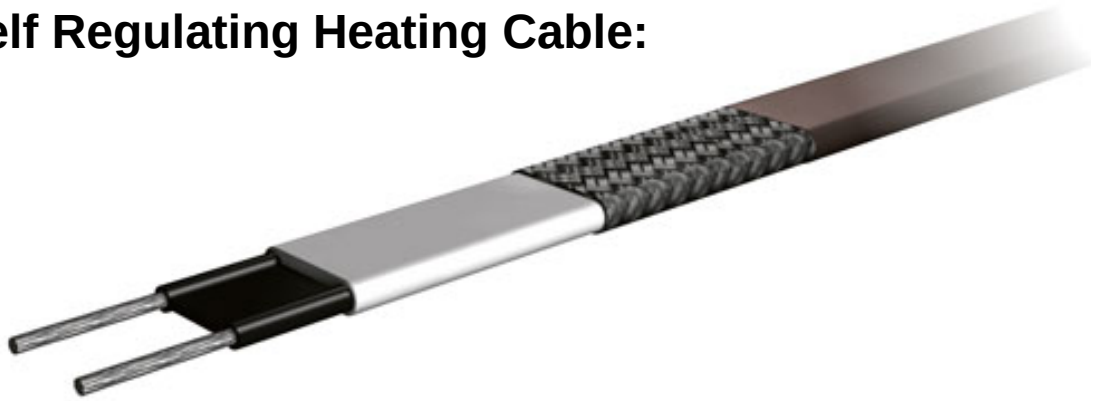
Space Passive Component Days, 1st International Symposium

ESA/ESTEC

24-26 September 2013

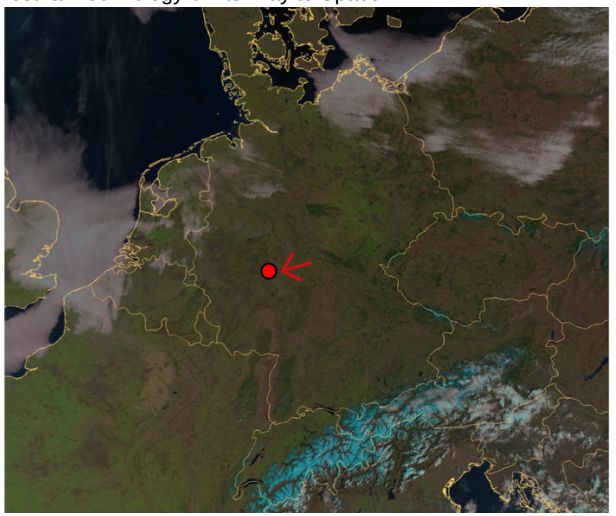
Self Regulating Heating Cable:



