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TEXAS TECH UNIVERSITY

Soil Moisture Active and Passive(SMAP) Cone Clutch Assembly (CCA) Thermal Conductance Test

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Purpose and Organization

Purpose:

To characterize the thermal conductance of the SMAP Cone Clutch Assembly to ensure that thermostatically controlled heaters on either side of the interface maintain all components within their allowable flight temperatures (AFT).

Organization:

- Overview of the SMAP Mission
- Overview of the SMAP Clutch Cone Assembly
- Test Set-up and Measurements
- Results and Conclusions

Overview of the SMAP Mission

The SMAP S/C will make measurements to determine soil moisture and its freeze/thaw states from a near-polar, sun-synchronous orbit.

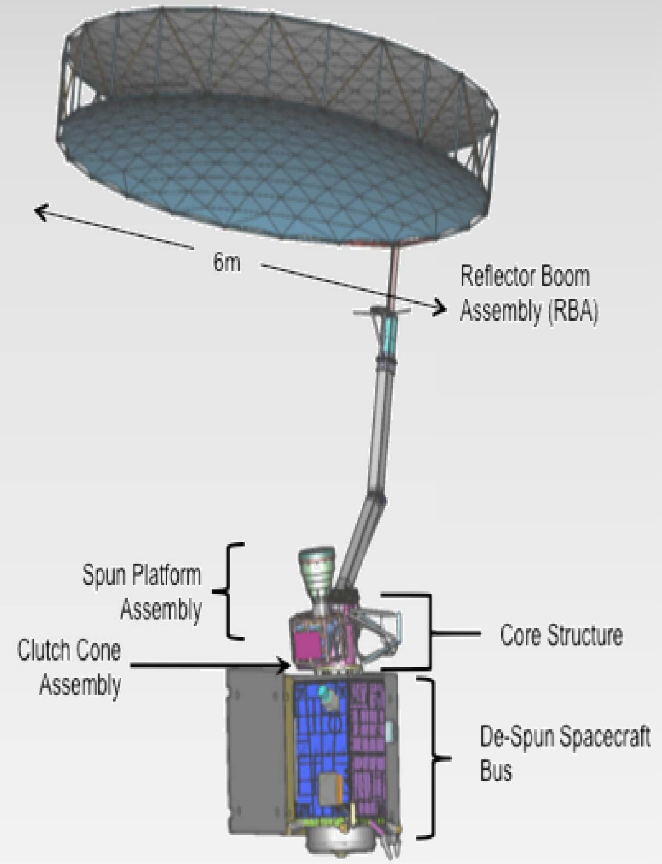
- In order to understand processes that link the water, energy and carbon cycles, and to extend the capabilities of weather and climate prediction models.

