

Anatomy of an Overrun What is your Role?



Captain Linda Orlady

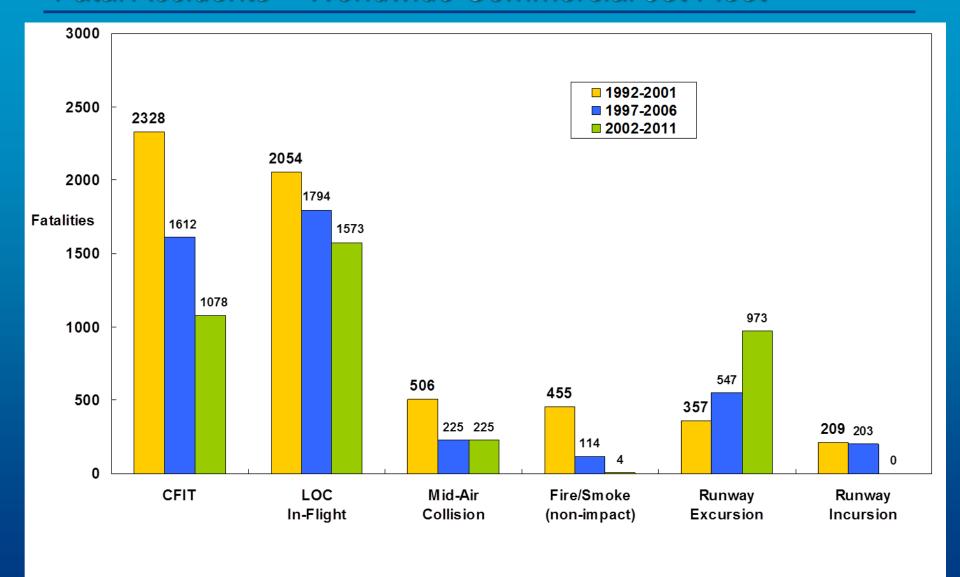
Chief Pilot, Flight Technical and Safety
The Boeing Company

National Airport Infrastructure Show & Civil Aviation
Moscow, Russia
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(Some material adapted from earlier presentation by Boeing Air Safety Investigator, Mark Smith)

Statistical Trends

Fatal Accidents - Worldwide Commercial Jet Fleet

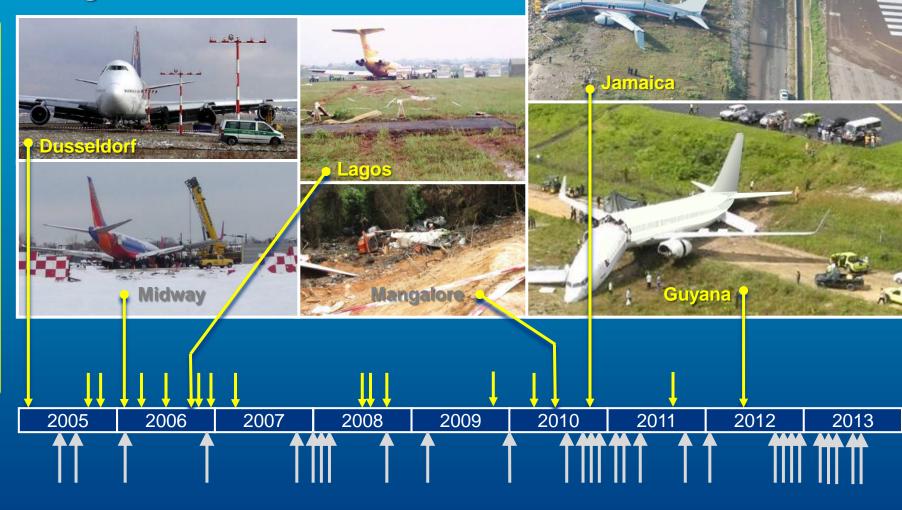


What is Your Role?

- 1) The pilot (Captain or F/O, PF or PM)
- 2) Airline management
- 3) Airport Manager
- 4) Air Traffic Controller
- 5) Regulator

Runway Overruns

Looking Back - What We've Seen



Primary Overrun Factors

2 of 3 primary factors are fixed at touchdown

- 1) Touchdown Point
- 2) Touchdown Speed
- 3) Deceleration after Touchdown

Approach



- Deceleration

- Touchdown Point
- Touchdown Speed

Runway

Departure

		Touch	down	Touch	down		Decele	ration			
		Po	int	Spe	eed	Spdbrake	Thrust R	Reversers	Runway	Res	sult
	Approach	Point	Runway	Airspd	Tail	When SB	When TR	When TR	Braking	Overrun	Hull
	прргодоп	000 (000000000000000000000000000000000	Used	>Vref	Wind	Deployed	Deployed	Reduced	Action	Speed	Loss
		(feet)	(% LDA)	(knots)	(knots)	(sec)	(sec)	(feet)		(knots)	
	Unstable	7000	72%	22	0	TD	TD + 3	departure	Good	81	yes
	Unstable	6200	70%	12	5	TD	never		Dry	50	no
	Unstable	5630	57%	11	14	TD	TD + 3		Med	100	yes
	Unstable	5300	60%	16	3	TD	TD + 4	departure	Good	35	no
	Unstable	5150	48%	20	0	TD + 5	TD + 7	900	Med	70	no
	Unstable	4700	52%	30	-1	TD	TD + 2	1000		100	yes
	Unstable	4500	60%	-3	1	TD	TD + 2	departure	Good	47	yes
	Unstable	4500	56%	6	3	TD	TD + 3	400	Dry	90	yes
ರಾ	Unstable	4380	55%	46	4	TD	TD + 2	departure	Good	65	no
Long	Unstable	4000	30%	0	10	TD	TD + 2	departure	Med	40	no
<u> </u>	Stable	3950	44%	0	14	TD	TD + 3	departure	Med	63	yes
	Unstable	3935	49%	7	10	TD	TD + 3	departure	Med	4	no
	Unstable	3840	48%	20	-8	TD	TD + 3	departure	Med	34	no
	Stable	3700	32%	0	10	TD	TD + 2	departure		50 40	no
	Stable Stable	3260 3200	41% 48%	20 -7	-1	TDth TD	TD + 3	2000	Med Good	40 30	no
	Stable	3120	40%	10	4 10	with TR TD	TD + 2	departure departure	Good	50 50	no no
	Stable	3000	37%	-5	6	TD	TD + 2	departure	Med	30	no
	Stable	3000	34%	3	5	TD	TD + 3	departure	Med	5	no
	Stable	2770	35%		12	TD	TD + 2	1000	Good	15	no
	Otable	2			12	10	1012	1000	Cood	10	110
										_	Ladesta 1
	Stable	1500	20%	20	10	TD	TD + 3	600	Med	5	no
	Stable	1450	20%	11	15	TD	TD + 3	1250	Med	20	no
st	Stable	1600	20%	12 5	10 10	TD	TD + 27	departure	Good	25	no
Fast	Stable Stable	1500 1450	23% 20%	6	9	TD TD	TD + 2 TD + 3	1550	Med Med	30	no
	Stable	1250	18%	4	11	TD	TD + 3	departure departure	Poor	0 45	no no
5.,	Stable	1230	1070		3	ID	IDTZ	departure	F 001	40	110
			4								
	Stable	2700	30%	0	0	never	never		Med	45	no
	Stable	400	6%	2	-6	never	TD + 22	departure	Med	48	no
_	Stable	500	8%	3	4	with TR	TD + 20	departure	Med	32	no
ō	Stable	1250	21%	0	9	TD	TD + 16	departure	Poor	42	no
芸	Unstable	1720	27%	6	5	TD + 9	TD + 13	departure	Good	20	no
20	Unstable	1800	23%	10	2 -2	with TR	TD + 11	departure	Poor	28	no
e	Stable	1900 1150	26% 24%	6 5	-2 -5	TD TD	TD + 8 TD + 6	departure 100	Med Med	20 12	no
Deceleration	Stable Stable	2900	28%	0	-5 -6	TD + 3	TD + 5	2800	Poor	12	no
é	Stable 	1480	20%	0	-6 8	TD	TD + 3	1300		30	no no
	Stable	2500	31%	0	2	TD	TD + 3	2250	Good	25	no
	Stable	2200	27%	5	7	TD	TD + 2	2000	Med	45	no
	Stable	1250	14%	2	4	TD	TD + 1	2400	Poor	15	no
	Oldbic	1200	1770		7		13		1 301	10	110
							- '	de la companya de la			

