Cryocoolers:

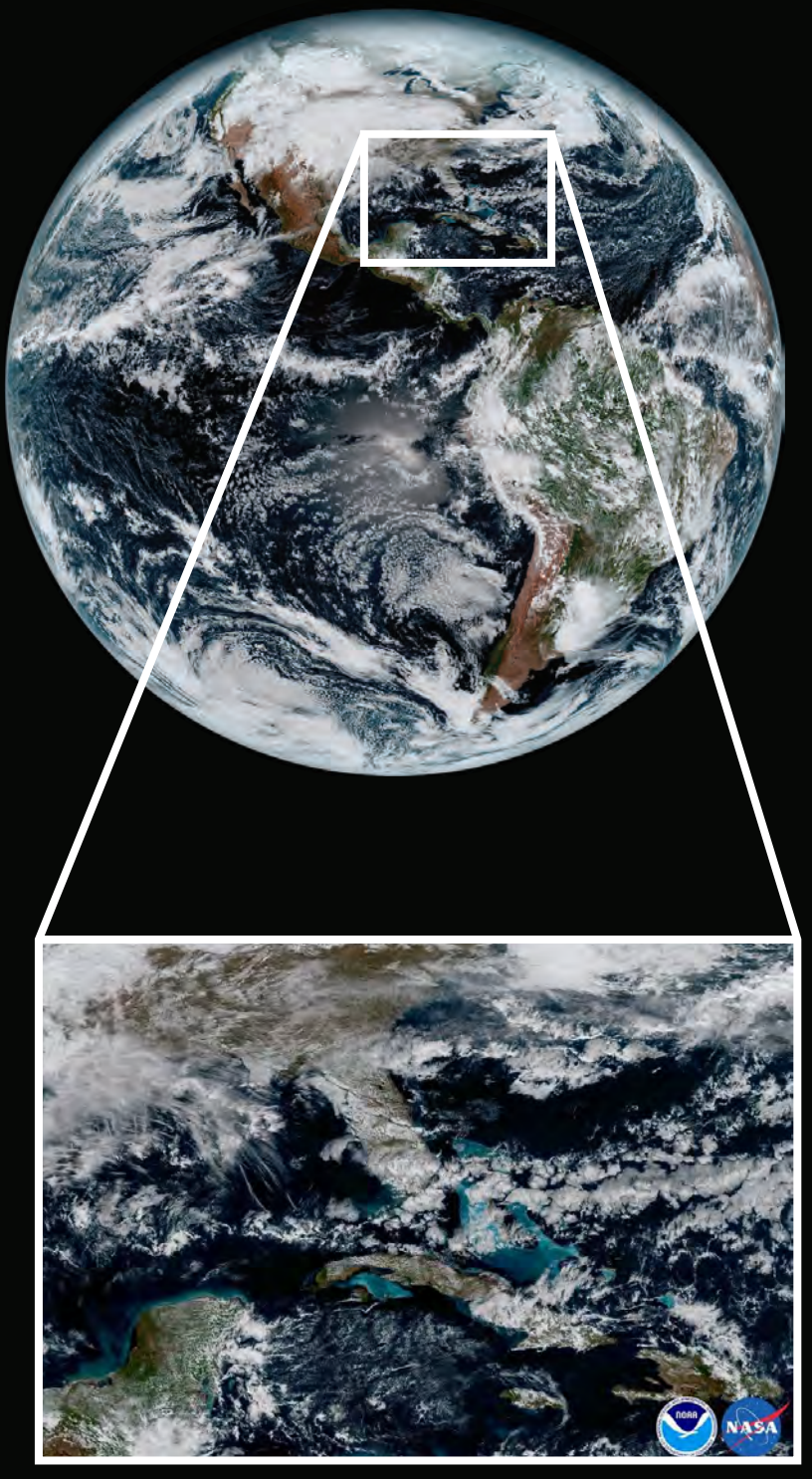
Space Missions Made Possible

Northrop Grumman's cryocoolers offer high reliability for critical space missions, including missile defense, climate science, astronomy, and weather tracking and prediction. Our pulse tube cryocoolers have more than 300 combined years of on-orbit operation, often exceeding their design life many times over with no degradation in performance.

Northrop Grumman is also using its space experience and cryocooler design to offer zero-maintenance cryocooler options for airborne and ground-based applications. These design variants offer the same reliability as those operating in space.

Our scalable design offers:

- Reliability
  - More than 10 years of continuous on-orbit operation.
- Efficiency
  - High efficiency over a wide range of operating temperatures.
- Best in Class Size, Weight, and Power (SWAP)
- Scalability
  - Four common compressor design sizes.
  - Designs offer cooling from 1.7 to 200 Kelvin.
  - Smallest two sizes applicable to tactical applications.
- Low Vibration
  - Balanced mechanical design.
  - Active vibration cancellation included in TRL9 designs.
- Simplified Integration
  - Standard design offers a single thermal/mechanical interface on the warm end.
  - Standard digital interfaces (RS422 and 1553)
- Flexibility
  - Single or multiple cooling loads.
  - Cooling interface local to the compressor, or remotely located.
- Space Rated
  - Radiation-hardened electronics and instrumentation



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High Efficiency Cryocoolers for Space

- Northrop Grumman's TRL 9 High Efficiency Cryocooler (HEC) - unmatched legacy of success in space cryocoolers.
- Space cryocooler system includes flight electronics and pulse tube cryocooler - all TRL 9.
- High reliability designed in - no moving parts in the cold head and non-wearing compressor for infinite life.
- Pulse Tube design provides very low output vibration.
- Electronics provide active vibration dampening, as well as temperature control.
- High efficiency over a wide range of operating temperature.
- Low mass and single thermal and structural interface reduce system level cost.

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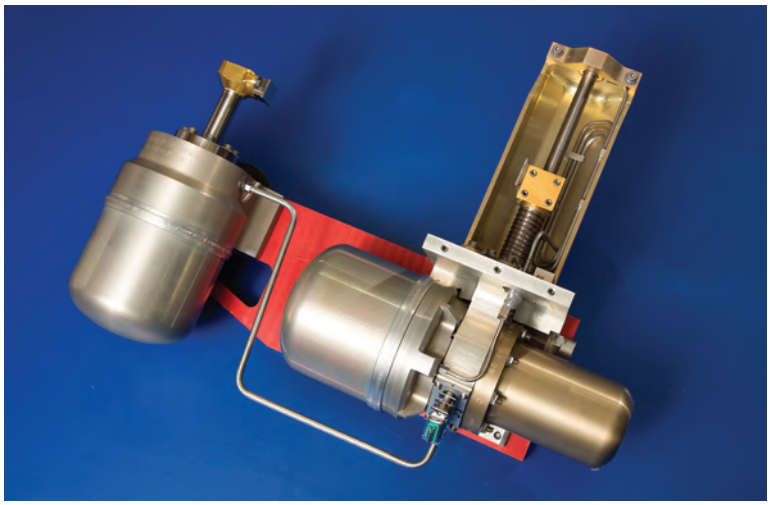

Capabilities

Refrigeration Capacity	2 W at 45 K 8 W at 77 K 23 W at 150 K
Compressor input power	Up to 180 W
Reliability	> 90% at 87,600 hours (10 years)
Environment	- 40 C to + 70 C
Exported Vibration	< 50 mN drive axis < 200 mN pulse tube axis
Mass (single stage)	< 4.5 kg
Mass (electronics)	< 3.8 kg