Payload Accommodations

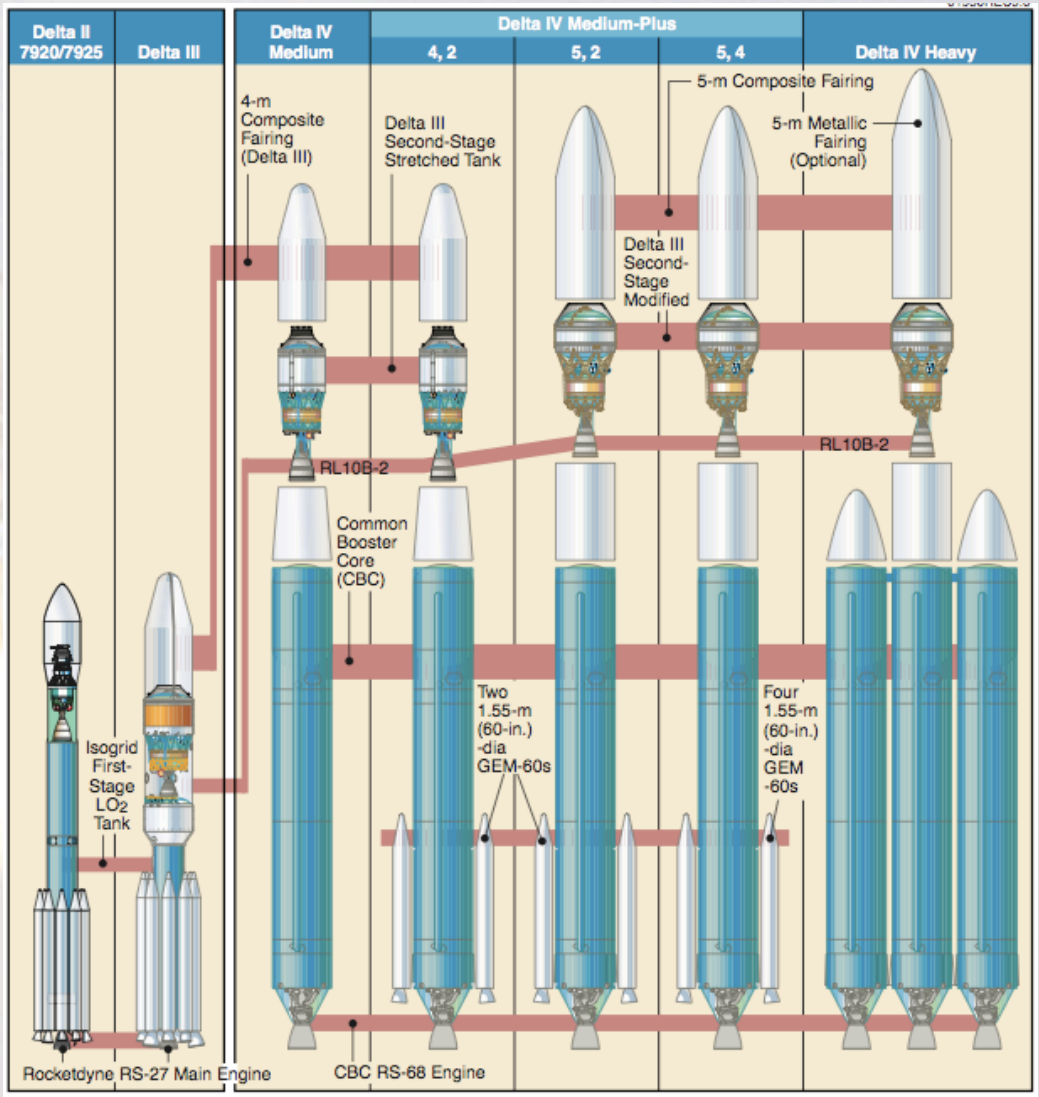
- Expendable Launch Vehicles
- Space Shuttle
- Secondary Payloads

UNIVERSITY OF MARYLAND

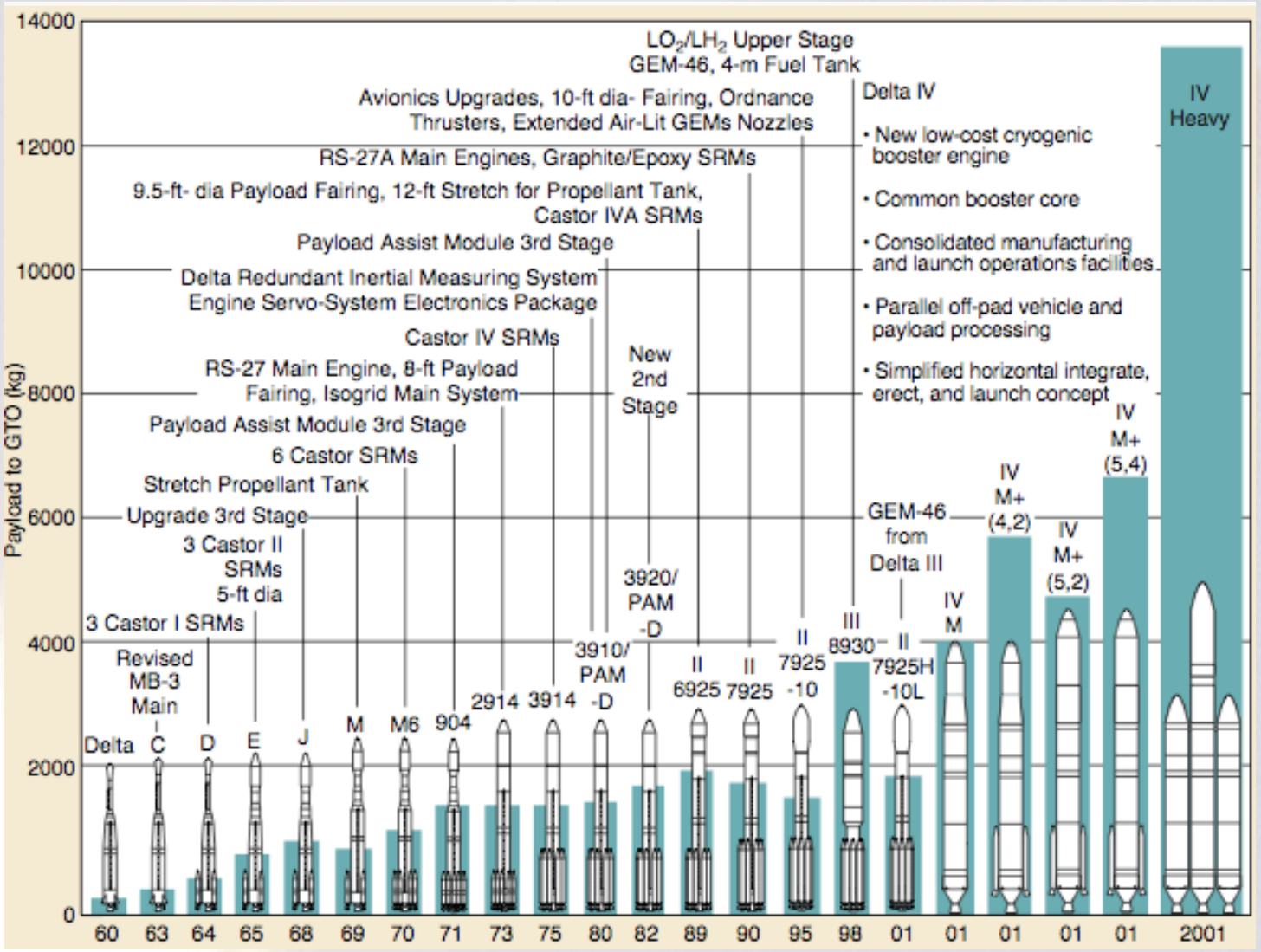
Evolved Expendable Launch Vehicles

Atlas V

Atlas V 400			Atlas V 500			
401	501	511	521	531	541	551
Performance to GTO, kg (lb)						
4,950	3,970	5,270	6,285	7,200	7,980	8,670
(10,913)	(8,752)	(11,618)	(13,856)	(15,873)	(17,593)	(19,114)

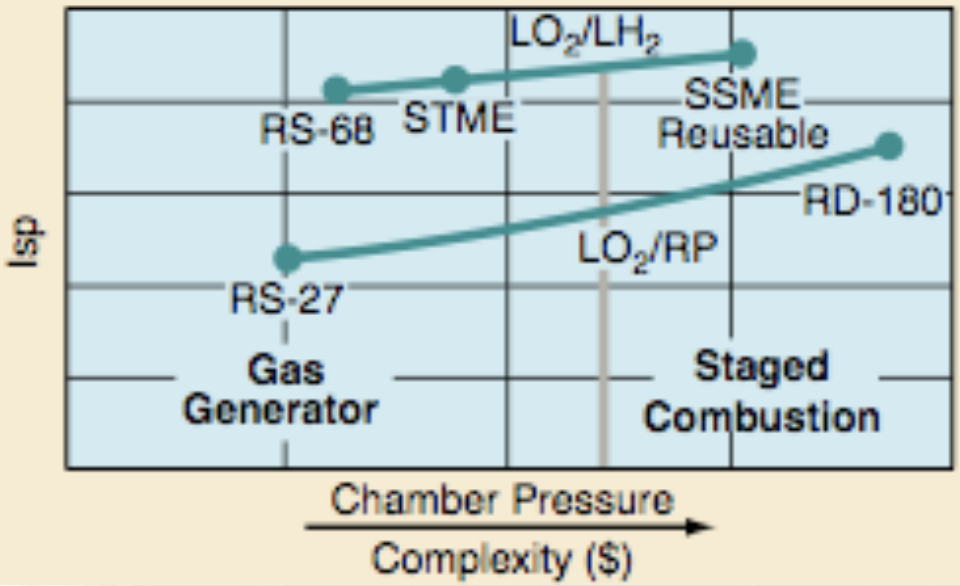


Delta IV Evolution and GTO Capability



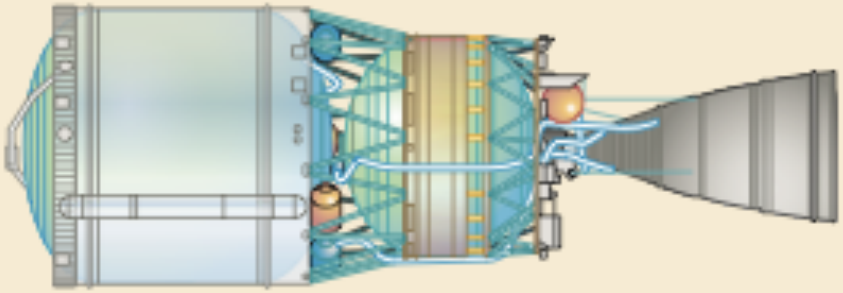
Delta IV RS-68 Engine

- Low-risk simplified LO_2/LH_2 engine improves reliability
- Minimal parts count and low fabrication cost
- Low to moderate chamber pressure reduces load
- Proven technology



Delta IV Upper Stages

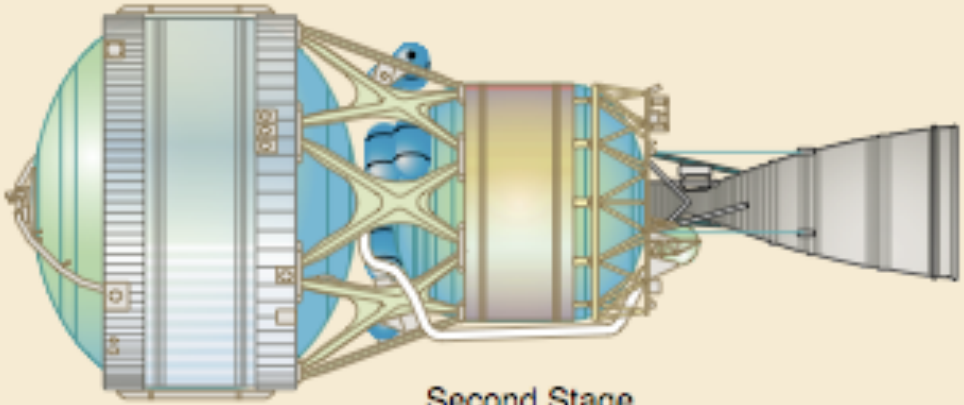
4-m Configuration (Delta IV-M, Delta IV-M+ (4,2))



Second Stage

- Modified Delta III second stage
- Delta III Pratt & Whitney RL10B-2 engine

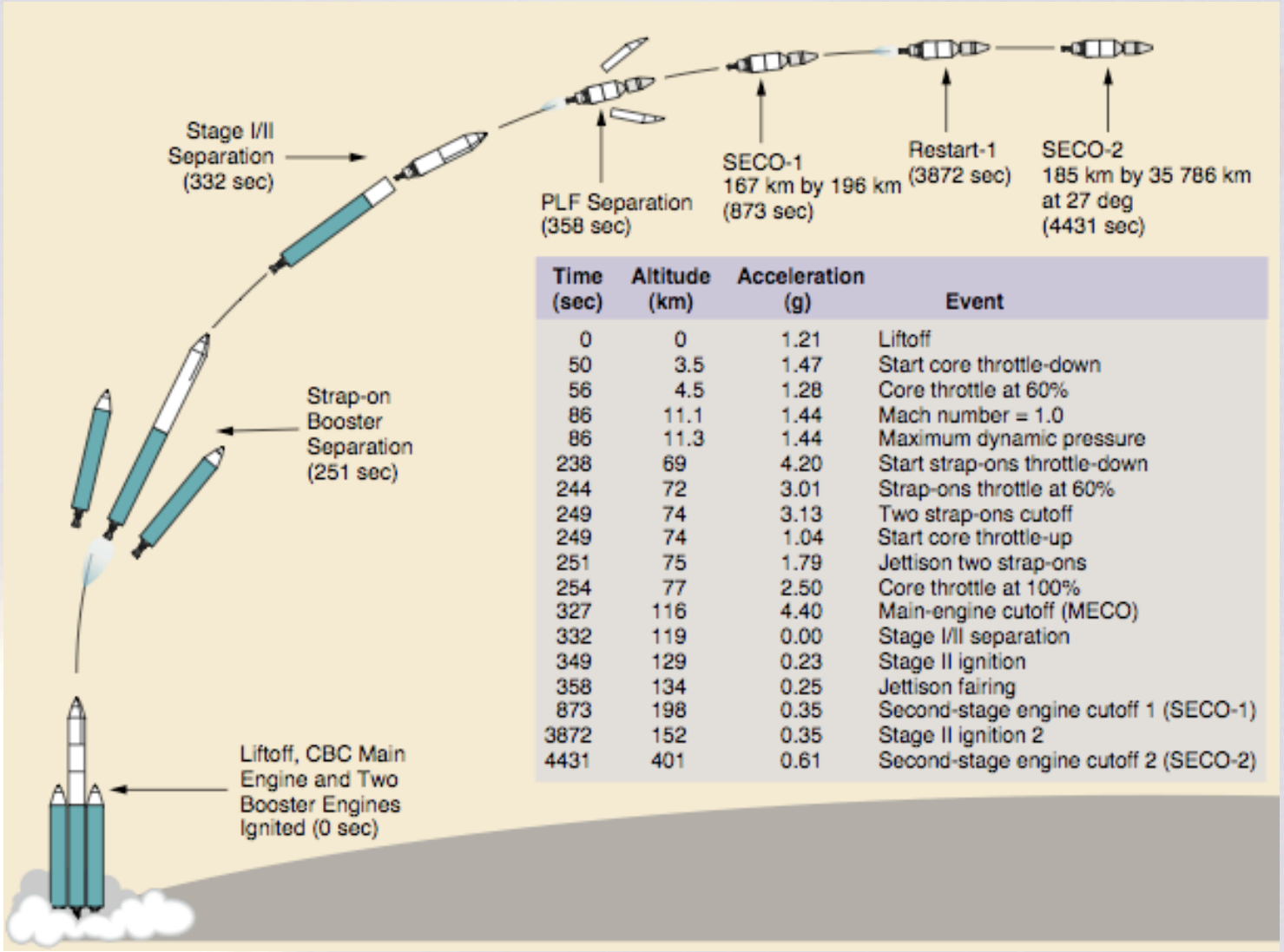
5-m Configuration (Delta IV-M+ (5,2), Delta IV-M+ (5,4), Delta IV-H)



Second Stage

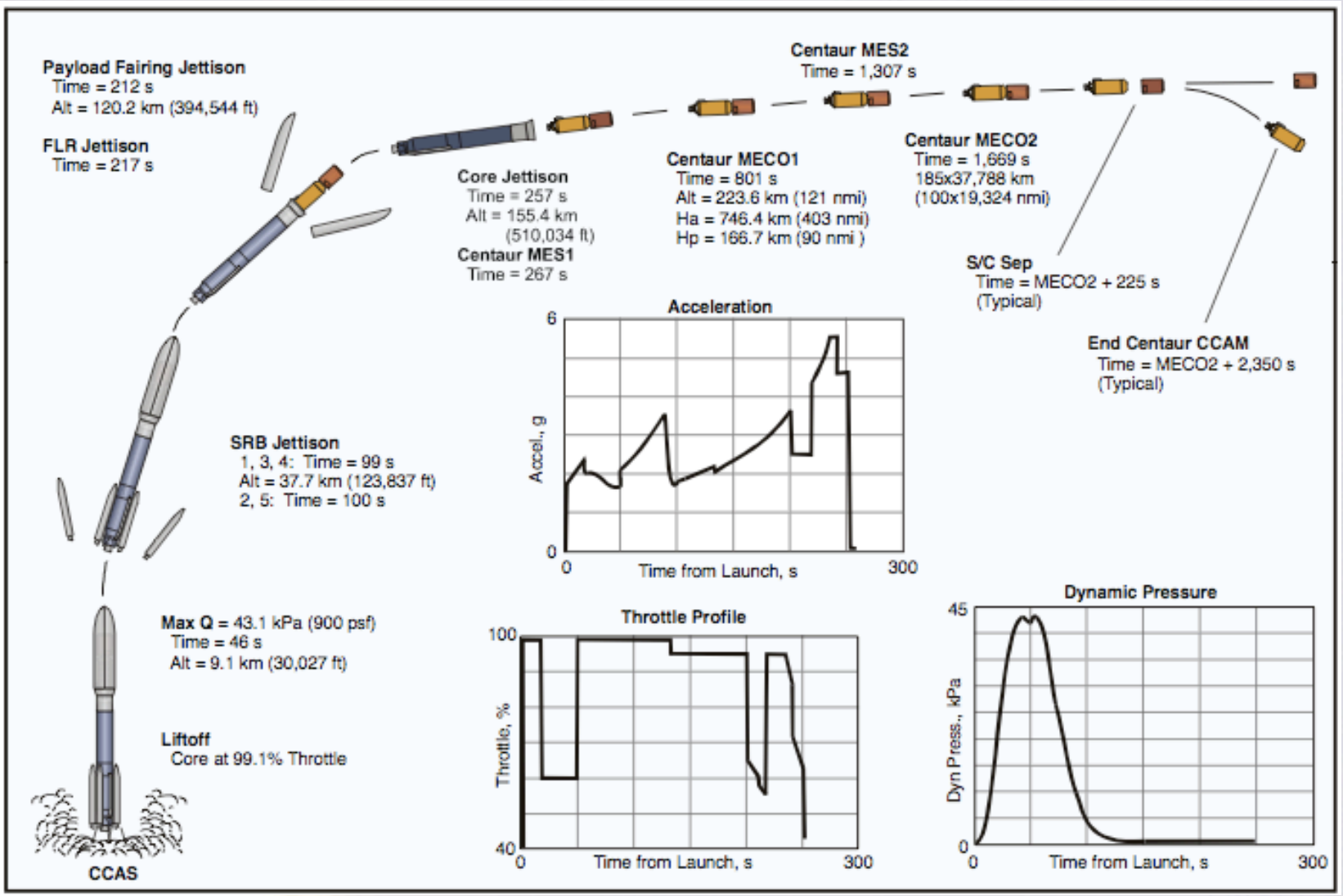
- 4-m stretched LO_2 tank
- 5-m LH_2 tank
- Delta III Pratt & Whitney RL10B-2 engine