39 Overruns

		Touch	down	Touch	down	Deceleration					
		Po	int	Spe	ed	Spdbrake	Thrust R	Reversers	Runway	Res	ult
	Approach	Point	Runway Used	Airspd >Vref	Tail Wind	When SB Deployed	When TR Deployed	When TR Reduced	Braking Action	Overrun Speed	Hull Loss
		(feet)	(% LDA)	(knots)	(knots)	(sec)	(sec)	(feet)	Action	(knots)	L033
	Unstable	7000	72%	22	0	TD	TD + 3	departure	Good	81	yes
	Unstable	6200	70%	12	5	TD	never		Dry	50	no
	Unstable	5630	57%	11	14	TD	TD + 3		Med	100	yes
	Unstable	5300	60%	16	3	TD	TD + 4	departure	Good	35	no
	Unstable	5150	48%	20	0	TD + 5	TD + 7	900	Med	70	no
	Unstable	4700	52%	30	-1	TD	TD + 2	1000		100	yes
	Unstable	4500	60%	-3	1	TD	TD + 2	departure	Good	47	yes
	Unstable	4500	56%	6 46	3 4	TD	TD + 3	400	Dry	90	yes
0	Unstable Unstable	4380 4000	55% 30%	0	10	TD TD	TD + 2 TD + 2	departure	Good Med	65 40	no
Long	Stable	3950	44%	0	14	TD	TD + 3	departure departure	Med	63	no yes
i i	Unstable	3935	49%	7	10	TD	TD + 3	departure	Med	4	no
	Unstable	3840	48%	20	-8	TD	TD + 3	departure	Med	34	no
	Stable	3700	32%	0	10	TD	TD + 2	departure		50	no
	Stable	3260	41%	20	-1	TD	TD + 3	2000	Med	40	no
	Stable	3200	48%	-7	4	with TR	TD + 2	departure	Good	30	no
	Stable	3120	42%	10	10	TD	TD + 2	departure	Good	50	no
	Stable	3000	37%	-5	6	TD	TD + 2	departure	Med	30	no
	Stable	3000	34%	3	5	TD	TD + 3	departure	Med	5	no
	Stable	2770	35%	0	12	TD	TD + 2	1000	Good	15	no
		2	0								
	Stable	1500	20%	20	10	TD	TD + 3	600	Med	5	no
	Stable	1450	20%	11	15	TD	TD + 3	1250	Med	20	no
+	Stable	1600	20%	12	10	TD	TD + 27	departure	Good	25	no
Fast	Stable	1500	23%	5	10	TD	TD + 2	1550	Med	30	no
111	Stable	1450	20%	6	9	TD	TD + 3	departure	Med	0	no
	Stable	1250	18%	4	11	TD	TD + 2	departure	Poor	45	no
				6	6						
	Stable	2700	30%	0	0	never	never		Med	45	no
	Stable	400	6%	2	-6	never	TD + 22	departure	Med	48	no
	Stable	500	8%	3	4	with TR	TD + 20	departure	Med	32	no
Z	Stable	1250	21%	0	9	TD	TD + 16	departure	Poor	42	no
ţ	Unstable	1720	27%	6	5	TD + 9	TD + 13	departure	Good	20	no
eration	Unstable	1800	23%	10	2	with TR	TD + 11	departure	Poor	28	no
	Stable	1900	26%	6	-2	TD	TD + 8	departure	Med	20	no
ece	Stable	1150	24%	5	-5	TD	TD + 6	100	Med	12	no
e e	Stable	2900	28%	0	-6	TD + 3	TD + 5	2800	Poor	10	no
	 Otable	1480	20%	0	8	TD	TD + 3	1300		30	no
	Stable	2500	31%	0 5	2	TD	TD + 2	2250	Good	25 45	no
	Stable Stable	2200	27%	5	7	TD TD	TD + 2 TD + 1	2000 2400	Med	45 15	no
	Stable	1250	14%	2	4	ID	10 + 1		Poor	15	no
		4					13				

		Touch	down	Touch	down		Decele	ration			
		Poi	int	Spe	eed	Spdbrake	Thrust F	Reversers	Runway	Res	ult
	Approach	Point	Runway Used	Airspd >Vref	Tail Wind	When SB Deployed	When TR Deployed	When TR Reduced	Braking Action	Overrun Speed	Hull Loss
		(feet)	(% LDA)	(knots)	(knots)	(sec)	(sec)	(feet)		(knots)	
	Unstable Unstable	7000 6200	72% 70% 57%	22 12 11	0 5 14	TD TD	TD + 3	departure	Good Dry	81 50	yes no
	Unstable Unstable Unstable	5630 5300 5150	60% 48%	16 20	3	TD TD TD+5	TD + 3 TD + 4 TD + 7	departure 900	Med Good Med	100 35 70	yes no no
	Unstable Unstable Unstable	4700 4500 4500	52% 60% 56%	30 -3 6	-1 1 3	TD TD TD	TD + 2 TD + 2 TD + 3	1000 departure 400	Good Drv	100 47 90	yes yes
ong	Unstable Unstable	4380 4000	55% 30%	46 0	4 10	TD TD	TD + 2 TD + 2	departure departure	Good Med	65 40	yes no no
2	Stable Unstable Unstable	3950 3935 3840	44% 49% 48%	0 7 20	14 10 -8	TD TD TD	TD + 3 TD + 3 TD + 3	departure departure departure	Med Med Med	63 4 34	yes no no
	Stable Stable Stable	3700 3260 3200	32% 41% 48%	0 20 -7	10 -1 4	TD TD with TR	TD + 2 TD + 3 TD + 2	departure 2000 departure	Med Good	50 40 30	no no no
	Stable Stable Stable	3120 3000 3000	42% 37% 34%	10 -5 3	10 6 5	TD TD TD	TD + 2 TD + 2 TD + 3	departure departure departure	Good Med Med	50 30 5	no no no
	Stable	2770 2 0	35%	0	12	TD	TD + 2	1000	Good	15	no
Fast	Stable Stable Stable Stable Stable Stable	1500 1450 1600 1500 1450 1250	20% 20% 20% 23% 20% 18%	20 11 12 5 6 4	10 15 10 10 9 11	TD TD TD TD TD TD	TD + 3 TD + 3 TD + 27 TD + 2 TD + 3 TD + 2	600 1250 departure 1550 departure departure	Med Med Good Med Med Poor	5 20 25 30 0 45	no no no no no
Deceleration	Stable Stable Stable Stable Unstable Unstable Stable Stable Stable	2700 400 500 1250 1720 1800 1900 1150 2900 1480	30% 6% 8% 21% 27% 23% 26% 24% 28% 20%	0 2 3 0 6 10 6 5 0	0 -6 4 9 5 2 -2 -5 -6 8	never never with TR TD TD + 9 with TR TD TD TD + 3 TD	never TD + 22 TD + 20 TD + 16 TD + 13 TD + 11 TD + 8 TD + 6 TD + 5 TD + 3	departure departure departure departure departure departure 100 2800 1300	Med Med Med Poor Good Poor Med Med Poor	45 48 32 42 20 28 20 12 10 30	no no no no no no no no no
	Stable Stable Stable	2500 2200 1250	31% 27% 14%	0 5 2	2 7 4	TD TD TD	TD + 2 TD + 2 TD + 1	2250 2000 2400	Good Med Poor	25 45 15	no no no

		Touch	down	Touch	Compared to the Compared Compa		Decele	ration			
		Poi	nt	Spe	eed	Spdbrake	Thrust F	Reversers	Runway	Res	ult
	Approach	Point	Runway	Airspd	Tail	When SB	When TR	When TR	Braking	Overrun	Hull
	Украгоскогт		Used	>Vref	Wind	Deployed	Deployed	Reduced	Action	Speed	Loss
		(feet)	(% LDA)	(knots)	(knots)	(sec)	(sec)	(feet)		(knots)	
	Unstable	7000	72%	22	0	TD	TD + 3	departure	Good	81	yes
	Unstable	6200	70%	12	5	TD	never		Dry	50	no
	Unstable	5630	57%	11	14	TD	TD + 3		Med	100	yes
	Unstable	5300	60%	16	3	TD	TD + 4	departure	Good	35	no
	Unstable	5150	48%	20	0	TD + 5	TD + 7	900	Med	70	no
	Unstable	4700	52%	30	-1	TD	TD + 2	1000		100	yes
	Unstable	4500	60% 56%	-3	1	TD	TD + 2	departure	Good	47 90	yes
	Unstable Unstable	4500 4380	55%	6 46	3 4	TD TD	TD + 3 TD + 2	400	Dry	90 65	yes
ong.	Unstable	4000	30%	0	10	TD	TD + 2	departure departure	Good Med	40	no no
0	Stable	3950	44%	ő	14	TD	TD + 3	departure	Med	63	yes
Ĭ	Unstable	3935	49%	7	10	TD	TD + 3	departure	Med	4	no
	Unstable	3840	48%	20	-8	TD	TD + 3	departure	Med	34	no
	Stable	3700	32%	0	10	TD	TD + 2	departure		50	no
	Stable	3260	41%	20	-1	TD	TD + 3	2000	Med	40	no
	Stable	3200	48%	-7	4	with TR	TD + 2	departure	Good	30	no
	Stable	3120	42%	10	10	TD	TD + 2	departure	Good	50	no
	Stable	3000	37%	-5	6	TD	TD + 2	departure	Med	30	no
	Stable	3000	34%	3	5	TD	TD + 3	departure	Med	5	no
	Stable	2770	35%	0	12	TD	TD + 2	1000	Good	15	no
		20)								
	Stable	1500	20%	20	10	TD	TD + 3	600	Med	5	no
	Stable	1450	20%	11	15	TD	TD + 3	1250	Med	20	no
st	Stable	1600	20%	12	10	TD	TD + 27	departure	Good	25	no
as	Stable	1500	23%	5	10	TD	TD + 2	1550	Med	30	no
ů.	Stable	1450	20%	6	9	TD	TD + 3	departure	Med	0	no
	Stable	1250	18%	4	11	TD	TD + 2	departure	Poor	45	no
				(3						
	Stable	2700	30%	0	0	never	never		Med	45	no
	Stable	400	6%	2	-6	never	TD + 22	departure	Med	48	no
	Stable	500	8%	3	4	with TR	TD + 20	departure	Med	32	no
_	Stable	1250	21%	ő	9	TD	TD + 16	departure	Poor	42	no
.9	Unstable	1720	27%	6	5	TD+9	TD + 13	departure	Good	20	no
ल	Unstable	1800	23%	10	2	with TR	TD + 11	departure		28	no
e e	Stable	1900	26%	6	-2	TD	TD + 8	departure	Med	20	no
o	Stable	1150	24%	5	-5	TD	TD + 6	100	Med	12	no
Deceleration	Stable	2900	28%	0	-6	TD + 3	TD + 5	2800	Poor	10	no
		1480	20%	0	8	TD	TD + 3	1300		30	no
	Stable	2500	31%	ō	2 7	TD	TD + 2	2250	Good	25	no
	Stable	2200	27%	5		TD	TD + 2	2000	Med	45	no
	Stable	1250	14%	2	4	TD	TD+1	2400	Poor	15	no
							13	3			

