



737

BREAKOUT SESSION

Reduced Thrust Considerations *Takeoff Performance Margins*

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Common Misconceptions

- “If reduced thrust is used, then the airplane will not be able to clear the obstacles if an engine fails during takeoff.”
- “If the maximum allowable assumed temperature is used, then there will be no stopping margin left if the takeoff is aborted.”



Regulatory Compliance

AC/AMJ 25-13

Boeing AFM states:

“Operations at reduced takeoff thrust based on an assumed temperature higher than the actual ambient temperature is permissible if the airplane meets ALL applicable performance requirements at the planned takeoff weight and reduced thrust setting.”

Regulatory Performance Requirements

- Have sufficient runway length for:
 - 115% of all-engine takeoff distance
 - One engine inoperative takeoff distance
 - Accelerate-stop distance
- Achieve the one engine inoperative minimum climb gradient for:
 - First segment
 - Second segment
 - Final segment
- Clear all obstacles in the intended takeoff flight path

Effect of Temperature on True Airspeed and Thrust

- Air density is lower at higher outside air temperature (OAT)
- For a given indicated airspeed (IAS), true airspeed (TAS) is higher at higher OAT
- For a given reduced engine power setting (N1 or EPR), lower air density (higher OAT) results in lower thrust



The Assumed Temperature Method

- Dispatch takeoff performance must assume the higher true airspeed at the assumed higher temperature
- Takeoff thrust assumed is the rated thrust at that assumed temperature

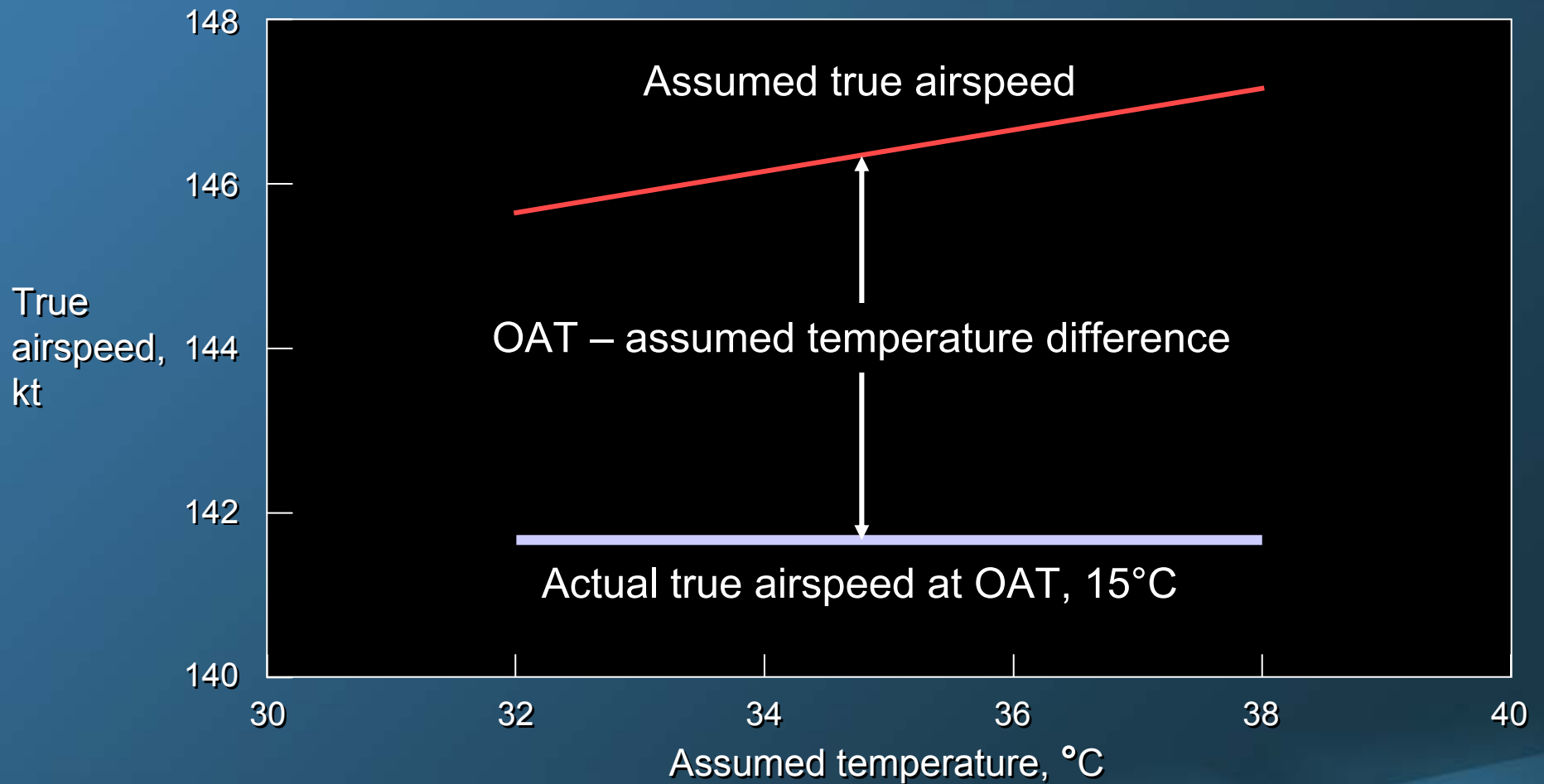


Inherent Conservatism of the Assumed Temperature Method

- The actual thrust will be higher than the rated thrust at the assumed temperature, because the actual air density is higher
- The actual true airspeed will be lower, because the actual ambient temperature is lower
- The lower true airspeed combined with the higher thrust will result in a shorter ground distance



The True Airspeed Effect



The Assumed Temperature Method

737-800W WITH CFM56-7B27 ENGINES
 PRESSURE ALTITUDE 0 FT
 RUNWAY LENGTH 7000 FT, DRY
 NO OBSTACLES
 FLAPS 5, A/C AUTO, STANDARD TAKEOFF SPEEDS

MAXIMUM RATED THRUST (27K)					24K DERATE					
OAT (C)	MTOW (KG)	PERF LIM	V1 (KT)	VR (KT)	V2 (KT)	MTOW (KG)	PERF LIM	V1 (KT)	VR (KT)	V2 (KT)
60	60400	FLD	134	135	140	55900	FLD	131	131	134
55	62000	FLD	136	137	142	57700	FLD	133	133	137
50	63600	FLD	138	139	144	59700	FLD	134	135	139
45	65200	FLD	140	141	146	61900	FLD	136	137	142
40	69300	FLD	141	143	150	64100	FLD	138	139	144
38	70300	FLD	142	144	151	65000	FLD	139	140	145
36	71100	FLD	142	145	152	65800	FLD	139	141	146
34	72000	FLD	143	145	153	66700	FLD	140	141	147
32	72900	FLD	143	146	154	67700	FLD	141	142	148
30	73700	FLD	144	147	155	68700	FLD	141	143	149
25	74300	FLD	144	147	155	70000	FLD	142	143	150
20	75000	FLD	145	148	156	71000	FLD	143	144	151
15	75600	FLD	146	149	157	70300	FLD	144	145	151
10	76200	FLD	146	149	157	71000	FLD	144	146	152

Maximum Allowable Assumed Temperature 38°C

27K, OAT 15°C
 Takeoff Weight 70300 KG

Margins Between Assumed and Actual Performance at the Maximum Allowable Assumed Temperature

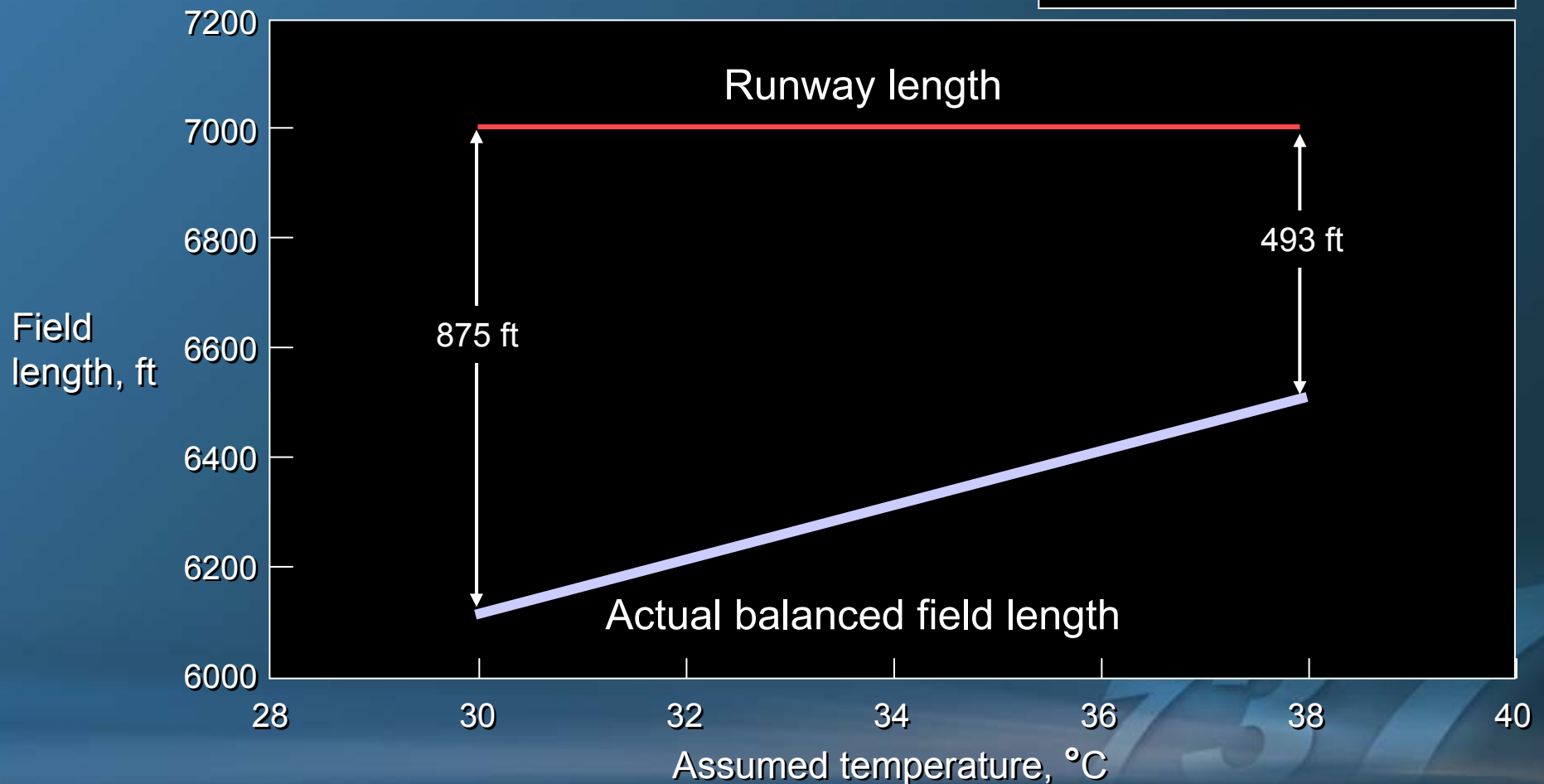
Parameter	OAT 38°C	OAT 15°C assume 38°C	Extra margin
V1 (KIAS / KTAS)	142 / 148	142 / 142	6
VR (KIAS / KTAS)	144 / 150	144 / 144	6
V2 (KIAS / KTAS)	151 / 157	151 / 151	6
Thrust per engine at V1, lb	23855	24061	206
Thrust per engine at VR, lb	19833	20019	186
Thrust per engine at V2, lb	19857	20034	177
One engine inoperative takeoff distance, ft	7000	6507	493
Accelerate-stop distance, ft	7000	6507	493
115% all-engine takeoff distance, ft	6942	6464	478

