CPL Applications on the EOS-TERRA Spacecraft

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STATUS OF CPL TECHNOLOGY

- STARTER PUMP CPL's

  - Single pump plumbed directly to the reservoir, with a bayonet insert

  - Flight proven via CAPL 2 (Sept 95) and HOST (Oct 98)

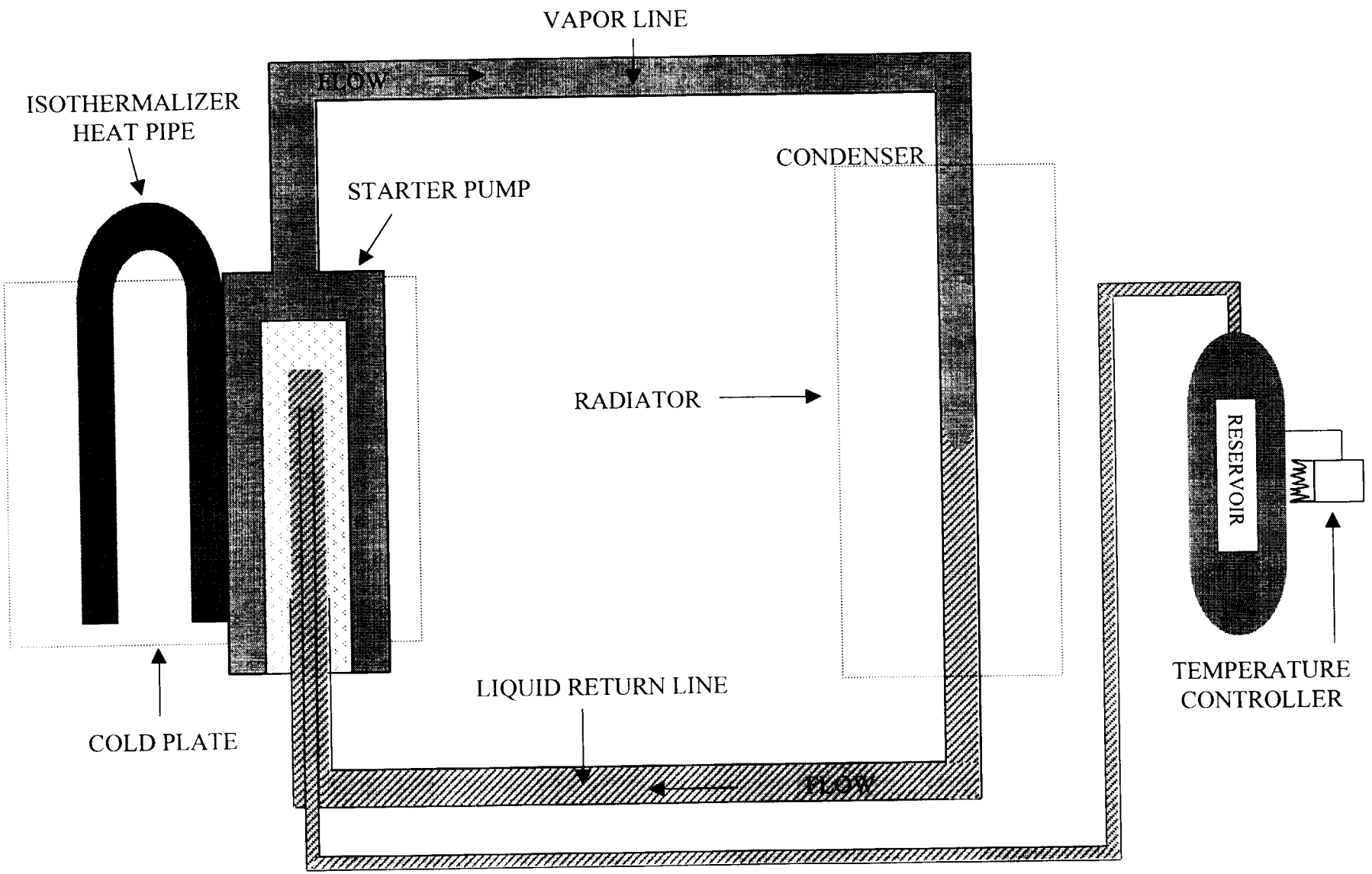
  - Baselined for the EOS-AM and HST SM-3 missions

- TRADITIONAL CPL'S - Multiple pump CPL's

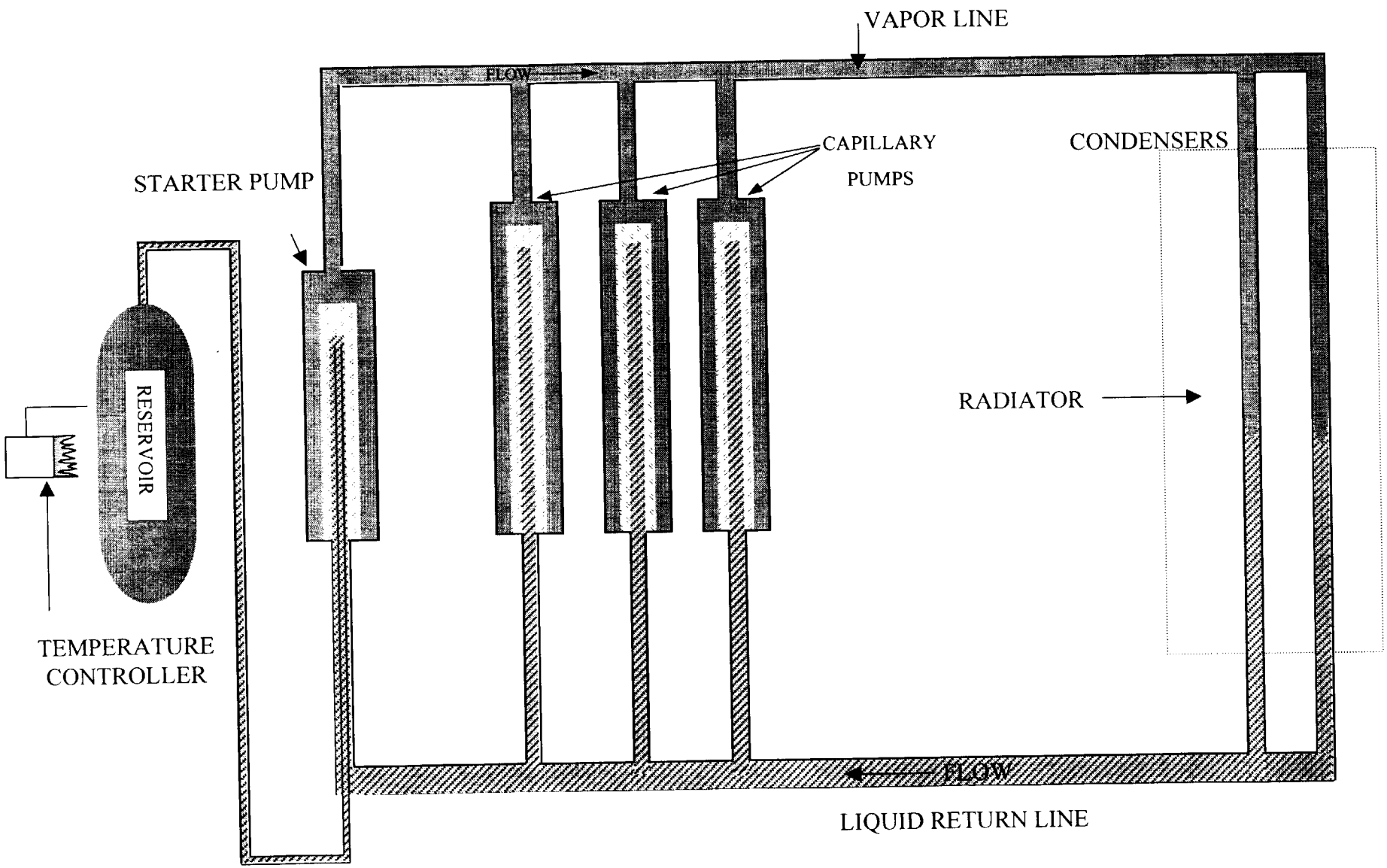
  - Provide heat sharing and multiple heat acquisition sites

  - Requires flight verification (CCQ and CAPL 3)