Delta IV Heavy GTO Ascent Profile

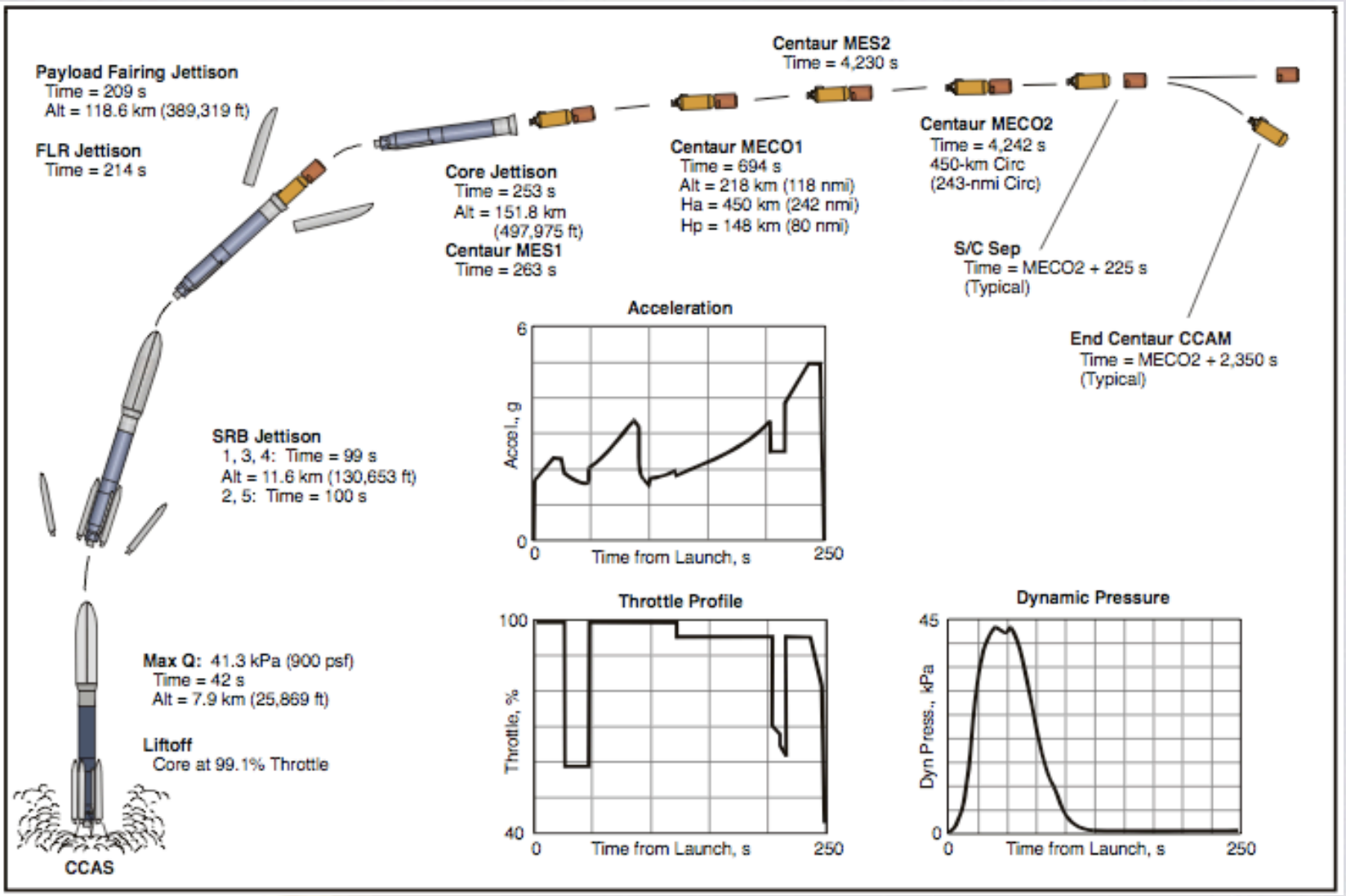


Time (sec)	Altitude (km)	Acceleration (g)	Event
0	0	1.21	Liftoff
50	3.5	1.47	Start core throttle-down
56	4.5	1.28	Core throttle at 60%
86	11.1	1.44	Mach number = 1.0
86	11.3	1.44	Maximum dynamic pressure
238	69	4.20	Start strap-ons throttle-down
244	72	3.01	Strap-ons throttle at 60%
249	74	3.13	Two strap-ons cutoff
249	74	1.04	Start core throttle-up
251	75	1.79	Jettison two strap-ons
254	77	2.50	Core throttle at 100%
327	116	4.40	Main-engine cutoff (MECO)
332	119	0.00	Stage I/II separation
349	129	0.23	Stage II ignition
358	134	0.25	Jettison fairing
873	198	0.35	Second-stage engine cutoff 1 (SECO-1)
3872	152	0.35	Stage II ignition 2
4431	401	0.61	Second-stage engine cutoff 2 (SECO-2)

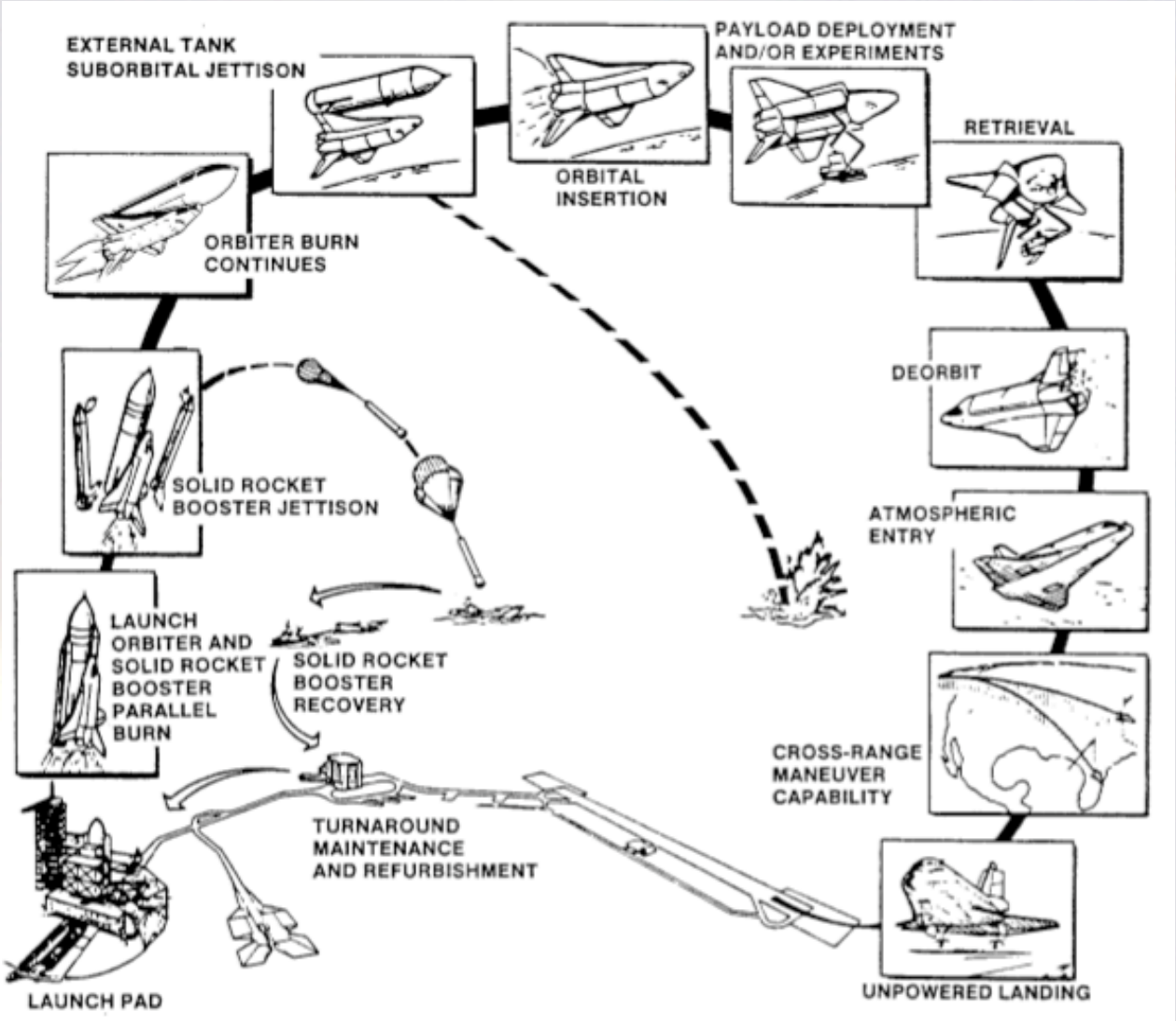
Atlas V 551 GTO Ascent Profile



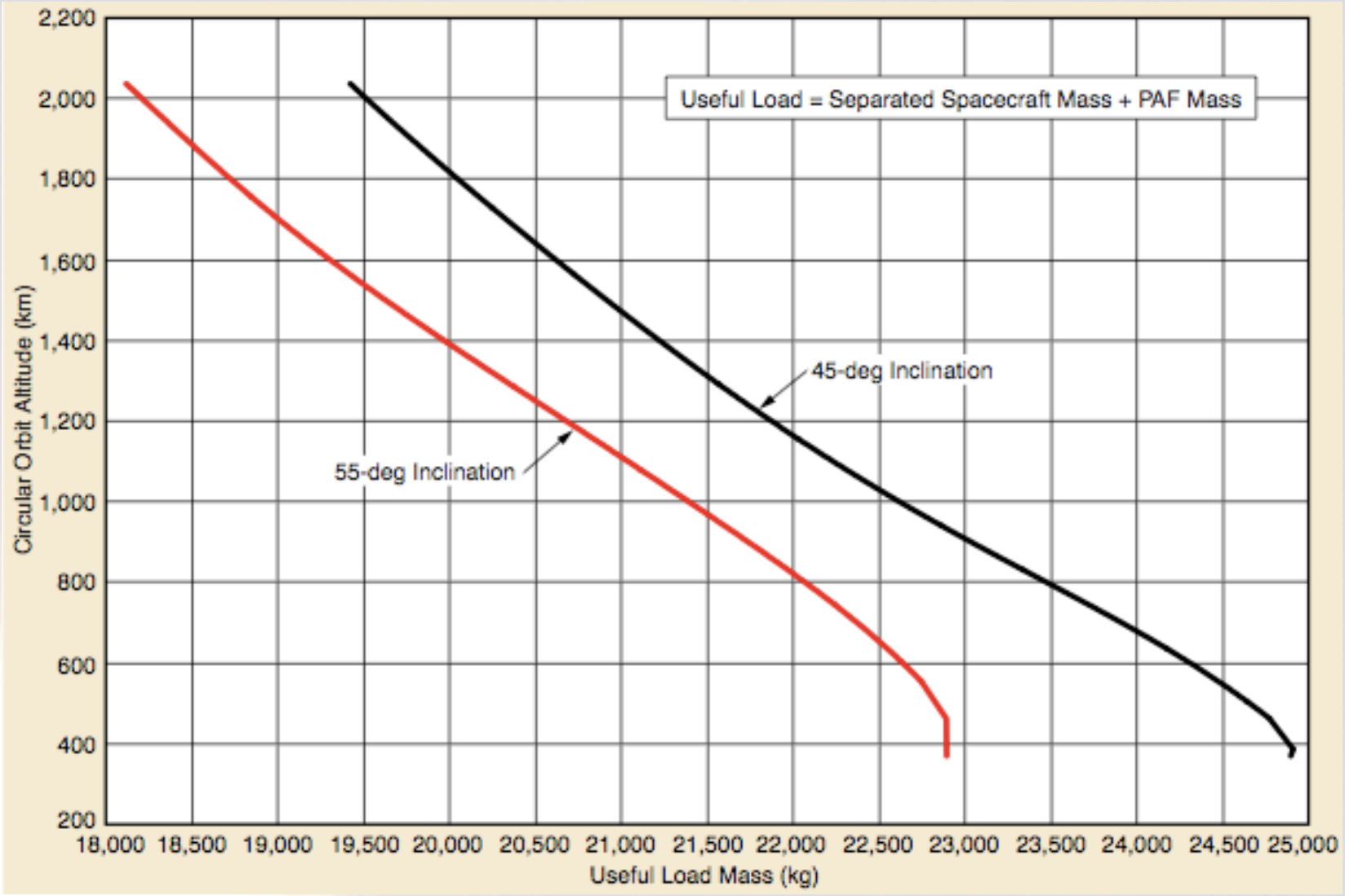
Atlas V 552 LEO Ascent Profile



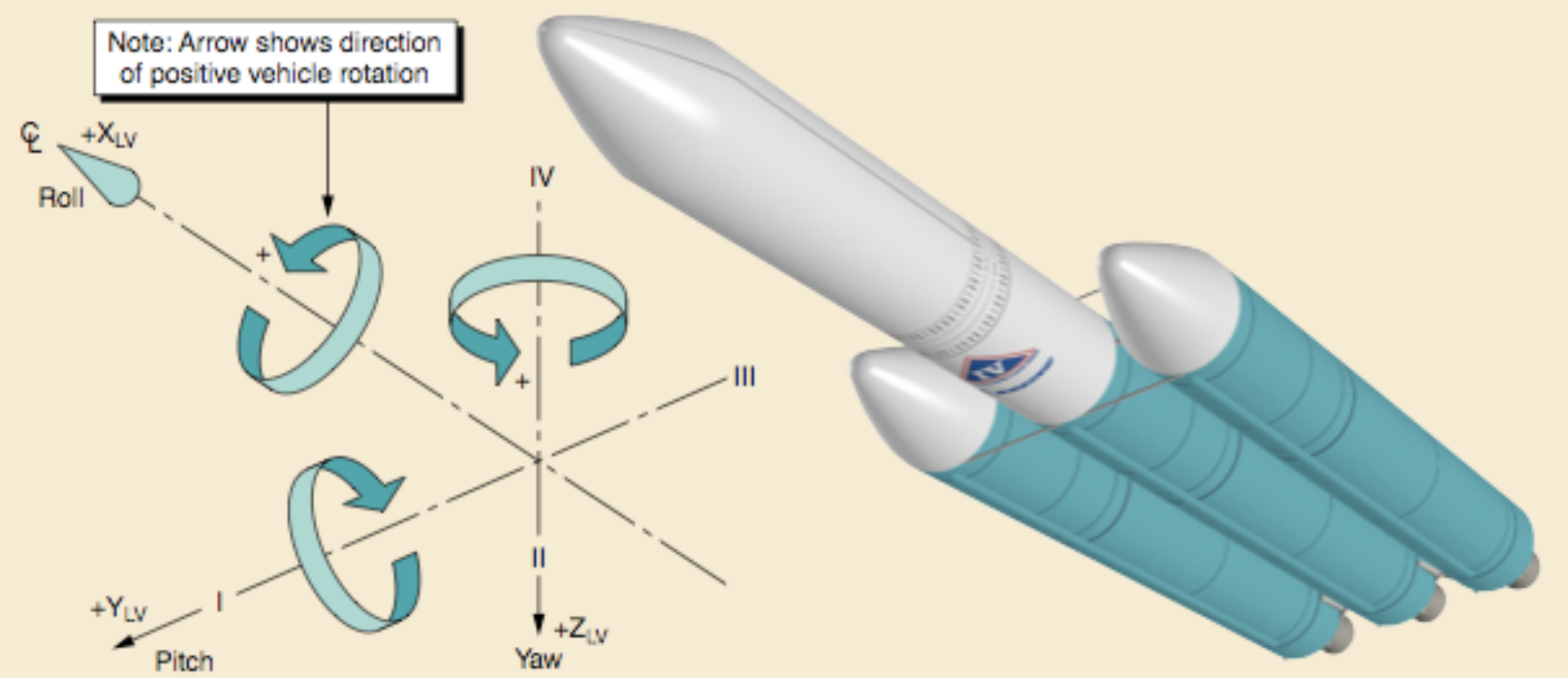
Shuttle Mission Profile



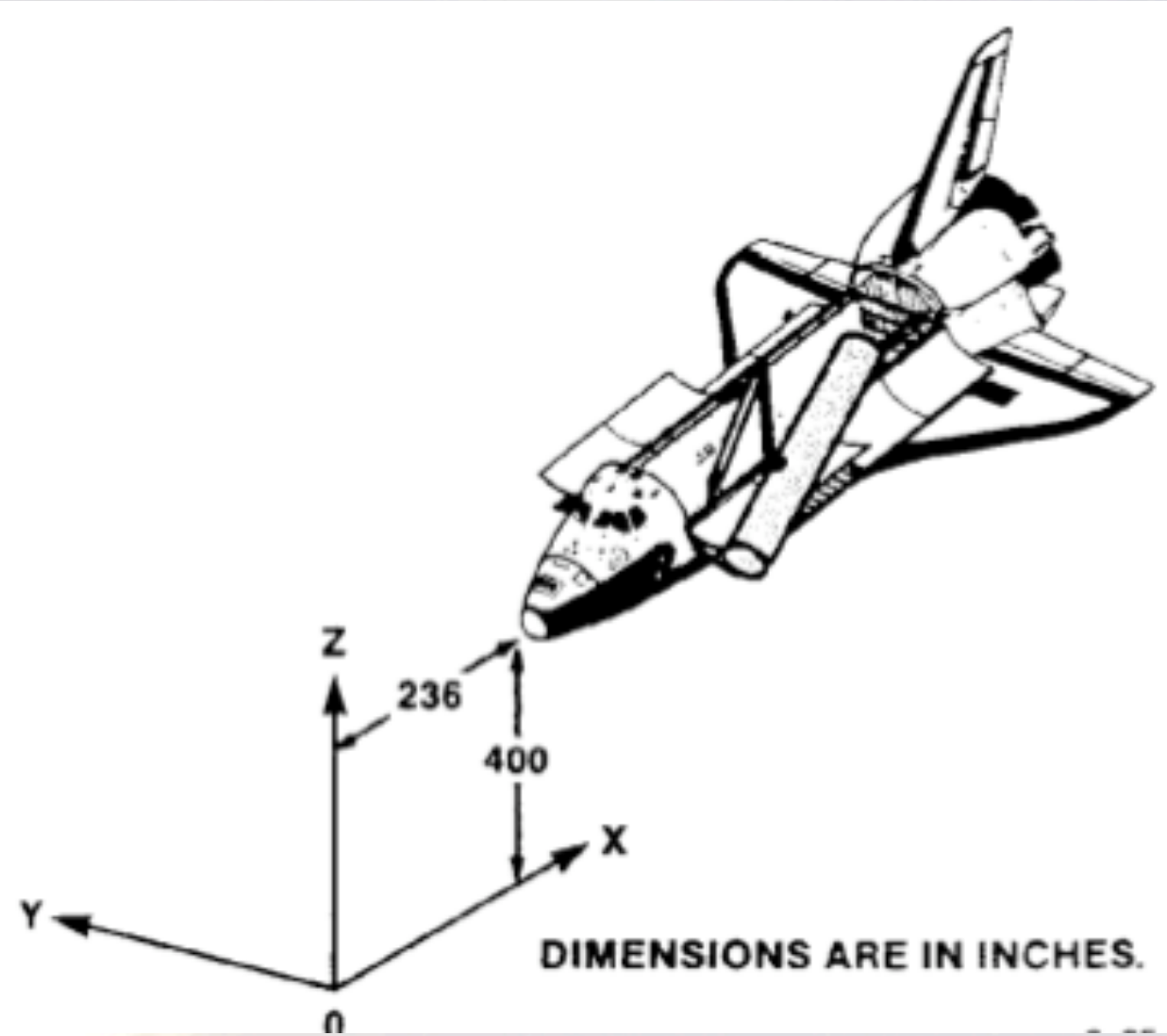
Delta IV Heavy Payload to LEO Circular



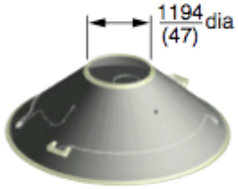
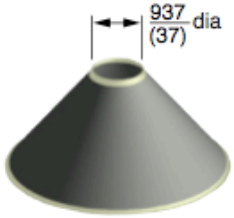
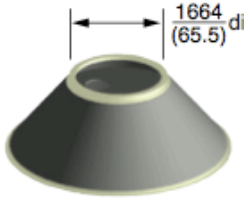
Delta IV Heavy Coordinate System

