TASOPT B737-800 Candidate 004 V&V Report

APD-only non-optimization calibration and joint constraint verification

ACCEPTED FOR THE CURRENT VALIDATION STAGE - all four APD mission-1 weight gates and all 14 current constraint rows pass.

4 / 4	14 / 14	1.91%	178
APD weight gates pass	Constraint rows pass	Mission-1 fuel margin	Project tests passed

Model identity and scope

Item	Value
Model	models/nonopt_candidate_004_joint_feasible_design.toml
Model SHA-256	956331e9157557abb668025b8716ccad30d4ef5aaf1dc3233d6070a1a694009a
Parent	Candidate 003 joint span/BFL/fuel design
TASOPT missions	6 (mission 1 sizing/calibration; missions 2-6 reporting-only)
Calibration source	Official Boeing 737-800 APD mission-1 targets only
Post-load mutation	None

Executive finding

Candidate 004 closes the Candidate 002 span and BFL failures while retaining the user-supplied wing and propulsion point as the preserved optimization seed. The final validation model passes the approved +/-5% APD weight policy, geometric mission fuel capacity, span, BFL, top-of-climb, thermal, fan diameter, and fan/LPC ordering checks.

Design lineage and preserved optimization seed

Candidate	Role	Disposition	Measured outcome
001	Weight-assumption trial	Revised	Three weight gates pass; MTOW and fuel capacity fail
002	Exact user seed point	Revised	All weight gates pass; span and BFL fail
003	Joint span/BFL/fuel design	Revised	All constraints pass; MLW misses lower gate by 186 lb
004	Final fixed-weight correction	Accepted	All four weight gates and all 14 constraints pass

Exact user-supplied Candidate 002 seed

The 14 user values were applied exactly before correction. Candidate 002 remains the reproducible initial point for later optimization.

Parameter	Exact seed value	Unit
Wing sweep	26.82690332526325	deg
Wing AR	9.540469254047448	-
Inner / outer taper	0.8313638871346632 / 0.18	-
Root / break t/c	0.13 / 0.14	-
Clean cls/clo / clt/clo	1.3999988236421035 / 1.3407113136832642	-
Tt4 takeoff / cruise	1740.684089267033 / 1463.0590941767673	K
BPR / OPR	5.513139728564802 / 27.8806015	-
Fan PR / LPC PR	1.7300218353151775 / 2.3613810158828255	-