Starter Pump Capillary Pumped Loop



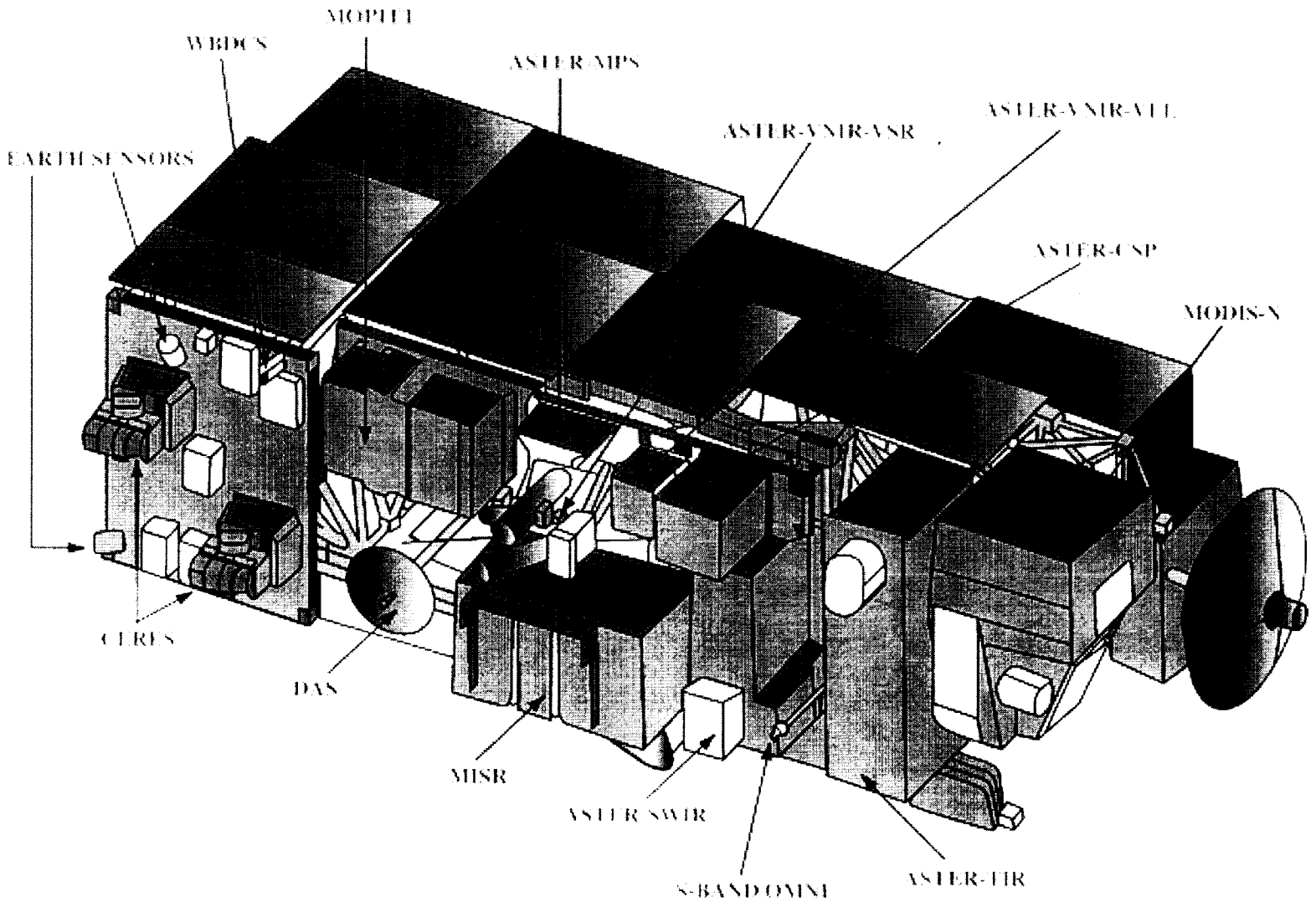
Multiple Evaporator Capillary Pumped Loop



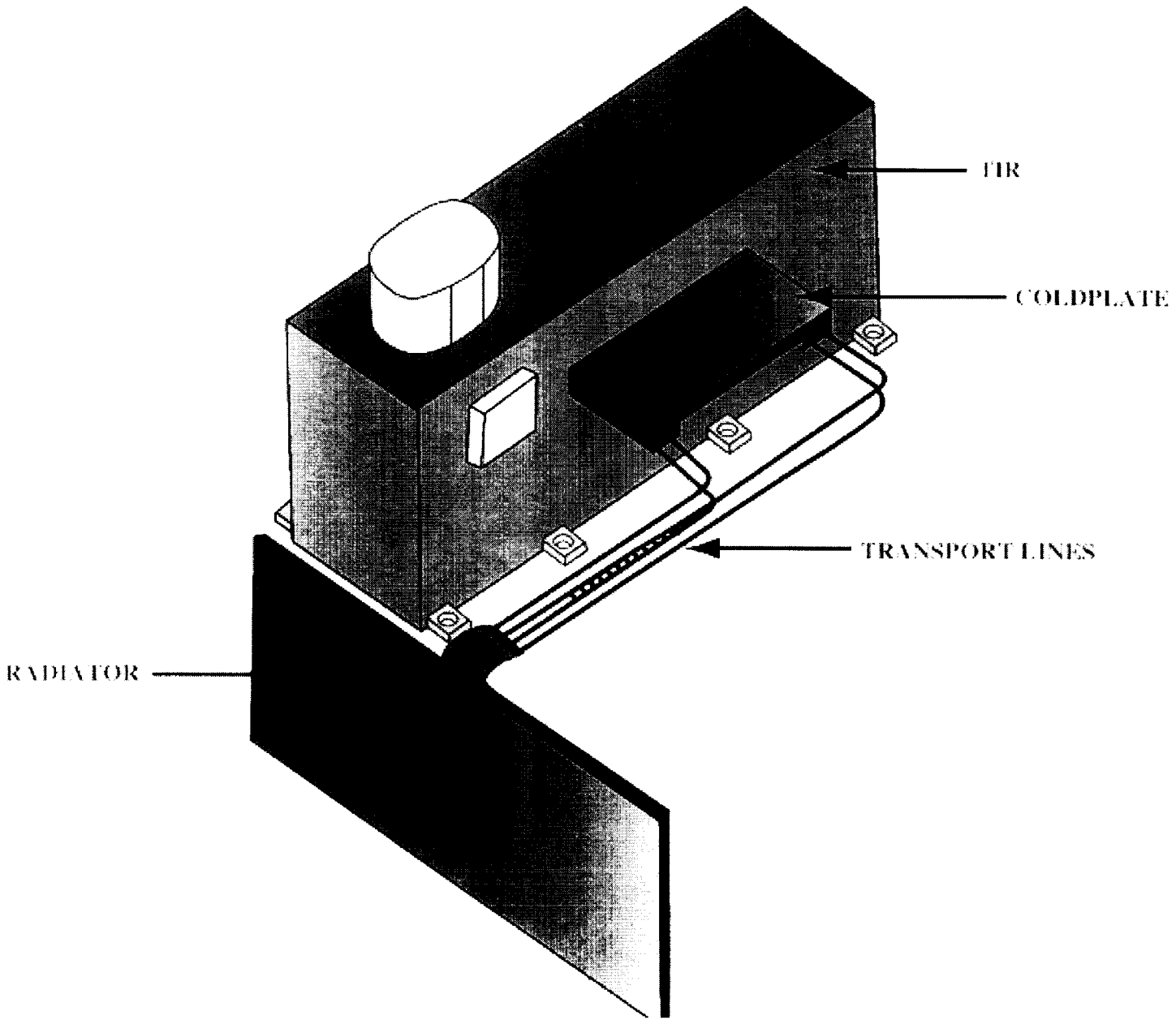
TERRA (EOS-AM) CPL APPLCIATIONS

- TERRA (EOS- AM) - 6 starter pump loops used for thermal control of 3 instruments (redundant loops)
  - MOPITT
  - ASTER SWIR
  - ASTER TIR
- All ground testing successful, S/C TV test run with loops in a reflux mode, (reservoir approx. 18 inches above evaporator)
  - Low power limit observed due to vapor line flooding
  - Reservoir set point adjusted during TV test to improve instrument performance
  - Loop shutdown accomplished by increasing reservoir temp
- Life test unit running continuously for 3 years - effort to be continued at GSFC after launch

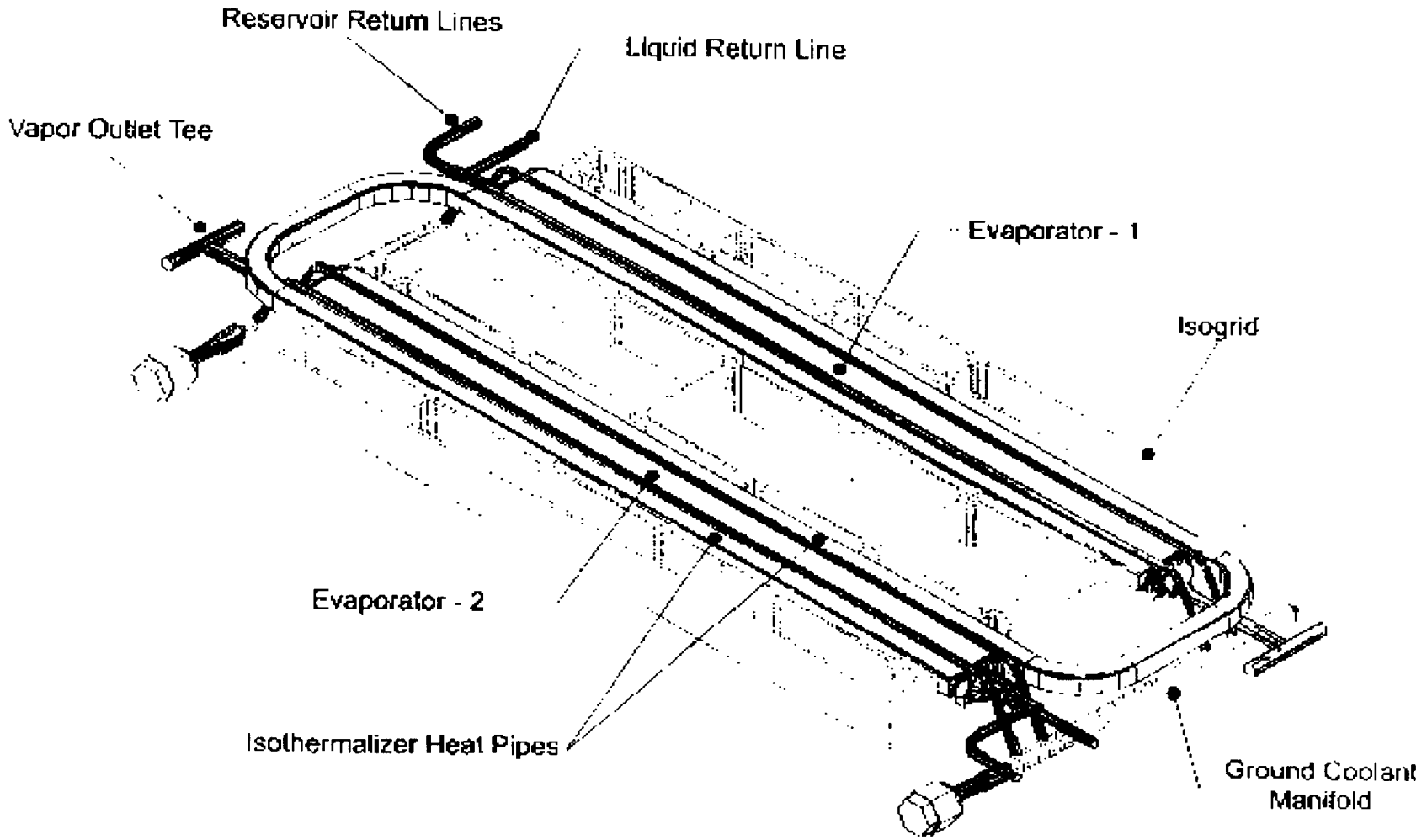
EOS-AM SPACECRAFT



ASTER – TIR CPL CONFIGURATION



EOS-AM CPHTS Cold Plate Assembly
(Face Sheet Removed)