Field Length Margin Increases With Lower Assumed Temperature Due to Higher Thrust

Field Length Margin

• 737-800W / CFM56-7B27

- Pressure Altitude 0 ft
- Runway Length 7000 ft, Dry
- Flaps 5, Standard Takeoff Speeds
- OAT 15°C, Takeoff Weight 70300 kg

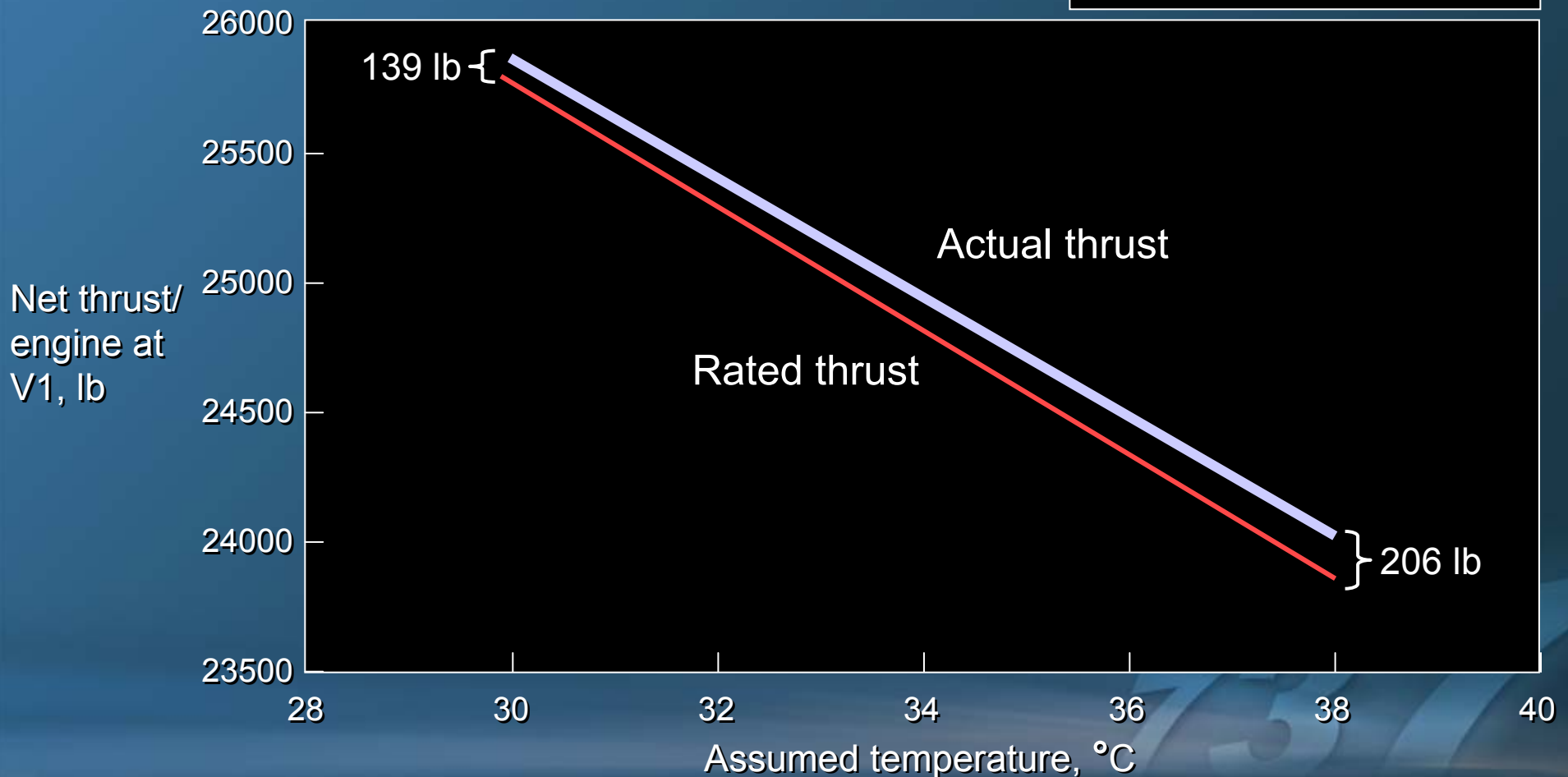


Thrust Margin Decreases With Lower Assumed Temperature

Rated Thrust Versus Actual Thrust

• 737-800W / CFM56-7B27

- Pressure Altitude 0 ft
- Runway Length 7000 ft, Dry
- Flaps 5, Standard Takeoff Speeds
- OAT 15°C, Takeoff Weight 70300 kg



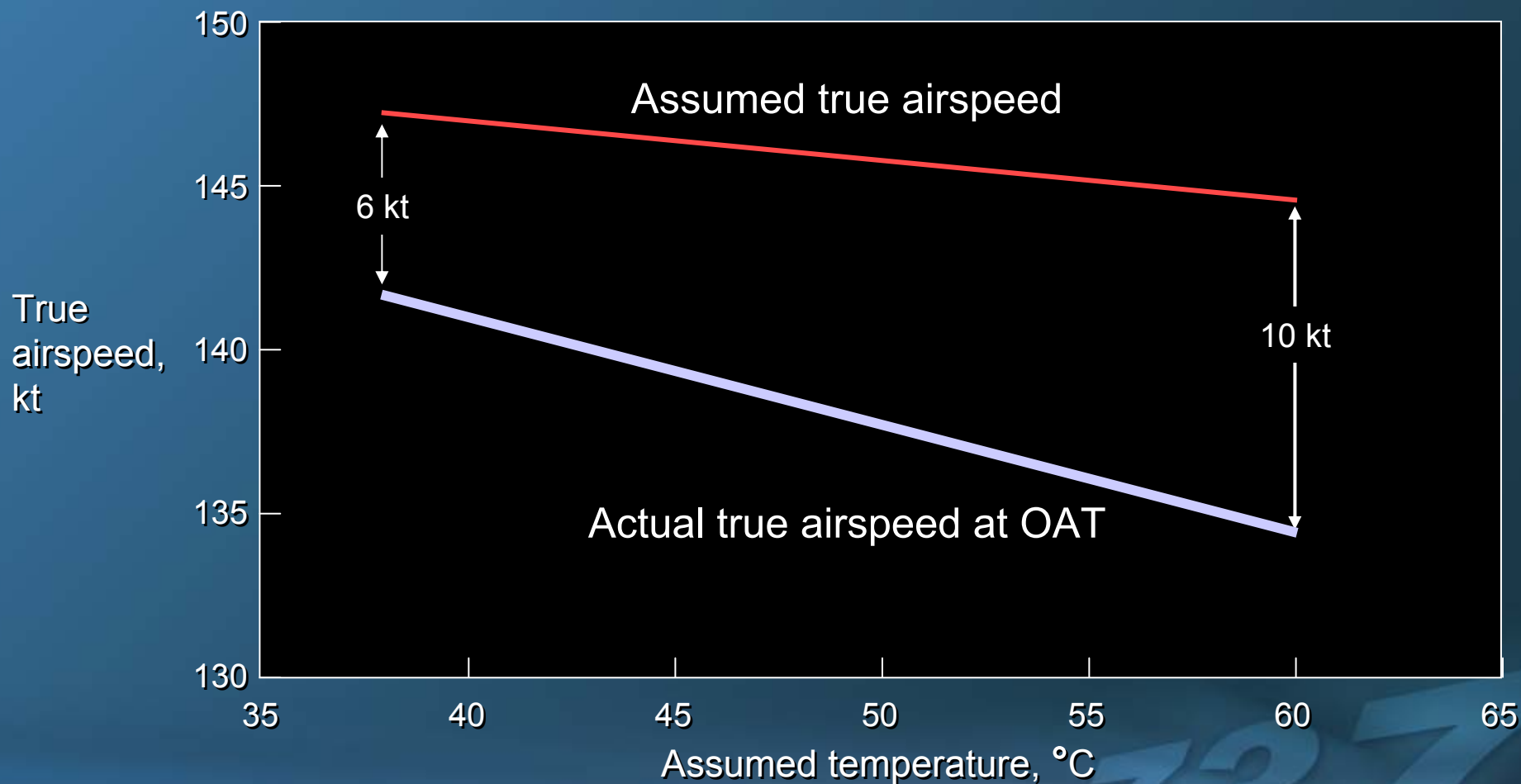
Lower Takeoff Weight May Permit Higher Maximum Allowable Assumed Temperature

737-800W WITH CFM56-7B27 ENGINES
 PRESSURE ALTITUDE 0 FT
 RUNWAY LENGTH 7000 FT, DRY
 NO OBSTACLES
 FLAPS 5, A/C AUTO, STANDARD TAKEOFF SPEEDS

MAXIMUM RATED THRUST (27K)					24K DERATE					
OAT (C)	MTOW (KG)	PERF LIM	V1 (KT)	VR (KT)	V2 (KT)	MTOW (KG)	PERF LIM	V1 (KT)	VR (KT)	V2 (KT)
60	60400	FLD	134	135	140	55900	FLD	131	131	134
55	62200	FLD	136	137	142	57700	FLD	133	133	137
50	65000	FLD	138	139	146	59700	FLD	134	135	139
45	67200	FLD	140	141	148	61900	FLD	136	137	142
40	69300	FLD	141	143	150	64100	FLD	138	139	144
38	70300	FLD	142	144	151	65000	FLD	139	140	145
36	71100	FLD	142	145	152	65800	FLD	139	141	146
34	72000	FLD	143	145	153	66700	FLD	140	141	147
32	72900	FLD	143	146	154	67700	FLD	141	142	148
30	73700	FLD	144	147	155	68600	FLD	141	143	149
25	74300	FLD	144	147	156	69200	FLD	142	144	150
20	75000	FLD	145	148	156	69800	FLD	143	144	151
15	75600	FLD	146	149	157	70300	FLD	144	145	151
10	76200	FLD	146	149	157	71000	FLD	144	146	152

