BELLCOMM, INC.

SUBJECT: Status of McDonnell-Douglas Thermal Analyses of the Orbital Workshop - Case 620

DATE: February 5, 1968

FROM: D. J. Belz

MEMORANDUM FOR FILE

A report on the "Status of McDonnell-Douglas Thermal Analyses of the Orbital Workshop" was presented by the author during the Apollo Applications (ML) Program Review on January 27. This report summarized the background and current status of efforts being undertaken to resolve discrepancies between the OWS thermal calculations of MSFC and McDonnell-Douglas (MCASTRO). Copies of vu-graphs used during the presentation are attached to this memorandum.

D. J. Belz

1022-DJB-mm

D. J. Belz

Attachments

NASA Headquarters

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(NASA-CR-95431) STATUS OF MCDONNELL-DOUGLAS THERMAL ANALYSES OF THE ORBITAL WORKSHOP (Bellcomm, Inc.) 12 p

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STATUS OF McDONNELL DOUGLAS (M-D) THERMAL ANALYSES OF THE ORBITAL WORKSHOP

STUDY OBJECTIVES

- ORIGINAL GOAL: EXAMINE CAPABILITY OF AIRLOCK ECS TO PROVIDE ACTIVE THERMAL CONTROL FOR THE ORBITAL WORKSHOP

- CURRENT GOAL: RESOLVE APPARENT DISCREPANCIES BETWEEN McDONNELL DOUGLAS' AND MSFC's THERMAL ANALYSES OF THE ORBITAL WORKSHOP

CHRONOLOGY

- OCTOBER 1967

  INDEPENDENT ANALYSIS OF ORBITAL WORKSHOP THERMAL CONTROL BY McDONNELL DOUGLAS DISAGREED WITH MSFC's PREDICTIONS OF ORBITAL THERMAL TRANSIENTS IN OWS.

- NOVEMBER 1-2, 1967

  DISCUSSION BETWEEN McDONNELL DOUGLAS AND MSFC DURING FOURTH AAP ECS/THERMAL SUBPANEL MEETING - AGREEMENT ON "FIRST CUT" REVISIONS OF McDONNELL DOUGLAS' ANALYSIS TO ADEQUATELY REPRESENT THE OWS.

- NOVEMBER 17, 1967

  PRESENTATION TO MSC OF McDONNELL DOUGLAS' REVISED THERMAL ANALYSIS. AGREEMENT WITH MSFC CALCULATIONS ON THERMAL TRANSIENTS. DISAGREEMENT WITH MSFC CALCULATIONS FOR GRAVITY GRADIENT, POP, AND MISSION B (INERTIAL) ORIENTATIONS OF THE OWS.

CHRONOLOGY (CONTINUED)

- DECEMBER 13, 1967

  DISCUSSION BETWEEN McDONNELL DOUGLAS (M-D) AND MSFC CONCERNING NOVEMBER 17th CALCULATIONS BY M-D. AGREEMENT BY M-D WITH MSFC's ANALYSIS OF MISSION B (INERTIAL) FLIGHT MODE FOR OWS. AGREEMENT ON FURTHER REVISIONS TO M-D THERMAL CALCULATIONS FOR ADEQUATE REPRESENTATION OF OWS POP FLIGHT MODE.