Proven Terrestrial Technology on its Way to Space

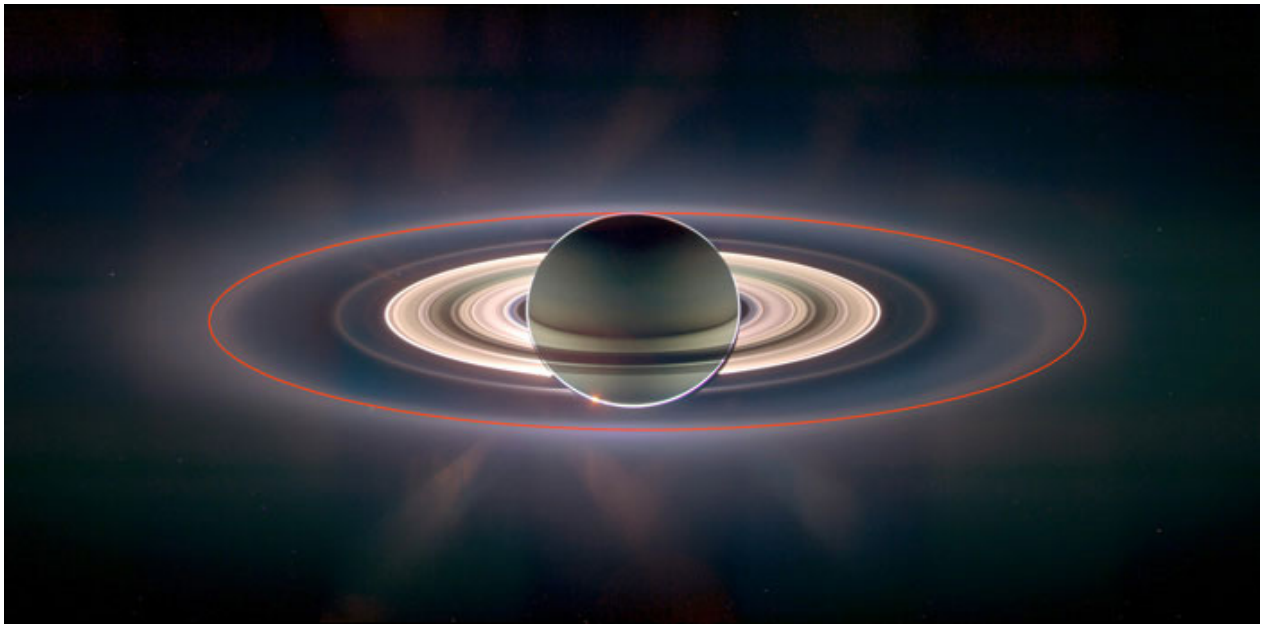
Contents

1. eltherm production GmbH – who are we?



- engineering and production company, founded 1991
- member of Indus Holding AG (SDAX listed)
- core competences: electrical industrial heat tracing
- headquarters and production in Burbach, Germany
- subsidiaries in Canada, China, Singapore, UK
- 150 employees in 2013
- turnover > 25 Mio € in 2011 (approx. 215,000€ per employee)
- main business areas: oil and gas industry, food industry, machine building industry, power plants, railway infrastructure, pharmaceutical industry

2. Introduction to Self Regulating Heating Cable



Approximately 1,500,000 km produced worldwide since 1975 (shown as imaginary red „Saturn ring“)

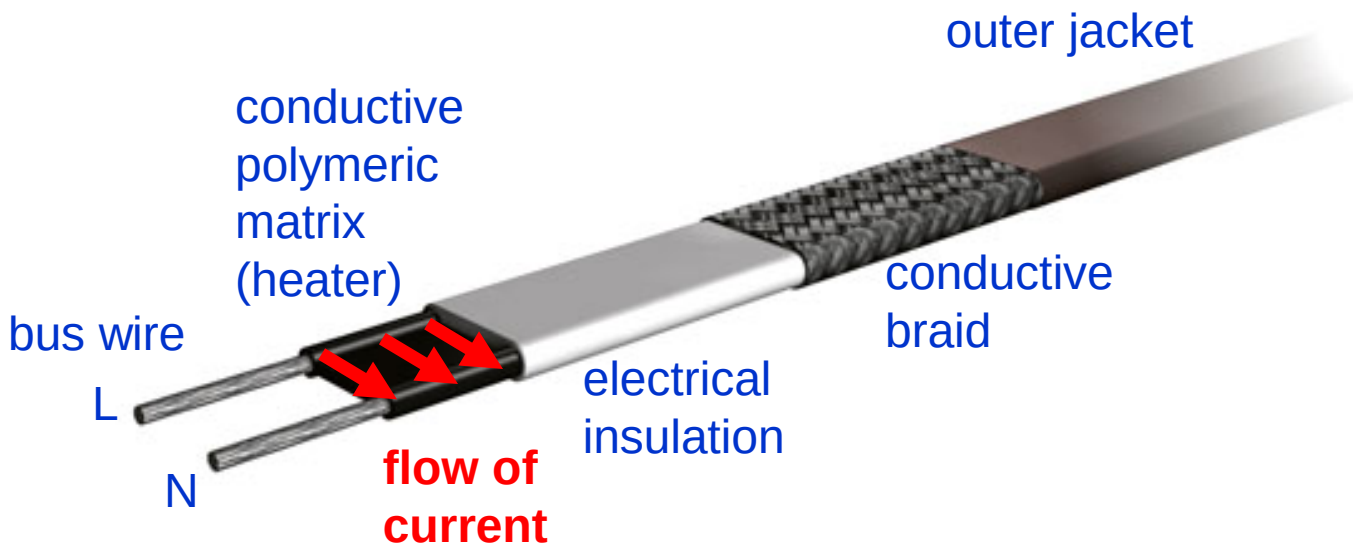
2. Introduction to Self Regulating Heating Cable (continued)