SMAP consists of a 3-axis stabilized spacecraft

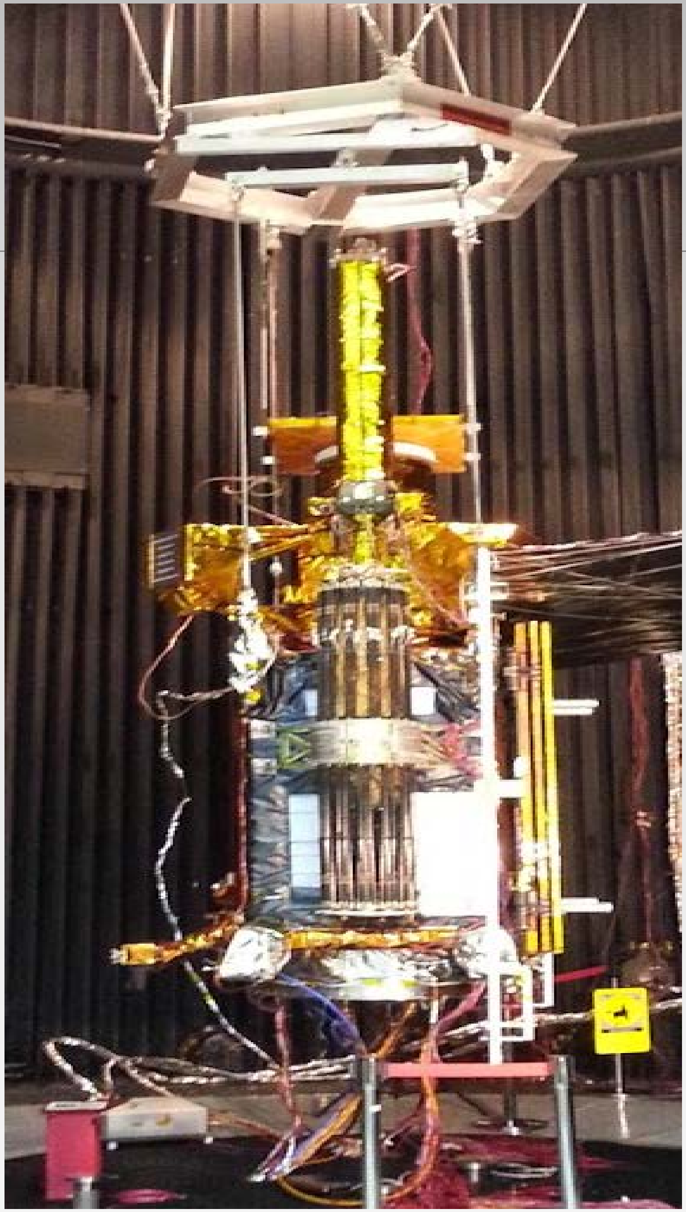
An instrument suite is mounted to a spun core structure.

The SMAP instruments are mounted to a spinning core structure

- Includes a 6-meter (deployed) reflector for active and passive measurements of Earth
- The SMAP Cone Clutch assembly and the bearing and power transfer assembly (BAPTA) are the transition between the despun spacecraft and the spinning instrument.



SMAP Spacecraft



SMAP Cone Clutch Assembly (CCA)

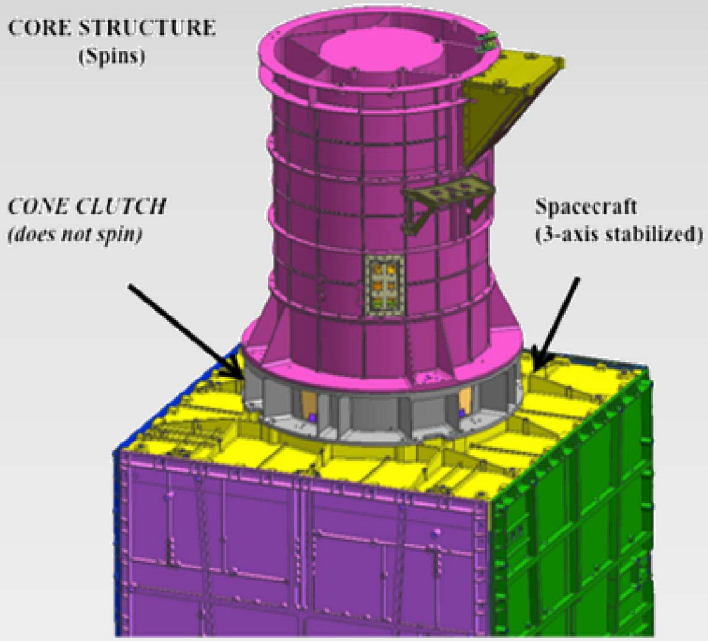
The Cone Clutch assembly (CCA) holds the spun instrument in place during launch, but once engaged allows the BAPTA to spin the instrument following commissioning.

- No part of the CCA is spun.