г					down		Decele	ration			
		Poi		Spe		Spdbrake	Thrust F	Reversers	Runway	Res	sult
	Approach	Point	Runway	Airspd	Tail	When SB	When TR	When TR	Braking	Overrun	Hull
L		(foot)	Used (% LDA)	>Vref	Wind	Deployed	Deployed	Reduced (feet)	Action	Speed	Loss
		(feet)		(knots)	(knots)	(sec)	(sec)			(knots)	
	Unstable	7000	72%	22	0	TD	TD + 3	departure	Good	81	yes
	Unstable Unstable	6200 5630	70% 57%	12 11	5 14	TD TD	never TD + 3		Dry Med	50 100	no
	Unstable	5300	60%	16	3	TD	TD + 3	departure	Good	35	yes no
	Unstable	5150	48%	20	0	TD+5	TD + 7	900	Med	70	no
	Unstable	4700	52%	30	-1	TD	TD + 2	1000		100	yes
	Unstable	4500	60%	-3	1	TD	TD + 2	departure	Good	47	yes
	Unstable	4500	56%	6	3	TD	TD + 3	400	Dry	90	yes
បា	Unstable	4380	55%	46	4	TD	TD + 2	departure	Good	65	no
Long	Unstable	4000	30%	0	10	TD	TD + 2	departure	Med	40	no
9	Stable	3950	44%	0	14	TD	TD + 3	departure	Med	63	yes
	Unstable	3935	49%	7	10	TD	TD + 3	departure	Med	4	no
	Unstable	3840	48%	20	-8	TD	TD + 3	departure	Med	34	no
	Stable Stable	3700 3260	32% 41%	20	10 -1	TD TD	TD + 2 TD + 3	departure 2000	 Med	50 40	no no
	Stable	3200	48%	-7	4	with TR	TD + 3	departure	Good	30	no
	Stable	3120	42%	10	10	TD	TD + 2	departure	Good	50	no
	Stable	3000	37%	-5	6	TD	TD + 2	departure	Med	30	no
	Stable	3000	34%	3	5	TD	TD + 3	departure	Med	5	no
	Stable	2770	35%	0	12	TD	TD + 2	1000	Good	15	no
		20									
	Stable	1500	20%	20	10	TD	TD + 3	600	Med	5	no
	Stable	1450	20%	11	15	TD	TD + 3	1250	Med	20	no
+:	Stable	1600	20%	12	10	TD	TD + 27	departure	Good	25	no
Fast	Stable	1500	23%	5	10	TD	TD + 2	1550	Med	30	no
ഥ	Stable	1450	20%	6	9	TD	TD + 3	departure	Med	0	no
	Stable	1250	18%	4	11	TD	TD + 2	departure	Poor	45	no
				6							
	Stable	2700	30%	0	0	never	never		Med	45	no
	Stable	400	6%	2	-6	never	TD + 22	departure	Med	48	no
_	Stable	500	8%	3	4	with TR	TD + 20	departure	Med	32	no
0	Stable	1250	21%	0	9	TD	TD + 16	departure	Poor	42	no
Ė	Unstable	1720	27%	6	5	TD + 9	TD + 13	departure	Good	20	no
5	Unstable	1800	23%	10	2	with TR	TD + 11	departure	Poor	28	no
<u>0</u>	Stable Stable	1900	26% 24%	6 5	-2 -5	TD TD	TD + 8 TD + 6	departure 100	Med Med	20 12	no
eceleration	Stable	1150 2900	28%	0	-5 -6	TD + 3	TD + 6	2800	Poor	10	no no
De	Stable	1480	20%	0	-0 8	TD	TD + 3	1300		30	no
	Stable	2500	31%	0	2	TD	TD + 3	2250	Good	25	no
	Stable	2200	27%	5	7	TD	TD + 2	2000	Med	45	no
	Stable	1250	14%	2	4	TD	TD + 1	2400	Poor	15	no
							13				

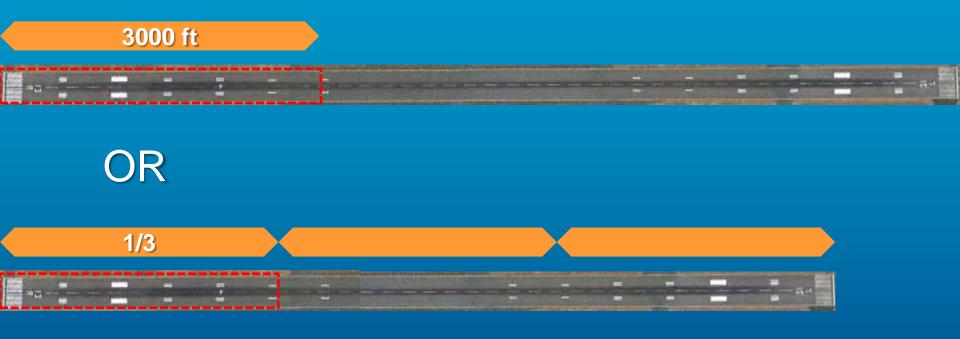
		Touch	down	Touch	down		Decele	ration			
		Poi	nt	Spe	ed	Spdbrake	Thrust F	Reversers	Runway	Res	ult
	Approach	Point	Runway	Airspd	Tail	When SB	When TR	When TR	Braking	Overrun	Hull
		(feet)	Used (% LDA)	>Vref (knots)	Wind (knots)	Deployed (sec)	Deployed (sec)	Reduced (feet)	Action	Speed (knots)	Loss
									0 1		10000
	Unstable Unstable	7000 6200	72% 70%	22 12	0 5	TD TD	TD + 3 never	departure	Good Dry	81 50	yes no
	Unstable	5630	57%	11	14	I TD	TD + 3		Med	100	ves
	Unstable	5300	60%	16	3	TD	TD + 4	departure	Good	35	no
	Unstable	5150	48%	20	0	TD + 5	TD + 7	900	Med	70	no
	Unstable	4700	52%	30	-1	TD	TD + 2	1000		100	yes
	Unstable	4500	60%	-3	1	TD	TD + 2	departure	Good	47	yes
	Unstable	4500	56%	6	3	TD	TD + 3	400	Dry	90	yes
ರಾ	Unstable	4380	55%	46	4	TD	TD + 2	departure	Good	65	no
Long	Unstable	4000 3950	30% 44%	0	10 14	TD TD	TD + 2 TD + 3	departure	Med	40	no
ĭ	Stable Unstable	3935	44%	7	10	TD	TD + 3	departure departure	Med Med	63 4	yes no
	Unstable	3840	48%	20	-8	I TD	TD + 3	departure	Med	34	no
	Stable	3700	32%	0	10	TD	TD + 2	departure		50	no
	Stable	3260	41%	20	-1	TD	TD + 3	2000	Med	40	no
	Stable	3200	48%	-7	4	with TR	TD + 2	departure	Good	30	no
	Stable	3120	42%	10	10	TD	TD + 2	departure	Good	50	no
	Stable	3000	37%	-5	6	TD	TD + 2	departure	Med	30	no
	Stable	3000	34%	3	5	TD	TD + 3	departure	Med	.5	no
	Stable	2770	35%	0	12	TD	TD + 2	1000	Good	15	no
		20)								
	Stable	1500	20%	20	10	TD	TD + 3	600	Med	5	no
	Stable	1450	20%	11	15	TD	TD + 3	1250	Med	20	no
+	Stable	1600	20%	12	10	TD	TD + 27	departure	Good	25	no
Fast	Stable	1500	23%	5	10	TD	TD + 2	1550	Med	30	no
ш	Stable	1450	20%	6	9	TD	TD + 3	departure	Med	0	no
	Stable	1250	18%	4	11	TD	TD + 2	departure	Poor	45	no
				6							
	Stable	2700	30%	0	0	never	never		Med	45	no
	Stable	400	6%	2	-6	never	TD + 22	departure	Med	48	no
_	Stable	500	8%	3	4	with TR	TD + 20	departure	Med	32	no
0	Stable	1250	21%	0	9	TD	TD + 16	departure	Poor	42	no
ij	Unstable	1720	27%	6	5	TD + 9	TD + 13	departure	Good	20	no
10	Unstable	1800	23%	10	2 -2	with TR	TD + 11	departure	Poor	28 20	no
<u>\tau</u>	Stable Stable	1900 1150	26% 24%	5	-2 -5	TD TD	TD + 8 TD + 6	departure 100	Med Med	20 12	no no
eceleration	Stable	2900	28%	0	-6	TD+3	TD + 5	2800	Poor	10	no
De		1480	20%	0	8	TD	TD + 3	1300		30	no
	Stable	2500	31%	0	2	TD	TD + 2	2250	Good	25	no
	Stable	2200	27%	5	7	TD	TD + 2	2000	Med	45	no
	Stable	1250	14%	2	4	TD	TD + 1	2400	Poor	15	no
							13	3			