- **Based on patents by Texas Instruments (Conductive polymers, 1973) and Raychem (Method of making a heater cable, 1975)**

- **Used mainly for heating of pipes transporting**
  - **gases (anti condensation)**
  - **water (frost protection, hot water supplies)**
  - **high viscosity liquids (ensure flowability of oil, fat, wax etc.)**

2. Introduction to Self Regulating Heating Cable (continued)

Typical design of standard industrial grade SR cable:

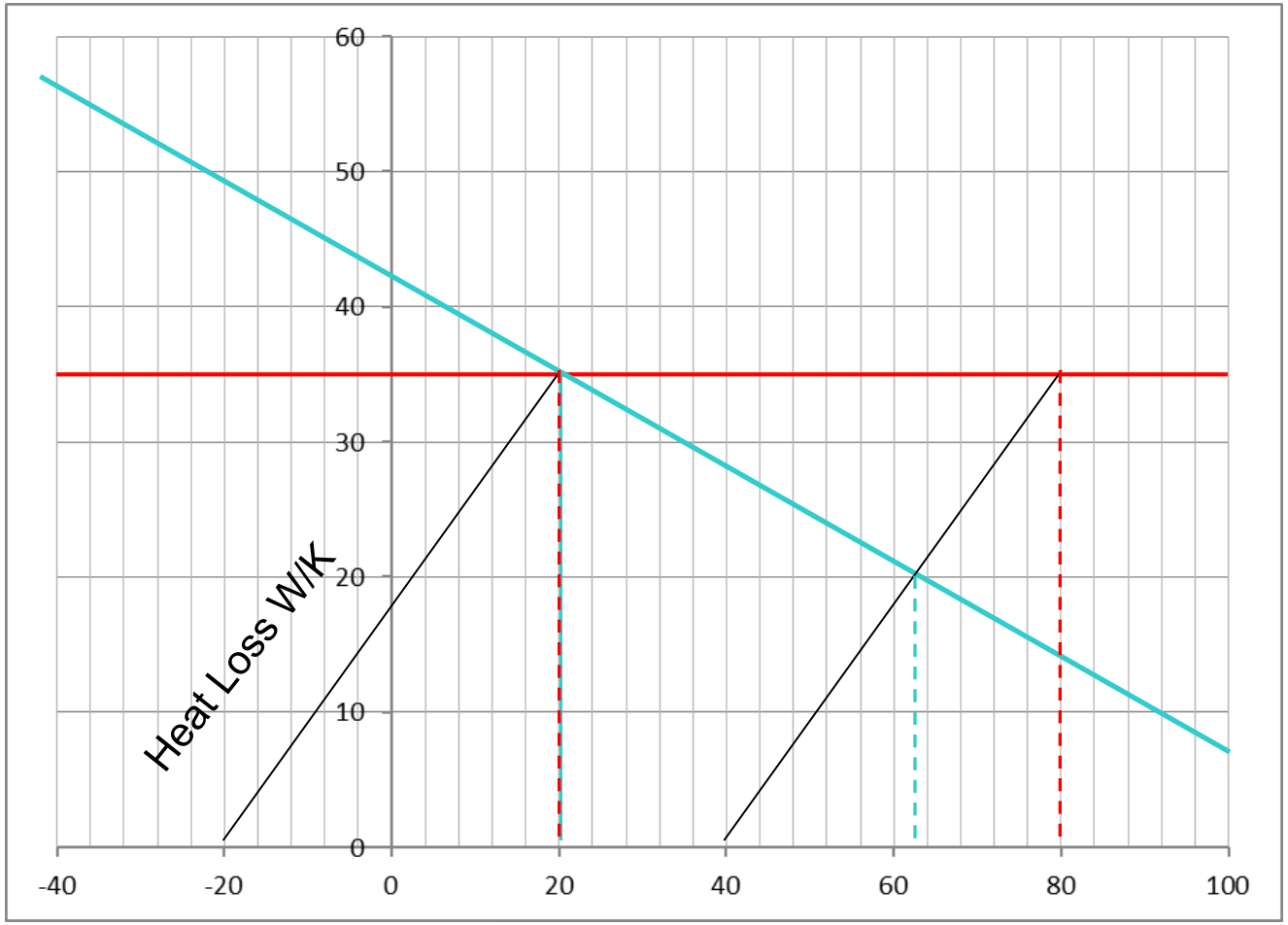


3. Key Feature “Positive Temperature Coefficient”