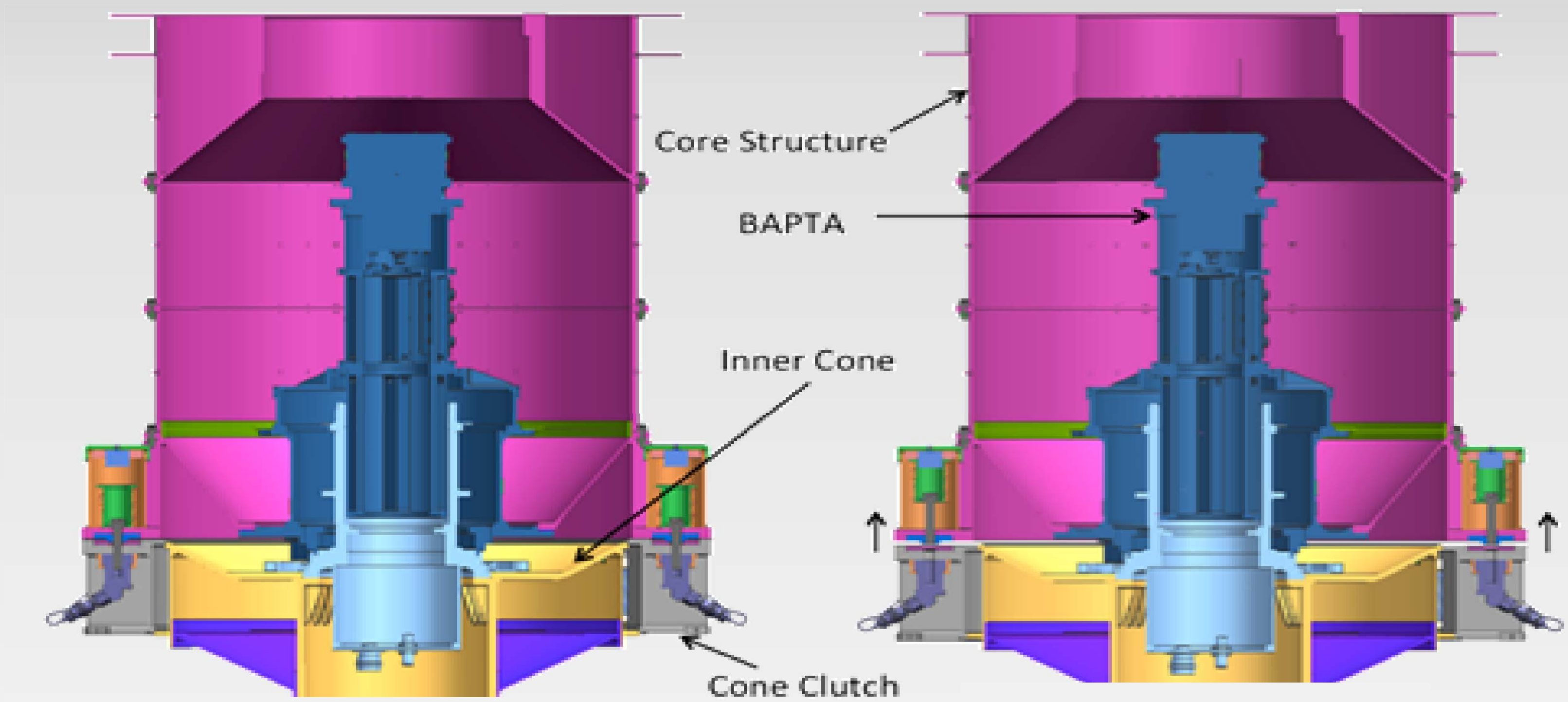
The stowed and deployed CCA configurations thus form two distinct thermal configurations.

Characterize the heat transfer from the instrument to the spacecraft in the engaged (flight commissioned) configuration .

- In the stowed configuration, the instrument has a degree of thermal isolation from the spacecraft.
- The SMAP CCA test was designed to characterize this thermal conductance in the engaged configuration to ensure that thermostatically controlled heaters on either side of the interface maintain all components within their allowable flight temperatures (AFT).



