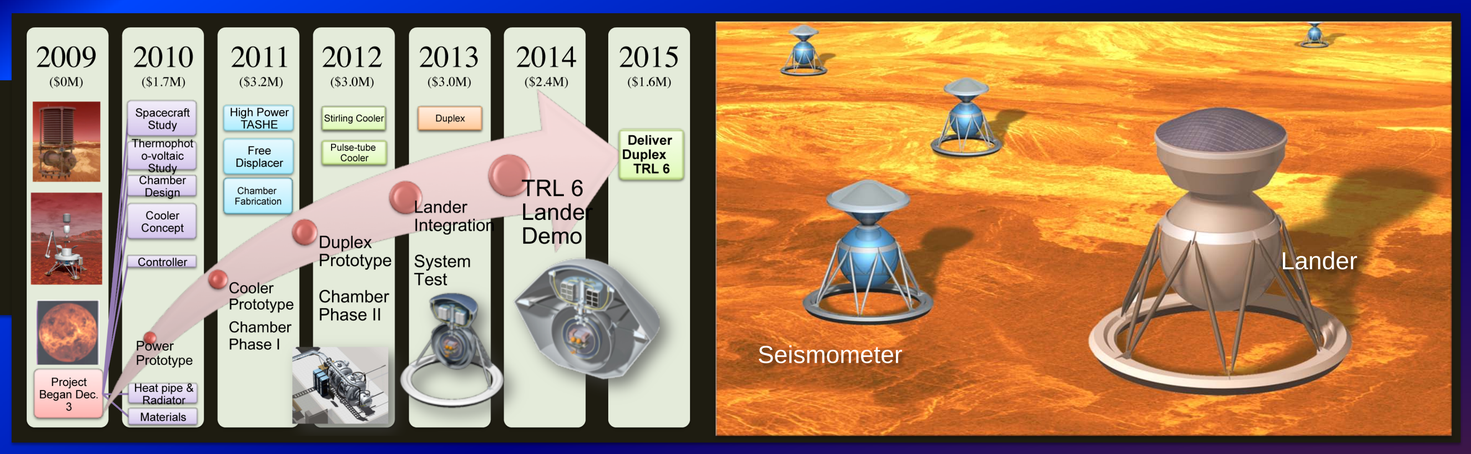
National Aeronautics and Space Administration