- **electrical conductivity is achieved by carbon black particles embedded in the polymeric matrix**
- **changing distances between particles due to thermal influence on the polymer lead to a change in the electrical resistance of the matrix**
- **change in the electrical resistance results in changes of the power output of the SR cable**

3. Key Feature “Positive Temperature Coefficient” (continued)

live demonstration of PTC effect

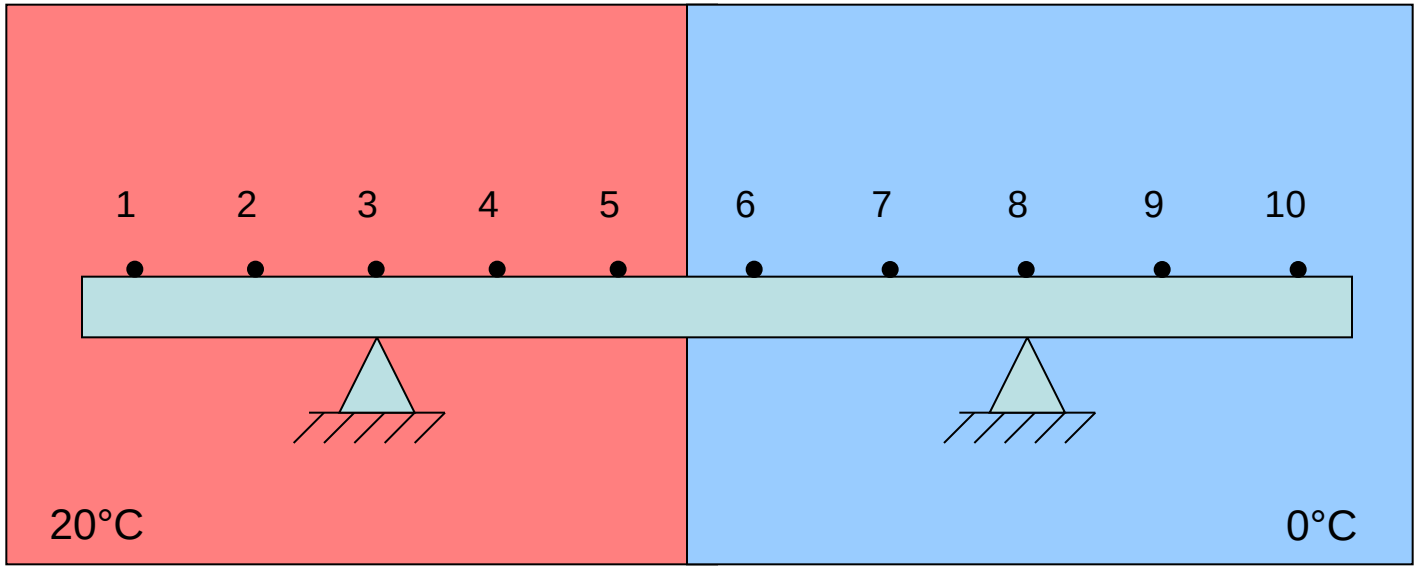


conventional series heater (negligible PTC effect)