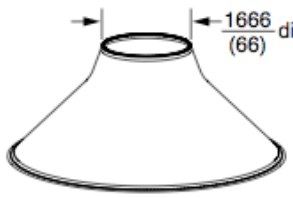
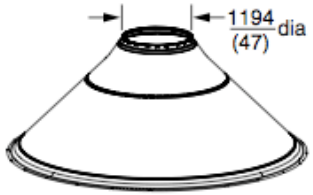
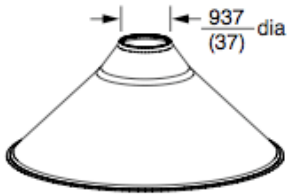
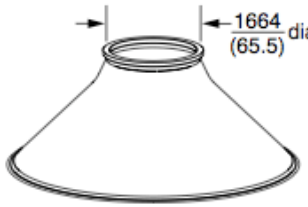
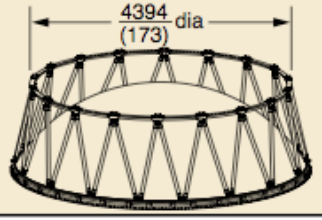


Orbiter Coordinate System

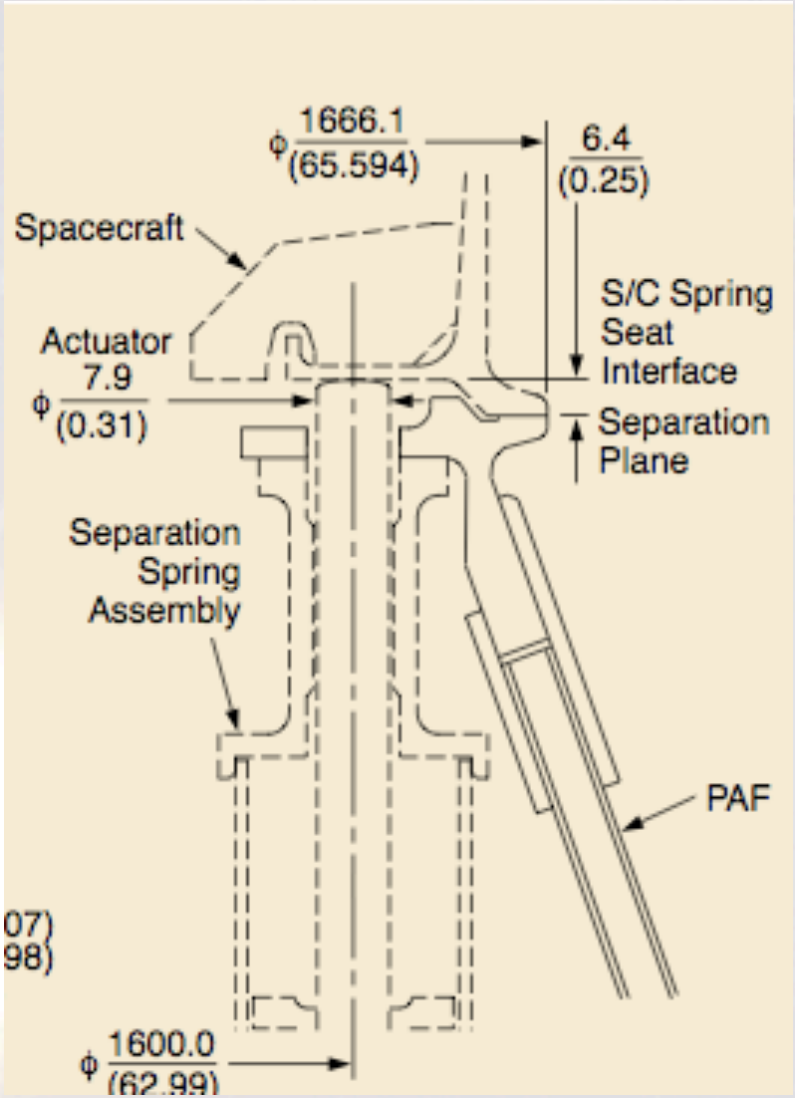


Delta Standard Payload Attach Fittings

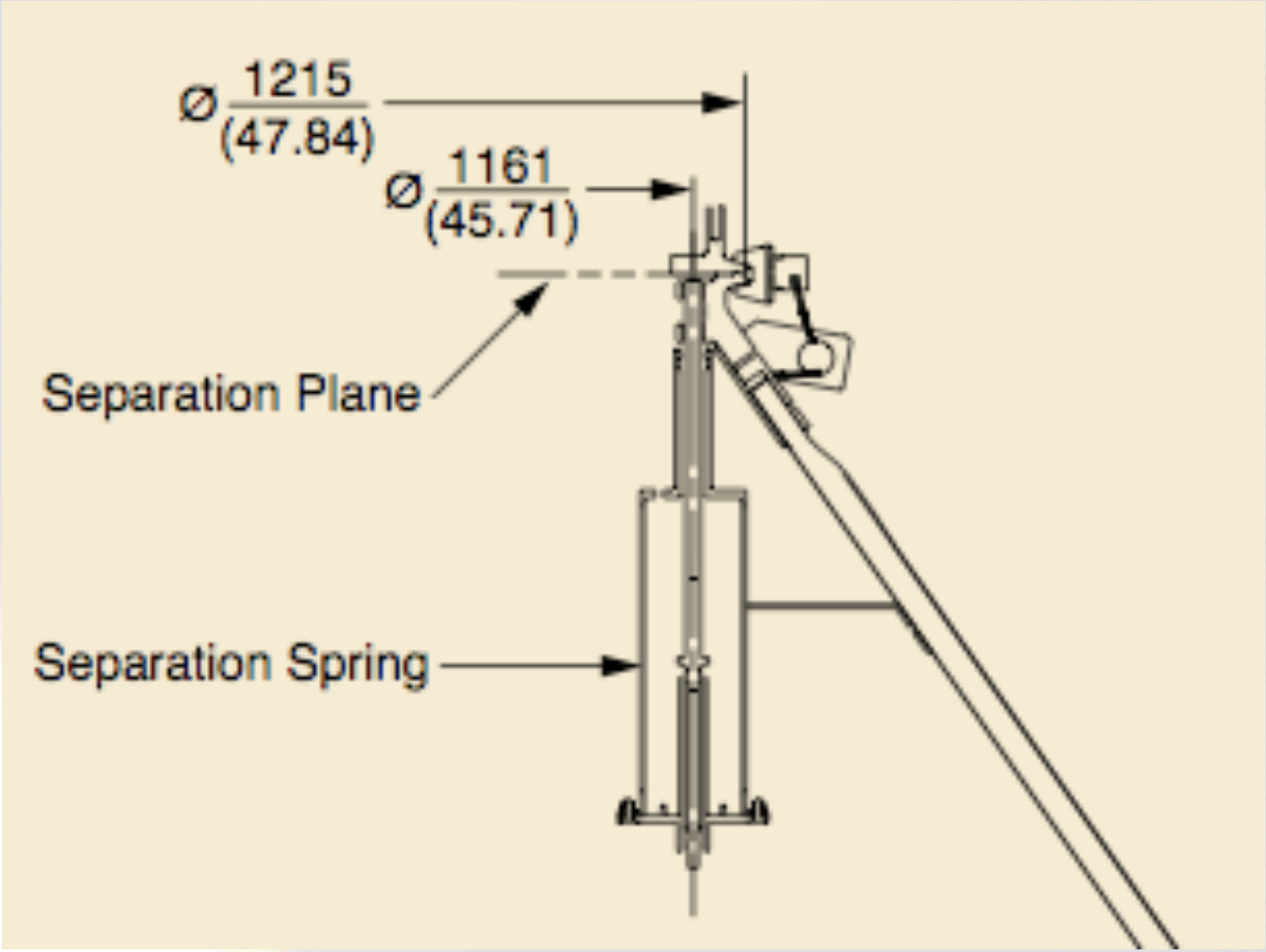
Delta IV 1666-4 PAF		1666 (66) dia clampband
Delta IV 1194-4 PAF		1194 (47) dia clampband
Delta IV 937-4 PAF		937 (37) dia clampband
Delta IV 1664-4 PAF		Four separation bolts in a 1664 (65.5) dia bolt circle
Delta IV 1575-4 PAF		121 bolts in a 1575 (62) dia bolt circle

Delta IV 1666-5 PAF		1666 (66) dia clampband
Delta IV 1194-5 PAF		1194 (47) dia clampband
Delta IV 937-5 PAF		937 (37) dia clampband
Delta IV 1664-5 PAF		Four separation bolts 1664 (65.5) dia bolt circle
Delta IV 4394-5 PAF		72 bolts in a 4394 (173) dia bolt circle