MAXIMUM ORBITAL VARIATION OF OWS INTERNAL WALL TEMPERATURES FOR POP ORIENTATION

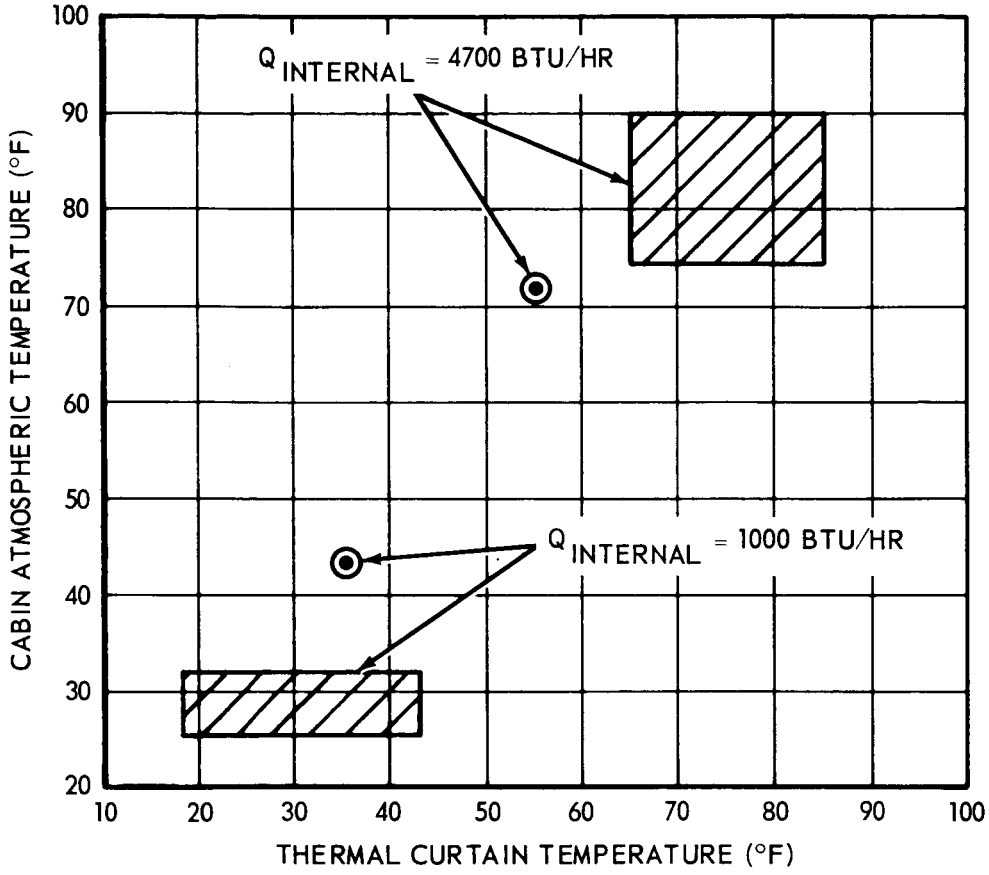
	NOVEMBER 2	NOVEMBER 17	DECEMBER 13
McDONNELL DOUGLAS	30. ^{0}F	12. ^{0}F	12. ^{0}F
MSFC/MARTIN	5. ^{0}F TO 10. ^{0}F	--	7. ^{0}F

MODIFICATIONS OF ORIGINAL McDONNELL DOUGLAS OWS THERMAL MODEL AGREED TO BY M-D ON NOVEMBER 1-2, 1967

- MODIFIED WALL/INSULATION NODES;
  - MSFC/MARTIN CAPACITANCES
  - TEMPERATURE DEPENDENT FOAM CONDUCTIVITY
  - INCLUDE MASS OF INTERIOR FLOORS
  - INCLUDE FIBERGLASS SEAL COAT
- INCLUDE THERMAL DUCTS PREVIOUSLY OMITTED
  - EIGHT DUCT SEGMENTS
  - GAS NODES WITHIN DUCTS