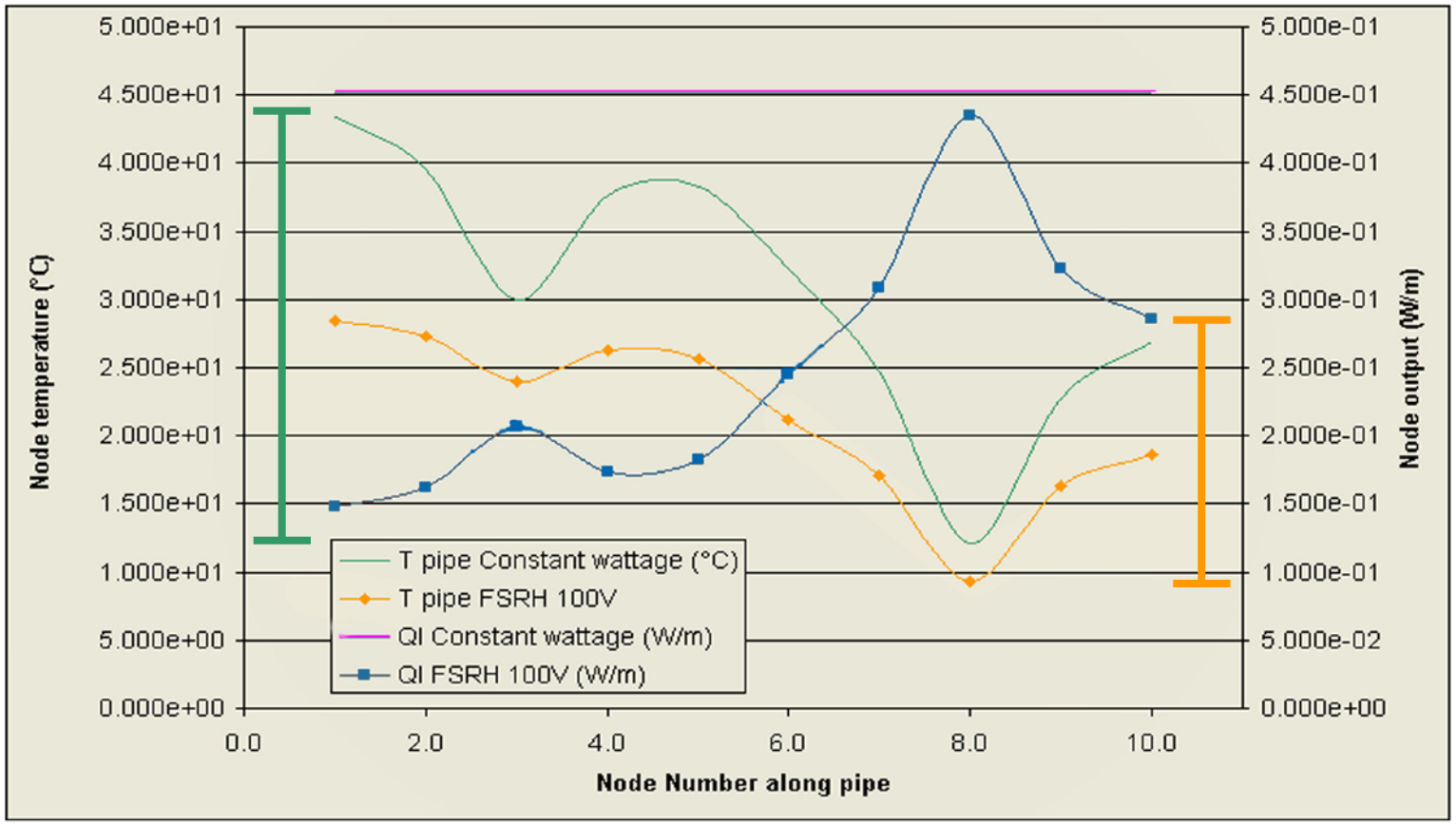
selfregulating heater (significant PTC effect)

