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Advances on Thermal Control for Space Exploration

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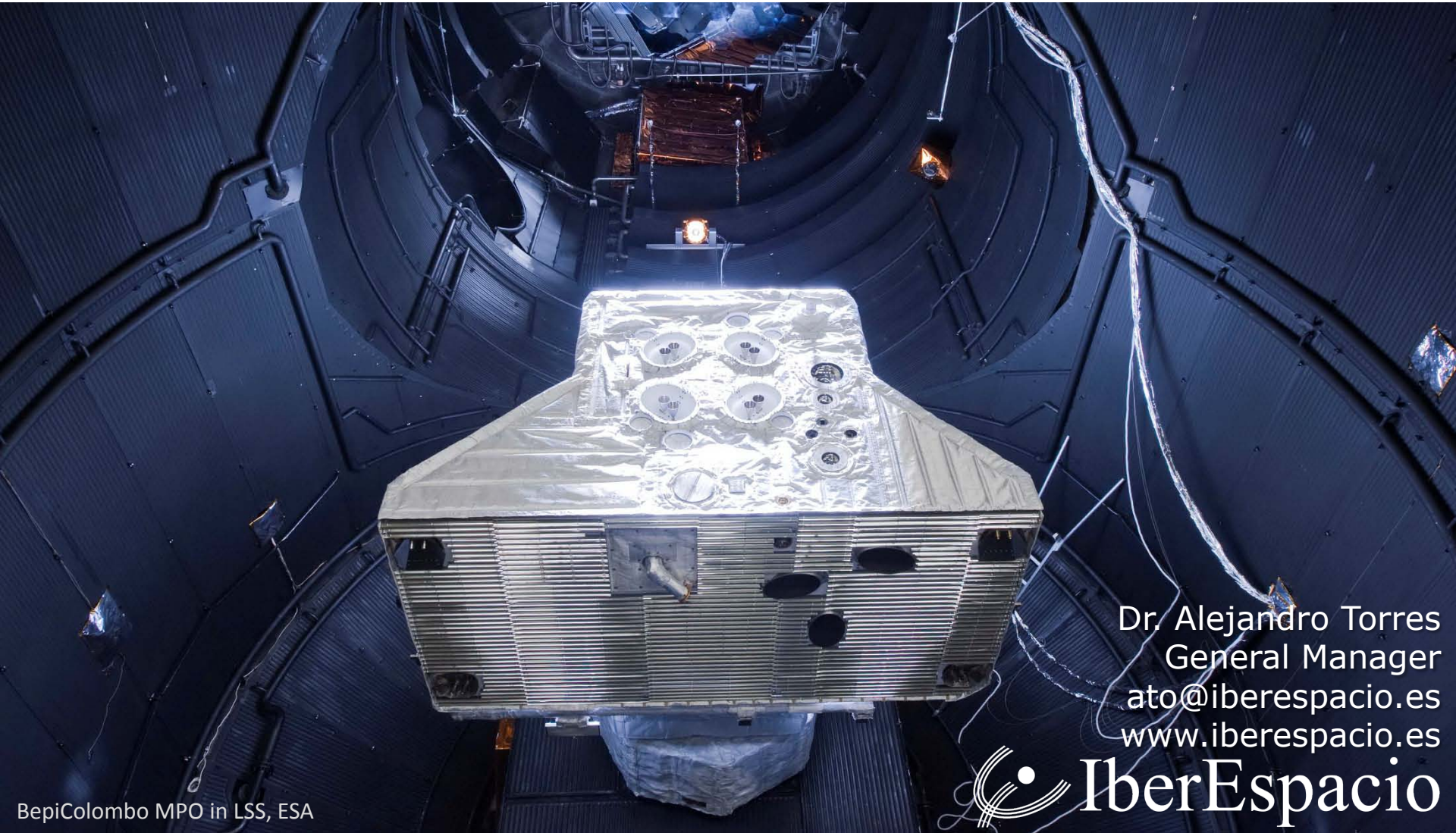
44th Space Congress – 25th May 2016



