NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C.

Group Chairman's Simulator Study II

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Office of Research and Engineering
Washington, D.C.

December 15, 1994

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A.   ACCIDENT   DCA-94-MA-076

Location: Aliquippa, Pennsylvania
Date   :   September 8, 1994
Time   :   1904 Eastern Daylight Time
Aircraft: Boeing 737-300, N513AU

B.   GROUP IDENTIFICATION

        The Aircraft Performance Group met at the airplane
manufacturer's facility in Seattle, Washington on October 12
and 13, 1994. The following group members participated in the
investigation:

Chairman: Thomas R. Jacky, NTSB
Member   :   Bob McCullough, USAir
Member   :   Steven E. O'Neal, FAA
Member   :   Keakini Kaulia, ALPA
Member   :   James Kerrigan, Boeing

        Additionally, the following persons participated in this
phase of the investigative effort:

                John Delisi,   NTSB
                Marty Ingham,   Boeing
                Jim Wilborn,   Boeing
                Mike Carriker,   Boeing
                Jim Vasatka,   Boeing
                Paul Sturpe,   USAir
                Les Berven,   FAA
                George Greene,   NASA
                Dan Vicroy,   NASA

C.   SUMMARY

        On September 8, 1994 at 1904 Eastern Daylight Time, USAir
Flight 427, a Boeing 737-3B7, N513AU, crashed while
maneuvering to land at Pittsburgh International Airport,
Pittsburgh, Pennsylvania. The airplane was being operated on
an instrument flight rules (IFR) flight plan under the
provisions of Title 14, code of Federal Regulation (CFR), Part
121, on a regularly scheduled flight from Chicago O'Hare
International Airport, Chicago, Illinois, to Pittsburgh. The
airplane was destroyed by impact forces and fire near

Aliquippa, Pennsylvania. All 132 persons on board the airplane were fatally injured.

D. DETAILS OF INVESTIGATION

The group met at Seattle, Washington to review simulator data provided by Boeing and to examine possible wake vortex participation in the accident sequence. Examination of radar and flight data recorder data plots indicated the possibility that USA427 may have flown into the wake of the aircraft preceding USA427, identified as Delta Airlines Flight 1083, a B-727.

A wake vortex model, along with a visual identifiers of the vortices, of Delta 1083's wake vortex was developed by Boeing. Additionally, a distributed lift model was developed to determine local angle of attack values over the airplane wings and integrate the resultant lift and rolling moments caused by wake vortex interaction.

Information received from Delta Airlines estimated the B-727's weight at the time of interest as 126,400 lbs, and that the aircraft would have been in a "clean", or no flaps, configuration.

Delta Airlines Flight 1083's wake was modeled using the Rankine potential vortex model. Vortex core diameters used were 17 feet and 4 feet. Span distance between the vortex cores used was 85 feet. Vortex circulation values (or Γ) used ranged between 500 ft^2/sec and 2125 ft^2/sec. Vortex "flight path angles" of 0.0°, 3.5°, and -3.5° were used.

To visualize the wake vortices, two cylinders were used to depict the vortex cores, with a red line used to indicate the vortex pair center-line.

To validate the simulation, the group's pilot participants first flew the simulator's distributed lift model and the wake vortex model. The pilots agreed that the models were accurate. Then different scenarios developed regarding wake vorticity, sink rate, position, core size, wake angle, and aircraft intercept angle were run. A listing of the simulator runs is included in Attachment 1. Data plots from the individual runs were not included in this report; However, a set of plots was given to each party's group member.

One hundred and five simulator runs were attempted on October 12 and 13, 1994. The group used the Boeing Multipurpose Engineering Cab (MCAB) Simulator with the Aerodynamic Data and Control System Description for the 737-300 Flight Simulator (Document D6-37908, rev. C).

Tom Jacky
Aerospace Engineer

Attachments

1. Simulator Run Log and Summary

ATTACHMENT 1

Simulator Run Log and Summary

**SUMMARY OF BOEING ENGINEERING FLIGHT SIMULATOR RUNS FOR
USAIR FLIGHT 427 INVESTIGATION AIRCRAFT PERFORMANCE GROUP
October 12, 1994**