True Airspeed Effect Increases With Higher Assumed Temperature

True Airspeed Effect

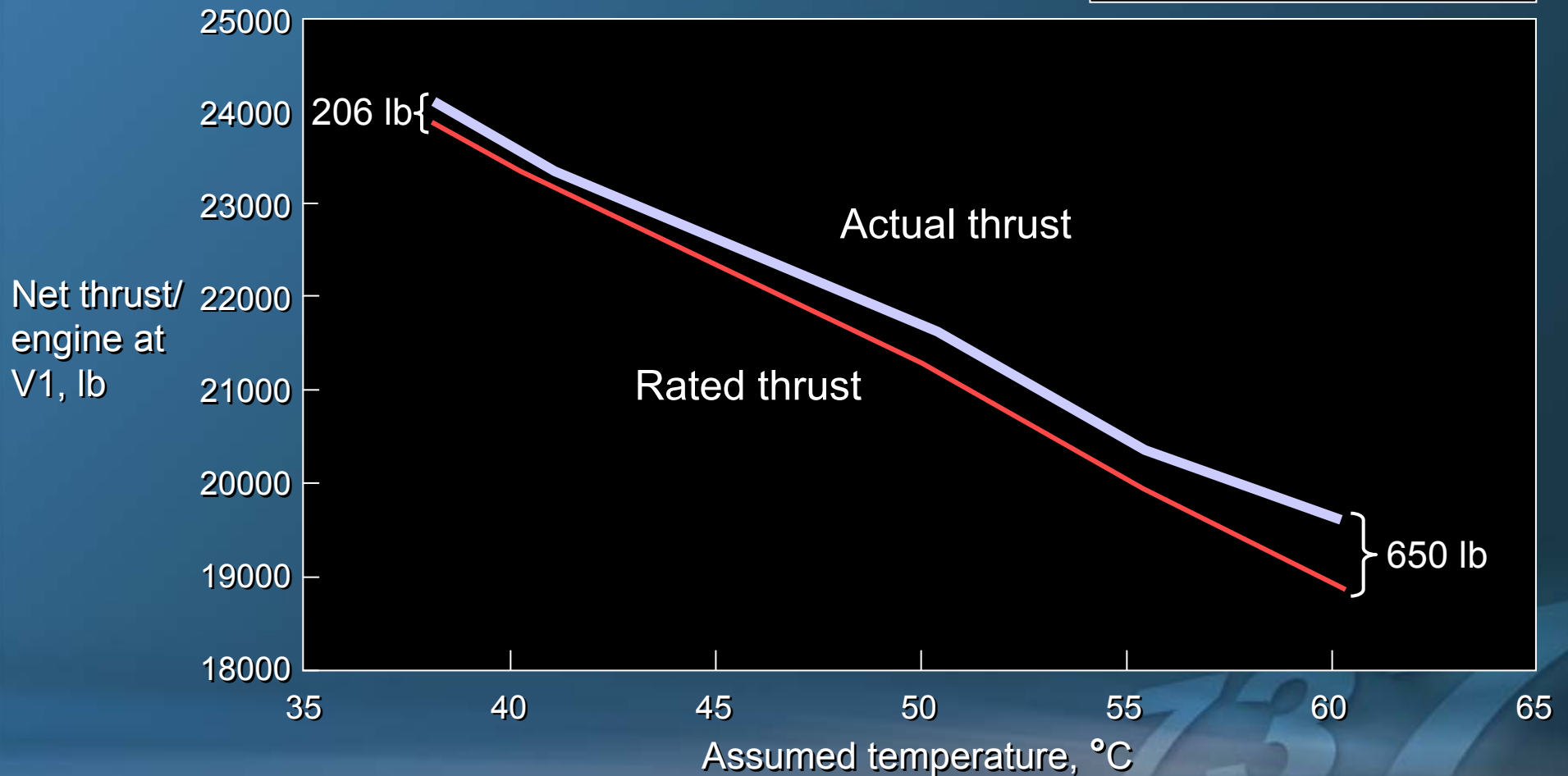


Thrust Margin Increases With Higher Assumed Temperature

Rated Thrust Versus Actual Thrust

• 737-800W / CFM56-7B27

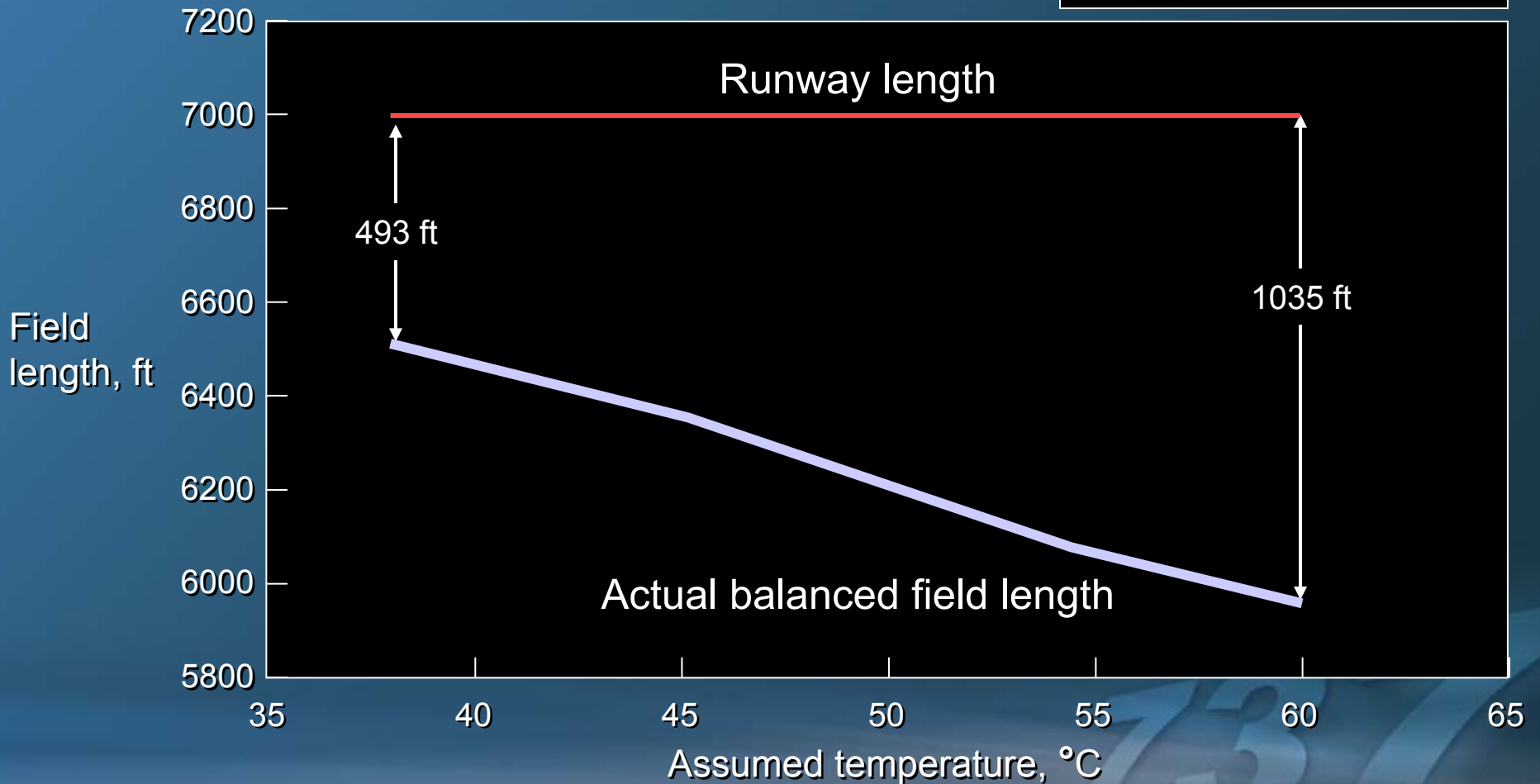
- Pressure Altitude 0 ft, OAT 15°C
- Runway Length 7000 ft, Dry
- Flaps 5, Standard Takeoff Speeds



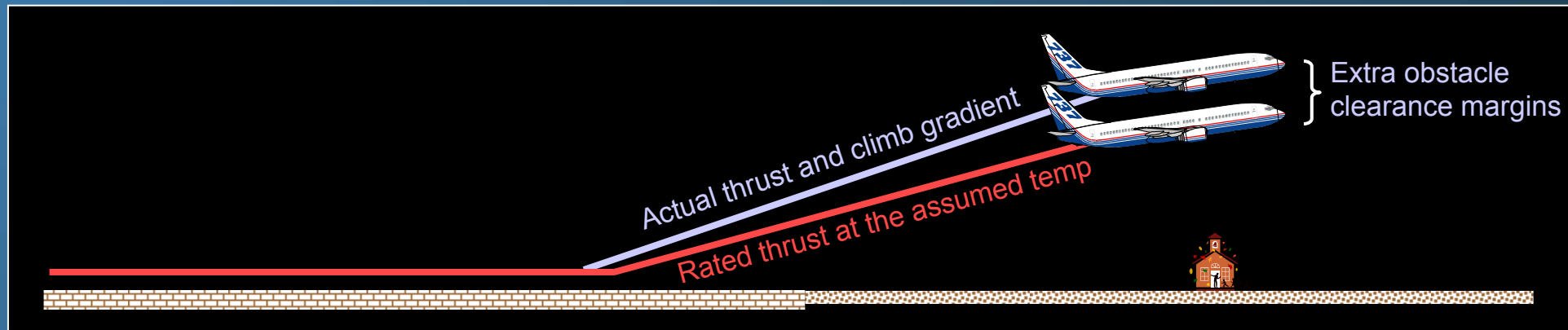
Field Length Margin Due to the True Airspeed Effect Increases With Higher Assumed Temperature

Field Length Margin

- 737-800W / CFM56-7B27
- Pressure Altitude 0 ft, OAT 15°C
- Runway Length 7000 ft, Dry
- Flaps 5, Standard Takeoff Speeds



Performance Margins in Flight Path With Assumed Temperature Reduced Thrust



- If performance is limited by the one engine inoperative minimum climb gradient requirements, the higher actual thrust will result in a higher climb gradient
- If performance is limited by obstacle clearance, the higher climb gradient combined with the shorter takeoff distance will result in extra clearance margin

Thrust And Climb Gradient Margins At The Maximum Allowable Assumed Temperature

737-800W WITH CFM56-7B27 ENGINES
PRESSURE ALTITUDE 5000 FT

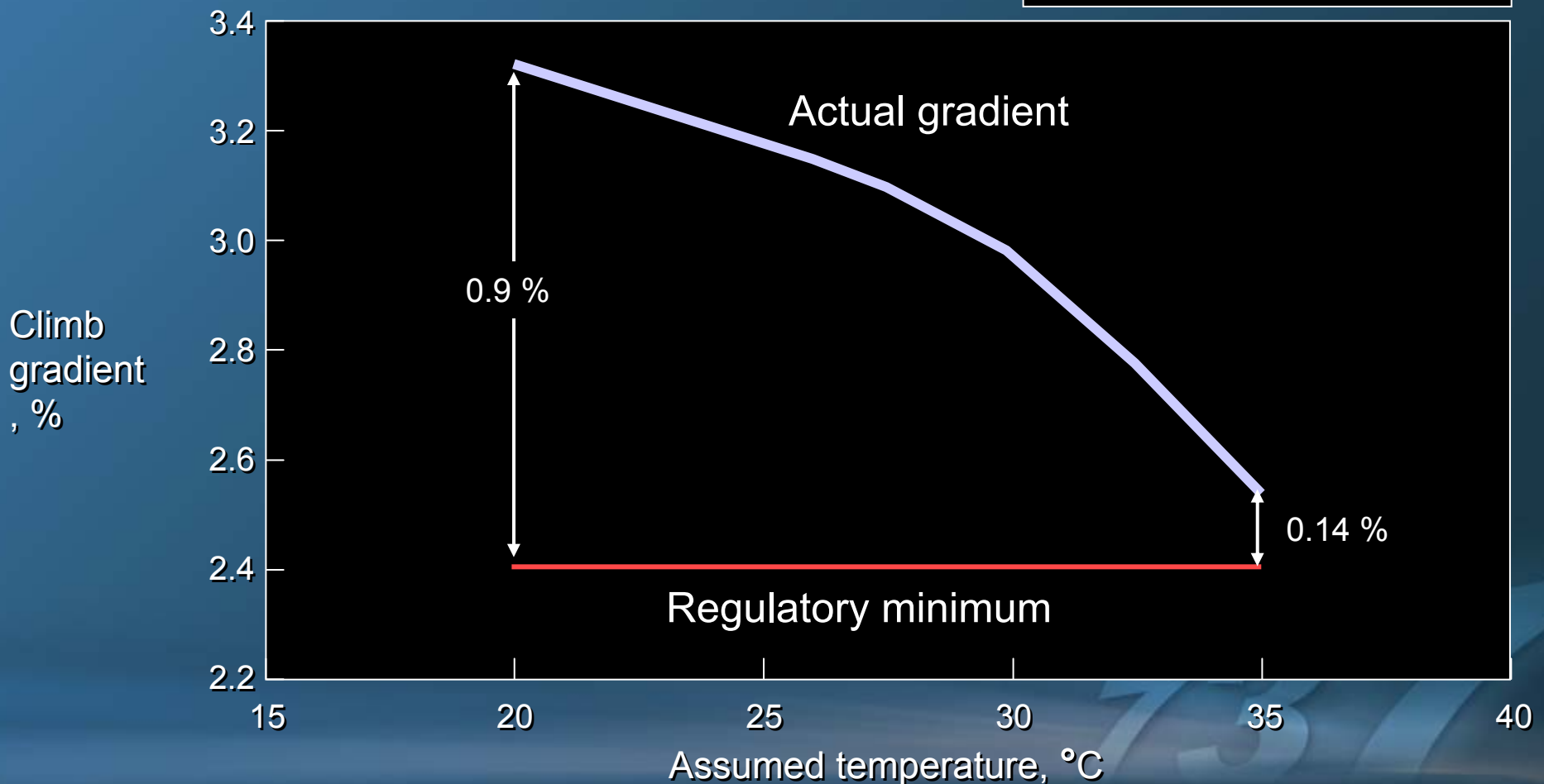
Parameter	OAT 35°C	OAT 10°C assume 35°C	Extra margin
Thrust per engine at V2, lb	20108	20355	247
One engine inoperative climb gradient, %	2.4	2.54	0.14

