THERMAL ANALYSIS

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Presentation Outline

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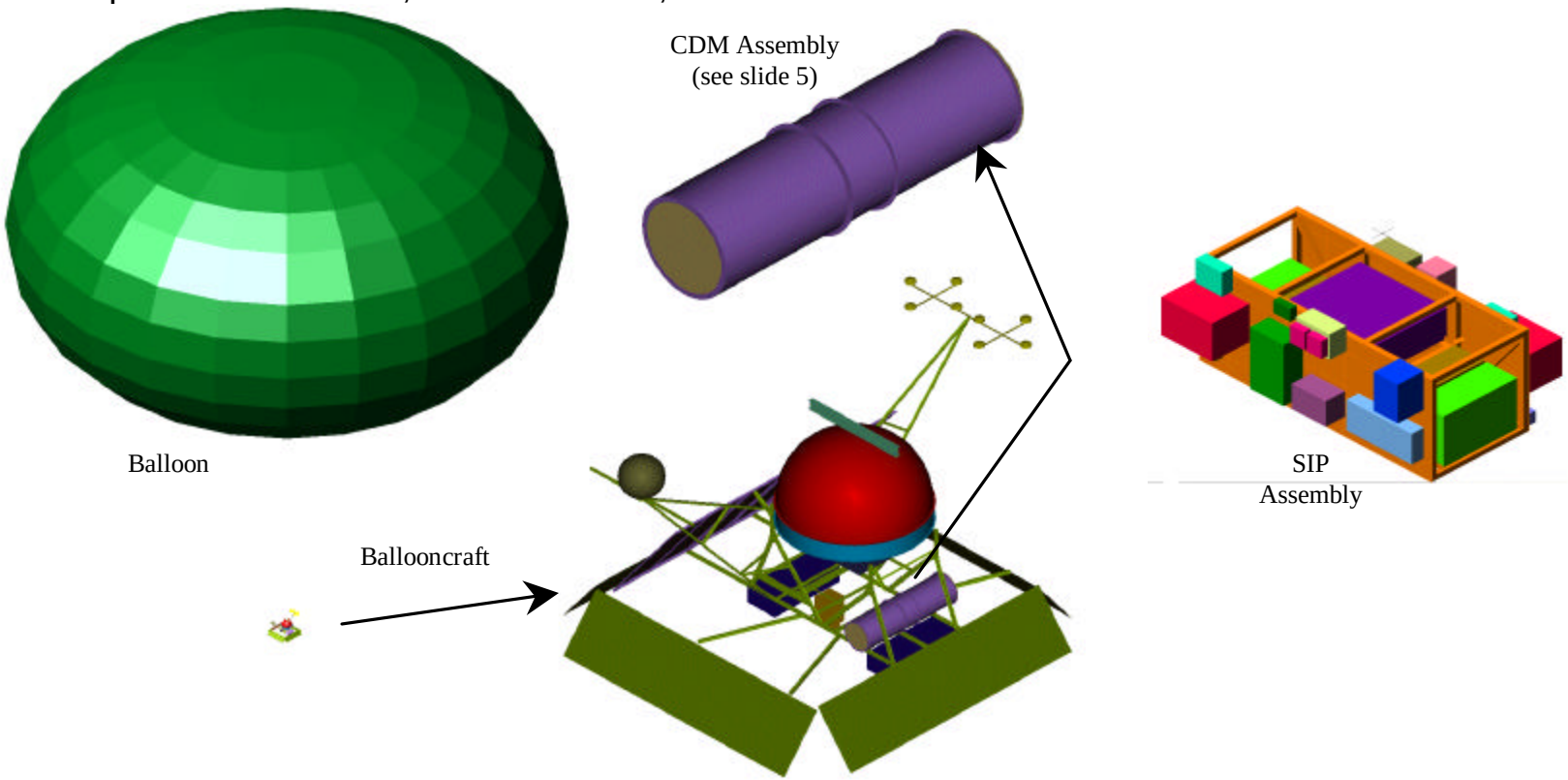
- Predictions
  - Ballooncraft
  - CDM

Model Overview - Balloncraft

- Software used:
  - Cullimore & Ring Technologies, Inc. Thermal Desktop / RadCAD v3.2Beta Release Candidate 2
- Balloncraft Model Statistics
  - 11034 total objects, including 6093 nodes, 4314 planar elements, 160 surfaces, 113 solids, 227 placed conductors, 109 heat loads, and 18 heaters



