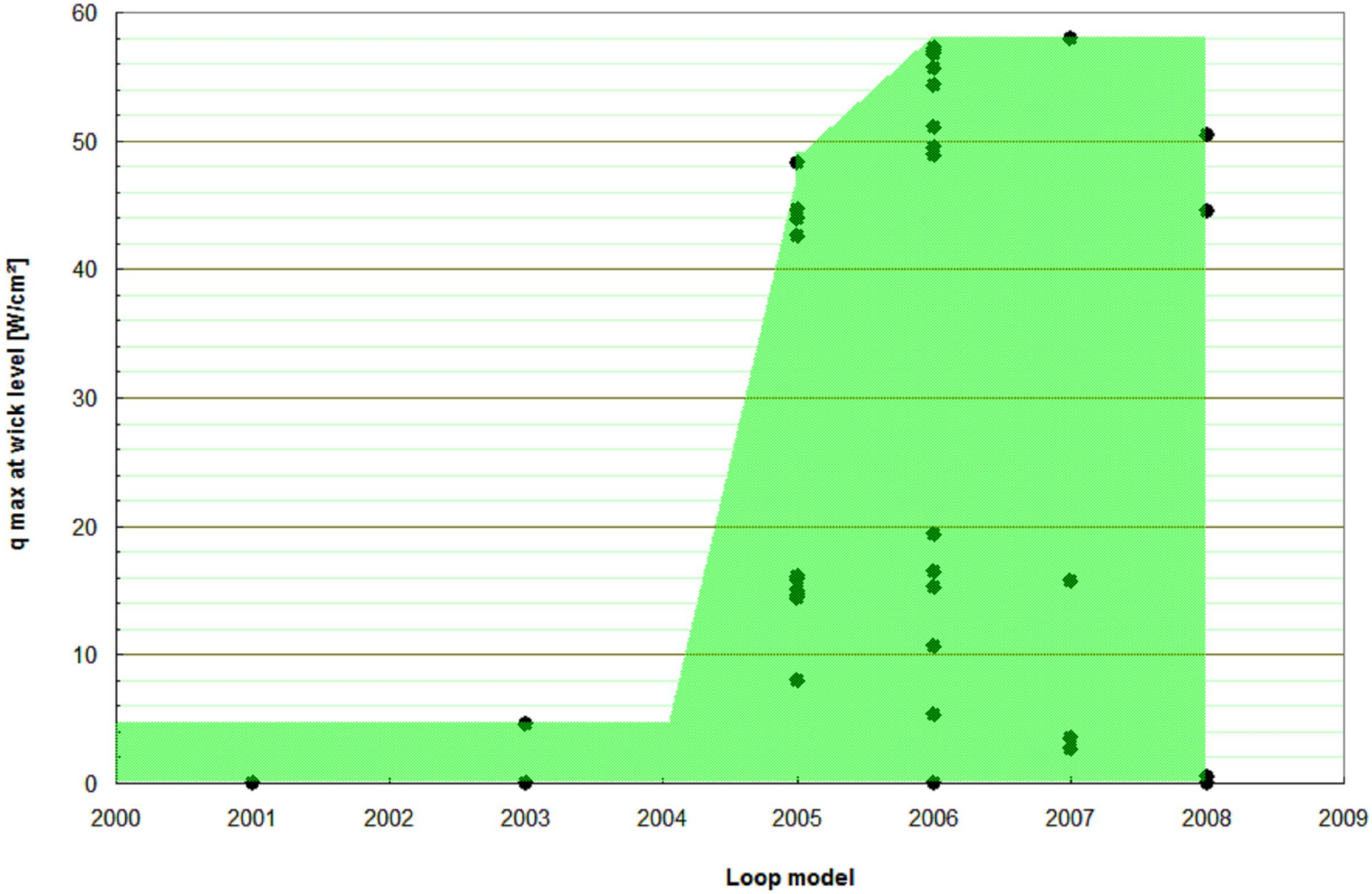
Loop overview – Evaporator Power



Loop overview – Heat flux at wick level



Loop overview – Heat flux at wick level