55	59900	CLB	136	136	139	51500	CLB	126	126	129	
5	Maximum Allowable Assumed Temperature 35°C					2	53800	CLB	129	129	132
4	Maximum Allowable Assumed Temperature 35°C					5	56200	CLB	132	132	134
40	68100	CLB	143	144	148	58900	CLB	135	135	138	
35	71000	CLB	146	147	151	61700	CLB	138	138	141	
30	73900	CLB	148	150	154	64600	CLB	140	141	144	
25	75400	CLB	149	151	155	67600	CLB	143	144	147	
20	76400	CLB	150	152	156	27K, OAT 10°C Takeoff Weight 71000 KG					
15	76400	CLB	150	152	156	27K, OAT 10°C Takeoff Weight 71000 KG					
10	76500	CLB	150	152	156	71000	CLB	146	147	151	

Climb Gradient Increases With Lower Assumed Temperature Due to Higher Thrust

Climb Gradient Margin

- 737-800W / CFM56-7B27
- Pressure Altitude 5000 ft
- Runway Length 12000 ft, Dry
- Flaps 5, Standard Takeoff Speeds
- OAT 10°C, Takeoff Weight 71000 kg



Lower Takeoff Weight May Permit A Higher Maximum Allowable Assumed Temperature

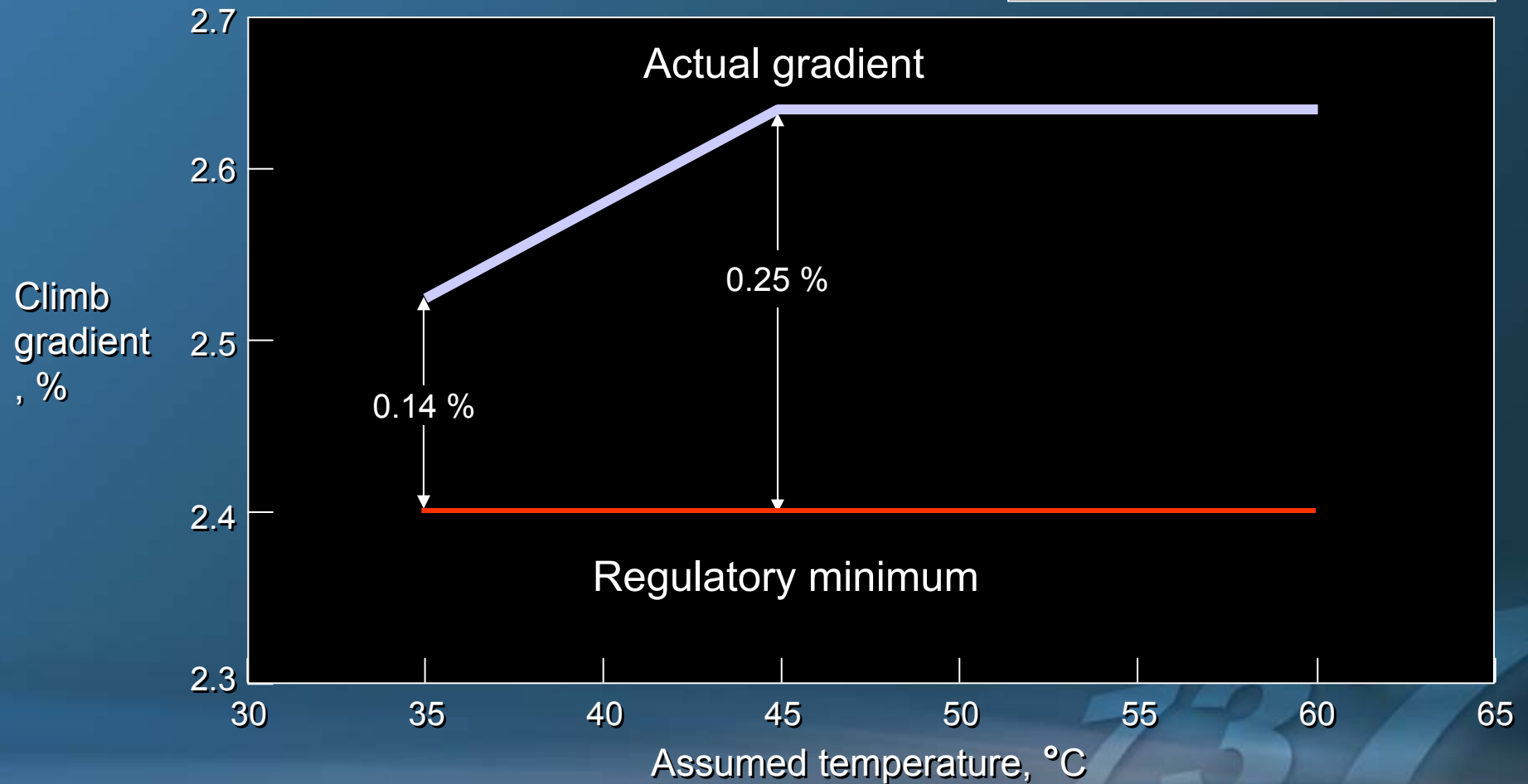
737-800W WITH CFM56-7B27 ENGINES
 PRESSURE ALTITUDE 5000 FT
 RUNWAY LENGTH 12000 FT, DRY
 NO OBSTACLES
 FLAPS 5, A/C AUTO, STANDARD TAKEOFF SPEEDS

MAXIMUM RATED THRUST (27K)						24K DERATE				
OAT (C)	MTOW (KG)	PERF LIM	V1	VR	V2	MTOW (KG)	PERF LIM	V1	VR	V2
			(KT)					(KT)		
60	57300	CLB	133	133	136	49300	CLB	124	124	126
55	59900	CLB	136	136	139	51500	CLB	126	126	129
50	62500	CLB	138	139	142	53800	CLB	129	129	132
45	65100	CLB	141	141	145	56200	CLB	132	132	134
40	68100	CLB	143	144	148	58900	CLB	135	135	138
35	71000	CLB	146	147	151	61700	CLB	138	138	141
30	73900	CLB	148	150	154	64600	CLB	140	141	144
25	75400	CLB	149	151	155	67600	CLB	143	144	147
20	76400	CLB	150	152	156	70800	CLB	146	147	151
15	76400	CLB	150	152	156	70900	CLB	146	147	151
10	76500	CLB	150	152	156	71000	CLB	146	147	151

Climb Gradient Margin Due to the True Airspeed Effect Increases With Higher Assumed Temperature

Climb Gradient Margin

- 737-800W / CFM56-7B27
- Pressure Altitude 5000 ft, OAT 10°C
- Runway Length 12000 ft, Dry
- Flaps 5, Standard Takeoff Speeds



Obstacle Clearance Margin at the Maximum Allowable Assumed Temperature

737-800W WITH CFM56-7B27 ENGINES
 PRESSURE ALTITUDE 0 FT
 RUNWAY 9000 FT. DRY

Parameter	OAT 41°C	OAT 15°C assume 41°C	Extra margin
Net clearance	35 ft	61 ft	26 ft

60	62900	OBS	138 138 143	57000	OBS	132 132 136
55	65200	OBS	140 141 145	59200	OBS	134 134 138
				61600	OBS	137 137 141
				64200	OBS	139 140 144
45	72400	OBS	145 147 153	65200	OBS	140 141 145
41	73500	OBS	146 148 154	66300	OBS	141 142 146
39	74600	OBS	147 149 155	67400	OBS	142 143 148
37	75700	OBS	147 150 156	68400	OBS	143 144 149
35	76700	OBS	148 151 157	69400	OBS	143 145 150
30	79300	OBS	149 153 160	72200	OBS	146 147 153
25	79800	OBS	150 153 160	72700	OBS	146 147 153
20	80300	OBS	150 154 161			
15	80800	OBS	151 154 161			
10	81300	OBS	151 155 161	73900	OBS	147 149 154

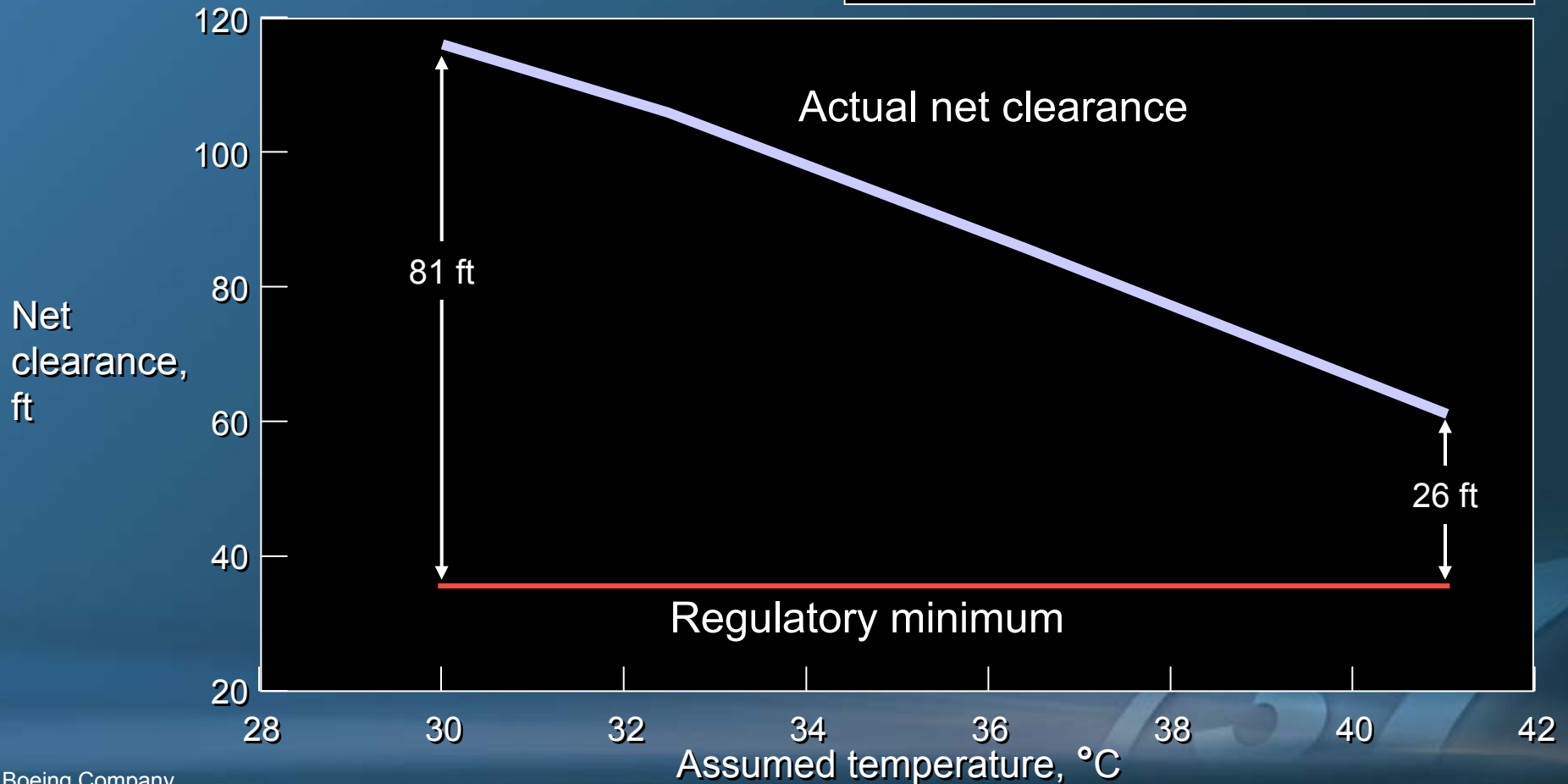
Maximum Allowable Assumed Temperature 41°C