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BepiColombo MPO in LSS, ESA

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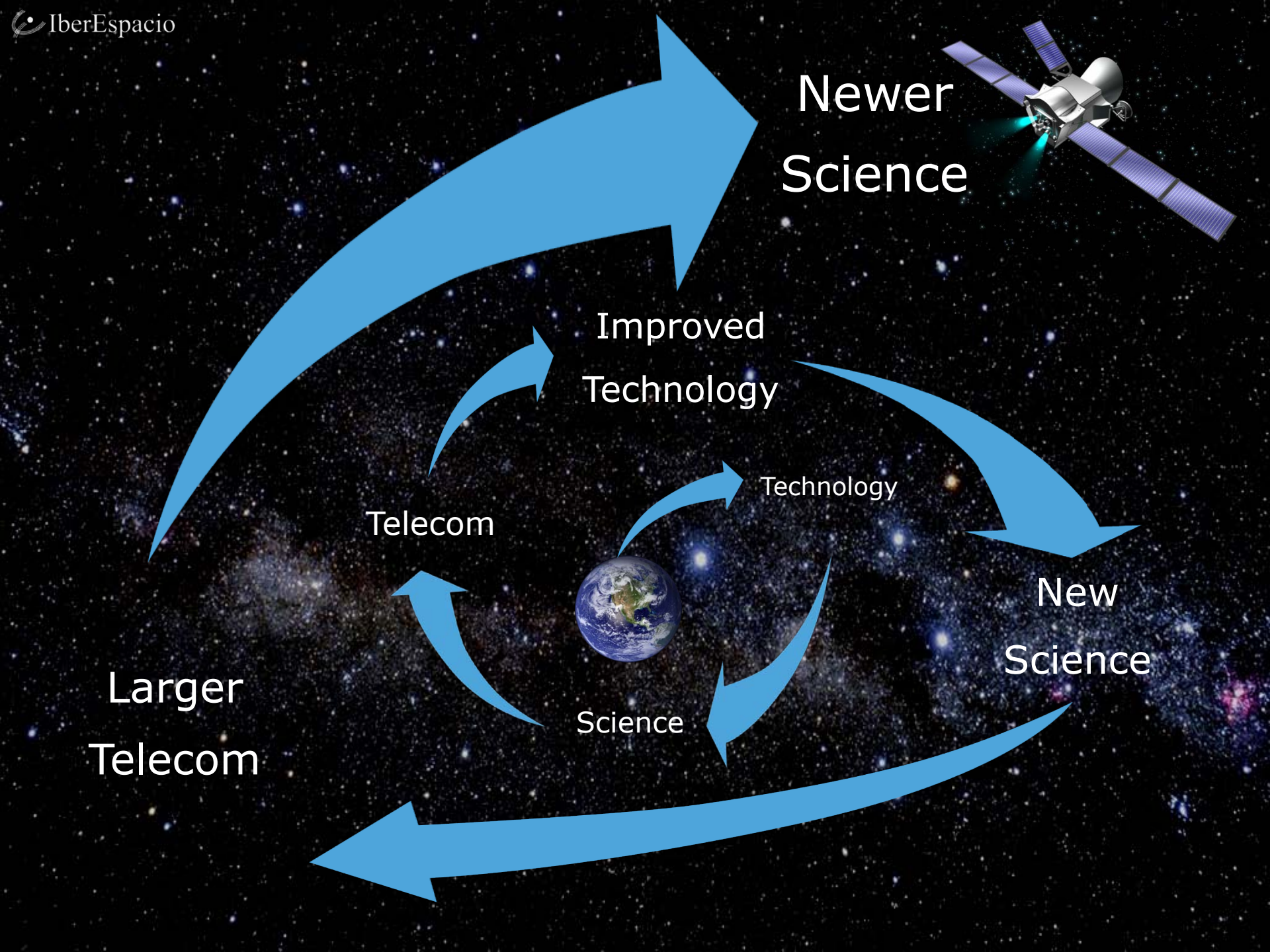


A. Heat Pipes – Origins

High efficiency heat transport system:

- Developed in 1940’ and 1960’
- Great interest for space applications due to significant mass saving