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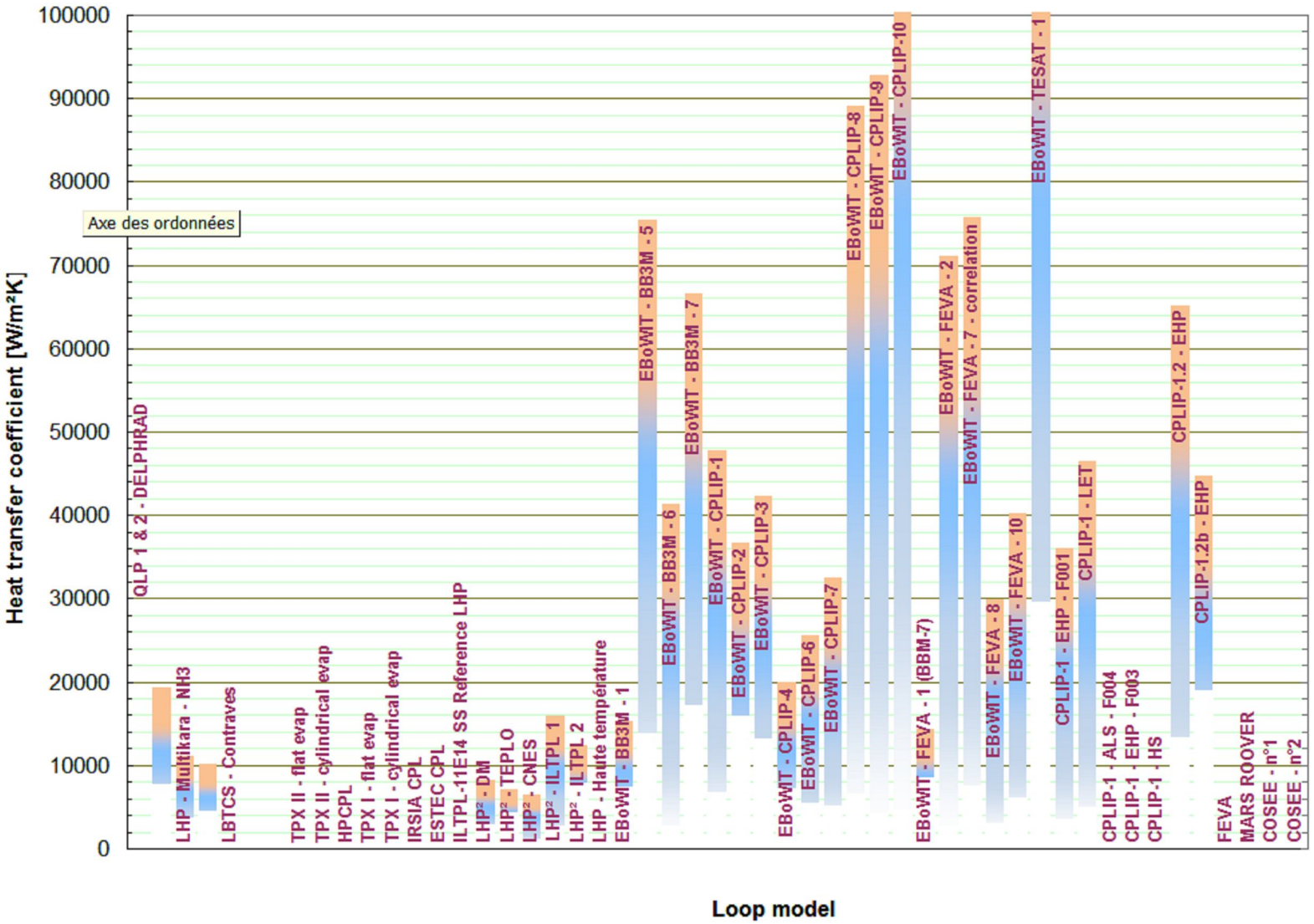
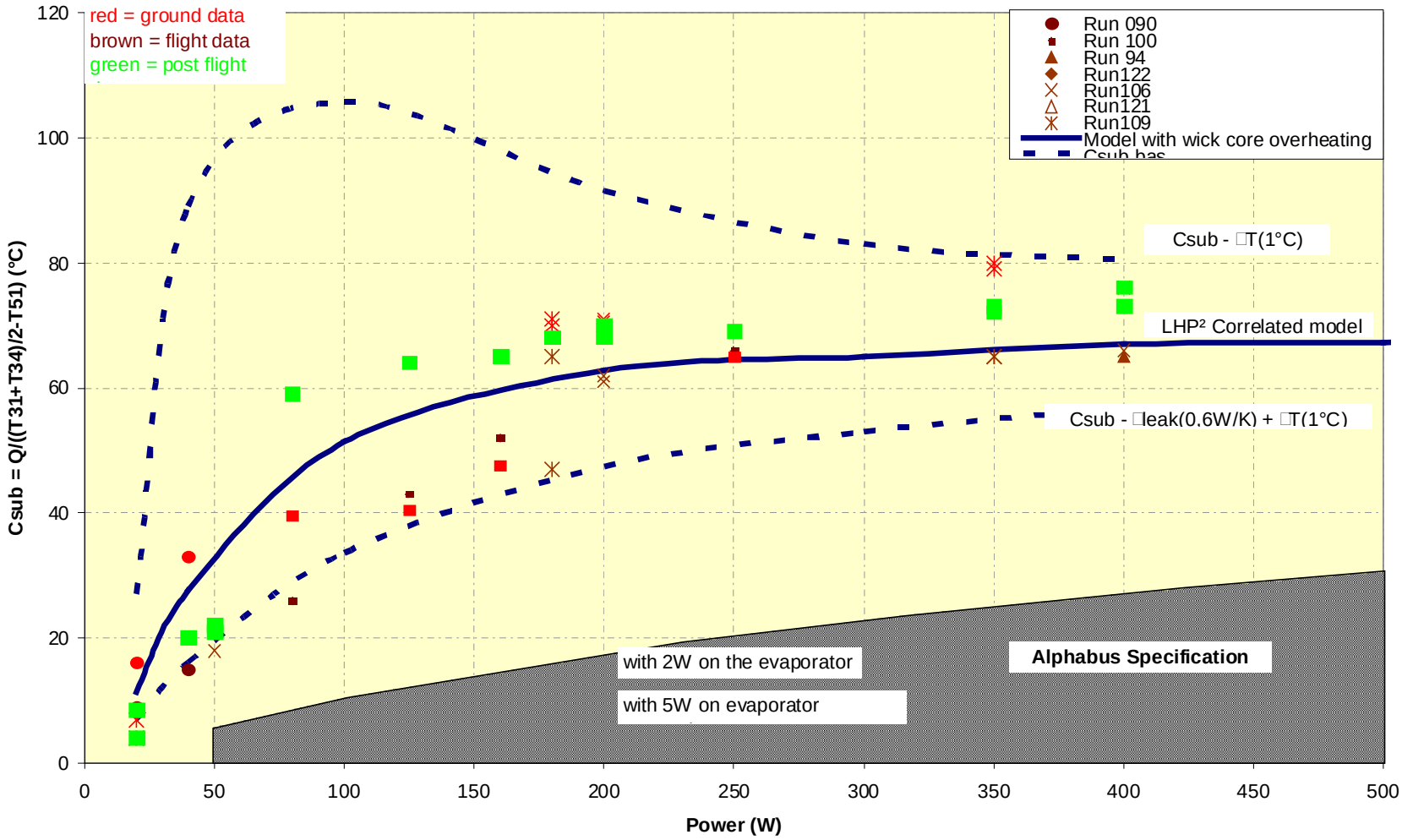
Loop overview – h vaporization



LHP² Performances – Global conductance (Csub)