THERMAL CURTAIN AND CABIN ATMOSPHERIC TEMPERATURES FOR OWS IN

POP ORIENTATION – "COLD" CASE



$\beta = 53°$

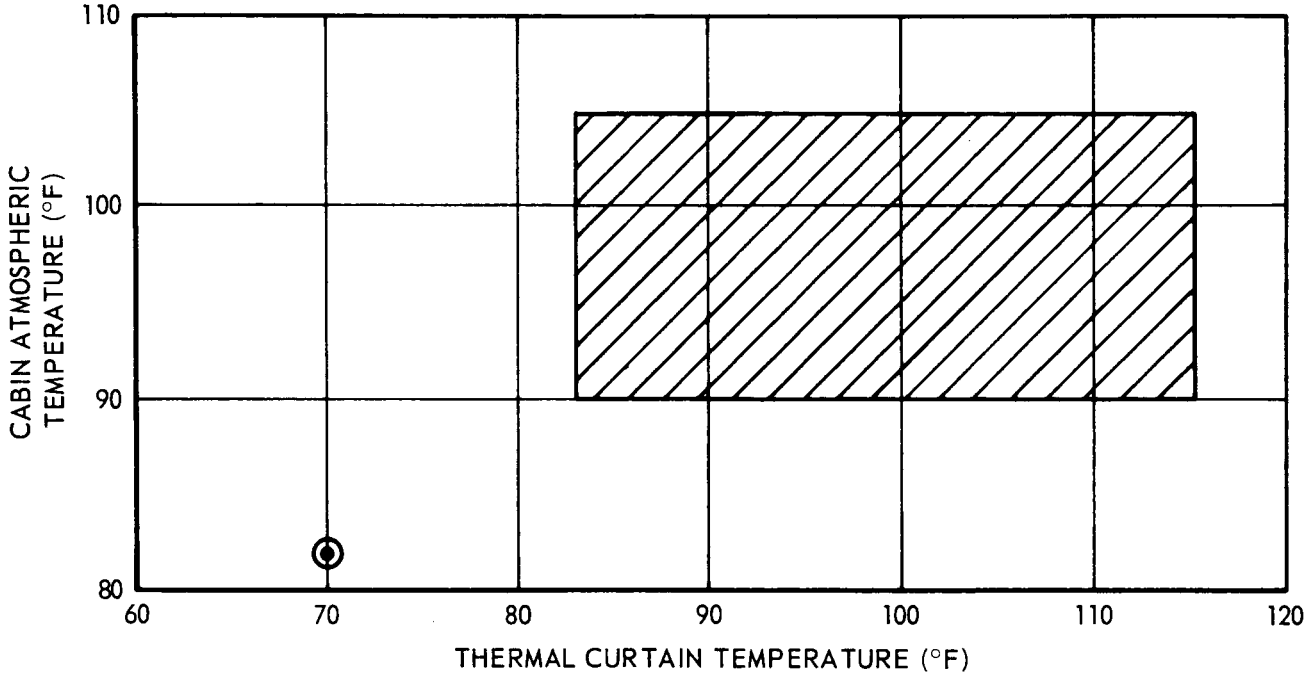
ALL FANS ON LOW SPEED

◉ = MSFC CALCULATIONS

▨ = McDONNELL DOUGLAS CALCULATIONS – NOVEMBER 17, 1967.

THERMAL CURTAIN AND CABIN ATMOSPHERIC TEMPERATURES FOR OWS IN

MISSION B (INERTIAL) ORIENTATION – "HOT" CASE



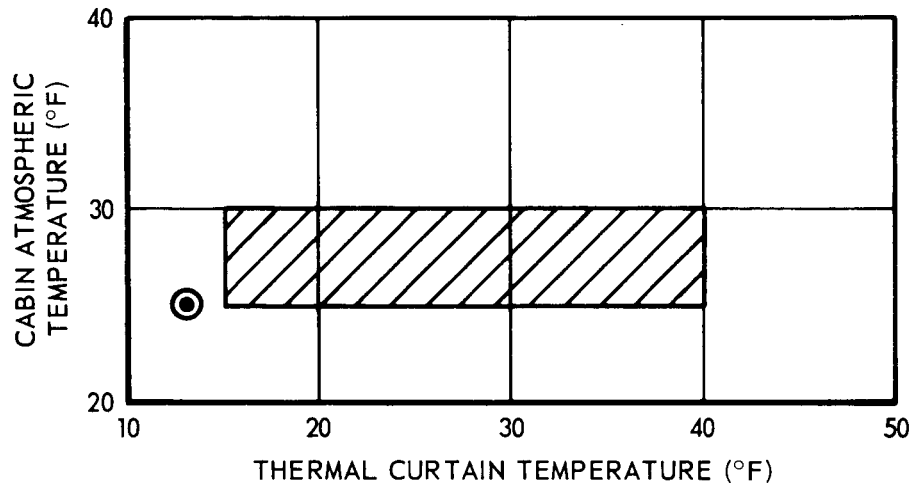
$\beta = 53°$

$Q_{INTERNAL} = 3{,}000$ BTU/HR

◉ = MSFC CALCULATIONS (5 COLD-SIDE FANS ON)

▨ = McDONNELL DOUGLAS CALCULATIONS (4 COLD-SIDE FANS ON) – NOVEMBER 17, 1967.