Mass properties for different Thermal Conductive Materials

Heat transfer system	Conductance (W/K)	Length (m)	Density (kg/m³)	Mass (kg)	Mass wrt HP
Aluminium	20	1	2.800	373	1.493
Copper	20	1	8.900	593	2.373
Heat Pipe	20	1	0,25	0,25	-

Apollo 11 view of Earth

A. Heat Pipes - First Space Application

Mission GEOS-B (1968, USA):

- 2 HP for transponders
- Up to 64 watts

GEOS-B Heat Pipes disposition

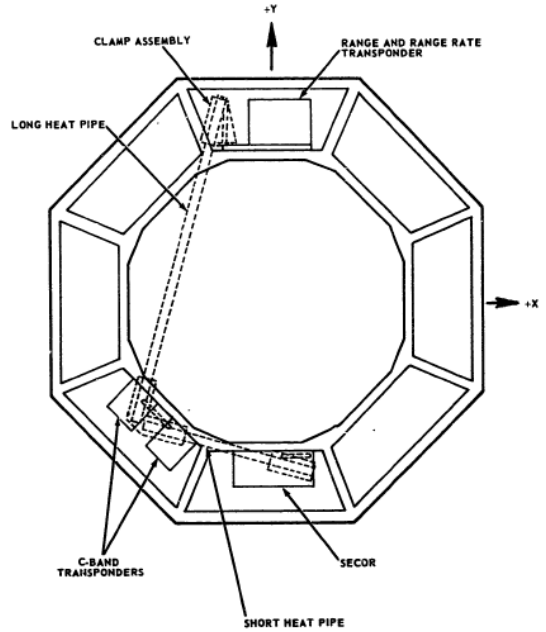
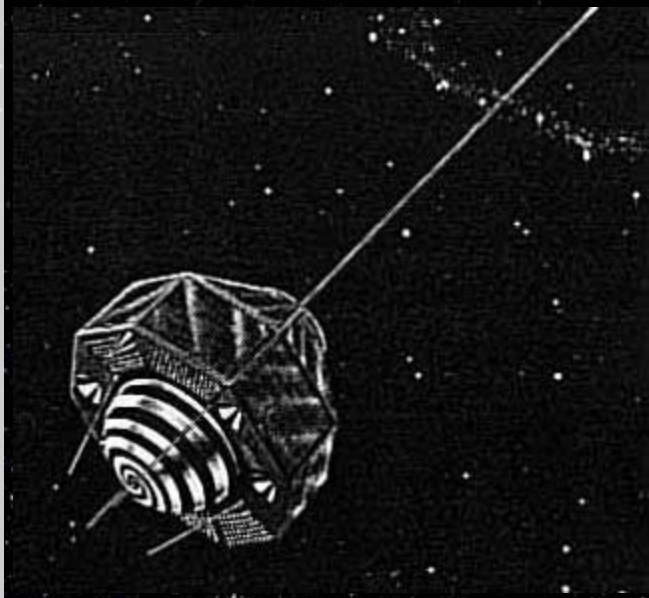


