A Tale of Two Cities

The San Francisco Crash
The Birmingham Crash

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Chapter 1:
San Francisco
Asiana flight 214

- July 6, 2013
- San Francisco, California
- 3 Fatalities
777 Mode Control Panel

Flight Level Change (FLCH) Button

Altitude Select Window
General Details

- 10 ½ hour flight from Korea
- Clear skies, light winds
- About 11:28 am local time (3:28 am Korean time)
- Visual approach
- Glideslope out of service
- 3 Fatal injuries
- 49 serious injuries
- 138 minor injuries
- 117 no injuries
Arrival Information

1119:25  9000 Feet
1120:57  7700 Feet
1121:57  6000 Feet
1123:17  4500 Feet

SFO Airport
Pilot Roles and Experience

- **LEFT SEAT: Pilot Flying**
  - 9,700 hours total
  - 45 hours in B777

- **RIGHT SEAT: Instructor Pilot**
  - 12,000 hours total
  - 3,200 hours in B777
  - New B777 instructor, first trip as instructor

- **JUMPSEAT: Relief Pilot (First Officer)**
Photos are for orientation purposes only and do not reflect the exact status of the accident airplane.
Final Approach Before FLCH Selected
Final Approach: FLCH SPD Selected
Final Approach: A/T in HOLD mode
If the autothrottles are disconnected, if speed gets too slow, the autothrottles will reactivate ("wake up") and increase speed.

If autothrottles are armed in their normal operating mode, but in HOLD mode, if speed gets slow, the autothrottles will not wake up.
Final Approach

• Flight passed through a 3° glidepath at about 500 feet
• Stabilized approach criteria not met
• Descent rate 1,200 fpm, throttles remained at idle
Final Approach

- PM – “speed” at 90 ft and 110 knots
- PM – added go-around thrust
- Column full aft
- Stick shaker activated
- Airplane did not have the performance to go around at that point
Estimated aircraft position at impact with seawall
The Big Question

How could an airline crew crash an airplane on a perfectly clear day with calm winds on a visual approach?
Some Answers

• Poor monitoring due to expectancy, increased workload, fatigue, and automation reliance

• Complexities in the 777 automation and inadequacies in related training and documentation
  - Led to PF’s inadvertent deactivation of automatic airspeed control
Autothrottle failing to wake up

- August 2010 - 787 certification test flight.
  - FAA test pilot noted concern
  - Autothrottle behavior “less than desirable”
Autothrottle failing to wake up
- EASA Concerns -

• “although the … ‘Autothrottle wake up’ feature is not required per certification requirements, these two exceptions look from a pilot’s perspective as an inconsistency in the automation behavior of the airplane.”

• “the manufacturer would enhance the safety of the product by avoiding exceptions in the ‘Autothrottle wake up’ mode condition.”
During a descent in FLCH mode or VNAV SPD mode, the A/T may activate in HOLD mode. When in HOLD mode, the A/T will not wake up even during large deviations from target speed and does not support stall protection.
Autothrottle failing to wake up

- PF’s ground instructor
  - “anomaly”
  - Happened to him 3 times
If the autothrottle automatic engagement function ("wakeup"), or a system with similar functionality, had been available during the final approach, it would likely have activated and increased power about 20 seconds before impact, which may have prevented the accident.
Profile View of Approach

CALCULATED PILOT EYE HEIGHT

PAPI GUIDANCE

ALTITUDE (FEET)

DISTANCE TO RUNWAY 28L DISPLACED THRESHOLD (NAUTICAL MILES)
Animation Items

CAM-3: sink rate sir.
HOT-1: cleared to land {?}

Profile View

HOLD | LOC | FLCH SPD

145 knots 680 feet 11:27:06

Thrust Levers
Limit
Idle

Flap
Limit
UP
5

Airspeed Low
1.6 nm to 28L

Stickshaker ON
Idle
-20
30

NTSB
National Transportation Safety Board

Descent Below Visual Glidepath and Impact with Seawall

Asiana Airlines Flight 214
Boeing 777-200ER, HL7742
San Francisco, California
July 6, 2013
DCA13MA120
Monitoring

Airspeed Monitoring Lapses

PM ≈ 17 Seconds

PF > 24 Seconds

200 Feet

Low Speed Alert

Thrust Levers
Move Forward

Shaker

Calibrated Airspeed (Knots)

Radar Altitude (Feet)

PM ≈ 17 Seconds

PF > 24 Seconds

200 Feet

Low Speed Alert

Thrust Levers
Move Forward

Shaker

Calibrated Airspeed (Knots)

Radar Altitude (Feet)
“Insufficient flight crew monitoring of airspeed indications during the approach likely resulted from expectancy, increased workload, fatigue, and automation reliance.”
Probable Cause

• The flight crew’s mismanagement of the airplane’s descent during the visual approach
• The pilot flying’s unintended deactivation of automatic airspeed control
• The flight crew’s inadequate monitoring of airspeed
• The flight crew’s delayed execution of a go-around after they became aware that the airplane was below acceptable glidepath and airspeed tolerances.
Contributing to the accident:

(1) the complexities of the autothrottle and autopilot flight director systems that were inadequately described in Boeing’s documentation and Asiana’s pilot training, which increased the likelihood of mode error

(2) the flight crew’s nonstandard communication and coordination regarding the use of the autothrottle and autopilot flight director systems

(3) the pilot flying’s inadequate training on the planning and executing of visual approaches

(4) the pilot monitoring/instructor pilot’s inadequate supervision of the pilot flying

(5) flight crew fatigue which likely degraded their performance.
27 Recommendations

- FAA (15)
- Asiana Airlines (4)
- Boeing (2)
- ARFF Working Group (4)
- City of San Francisco (2)
Chapter 2: Birmingham
UPS flight 1354

- August 14, 2013
- Birmingham, AL
- 4:47 am
- 2 fatalities
Sequence of Events

- Captain: pilot flying
- First officer: pilot monitoring
- Runway 6/24 closed for repairs between 0400 and 0500 local time
Distance north of Birmingham runway 18 threshold, nm

**Captain enters vertical speed value**

**AUTOPILOT STATUS**

AP: VERT SPEED
V/S: -700 fpm

4:46:08 CDT

**DA = 1200 ft**

**Terrain**

**Distance north of KBHM runway 18 threshold, nmi**

**Altitude, ft, MSL**
First officer completes landing checklist

**AUTOPILOT STATUS**

- **AP**: VERT SPEED
- **V/S**: -700 fpm

4:46:17 CDT

**DA = 1200 ft**

**3.28°**

**BASKN**

**TERRAIN**

Distance north of Birmingham runway 18 threshold, nm
Distance north of Birmingham runway 18 threshold, nm

Altitude, ft, msl

Distance north of KBHM runway 18 threshold, nmi

TERRAIN

MDA = 1200 ft.

DA = 1200 ft

3.28°

Captain increases vertical speed

4:46:20 CDT

AUTOPILOT STATUS
AP: VERT SPEED
V/S: -1000 fpm
Distance north of Birmingham runway 18 threshold, nm

FO “...you’re in vertical speed...”

DA = 1200 ft

IMTOY

AP : VERT SPEED

V/S : -1000 fpm

4:46:27 CDT

BASKN

TERRAIN

3.28°
Distance north of Birmingham runway 18 threshold, nm

Captain increases vertical speed

4:46:34 CDT

DA = 1200 ft

3.28°

Terrain

Distance north of KBHM runway 18 threshold, nmi

Altitude, ft. MSL

AUTOPILOT STATUS
AP : VERT SPEED
V/S : -1500 fpm
Estimated cloud height

BASKN

Distance north of KBHM runway 18 threshold, nmi

Altitude, ft. MSL

MDA = 1200 ft.

IMTOY

First officer: “there’s a thousand”

Captain: “DA is 1200”

AUTOPILOT STATUS

AP : VERT SPEED

V/S : -1500 fpm

4:47:03 CDT

DA = 1200 ft

Estimated cloud base

Distance north of Birmingham runway 18 threshold, nm

TERRAIN

IMTOY

First officer: “there’s a thousand”

Captain: “DA is 1200”

4:47:03 CDT

DA = 1200 ft

Estimated cloud base

TERRAIN

Distance north of Birmingham runway 18 threshold, nm
4:47:11 CDT
Captain: “two miles”

DA = 1200 ft

Estimated cloud base

3.28°

Distance north of Birmingham runway 18 threshold, nm

TERRAIN
Distance north of Birmingham runway 18 threshold, nmi

Altitude, ft, msl

Estimated cloud base

Terrain

Auto Pilot Status
AP: VERT SPEED
V/S: -1500 fpm

4:47:16 CDT

DA = 1200 ft

IMTOY

Estimated cloud height

3.28°
First Officer: "it wouldn't happen to be actual"

Estimated cloud base

4:47:19 CDT

DA = 1200 ft
Distance north of Birmingham runway 18 threshold, nm

Altitude, ft, msl

Estimated cloud base

EGPWS: "sink rate"

TERRAIN

4:47:25 CDT

DA = 1200 ft

3.28°
Captain reduces vertical speed.

Estimated cloud base:

4:47:28 CDT

DA = 1200 ft

TERRAIN

Distance north of Birmingham runway 18 threshold, nm
Captain “…got the runway…”

Estimated cloud base

Distance north of Birmingham runway 18 threshold, nm

Altitude, ft. MSL

TERRAIN

MDA = 1200 ft.