3. Key Feature “Positive Temperature Coefficient” (continued)

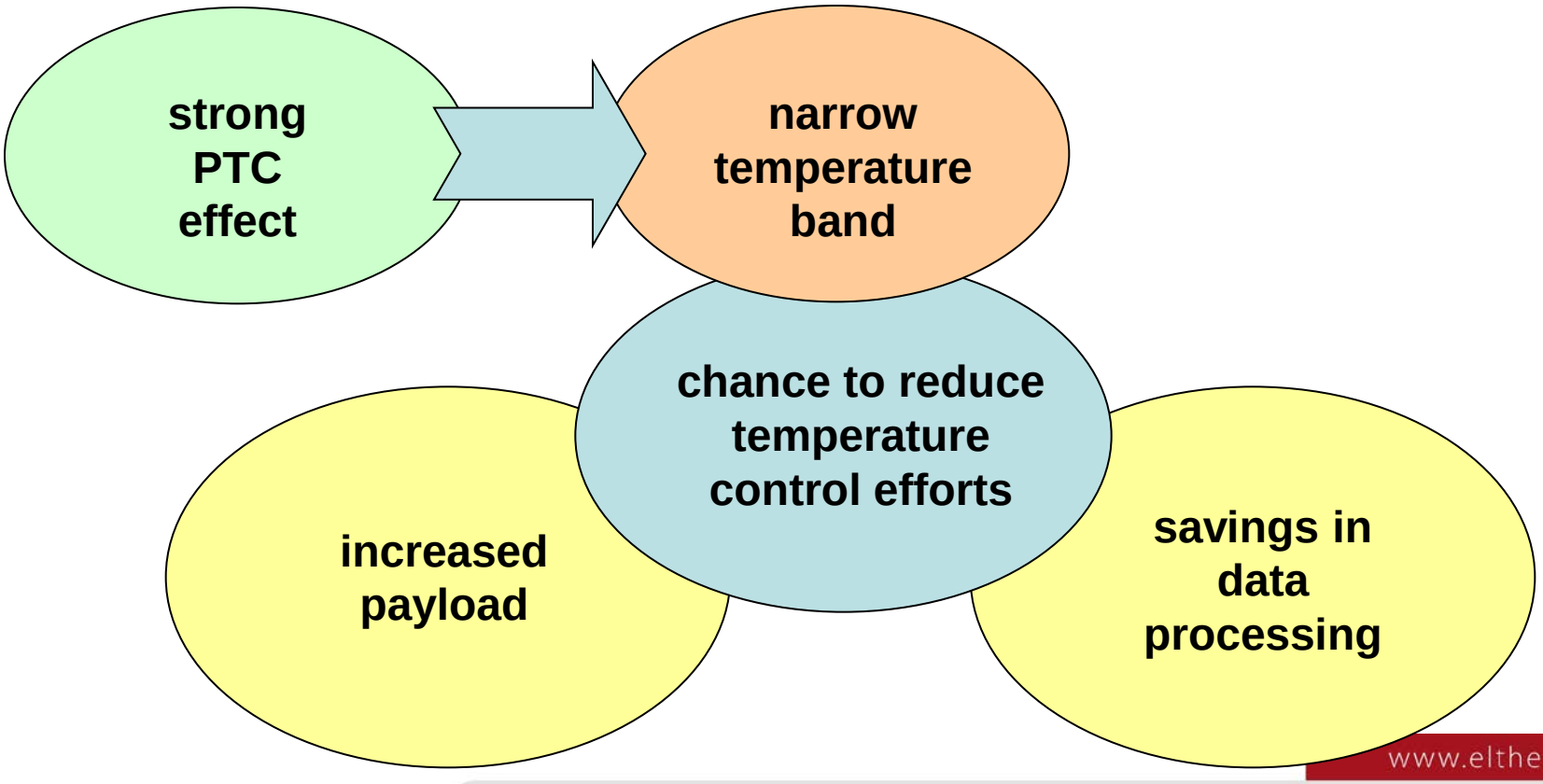
Demonstration of PTC effect by simulation of satellite propellant line application



schematic of test setup


5.000e+01
4.500e+01
4.000e+01
3.500e+01
3.000e+01
2.500e+01
2.000e+01
1.500e+01
1.000e+01
5.000e+00
0.000e+00
Node temperature (°C)
5.000e-01
4.500e-01
4.000e-01
3.500e-01
3.000e-01
2.500e-01
2.000e-01
1.500e-01
1.000e-01
5.000e-02
0.000e+00
Node output (W/m)
0.0
2.0
4.0
6.0
8.0
10.0
Node Number along pipe
T pipe Constant wattage (°C)
T pipe FSRH 100V
QI Constant wattage (W/m)
QI FSRH 100V (W/m)