Fig. 2 GENERAL ARRANGEMENT OF HEAT PIPE SYSTEM

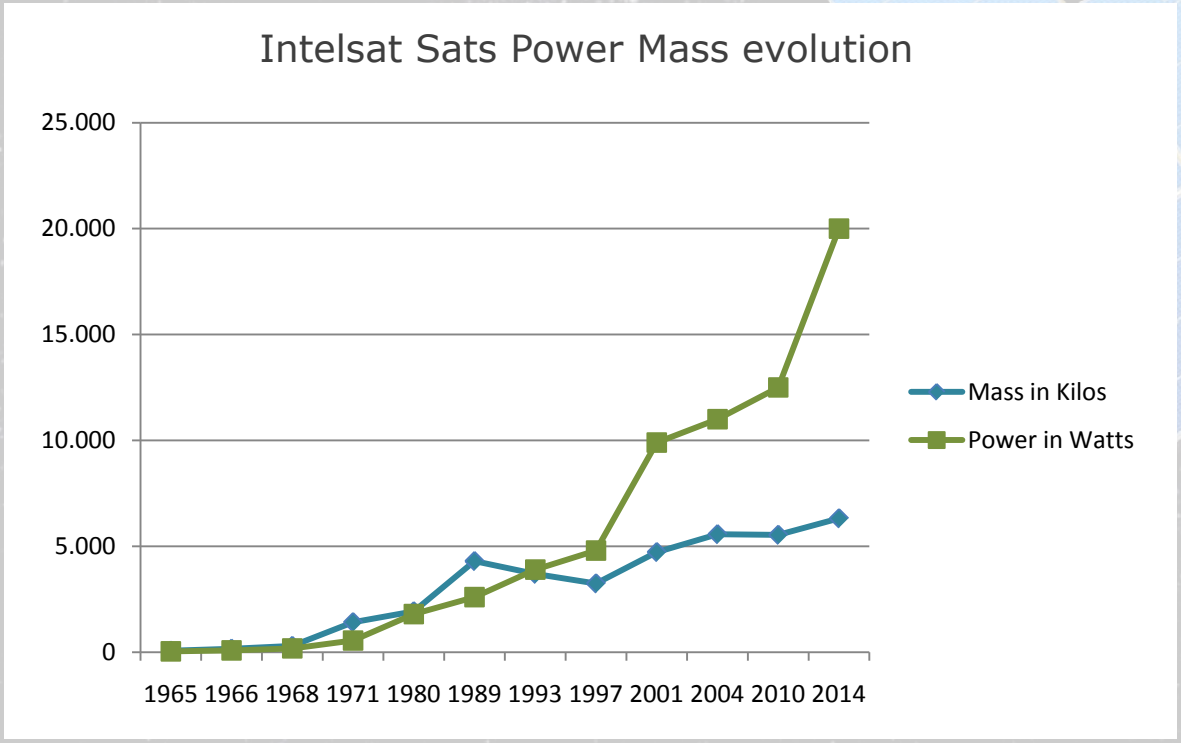


GEOS-B

A. Heat Pipes – Adoption for Telecom

Late introduction (end 80') due to complex thermal system tests:

- Platforms: 601, LS-1300, Gonets-D, etc.
- Multiple applications



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A. Heat Pipes – Benefits on science

BepiColombo mission to Mercury uses Heat Pipes as critical elements (MPO and MTM):