**27K, OAT 15°C
Takeoff Weight 73500 KG**

Net Clearance Margin Increases With Lower Assumed Temperature Due to Higher Thrust

Obstacle Clearance Margin

- 737-800W / CFM56-7B27
- Pressure Altitude 0 ft
- Runway Length 9000 ft, Dry
- Obstacle: 50 ft Ht at 1000 ft Dist from liftoff end
- Flaps 5, Standard Takeoff Speeds
- OAT 15°C, Takeoff Weight 73500 kg



Lower Takeoff Weight May Permit Higher Maximum Allowable Assumed Temperature

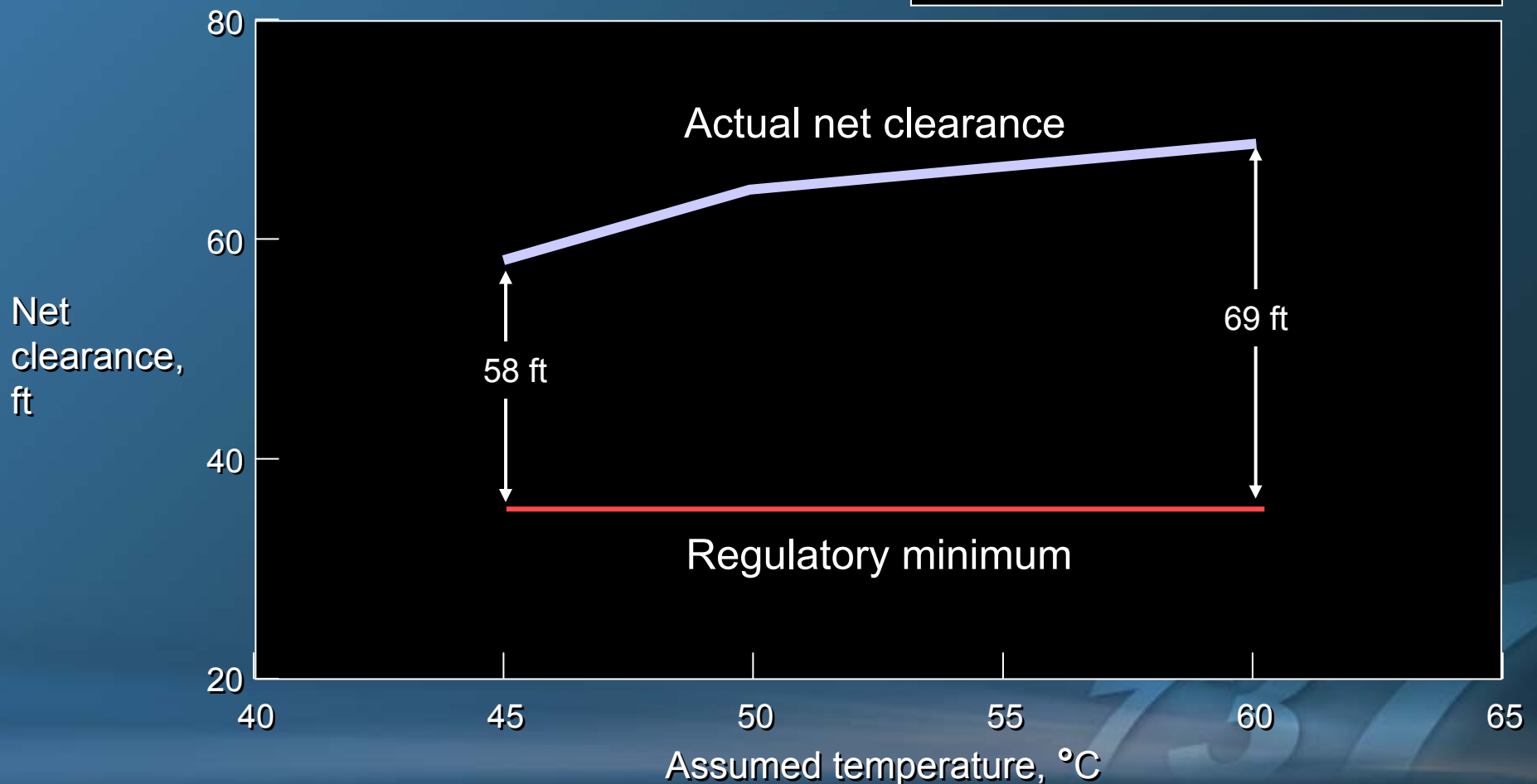
737-800W WITH CFM56-7B27 ENGINES										
PRESSURE ALTITUDE 0 FT										
RUNWAY 9000 FT, DRY										
OBSTACLE: 50 FT HT AT 1000 FT DIST FROM LIFTOFF END										
FLAPS 5, A/C AUTO, STANDARD TAKEOFF SPEEDS										
MAXIMUM RATED THRUST (27K)					24K DERATE					
OAT (C)	MTOW (KG)	PERF LIM	V1 (KT)	VR (KT)	V2 (KT)	MTOW (KG)	PERF LIM	V1 (KT)	VR (KT)	V2 (KT)
60	62900	OBS	138	138	143	57000	OBS	132	132	136
55	65200	OBS	140	141	145	59200	OBS	134	134	138
50	68600	OBS	142	144	149	61600	OBS	137	137	141
45	71300	OBS	144	146	152	64200	OBS	139	140	144
43	72400	OBS	145	147	153	65200	OBS	140	141	145
41	73500	OBS	146	148	154	66300	OBS	141	142	146
39	74600	OBS	147	149	155	67400	OBS	142	143	148
37	75700	OBS	147	150	156	68400	OBS	143	144	149
35	76700	OBS	148	151	157	69400	OBS	143	145	150
30	79300	OBS	149	153	160	72200	OBS	146	147	153
25	79800	OBS	150	153	160	72700	OBS	146	147	153
20	80300	OBS	150	154	161	73100	OBS	147	148	153
15	80800	OBS	151	154	161	73500	OBS	147	148	154
10	81300	OBS	151	155	161	73900	OBS	147	149	154

Net Clearance Margin Due to True Airspeed Effect Increases With Higher Assumed Temperature

Obstacle Clearance Margin

• 737-800 / CFM56-7B27

- Pressure Altitude 0 ft, OAT 15°C
- Runway Length 9000 ft, Dry
- Obstacle: 50 ft Ht at 1000 ft Dist from liftoff end
- Flaps 5, Standard Takeoff Speeds



Issues With Takeoff Speeds

- Standard takeoff speeds depend on:
 - Takeoff weight
 - Flap setting
 - **Thrust (temperature)**, pressure altitude, and engine bleed configuration
 - V1 also depends on runway slope, wind, and surface condition (dry or wet)
- **Takeoff speeds vary with thrust, therefore, they vary with assumed temperature**

Effect of Thrust on Takeoff Speeds (IAS)

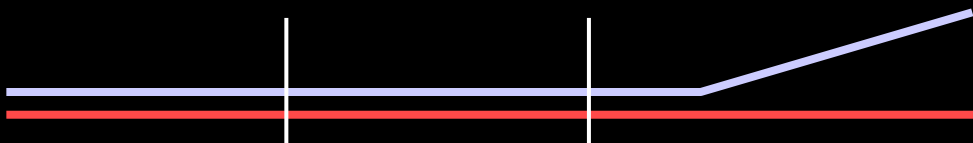
Higher thrust



V1 = 135

VR = 140

V2 = 155



Proper takeoff speeds for a balanced field length

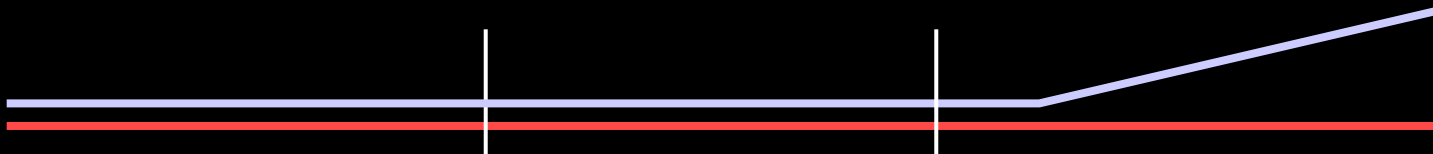
Lower thrust



V1 = 140

VR = 145

V2 = 150

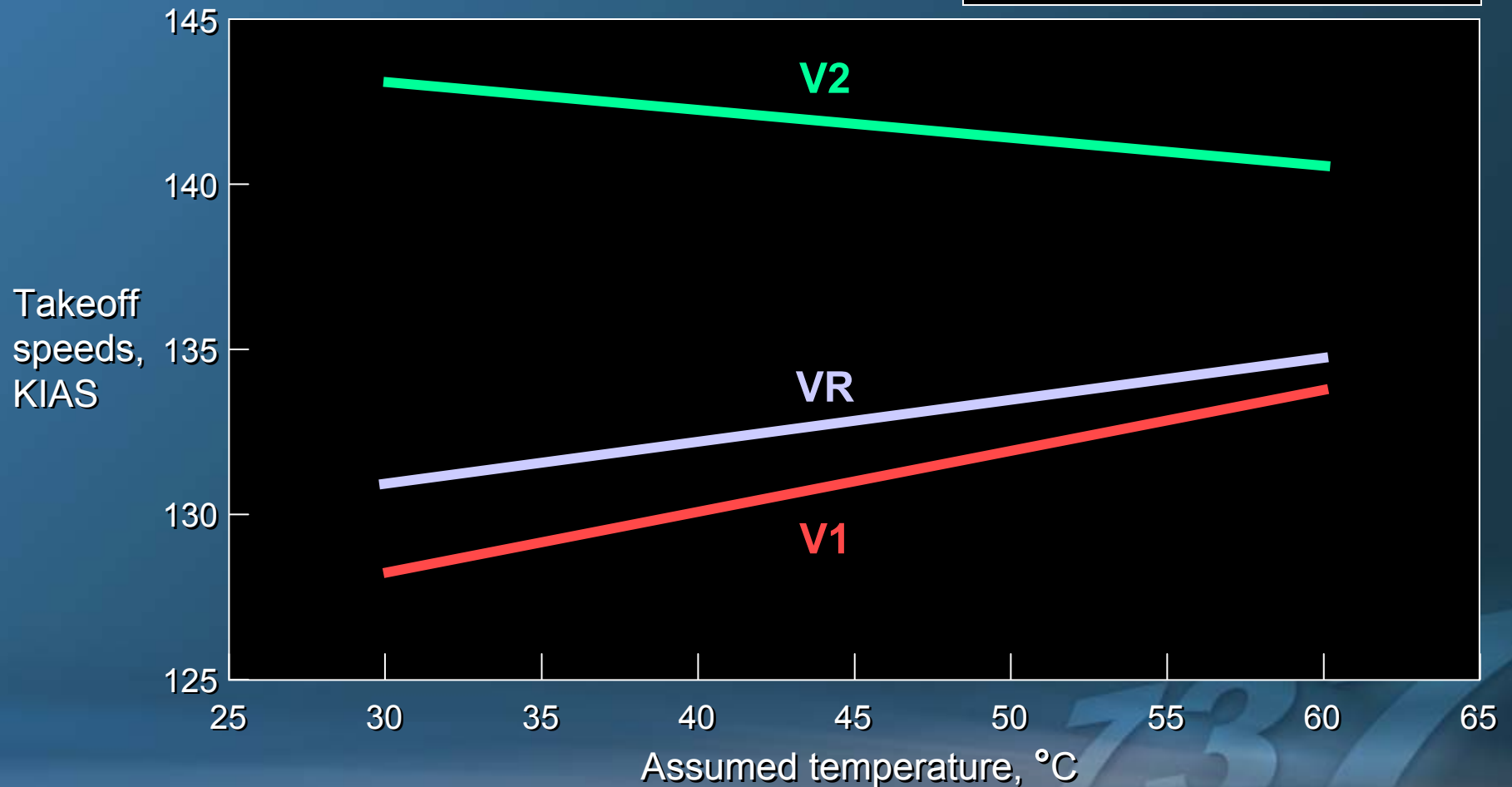


Increasing V1 and VR, typically resulting in lower V2, will re-balance field length