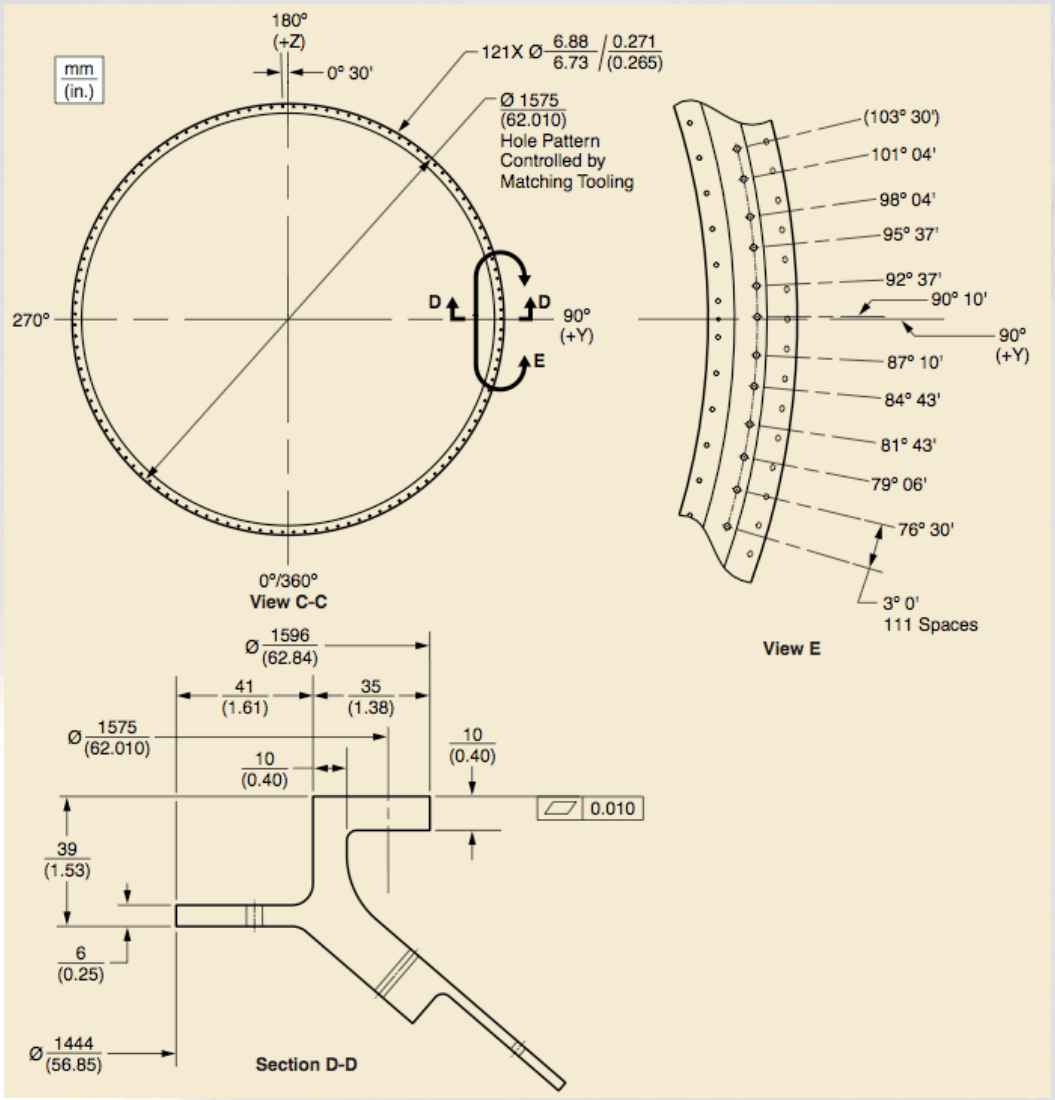
Marmon Band/Separation Springs



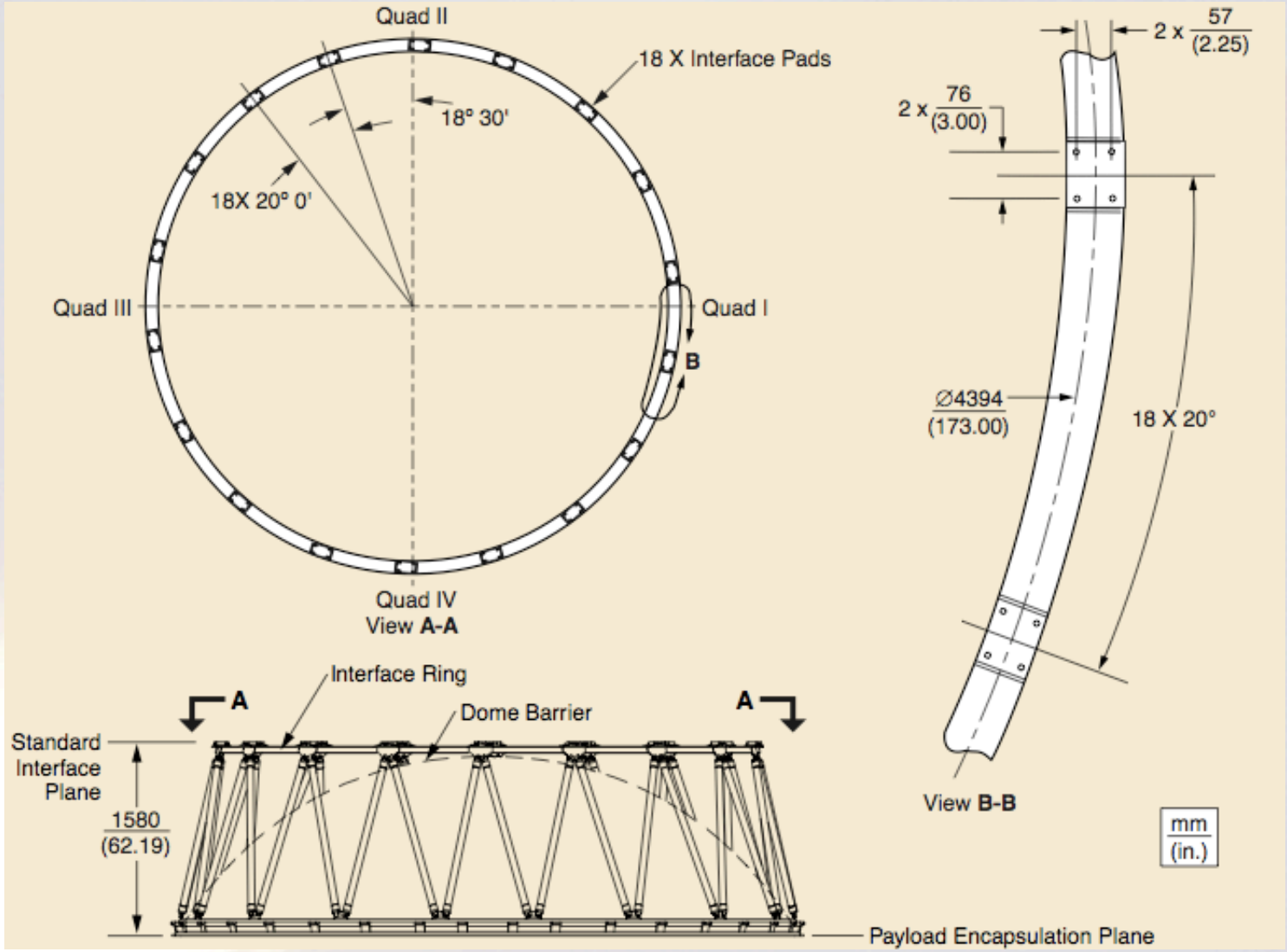
Marmon Band/Separation Springs



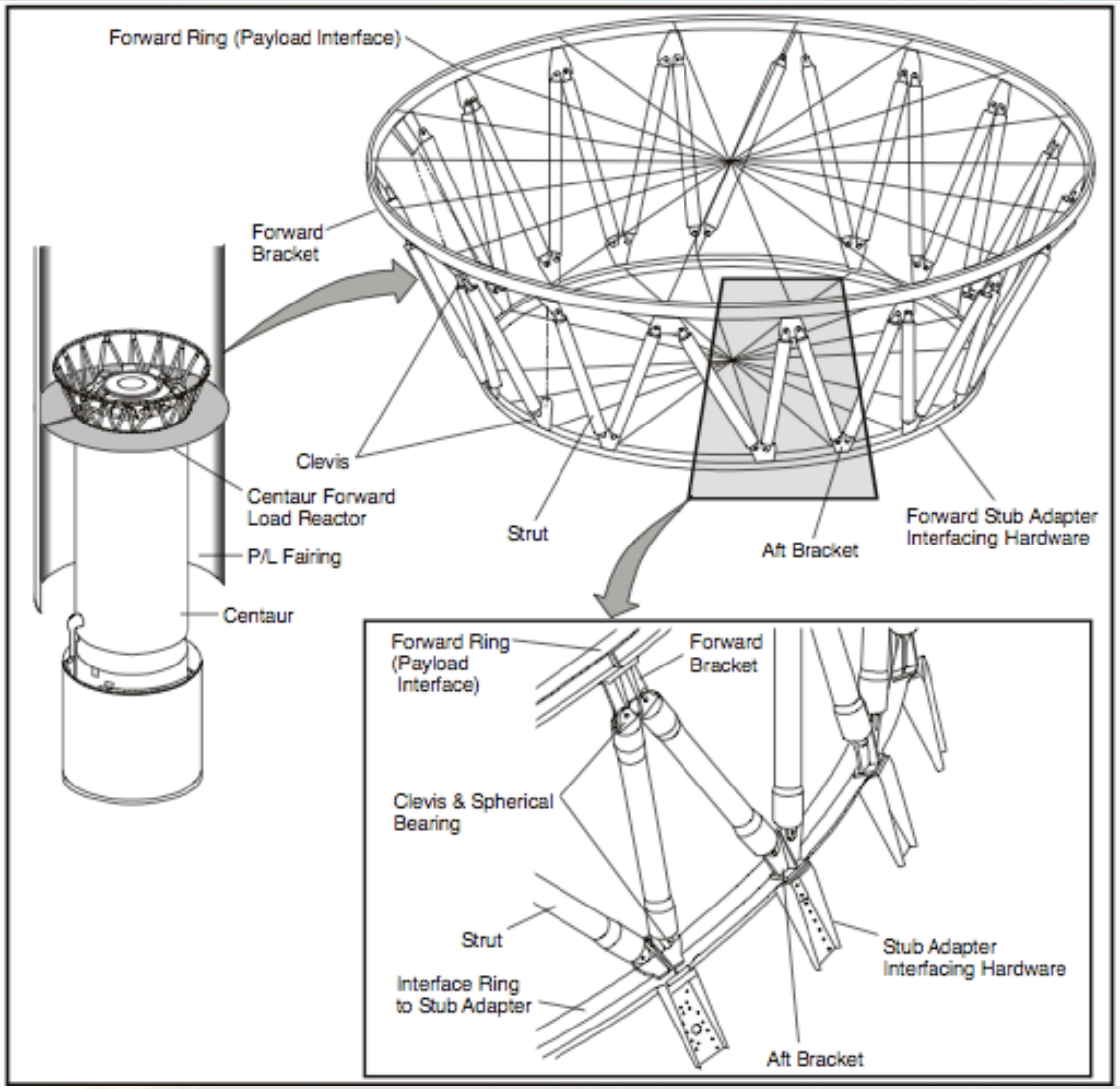
Delta 1575-4 Bolted Payload Interface



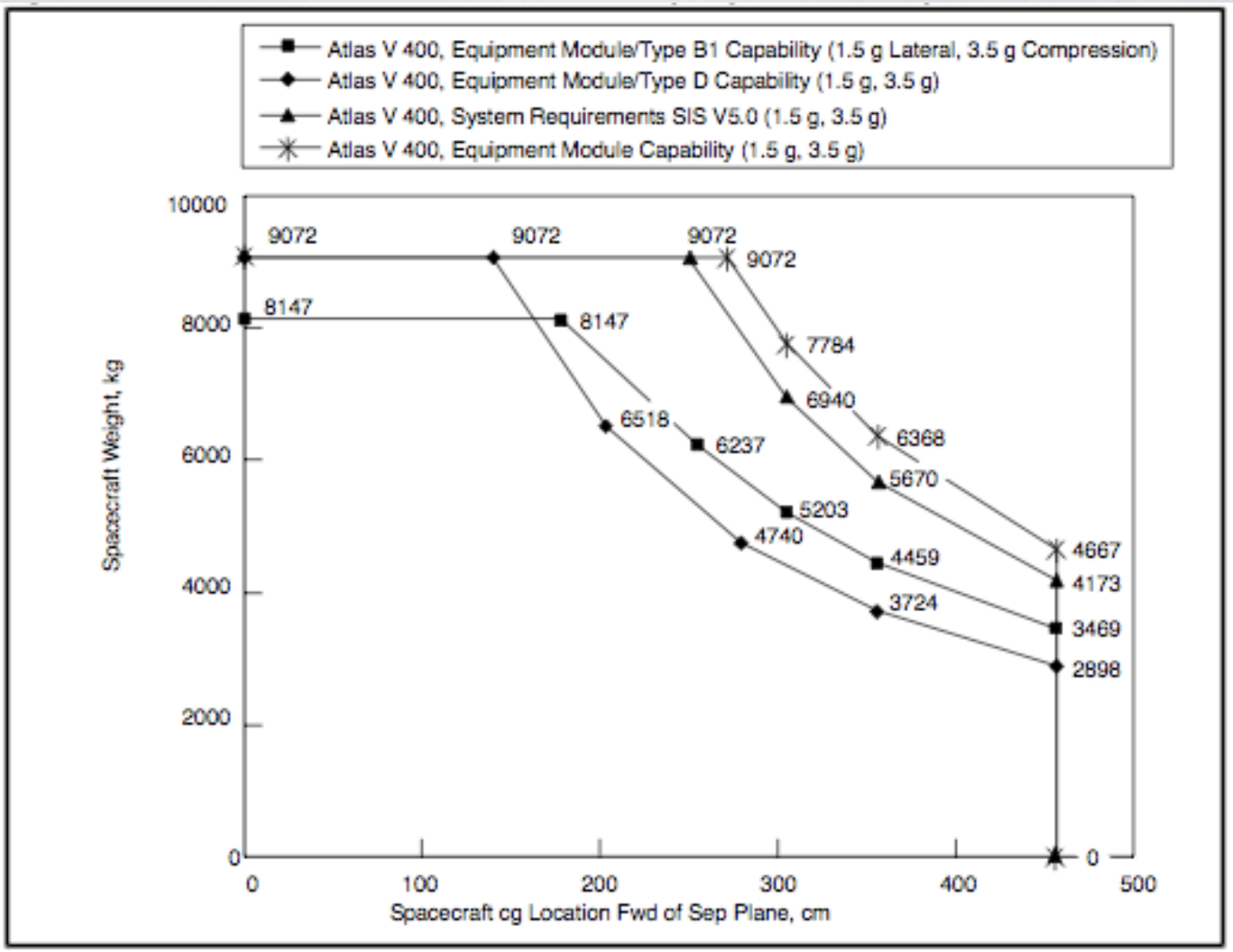
Delta 4394-5 Bolted Interface



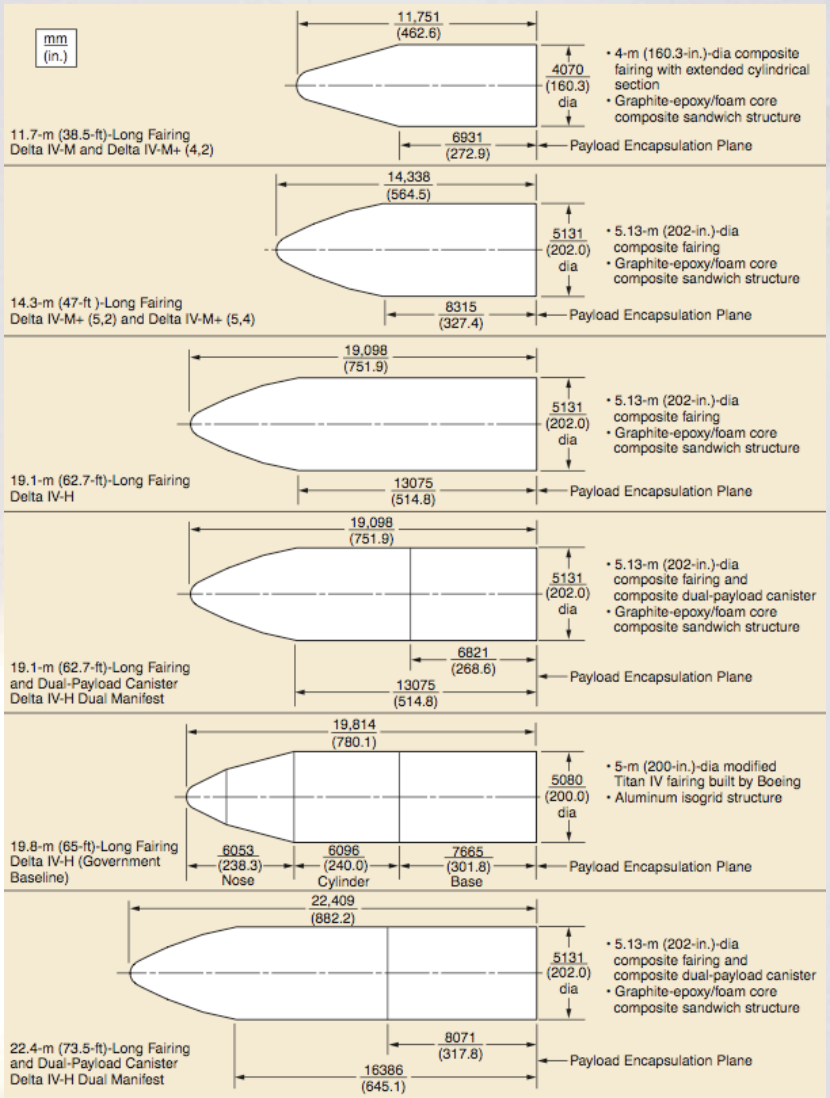
Atlas V Bolted 173 inch PAF



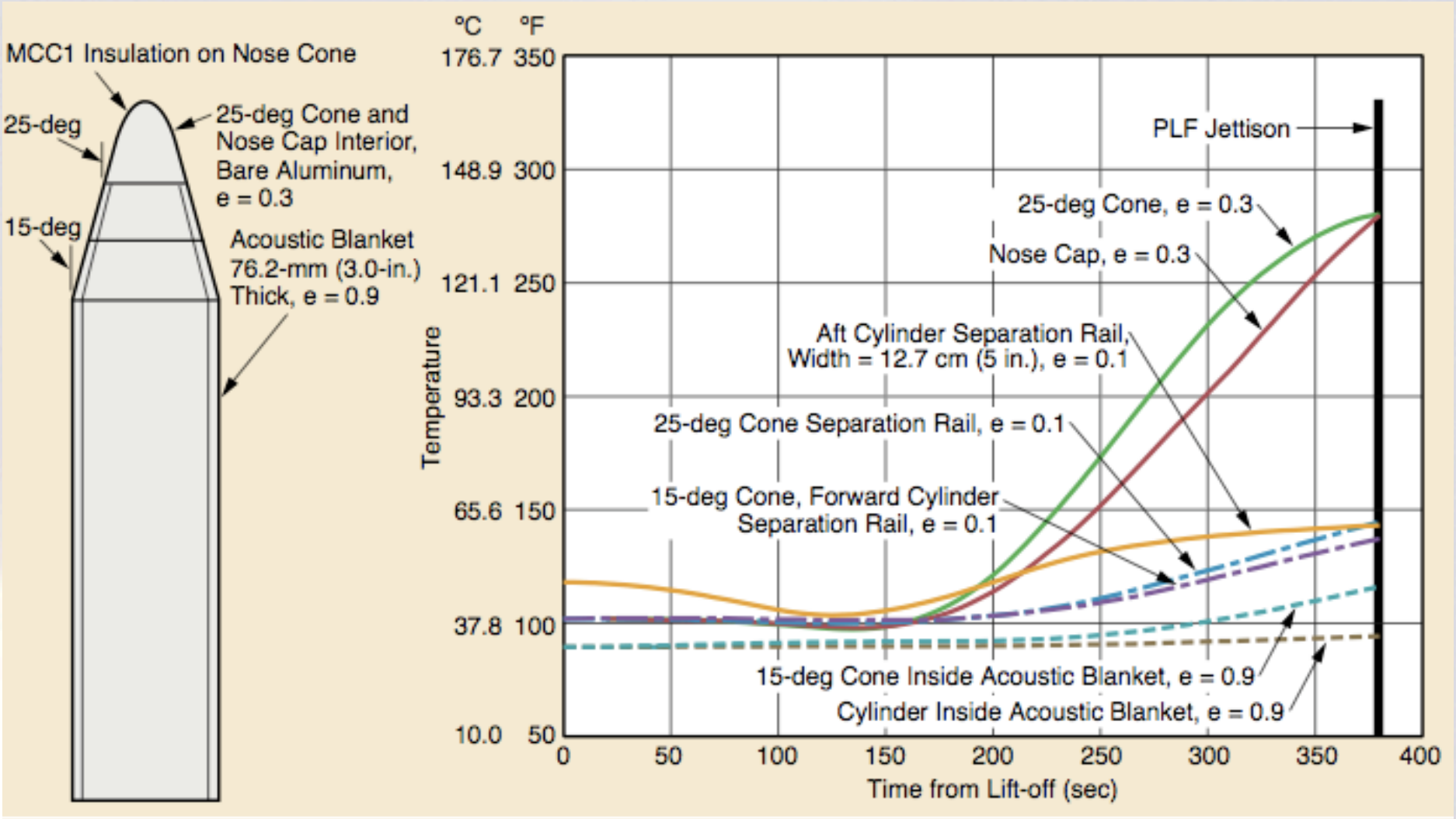
Atlas V 400 Allowable CG Locations



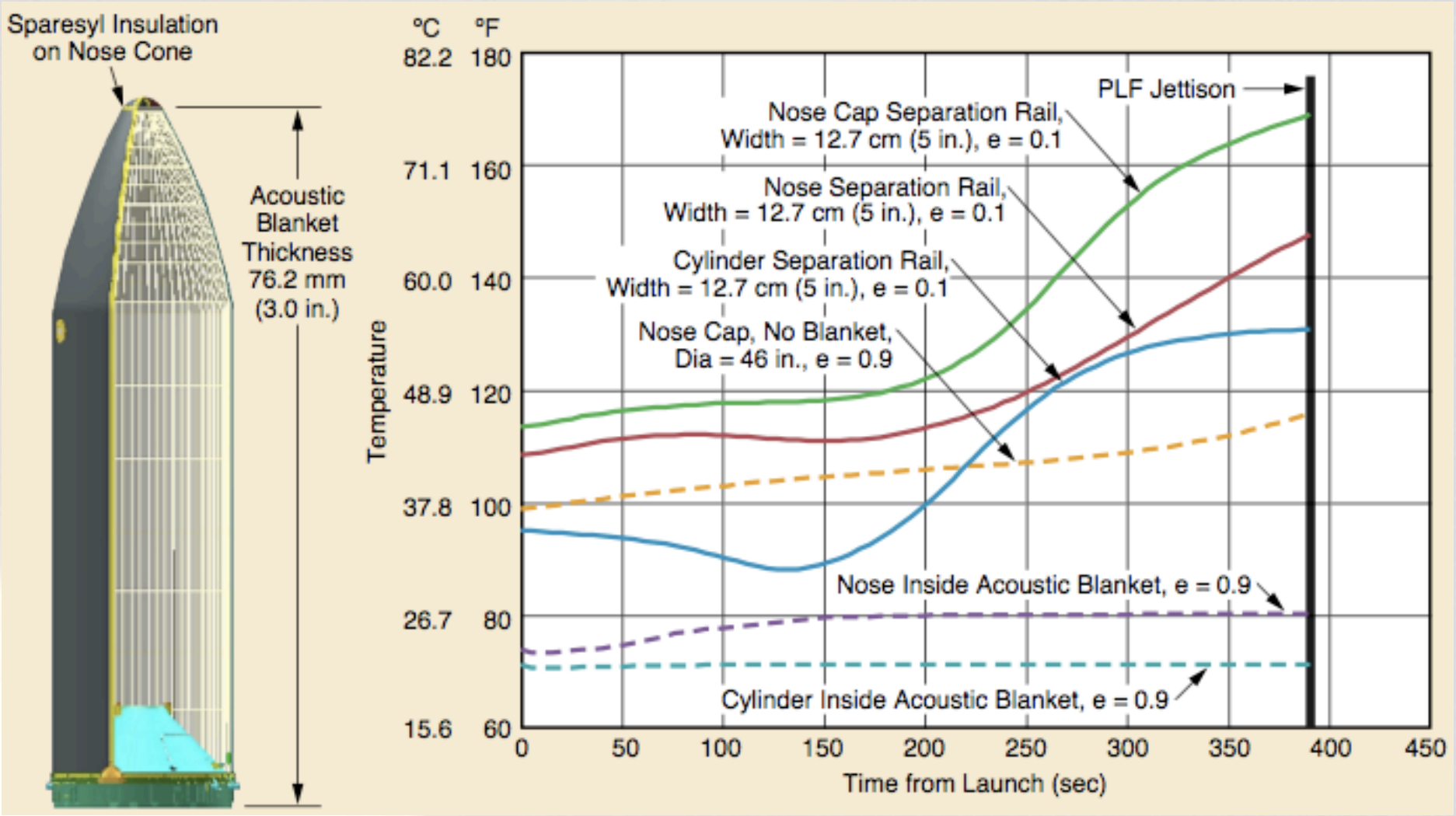
Delta Payload Fairings



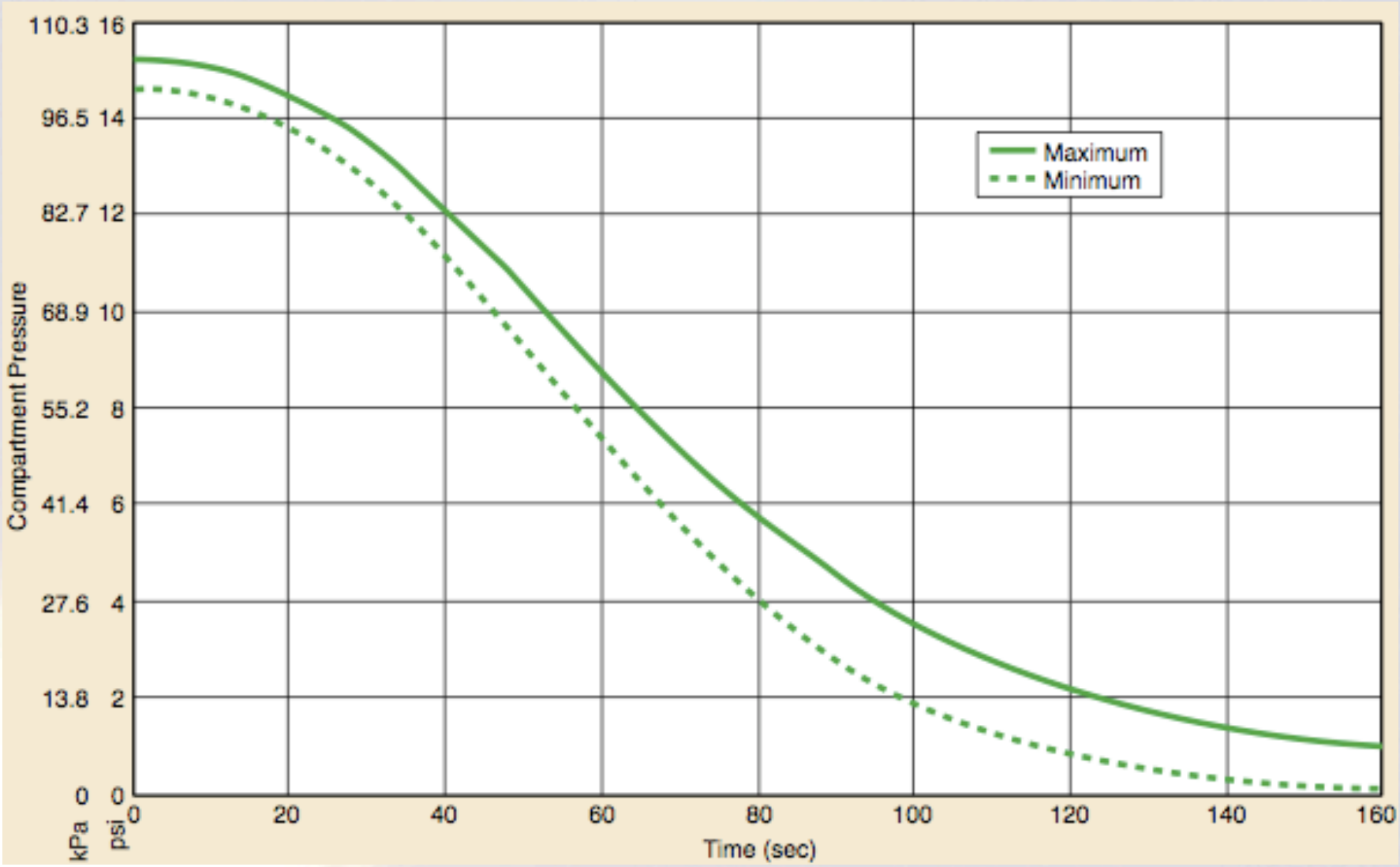