- Heritage from telecom
- Up to 3800 W heat management
- 360 Heat Pipes

BepiColombo MPO

BepiColombo

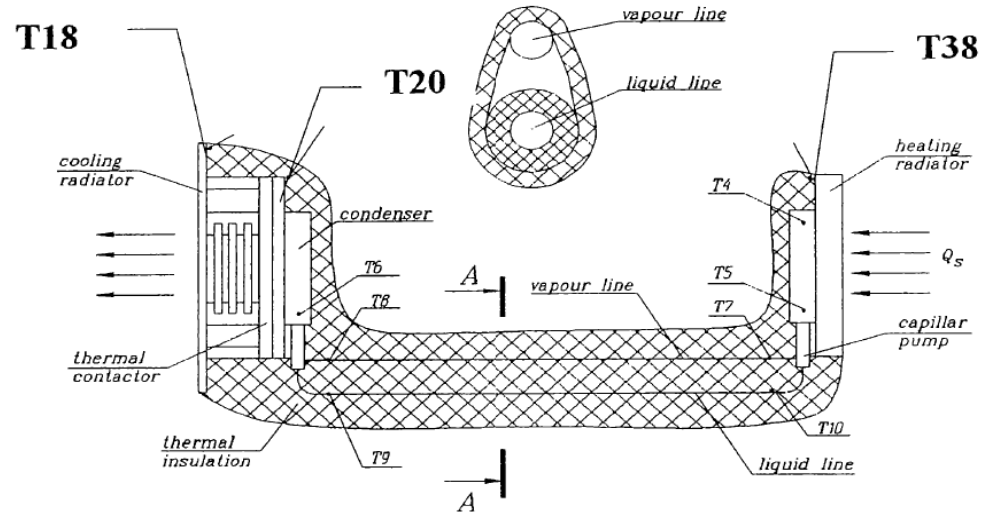
GRANAT

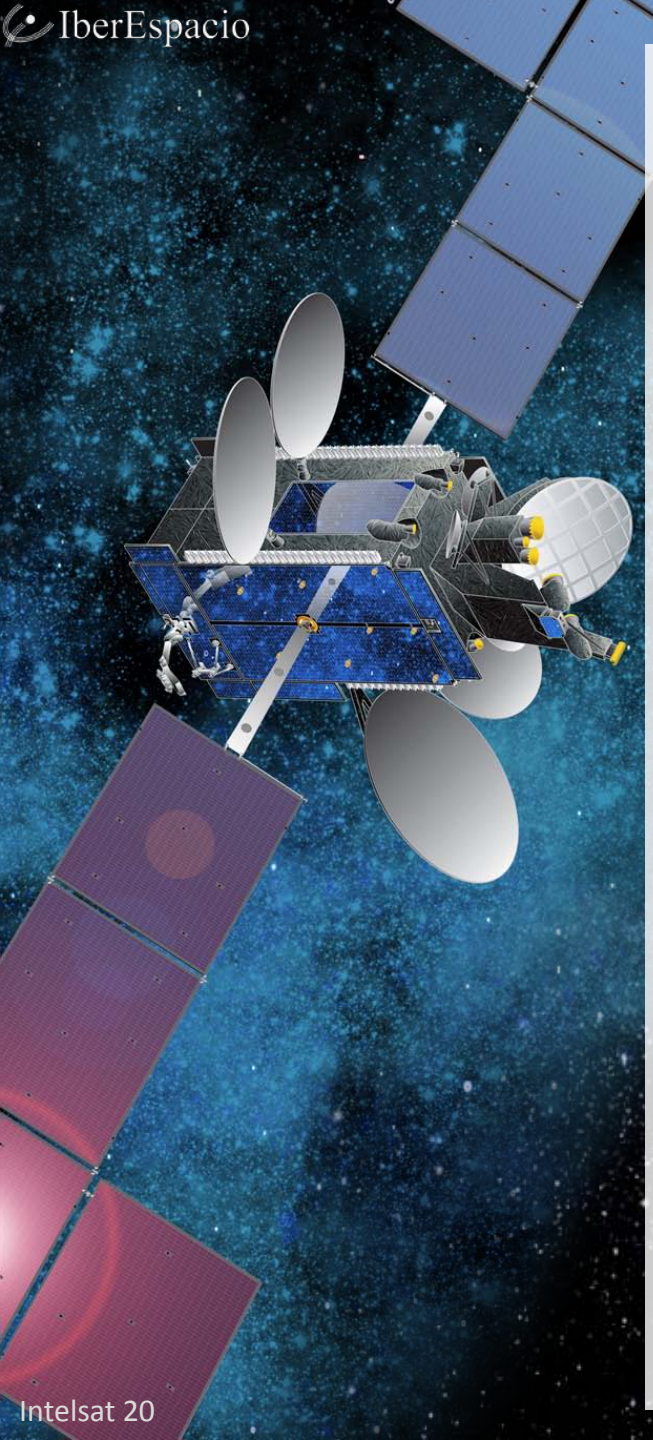
B. Loop Heat Pipes – Origins

Efficient and flexible heat transport system:

- Developed in 1960’ (CPL) and 1970’ (LHP)
- 1st CPL mission: 2 CPL up to 200 W experiment in STS 51 (1986, USA)
- 1st LHP mission: 1 LHP up to 37 W experiment in GRANAT (1989, USSR)