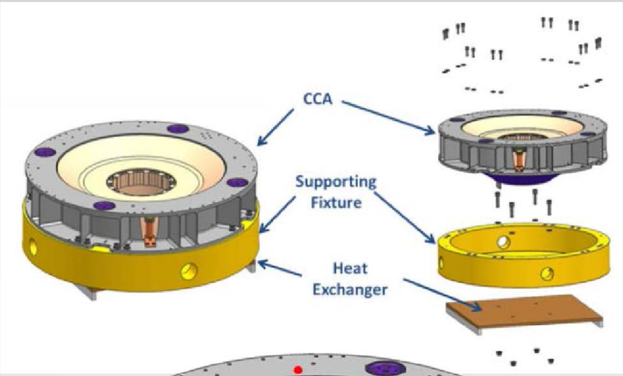
Stowed & Engaged Configurations

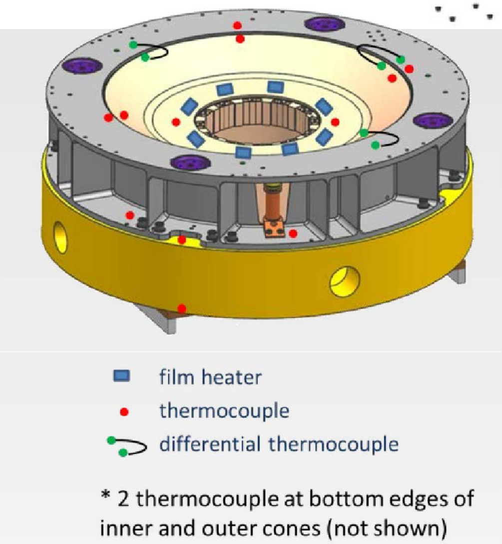


Launch Configuration
Stowed

After RBA Deployment
Engaged/Deployed

CCA Conductance Test Set-up





Conducted in a 3’ thermal chamber in high vacuum.

- Isolated from chamber by teflon stand-offs on heat exchanger and MLI overwrap

Thermal gradient:

- Film heaters were mounted along the inside of the inner cone
- Support fixture mounted to a GN_2 /LN_2 heat exchanger.
- The support fixture supported the outside structure of the CCA.

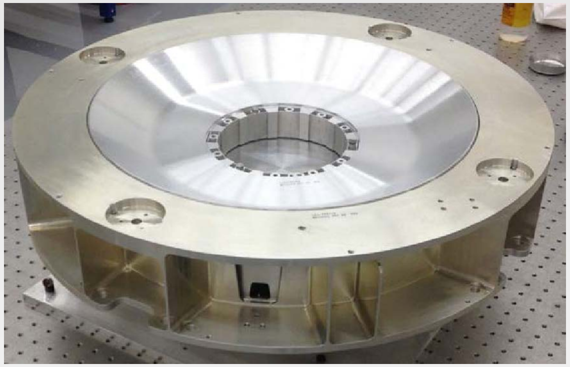
Temperature measurements:

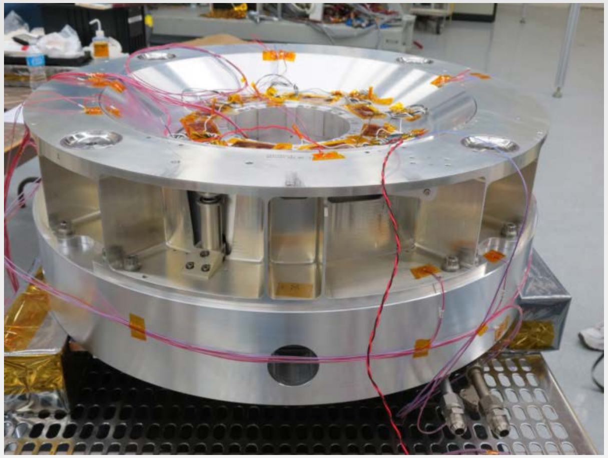
- Differential Thermal couples accurately measured the temperature across the gap between the CCA and the inner cone.
- Type E thermal couples