Validation-stage adjustments after the user seed

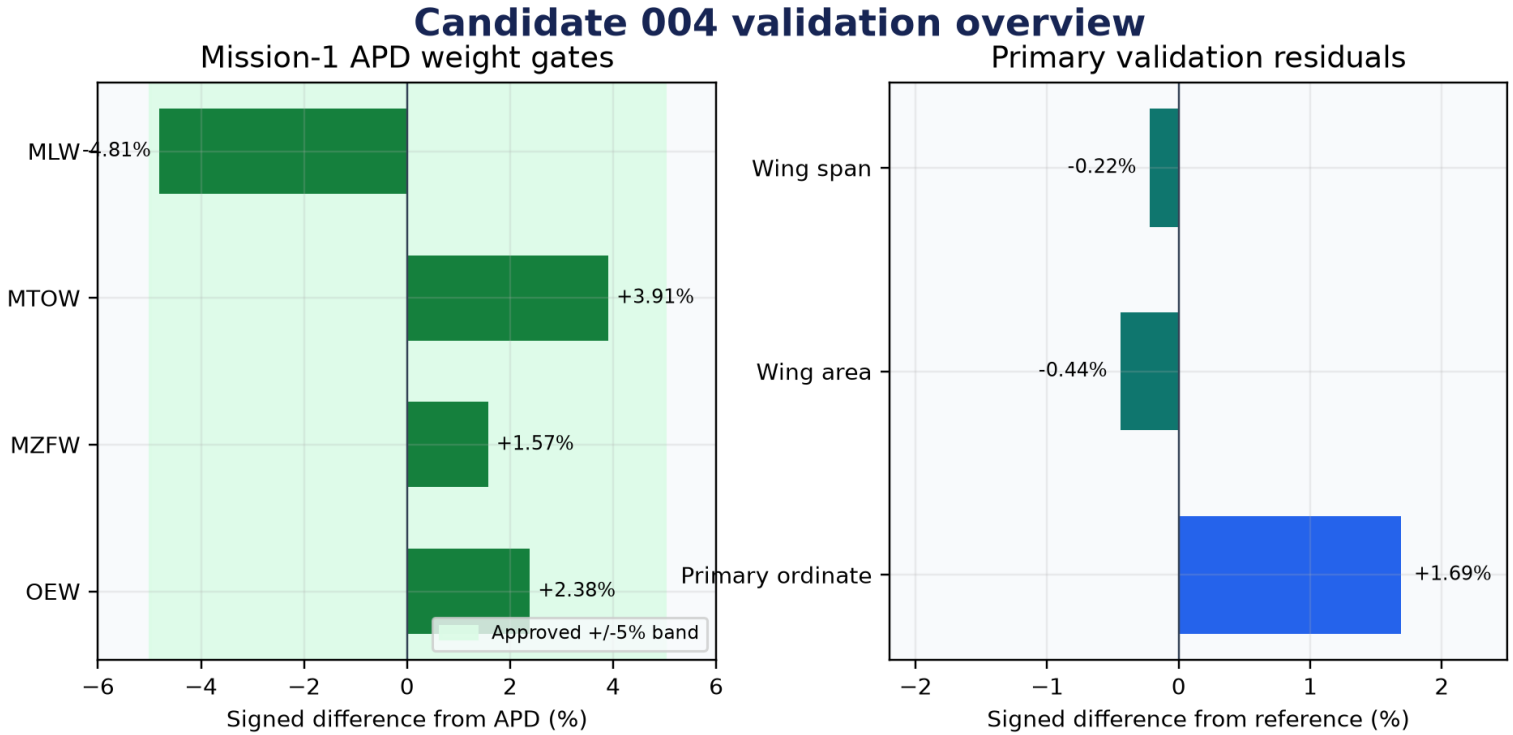
These six pre-registered changes are model/design assumptions used to reach joint validation feasibility; they are not claimed as APD component observations.

Field	Old	New	Recorded reason
Mission.Takeoff.CL_max_perp	2.25	2.45	Use the measured CLmax sensitivity to target BFL at or below the unchanged 7000-ft APD requirement.
Mission.Cruise.cruise_CL[1]	0.57	0.593	Interpolate the measured cruise-CL sensitivity to reduce span with less fuel-capacity and MLW penalty than CL=0.60.
Wing.AR	9.5404693	9.46468	Return from the preserved user optimization seed to the reviewed APD span-area aspect ratio for this validation design.
Wing.box_width_to_chord	0.5	0.525	Increase internal spar-box width to restore geometric fuel capacity after reducing sized wing area.
Fuselage.Weights.fixed_weight	2700 lbf	3200 lbf	Apply an explicit fixed-weight rebalance to keep the MLW comparator away from its lower acceptance boundary after smaller-wing sizing.
Fuselage.Weights.fixed_weight	3200 lbf	3500 lbf	Candidate 003 MLW was 185.63 lb below the approved lower acceptance boundary; apply a single explicit fixed-weight correction.

Interpretation

Mission-1 cruise CL and AR reduce sized area/span; internal box width restores geometric fuel capacity; takeoff CLmax closes BFL; the fixed-weight correction moves MLW just inside its lower +/-5% boundary. The final design retains the user's sweep, taper ratios, thickness ratios, clean lift distribution, and all supplied propulsion seeds.

