

SWaP rotary coolers for IR space application

IR detector workshop –
Toulouse – June 2023
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Introduction

- Cryocoolers are an enabling technology for space missions viewing in the Infrared, gamma-ray and x-ray spectrums
- Current typical space cryocooler = Pulse-Tube cooler
 - very high reliability but low efficiency and high size and weight (about 4kg)
- The mass and size limitations of new applications and even a 6U CubeSat require significantly smaller, lighter cryocoolers
- Rotary cooler are good opportunities for CubeSat and new space applications



Agenda

01



New space application

02



Cryocoolers for space applications

03



Thales rotary coolers

04



Conclusion

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New space applications



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New space applications

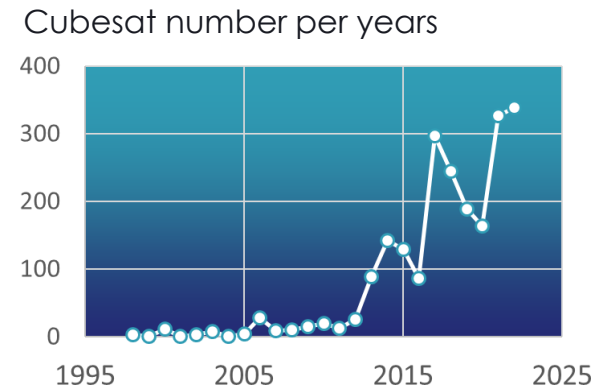
➤ Trend : Reduce costs and lead time for new satellites

➤ CubeSat example

- ▶ Limited volume (1U, 3U, 6U)
- ▶ Limited power available
 - Limited volume available for solar panels and batteries
 - Limited capacity to dissipate cooler heat
- ▶ Low weight (less than 3kg)
- ▶ Less radiation stress
- ▶ Standardization
 - Use of COTS for components
 - Higher quantities
- ▶ Lower cost

Thermodynamic efficiency of the cryogenic system becomes a critical consideration

“Full space” qualified product not required



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Cryocoolers for IR space applications



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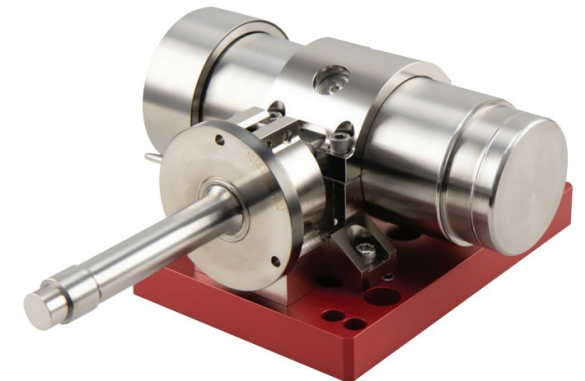
Cryocoolers for IR space applications