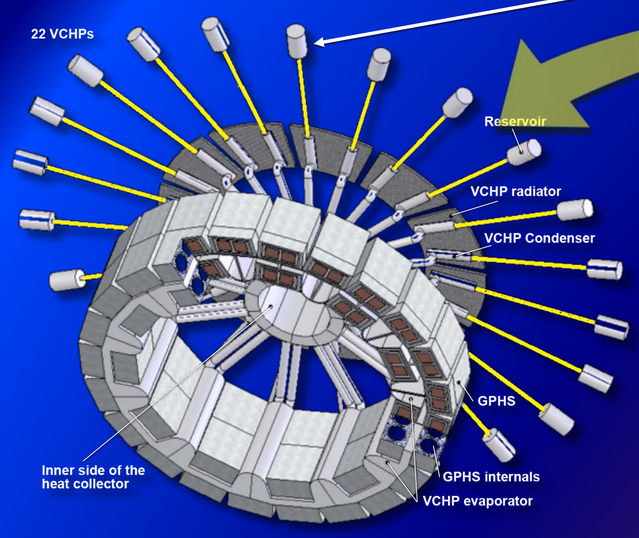
Advanced Stirling Duplex

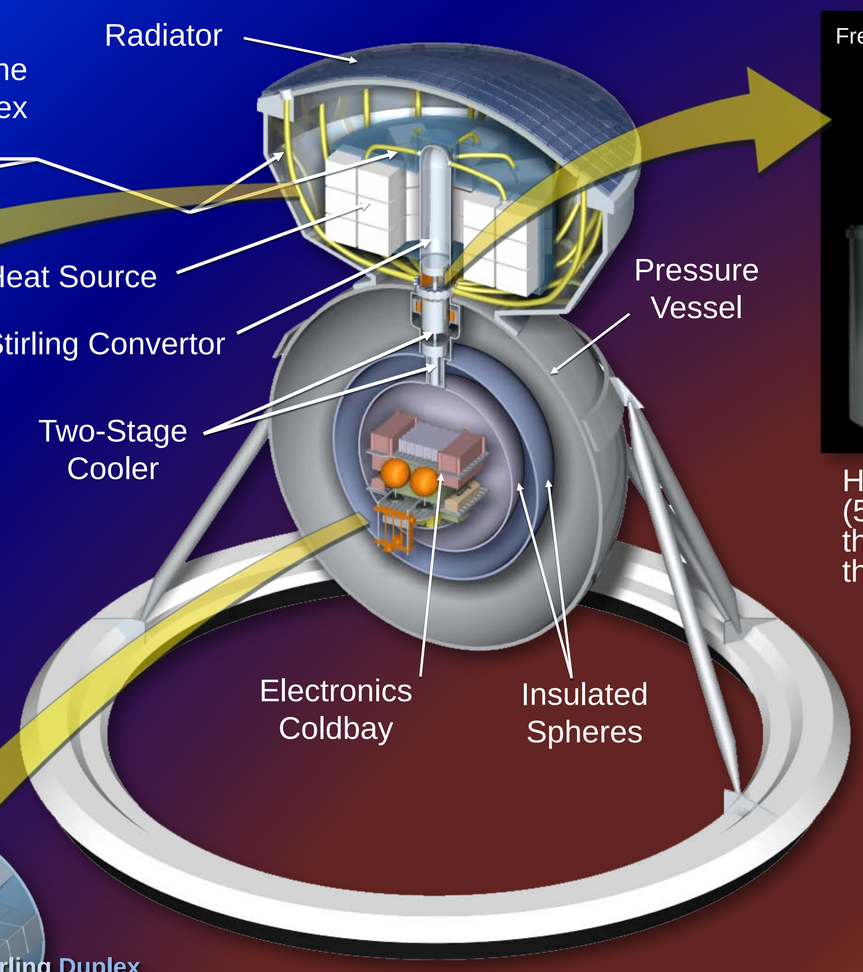
Project Abstract: RPT has begun the development of a combined Stirling cycle power and cooling system (duplex) to enable the long-lived surface exploration of Venus and other harsh environments in the solar system. The duplex system will operate on the heat provided by General Purpose Heat Sources or a fission reactor. Since the surface of Venus has a thick, hot, and corrosive atmosphere, it is a challenging proposition to maintain sensitive lander electronics under survivable conditions. This development effort requires the integration of at least a heat source, heat pipes, high temperature, corrosion resistant materal, multi-stage cooling, a novel free-displacer Stirling convertor for the lander, and a minimal vibration thermo-acoustic Stirling convertor for seismometer operations. The first year effort includes conceptual system design and control studies, materials development, and prototype hardware testing.

Mission Objectives:
Long-lived surface Exploration including: Mineralogy, seismometry, meteorology, and spectroscopy.



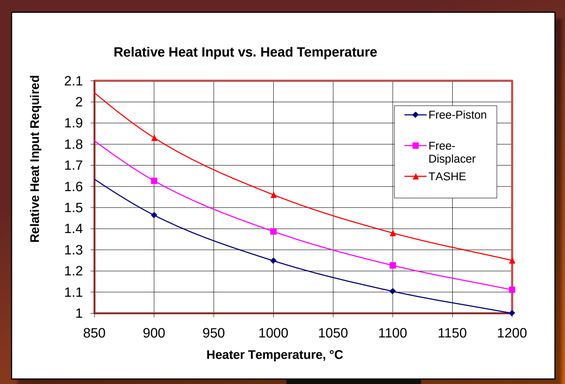
Variable Conductance Heat Pipes:
Enables the modulated delivery of heat from the source to the engine or radiator-insuring the duplex receives 16kW of heat while operating.