Model Overview - Balloncraft *(cont.)*

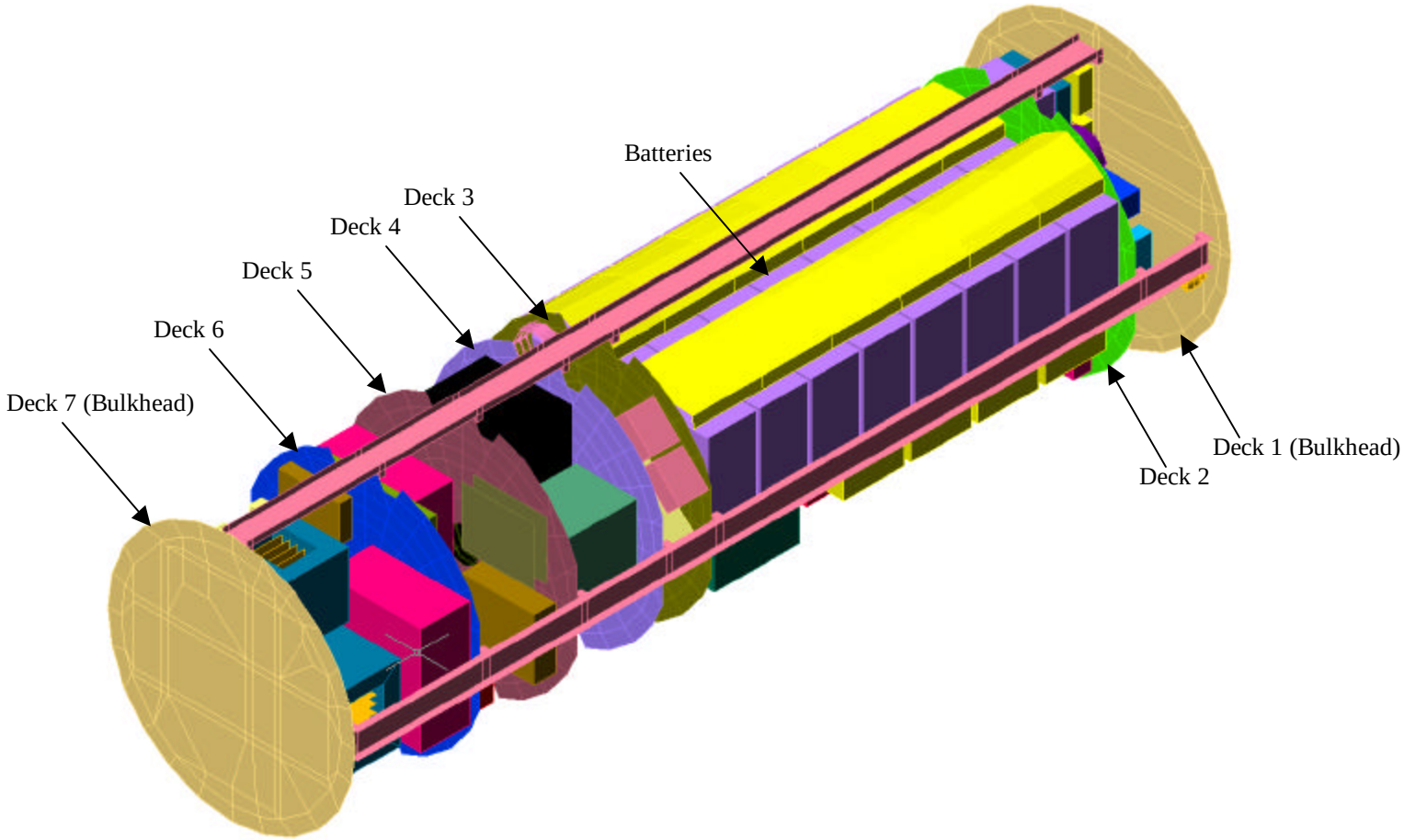
- Model includes:
  - Balloon (with revised optical properties)
  - Balloncraft gondola structure
  - Upper hemisphere/belly band, science support structure and plywood deck
  - Aggregate “Dummy” LDB components, science simulator
  - Directional TDRSS Antenna, gimbal and motors
  - High-fidelity Inmarsat/TDRSS SIP
  - High-fidelity CDM
  - ULDB and LDB solar arrays
  - Ballast hopper, and crush pads

- Model does not include:
  - Flight train, UTP, Rotator, chute, RFU,
  - Apex adapter plate, CAP, valve(s)
  - These components are available in separate model but not included because:
    - Insignificant contribution to balloncraft overall heat balance
    - Creates unnecessarily complex model and subsequently long execution times