**Rotary stirling
cooler**



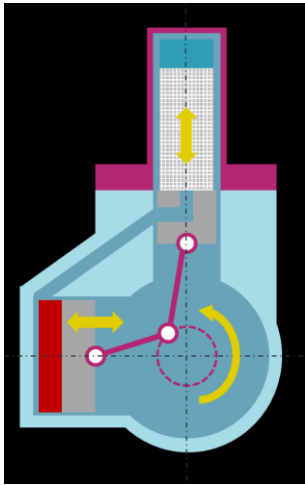
**Linear stirling
cooler**



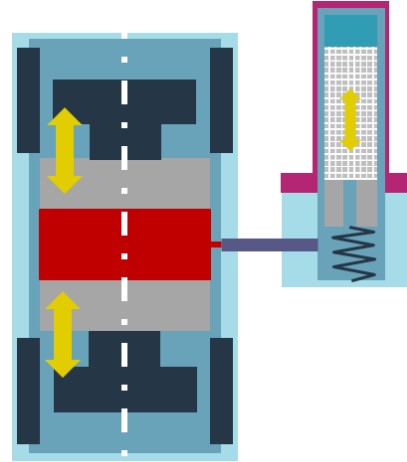
**Linear pulse tube
cooler**

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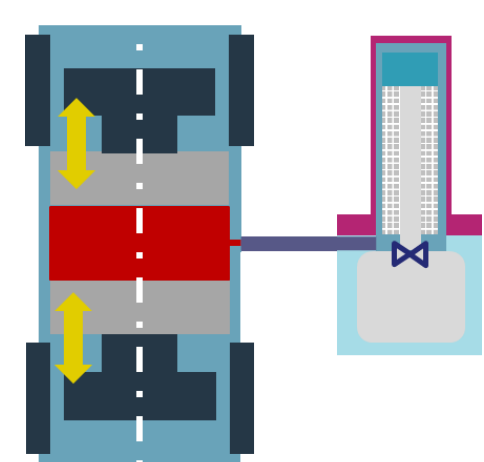
Cryocoolers for IR space applications



Rotary stirling
cooler



Linear stirling
cooler



Linear pulse tube
cooler



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Thales rotary coolers

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Key Figures



Thales LAS FRANCE

- **5,000 coolers** per years
- Revenue : **10.2 M€** (2022 - Thales needs excluded)
- **100 employees**
- **3,500 m²** manufacturing facility (400m² of clean room)
- Defense / Civil
- ISO 9001: 2015 / ISO 14001 / ISO45001
- Lean manufacturing since 2013



Cryogenics BV

- **1,000 coolers** per years
- Revenue : **16 M€** (2022)
- **75 employees**
- **7,500 ft²** manufacturing facility (about 700m²)
- Defense / Civil / Space
- ISO 9001 / ISO 14001
- Extensive environmental testing capabilities (shakers, shock, thermal, vacuum)

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Thales rotary cryocoolers

Thales current
portfolio for
rotary coolers



RM1s1

Best SWaP cooler for HOT applications
1000mW @ 150K/20°C



RM2

Best cooler for compact and reliable
applications
400mW @ 77K/20°C



RM3

Flexible cooler with integrated drive
electronic
600mW @ 77K/20°C



RM4

High power and robust cooler
850mW @ 77K/20°C



TOTAL COOLING POWER (W)

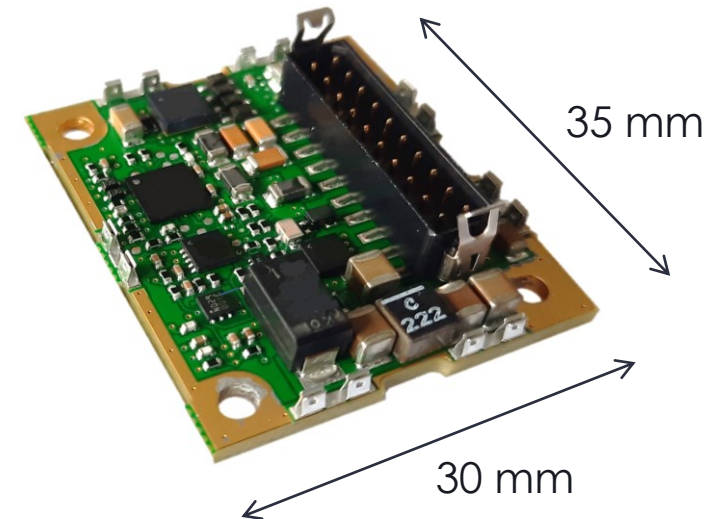


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Cooler drive electronic

► Full digital electronic driver available for all Thales cooler

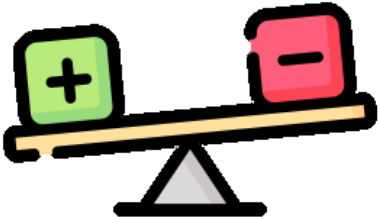
- ▶ COTS solution / Not space qualified
- ▶ Small and efficient driver
 - 30 x 35 mm
- ▶ Setting of digital solution through USB interface
- ▶ Adjustable safety functions
- ▶ Hour counter
- ▶ Failure reporting



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Rotary coolers advantages and drawbacks

➤ Rotary Stirling micro-coolers are good candidates for space missions on Nano- MicroSats or space instruments.