Grouped by Primary Overrun Factor

- **Touchdown Point**
- **Touchdown Speed**
- **Deceleration after Touchdown**

	Touchdown Point			Touchdown Speed				Deceleration					
		Poi	nt			0.00139990.		Spdbrake	Thrust F	Reversers	Runway	Res	sult
	Approach	Point	Runway		irspd	Tail	Ī	When SB	When TR	When TR	Braking	Overrun	Hull
		(reet)	Used (% LDA)	_	Vref	Wind (Knots)	ł	Deployed (sec)	Deployed (Sec)	Reduced (Teet)	Action	Speed (Knots)	Loss
	Unstable	7000	72%	(1)	22	0	İ	TD	TD + 3	departure	Good	81	yes
	Unstable	6200	70%		12	5	١	TD	never	ueparture	Dry	50	no
	Unstable	5630	57%		11	14	١	TD	TD + 3		Med	100	yes
	Unstable	5300	60%		16	3	ı	TD	TD + 4	departure	Good	35	no
	Unstable	5150	48%		20	0	١	TD + 5	TD + 7	900	Med	70	no
	Unstable	4700	52%		30	-1	1	TD	TD + 2	1000		100 47	yes
	Unstable Unstable	4500 4500	60% 56%		-3 6	1 3	١	TD TD	TD + 2 TD + 3	departure 400	Good Dry	47 90	yes yes
	Unstable	4380	55%		46	4	١	TD	TD + 2	departure	Good	65	no
ව	Unstable	4000	30%		0	10	1	TD	TD + 2	departure	Med	40	no
Long	Stable	3950	44%		0	14	١	TD	TD + 3	departure	Med	63	yes
	Unstable	3935	49%		7	10	-	TD	TD + 3	departure	Med	4	no
	Unstable	3840	48%		20	-8	١	TD	TD + 3	departure	Med	34	no
	Stable Stable	3700	32%		0 20	10 -1	١	TD TD	TD + 2 TD + 3	departure 2000	Mod	50 40	no
	Stable	3260 3200	41% 48%		-7	4	ł	with TR	TD + 3	departure	Med Good	40 30	no no
	Stable	3120	42%		10	10	ı	TD	TD + 2	departure	Good	50	no
	Stable	3000	37%		-5	6	١	TD	TD + 2	departure	Med	30	no
	Stable	3000	34%		3	5	-	TD	TD + 3	departure	Med	5	no
	Stable	2770	35%		0	12	_	TD	TD + 2	1000	Good	15	no
		20)										
	Stable	1500	20%		20	10	1	TD	TD + 3	600	Med	5	no
	Stable	1450	20%		11 12	15		TD TD	TD + 3	1250	Med	20 25	no
ast	Stable Stable	1600 1500	20% 23%		5	10 10		TD	TD + 27 TD + 2	departure 1550	Good Med	30	no no
T C	Stable	1450	20%		6	9		TD	TD + 3	departure	Med	0	no
	Stable	1250	18%		4	11		TD	TD + 2	departure	Poor	45	no
					6								
	Stable	2700	30%		0	0		never	never		Med	45	no
	Stable	400	6%		2	-6		never	TD + 22	departure	Med	48	no
_	Stable	500	8%		3	4		with TR	TD + 20	departure	Med	32	no
O	Stable	1250	21%		0	9	-	TD	TD + 16	departure		42	no
Ţ.	Unstable	1720	27%		6	5	1	TD + 9	TD + 13	departure	Good	20	no
10	Unstable Stable	1800 1900	23% 26%		10 6	2 -2	1	with TR TD	TD + 11 TD + 8	departure departure	Poor Med	28 20	no no
0	Stable	1150	24%		5	-2 -5		TD	TD+6	100	Med	12	no
eceleration	Stable	2900	28%		0	-6		TD+3	TD + 5	2800	Poor	10	no
De		1480	20%		0	8		TD	TD + 3	1300		30	no
	Stable	2500	31%		0	2		TD	TD + 2	2250	Good	25	no
	Stable	2200	27%		5	7		TD	TD + 2	2000	Med	45	no
	Stable	1250	14%		2	4	J	TD	TD + 1	2400	Poor	15	no
									13	3			

Touchdown Zone



Touch down in this zone or Go-around

Long Touchdown

Issues we see in the data

Long touchdowns generally fall into two categories:

- Path control
- about half crossed the threshold significantly high
- with thrust near idle
- Thrust control
- about half crossed the threshold at correct height
- but maintained advanced thrust well beyond the threshold

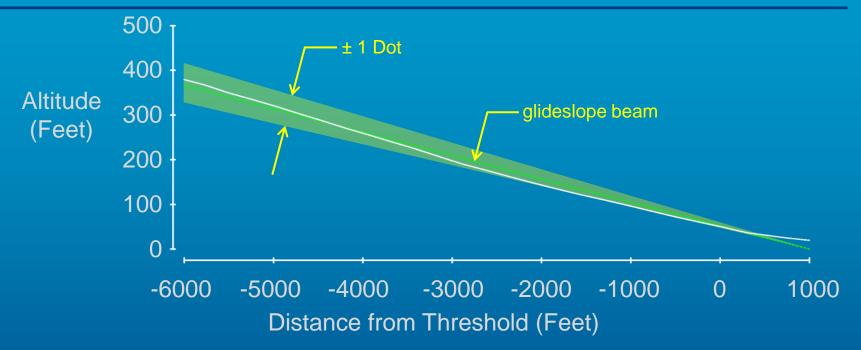
Grouped by Primary Overrun Factor

- **Touchdown Point**
- Touchdown Speed
- **Deceleration after Touchdown**

		Touch	Processor Accounts	Touch	Carlo de Carlo Car		Decele	ration			
		Poi	581507MC	Spe	***************************************	Spdbrake	Thrust F	Reversers	Runway	Res	
	Approach	Point	Runway	Airspd	Tail	When SB	When TR	When TR	Braking	Overrun	Hull
		(feet)	Used (% LDA)	>Vref (knots)	Wind (knots)	Deployed (sec)	Deployed (sec)	Reduced (feet)	Action	Speed (knots)	Loss
	Unstable	7000	72%	22	0	TD	TD + 3	departure	Good	81	yes
	Unstable	6200	70%	12	5	TD	never	acpartare	Dry	50	no
	Unstable	5630	57%	11	14	TD	TD + 3		Med	100	yes
	Unstable	5300	60%	16	3	TD	TD + 4	departure	Good	35	no
	Unstable	5150	48%	20	0	TD + 5	TD + 7	900	Med	70	no
	Unstable	4700	52%	30	-1	TD	TD + 2	1000		100	yes
	Unstable	4500	60%	-3	1	TD	TD + 2	departure	Good	47	yes
	Unstable Unstable	4500 4380	56% 55%	6 46	3 4	TD TD	TD + 3 TD + 2	400 departure	Dry Good	90 65	yes
ong	Unstable	4000	30%	0	10	TD	TD + 2	departure	Med	40	no no
0	Stable	3950	44%	0	14	TD	TD + 3	departure	Med	63	yes
	Unstable	3935	49%	7	10	TD	TD + 3	departure	Med	4	no
	Unstable	3840	48%	20	-8	TD	TD + 3	departure	Med	34	no
	Stable	3700	32%	0	10	TD	TD + 2	departure		50	no
	Stable	3260	41%	20	-1	TD	TD + 3	2000	Med	40	no
	Stable	3200	48%	-7	4	with TR	TD + 2	departure	Good	30	no
	Stable	3120	42%	10	10	TD	TD + 2	departure	Good	50	no
	Stable	3000	37%	-5	6	TD	TD + 2	departure	Med	30	no
	Stable Stable	3000 2770	34% 35%	3 0	5 12	TD TD	TD + 3 TD + 2	departure 1000	Med Good	5 15	no no
	Stable	20		Ů,	12	10	IDTZ	1000	Good	10	110
	Stable	J-WW									
		1500	20%	20	10	TD	TD + 3	600	Med	5	no
		1500 1450	20% 20%	20 11	10 15	TD TD	TD + 3 TD + 3	600 1250	Med Med	5 20	no no
يبا	Stable Stable	1500 1450 1600	20% 20% 20%	11	10 15 10	TD TD TD	TD + 3 TD + 3 TD + 27	600 1250 departure	Med Med Good	5 20 25	no no no
ast	Stable	1450	20%		15	TD	TD + 3 TD + 27 TD + 2	1250	Med	20	no
Fast	Stable Stable Stable Stable	1450 1600 1500 1450	20% 20% 23% 20%	11 12 5 6	15 10 10 9	TD TD TD TD	TD + 3 TD + 27 TD + 2 TD + 3	1250 departure 1550 departure	Med Good Med Med	20 25 30 0	no no no no
Fast	Stable Stable Stable	1450 1600 1500	20% 20% 23%	11 12 5 6 4	15 10 10 9 11	TD TD TD	TD + 3 TD + 27 TD + 2	1250 departure 1550	Med Good Med	20 25 30	no no no
Fast	Stable Stable Stable Stable	1450 1600 1500 1450	20% 20% 23% 20%	11 12 5 6	15 10 10 9 11	TD TD TD TD	TD + 3 TD + 27 TD + 2 TD + 3	1250 departure 1550 departure	Med Good Med Med	20 25 30 0	no no no no
Fast	Stable Stable Stable Stable Stable	1450 1600 1500 1450 1250	20% 20% 23% 20% 18%	11 12 5 6 4	15 10 10 9 11	TD TD TD TD TD	TD + 3 TD + 27 TD + 2 TD + 3 TD + 2	1250 departure 1550 departure departure	Med Good Med Med Poor	20 25 30 0 45	no no no no no
Fast	Stable Stable Stable Stable Stable Stable Stable	1450 1600 1500 1450 1250 2700 400	20% 20% 23% 20% 18%	11 12 5 6 4	15 10 10 9 11 5	TD TD TD TD TD TD	TD + 3 TD + 27 TD + 2 TD + 3 TD + 2 never TD + 22	1250 departure 1550 departure departure	Med Good Med Med Poor	20 25 30 0 45	no no no no no
L	Stable Stable Stable Stable Stable Stable Stable Stable	1450 1600 1500 1450 1250 2700 400 500	20% 20% 23% 20% 18% 30% 6% 8%	11 12 5 6 4 0 2 3	15 10 10 9 11 6 -6 4	TD TD TD TD TD TD	TD + 3 TD + 27 TD + 2 TD + 3 TD + 2 never TD + 22 TD + 20	departure 1550 departure departure departure departure	Med Good Med Med Poor Med Med Med	20 25 30 0 45 45 48 32	no no no no no
L	Stable	1450 1600 1500 1450 1250 2700 400 500 1250	20% 20% 23% 20% 18% 30% 6% 8% 21%	11 12 5 6 4 0 2 3 0	15 10 10 9 11 6 -6 4 9	TD	TD + 3 TD + 27 TD + 2 TD + 3 TD + 2 Period of the control of	departure 1550 departure departure departure departure departure departure	Med Good Med Med Poor Med Med Med Poor	20 25 30 0 45 45 48 32 42	no no no no no
L	Stable Stable Stable Stable Stable Stable Stable Stable Unstable	1450 1600 1500 1450 1250 2700 400 500 1250 1720	20% 20% 23% 20% 18% 30% 6% 8% 21% 27%	11 12 5 6 4 0 2 3 0 6	15 10 10 9 11 5 0 -6 4 9 5	TD T	TD + 3 TD + 27 TD + 2 TD + 3 TD + 2 TD + 2 TD + 22 TD + 20 TD + 16 TD + 13	departure 1550 departure departure departure departure departure departure departure	Med Good Med Med Poor Med Med Med Med Med Poor Good	20 25 30 0 45 45 48 32 42 20	no no no no no no no no
L	Stable	1450 1600 1500 1450 1250 2700 400 500 1250	20% 20% 23% 20% 18% 30% 6% 8% 21%	11 12 5 6 4 0 2 3 0	15 10 10 9 11 6 -6 4 9 5 2	TD	TD + 3 TD + 27 TD + 2 TD + 3 TD + 2 Period of the control of	departure 1550 departure departure departure departure departure departure	Med Good Med Med Poor Med Med Med Poor	20 25 30 0 45 45 48 32 42 20 28	no no no no no
L	Stable Stable Stable Stable Stable Stable Stable Unstable Unstable	1450 1600 1500 1450 1250 2700 400 500 1250 1720 1800	20% 20% 23% 20% 18% 30% 6% 8% 21% 27% 23%	11 12 5 6 4 0 2 3 0 6 10	15 10 10 9 11 5 0 -6 4 9 5	TD T	TD + 3 TD + 27 TD + 2 TD + 3 TD + 2 TD + 22 TD + 20 TD + 16 TD + 13 TD + 11	departure	Med Good Med Med Poor Med Med Med Med Med Poor Good Poor	20 25 30 0 45 45 48 32 42 20	no no no no no no no no no
L	Stable Stable Stable Stable Stable Stable Stable Unstable Unstable Stable	1450 1600 1500 1450 1250 2700 400 500 1250 1720 1800 1900	20% 20% 23% 20% 18% 30% 6% 8% 21% 27% 23% 26%	11 12 5 6 4 0 2 3 0 6 10 6	15 10 10 9 11 6 4 9 5 2 -2 -5 -6	never never with TR TD TD + 9 with TR TD	TD + 3 TD + 27 TD + 2 TD + 3 TD + 2 TD + 22 TD + 20 TD + 16 TD + 13 TD + 11 TD + 8	departure 2800	Med Good Med Med Poor Med Med Med Med Poor Good Poor Med	20 25 30 0 45 45 48 32 42 20 28 20 12 10	no n
Deceleration Fast	Stable Unstable Unstable Stable Stable	1450 1600 1500 1450 1250 2700 400 500 1250 1720 1800 1900 1150 2900 1480	20% 20% 23% 20% 18% 30% 6% 8% 21% 27% 23% 26% 24% 28% 20%	11 12 5 6 4 0 2 3 0 6 10 6 5 0	15 10 10 9 11 0 -6 4 9 5 2 -2 -5 -6 8	never never with TR TD TD + 9 with TR TD TD + 3 TD	TD + 3 TD + 27 TD + 2 TD + 3 TD + 2 TD + 2 TD + 22 TD + 20 TD + 16 TD + 13 TD + 11 TD + 8 TD + 6 TD + 5 TD + 3	departure 100 2800 1300	Med Good Med Med Poor Med Med Med Med Poor Good Poor Med Med Poor	20 25 30 0 45 45 48 32 42 20 28 20 12 10 30	no n
L	Stable Unstable Unstable Stable Stable Stable Stable Stable Stable Stable Stable	1450 1600 1500 1450 1250 2700 400 500 1250 1720 1800 1900 1150 2900 1480 2500	20% 20% 23% 20% 18% 30% 6% 8% 21% 27% 23% 26% 24% 28% 20% 31%	11 12 5 6 4 0 2 3 0 6 10 6 5 0	15 10 10 9 11 6 4 9 5 2 -2 -5 -6 8 2	never never with TR TD TD + 9 with TR TD TD + 3 TD TD	TD + 3 TD + 27 TD + 2 TD + 3 TD + 2 TD + 3 TD + 2 TD + 22 TD + 20 TD + 16 TD + 13 TD + 11 TD + 8 TD + 6 TD + 5 TD + 3 TD + 2	departure 100 2800 1300 2250	Med Good Med Med Poor Med Med Med Poor Good Poor Med Med Poor Good Cood Cood Cood Med Med Coor	20 25 30 0 45 45 48 32 42 20 28 20 12 10 30 25	no n
L	Stable Unstable Unstable Stable Stable Stable Stable Stable Stable Stable Stable Stable	1450 1600 1500 1450 1250 2700 400 500 1250 1720 1800 1900 1150 2900 1480 2500 2200	20% 20% 23% 20% 18% 30% 6% 8% 21% 27% 23% 26% 24% 28% 20% 31% 27%	11 12 5 6 4 0 2 3 0 6 10 6 5 0 0 0 5	15 10 10 9 11 0 -6 4 9 5 2 -2 -5 -6 8 2 7	never never with TR TD TD + 9 with TR TD TD + 3 TD TD TD	TD + 3 TD + 27 TD + 2 TD + 3 TD + 2 TD + 3 TD + 2 TD + 22 TD + 20 TD + 16 TD + 13 TD + 11 TD + 8 TD + 6 TD + 5 TD + 3 TD + 2 TD + 2 TD + 2	departure 100 2800 1300 2250 2000	Med Good Med Med Poor Med Med Med Poor Good Poor Med Med Poor Med Med Med Med Med	20 25 30 0 45 45 48 32 42 20 28 20 12 10 30 25 45	no n
L	Stable Unstable Unstable Stable Stable Stable Stable Stable Stable Stable Stable	1450 1600 1500 1450 1250 2700 400 500 1250 1720 1800 1900 1150 2900 1480 2500	20% 20% 23% 20% 18% 30% 6% 8% 21% 27% 23% 26% 24% 28% 20% 31%	11 12 5 6 4 0 2 3 0 6 10 6 5 0	15 10 10 9 11 6 4 9 5 2 -2 -5 -6 8 2	never never with TR TD TD + 9 with TR TD TD + 3 TD TD	TD + 3 TD + 27 TD + 2 TD + 3 TD + 2 TD + 3 TD + 2 TD + 22 TD + 20 TD + 16 TD + 13 TD + 11 TD + 8 TD + 6 TD + 5 TD + 3 TD + 2	departure 2800 1300 2250 2000 2400	Med Good Med Med Poor Med Med Med Poor Good Poor Med Med Poor Good Cood Cood Cood Med Med Coor	20 25 30 0 45 45 48 32 42 20 28 20 12 10 30 25	no n