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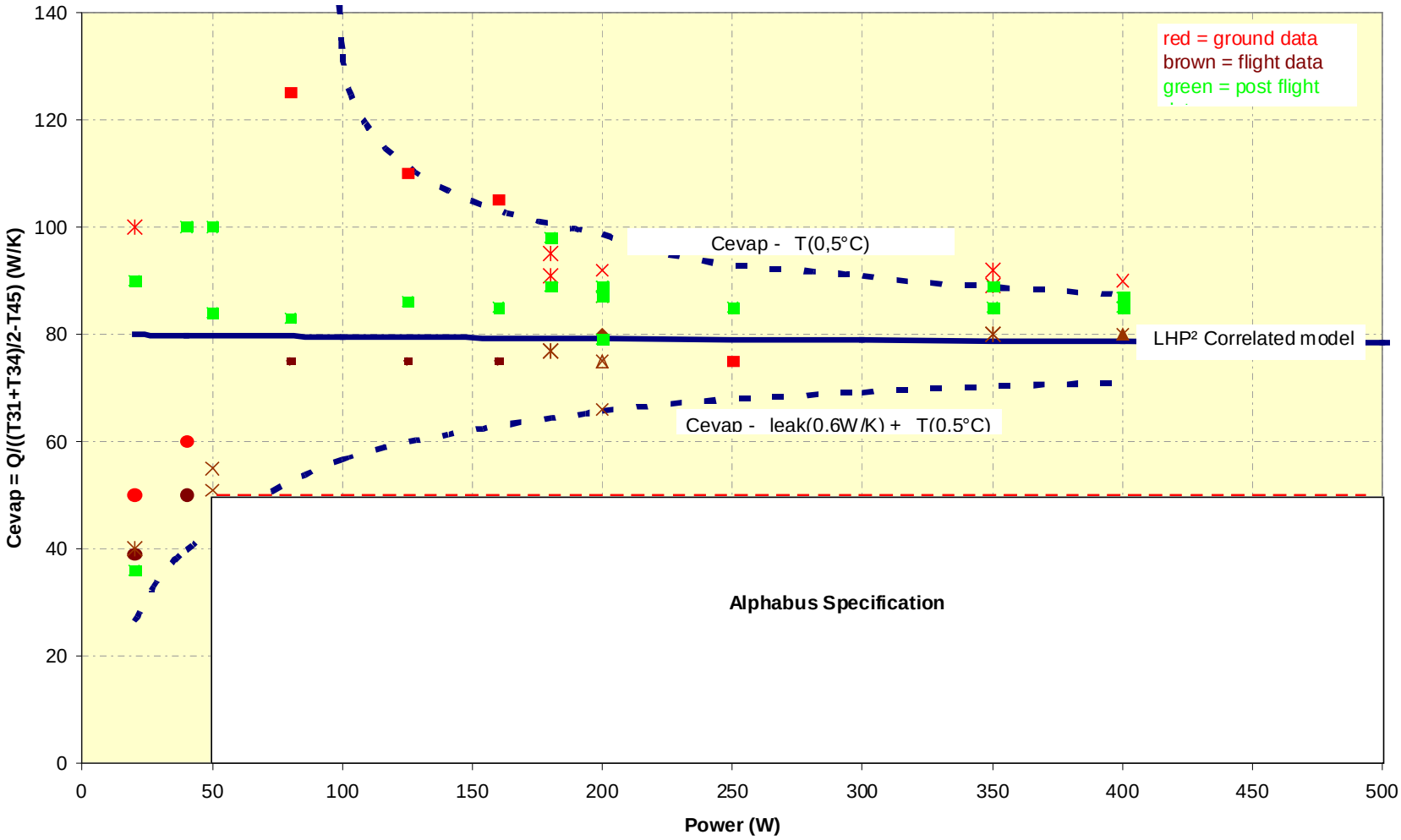
LHP² Performances – Evaporator conductance (Cevap)



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- COSEE

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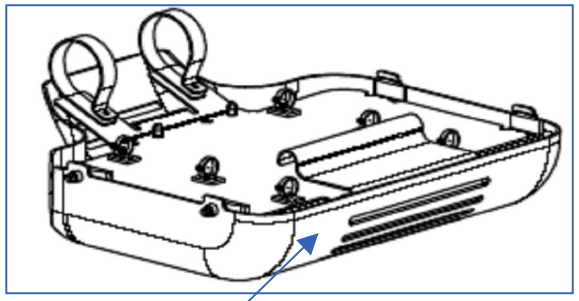
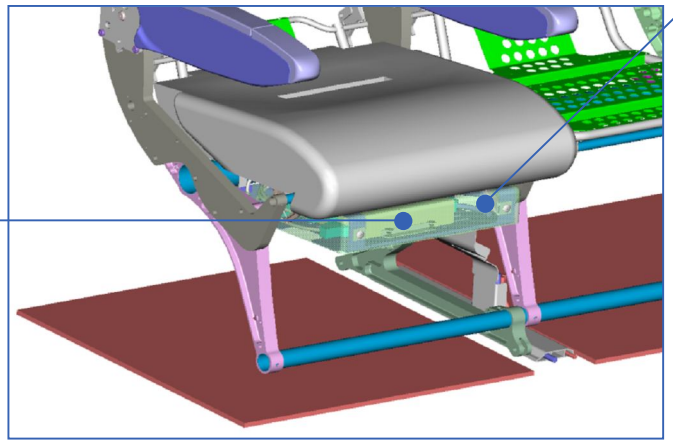
COSEE Objectives

Use the seat structure as heat sink passive phase change cooling system a reliable efficient alternative to fan cooling

AIR France A 380: Installation example





SEB

SEB shroud

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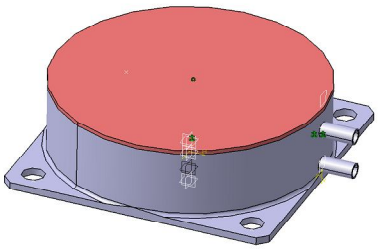
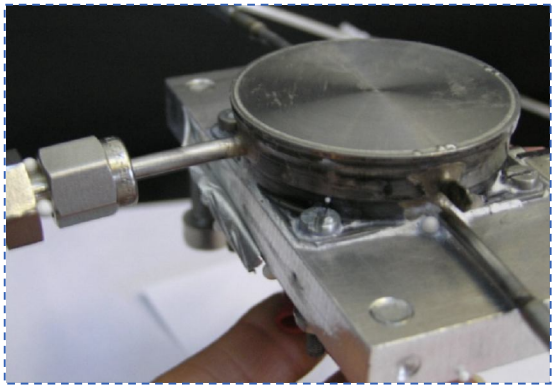
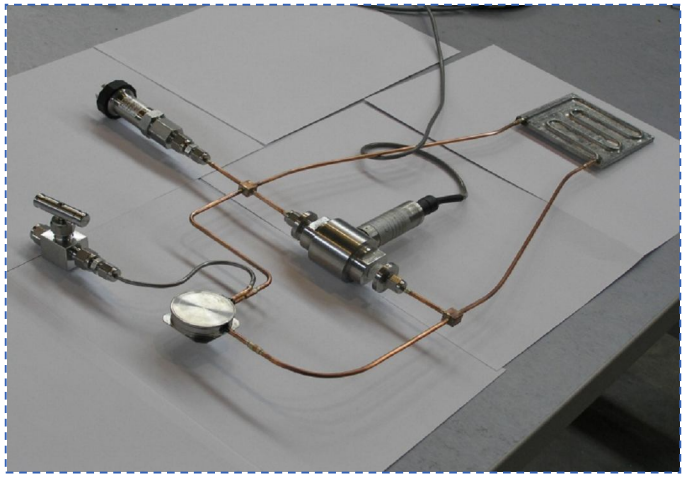
Trade-Off Analysis - Selection of Evaporator geometry

Selection of Flat evaporator & Embedded reservoir







Option 1:

Fluid: **R245fa**
Wick material: Nickel
Body material: Stainless steel

Option 2:

Fluid: **Ultra pure water**
Wick material: Titanium
Body material: Titanium

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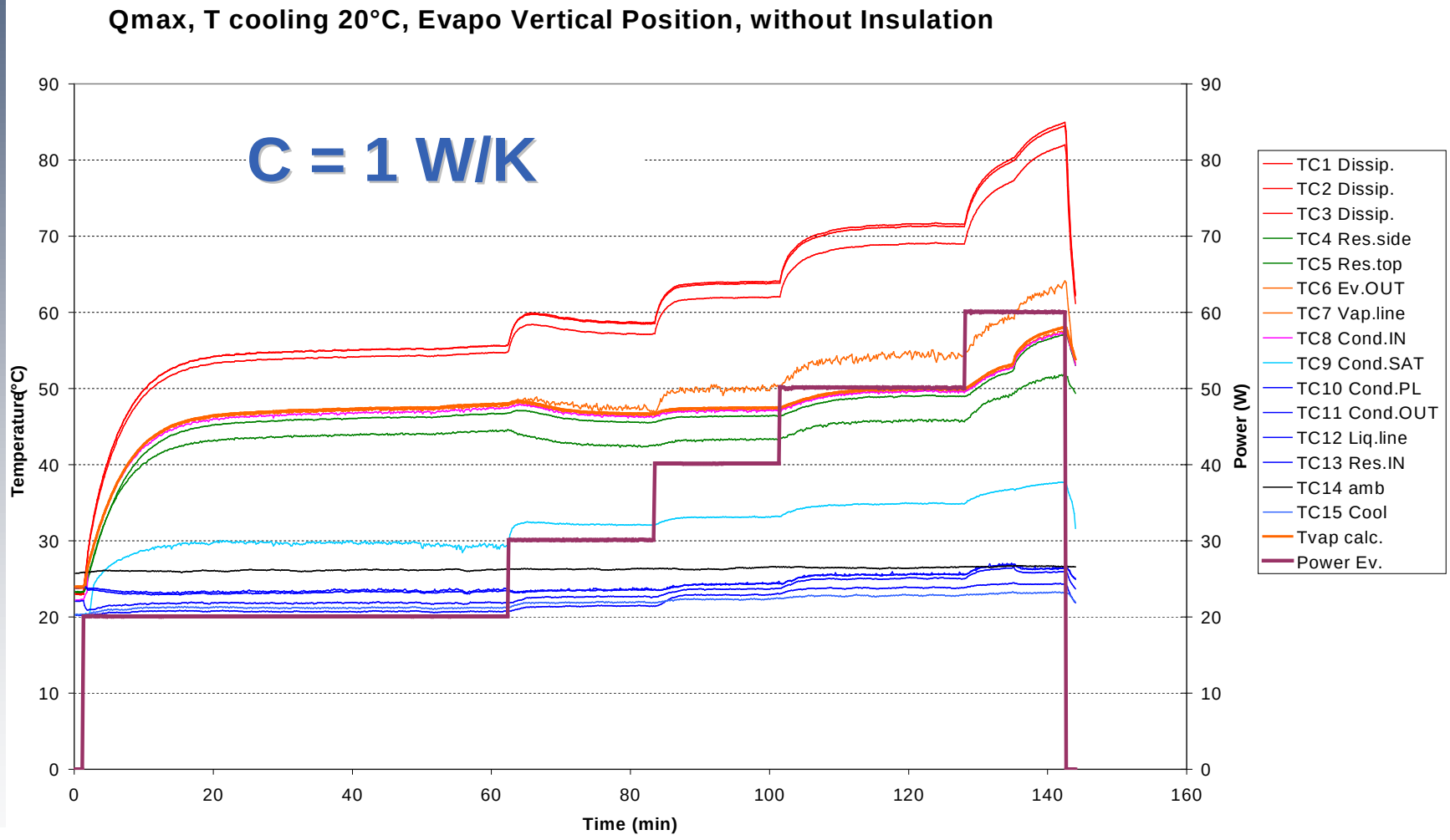
Preliminary Tests Results (R245fa)



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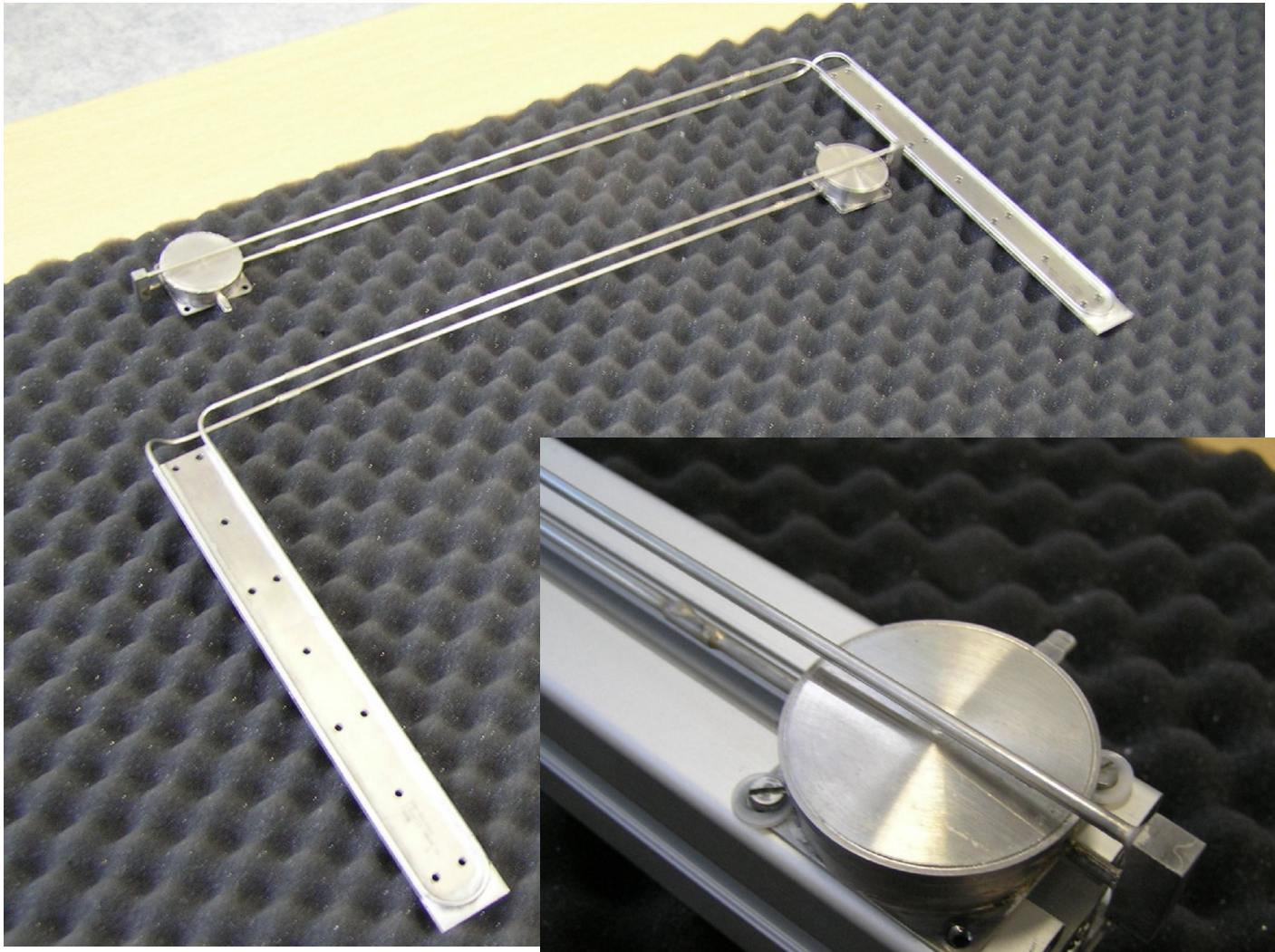
Industrial version of mini-LHP adapted to the seat I/F