Delta Metallic Fairing Temperatures



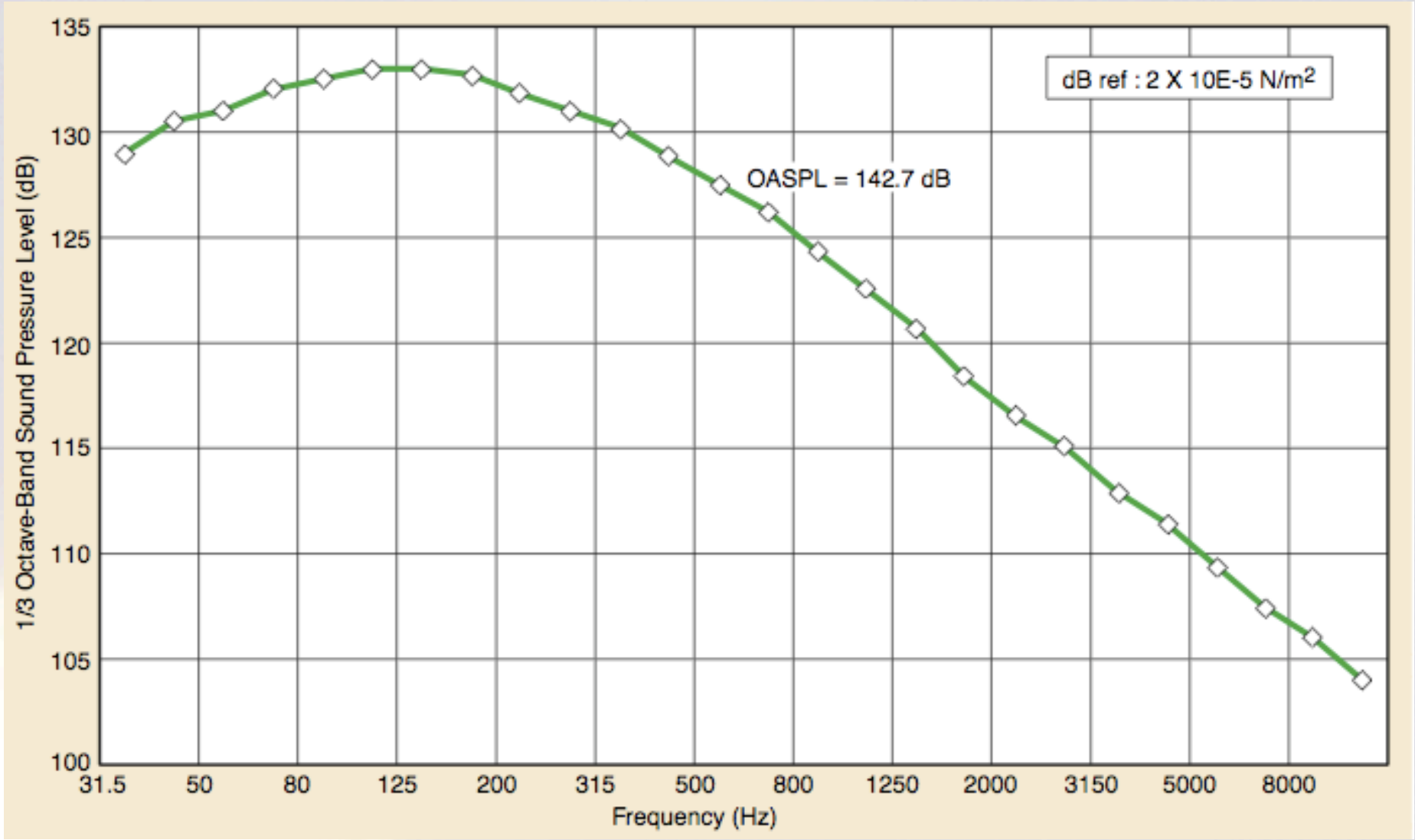
Delta Composite Fairing Temperatures



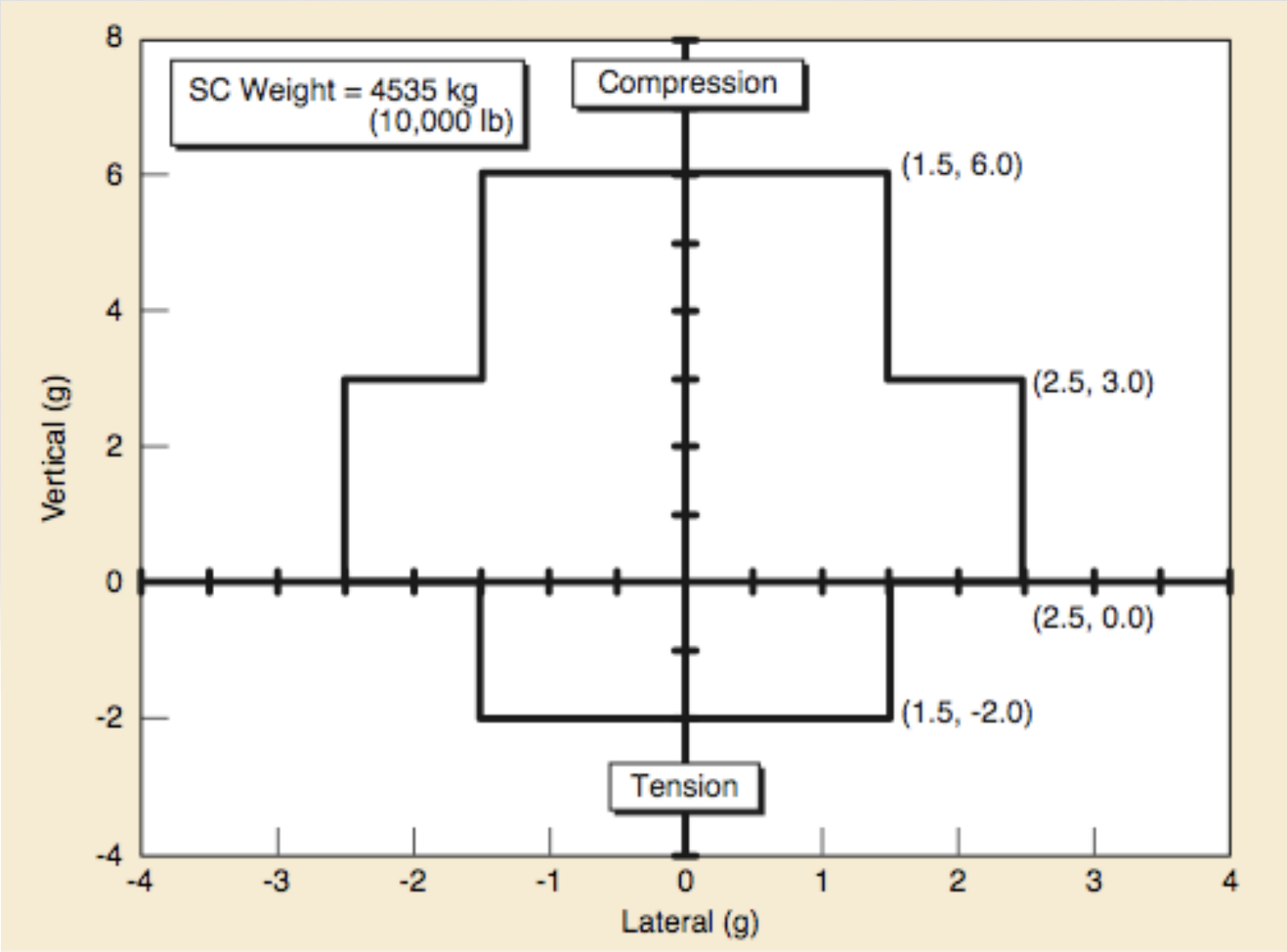
Delta IV Heavy Payload Venting



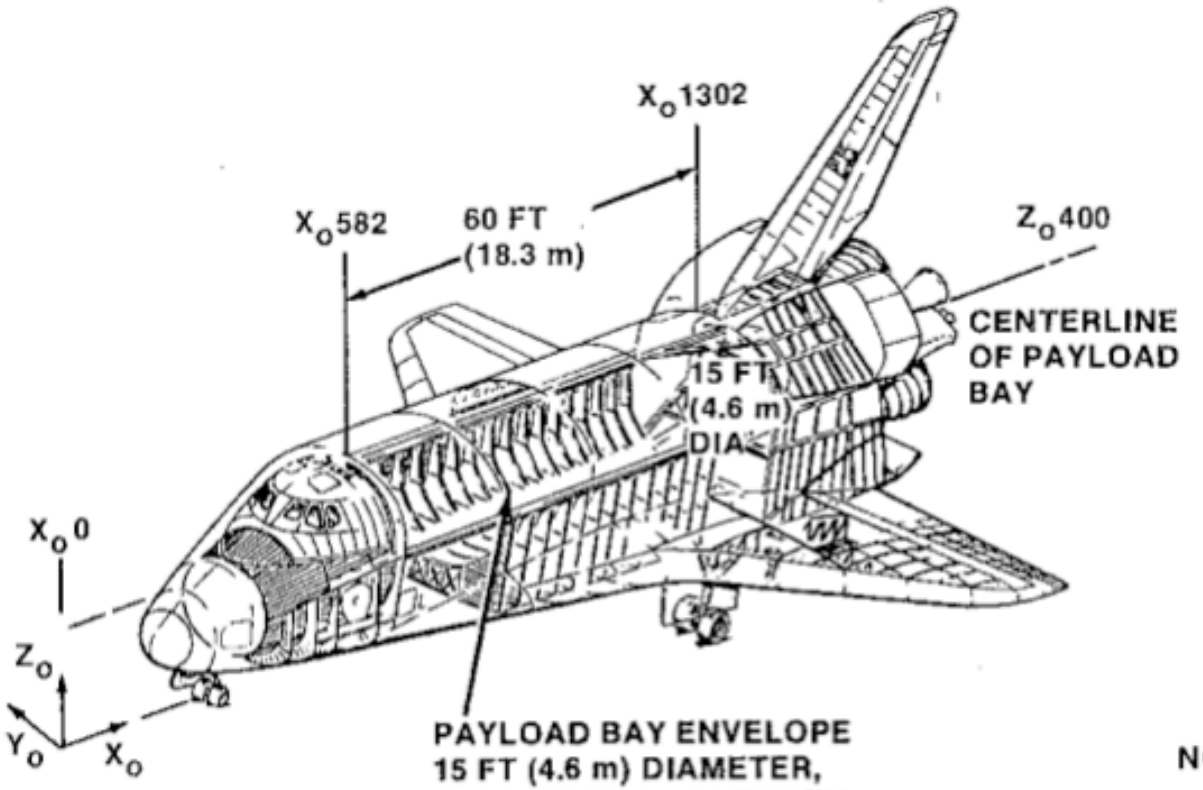
Delta IV Heavy Acoustic Environment

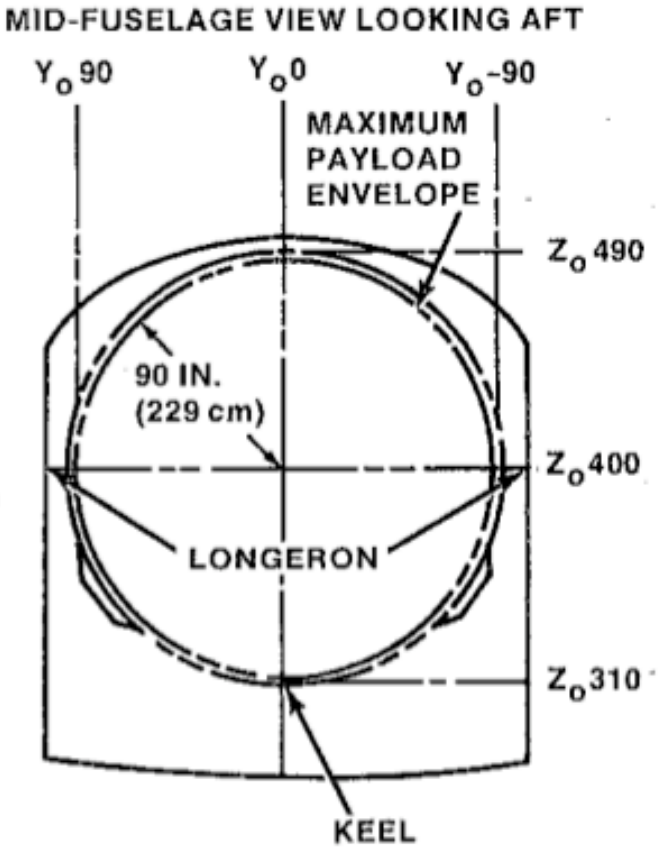


Delta IV Heavy Dynamic Loads Envelope



Orbiter Payload Bay Envelope

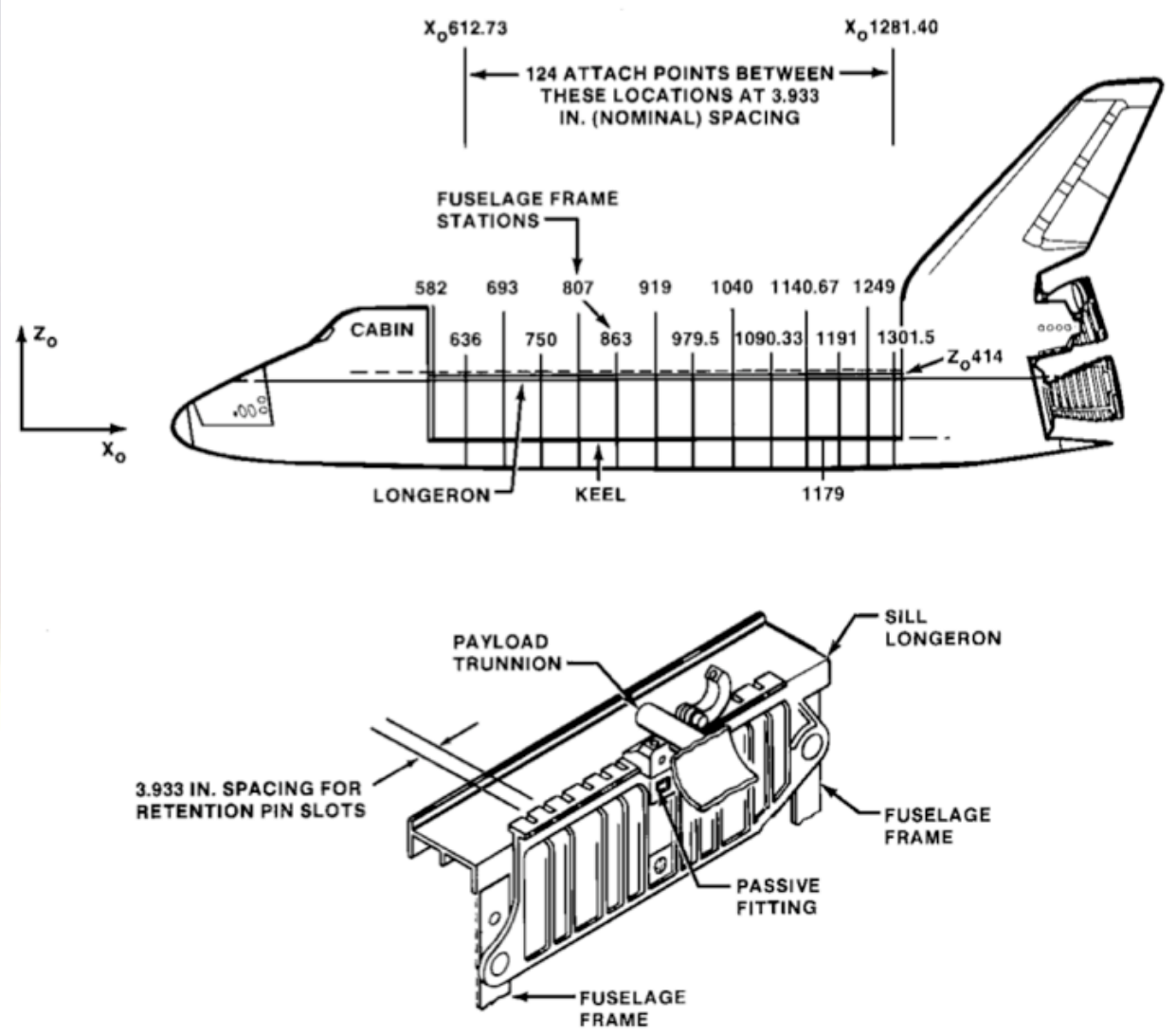




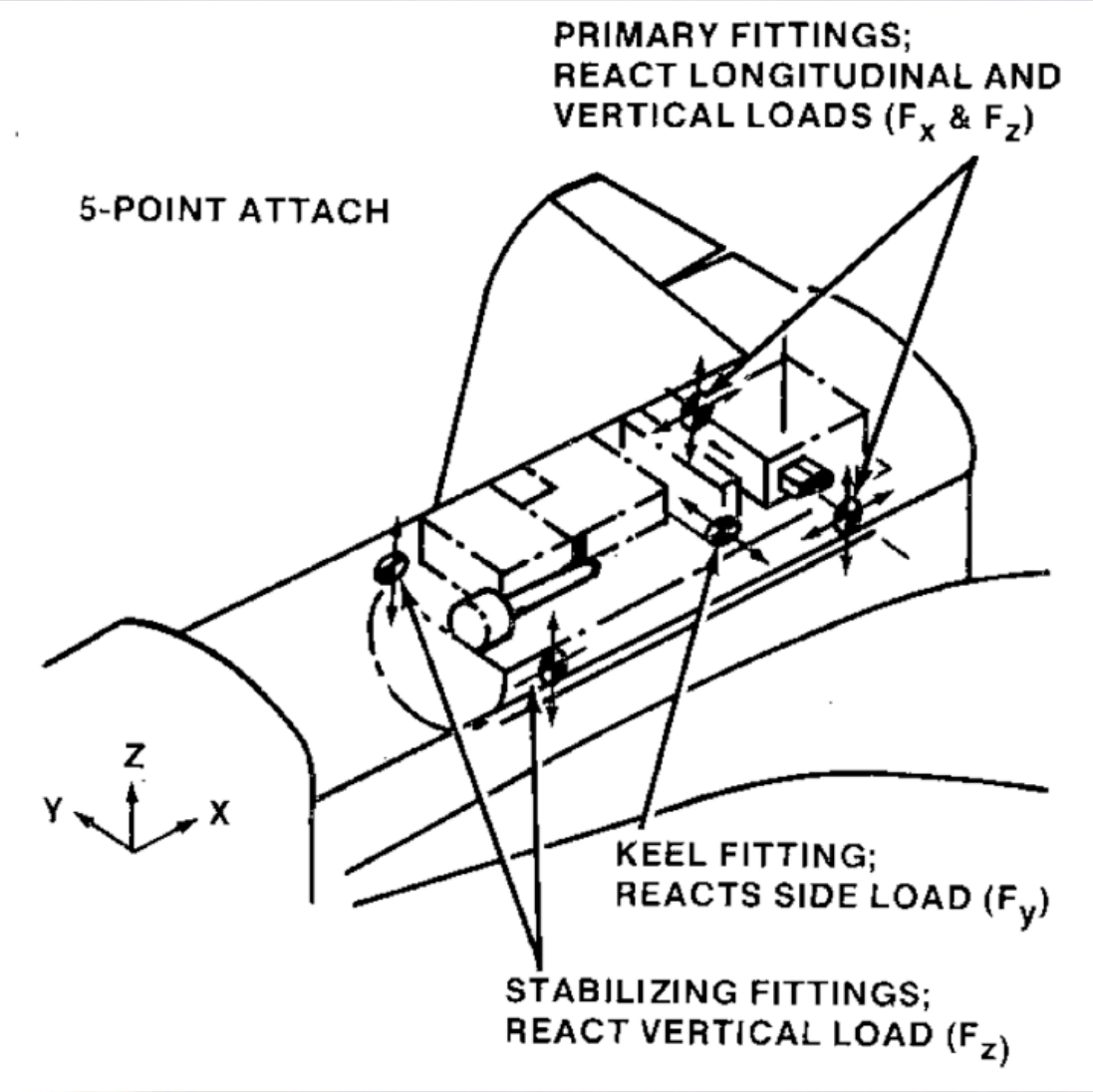
NOTE:
CENTER OF 90 IN. ENVELOPE @ Z_o400
LONGERON ATTACH @ Z_o414