GRANAT experiment





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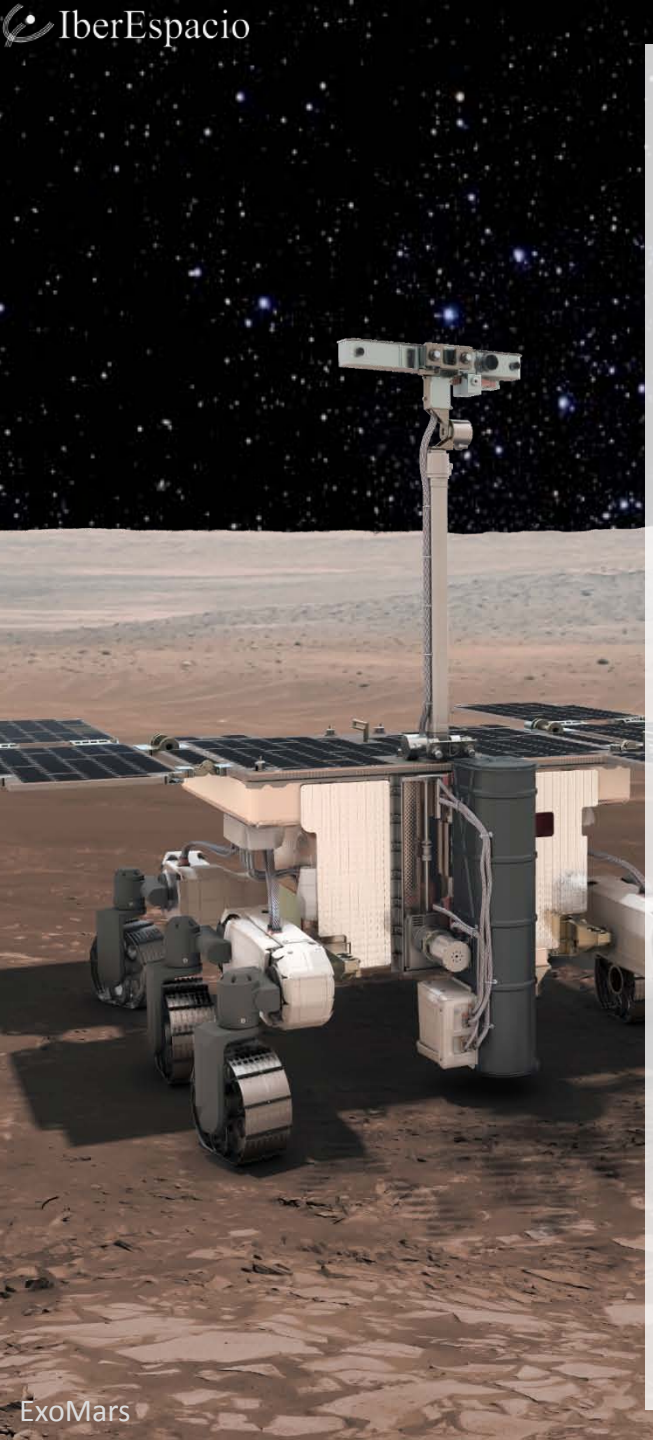
B. Loop Heat Pipes – Adoption for Telecom

Introduced in telecom end of 1990'

- Platforms: HS 702, SSL-1300
- All kind of application requiring high power, compact system, modularity and low mass

Mass properties for HP and LHP

Heat transfer system	Power (W)	Length (m)	Mass (kg)	Mass wrt LHP
Heat Pipe	1000	5	26	4,3
Loop Heat Pipe	1000	5	6	-