Touchdown Fast

What We've Seen



"Duck Under" maneuver

- Intending to assure short touchdown
- +20 knots airspeed increase at touchdown resulted
- +10 knots unreported tailwind was also present
- +30 knots fast at touchdown Total

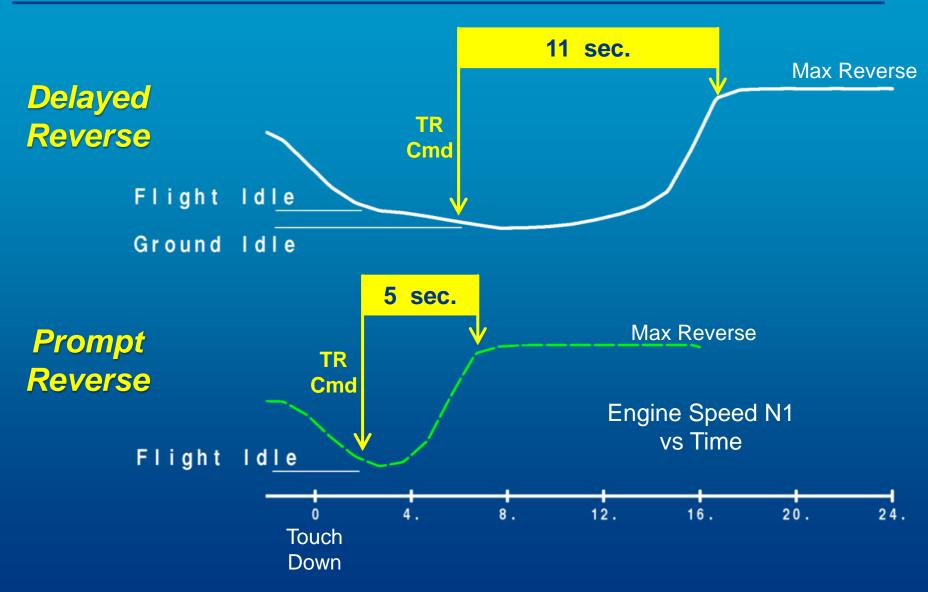
Grouped by Primary Overrun Factor

- **Touchdown Point**
- **Touchdown Speed**
- **Deceleration after Touchdown**

		Touch	MARKET PRODUCTION	Touch	Carrotte Carrotte Carrotte		Decele	ration		3	
		Poi	nt	Spe	ed	Spdbrake	Thrust F	Reversers	Runway	Res	sult
	Approach	Point	Runway	Airspd	Tail	When SB	When TR	When TR	Braking	Overrun	Hull
	, , , , , , , , , , , , , , , , , , , ,	050 (0000000000)	Used	>Vref	Wind	Deployed	Deployed	Reduced	Action	Speed	Loss
		(feet)	(% LDA)	(knots)	(knots)	(sec)	(sec)	(feet)		(knots)	
	Unstable	7000	72%	22	0	TD	TD + 3	departure	Good	81	yes
	Unstable	6200	70%	12	5	TD	never		Dry	50	no
	Unstable	5630	57%	11	14	TD	TD + 3		Med	100	yes
	Unstable	5300	60%	16	3	TD	TD + 4	departure	Good	35	no
	Unstable	5150	48%	20	0 -1	TD + 5	TD + 7	900	Med	70	no
	Unstable	4700 4500	52% 60%	30 -3	1	TD TD	TD + 2 TD + 2	1000	Cood	100 47	yes
	Unstable Unstable	4500	56%	-3	3	TD	TD + 2	departure 400	Good	90	yes
	Unstable	4380	55%	46	4	TD	TD + 2	departure	Dry Good	65	yes
Long	Unstable	4000	30%	0	10	TD	TD + 2	departure	Med	40	no
ō	Stable	3950	44%	0	14	TD	TD + 3	departure	Med	63	yes
	Unstable	3935	49%	7	10	TD	TD + 3	departure	Med	4	no
	Unstable	3840	48%	20	-8	TD	TD + 3	departure	Med	34	no
	Stable	3700	32%	0	10	TD	TD + 2	departure		50	no
	Stable	3260	41%	20	-1	TD	TD + 3	2000	Med	40	no
	Stable	3200	48%	-7	4	with TR	TD + 2	departure	Good	30	no
	Stable	3120	42%	10	10	TD	TD + 2	departure	Good	50	no
	Stable	3000	37%	-5	6	TD	TD + 2	departure	Med	30	no
	Stable	3000	34%	3	5	TD	TD + 3	departure	Med	5	no
	Stable	2770	35%	0	12	TD	TD + 2	1000	Good	15	no
		20)								
	Stable	1500	20%	20	10	TD	TD + 3	600	Med	5	no
	Stable	1450	20%	11	15	TD	TD + 3	1250	Med	20	no
	Stable	1600	20%	12	10	TD	TD + 27	departure	Good	25	no
ast	Stable	1500	23%	5	10	TD	TD + 2	1550	Med	30	no
T a	Stable	1450	20%	6	9	TD	TD + 3	departure	Med	0	no
	Stable	1250	18%	4	11	TD	TD + 2	departure	Poor	45	no
		30,000		6				1		11.00.00	
	01-1-1-	0700	200/		0		10.00	_	NAI	45	
	Stable	2700 400	30% 6%	0 2	0 -6	never	never TD + 22	donorturo	Med	45 48	no
	Stable Stable	500	8%	3	-6 4	never with TR	TD + 22 TD + 20	departure departure	Med Med	32	no
_	Stable	1250	21%	0	9	TD	TD + 20	departure	Poor	42	no no
<u>.</u>	Unstable	1720	27%	6	5	TD + 9	TD + 13	departure	Good	20	no
at 📕	Unstable	1800	23%	10	2	with TR	TD + 11	departure	Poor	28	no
ō	Stable	1900	26%	6	-2	TD	TD + 8	departure	Med	20	no
<u>0</u>	Stable	1150	24%	5	-5	TD	TD+6	100	Med	12	no
ပ္ထ	Stable	2900	28%	0	-6	TD + 3	TD + 5	2800	Poor	10	no
Deceleration		1480	20%	Ö	8	TD	TD + 3	1300		30	no
	Stable	2500	31%	0	2	TD	TD + 2	2250	Good	25	no
	Stable	2200	27%	5	7	TD	TD + 2	2000	Med	45	no
	Stable	1250	14%	2	4	TD	TD + 1	2400	Poor	15	no
							13	3			