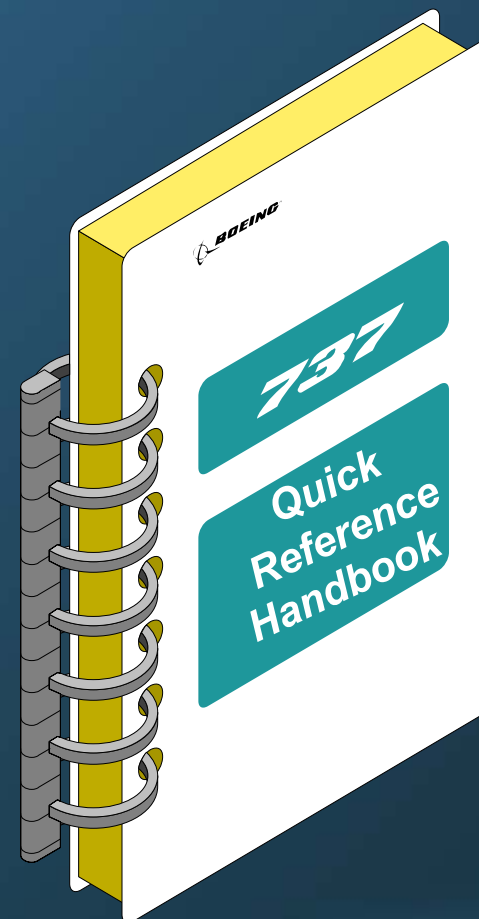
Takeoff Speeds (IAS) Vary With Assumed Temperature

Thrust Effect on Takeoff Speeds

- 737-800W / CFM56-7B27
- Pressure Altitude 0 ft
- Flaps 5, Dry Runway, Standard Speeds
- OAT 15°C, Takeoff Weight 60400 kg



Use the FMC or QRH to Obtain Proper Standard Takeoff Speeds



Standard Takeoff Speeds Only

Standard takeoff speeds, plus adjustments for clearway and stopway, slippery and contaminated runways, and inoperative system. No optimized V1 or improved climb.

Overspeed

Use Speeds for the Maximum Allowable Assumed Temperature, Ignoring Thrust Effect on Speeds

737-800W WITH CFM56-7B27 ENGINES
PRESSURE ALTITUDE 0 FT
RUNWAY LENGTH 7000 FT, DRY
NO OBSTACLES

<div style="border: 1px solid red; padding: 5px; color: red; text-align: center;"> Maximum Allowable Assumed Temperature 60°C </div>				STANDARD TAKEOFF SPEEDS				
				MTOW (KG)	PERF LIM	24K DERATE		
(C)	(KG)	LIM	(KT)			(KG)	LIM	V1 (KT)
60	60400	FLD	134 135 140	55900	FLD	131 131 134		
55	62200	FLD	136 137 142	57700	FLD	133 133 137		
50	65000	FLD	138 139 146	59700	FLD	134 135 139		
45	67200	FLD	140 141 148	61900	FLD	136 137 142		
40	69300	FLD	141 143 150	64100	FLD	138 139 144		
38	70300	FLD	142 144 151	65000	FLD	139 140 145		
36	71100	FLD	142 145 152	65800	FLD	139 141 146		
34	72000	FLD	143 145 153	66700	FLD	140 141 147		
32	72900	FLD	143 146 154	67700	FLD	141 142 148		
30	73700	FLD	144	<div style="border: 1px solid blue; padding: 5px; color: blue;"> 27K, OAT 15°C Takeoff Weight 60400 KG </div>	43 149			
25	74300	FLD	144		44 150			
20	75000	FLD	145		44 151			
15	75600	FLD	146 149 157	70300	FLD	144 145 151		
10	76200	FLD	146 149 157	71000	FLD	144 146 152		

Proper Takeoff Speeds From QRH

737-800W/CFM56-7B27
 FAA/JAROPS
 Category C Brakes



737 Operations Manual

Performance Inflight
 General

Chapter PI
 Section 10

Takeoff Speeds - Dry Runway V1, VR, V2 for Max Takeoff Thrust

WEIGHT (1000 KG)	FLAPS 1			FLAPS 5			FLAPS 10			FLAPS 15			FLAPS 25		
	V1	VR	V2	V1	VR	V2	V1	VR	V2	V1	VR	V2	V1	VR	V2
90	167	169	176	160	163	167	160	161	166						
85	162	165	171	156	159	164	155	157	162	151	153	159	149	150	157
80	157	160	167	151	154	160	150	152	158	147	148	155	144	145	153
75	152	155	162	146	148	156	145	147	154	142	144	151	139	141	149
70	146	149	158	140	143	152	139	141	150	136	138	147	134	136	145
65	140	143	153	135	137	148	133	136	146	130	133	143	128	130	141
60	134	136	148	128	131	143	127	129	141	124	126	138	122	124	136
55	127	129	143	122	124	137	121	123	136	118	120	133	116	118	131
50	120	122	137	115	117	132	114	116	131	112	113	128	110	111	126
45	113	114	131	109	110	126	107	108	125	105	106	123	103	104	121
40	106	106	125	101	102	121	100	101	119	98	99	117	96	97	115

Check V1(MCG).

V1, VR, V2 Adjustments*

TEMP	V1										VR										V2									
	PRESS ALT (1000 FT)										PRESS ALT (1000 FT)										PRESS ALT (1000 FT)									
	°C	°F	-2	0	2	4	6	8	10		-2	0	2	4	6	8	10		-2	0	2	4	6	8	10					
70	158	5	6							4	5							-3	-4											
60	140	4	5	6	7					4	4	5	6					-3	-3	-4	-4									
50	122	2	3	4	5	6	8	9		2	3	4	5	6	8	9		-1	-2	-3	-3	-4	-5	-6						
40	104	0	1	3	4	5	6	8	0	1	3	4	5	6	8	0	0	-1	-2	-2	-3	-4	-5							
30	86	0	0	1	3	4	5	7	0	0	1	3	4	5	7	0	0	-1	-2	-2	-3	-4								
20	68	0	0	1	2	3	4	6	0	0	1	2	3	4	6	0	0	-1	-1	-2	-3	-4								
-60	-76	0	0	1	2	3	4	6	0	0	1	2	3	4	5	0	0	-1	-1	-2	-2	-3								

Slope and Wind V1 Adjustments*

WEIGHT (1000 KG)	SLOPE (%)						WIND (KTS)									
	-2	-1	0	1	2		-15	-10	-5	0	10	20	30	40		
90	-4	-3	0	0	1		-4	-3	-2	0	0	-1	0	0		
80	-3	-2	0	0	1		-3	-2	-1	0	0	0	1	1		
70	-2	-1	0	1	2		-2	-1	-1	0	0	1	1	1		
60	-1	-1	0	1	1		-2	-1	0	0	0	1	1	1		
50	-1	-1	0	0	0		-2	-1	-1	0	0	0	0	1		
40	-1	-1	0	-1	-1		-3	-2	-1	0	0	-1	-1	-1		

*V1 not to exceed VR

V1(MCG)

Max Takeoff Thrust

TEMP	PRESSURE ALTITUDE (FT)								
	°C	°F	-2000	0	2000	4000	6000	8000	10000
70	158	97		94					
60	140	97		94	92	91			
50	122	99		97	93	91	89	86	83
40	104	103		101	98	94	90	86	83
30	86	106		105	101	97	94	89	85
20	68	106		106	102	99	95	91	87
-60	-76	108		107	104	100	97	93	89

737-800W / CFM56-7B27
 Pressure Altitude 0 ft, OAT 15°C
 Dry Runway, Standard Speeds
 Flaps 5, Takeoff Weight 60400 kg

Assumed
 temperature

V1 / VR / V2
 (kt)

60°C

134 / 135 / 140

45°C

131 / 133 / 142

15°C

128 / 131 / 143

Overspeed

*Use Speeds for the Lower Assumed Temperature,
Ignoring Weight Effect on Speeds*

737-800W WITH CFM56-7B27 ENGINES
PRESSURE ALTITUDE 0 FT
RUNWAY LENGTH 7000 FT, DRY
NO OBSTACLES

Maximum Allowable Assumed Temperature 60°C				STANDARD TAKEOFF SPEEDS		
				24K DERATE		
(C)	(KG)	LIM	(KT)	MTOW (KG)	PERF LIM	V1 VR V2 (KT)
60	60400	FLD	134 135 140	55900	FLD	131 131 134
55	62200	FLD	136 137 142	57700	FLD	133 133 137
50	65000	FLD	138 139 146	59700	FLD	134 135 139
45	67200	FLD	140 141 148	61900	FLD	136 137 142
40	69300	FLD	141 143 150	64100	FLD	138 139 144
38	70300	FLD	142 144 151	65000	FLD	139 140 145
36	71100	FLD	142 145 152	65800	FLD	139 141 146
34	72000	FLD	143 145 153	66700	FLD	140 141 147
32	72900	FLD	143 146 154			
30	73700	FLD	144 147 155			
25	74300	FLD	144 147 156			
20	75000	FLD	145 148 156	69800	FLD	143 144 151
15	75600	FLD	146 149 157	70300	FLD	144 145 151
10	76200	FLD	146 149 157	71000	FLD	144 146 152