app4g2

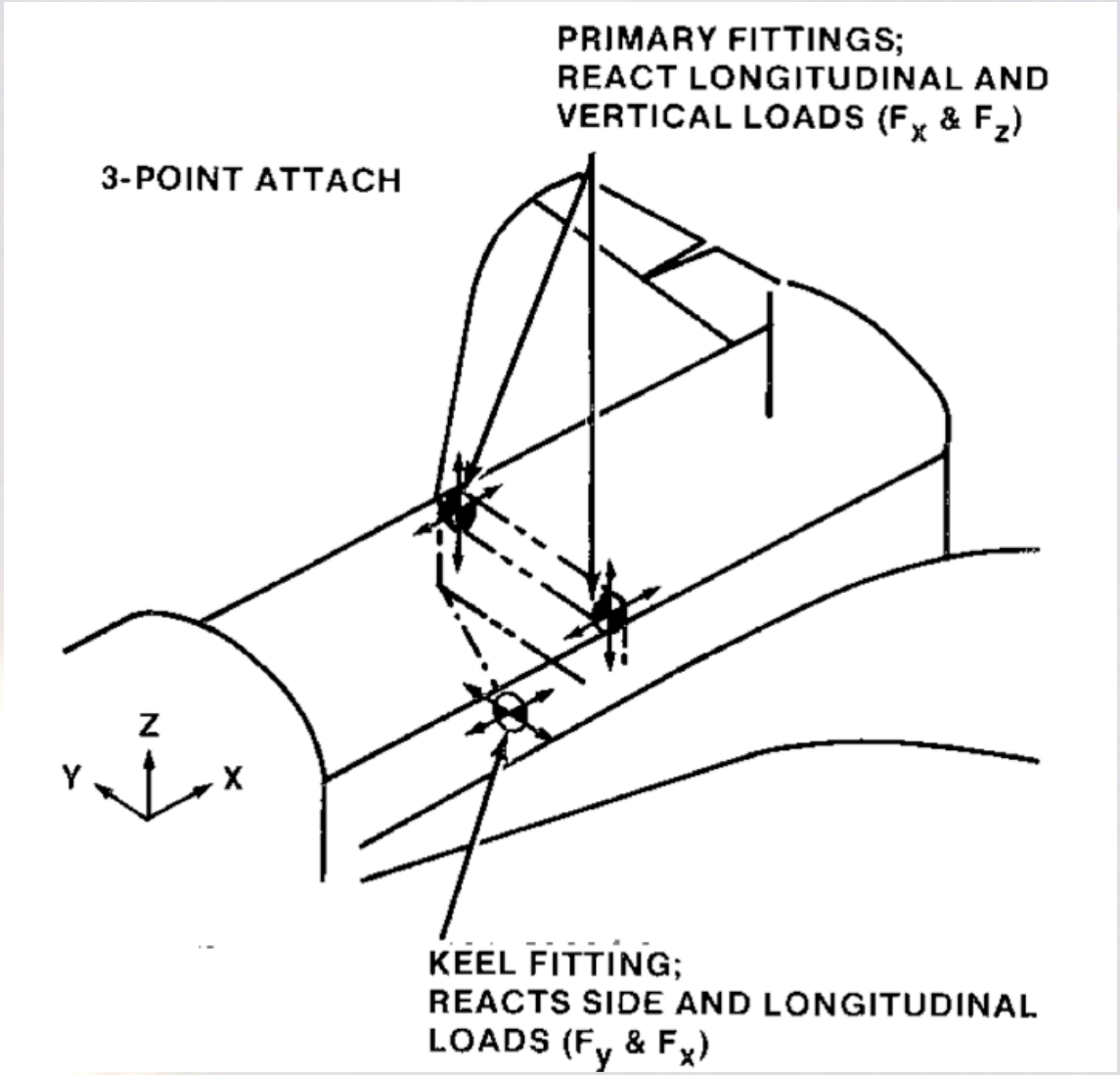
Orbiter Longeron Bridge Fittings



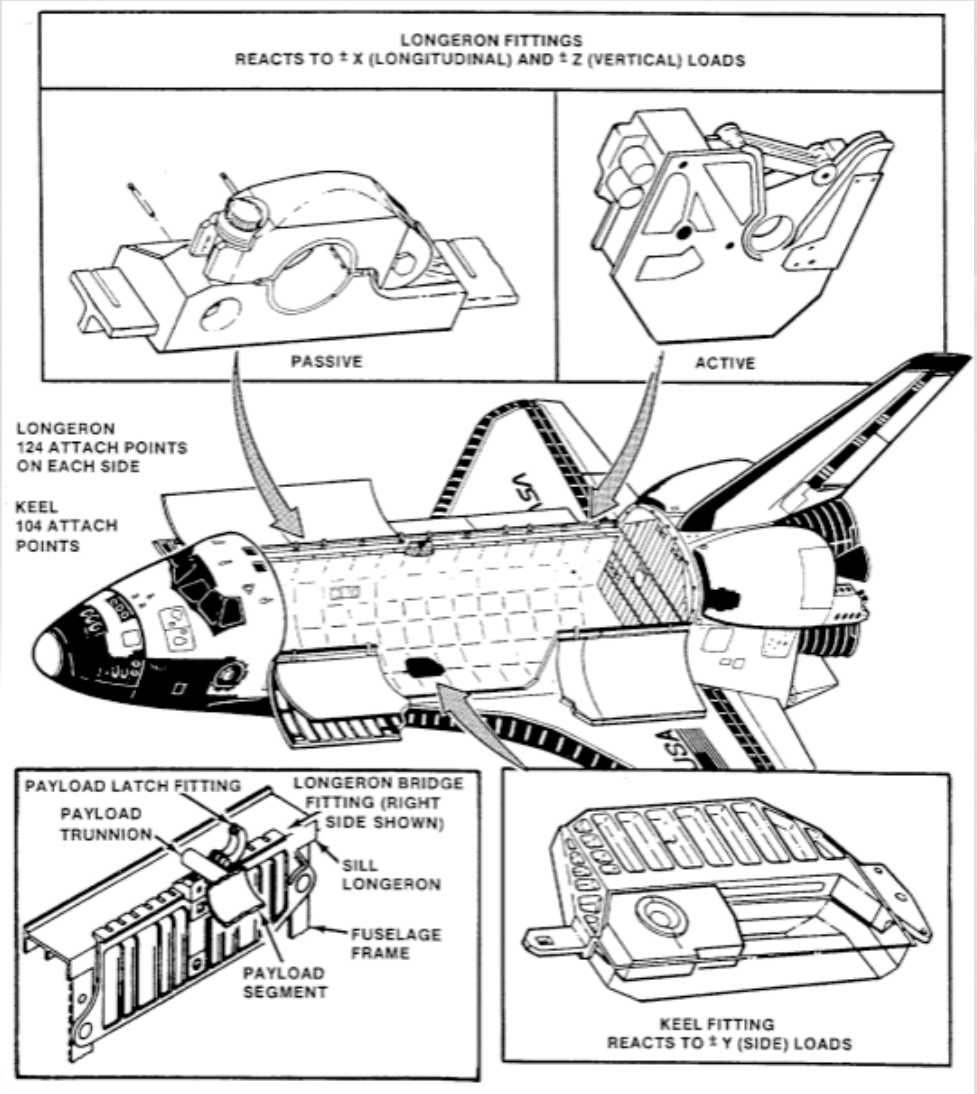
Orbiter Five-Point Attach System



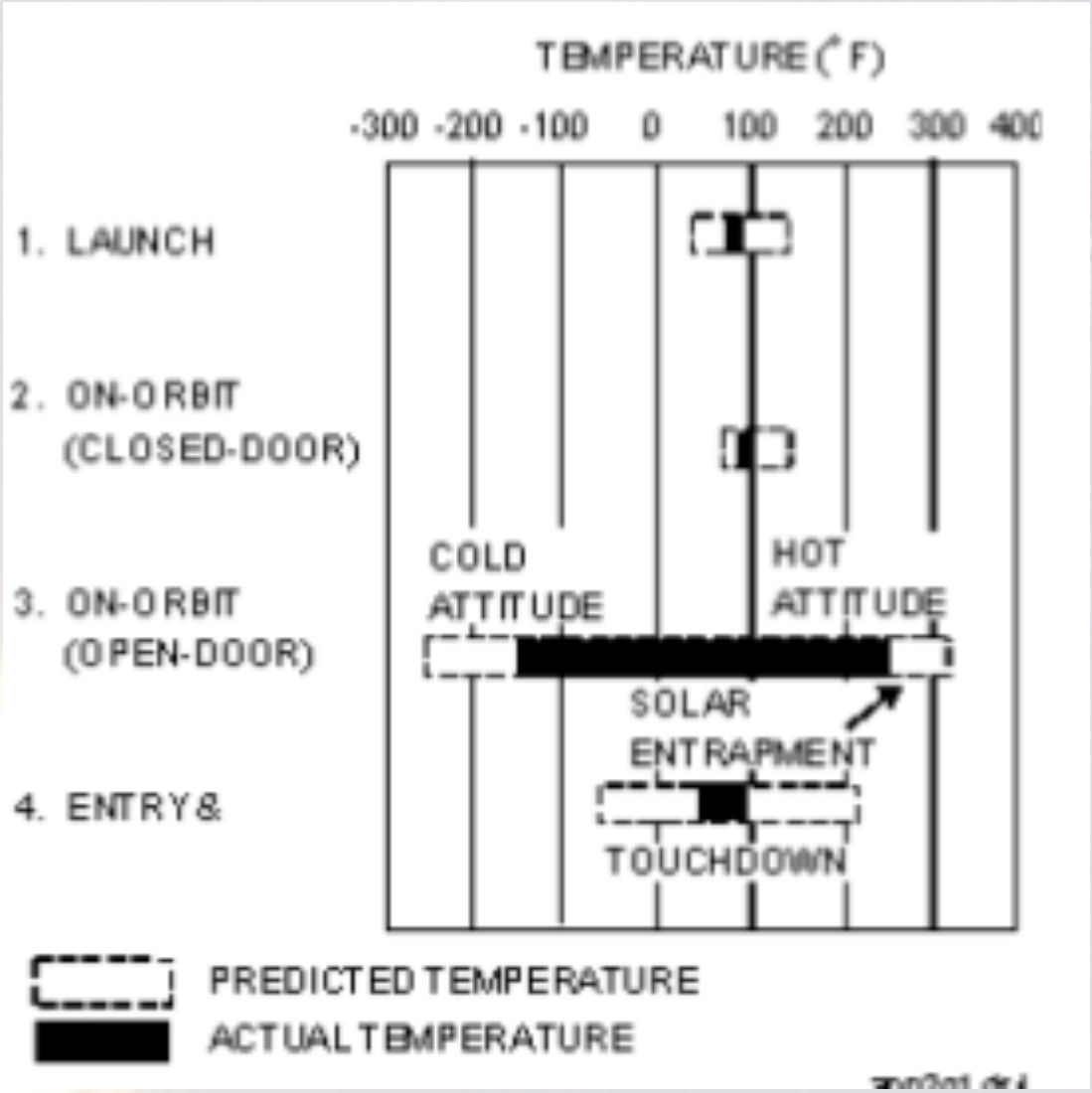
Orbiter Three-Point Attach System



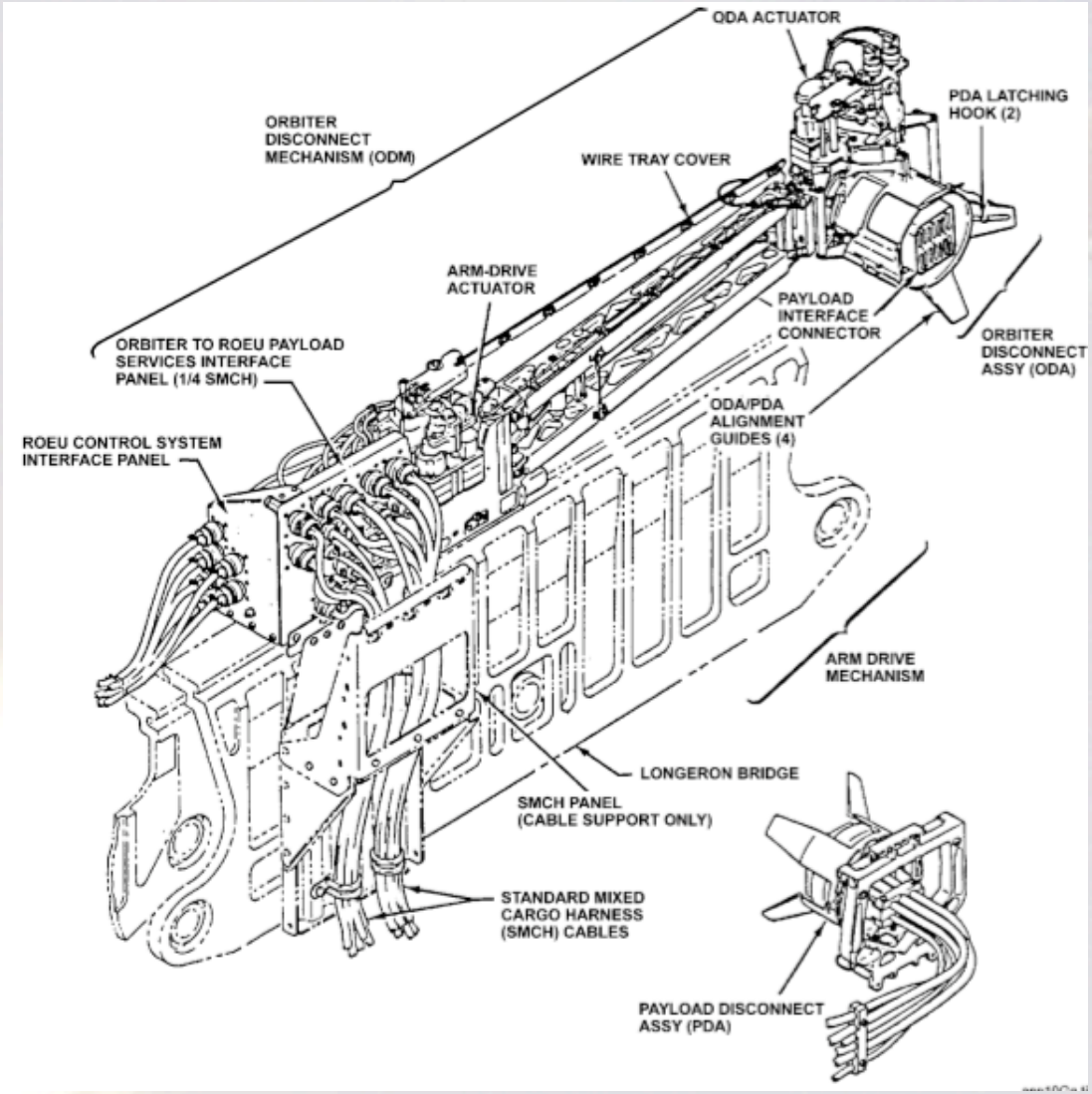
Orbiter Payload Attach Fittings



Shuttle Payload Bay Temperatures



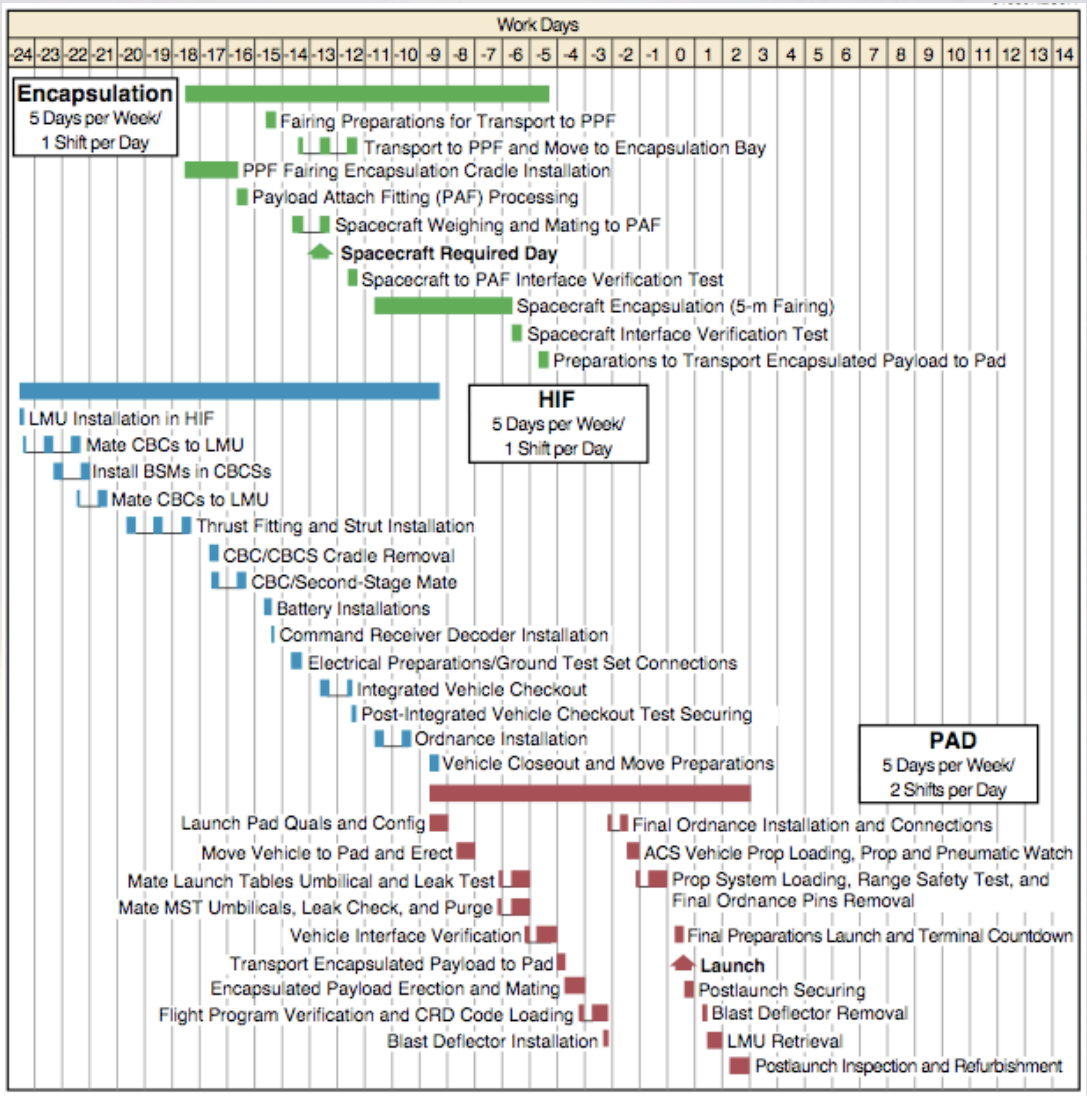
Orbiter ROEU



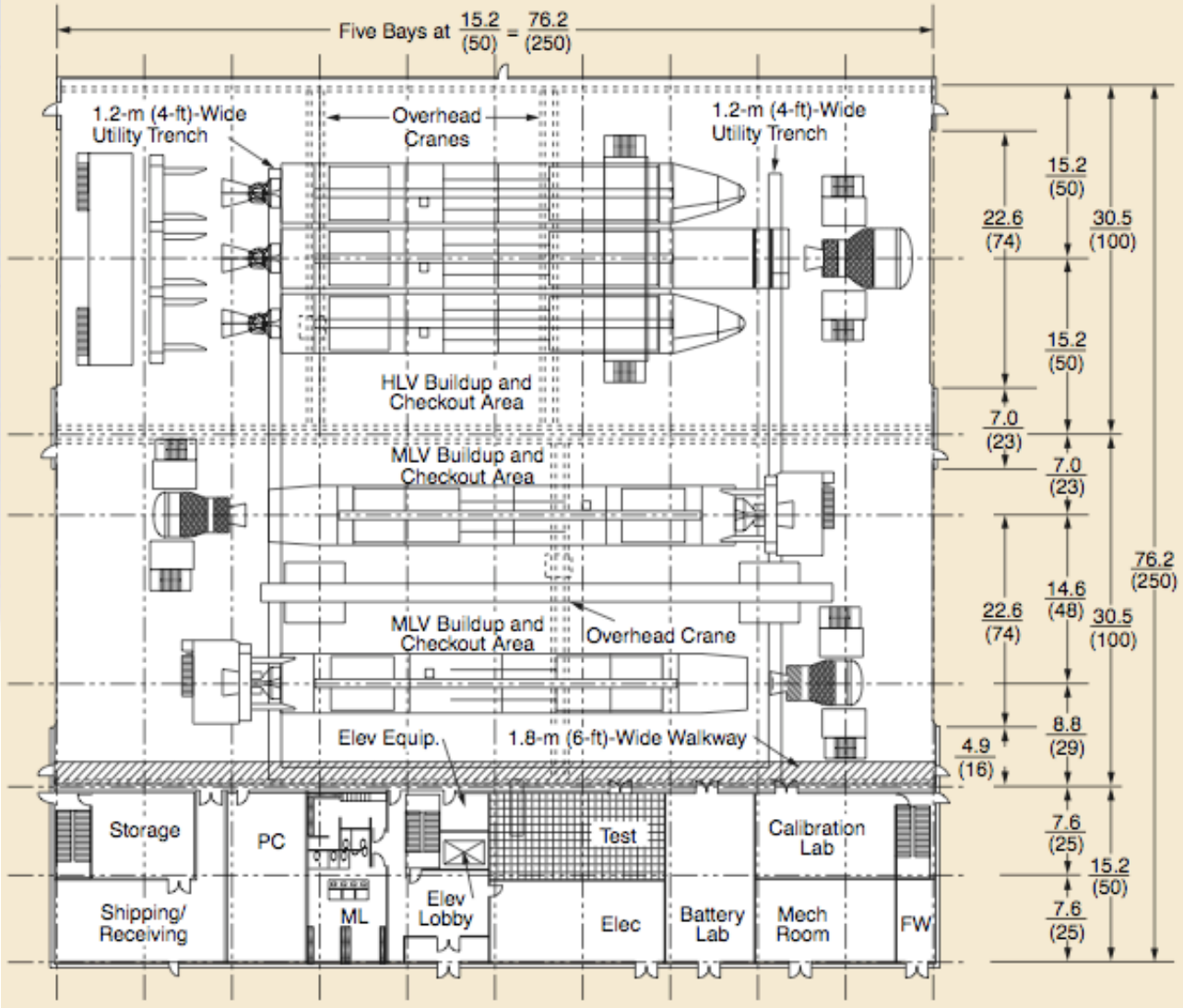
Payload Qualification Testing

- Structural load testing (flight x 1.25)
- Acoustic load testing (flight + 3 dB)
- Sinusoidal vibration testing (flight + 3 dB at 2 octaves/min sweep rate)
- Shock testing (actuation of pyrotechnics)

Delta IV Heavy Launch Processing Flow

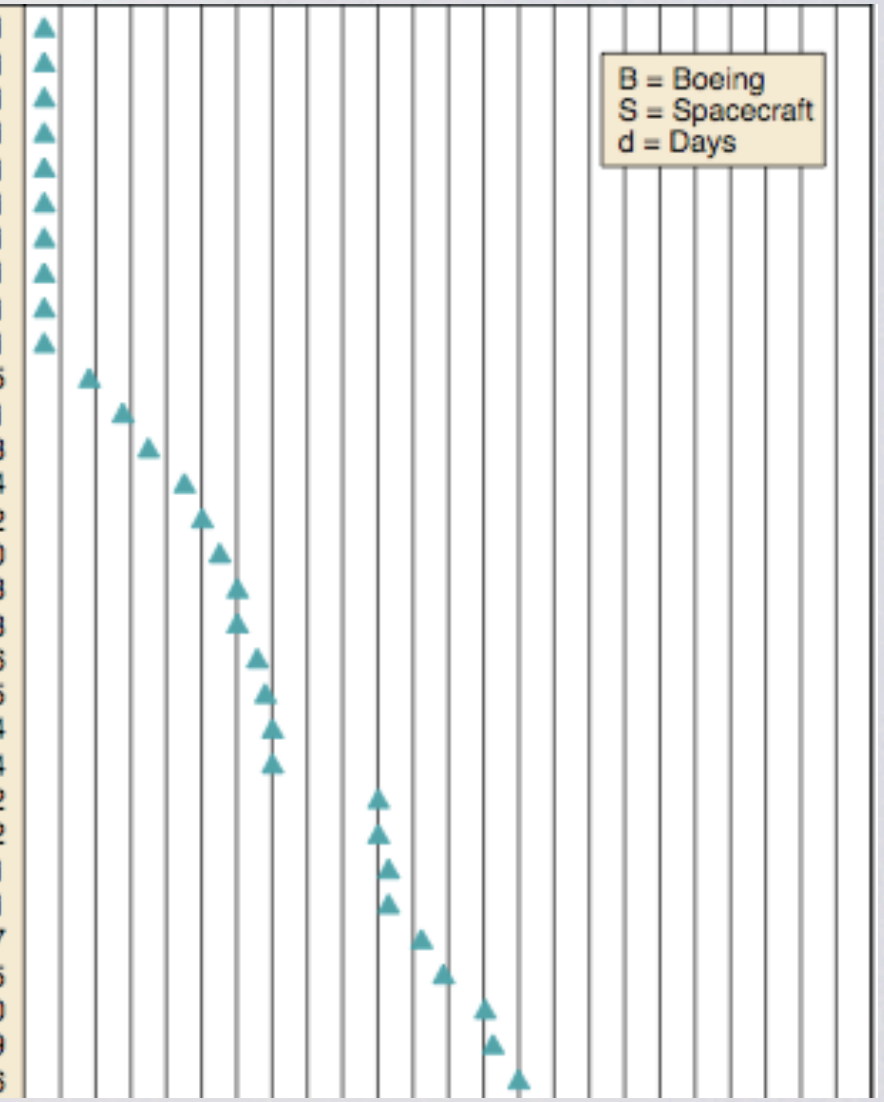


Delta IV Horizontal Integration Facility



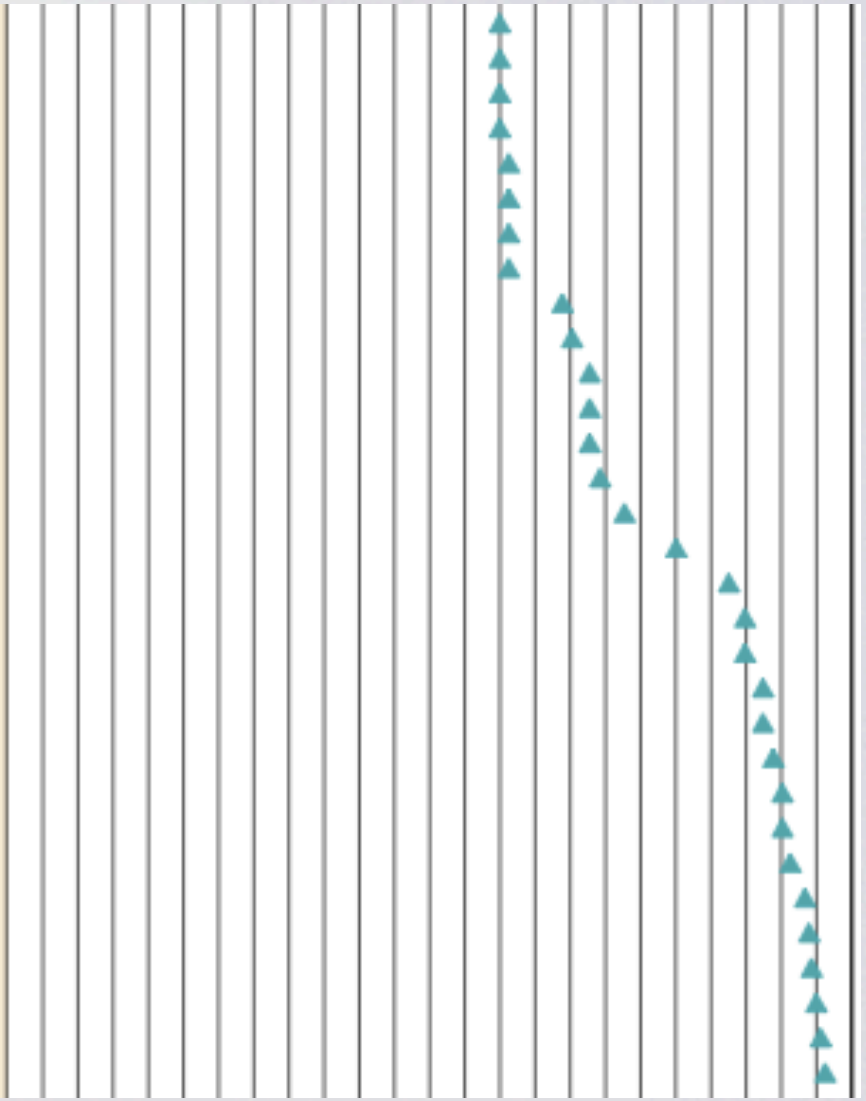
Integration Documentation (part 1)

1. Spacecraft Questionnaire	S	L-91
2. Fairing Requirements	S	L-91
3. SC Drawings	S	L-91
4. SC Mass Properties Statement	S	L-91
5. SC Environmental Test Document (Test Plan)	S	L-91
6. MSPSP Inputs	S	L-91
7. Preliminary Mission Analysis (PMA) Rqmts	S	L-91
8. Program Requirements Document - SC Inputs	S	L-91
9. Mission Operations and Support Requirements	S	L-91
10. P/L Processing Requirements Document Inputs	S	L-91
11. SC Mathematical Model	S	L-85
12. Separation Analysis	B	L-81
13. Mission Specification (Initial)	B	L-78
14. Program Requirements Document (PRD)	B	L-74
15. SC Launch Site Operations Plan (Initial)	S	L-72
16. Plume/Contamination Analysis Report	B	L-70
17. Payload Compatibility Drawing (Initial)	B	L-68
18. SC-to-Control Center Wiring Diagram (Initial)	B	L-68
19. Coupled Dynamic Loads Analysis (FDLC)	B	L-66
20. Radio Frequency Applications Inputs	S	L-65
21. Mission Specification Review (Initial)	S	L-64