Inadequate Deceleration

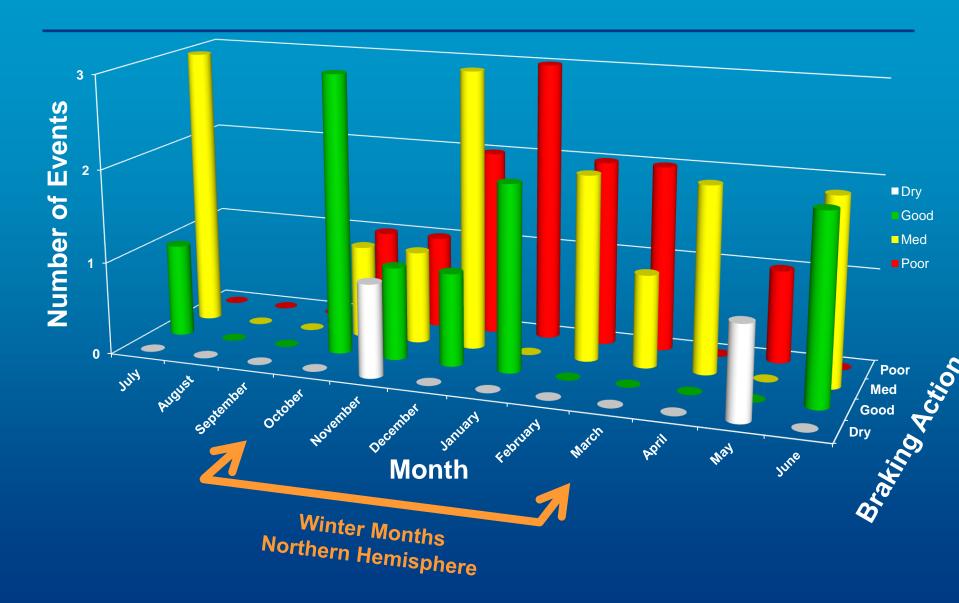
Delayed Thrust Reverser (TR) Usage



Grouped by Primary Overrun Factor

- **Touchdown Point**
- Touchdown Speed
- **Deceleration after Touchdown**
- Other observations

Seasonal Effects



			Touch	down	Touch	down	11		Decele	ration			
		رو الور	Po	int	Spe	eed		Spdbrake	Thrust R	Reversers	Runway	Res	ult
Ambient		Approach	Point	Runway	Airspd	Tail	11	When SB	When TR	When TR	Braking	Overrun	Hull
Light		1917-1917		Used	>Vref	Wind	П	Deployed	Deployed	Reduced	Action	Speed	Loss
			(feet)	(% LDA)	(knots)	(knots)	11	(sec)	(sec)	(feet)		(knots)	
Night		Unstable	7000	72%	22	0	Ш	TD	TD + 3	departure	Good	81	yes
Twilight		Unstable	6200	70%	12	5	Ш	TD	never		Dry	50	no
Night		Unstable	5630	57%	11	14	Ш	TD	TD + 3		Med	100	yes
Day		Unstable	5300	60%	16	3	П	TD	TD + 4	departure	Good	35 70	no
Night		Unstable	5150	48%	20	0	П	TD + 5	TD + 7	900	Med	70	no
Day		Unstable	4700	52% 60%	30	-1	Н	TD TD	TD + 2 TD + 2	1000	Occarl	100	yes
Night		Unstable	4500		-3 6	1	Н			departure	Good	47	yes
Day		Unstable Unstable	4500 4380	56% 55%	46	3	Н	TD TD	TD + 3 TD + 2	400	Dry	90 65	yes
 Night	Long	Unstable	4000	30%	0	10	Н	TD	TD + 2 TD + 2	departure	Good	40	no
	5		3950	44%	0	14	Н	TD		departure	Med	63	no
Night Twiliaht	ĭ	Stable Unstable	3935	44%	7	10	Н	TD	TD + 3 TD + 3	departure departure	Med Med	4	yes
Twilight		Unstable	3840	49%	20	-8	Н	TD	TD + 3	departure	Med	34	no no
Day 		Stable	3700	32%	0	-0 10	Н	TD	TD + 3	departure		50 50	no
Night		Stable	3260	41%	20	-1	П	TD	TD + 3	2000	Med	40	no
Day		Stable	3200	48%	-7	4	Н	with TR	TD + 2	departure	Good	30	no
		Stable	3120	42%	10	10	Н	TD	TD + 2	departure	Good	50	no
Day		Stable	3000	37%	-5	6	1 1	TD	TD + 2	departure	Med	30	no
Day		Stable	3000	34%	3	5	Н	TD	TD + 3	departure	Med	5	no
		Stable	2770	35%	I ŏ	12	Н	TD	TD + 2	1000	Good	15	no
		Ctubic	2			12			10.2	1000	Good	10	110
Night		Stable	1500	20%	20	10	П	TD	TD + 3	600	Med	5	no
Day		Stable	1450	20%	11	15	Ш	TD	TD + 3	1250	Med	20	no
Day	+	Stable	1600	20%	12	10	Н	TD	TD + 27	departure	Good	25	no
	Fast	Stable	1500	23%	5	10	Н	TD	TD + 2	1550	Med	30	no
Night	T.	Stable	1450	20%	6	9	Ш	TD	TD + 3	departure	Med	0	no
Twilight		Stable	1250	18%	4	11	Ш	TD	TD + 2	departure	Poor	45	no
						3							
		Stable	2700	30%	0	0		never	never		Med	45	no
Day		Stable	400	6%	2	-6	Ш	never	TD + 22	departure	Med	48	no
Day		Stable	500	8%	3	4	Ш	with TR	TD + 20	departure	Med	32	no
Night	Ĕ	Stable	1250	21%	0	9	П	TD	TD + 16	departure	Poor	42	no
Day	<u>:</u>	Unstable	1720	27%	6	5	П	TD+9	TD + 13	departure	Good	20	no
Night	ल	Unstable	1800	23%	10	2	П	with TR	TD + 11	departure	Poor	28	no
Night	ā	Stable	1900	26%	6	-2	П	TD	TD + 8	departure	Med	20	no
Twilight	Deceleration	Stable	1150	24%	5	-5	П	TD	TD + 6	100	Med	12	no
Twilight	S	Stable	2900	28%	0	-6	П	TD + 3	TD + 5	2800	Poor	10	no
	Ŏ		1480	20%	0	8	П	TD	TD + 3	1300		30	no
Day		Stable	2500	31%	0	2	H	TD	TD + 2	2250	Good	25	no
Day		Stable	2200	27%	5	7	H	TD	TD + 2	2000	Med	45	no
		Stable	1250	14%	2	4	Ц	TD	TD + 1	2400	Poor	15	no
									13				

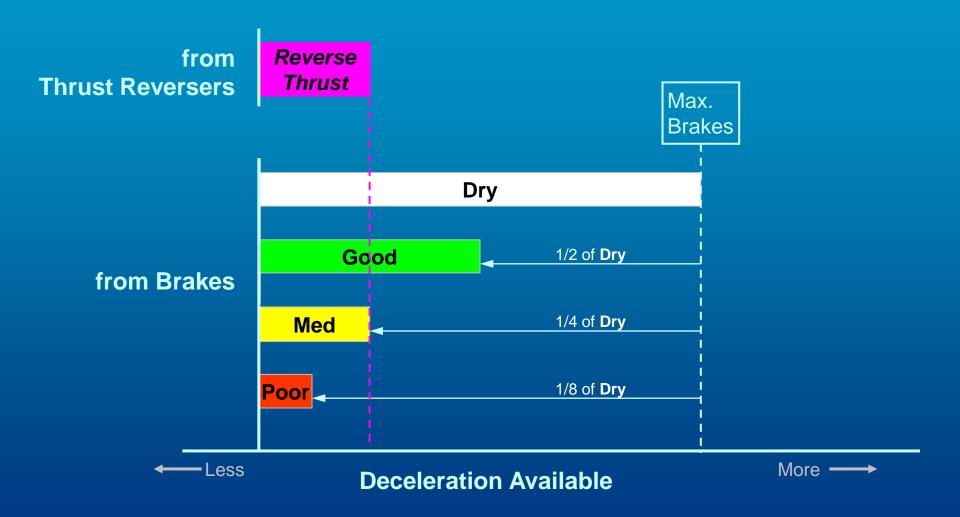
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1200 yes yes 210 yes 400 yes 700 yes 300 yes 900 yes 500 yes 500 yes 500 yes 500 yes 300 yes 400 yes 400 yes 1000 yes 400 yes 1000 yes yes 400 yes 250 yes 250 yes 360 yes 360 yes 300	-	
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yes 700 yes 300 yes 900 yes 900 yes 500 yes 500 yes 500 yes 500 yes 300 yes 400 yes 400 yes 1000 yes yes 1100 yes 250 yes 250 yes yes 1500 yes 360 yes 300	yes	
yes 300 yes 900 yes 900 yes 500 yes 500 yes 500 yes 300 yes 400 yes 400 yes 1000 yes yes 1100 yes 250 yes 250 yes 1500 yes 360 yes 300	1.	
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yes 300 yes yes 400 yes 1000 yes yes 1100 yes 250 yes yes 1500 yes 360 yes 300	1000	
yes yes 400 yes 1000 yes yes yes 1100 yes 250 yes yes 1500 900 yes 360 yes 300		
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yes 1000 yes yes 1100 yes 250 yes yes 1500 900 yes 360 yes 300	350	400
yes yes 1100 yes 250 yes yes 1500 900 yes 360 yes 300	950	1000
yes 1100 yes 250 yes yes 1500 900 yes 360 yes 300		
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yes yes 1500 900 yes 360 yes 300	150	
yes 1500 900 yes 360 yes 300	1.50	200
yes 360 yes 300	1.50	1500
yes 300		900
2.55		
yes 300		8.5.5
	yes	300