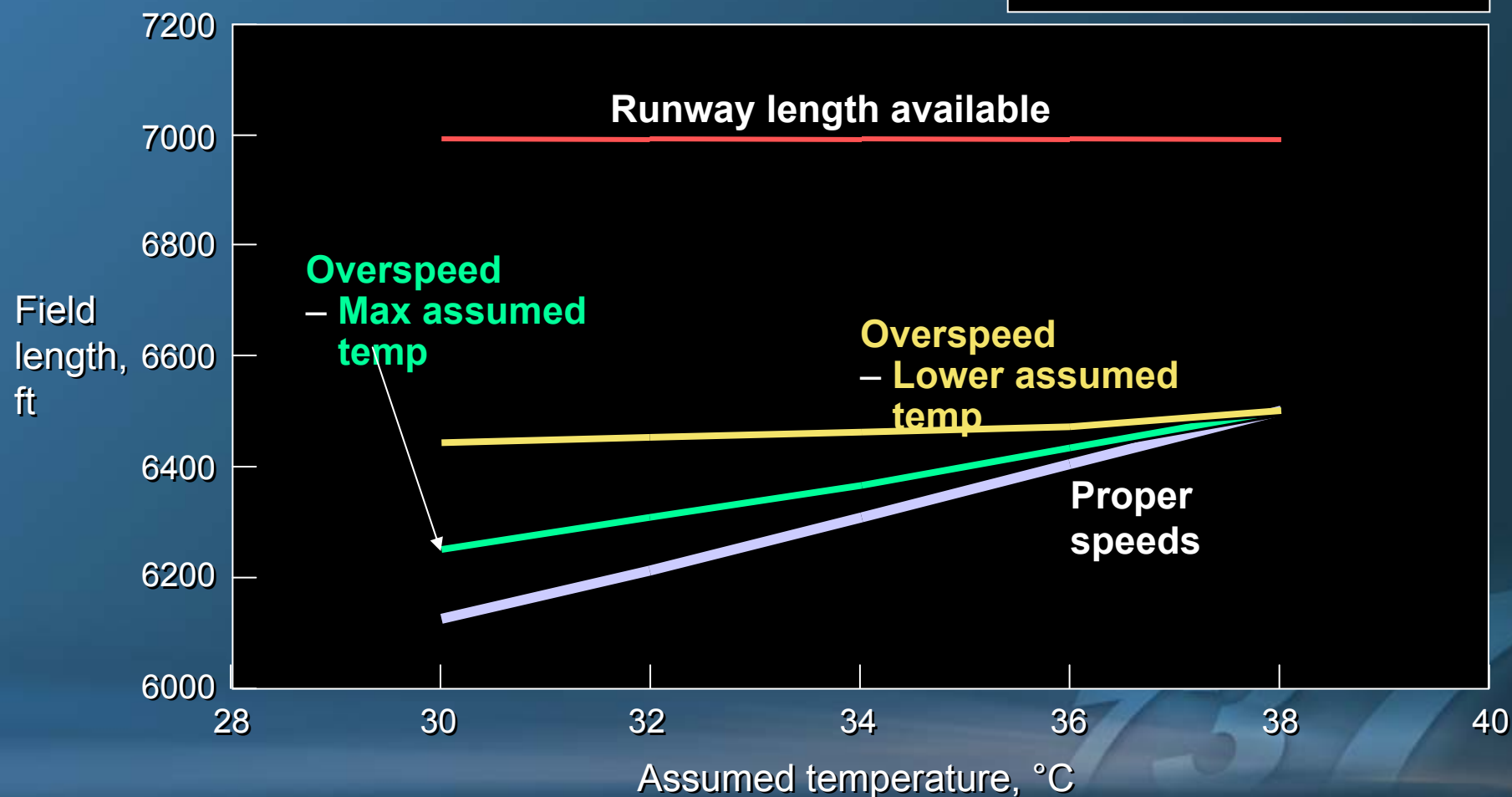
**27K, OAT 15°C
Takeoff Weight 60400 KG**

Overspeed Reduces Field Length Margin

Field Length Margin With Overspeed

• 737-800W / CFM56-7B27

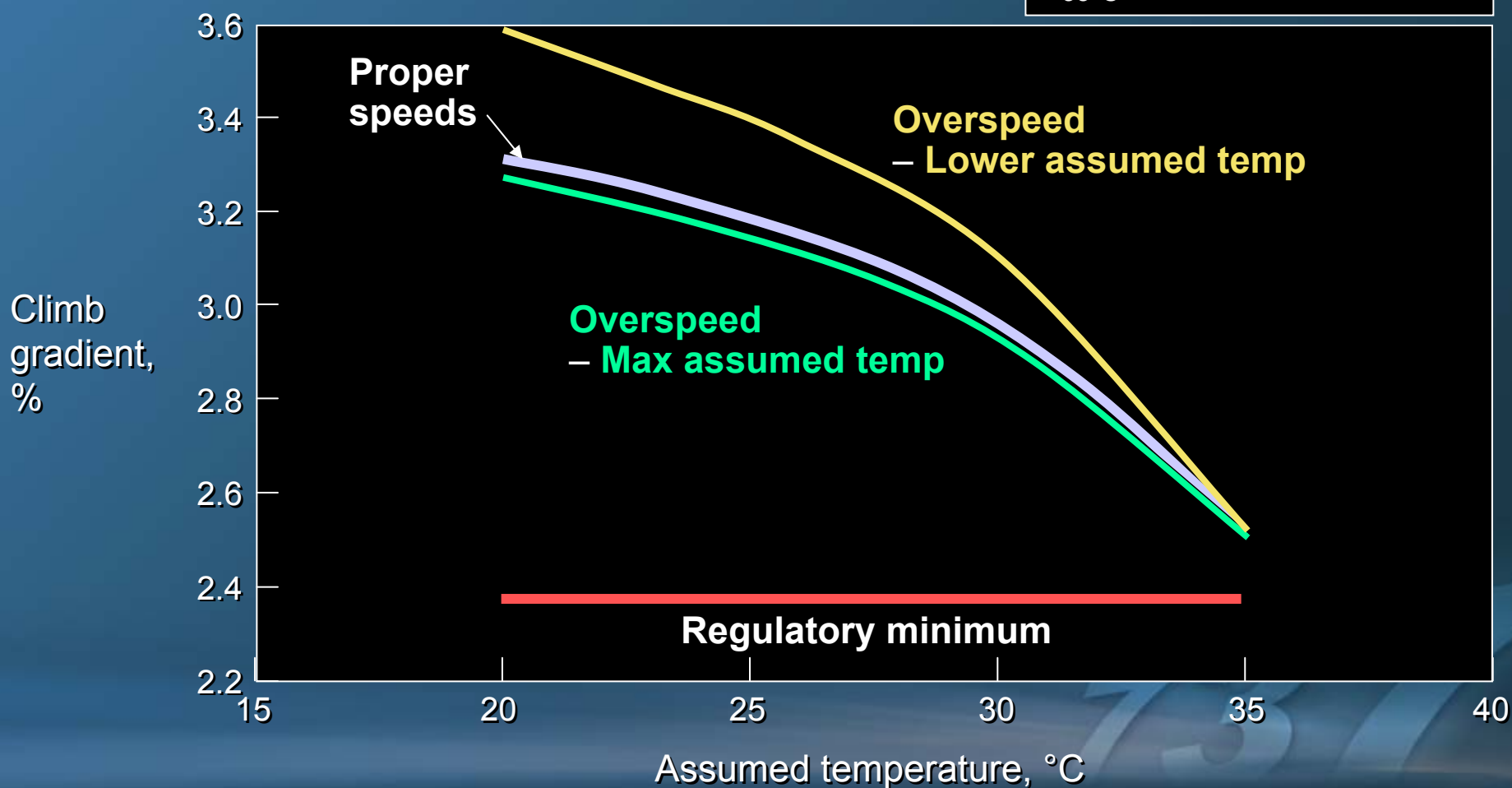
- Pressure Altitude 0 ft, OAT 15°C
- Runway Length 7000 ft, Dry
- Flaps 5, Takeoff Weight 70300 kg
- Max Allowable Assumed Temp 38°C



Effect of Overspeed on Climb Gradient

Climb Gradient Margin With Overspeed

- M56-7B27
- Pressure Altitude 5000 ft, OAT
- 10°C
- Runway Length 12000 ft, Dry
- Flaps 5, Takeoff Weight 71000 kg
- Max Allowable Assumed Temp 35°C

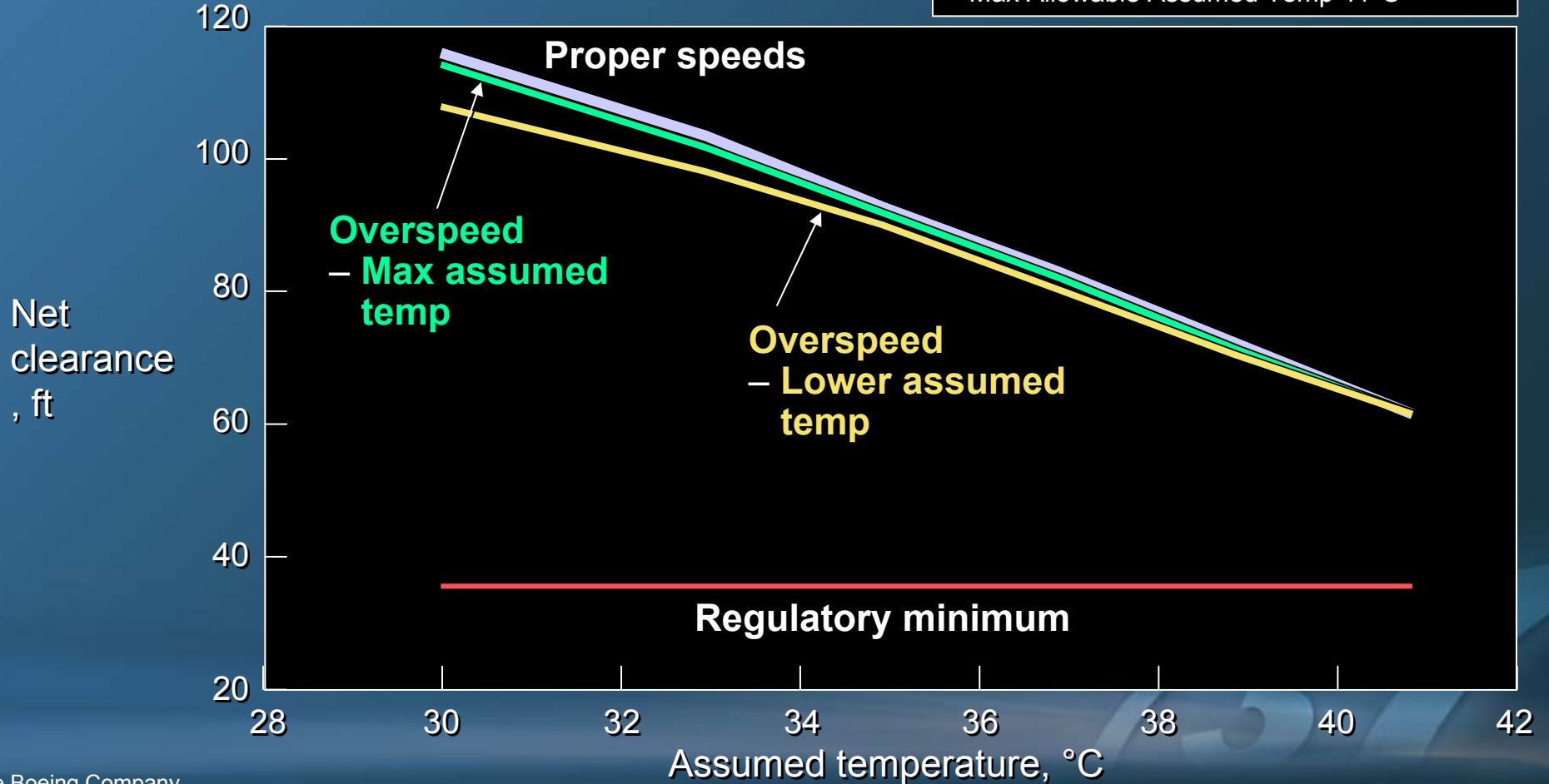


Overspeed Reduces Obstacle Clearance Margin

Obstacle Clearance With Overspeed

• 737-800W / 747-400 / A320neo / A321XLR

- Pressure Altitude 0 ft, OAT 15°C
- Runway Length 9000 ft, Dry
- Obstacle: 50 ft Ht at 1000 ft Dist from liftoff end
- Flaps 5, Takeoff Weight 73500 kg
- Max Allowable Assumed Temp 41°C



Means to Maximize Thrust Reduction and Performance Margins

- Takeoff configuration:
 - Flaps setting selection
 - No engine bleed for A/C packs
- Takeoff speeds options:
 - Improved climb
 - Optimized V1 (unbalanced)
- **Goal: Increase the difference between the OAT and the assumed temperature, thus increasing the true airspeed effect.**

Means to Maximize Thrust Reduction and Margin

Performance Limited by Field Length

737-800W WITH CFM56-7B27 ENGINES
 PRESSURE ALTITUDE 0 FT
 RUNWAY LENGTH 7000 FT, DRY
 NO OBSTACLES
 27K, STANDARD TAKEOFF SPEEDS