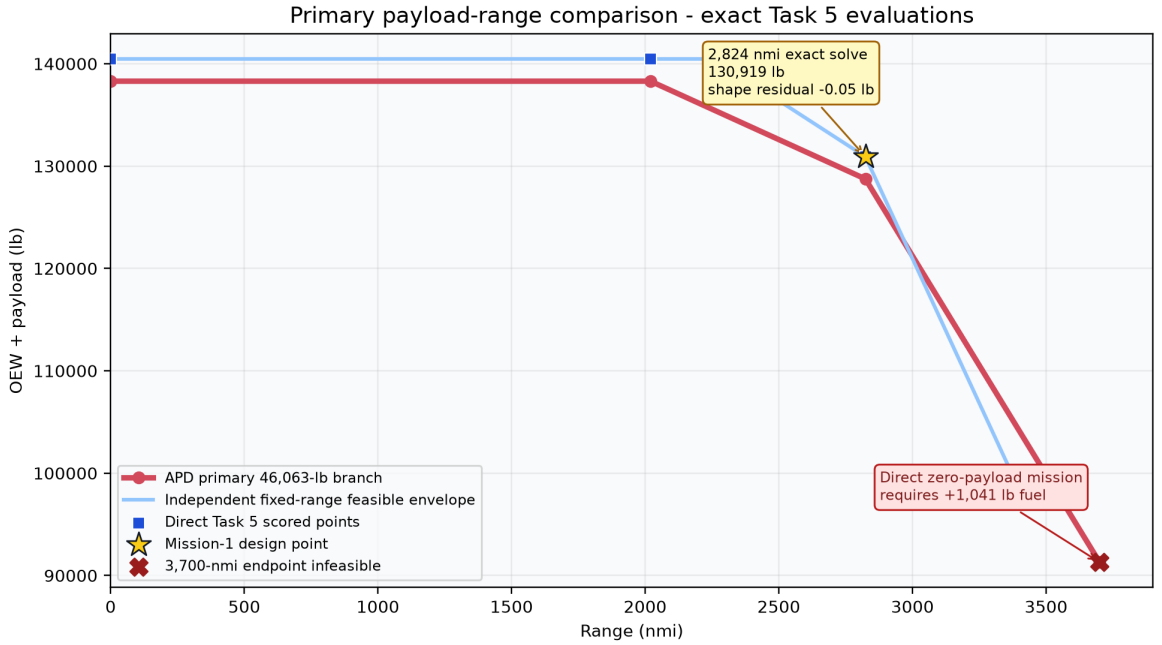
Mission-1 APD validation



Quantity	APD lb	Candidate lbf	Difference	Gate	Status
MTOW / brake-release gross weight	174,200.0	181,002.6	+3.91%	+/-5%	pass
Operating empty weight	91,300.0	93,473.2	+2.38%	+/-5%	pass
Maximum zero-fuel weight	138,300.0	140,473.2	+1.57%	+/-5%	pass
Maximum landing weight	146,300.0	139,266.5	-4.81%	+/-5%	pass

The exact 2,824-nmi point retains the +2,173.2-lb total ordinate residual, but Task 5 shows that only -0.05 lb is curve-shape error; the remainder is the common empty-weight offset.

Primary payload-range validation



Zero range is analytic; 2,020/2,824 nmi use fixed-range bisection; 3,700 nmi is a direct zero-payload mission.