		Touch	down	Touchdown		down	Deceleration					
		Po	int		Spe	ed	Spdbrake	Thrust F	Reversers	Runway	Res	ult
	Approach	Point	Runway		spd	Tail	When SB	When TR	When TR	Braking	Overrun	Hull
	7 .pp. od.o.		Used		ref	Wind	Deployed	Deployed	Reduced	Action	Speed	Loss
		(feet)	(% LDA)	(kn	ots)	(knots)	(sec)	(sec)	(feet)		(knots)	
	Unstable	7000	72%		22	0	TD	TD + 3	departure	Good	81	yes
	Unstable	6200	70%		12	5	TD	never		Dry	50	no
	Unstable	5630	57%		11	14	TD	TD + 3		Med	100	yes
	Unstable	5300	60%		16	3	TD	TD + 4	departure	Good	35	no
	Unstable	5150	48%		20	0	TD + 5	TD + 7	900	Med	70	no
	Unstable	4700	52%		30	-1	TD	TD + 2	1000		100	yes
	Unstable	4500	60%	5-	-3	1	TD	TD + 2	departure	Good	47	yes
	Unstable	4500	56%		6	3	TD	TD + 3	400	Dry	90	yes
ರಾ	Unstable	4380	55%		46	4	TD	TD + 2	departure	Good	65	no
Long	Unstable	4000	30%		0	10	TD	TD + 2	departure	Med	40	no
9	Stable	3950	44%		0	14	TD	TD + 3	departure	Med	63	yes
_	Unstable	3935	49%		7	10	TD	TD + 3	departure	Med	4	no
	Unstable	3840	48%		20	-8	TD	TD + 3	departure	Med	34	no
	Stable	3700	32%		0	10	TD	TD + 2	departure		50	no
	Stable	3260	41%		20	-1	TD	TD + 3	2000	Med	40	no
	Stable	3200	48%		-7	4	with TR	TD + 2	departure	Good	30	no
	Stable	3120	42%		10	10	TD	TD + 2	departure	Good	50	no
	Stable	3000	37%		-5 3	6 5	TD	TD + 2	departure	Med	30	no
	Stable	3000 2770	34%		0	12	TD	TD + 3 TD + 2	departure	Med	5 15	no
	Stable	2110 2	35%		U	12	TD	10+2	1000	Good	15	no
	Stable	1500	20%		20	10	TD	TD + 3	600	Med	5	no
	Stable	1450	20%		11	15	TD	TD + 3	1250	Med	20	no
to	Stable	1600	20%		12	10	TD	TD + 27	departure	Good	25	no
Fast	Stable	1500	23%		5	10	TD	TD + 2	1550	Med	30	no
4	Stable	1450	20%		6	9	TD	TD + 3	departure	Med	0	no
	Stable	1250	18%	_	4	11	TD	TD + 2	departure	Poor	45	no
					6							
	Stable	2700	30%		0	0	never	never		Med	45	no
	Stable	400	6%		2	-6	never	TD + 22	departure	Med	48	no
	Stable	500	8%		3	4	with TR	TD + 20	departure	Med	32	no
드	Stable	1250	21%		0	9	TD	TD + 16	departure	Poor	42	no
뜵	Unstable	1720	27%		6	5	TD + 9	TD + 13	departure	Good	20	no
Ö	Unstable	1800	23%		10	2	with TR	TD + 11	departure	Poor	28	no
<u>a</u>	Stable	1900	26%		6	-2	TD	TD + 8	departure	Med	20	no
ल	Stable	1150	24%		5	-5	TD	TD + 6	100	Med	12	no
Deceleration	Stable	2900	28%		0	-6	TD + 3	TD + 5	2800	Poor	10	no
		1480	20%		0	8	TD	TD + 3	1300		30	no
	Stable	2500	31%		0	2 7	TD	TD + 2	2250	Good	25	no
	Stable	2200	27%		5		TD	TD + 2	2000	Med	45	no
	Stable	1250	14%		2	4	TD	TD + 1	2400	Poor	15	no
								13				

	Touchdown	Touchdown	Deceleration	
	Point	Speed	Spdbrake Thrust Reversers	Runway Result
Who was Approach	Point Runway	Airspd Tail	When SB When TR When TR	Braking Overrun Hull
flying?	Used	>Vref Wind	Deployed Deployed Reduced	Action Speed Loss
	(feet) (% LDA)	(knots) (knots)	(sec) (sec) (feet)	(knots)
Unstable	7000 72%	22 0	TD TD + 3 departure	Good 81 yes
Capt Unstable	6200 70%	12 5	TD never	Dry 50 no
Capt Unstable	5630 57%	11 14	TD TD+3	Med 100 yes
FO Unstable	5300 60%	16 3 20 0	TD TD + 4 departure	Good 35 no
Capt Unstable Unstable	5150 48% 4700 52%	20 0 30 -1	TD + 5 TD + 7 900 TD TD + 2 1000	Med 70 no 100 yes
Unstable Capt Unstable	4500 60%	-3 1	TD TD + 2 departure	100 yes Good 47 yes
Capt Unstable	4500 56%	6 3	TD TD+3 400	Dry 90 yes
	4380 55%	46 4	TD TD + 2 departure	Good 65 no
Capt Capt Stable Unstable Unsta	4000 30%	0 10	TD TD + 2 departure	Med 40 no
Capt Stable	3950 44%	0 14	TD TD + 3 departure	Med 63 yes
Clistable	3935 49%	7 10	TD TD + 3 departure	Med 4 no
Unstable	3840 48%	20 -8	TD TD + 3 departure	Med 34 no
Stable	3700 32%	0 10	TD TD + 2 departure	50 no
Capt Stable	3260 41%	20 -1	TD TD + 3 2000	Med 40 no
Stable Stable	3200 48% 3120 42%	-7 4 10 10	with TR TD + 2 departure TD TD + 2 departure	Good 30 no Good 50 no
Capt Stable	3000 37%	-5 6	TD TD + 2 departure TD TD + 2 departure	Good 50 no Med 30 no
Stable	3000 37%	3 5	TD TD + 3 departure	Med 5 no
Stable	2770 35%	0 12	TD TD + 2 1000	Good 15 no
	20			
0.11		00 40	TD TD . 0	
Capt Stable Stable	1500 20% 1450 20%	20 10 11 15	TD TD+3 600 TD TD+3 1250	Med 5 no Med 20 no
	1600 20%	12 10	TD TD + 3 1250 TD + 27 departure	Med 20 no Good 25 no
Capt Stable Stable Stable Stable	1500 23%	5 10	TD TD + 2 1550	Med 30 no
FO L Stable	1450 20%	6 9	TD TD+3 departure	Med 0 no
Stable	1250 18%	4 11	TD TD + 2 departure	Poor 45 no
		6		
Stable	2700 30%	0 0	povor povor	Med 45 no
FO Stable	400 6%	2 -6	never never never TD + 22 departure	Med 45 no Med 48 no
Capt Stable	500 8%	3 4	with TR TD + 20 departure	Med 32 no
Capt Stable	1250 21%	0 9	TD TD + 16 departure	Poor 42 no
Capt Unstable	1720 27%	6 5	TD + 9 TD + 13 departure	Good 20 no
FO Unstable	1800 23%	10 2	with TR TD + 11 departure	Poor 28 no
FO Stable	1900 26%	6 -2	TD TD + 8 departure	Med 20 no
Stable	1150 24%	5 -5	TD TD + 6 100	Med 12 no
Capt Capt FO FO FO FO Stable Unstable Unstable Stable Stable Stable Stable	2900 28%	0 -6	TD+3 TD+5 2800	Poor 10 no
	1480 20% 2500 31%	0 8 0 2	TD TD + 3 1300 TD TD + 2 2250	30 no Good 25 no
Capt Stable Stable	2500 31%	5 7	TD TD + 2 2250 TD TD + 2 2000	Good 25 no Med 45 no
Stable	1250 14%	2 4	TD TD + 2 2000 TD TD + 1 2400	Poor 15 no
Stable	1200 1470	4 7	13	10 110
			L IV	