3. Key Feature “Positive Temperature Coefficient” (continued)



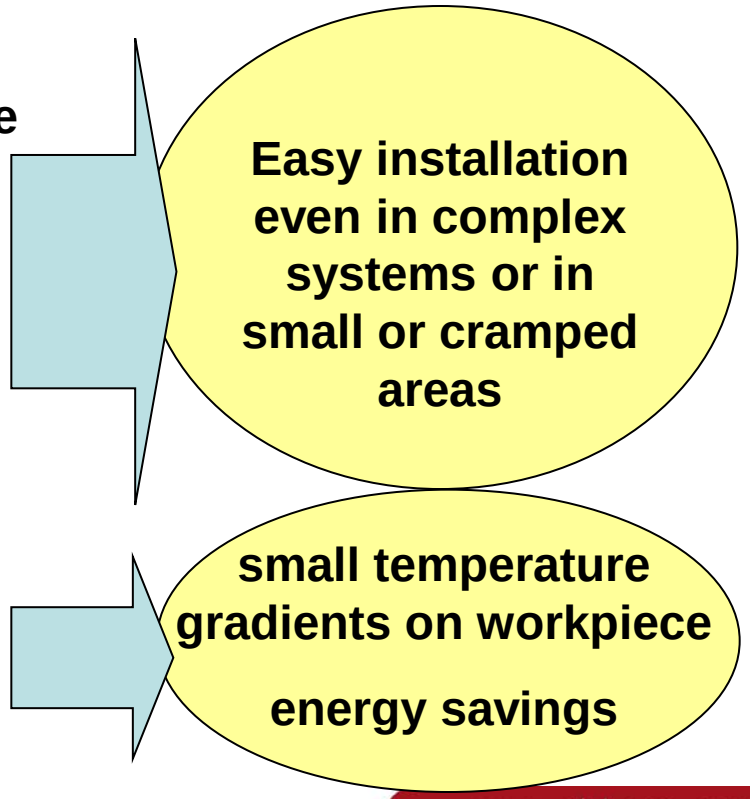
4. Other Features and Benefits for Space Applications

- touching or crossing of heaters will not cause overheating of heater or workpiece

- heater can be cut to any desired length without impact on supply voltage

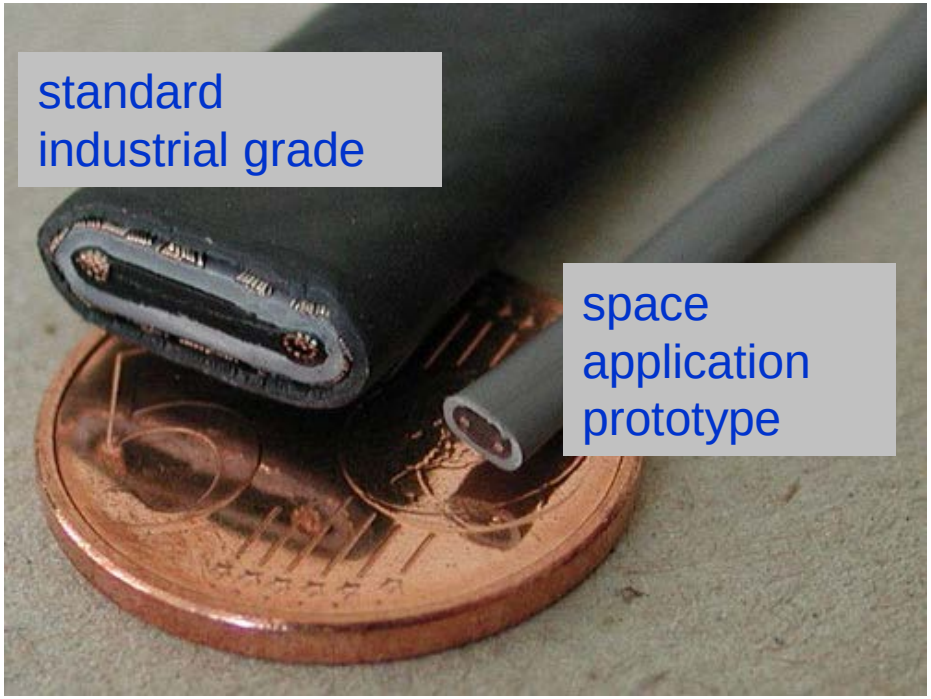
- high flexibility (small bend radius)