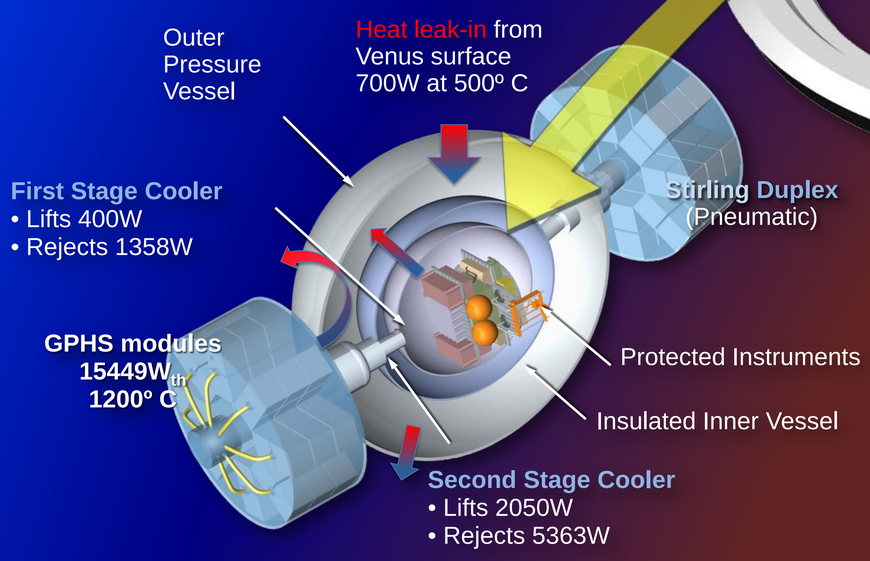




Novel Free Displacer and Thermoacoustic Stirling Engine:

High temperatures on the surface of Venus (500 ˚C), require eliminating moving parts in the hottest parts of the engine by shortening the displacer or using thermo-acoustics.

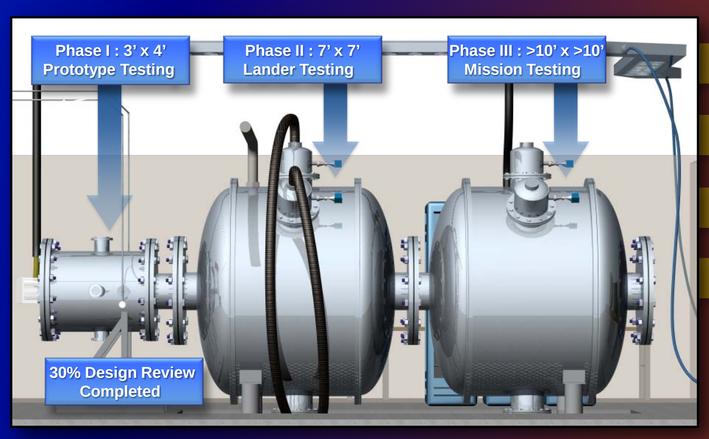


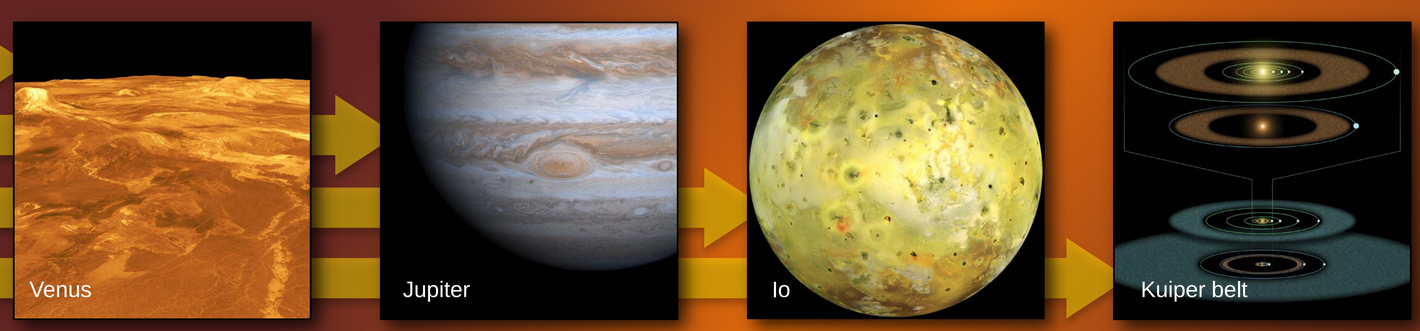


Stirling power cooling offers most potential when combined into duplex

Approach	Efficiency, % $\frac{T_{hot}}{T_{cold}} = \frac{1123K}{773K}$
Free-Piston Stirling	17
Free-Displacer Stirling	15
Thermoacoustic Stirling	13
Brayton/Rankine	11
Thermoelectric (Segmented)	3-4
Solar Array	< 1
Beamed Power	< 1
Thermionic	< 1
Battery	-

Approach	Efficiency % of Carnot
Free-Piston Stirling	28
Free-Displacer Stirling	24
Thermoacoustic/Pulse Tube	20
Brayton/Rankine	18
Thermionic	15
Thermoelectric (Segmented)	1
Mixed Refrigerant	-
Phase Change	-





Environmental Testing: A first-of-its-kind test chamber is being developed over several phases to enable simulated Venus, Jupiter, Io, and Kuiper belt in situ operations.

Thermal Energy and Conversion

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