Model Overview - CDM

CDM Model Statistics

- 4951 objects total, including: 2698 nodes, 1791 planar elements, 61 surfaces, 83 solids, 225 placed conductors, 80 heat loads and 13 heaters



Analysis Methods

- All component temperatures initialized at 20 °C
- 2-hour convective ascent transient analysis, initialize float transient analysis temps
- 24-hour transient float analysis (used for predictions, cold case float worst case)
- Float transient analysis starts at midnight for hot case and noon for cold case
- Solar panels track the sun, off-pointing addressed previously

Environments/Assumptions

- Environments
  - Hot Case
    - Latitude: 70° South
    - Date: Dec. 21, 2000 (Solstice)
    - Time: Near midpoint of midnight-midnight "orbit" (approx. noon)
    - Solar Flux: 1398 W/m^2 (Seasonal Variation on 1351 W/m^2 standard)
    - Albedo: 95% (maximum with Snow, Ice and Clouds)
    - Earth Flux: 264 W/m^2 (-12C)

    Note: Antarctic environment more extreme than mid-latitude "desert" environment
  - Cold Case
    - Latitude: 18° South (78° - 5)
    - Date: Apr 1, 2001 (End of Flight Window)
    - Time: Near midpoint of noon-noon "orbit" (approx midnight)
    - Solar Flux: 1044 W/m^2 (1351 W/m^2, Seasonal Variation, -25% atm. attenuation)
    - Albedo: 10% (Over Ocean)
    - Earth Flux: 106 W/m^2 (-65C)
- Assumptions
  - ULDB trajectory ranges from 18° South to 90° South
  - Cold case includes mid-latitude severe tropical storm (-65C apparent earth temp)
  - Ascent rate of 1000 fpm, profile: U.S. Std. Atm. Supplements, 1966 - 30°N January
  - Batteries charged to at or below 90% SOC (≤ 15W dissipation)

Ft. Sumner Test Flight - Lesson Learned

- Ft. Sumner Balloon Vehicle Test Flight - Early June
- Post-flight data review CAP temperatures overestimated by as much as 20°C
- Obtained ULDB balloon film (Stratofilm) optical property test results (Henry Cathey)
  - α/ε = 0.12 rather than the 0.30 used previously $\rightarrow$ colder daytime temperatures
- New film properties added to Ft. Sumner model, recreated flight temperature profiles
- Flight temperatures correlation improved greatly (3-5 °C) - report forthcoming
- New balloon film properties used in current and future ULDB thermal models

Physical Configuration Summary

- Balloncraft
  - Gondola frame - Aeroglaze
  - PV Panels - Aeroglaze on frame and back of panels
  - TDRSS Radome - Aeroglaze In/Out (done)
  - Hemisphere - 1mil 2nd surface Alum-Mylar on Kevlar/bladder (Tiger will have foam, MLI, etc)
  - Crush pads and ballast - white paint
- CDM
  - As per Bob Ray's spreadsheet - no changes

Heater/Fan Configuration

- Heaters
  - Balloncraft
    - TDRSS Antenna (15W), TDRSS Motors (5W each), GPS Antennas (5W each)
  - CDM
    - Batteries (15W in 4 places) - Set at 0°C and never turned-on
    - Decks 2, 3, 4, 5, and 6 - approx. center (30W total) - Set at -20°C and never turned-on
    - Altitude transducers (2W each for 10W)
    - Hard drive case (5W)
    - TDRSS Motor Controllers (2 @ 5W) - Set at 0°C and never turned-on
    - Inmarsat Transceiver (10W)
    - Gas makeup solenoid and relief valve (10W each)
- Fans
  - Balloncraft
    - None
  - CDM
    - Deck 2 (plenum inlet) - 20 CFM muffin
    - Deck 3 (plenum exit) - 20 CFM muffin
    - Deck 5 (deck 4 side) - 20 CFM muffin
    - Flight Computer Chassis - two 20 CFM muffins (1 each chassis)

Predictions - Balloncraft

Balloncraft Component	Cold Margin	Cold Limit	Cold Predict	Hot Predict	Hot Limit	Hot Margin	Notes
GPS Sensors	See Note	-30	-30	42	150	108	Heater setpoint at/above -30
ULDB Solar Cells	n/a	none	-52	82	95	13	
TDRSS Antenna	See Note	-30	-30	35	60	25	Heater setpoint at/above -30
TDRSS Motors	See Note	-20	-20	39	55	16	Heater setpoint at/above -20
TDRSS Gimbal	n/a	none	-28	38	none	n/a	
Gondola (aggregate)	n/a	none	-84	30	none	n/a	