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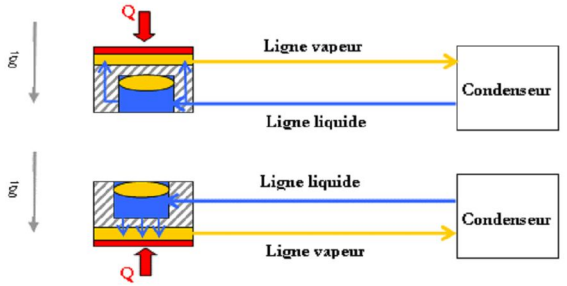
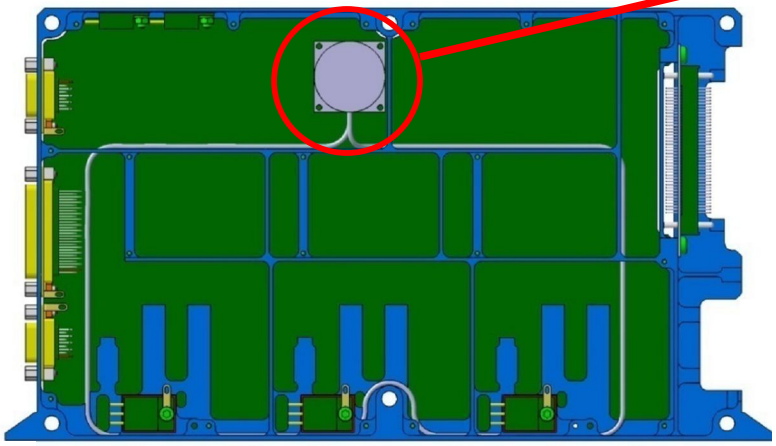
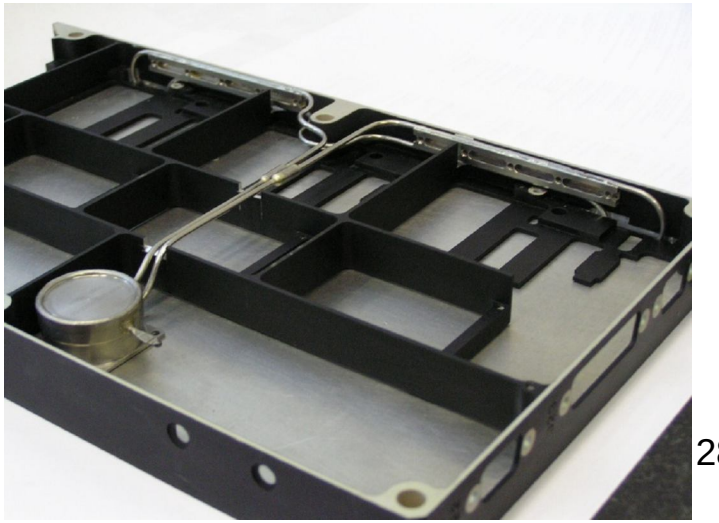
- Mini-LHP for electronic board applications

Mini Flat Loop Heat Pipes (NH3)



- Power : Up to **100 Watts and 15 W/cm²**
- Thermal conductance (evaporator): **> 2.2 W/K** at 8W/cm²
- Flat evap. size : 15mm height
- Weight evap : 50 gr typical
- Operation in all orientation under gravity
- Active Thermal control (variable conductance)





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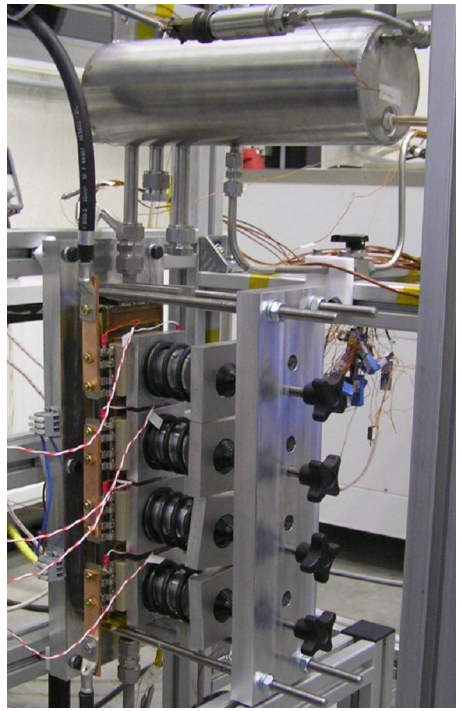
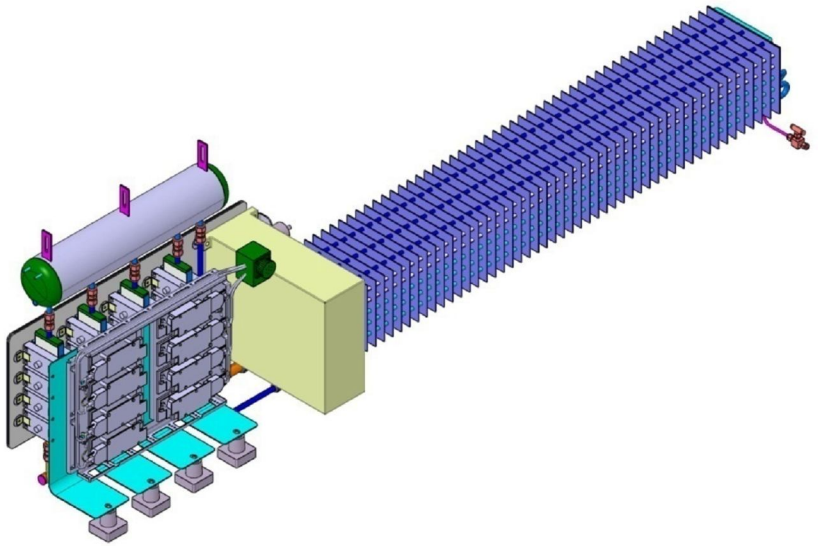
- CPLIP