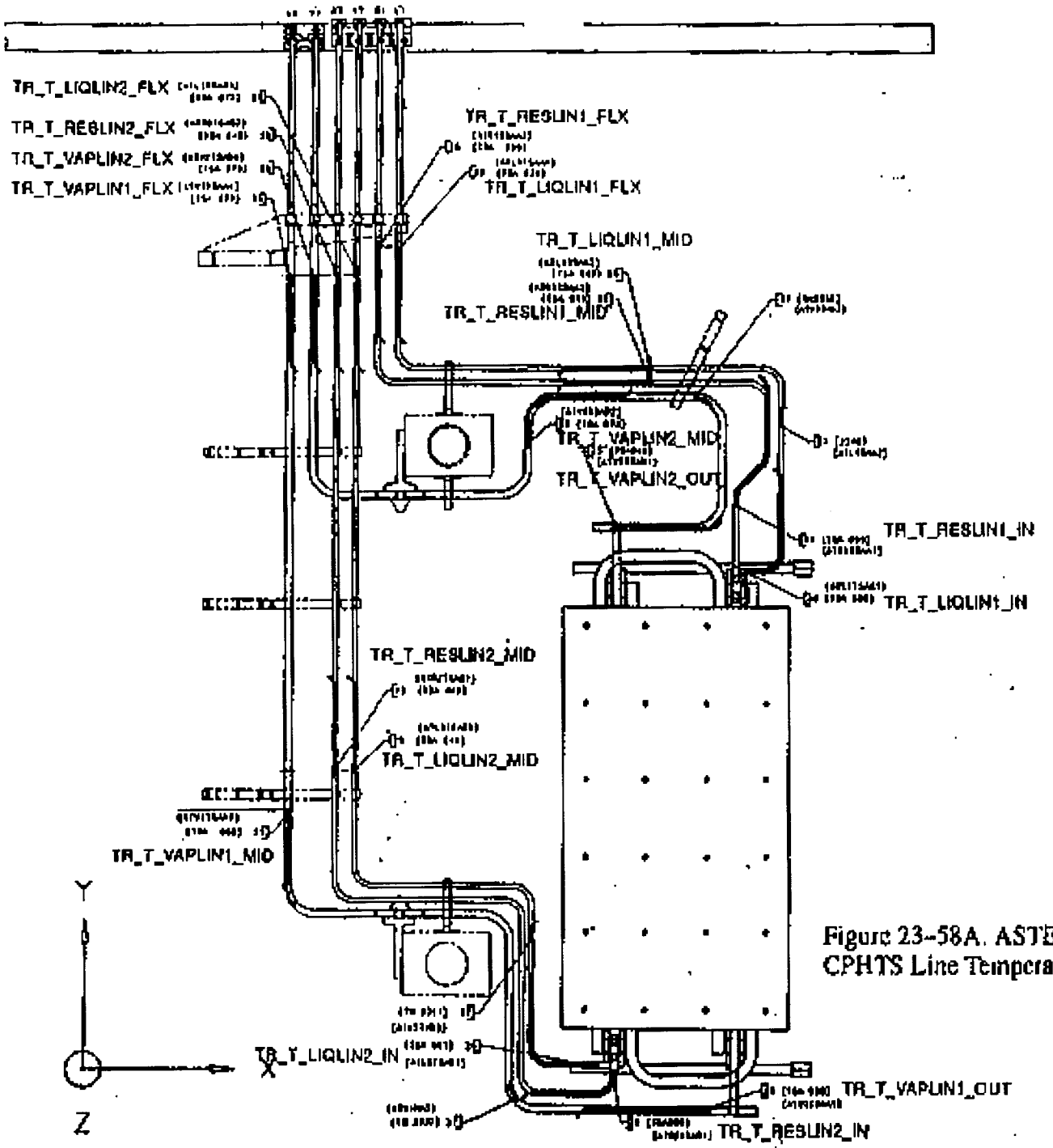
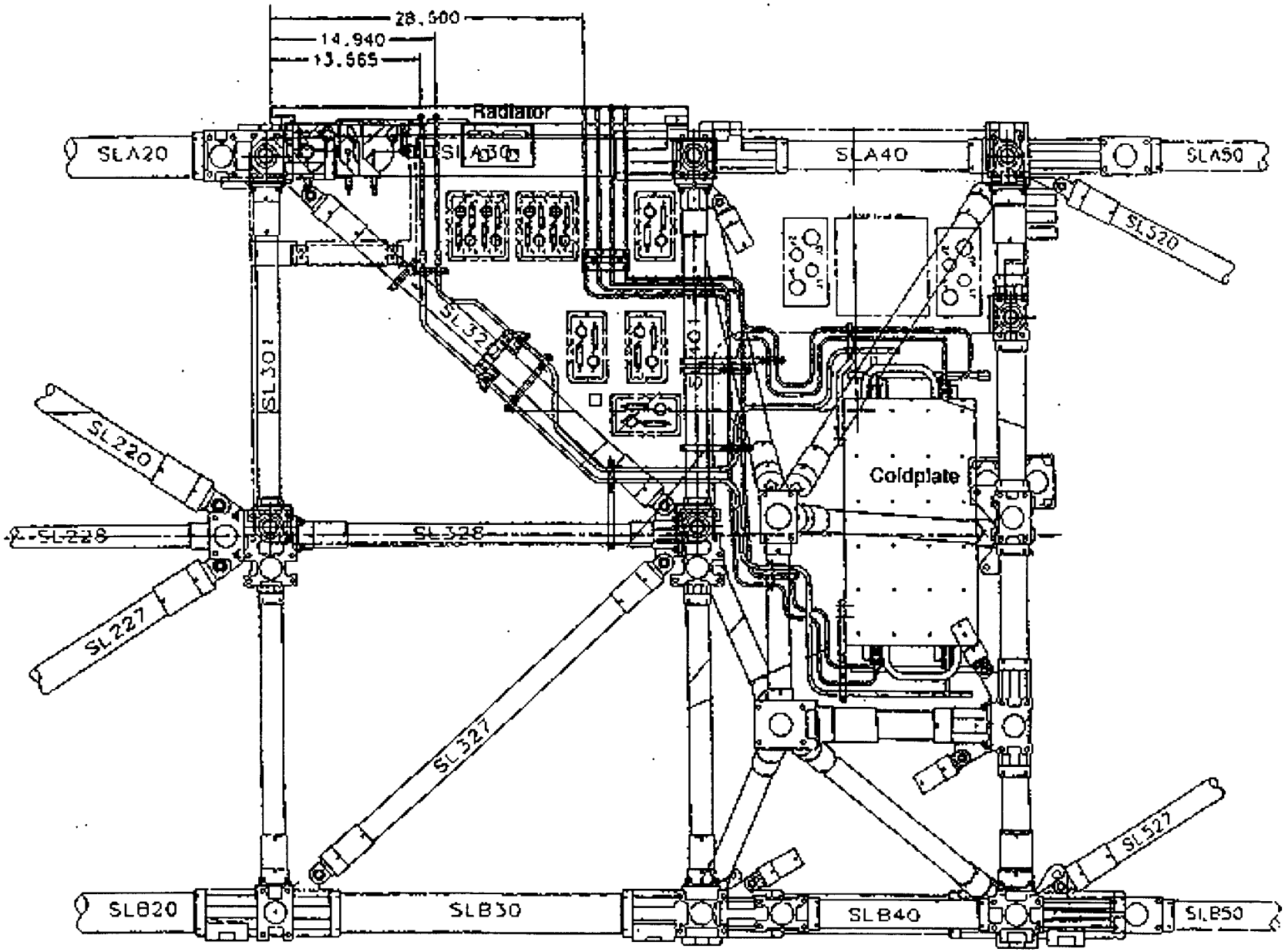


Figure 23-58A. ASTER TIR CPHTS Line Temperature Sensors

CPHTS – SWIR Tubing Layout

LOCKHEED MARTIN



Start-up Summary

- Each instrument has primary loop (Loop 1) and backup loop (Loop 2) with evaporator starter heaters and various other heaters.
- Standard start-up uses both starter heaters (150W total) located on the evaporator pumps, with later transition to instrument power.
  - Reservoir set to 20 C prior to start-up
- Contingency start-up uses vapor line heater, outlet heater, button heater, and starter heaters.
  - Reservoir set to 20 C prior to start-up
  - Heaters used to force liquid into reservoir prior to start to reduce start-up "shock" to the loop
  - "Button" heater on evaporator reduces superheat required to start the loop, also reduces "shock" to the loop