Predictions - CDM

CDM Component	Cold Margin	Cold Limit	Cold Predict	Hot Predict	Hot Limit	Hot Margin	Notes
1553 Bus Coupler #1	52	-55	-3	41	130	89	
1553 Bus Coupler #2	52	-55	-3	41	130	89	
3 X 50 Pin (3 each) Buss	36	-40	-4	40	60	20	
Altitude Transducers	See Note	0	0*	42	50	8	Heater setpoint at/above 0
Backup Command Stacks	26	-40	-14	39	60	21	
Band Reject Filter	16	-20	-4	41	70	29	
Batteries (8 each)	See Note	0	0	43	50	7	Heater setpoint at/above 0
Charge Controllers (4 each)	34	-40	-6	43	60	17	
Current Sensors (4 each)	15	-20	-5	42	60	18	
DC-DC Cnvtr, Computer	28	-40	-12	43	85	42	
DC-DC Cnvtr, Harddrive	28	-40	-12	43	85	42	
DC-DC Cnvtr, Sensors	27	-40	-13	43	85	42	
Diode BoardCurrent Sensors	42	-40	2	56	60	4	
External Stacks 1	36	-40	-4	41	60	19	
External Stacks 2	35	-40	-5	41	60	19	
Flight Computer #1							
Processor Board	53	-40	13	63	85	22	
1553 Board	56	-40	16	66	85	19	
TDI Board	39	-40	-1	51	85	34	
UART Quad Board	33	-40	-7	43	85	42	
UART Octal Board	34	-40	-6	44	85	41	
SCSI Board	33	-40	-7	45	85	40	
Flight Computer #2							
Processor Board	53	-40	13	63	85	22	
1553 Board	56	-40	16	66	85	19	
TDI Board	39	-40	-1	51	85	34	
UART Quad Board	33	-40	-7	43	85	42	
UART Octal Board	34	-40	-6	44	85	41	
SCSI Board	33	-40	-7	45	85	40	

Predictions - CDM *(cont.)*

CDM Component	Cold Margin	Cold Limit	Cold Predict	Hot Predict	Hot Limit	Hot Margin	Notes
Gas Makeup Relief Valve	38	-60	-22	42	150	108	
Gas Makeup Solenoid	12	-30	-18	38	150	112	
GPS ADU Box #1	29	-40	-11	44	60	16	
GPS ADU Box #2	28	-40	-12	43	60	17	
Hard Drive Enclosure	See Note	5	5	42	55	13	Heater setpoint at/above 5
Inmarsat Transceiver TT302C	See Note	-25	-25	38	55	17	Heater setpoint at/above -25
Large Power Relays	28	-40	-12	40	60	20	
LOS Receiver #1	27	-30	-3	40	60	20	
LOS Receiver #2	26	-30	-4	41	60	19	
LOS Receiver Modem #1	24	-30	-6	42	60	18	
LOS Receiver Modem #2	24	-30	-6	42	60	18	
LOS Transmitter #1 T602	19	-20	-1	41	70	29	
LOS Transmitter #2 T602	20	-20	0	42	70	28	
PCM Encoder	29	-40	-11	43	60	17	
Power Relay Boards (9 ea.)	31	-40	-9	44	60	16	
RF Switch #1	52	-55	-3	41	85	44	
RF Switch #2	51	-55	-4	40	85	45	
Signal Conditioning #1	18	-20	-2	41	60	19	
Signal Conditioning #2	18	-20	-2	42	60	18	
Signal Conditioning #3	18	-20	-2	40	60	20	
Signal Conditioning #4	18	-20	-2	41	60	19	
Signal Switching Boards	25	-40	-15	42	60	18	
ST13 Argos Transmitter #1	37	-40	-3	41	60	19	
ST13 Argos Transmitter #2	37	-40	-3	41	60	19	
ST14 Argos Transmitter	37	-40	-3	41	60	19	
System Stack #1	26	-40	-14	39	60	21	
System Stack #2	27	-40	-13	40	60	20	
TDRSS Diplexor 1	16	-20	-4	41	70	29	
TDRSS Diplexor 2	16	-20	-4	42	70	28	
TDRSS Motor Controller	4	0	4	54	70	16	
TDRSS Motor Controller	5	0	5	53	70	17	
TDRSS Tracking Controller	39	-40	-1	43	85	42	
TDRSS Transceiver	2	-10	-8	45	55	10	