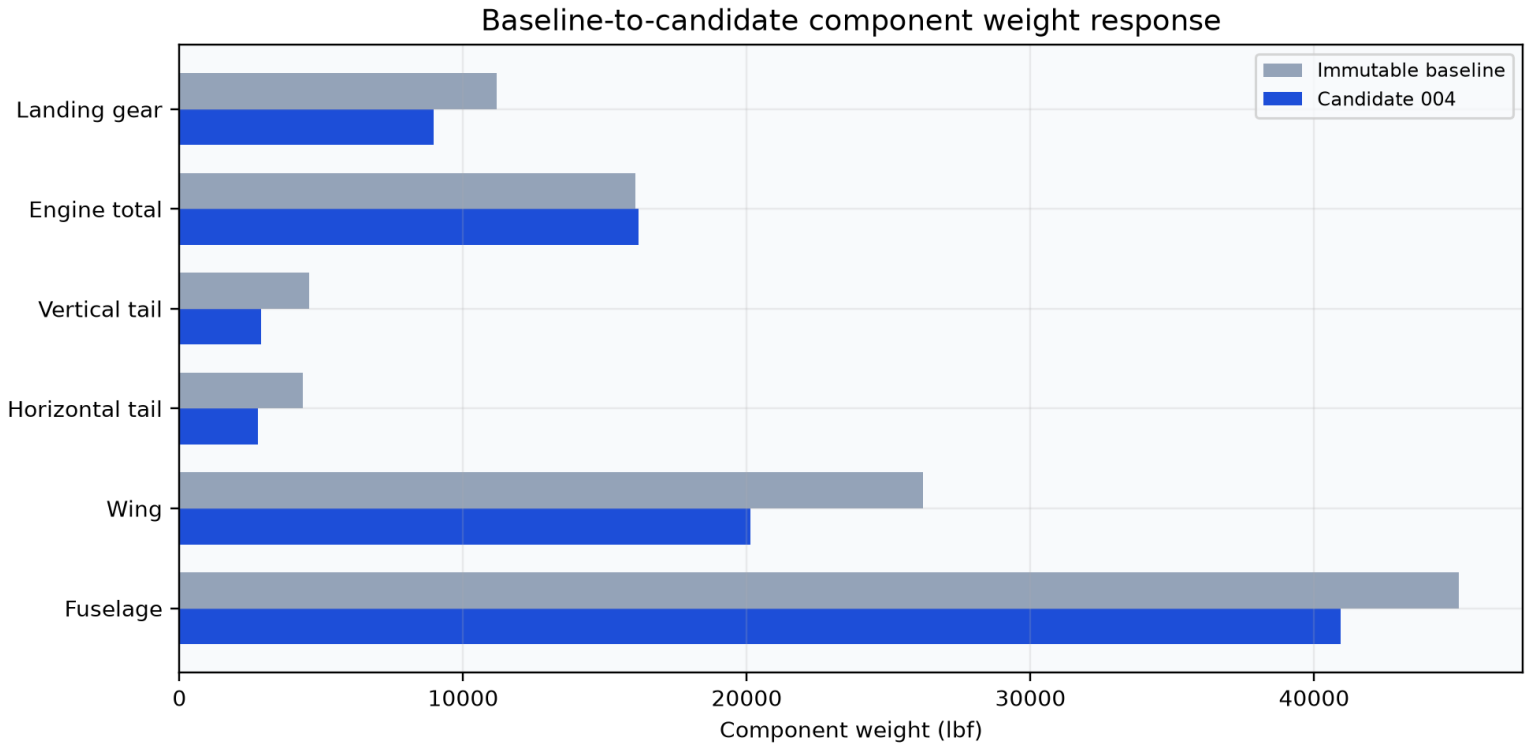
Point	Method	APD ordinate	Candidate	Total error	Shape error	Result / blocker
0 nmi max payload	Analytic zero range	138,300.0	140,473.2	+2,173.2 lb	+0.00 lb	Scored
2,020 nmi MZFW/BRGW	Fixed-range bisection	138,300.0	140,473.2	+2,173.2 lb	+0.00 lb	Scored
2,824 nmi design	Fixed-range bisection	128,746.0	130,919.2	+2,173.2 lb	-0.05 lb	Scored
3,700 nmi zero payload	Direct zero-payload mission	91,300.0	N/A	N/A	N/A	Fuel capacity +1,041.2 lb

Residual decomposition: common OEW offset +2,173.2 lb; 2,020/2,824-nmi shape error <= 0.05 lb. A 750-lb total-error objective needs at least 1,423.2 lb OEW reduction, but Candidate 003 already failed MLW after 300 lb less fixed weight. The ferry endpoint exceeds geometric fuel capacity by 1,041.2 lb. Solver refinement changed payload by at most 4.30 lb.