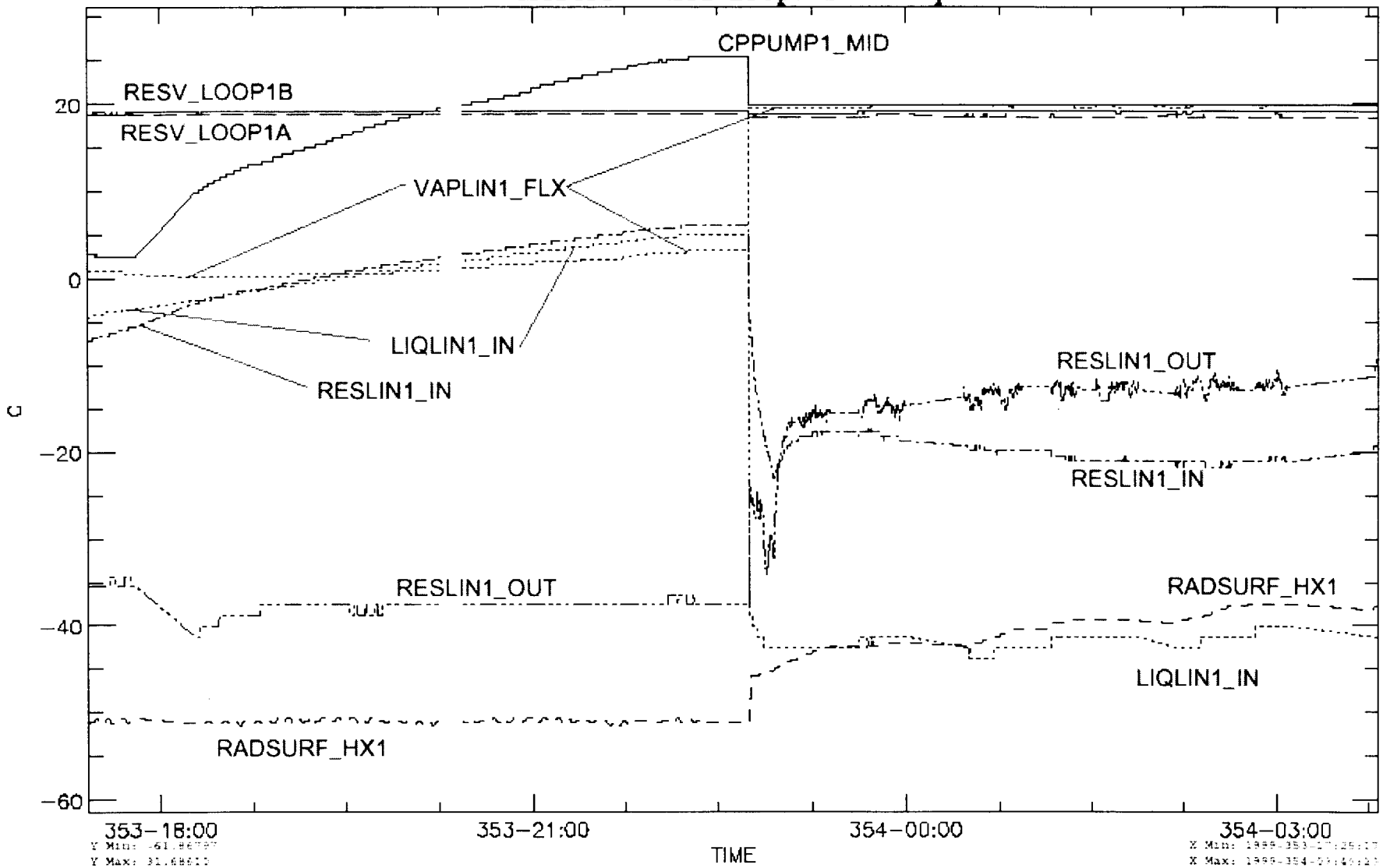
Start-up History

- TERRA launched on December 18, 1999
- MOPITT:
  - Loop 1 started successfully on 12/19/99, running OK
- ASTER SWIR:
  - Loop 1 started successfully on 1/5/00, running OK
- ASTER TIR:
  - Loop 1 deprimed 62 hours after standard start-up, 1/10/00
  - Loop 2 deprimed 48 hours after standard start-up, 1/15/00
  - Loop 2 operates steadily from 1/19/00 to 2/20/00 following contingency start-up, deprimed after numerous orbital adjust burns
  - Loop 2 restarted on 2/24/00 with contingency start-up

MOPITT CPHTS

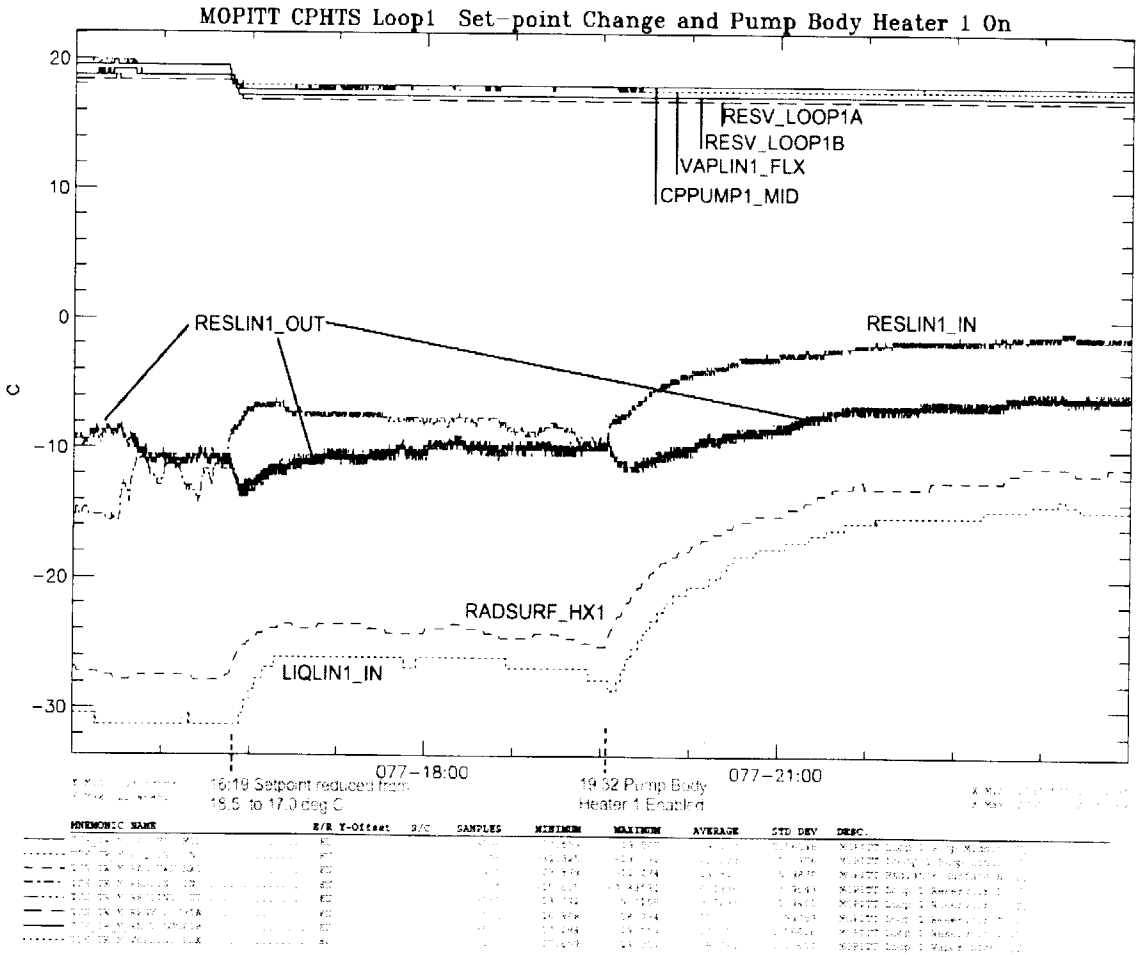
- 12/19/99 Standard Start-up
  - Loop 1 started with two starter heaters (total 150W).
    - Superheat at nucleate boiling: about 7 °C
    - Reservoir cold shock: less than 2 °C
- 1/4/00
  - 12:00 Loop operated with one starter heater (75W).
  - 16:57 Loop operated on safe mode (total ~ 145W)
  - 19:25 Starter heater off (total ~ 70W)
- 3/17/00
  - Reservoir temperature reduced 1.5 C due to instrument request to run colder