22. SC Compatibility Drawing Comments (Initial)	S	L-64
23. Radio Frequency Applications (RFA)	B	L-52
24. DOT License Information	S	L-52
25. SC-to-Control Ctr Wiring Requirements (Initial)	S	L-51
26. Preliminary Mission Analysis	B	L-51
27. SC Ctrl Ctr Wiring Diagram Comments (Initial)	S	L-47
28. DOT License Application	B	L-45
29. SC Compatibility Drawing	B	L-40
30. Mission Specification (Final)	B	L-39
31. SC Mass Properties Statement (Update)	S	L-36



Integration Documentation (part 2)

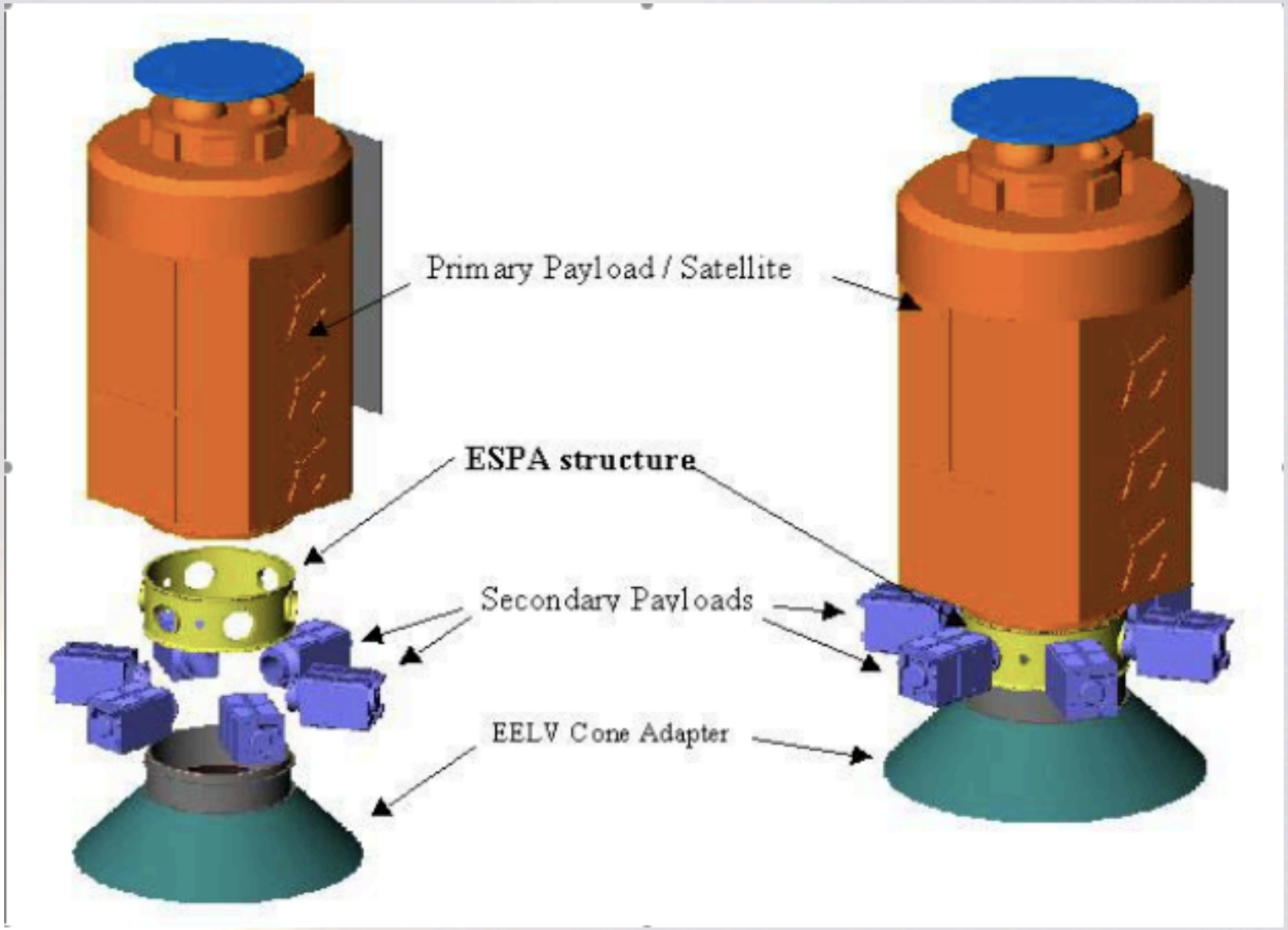
32. Real-Time Tracking Data Requirements	S	L-36
33. SC-to-Control Ctr Wiring Diagram Comm (Final)	B	L-36
34. Mission Specification Review (Review)	S	L-36
35. SC Clearance Drawing	S	L-36
36. SC-to-Control Center Wiring Diagram (Final)	B	L-35
37. Launch Vehicle Insignia	S	L-35
38. Final Mission Analysis (FMA) Requirements	S	L-35
39. Launch Window (Initial)	S	L-35
40. Spacecraft Thermal Model	S	L-29
41. Coupled Dynamic Loads Analysis (LVC)	B	L-28
42. Delta IV/SC Combined Ops Reqmts Doc (OR)	B	L-26
43. SC Integrated Test Procedure	S	L-26
44. SC Launch Site Procedures	S	L-26
45. Final Mission Analysis (FMA)	B	L-25
46. Thermal Analysis Report	S	L-22
47. SC/Fairing Clearance Analysis (Initial)	B	L-16
48. MSPSP (Final)	B	L-10
49. Launch Window (Final)	S	L-08
50. SC Mass Properties Statement (Final)	S	L-08
51. Launch Site Procedures	B	L-06
52. SC Launch Site Operations Plan (Final)	S	L-06
53. Launch Operations Plan (LOP)	B	L-05
54. Best-Estimate Trajectory	B	L-04
55. Vehicle Information Memorandum (VIM) Data	B	L-04
56. SC/Fairing Clearance Analysis	B	L-03
57. RF Compatibility Analysis Report	B	L-01
58. Vehicle Information Memorandum (VIM)	B	L-4d
59. Launch Readiness Review Data Package	B	L-1d
60. Launch	B	L-0
61. Post-Launch Report	S	L+2hr
62. Post-Launch Orbit Confirmation Data	B	L+7d