RUN #	SCENARIO SUMMARY
1	Check of airplane model, distributed lift model off
2	Repeat scenario 1, distributed lift model off, on, and off
3	Distributed lift model on, Γ =2125 ft^2/sec, intercept vortex
4	Repeat of scenario no. 3
5	Repeat scenario no. 3, intercept angle of airplane to vortex = 5°, auto-pilot (A/P) on
6	Hand-fly airplane, check of distributed lift model
7	Descend through vortex, with A/P on
8	Repeat scenario 7
9	Below vortex
10	Below vortex
11	Airplane placed in center of the vortex
12	Repeat scenario no. 11
13	Repeat scenario no. 11, airplane altitude +8'
14	Abort
15	Wake Γ = 1200 ft^2/sec, a/c left of vortex, A/P on
16	Repeat scenario no. 15, MCAB motion on
17	Wake Γ = 1700 ft^2/sec, a/c left of vortex, A/P on
18	A/C below wake, A/P on, climb through wake
19	Repeat scenario 18, climb at 350 FPM
20	Wake Γ= 2125 ft^2/sec
21	A/C cg in middle of wake, free response
22	A/C in center of wake
23	Wake Γ= 1200 ft^2/sec, fly through middle of wake
24	Repeat scenario 23
25	Wake Γ= 1500 ft^2/sec, wake descend on airplane
26	Repeat scenario 25
27	Repeat scenario 25
28	Repeat scenario 25
29	ABORT
30	ABORT
31	Wake speed -10, A/C placed 200' left of vortex
32	Repeat scenario 31
33	Repeat scenario 31
51	Wake Γ = 1500 ft^2/sec, a/c left of wake intercept angle = 10°
52	Repeat scenario 51, a/c position -10'
53	Repeat scenario 51, a/c position -20'

RUN #	SCENARIO SUMMARY
53a	Repeat scenario 51, a/c position -30'
54	Increase intercept angle to 20°
55	Repeat scenario 54, a/c position change to 5980 (-20)
56	Repeat scenario 54, a/c position change to 5990 (-10)
57	Increase intercept angle to 30°
59	Wake Γ = 1200 ft²/sec, a/c intercept angle = 5°
60	Wake Γ = 1000 ft²/sec
61	Wake Γ = 800 ft²/sec
62	Repeat scenario 61
63	Repeat scenario 61
64	Wake Γ = 1500 ft²/sec, core radius = 2', positon = -10
65	Repeat scenario 64
66	Repeat scenario 64
67	Change a/c position to 5990'
68	Repeat scenario 67
69	Wake Γ= 2125 ft²/sec, a/c position 5980'
70	Repeat scenario 69, a/c position -10'
71	Repeat scenario 70
72	Repeat scenario 70, a/c positon below wake, 300 FPM
73	Repeat scenario 72, climb at 800 FPM
74	Repeat scenario 73
75	A/C top of wake, descend to right of wake
76	Start in core of vortex, A/P off
77	CG in center of wake, free response of a/c
78	Repeat scenario 77
79	Pilot attempt to stay in vortex core
80	Wake Γ = 1500 ft²/sec, pilot attempt to stay in vortex core
81	Repeat 80

START P.M. SESSION

100	Wake Γ = 1500 ft²/sec, core r = 8.5', A/P on, a/c below wake, wake phi = -3.5°, wake Vspd=0
101	repeat scenario 100, wake vspd = 300 FPM
102	Repeat 101
103	Airplane offset to left of wake
104	Repeat 103
105	Offset
106	Cancel
107	Repeat 105 - problem of run 106 corrected
108	SImulator motion on - repeat 105
109	Wake Γ = 2125 ft²/sec

RUN #	SUMMARY SCENARIO
110	Repeat 109, A/C offset 29' below wake
111	Repeat 109, A/C offset 39' below wake
112	Repeat 109, A/C offset 50' below wake
113	Repeat 109, A/C offset 60', middle of vortex
114	Change core radius to r = 2'
115	Repeat 114
116	Repeat 114
117	Wake Γ= 1500 ft^2/sec
118	Change offset to 50' below wake
119	Wake vspd = 300 FPM
120	Wake Γ= 2125 ft^2/sec
121	Airplane intercept = 30°
122	Airplane intercept = 20°
123	Airplane intercept = 10°
124	Core size r = 8.5'
125	A/P turn - missed wake
126	Repeat 125
127	Repeat 125
128	Wake Γ = 1500 ft^2/sec, repeat A/P turn
129	Core radius r = 2', A/P turn
130	Left core Γ= 1500 ft^2/sec, right core Γ= 2125 ft^2/sec
131	Left core Γ= 2125 ft^2/sec, right core Γ= 1500 ft^2/sec
132	Left core Γ= 2100 ft^2/sec, right core Γ= 500 ft^2/sec
133	Repeat scenario 132
134	A/P off - end below wake
135	Wake = 0, A/P off
136	Repeat 135
137	Left wake Γ= 0, right wake Γ = 2125 ft^2/sec, core = 2', phi =10°, A/P on
138	Reverse intercept
139	A/P turn from 140° to 100° heading
140	+15 FFA