MOPITT CPHTS Loop1 Start-up

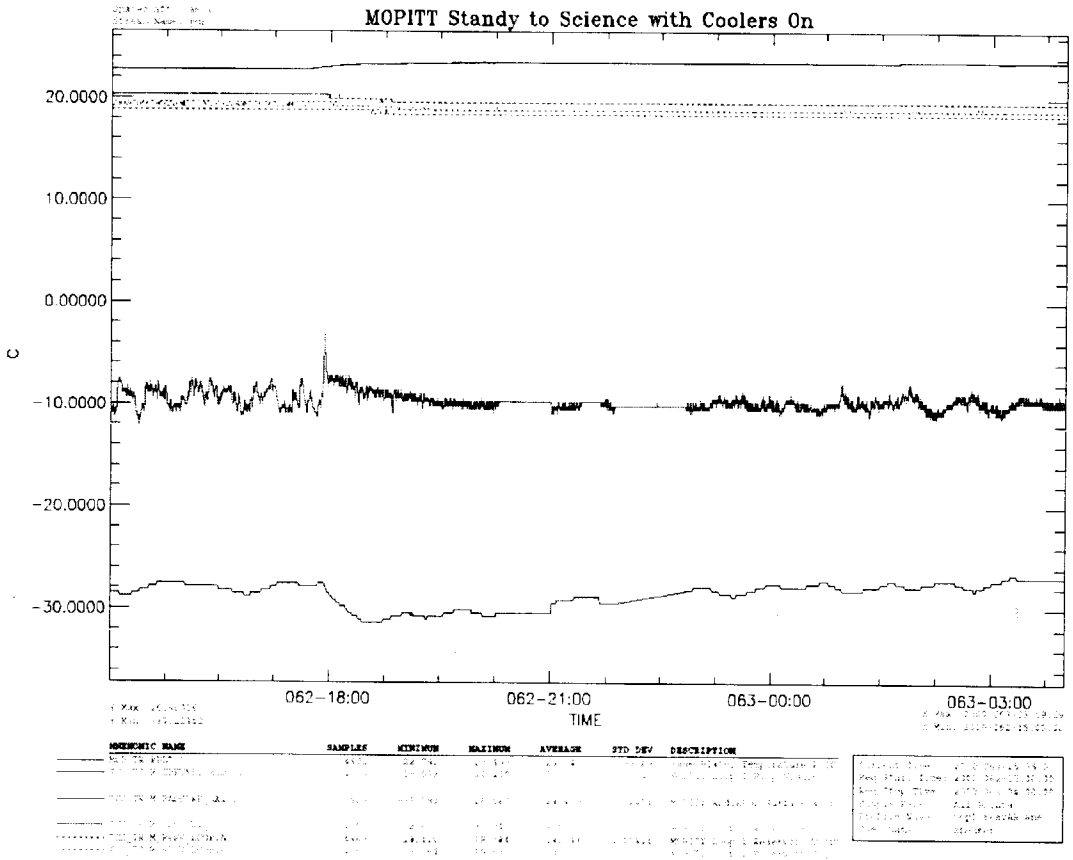


MNEMONIC NAME	E/R	Y-Offset	S/C	SAMPLES	MINIMUM	MAXIMUM	AVERAGE	STD DEV	DESC.
TCS TR M CPPUMP1 MID	EU			4052	[illegible]	119.58	15.695	11.644	MOPITT Loop 1 Pump Middle (C).
TCS TR M LIQLIN1 IN	EU			4052	[illegible]	119.58	-12.730	21.695	MOPITT Loop 1 Pump Liqui (C).
TCS TR M RADSURF HX1	EU			524	[illegible]	62.748	-46.845	10.939	MOPITT Radiator Surface H (C).
TCS TR M RESLIN1 IN	EU			4049	[illegible]	119.58	-8.7059	12.282	MOPITT Loop 1 Reservoir L (C).
TCS TR M RESLIN1 OUT	EU			4052	[illegible]	119.58	-42.026	12.697	MOPITT Loop 1 Reservoir L (C).
TCS TR M RESV LOP1A	EU			4052	[illegible]	119.58	15.421	11.819	MOPITT Loop 1 Reservoir T (C).
TCS TR M RESV LOP1B	EU			4049	[illegible]	119.58	16.667	4.7629	MOPITT Loop 1 Reservoir T (C).
TCS TR M VAPLIN1 FLX	EU			4052	[illegible]	119.58	6.3987	11.023	MOPITT Loop 1 Vapor Line (C).

TCS Performance Summary: MOP CPHTS Setpoint Change and Pump Body Heater 1 On



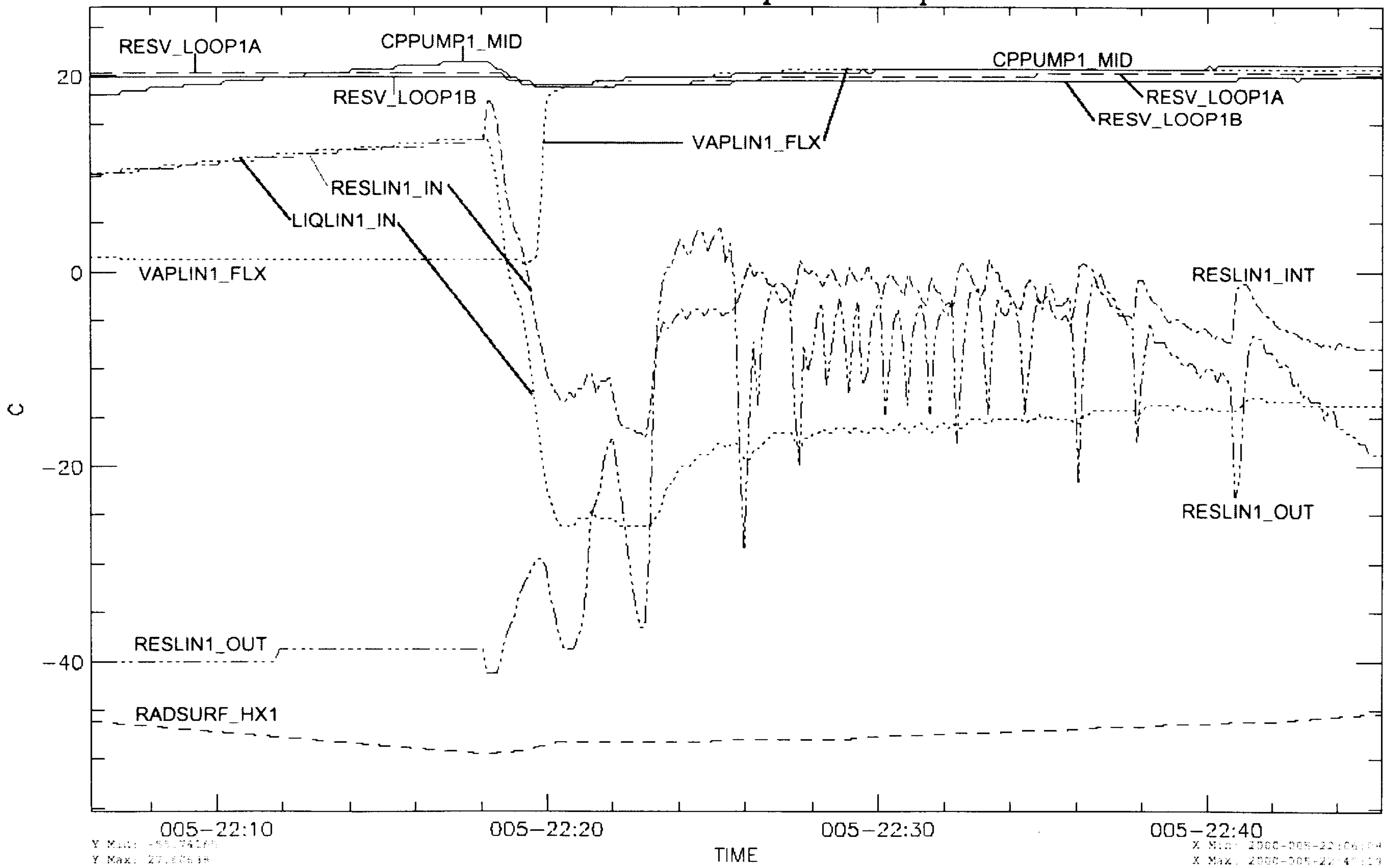
TCS Performance Summary: MOP CPHTS Doors Open/ Operational Transition



ASTER SWIR CPHTS

- 1/5/00 Standard Start-up
  - Loop 1 started with two starter heaters (total 150W).
    - Superheat at nucleate boiling: less than 2 °C
    - Reservoir cold shock: less than 2 °C
- 1/6/00
  - 00:40 Loop operated with one starter heater (75W).
- 1/7/00
  - 23:30 Loop operated on observation mode (total ~ 205W)
- 1/27/00
  - 14:00 Loop operated on safe mode (total ~ 145W)

SWIR CPHTS Loop1 Start-up

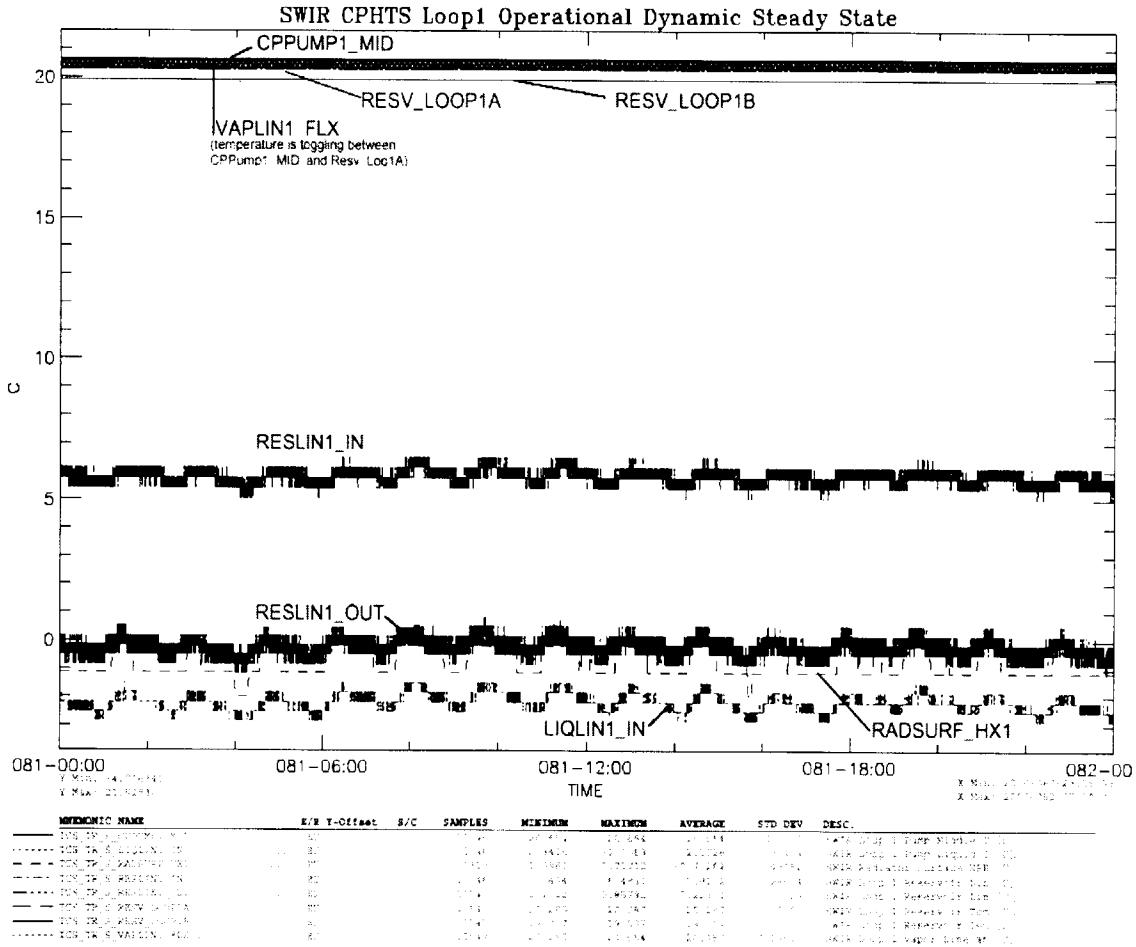


Y Min: -55.74[illegible]
Y Max: 27.[illegible]