Macro Capillary Loop

- Power : Up to **5.3 kW i.e. 45 W/cm²**
- Thermal conductance (evaporator): **> 100 W/K** at 30 W/cm²
- Flat evaporator size : 20 mm height
- Weight evaporator : 1600 gr
- Operation with 2 active sides and multi evaporator configurations
- Active Thermal control (variable conductance)





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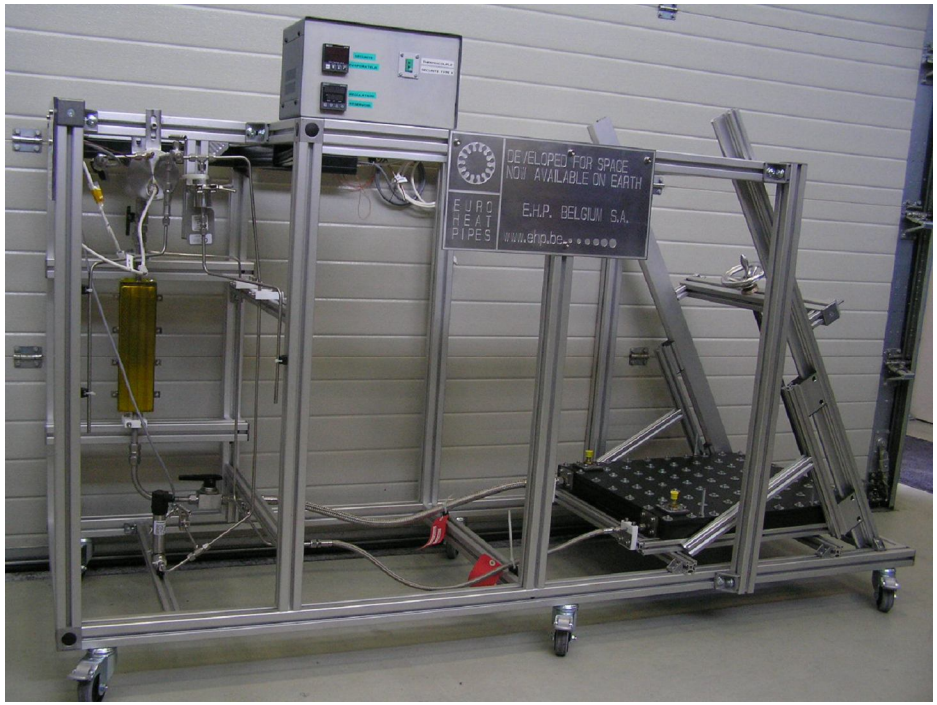
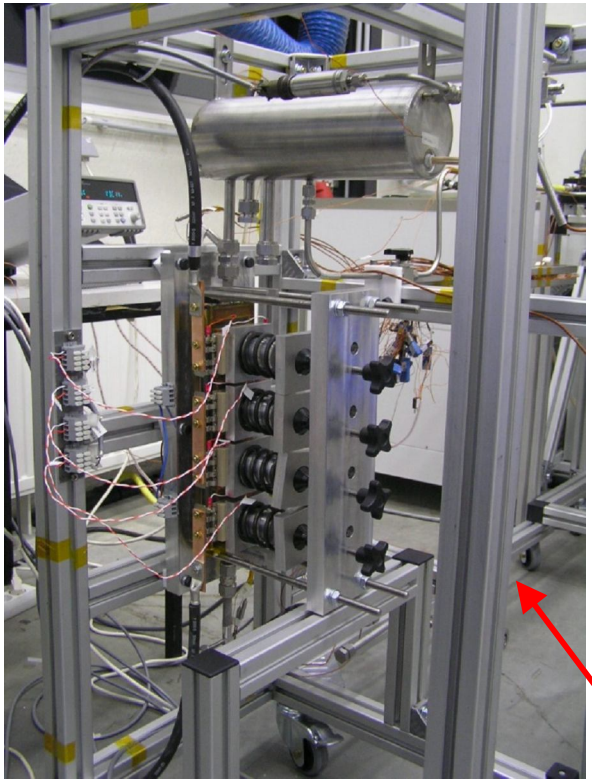
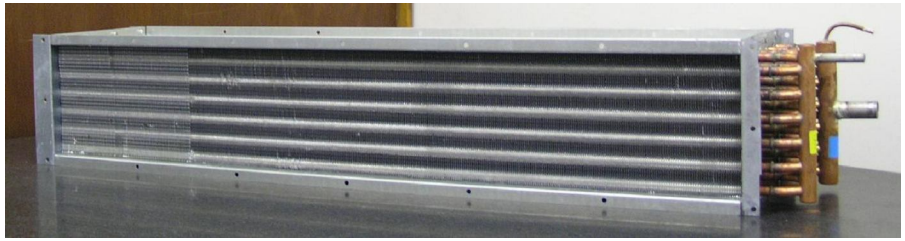
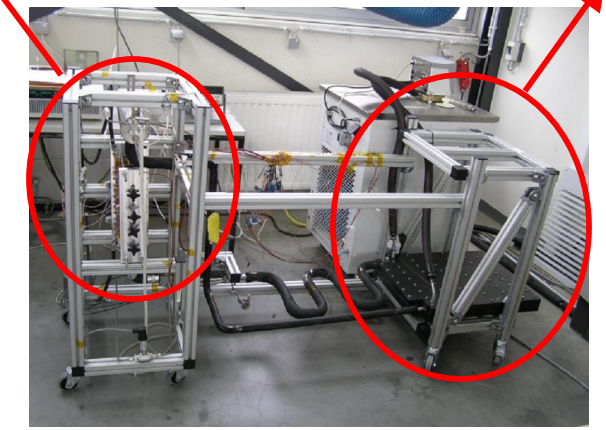
Macro Loop Heat Pipes