OAT (C)	FLAPS 5 A/C AUTO	FLAPS 15 A/C AUTO	FLAPS 5 A/C OFF
60	60400	60800	61300
55	62200	63400	63200
50	65000	66100	66000
45	67200	68200	68100
40	69300	70500	70300
38	70300	71400	71100
36	71100	72300	72000
34	72000	73200	72800
32	72900	74100	73600
30	73700	75000	74400
25	74300	75800	75200
20	75000	76600	76000
15	75600	77400	76800
10	76200	77600	76900

**OAT 15°C
Takeoff Weight 70300 KG**

Field Length Margin With Optimum Takeoff Configuration

Assumed temperature	Takeoff configuration	Field length required, ft	Extra margin, ft
38°C	Flaps 5, A/C Auto	6507	493
38°C	Flaps 15, A/C Auto	6314	686
38°C	Flaps 5, A/C Off	6360	640
40°C	Flaps 15, A/C Auto	6416	584
40°C	Flaps 5, A/C Off	6461	539

Means to Maximize Thrust Reduction and Margin

Performance Limited by Climb or Obstacle Clearance

737-800W WITH CFM56-7B27 ENGINES
 PRESSURE ALTITUDE 5000 FT
 RUNWAY LENGTH 12000 FT, DRY
 NO OBSTACLES
 27K, A/C AUTO

OAT (C)	FLAPS 5 NO IMP CLB	FLAPS 1 NO IMP CLB	FLAPS 5 WITH IMP CLB
60	57300	59300	60600
55	59900	62000	63200
50	62500	64700	65700
45	65100	67400	68300
40	68100	70500	71100
39	68700	71100	71600
37	69900	72400	72500
35	71000	73100	73400
30	73900	74000	75300
25	75400		
20	76400		
15	76400	76100	77100
10	76500	76800	78100

**OAT 10°C
 Takeoff Weight 71000 KG**

Performance Margins With Optimum Takeoff Option

Assumed temperature	Takeoff option	Field length required, ft	Extra margin, ft	Climb gradient, %
35°C	Flaps 5, No Imp Climb	9086	2914	2.54
35°C	Flaps 1, No Imp Climb	9804	2196	2.93
39°C	Flaps 1, No Imp Climb	10153	1847	2.58
40°C	Flaps 5, Improved Climb	10642	1358	2.58

The Takeoff Derate Method

- Available for use on slippery or contaminated runways and with inoperative antiskid
- Can be combined with use of assumed temperature



Runway Length Consideration

737-800W WITH CFM56-7B27 ENGINES
 PRESSURE ALTITUDE 0 FT
 RUNWAY LENGTH 7000 FT, DRY
 NO OBSTACLES
 FLAPS 5, A/C AUTO, STANDARD TAKEOFF SPEEDS

MAXIMUM RATED THRUST (27K)						24K DERATE				
OAT (C)	MTOW (KG)	PERF LIM	V1 (KT)	VR (KT)	V2 (KT)	MTOW (KG)	PERF LIM	V1 (KT)	VR (KT)	V2 (KT)
60	60400	FLD	134	135	140	55900	FLD	131	131	134
55	62200	FLD	136	137	142	57	OAT 15°C Takeoff Weight 70300 KG			
50	65000	FLD	138	139	146	59				
45	67200	FLD	140	141	148	61900	FLD	136	137	142
40	69300	FLD	141	143	150	64100	FLD	138	139	144
38	70300	FLD	142	144	151	65000	FLD	139	140	145
36	71100	FLD	142	145	152	65800	FLD	139	141	146
34	72000	FLD	143	145	153	66700	FLD	140	141	147
32	72900	FLD	143	146	154	67700	FLD	141	142	148
30	73700	FLD	144	147	155	68600	FLD	141	143	149
25	74300	FLD	144	147	156	69200	FLD	142	144	150
20	75000	FLD	145	148	156	69800	FLD	143	144	151
15	75600	FLD	146	149	157	70300	FLD	144	145	151
10	76200	FLD	146	149	157	71000	FLD	144	146	152

Using Derate Reduces Performance Margins

Parameter	24K Derate OAT 15°C	27K assume 38°C
Field Length Required, ft	7000	6507
Thrust per Engine at V1, lb	22353	24061
Takeoff N1 Setting	93.8	97.2

Climb Consideration

737-800W WITH CFM56-7B27 ENGINES
 PRESSURE ALTITUDE 5000 FT
 RUNWAY LENGTH 12000 FT, DRY
 NO OBSTACLES
 FLAPS 5, A/C AUTO, STANDARD TAKEOFF SPEEDS

MAXIMUM RATED THRUST (27K)						24K DERATE				
OAT (C)	MTOW (KG)	PERF LIM	V1 (KT)	VR (KT)	V2 (KT)	MTOW (KG)	PERF LIM	V1 (KT)	VR (KT)	V2 (KT)
60	57300	CLB	133	133	136	49000	CLB	126	126	129
55	59900	CLB	136	136	139	51500	CLB	126	126	129
50	62500	CLB	138	139	142	53800	CLB	129	129	132
45	65100	CLB	140	141	145	56200	CLB	132	132	134
40	68100	CLB	141	141	148	58900	CLB	135	135	138
35	71000	CLB	146	147	151	61700	CLB	138	138	141
30	73900	CLB	148	150	154	64600	CLB	140	141	144
25	75400	CLB	149	151	155	67600	CLB	143	144	147
20	76400	CLB	150	152	156	70800	CLB	146	147	151
15	76400	CLB	150	152	156	70900	CLB	146	147	151
10	76500	CLB	150	152	156	71000	CLB	146	147	151

OAT 10°C
 Takeoff Weight 71000 KG

Using Derate Reduces Performance Margins

Parameter	24K Derate OAT 10°C	27K assume 35°C
One Engine Inoperative Climb Gradient (%)	2.4	2.54

Obstacle Clearance Consideration

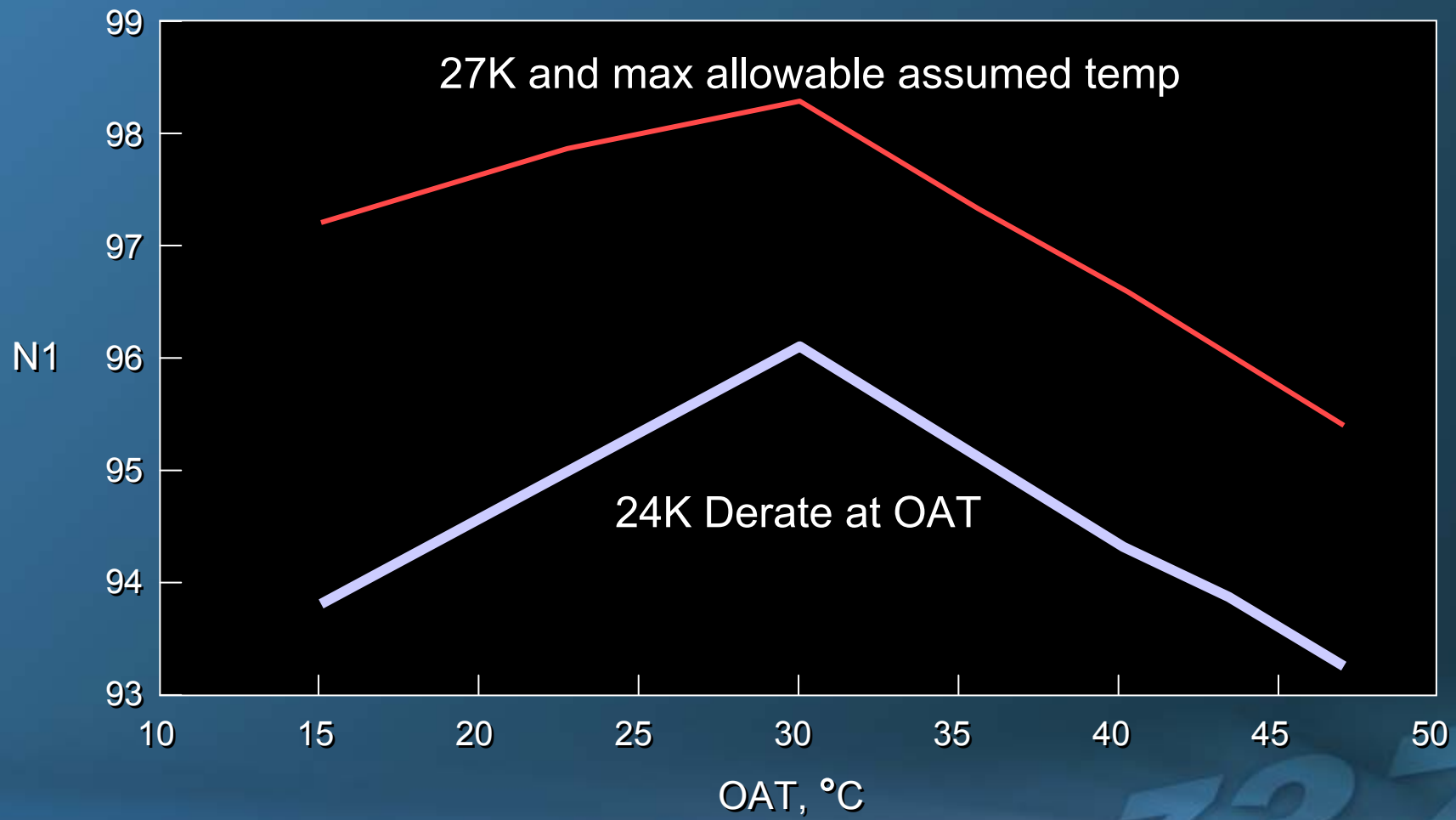
737-800W WITH CFM56-7B27 ENGINES
 PRESSURE ALTITUDE 0 FT
 RUNWAY LENGTH 9000 FT, DRY
 OBSTACLE: 50 FT HT AT 1000 FT DIST FROM LIFTOFF END
 FLAPS 5, A/C AUTO, STANDARD TAKEOFF SPEEDS

MAXIMUM RATED THRUST (27K)					24K DERATE					
OAT (C)	MTOW (KG)	PERF LIM	V1 (KT)	VR (KT)	V2 (KT)	MTOW (KG)	PERF LIM	V1 (KT)	VR (KT)	V2 (KT)
60	62900	OBS	138	138	143	57000	OBS	132	132	136
55	65200	OBS	140	141	145	59	OAT 15°C Takeoff Weight 73500 KG			
50	68600	OBS	142	144	149	61				
45	71300	OBS	144	146	152	64200	OBS	139	140	144
43	72400	OBS	145	147	153	65200	OBS	140	141	145
41	73500	OBS	146	148	154	66300	OBS	141	142	146
39	74600	OBS	147	149	155	67400	OBS	142	143	148
37	75700	OBS	147	150	156	68400	OBS	143	144	149
35	76700	OBS	148	151	157	69400	OBS	143	145	150
30	79300	OBS	149	153	160	72200	OBS	146	147	153
25	79800	OBS	150	153	160	72700	OBS	146	147	153
20	80300	OBS	150	154	161	73100	OBS	147	148	153
15	80800	OBS	151	154	161	73500	OBS	147	148	154
10	81300	OBS	151	155	161	73900	OBS	147	149	154

Using Derate Reduces Performance Margins

Parameter	24K Derate OAT 15°C	27K assume 41°C
Net Clearance (ft)	35	61

For Equivalent Performance, Using Derate Lowers N1 (RPM) and Achieves More Effective Thrust Reduction



Other Advantages Of Takeoff Derate

- Permitted on slippery or contaminated runways, where the use of assumed temperature reduced thrust is prohibited
- Permitted with anti-skid system inoperative
- May increase maximum takeoff weight when performance is limited by V_{MCG}
- May improve aircraft loadability, for some models, by extending aft takeoff CG limit
- Better trimmed for rotation and climbout for most models

Summary On Performance Margins

- Extra performance margins are inherent in the Assumed Temperature method of reduced thrust, including at the maximum allowable assumed temperature
- Using those inherent margins for takeoff weight planning is prohibited!