THERMAL CURTAIN AND CABIN ATMOSPHERIC TEMPERATURES FOR OWS IN GRAVITY GRADIENT ORIENTATION WITH ROLL CONTROL – "COLD" CASE



$\beta = 0°$

ALL FANS ON LOW SPEED

$Q_{INTERNAL} = 1000$ BTU/HR

⊙ = MSFC CALCULATIONS

▨ = McDONNELL DOUGLAS CALCULATIONS – NOVEMBER 17, 1967.

INACCURACIES IN McDONNELL DOUGLAS THERMAL MODEL OF OWS

AS OF NOVEMBER 17

- THERMAL CONTROL DUCT LENGTH WAS ASSUMED TO BE 206 INCHES (17.4 FEET); ACTUAL LENGTH IS 20. FEET
- INDEXING OF THERMAL CONTROL DUCTS RELATIVE TO OWS/SUN LINE RESULTED IN 4 "HOT" AND 4 "COLD" DUCTS. MSFC INDEXING PROVIDES FOR 3 "HOT" AND 5 "COLD" DUCTS
- CIRCULAR CROSS SECTION OF OWS WAS APPROXIMATED BY AN OCTAGON; THIS COUPLED WITH ASSUMED DUCT INDEXING RESULTED IN 2.7% MORE INCIDENT SOLAR FLUX IN THE MISSION B ORIENTATION
- EACH OF THE ABOVE CONTRIBUTES TO HIGHER TEMPERATURES REPORTED BY McDONNELL DOUGLAS, RELATIVE TO THOSE REPORTED BY MSFC, FOR THE MISSION B ORIENTATION. (AGREED TO BY M-D AND MSFC ON DECEMBER 13.)

INACCURACIES IN McDONNELL DOUGLAS THERMAL MODEL OF OWS AS OF NOVEMBER 17 (CONTINUED)

- SOLAR ARRAY SHADOWING OF OWS AND RADIATIVE HEAT EXCHANGE BETWEEN ARRAYS AND OWS WERE NEGLECTED

- DEFINITION OF ROLL CONTROL AND DEADBAND FOR GRAVITY GRADIENT MODE DIFFER FROM MSFC's DEFINITION:
    - McDONNELL DOUGLAS: CONSTANT ROLL RATE THROUGHOUT SUNLIT PORTION OF ORBIT; ZERO DEADBAND (NOMINAL ATTITUDE)
    - MSFC: DURATION OF CONSTANT-RATE ROLL VARIES WITH ANGLE BETWEEN EARTH/SUN LINE AND ORBITAL PLANE; $\pm 5^{0}$ DEADBAND FROM NOMINAL AXIS ORIENTATIONS

SUMMARY

JOINT CONCLUSIONS OF MSFC AND McDONNELL DOUGLAS AS OF DECEMBER 13, 1967

- MSFC AND M-D CALCULATIONS OF ORBITAL TRANSIENT TEMPERATURES WITHIN THE OWS ARE NOW IN SUBSTANTIAL AGREEMENT
- MSFC's TEMPERATURE PREDICTIONS FOR THE OWS IN A MISSION B (INERTIAL) ORIENTATION HAVE NOT BEEN INVALIDATED BY McDONNELL DOUGLAS
- IF COMMON DEFINITIONS OF THE GRAVITY GRADIENT MODE OF STABILIZATION AND IDENTICAL DESCRIPTIONS OF THE OWS AND BEEN EMPLOYED BY McDONNELL DOUGLAS AND MSFC, THERE IS NO REASON TO EXPECT THAT THEIR RESULTS WOULD HAVE DIFFERED
- ADDITIONAL CALCULATIONS WILL BE REQUIRED TO RESOLVE DISCREPANCIES BETWEEN McDONNELL DOUGLAS AND MSFC THERMAL ANALYSES OF THE POP MODE
- ADDITIONAL MODIFICATIONS TO THE McDONNELL DOUGLAS THERMAL PROGRAM INCLUDE: CORRECT INDEXING AND LENGTH OF THERMAL DUCTS; INCLUSION OF SOLAR ARRAYS AND CREW QUARTERS PARTITIONS; A MINIMUM OF 3 LONGITUDINAL NODES.