X Min: 2000-005-22:06:[illegible]
X Max: 2000-005-22:4[illegible]:19

MNEMONIC NAME	E/R	Y-Offset	S/C	SAMPLES	MINIMUM	MAXIMUM	AVERAGE	STD DEV	DESC.
TCS_TR_S_CPPUMP1_MID	EU			11371	[illegible]	21.399	18.692	[illegible]	SWIR Loop 1 Pump Middle T [C]
TCS_TR_S_LIQLIN1_IN	EU			11371	-32.194	13.598	-16.24[illegible]	10.156	SWIR Loop 1 Pump Liquid I [C]
TCS_TR_S_RADSURF_HX1	EU			1434	-56.[illegible]	-1.9881	[illegible]	15.043	SWIR Radiator Surface HPH [C]
TCS_TR_S_RESLIN1_IN	EU			11371	-32.[illegible]	17.653	-8.4654	[illegible]	SWIR Loop 1 Reservoir Lin [C]
TCS_TR_S_RESLIN1_OUT	EU			11391	[illegible]	12.221	-11.[illegible]	10.176	SWIR Loop 1 Reservoir Lin [C]
TCS_TR_S_RESV_LOOP1A	EU			11391	[illegible]	2[illegible].654	17.690	8.7017	SWIR Loop 1 Reservoir Tem [C]
TCS_TR_S_RESV_LOOP1B	EU			11391	-22.[illegible]	20.280	17.[illegible]	[illegible].6166	SWIR Loop 1 Reservoir Tem [C]
TCS_TR_S_VAPLIN1_FLX	EU			11391	[illegible]	21.726	18.221	[illegible]	SWIR Loop 1 Vapor Line at [C]

TCS Performance Summary: SWIR CPHTS Typical Operational Performance



ASTER TIR

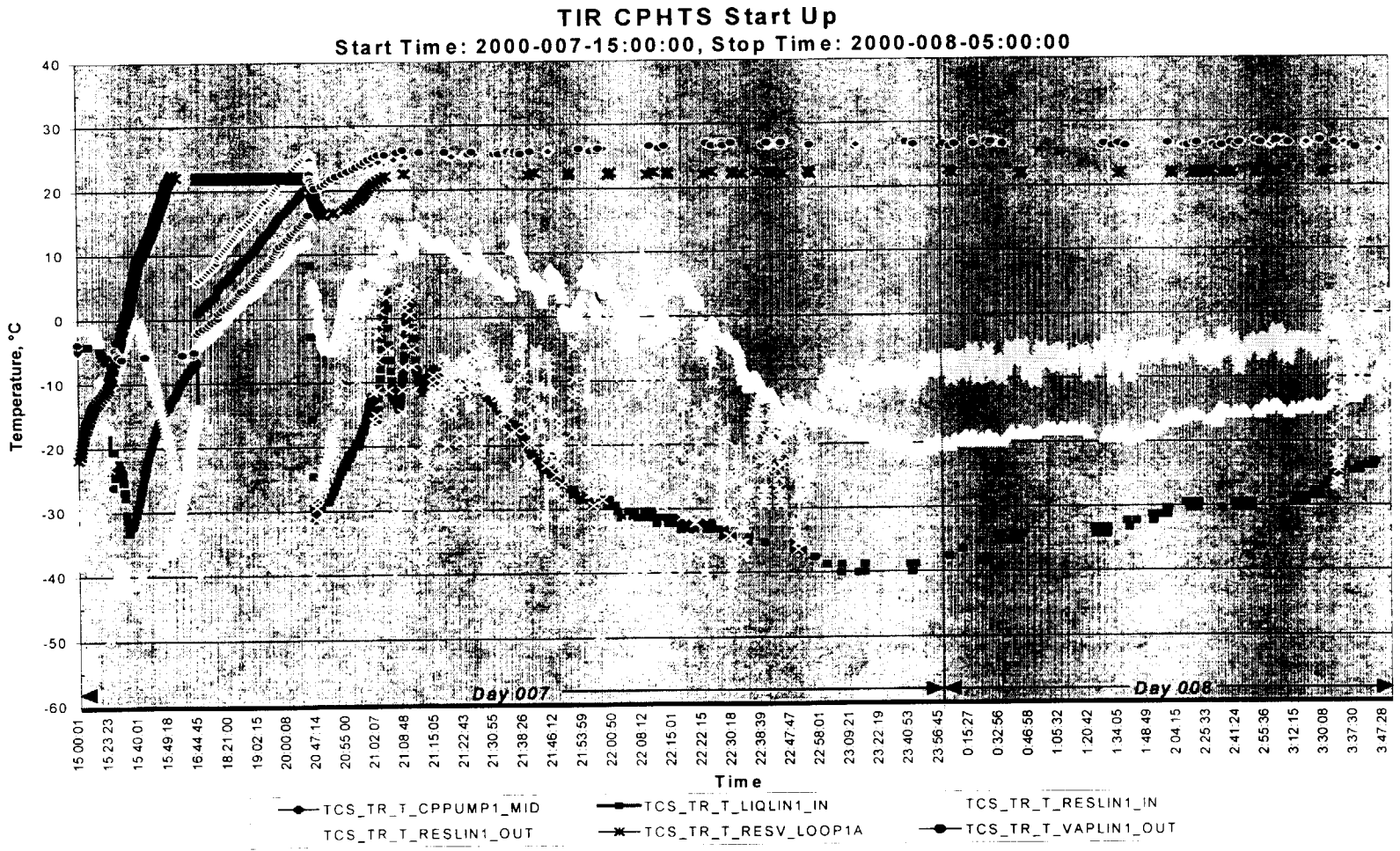
- TIR Loop 1 Standard Start-up
  - 1/ 7/00 Started with two starter heaters (150W)
    - Superheat: 4 °C; Reservoir cold shock: **7 °C**.
  - 1/ 8/00 Starter heater 1 off
  - 1/ 9/00 ASTER TIR on
  - 1/10/00 Loop 1 deprimed
- TIR Loop 2 Standard Start-up
  - 1/13/00 Started with two starter heaters (150W)
    - Superheat: 4 °C; Reservoir cold shock: 7 °C.
  - 1/15/00 Loop 2 deprimed

ASTER TIR (cont)