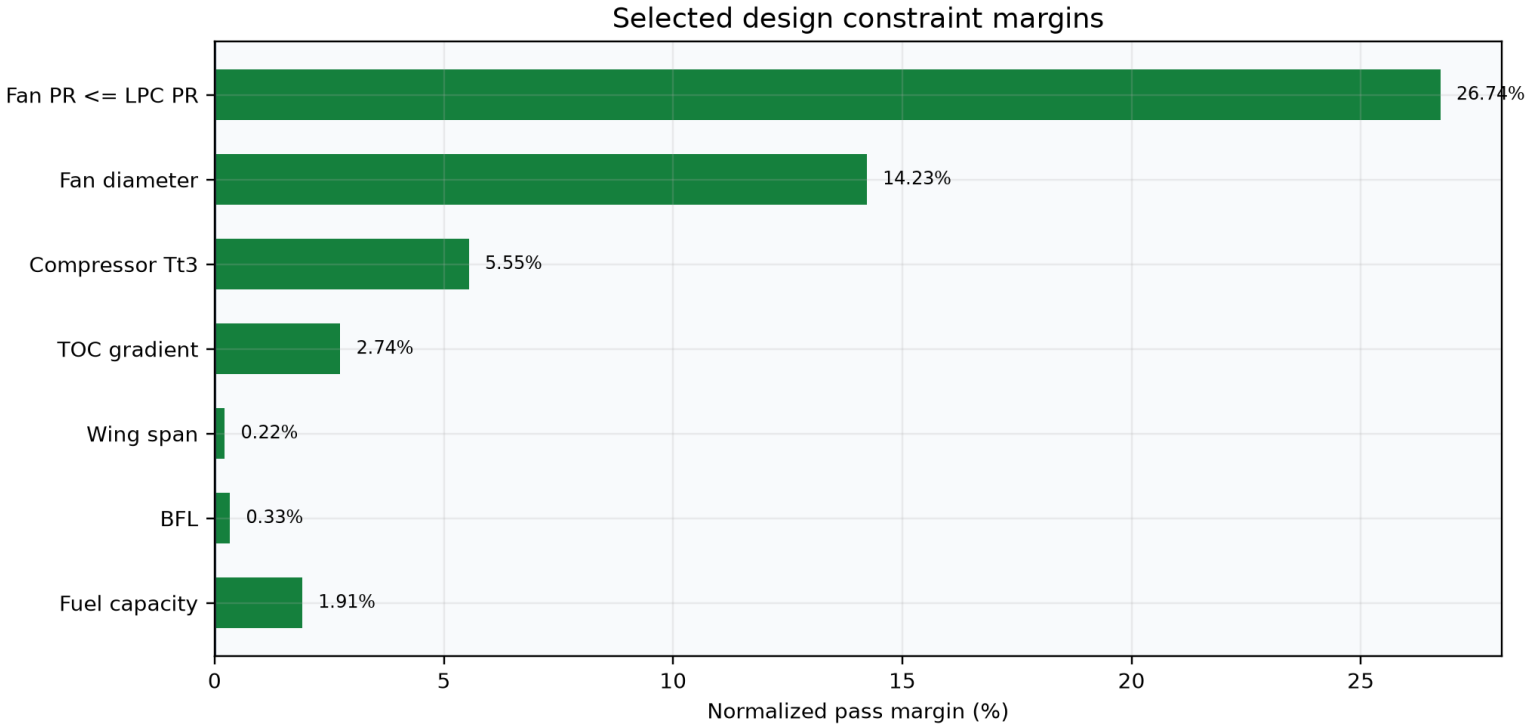
Geometry and geometric fuel capacity

Quantity	APD/reference	Candidate 004	Difference	Uncertainty / policy
Wing span	112.58 ft	112.33 ft	-0.22%	APD labelled value to nearest inch; +/-0.5 in; metric companion 34.32 m agrees within rounding
Wing area	1,339.2 ft^2	1,333.3 ft^2	-0.44%	+/-80 ft^2 from root leading-edge/fairing ambiguity, rounded-tip extrapolation, and +/-8 px span calibration
Wing aspect ratio	9.46 dimensionless	9.46 dimensionless	+0.00%	+/-0.6 propagated from area uncertainty; exact formula AR=b^2/S
Wing sweep	24.25 deg	26.83 deg	+10.61%	+/-1.5 deg from root leading-edge and tip extrapolation ambiguity
Root chord	19.70 ft	18.24 ft	-7.40%	+/-1.2 ft; root leading edge is obscured by fairing/nacelle and was extrapolated from exposed leading edge
Geometric Wfmax	46,062 lb comparison	51,059.1 lbf	+10.85%	No approved independent threshold
Mission-1 design fuel	45,454 lb implied	50,083.3 lbf	+10.18%	Fuel <= Wfmax is the formal constraint