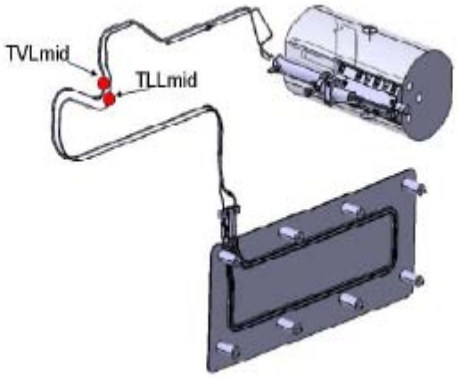


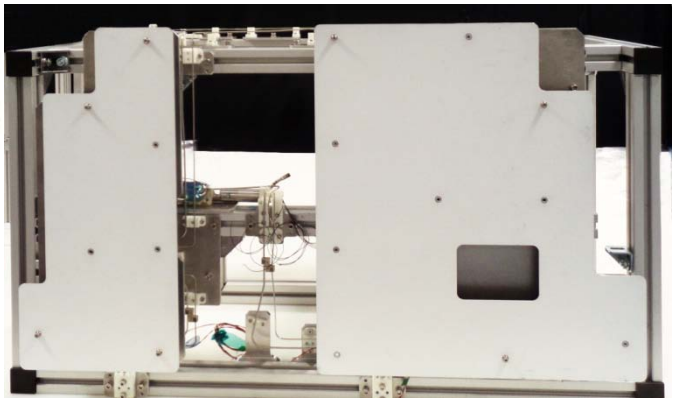
B. Loop Heat Pipes - Back to science

ExoMars four Loop Heat Pipes as critical elements:

- Heat transport during power peaks
- Thermal switches to insulate Rover internal payloads during Martian night
- Minimize Heater Power

ExoMars LHP with radiators

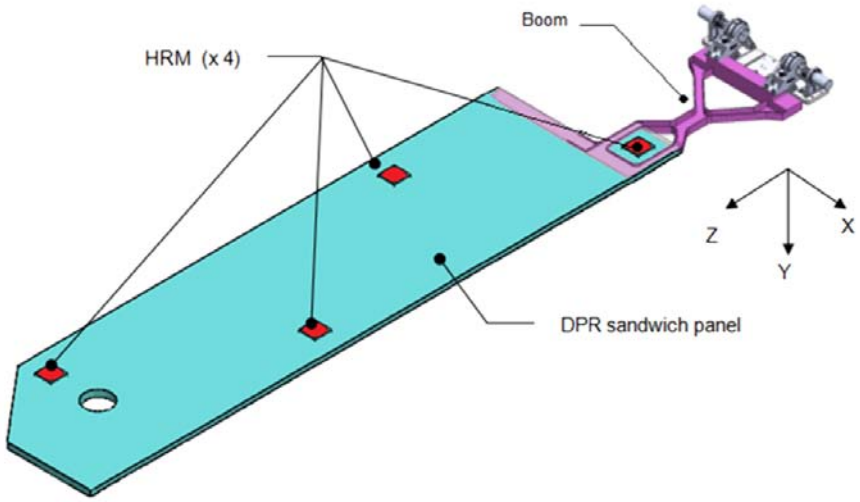




C. What's cooking - Deployable Radiators

- First development in 1980'
- In telecom (Boeing), ISS, Space Shuttle
- Under development for Lunar Lander
- Advantages for Space Exploration:
  - Heat rejection capability due to increase of payload

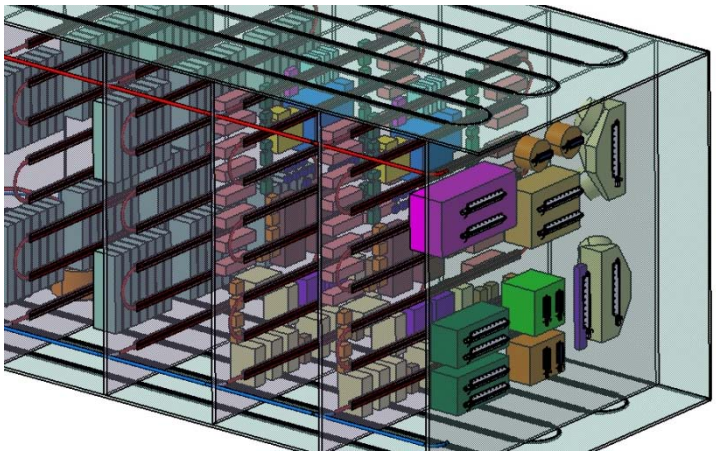
Deployable Radiator



Mars 96

C. What's cooking - Autonomous Thermal Control System

- Developed in 2000'
- 1st space mission Hispasat 1E experiment with 2 HP and 2 LHP
- Advantages for space exploration
  - Self heat management
  - Radiator switching
  - Flexible design
  - Modular technology



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Thank you

Buzz Aldrin performing an EVA during Gemini XII,, 1966