IMTOY

4:47:28 CDT

DA = 1200 ft

AUTOPILOT STATUS

AP : VERT SPEED
V/ S : -400 fpm
Distance north of Birmingham runway 18 threshold, nmi

Altitude, ft, MSL

-0.2
-0.4
-0.6
-0.8
-1.0
-1.2
-1.4
-1.6
-1.8
-2.0
-2.2
-2.4

500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700
1800

Estimated cloud base

Autopilot off
First sound of impact

4:47:33 CDT

DA = 1200 ft

EGPWS: “too low, terrain”

3.28°

Estimated cloud height

TERRAIN

AUTOPilot Status
AP: OFF
V/S:

IMTOY

4:47:33 CDT

DA = 1200 ft

EGPWS: “too low, terrain”

3.28°

Estimated cloud base

TERRAIN

Distance north of Birmingham runway 18 threshold, nm
Two critical errors

- Not sequencing the FMS flight plan
- Not monitoring
Not sequencing the flight plan
Approach Setup
Navigation Display
The distraction

- **F/O**: “I don’t think we have many choices if runway 6 is closed” [laughter]
- **Captain**: “Ahhh [laughter] I know. What else can we do” [laughing].
- **F/O**: “I’m like, ahhh, well, what else ahh you gonna – unroll another one out there for us real quick or whatever” [chuckling]
- **Captain**: “It’s like, okay, yeah, you got another… yeah you got an ILS on some’m else?” [chuckling]
- **F/O**: “Uhh… I know” [chuckling]
During the Approach

Captain

– Changed from previously briefed profile mode to vertical speed mode
– Did not verbalize his intentions to first officer
– Increased descent rate to 1,500 fpm
Approach Callouts

• First officer made 1,000-foot callout
• Descent rate exceeded stable approach criteria
• First officer did not make:
  – 500-foot callout
  – “Approaching minimums” callout
  – “Minimums” callout
• TAWS low-altitude aural callouts (“smart callouts”) were not enabled by UPS
Workload: First Officer

- Had to mentally process change in autopilot mode
- No shared expectation of approach
- 1500-fpm descent twice as fast as normal descent rate
- Pace of duties increased
Expectancy

- They were high on the approach
- They would break out of the clouds at 1,000 agl.
EGPWS Terrain Clearance Floor

Distance north of BHM runway 18, nm

Altitude, ft, msl

Accident flight path

DA = 1200 ft.

3.28° flight path

Tree
EGPWS Terrain Clearance Floor

- Altitude, ft, msl

- Distance north of BHM runway18, nm

TCF envelope

“too low terrain”

Tree

DA = 1200 ft.
EGPWS Terrain Clearance Floor

Distance north of BHM runway 18, nm

Altitude, ft, msl

DA = 1200 ft.

Improved TCF envelope

MTOW

TERRAIN
NTSB Findings: TAWS

• Newer TAWS software would have provided a “too low terrain” caution alert 6.5 seconds sooner and 150 feet higher.
  - Because of the excessive descent rate and not knowing how aggressively the pilots would have responded, the effect on the accident could not be determined.

• An escalating series of TAWS alerts before impact with terrain or obstacles is not always guaranteed due to technological limitations, which reduces the safety effectiveness of the TAWS during the approach to landing.
• An automated “minimaums” and/or altitude above terrain alert would have potentially provided the flight crewmembers with additional situational awareness upon their arrival at the MDA.

• In the absence of the automated “minimaums” alert, an automated “500-ft” callout could have made the flight crewmembers aware of their proximity to the ground, and they could have taken action to arrest the descent.
NTSB Finding: Monitoring

“The flight crew did not sufficiently monitor the airplane’s altitude during the approach and subsequently allowed the airplane to descend below the minimum altitude without having the runway environment in sight.”
“The first officer poorly managed her off-duty time by not acquiring sufficient sleep, and she did not call in fatigued; she was fatigued due to acute sleep loss and circadian factors, which, when combined with the time compression and the change in approach modes, likely resulted in the multiple errors she made during the flight.”
Probable Cause

The flight crew’s continuation of an unstabilized approach and their failure to monitor the aircraft’s altitude during the approach, which led to an inadvertent descent below the minimum approach altitude and subsequently into terrain.
Contributing to the accident

(1) the flight crew’s failure to properly configure and verify the FMS for the profile approach;

(2) the captain’s failure to communicate his intentions to the first officer once it became apparent the vertical profile was not captured;

(3) the flight crew’s expectation that they would break out of the clouds at 1,000 feet above ground level due to incomplete weather information;
 Contributing to the accident

(4) the first officer’s failure to make the required minimums callouts;

(5) the captain’s performance deficiencies likely due to factors including, but not limited to, fatigue, distraction, or confusion, consistent with performance deficiencies exhibited during training; and

(6) the first officer’s fatigue due to acute sleep loss resulting from her ineffective off-duty time management and circadian factors.
20 Recommendations

• FAA (15)
• Independent Pilots Assn. (2)
• UPS (2)
• Airbus (1)
Recommendation to FAA

• Prohibit “dive and drive” approaches.
Recommendation to FAA

• Advise operators that, in certain situations, an escalating series of TAWS warnings may not occur before impact with terrain or obstacles.

• Encourage operators to review their procedures for responding to alerts on final approach to ensure that these procedures are sufficient to enable pilots to avoid impact with terrain or obstacles in such situations.
Recommendation to FAA

• Require all operators of airplanes equipped with the automated “minimums” alert to activate it, and to activate the TAWS 500-ft voice callout or similar alert.
Neither approach was stabilized
Neither had effective monitoring
Neither had effective intra-cockpit communications
ILS was unavailable in both cases
Fatigue