Future instruments for NASA’s Science Mission Directorate will require increasingly sophisticated thermal control technology. Innovative proposals for thermal control technologies are sought in the following areas:

- Instrument Optical alignment needs, lasers, and detectors that require tight temperature control, often to better than \(\pm 1\degree \text{C}\). Some new missions, such as LISA and TPF, require methods of temperature measurement and control to micro-Kelvin levels.

- Heat flux levels from lasers and other high power devices are increasing with some projected to go as high as 100 W/cm\(^2\). They will require thermal technologies such as spray and jet impingement cooling. Also, high conductivity, vacuum compatible interface materials will be needed to minimize thermal losses across make/break interfaces.

- Future missions will utilize large, distributed structures such as mirrors and detector arrays at both ambient and cryogenic temperatures. These missions will require creative techniques to integrate thermal control functions and minimize weight. Some anticipated technology needs include: advanced thermoelectric coolers capable of providing cooling at ambient and cryogenic temperatures, high conductivity structural materials to minimize temperature gradients and provide high efficiency lightweight radiators, and advanced thermal control coatings such as variable emittance surfaces and coatings with a high emissivity at ambient and cryogenic temperatures.

- The push for miniaturization also drives the need for new thermal technologies towards the MEMS level. Miniaturized heat transport devices, especially those suitable for cooling small sensors, devices, and electronics, include miniaturized mechanical pumps, Loop Heat Pipes (LHPs), and Capillary Pumped Loops (CPLs) which allow multiple heat load sources and multiple sinks.

- The drive towards robotic missions and reconfigurable spacecraft presents engineering challenges for science instruments, which must become more self-sufficient. Some of the technology needs are:
  - Advanced analytical techniques for thermal modeling focusing on techniques that can be easily integrated into existing codes, emphasizing inclusion of LHPs, CPLs, and mechanically pumped system models;
  - Single and two-phase mechanically pumped fluid loop systems, which accommodate multiple heat sources and sinks, and long life, lightweight pumps for these systems; and
Efficient, lightweight vapor compression systems for cooling up to 2 KW.