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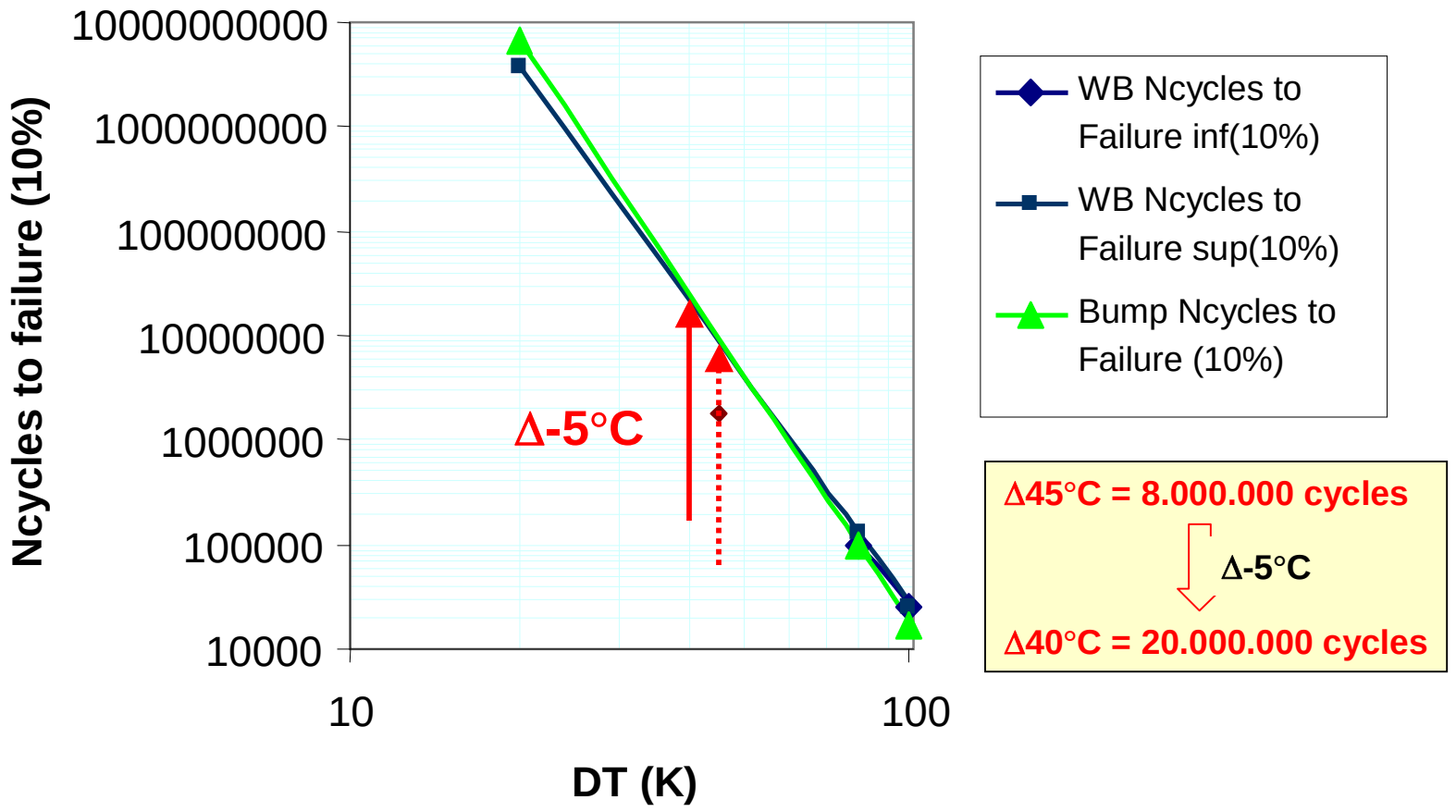
Macro LOOP HEAT PIPES key Performances

power cycles vs failure

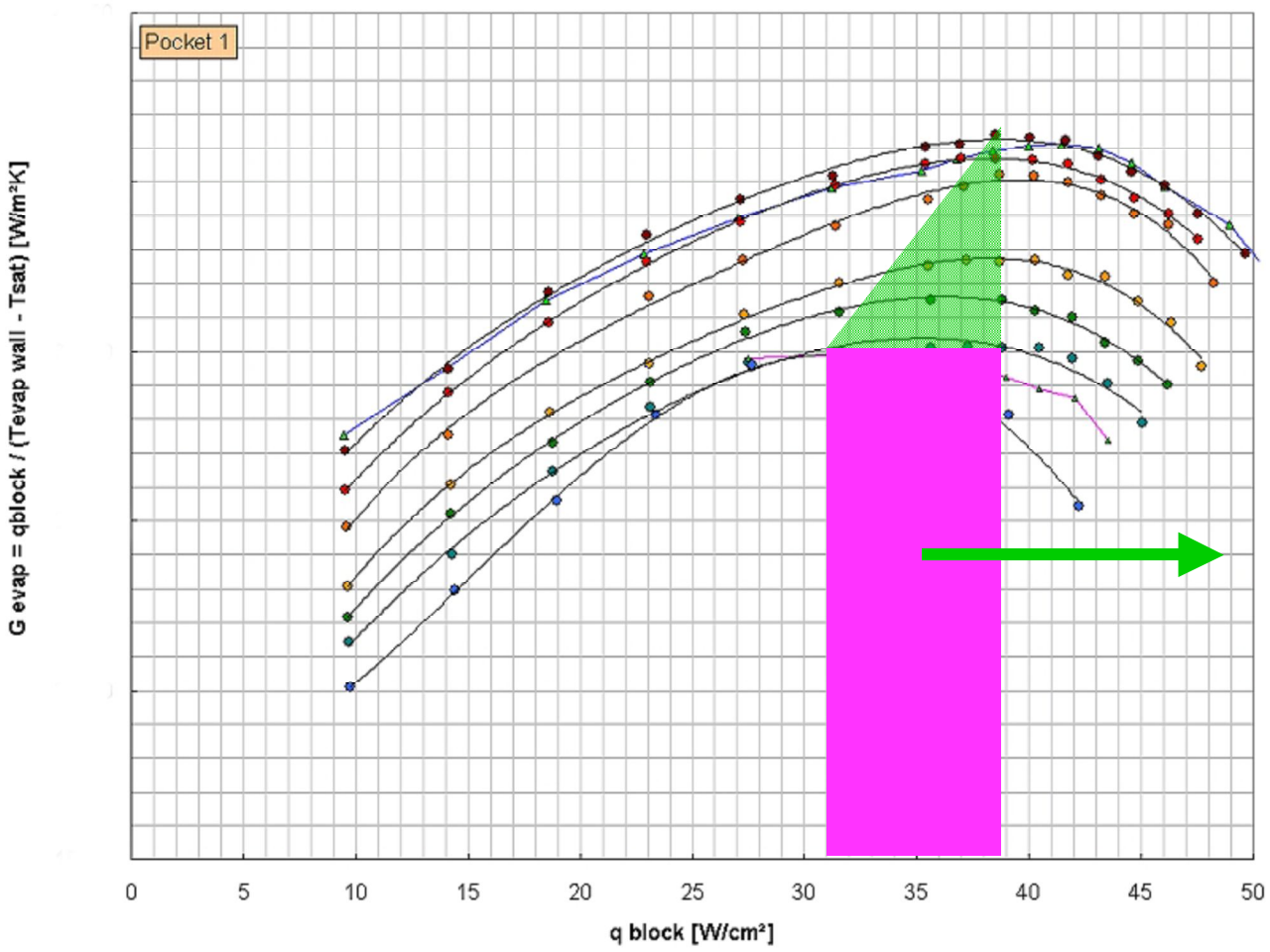


From IMAPS PEARL presentation dated 01/02/07

- On going / Future Developments

Scientific challenge 1

How to improve performances of evaporator for high heat flux application ?