		RM <i>s</i> 1	RM2 <i>i</i>	RM3
Lower size and weight	+	72 x 42 x 42 mm 140 gr	96 x 85 x 47 mm 275 gr	117 x 71 x 56 mm 450 gr
Lower power consumption	+	< 1 W @ 150K / 150mW / 20°C	< 3 W @ 77K / 130mW / 20°C	< 4 W @ 77K / 180mW / 20°C
Fast cool down time	+	< 2min @150K / 120J / 20°C	< 5min30 @77K / 150J / 20°C	< 4min30 @77K / 360J / 20°C
Improved reliability	-	>15,000h	>50,000h	>17,000h
Induced vibrations	-	Low induced vibration level on 3 axis		
Mechanical environment	?	Qualified on harsh mechanical environments (missile applications)		
Lower cost	+	COTS products		



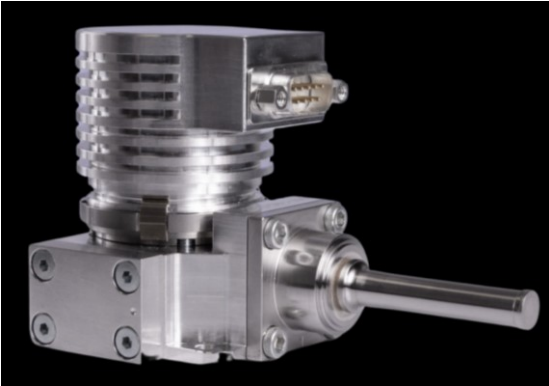
High efficiency
=> Low thermal dissipation



RMs1 and RM3 characterization

► Characterization under progress by the CNES

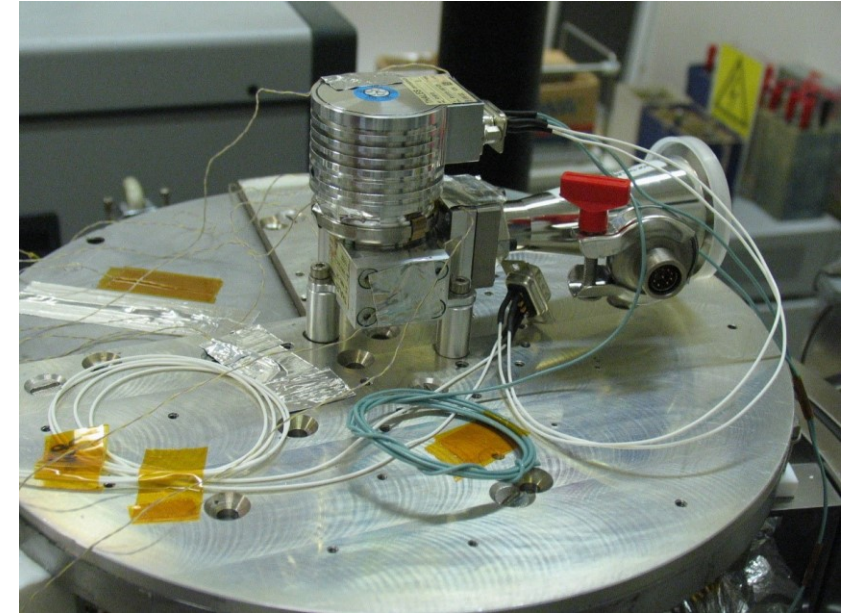
- Cryogenic power and cooling capacities
- Thermal
- Mechanical



RM3



RMs1



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Conclusion

- New satellites required more efficient and COTS coolers
- Rotary coolers are good opportunities for these applications
- Thales is increasing his knowledge about rotary coolers for space applications
 - Characterization under progress
 - New applications to be defined

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Thank you

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