Component-weight response



Complete constraint verification



Constraint	Mission	Actual	Limit	Unit	Sense	Pass margin	Status
Fuel capacity M1	1	50,083.3	51,059.1	lbf	actual <= limit	1.91%	pass
Fuel capacity M2	2	10,200.1	51,059.1	lbf	actual <= limit	80.02%	pass
Fuel capacity M3	3	14,014.8	51,059.1	lbf	actual <= limit	72.55%	pass
Fuel capacity M4	4	21,788.6	51,059.1	lbf	actual <= limit	57.33%	pass
Fuel capacity M5	5	29,869.2	51,059.1	lbf	actual <= limit	41.50%	pass
Fuel capacity M6	6	38,552.8	51,059.1	lbf	actual <= limit	24.49%	pass
Balanced field length M1	1	6,976.6	7,000.0	ft	actual <= limit	0.33%	pass
Wing span	shared	112.33	112.58	ft	actual <= limit	0.22%	pass
Top-of-climb gradient M1	1	0.01541	0.01500	dimensionless	actual >= limit	2.74%	pass
Compressor exit temperature M1	1	850.08	900.00	K	actual <= limit	5.55%	pass
Vane metal temperature M1	1	1,280.0	1,280.0	K	actual <= limit	0.00%	pass
Takeoff weight consistency M1	1	181,002.6	181,002.6	lbf	actual <= sized WMTO	0.00%	pass
Fan diameter	shared	1.72	2.00	m	actual <= limit	14.23%	pass
Fan PR <= LPC PR M1	1	1.73	2.36	pressure ratio	fan PR <= LPC PR	26.74%	pass

Mission roles and reporting boundaries

Mission	Role	Range nmi	Payload lbf	Fuel lbf	BFL ft	Converged	Weight calibration
1	design sizing	2,824.0	37,446.0	50,083.3	6,976.6	Yes	Yes
2	off design	500	37,446.0	10,200.1	4,257.9	Yes	No
3	off design	750	37,446.0	14,014.8	4,486.7	Yes	No
4	off design	1,250.0	37,446.0	21,788.6	4,973.0	Yes	No
5	off design	1,750.0	37,446.0	29,869.2	5,507.3	Yes	No
6	off design	2,250.0	37,446.0	38,552.8	6,114.9	Yes	No

Selected engine point

Metric	Value	Unit	Flight point
Net thrust per engine	138.9914	kN	static
Bypass ratio	5.5131	dimensionless	cruise1
Overall pressure ratio	27.8806	dimensionless	cruise1
Low-pressure compressor ratio	2.3614	dimensionless	cruise1
High-pressure compressor ratio	11.8069	dimensionless	cruise1
Fan pressure ratio	1.7300	dimensionless	cruise1

EDB holdout validation

EDB comparisons are included only to report holdout behavior. They did not enter mutation selection, ranking, or acceptance.

Parameter	EDB	Candidate	Difference	Use
rated thrust	121.4000	138.9914	+14.49%	validation-only
fuel flow takeoff	1.2930	1.5012	+16.10%	validation-only
fuel flow climbout	1.0310	1.2107	+17.43%	validation-only
fuel flow approach	0.3430	0.4222	+23.09%	validation-only
fuel flow idle	0.1100	0.1635	+48.67%	validation-only

Residual validation gaps and reproducibility

Task 5 compatibility result: all four APD ranges were evaluated directly. The comparable points share a +2,173.2-lb OEW offset while curve-shape error is <= 0.05 lb. The MLW gate blocks the smallest common-weight correction, and the direct 3,700-nmi zero-payload mission exceeds geometric fuel capacity by 1,041.2 lb.

Evidence boundaries

Component-weight identifiability is not claimed: the APD provides aggregate weights, not a lower-level weight schedule. Candidate 004 is accepted under the approved four-weight +/-5% policy and complete constraint checks. Wfmax and implied design fuel are reported without inventing independent percentage gates.

Reproduction

Step	Command
Run Candidate 004	julia --project=<TASOPT.jl> scripts/run_nonopt_baseline.jl --input models/nonopt_candidate_004_joint_feasible_design.toml --output outputs/nonopt_candidate_004_joint_feasible_design
Build machine-readable report	python scripts/build_nonopt_candidate_report.py --candidate-dir outputs/nonopt_candidate_004_joint_feasible_design --parent-dir outputs/nonopt_candidate_003_joint_span_bfl_fuel --assumption-log references/nonopt_candidate_004_design_log.md
Run exact payload evidence	julia --project=<TASOPT.jl> scripts/run_nonopt_baseline.jl --input models/nonopt_candidate_004_joint_feasible_design.toml --output outputs/task_5_candidate_004_payload_solver --payload-range-rpts 11
Build compatibility analysis	python scripts/build_task_5_payload_range_report.py
Build this PDF	python scripts/build_candidate_004_pdf_report.py
Verify tests	uv run pytest -q

The companion JSON manifest records SHA-256 hashes for every input consumed here and for the final PDF. Candidate raw runner artifacts remain the calculation source of record.