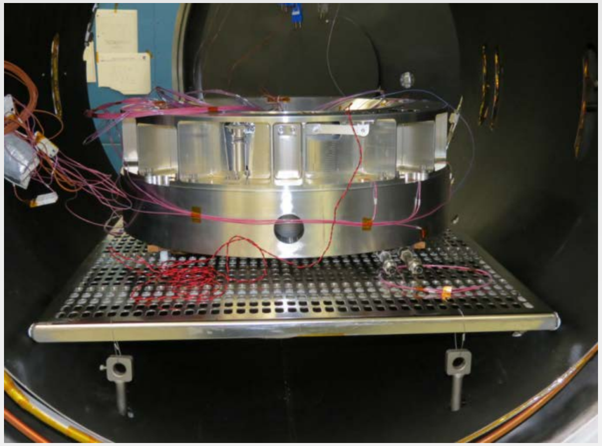
Test Article

Flight-like CCA test article

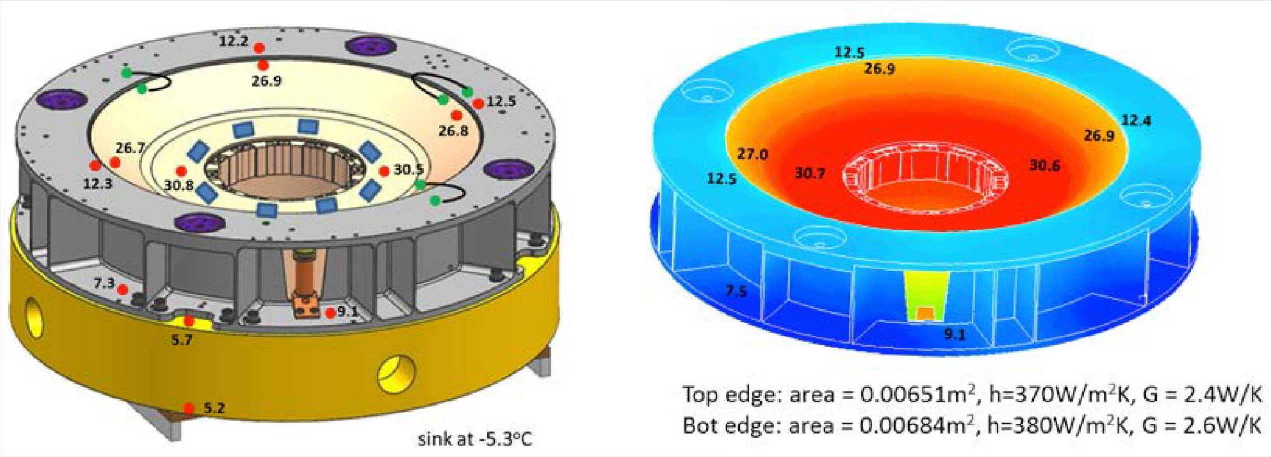
- Uniform contact along the edges was observed for both top and bottom edges, and
- No noticeable slips were observed between edges.
- MLI Overwrap to isolate from chamber (not shown)