- different power outputs along the heater as response to local variations in workpiece temperature



5. Ongoing Tasks to achieve Full Suitability for Space Applications

completion of heater miniaturisation



5. Ongoing Tasks to achieve Full Suitability for Space Applications (continued)

- **implementation of optimised power output characteristics (absolute values, tolerances, slope)**
- **achieving of maximum uniformity of matrix properties (especially resistance and bond to bus wires)**
- **identification of meaningful testing procedures for evaluation / prediction of long term performance (min. 15 years)**
- **implementation of suitable production processes, equipment and environment**

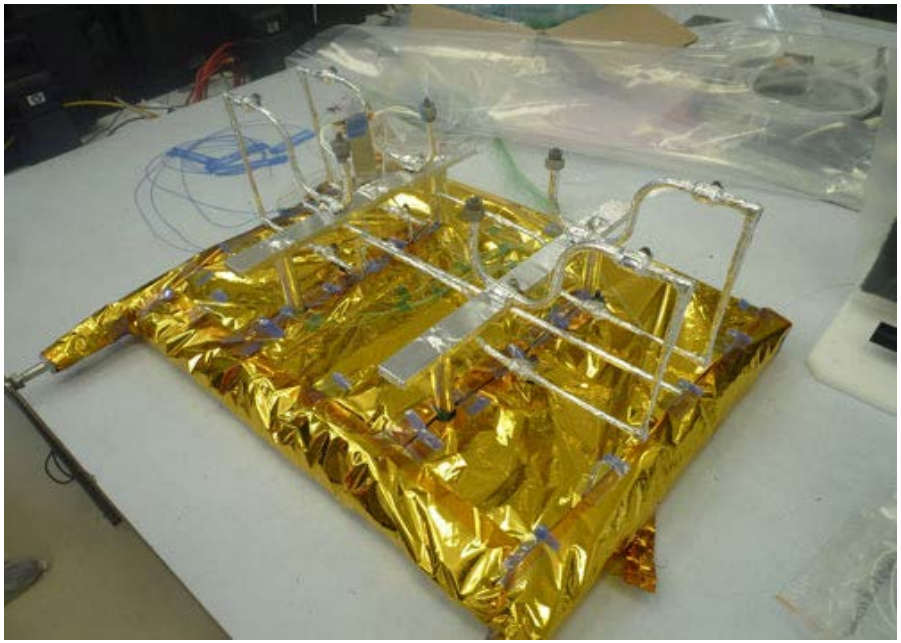
6. Current status and conclusion

Prototype data:

Dimensions w x h:	**approx. 3 x 2 mm**
Bend radius:	**approx. 5 mm (on neutral axis)**
Weight:	**< 7 g/m**
Power output at -20°C / +40°C:	**0.5 W/m / 0.03 W/m**
Max. withstand temperature:	**80°C (continuous exposure)**

6. Current status and conclusion (continued)

Testing of improved polymers for matrix and electrical insulation in progress as part of an ITI B Project



6. Current status and conclusion (continued)

Promising test results with regard to

- **resistance against x-rays**
- **outgassing**
- **power output characteristics**
- **thermal ageing**
- **handling and system integration**

6. Current status and conclusion (continued)

Possible foreseeable space applications:

- **temperature maintenance on satellite propellant lines**
- **heating of battery packs**
- **heating of structural parts and fuselage**
- **others as per customer requirements**

6. Current status and conclusion (continued)

Next milestone: achieving of a technological level equivalent to TRL 6 in first half of 2014

End of presentation -

questions welcome!

www.eltherm.com

Photos: slide 3 courtesy EUMETSAT; slide 4 courtesy NASA; slides 11, 17 courtesy Thales Alenia Space