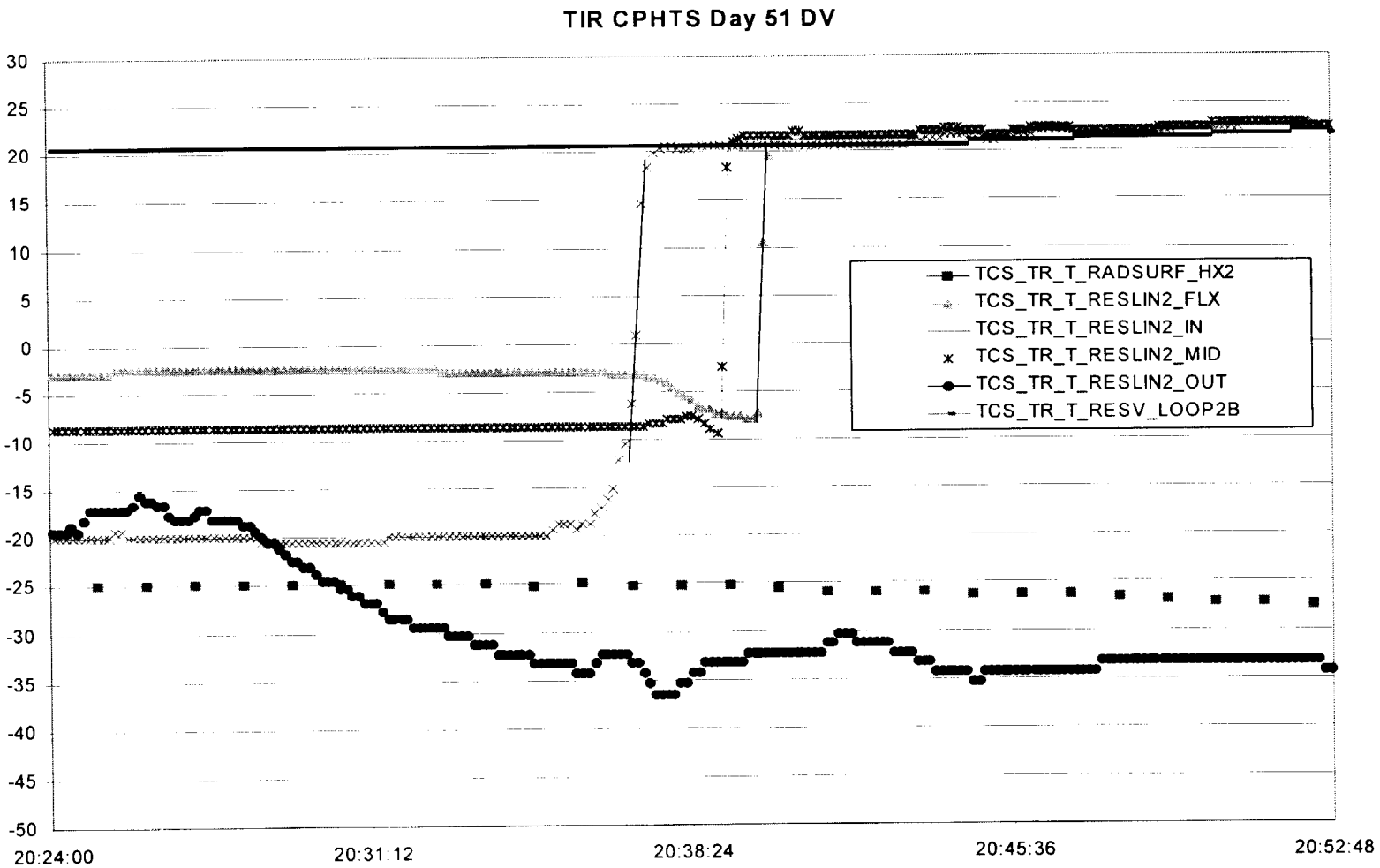
- TIR Loop 2 Contingency Start 1
  - 1/19/00 Started with two starter heaters (150W)
    - Superheat, < 1 C, Reservoir cold shock, 1.5 C
  - 1/24/00 Set Point change reservoir 2B heater - 2A not controlling well
  - 1/27/00 Operated with one starter heater (75W)
  - 1/28/00 Operated with two starter heaters (150W)
  - 2/20/00 Deprimed after numerous orbital adjust burns
- TIR Loop 2 Contingency Start 2
  - 2/24/00 Started with two starter heaters (150 W)
    - Superheat, < 1 C, Reservoir cold shock, 1.5 C
    - Still Running