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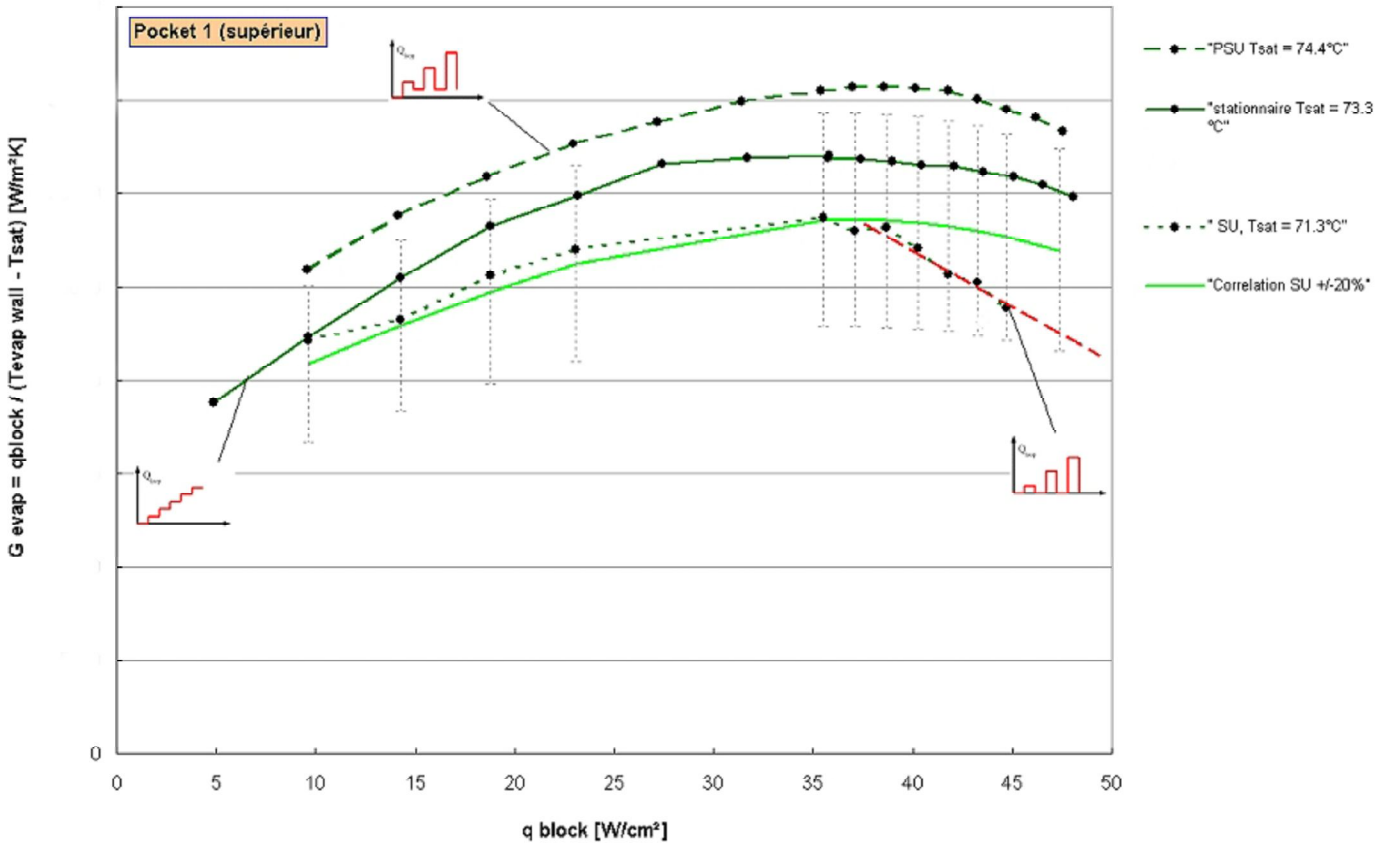
Scientific challenge 2

How to improve performances at startup ?



- today 4.8 kW at SU vs 5.6 kW for continuous power steps increase
- passive way to reduce boiling incipience superheat ?
- transient numerical models at wick and system level ?

Scientific challenge 3

Behaviour under vibration / acceleration

- 0-g : vibrations only during take-off.
- x-g (onboard systems) : vibrations during the complete life time.
- new issue for European labs
- impact at meniscus level and/or system level
- EHP will make tests soon with a methanol CPL (TRL-3) and a R245fa mini-LHP (TRL-5)

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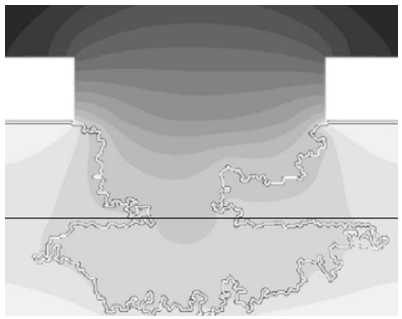
Scientific challenge 4

How to reduce parasitic heat flux through the wick ?



- conduction vs percolation
- hysteresis phenomena in LHP core
- multilayer wicks
- new material for the wick

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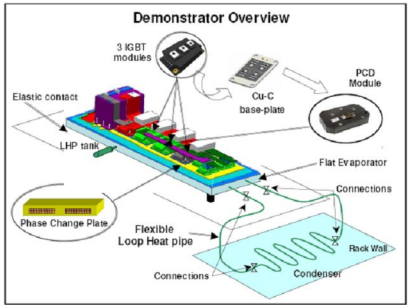
Astrium / Euro Heat Pipes developments

- ESA : Cryogenic LHP
- Aeronautics : Intelligent Cooling Systems
- High T° macro LHP (160°C)
- Automotive thermal control
- Defense Loop : Tersyte (to be started)



EURO HEAT PIPES

EURO HEAT PIPES SA
Rue de l'Industrie 24 B-1400 Nivelles Belgium
Tel +32 67 889494 Fax +32 67 889499

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