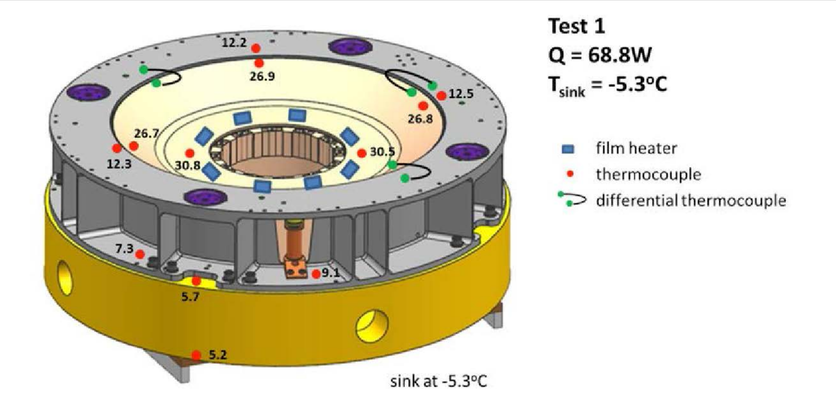


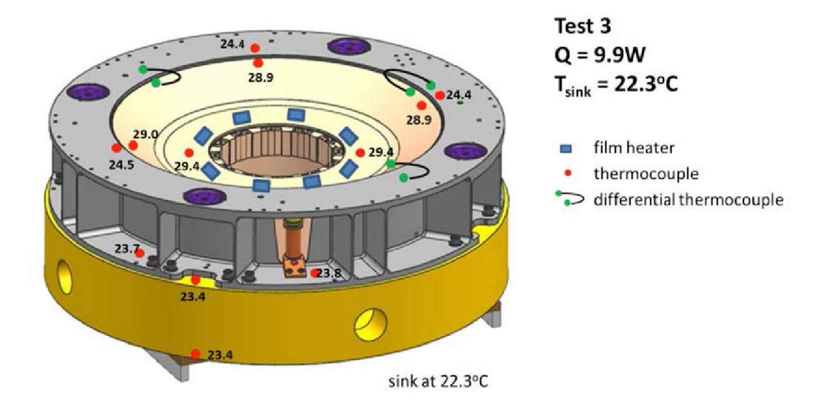


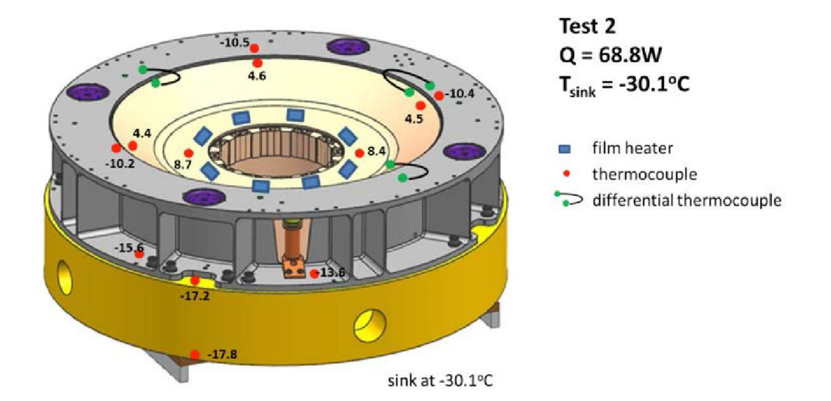
TMG Model of Test Case 1

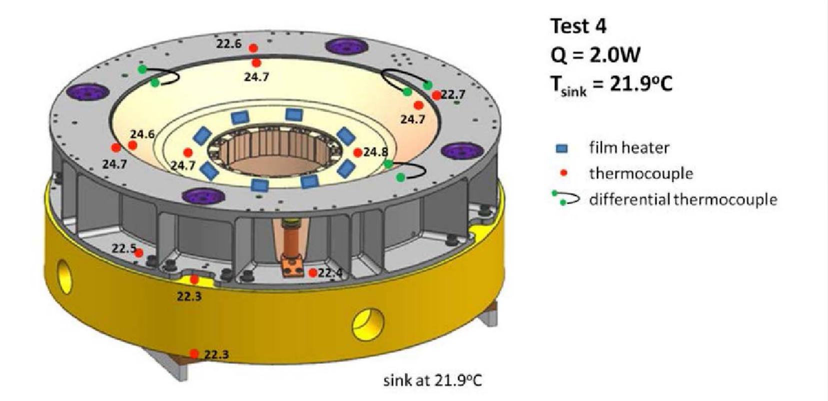


Test Cases 1 -4









Thermal Conductance Values

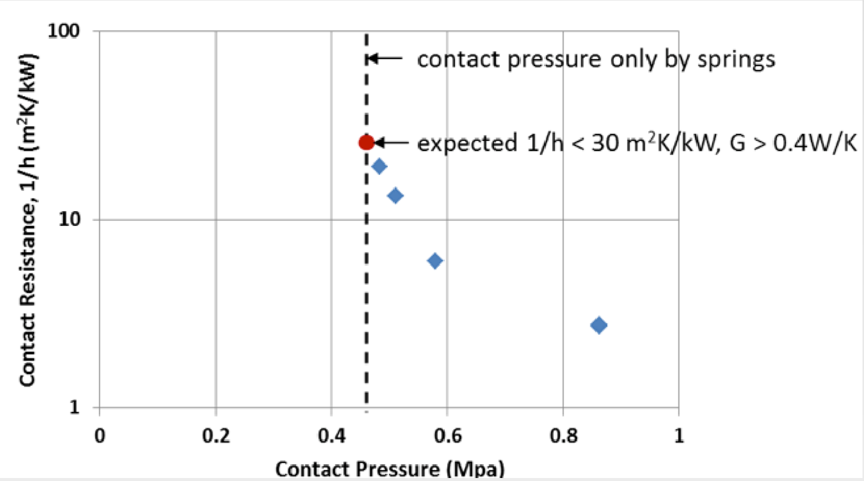
Thermal conductance values (W/K) bottom row calculated from measurements (°C) for each of the powered test cases 1 - 5.

Highlight rows show that the differential TC and regular TC pair along the –X side recorded essentially the same values.

Power (Watts) Measured ΔT (°C)	Test 1 68.80	Test 2 68.80	Test 3 9.88	Test 4 2.02	Test 5 0.87
Differential Top Edge 2 (-X)	14.4	14.8	4.5	2.0	1.2
Differential Top Edge 1 (+Y)	14.8	15.2	4.6	2.0	1.3
Differential Top Edge 3 (-Y)	15.2	15.3	4.7	2.1	1.3
Differential Bottom Edge (-X)	12.1	12.7	4.5	2.0	1.2
dT, Top Edge (-X)	14.3	14.9	4.5	2.0	1.2
dT, Top Edge (+X)	14.4	14.6	4.5	1.9	1.3
dT, Top Edge (-Y)	14.7	15.1	4.5	2.1	1.3
dT, Bottom Edge (+X)	12.8	13.3	4.2	2.0	1.2
dT, Bottom Edge (-X,+Y)	13.6	14.0	4.4	2.0	1.2
dT, Bottom Edge (-X,-Y)	13.5	13.9	4.4	2.2	1.2
Caclulated Thermal Conductance, W/K	**4.9**	**4.8**	**2.2**	**1.0**	**0.70**

Expected Contact Resistance for Contact Pressure

Test data indicated that the conductance value increased from 0.7 to 5 W/K across the flight-expected 0°C to 40°C temperature range for measured temperature differences across the cone and clutch edges from 2°C to 14.5°C as the contact pressure increased due to thermal expansion.



Observations from the CCA Test

1. Both the top and bottom edges of the Cone Clutch assembly (CCA) demonstrated uniform contact along edges as supported by similar temperature measurements at these sites.