TCS Performance Summary: TIR CPHTS Loop 1 Standard Start

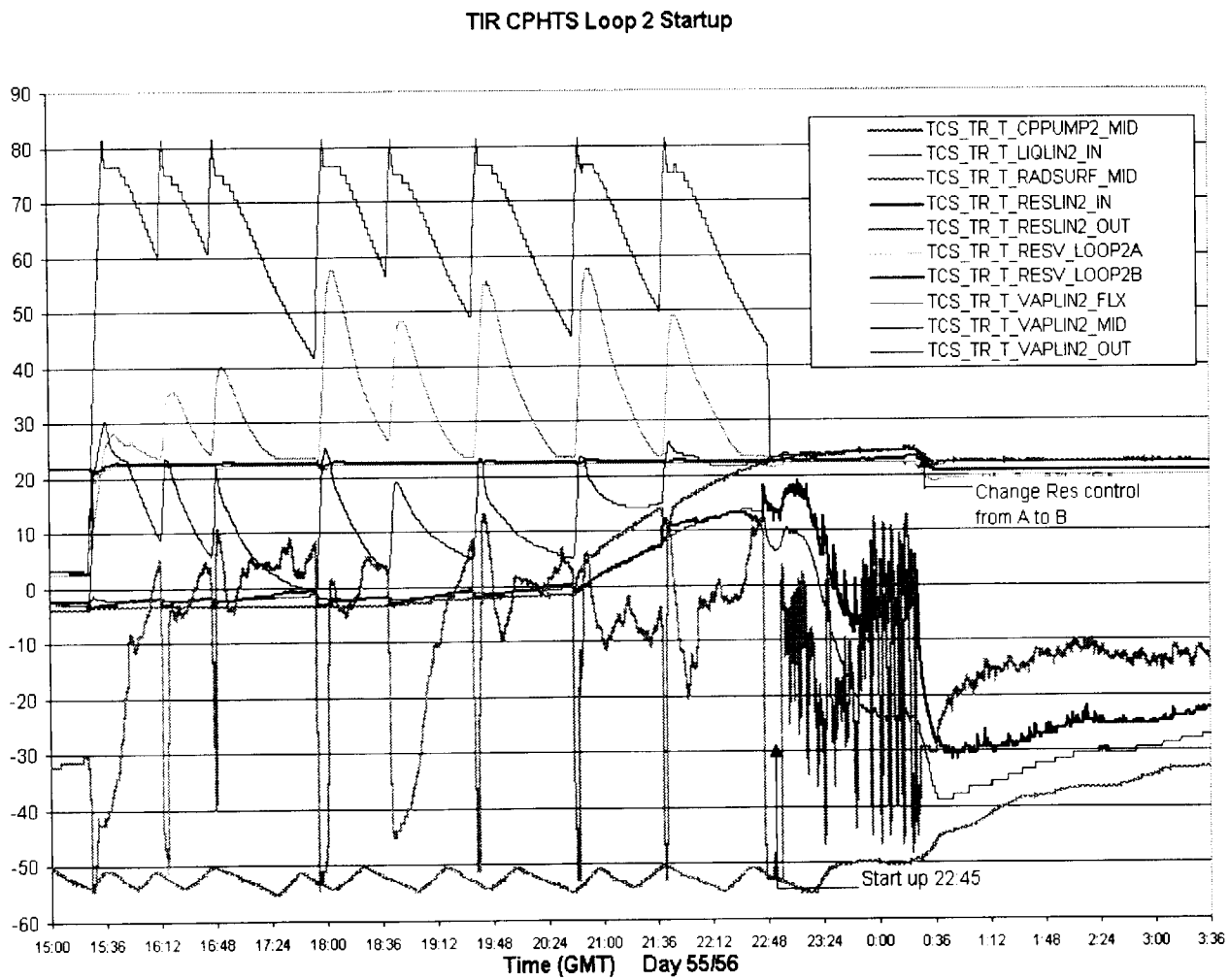
LOCKHEED MARTIN



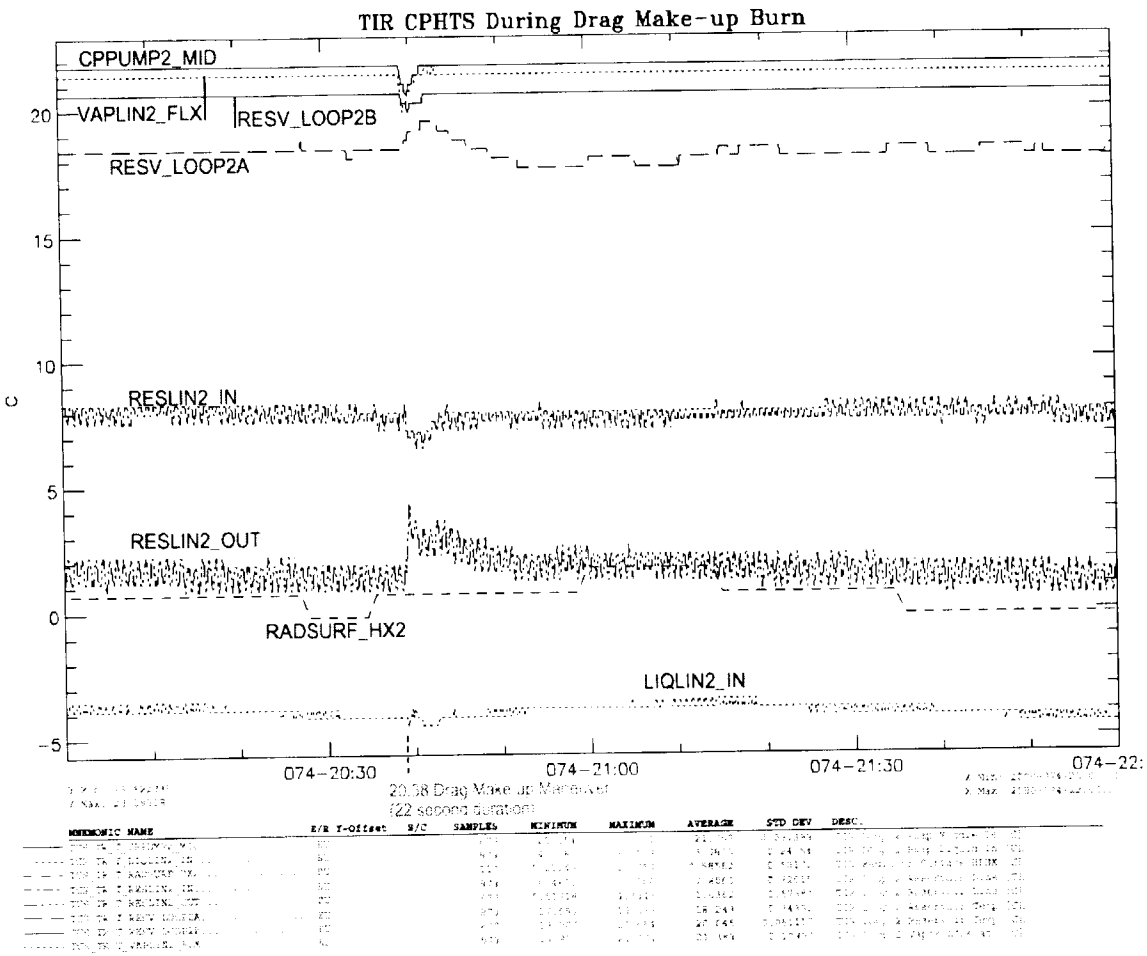
TIR CPHTS Loop 2 Deprime



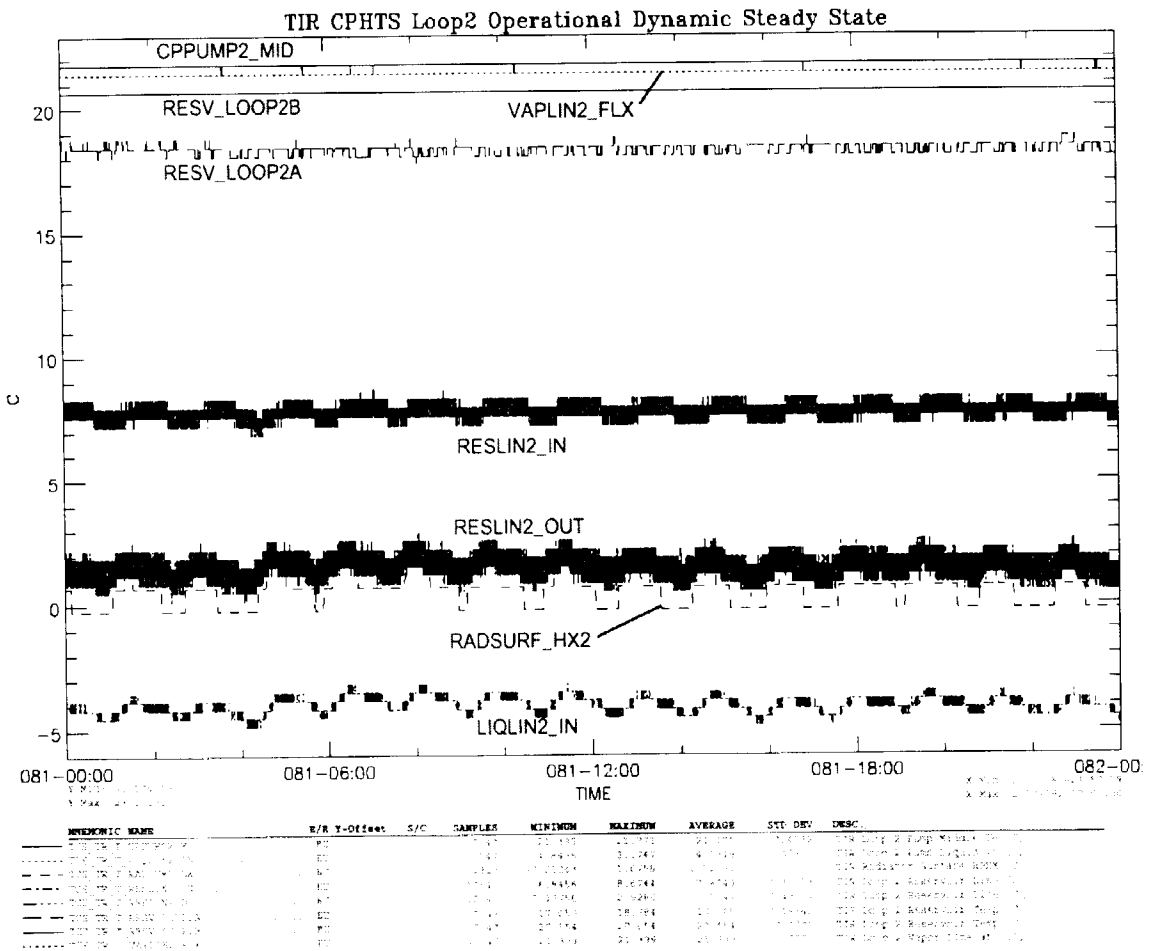
TCS Performance Summary: TIR CPHTS Loop 2 Restart 3 (Contingency start)



TCS Performance Summary: TIR CPHTS Drag Make-up Burn

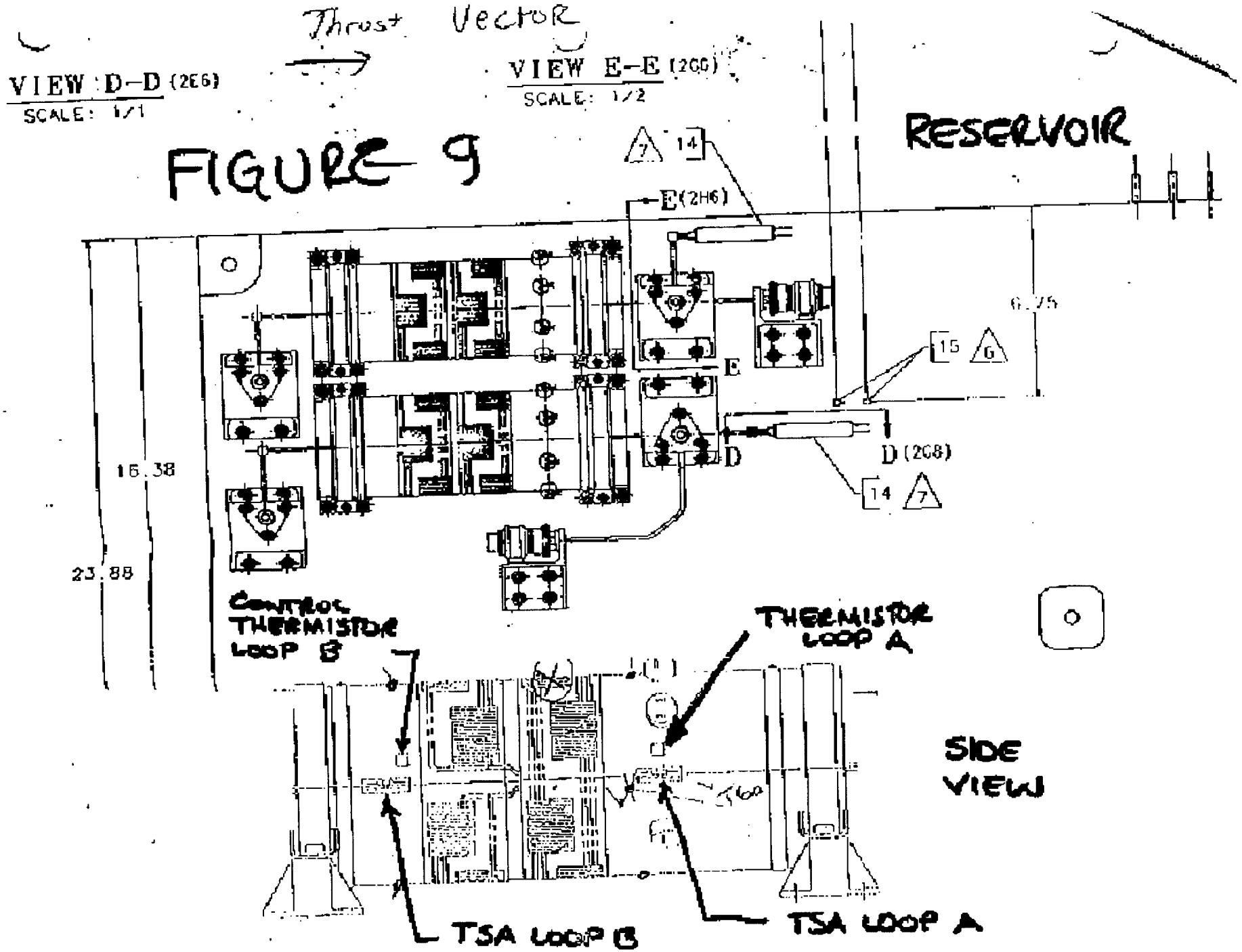


TCS Performance Summary: TIR CPHTS Typical Operational Performance



Problems with Loop 2 Temperature Control

- Loop 2 operated at higher than expected temperatures, with fluctuations on the order of 2 C (should be +/- 0.1 C)
- MOPITT and SWIR loops have stable temperature control
- Reservoir heater control position on TIR different than that of MOPITT and SWIR (by design for ground testing).
- The cause of "erratic" loop temperatures results from the primary (A) thermistor probably being located over a transition area (vapor/liquid) in the reservoir. Backup (B) control is located nearer the heater, and thus has a higher probability of being located over a vapor space.
- 1/14/00 Control changed from A to B. Immediately, loop temperatures dropped and stabilized at the expected temperature level. Loop temperatures have remained steady since then, and are behaving similarly to those on MOPITT and SWIR.


Thrust Vector
VIEW D-D (2E6)
SCALE: 1/1
VIEW E-E (2G6)
SCALE: 1/2
FIGURE 9
RESERVOIR
E(2H6)
E
D
D (2G8)
15.38
23.88
CONTROL THERMISTOR LOOP B
THERMISTOR LOOP A
SIDE VIEW
TSA LOOP B
TSA LOOP A

TIR Loop 1 and Loop 2 Deprime

- Vapor in the pump core from start-up (likely cause)
  - Large reservoir cold shock (7 °C in both cases) for standard start.
  - Vapor in the pump traveled down the reservoir line during deprime.
- Loop deficiency (inventory, NCG, breakage/leakage)?
  - Ground I & T Data does not support any significant deviation from normal inventory. However, loop exhibited unusual behavior in ground test, but only had a few hours of testing with instrument. Also, Lockheed-Martin charge procedure does not measure weight.
  - NCG in the loop ? Loops were dormant for 2 years before launch
  - Data does not indicate breakage in any of the loop's components.
  - Other loops OK, why do both TIR loops have problems ?
- External influences (TIR HP, heaters)?
  - TIR heat pipes may cause adverse start conditions (non-op on the ground)
  - Large TIR mass could affect loop performance
  - Telemetry, heaters, and heater controllers all appear to function normally.