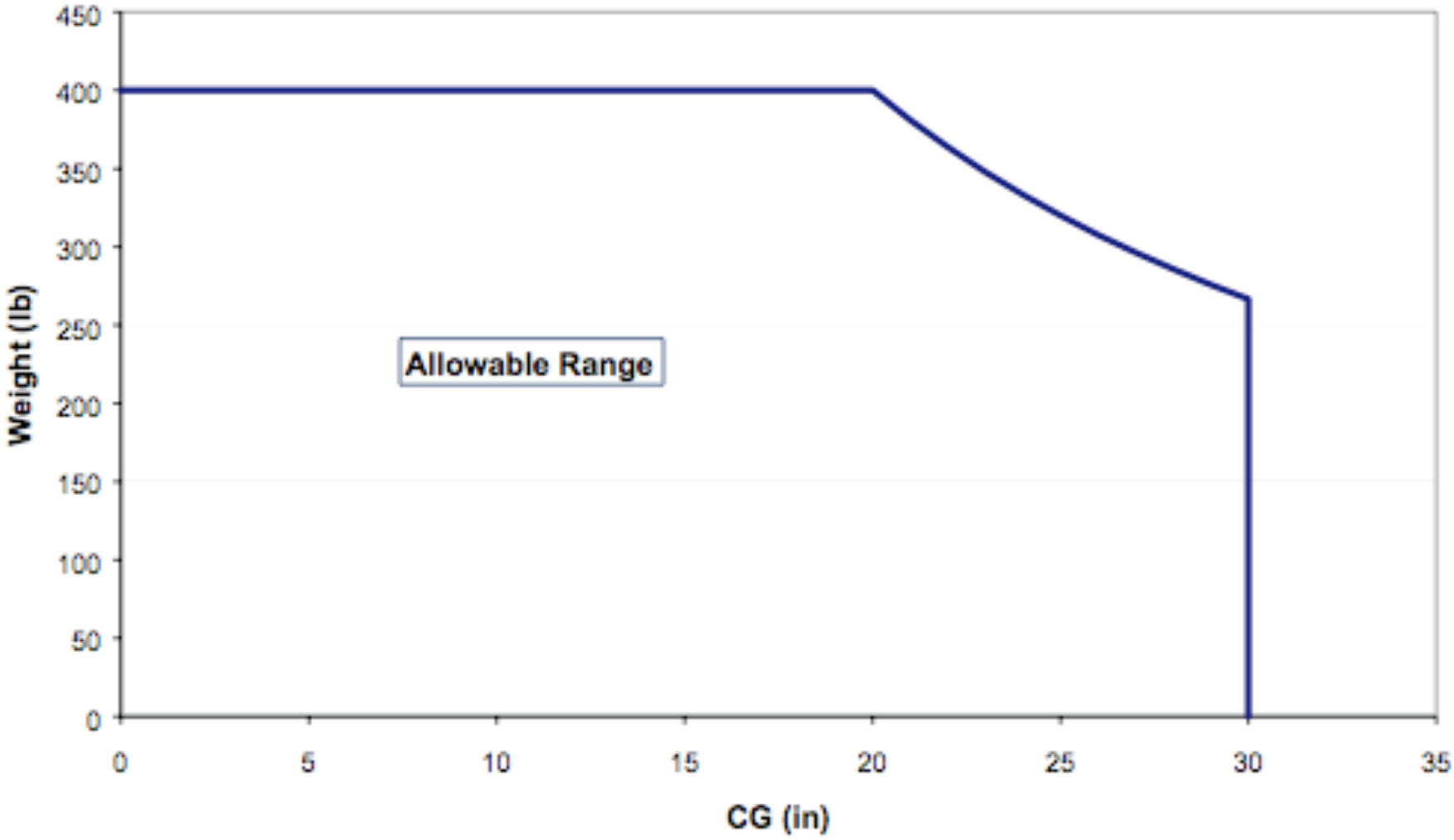
Spacecraft Contractor Data Requirements

Spacecraft Questionnaire	2	L-91
Fairing Requirements	8	L-91
SC Drawings	18	L-91
SC Mathematical Model	3	L-91
Preliminary Mission Analysis (PMA) Inputs	11	L-91
Missile System Prelaunch Safety Package SC Inputs	9	L-91
SC Mass Properties Statement (Initial/Update)	22	L-91/L-36
SC Environmental Test Documents	5	L-85
Mission Specification Comments	4	L-64
SC Compatibility Drawing Comments	18	L-64
SC-to-LCC Wiring Diagram Review	28	L-64
Mission Operational and Support Requirements	12, 13	L-52
Payload Processing Requirements Document	14	L-52
FAA License Information	2	L-52
Radio Frequency Applications Inputs	10	L-52
Electrical Wiring Requirements	7	L-51
Launch Vehicle Insignia	15	L-35
Final Mission Analysis (FMA) Inputs	17	L-35
SC Integrated Test Procedure	21	L-26
SC Launch-Site Procedures	20	L-26
Launch Window (Initial/Final)	16	L-08
Postlaunch Orbit Confirmation Data	27	L+2 hr

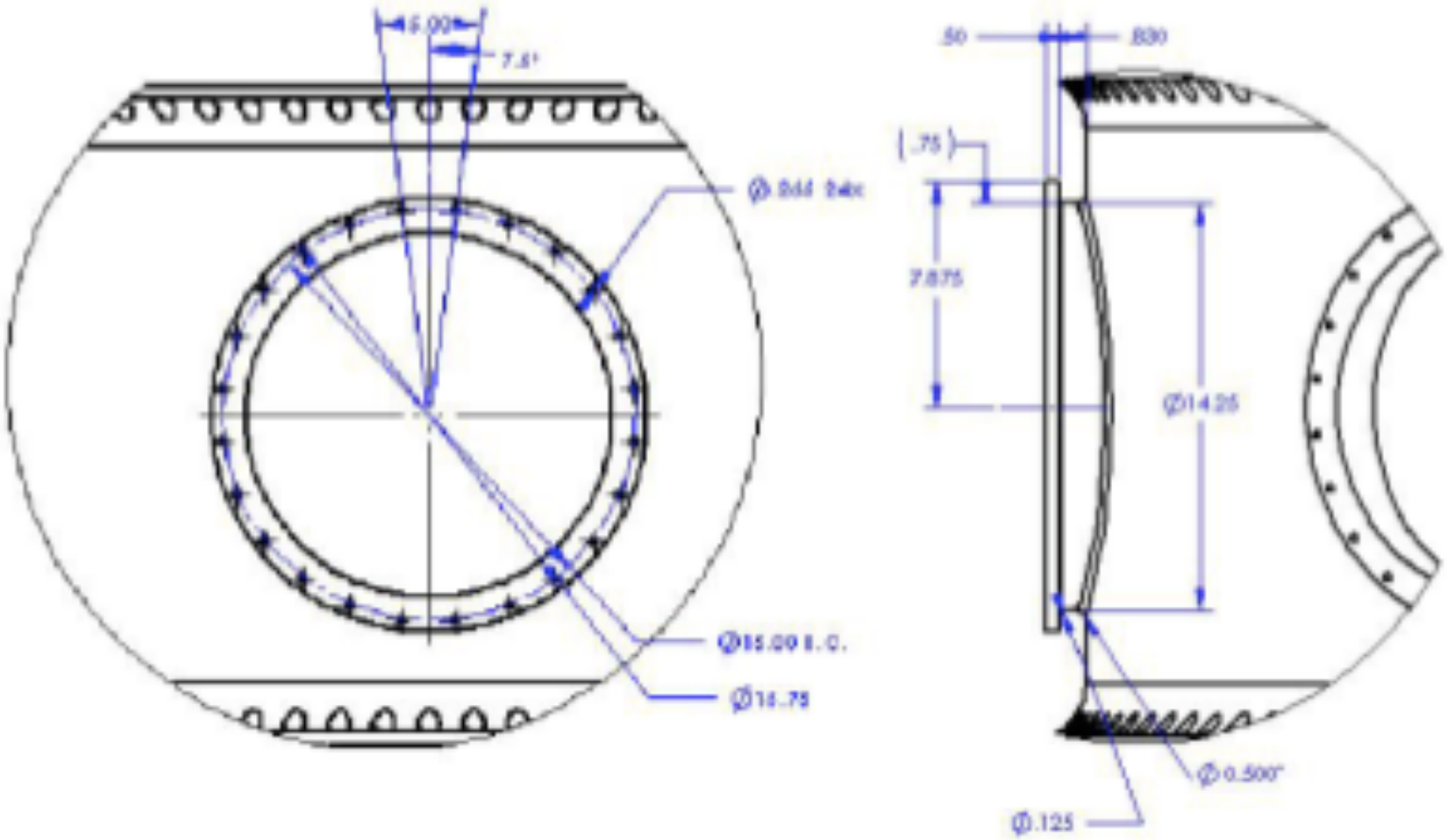
EELV Secondary Payload Adapter (ESPA)



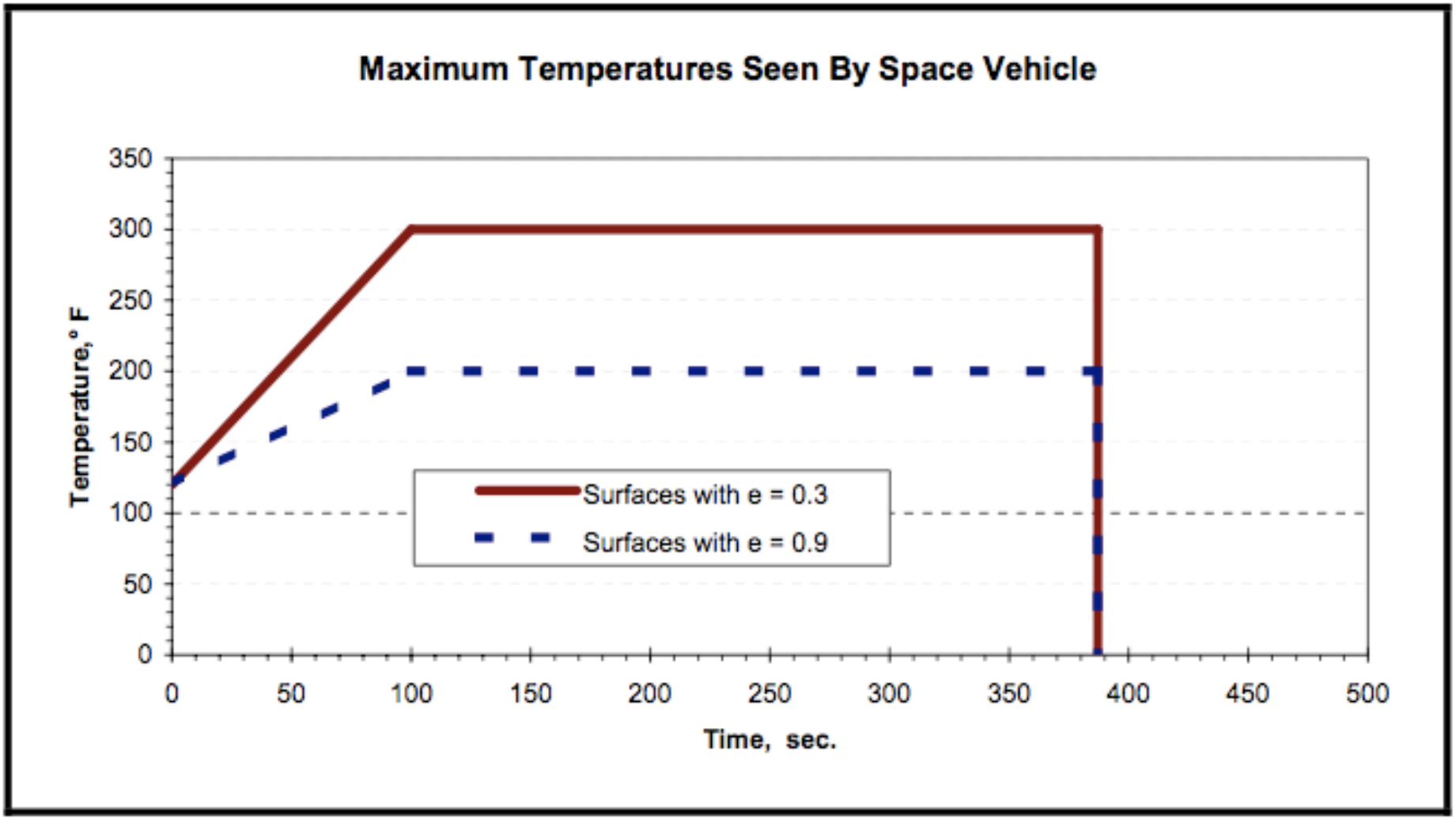
ESPA Mass/CG Limitations



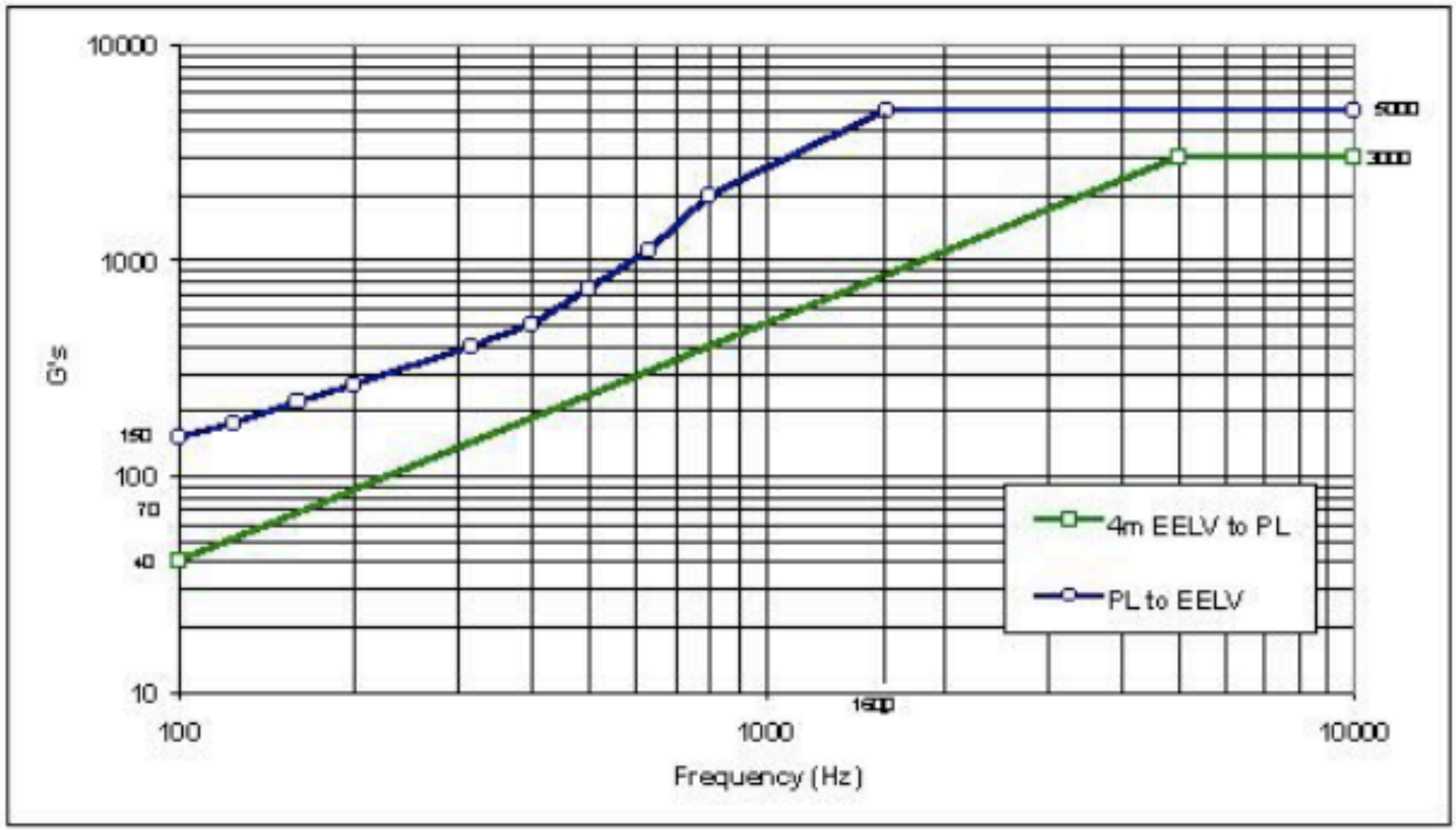
ESPA Mechanical Interface



ESPA Surface Temperature Profiles



ESPA Shock Environment



Final Thoughts about Payloads

- Payload development details are specific to the launch vehicle
- Integration processes are unique to the individual launch site
- Every launch is a custom operation
- Payload documentation for launch is comparable to complexity of payload itself
- But there's nothing like seeing your payload heading to orbit!!!