2. There was no noticeable slip between edges when the inner cone was warmer than the outer cone.

3. The thermal conductance across the hard anodized cone and clutch was six times smaller than expected
   - Varied from 0.7 W/K to 5 W/K when the inner cone was 1.0ºC to 14.5^{o}C warmer than the outer cone.
   - Corresponds to the expected bearing and power transfer assembly (BAPTA) operational AFT range.

4. The differential thermocouples are useful for measuring temperature differences accurately;
   - They require an accurate and stable voltmeter to measure a difference smaller than 1^{o}C (on the order of 40 micro-Volts).
   - Standard thermocouple data matched the applicable differential thermocouple measurement to within 0.3°C or less.

Conclusion

Low thermal conductance values were unanticipated

- The measured thermal conductance values were much smaller than expected likely due to the high thermal resistance across the hard coating on the inner and outer cone edges
- Provide additional thermal isolation between the BAPTA and the spacecraft.
- Post-test thermal model runs show that the outer cone temperature could be higher than the inner cone by $1^{o}C$ but, this should not present a structural design problem.
  - If the outer cone is warmer than inner cone, the extrapolated value of 0.4W/K will be used.

The conductance values will be used in model correlation before launch when the inner cone is warmer than the outer cone.

This test provided valuable data to improve the accuracy of the predicted on-orbit instrument performance since it was the only opportunity to measure the conductance across the CCA when the clutch was in the flight-like deployed (engaged) position.