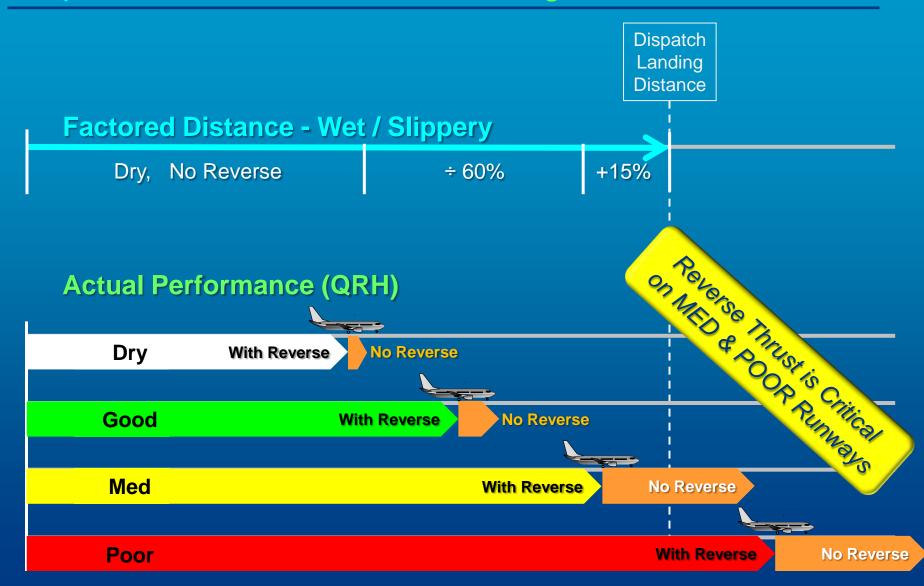
		Toucho	Production Accounts to the Control of the Control o			Decele ration				3	
		Point		Speed		Spdbrake	Thrust	eversers	Runway	Res	
	Approach	Point	Runway	Airspd	Tail	When SB	When TR	When TR	Braking	Overrun	Hull
	7,100011	3 (30000	Used	>Vref	Wind	Deployed	Deployed	Reduced	Action	Speed	Loss
		(feet)	(% LDA)	(knots)	(knots)	(sec)	(sec)	(feet)	_	(knots)	
	Unstable	7000	72%	22	0	TD	TD + 3	departure	Good	81	yes
	Unstable	6200	70%	12	5	TD	never		Dry	50	no
	Unstable	5630	57%	11	14	TD	TD + 3		Med	100	yes
	Unstable	5300	60%	16	3	TD	TD + 4	departure	Good	35	no
	Unstable	5150	48%	20	0 -1	TD + 5	TD + 7	900	Med	70	no
	Unstable Unstable	4700 4500	52% 60%	30	1	TD TD	TD + 2 TD + 2	1000	Good	100 47	yes
	Unstable	4500	56%	6	3	TD	TD + 3	departure 400	Dry	90	yes
	Unstable	4380	55%	46	4	I TD	TD + 3	departure	Good	65	yes no
D D	Unstable	4000	30%	0	10	TD	TD + 2	departure	Med	40	no
Long	Stable	3950	44%	0	14	TD TD	TD + 3	departure	Med	63	yes
	Unstable	3935	49%	7	10	TD	TD + 3	departure	Med	4	no
	Unstable	3840	48%	20	-8	TD	TD + 3	departure	Med	34	no
	Stable	3700	32%	0	10	TD	TD + 2	departure		50	no
	Stable	3260	41%	20	-1	TD	TD + 3	2000	Med	40	no
	Stable	3200	48%	-7	4	with TR	TD + 2	departure	Good	30	no
	Stable	3120	42%	10	10	TD	TD + 2	departure	Good	50	no
	Stable	3000	37%	-5	6	TD	TD + 2	departure	Med	30	no
	Stable	3000	34%	3	5	TD	TD + 3	departure	Med	5	no
	Stable	2770	35%	0	12	TD	TD + 2	1000	Good	15	no
		20									
	Stable	1500	20%	20	10	TD	TD + 3	600	Med	5	no
	Stable	1450	20%	11	15	TD	TD + 3	1250	Med	20	no
<u> </u>	Stable	1600	20%	12	10	TD	TD + 27	departure	Good	25	no
ast	Stable	1500	23%	5	10	TD	TD + 2	1550	Med	30	no
正	Stable	1450	20%	6	9	TD	TD + 3	departure	Med	0	no
	Stable	1250	18%	4	11	TD	TD + 2	departure	Poor	45	no
				6							
	Stable	2700	30%	0	0	never	never		Med	45	no
	Stable	400	6%	2	-6	never	TD + 22	departure	Med	48	no
	Stable	500	8%	3	4	with TR	TD + 20	departure	Med	32	no
L C	Stable	1250	21%	ō	9	TD	TD + 16	departure	Poor	42	no
tio	Unstable	1720	27%	6	5	TD+9	TD + 13	departure	Good	20	no
न	Unstable	1800	23%	10	2	with TR	TD + 11	departure	Poor	28	no
ē	Stable	1900	26%	6	-2	TD	TD + 8	departure	Med	20	no
Deceleration	Stable	1150	24%	5	-5	TD	TD + 6	100	Med	12	no
e	Stable	2900	28%	0	-6	TD + 3	TD + 5	2800	Poor	10	no
Ó		1480	20%	0	8	TD	TD + 3	1300		30	no
	Stable	2500	31%	0	2	TD	TD + 2	2250	Good	25	no
	Stable	2200	27%	5	7	TD	TD + 2	2000	Med	45	no
	Stable	1250	14%	2	4	TD	TD + 1	2400	Poor	15	no
							1				

Deceleration from Brakes & Thrust Reversers



Reverse Thrust and Landing Distance

Dispatch Calculation vs QRH Landing Distance



		Touchdown		Touchdown		Deceleration						
		Point		Speed		Spdbrake	Thrust Reversers		Runway	Res	Result	
	Approach	Point	Runway	Airspd	Tail	When SB	When TR	When TR	Braking	Overrun	Hull	
	7.00.011	050 100000000000	Used	>Vref	Wind	Deployed	Deployed	Reduced	Action	Speed	Loss	
		(feet)	(% LDA)	(knots)	(knots)	(sec)	(sec)	(feet)		(knots)		
	Unstable	7000	72%	22	0	TD	TD + 3	departure	Good	81	yes	
	Unstable	6200	70%	12	5	TD	never		Dry	50	no	
	Unstable	5630	57%	11	14	TD	TD + 3		Med	100	yes	
	Unstable	5300	60%	16	3	TD	TD + 4	departure	Good	35	no	
	Unstable	5150	48%	20	0	TD + 5	TD + 7	900	Med	70	no	
	Unstable	4700	52%	30	-1	TD	TD + 2	1000		100	yes	
	Unstable	4500	60%	-3	1	TD	TD + 2	departure	Good	47	yes	
	Unstable	4500	56%	6	3	TD	TD + 3	400	Dry	90	yes	
ס	Unstable	4380	55%	46	4	TD	TD + 2	departure	Good	65	no	
Long	Unstable	4000	30%	0	10	TD	TD + 2	departure	Med	40	no	
2	Stable	3950	44%	0	14	TD	TD + 3	departure	Med	63	yes	
	Unstable	3935	49%	7	10	TD	TD + 3	departure	Med	4	no	
	Unstable	3840	48%	20	-8	TD	TD + 3	departure	Med	34	no	
	Stable	3700	32%	0	10	TD	TD + 2	departure	 NAI	50	no	
	Stable Stable	3260	41%	20 -7	-1	TD	TD + 3	2000	Med	40 30	no	
	Stable	3200	48% 42%		4 10	with TR	TD + 2	departure	Good	50 50	no	
	Stable	3120 3000		10 -5	6	TD TD	TD + 2 TD + 2	departure	Good		no	
	Stable	3000	37% 34%	3	5	TD	TD + 2	departure departure	Med Med	30 5	no no	
	Stable	2770	35%	0	12	TD	TD + 2	1000	Good	15	no	
4	Otable	2//0		0	12	10	1012	1000	O000	10	110	
	Stable	1500	20%	20	10	TD	TD + 3	600	Med	5	no	
	Stable	1450	20%	11	15	TD	TD + 3	1250	Med	20	no	
Fast	Stable	1600	20%	12	10	TD	TD + 27	departure	Good	25	no	
Ö	Stable	1500	23%	5	10	TD	TD + 2	1550	Med	30	no	
<u> </u>	Stable	1450	20%	6	9	TD	TD + 3	departure	Med	0	no	
5.	Stable	1250	18%	4	11	TD	TD + 2	departure	Poor	45	no	
			J.		6							
	Stable	2700	30%	0	0	never	never		Med	45	no	
	Stable	400	6%	2	-6	never	TD + 22	departure	Med	48	no	
	Stable	500	8%	3	4	with TR	TD + 20	departure	Med	32	no	
Deceleration	Stable	1250	21%	0	9	TD	TD + 16	departure	Poor	42	no	
ij	Unstable	1720	27%	6	5	TD+9	TD + 13	departure	Good	20	no	
ā	Unstable	1800	23%	10	2	with TR	TD + 11	departure	Poor	28	no	
<u>a</u>	Stable	1900	26%	6	-2	TD	TD + 8	departure	Med	20	no	
e e	Stable	1150	24%	5	-5	TD	TD + 6	100	Med	12	no	
ĕ	Stable	2900	28%	0	-6	TD + 3	TD + 5	2800	Poor	10	no	
		1480	20%	0	8	TD	TD + 3	1300		30	no	
	Stable	2500	31%	0	2	TD	TD + 2	2250	Good	25 45	no	
	Stable	2200	27%	5	7	TD	TD + 2	2000	Med	45	no	
4	Stable	1250	14%	2	4	TD	TD + 1	2400	Poor	15	no	
							13					

Conclusions and Some Questions

Pilots:

- Land in the Touchdown Zone or Go-Around!
- Use Thrust Reversers promptly and until stop is assured!

Management

- How are you receiving and sharing information?
- What messages are you sending that might contribute?

Air Traffic Control

Safe guidance, timely reports

Airport managers

Timely information about runway conditions, NOTAMS, markings

Last Thoughts

- Don't miss opportunities to learn!
- Guidance available
 - Flight Safety Foundation (www.flightsafety.org)
 - Skybrary (www.skybrary.aero)
 - European Action Plan for the Prevention of Runway Excursions (EAPPRE)
 - **Boeing Flight Crew Training Manual**
- Boeing is here to help with your investigations
 - Have been through ~30 of these analyses in the past several years
 - Provided at no cost by Boeing for incidents/accidents with Boeing products
 - Data from individual investigations helps us understand industry issues

Thank you!

EDEING.