NATIONAL TRANSPORTATION SAFETY BOARD
Office of Aviation Safety
Washington, D.C. 20594

STRUCTURES GROUP FACTUAL REPORT

June 10, 2009

A. ACCIDENT DCA09MA021

Location:	Denver, Colorado
Date:	December 20, 2008
Time:	1818 Mountain Standard Time (MST)
Aircraft:	Continental Airlines Flight 1404, Boeing 737-524, N18611

B. SRUCTURES GROUP

Chairman:	Clinton R. Crookshanks National Transportation Safety Board Denver, Colorado
Member:	Dave Carroll Federal Aviation Administration Denver, Colorado
Member:	Steve Demko Air Line Pilots Association Ashburn, Virginia
Member:	Joe Schlueter The Boeing Company Seattle, Washington
Member:	Joe Moses Continental Airlines Houston, Texas

C. SUMMARY

On December 20, 2008, at 1818 mountain standard time, Continental flight 1404, a Boeing 737-524 (registration N18611), equipped with CFM56-3B1 engines, departed the left side of runway 34R during takeoff from Denver International Airport (DEN). The scheduled, domestic passenger flight, operated under the provisions of Title 14 CFR Part 121, was enroute to George Bush Intercontinental Airport (IAH), Houston, Texas. There were 37 injuries among the passengers and crew, and no fatalities. The airplane was substantially damaged and experienced post-crash fire. The weather observation in effect at the time of the accident was reported to be winds at 290 and 24 knots with gusts to 32 knots, visibility of 10 miles, a few clouds at 4000 feet and scattered clouds at 10,000 feet. The temperature was reported as -4 degrees Celsius.

D. DETAILS OF THE INVESTIGATION

1.0 Overview

The Boeing 737-500 is a twin turbofan engine, short to medium range, narrow body airliner. It has a low wing, conventional tail, and tricycle landing gear. The airplane is 97 feet, 9 inches long, has a wingspan of 94 feet, 9 inches, and has a tail height of 36 feet, 6 inches. The 737-500 is one of the 737 Classic variations that also include the 737-300 and 737-400. It remained in production from 1990 to 1999. The accident airplane was configured to seat 8 first class and 106 economy class passengers, and carried a crew of 2 pilots and 3 flight attendants. The maximum takeoff weight is 138,500 pounds. The accident airplane (S/N 27324) had winglets installed in November 2008 increasing the wingspan to 102 feet, 5 inches. See Figure 1 for a diagram of the airplane.

2.0 Debris Path

Two sets of skid[1] marks initiated about 1,910 feet north of the approach end (threshold) of runway 34R. The skid marks were positioned consistent with the tires from the right and left main landing gear (MLG). The skid marks continued on a straight track for about 60 feet and then began to arc to the left (west). See Figure 2 for an aerial view of the runway skid marks.

The right skid mark set consisted of two parallel skid marks that were positioned 4 feet, 7 inches and 6 feet, 5 inches east of the runway centerline. The width of the individual skid marks varied between 4 and 9 inches. The right set of skid marks started light and increased in intensity to a moderate level. The entire skid mark length measured 837 feet from the point of initiation to the point of departure from the west runway edge. The right skid mark set departed the west edge of the runway about 2,640 feet from the threshold.

The left skid mark set consisted of two parallel skid marks that were positioned 11 feet, 3 inches and 13 feet west of the runway centerline. The width of the individual skid marks

[1] For the purposes of this report, a skid mark refers to a black rubber transfer mark caused by relative motion between the tire and runway/taxiway surface, but not necessarily caused by a locked wheel due to braking action.

varied between 5 and 8 inches. The initiation of the left skid mark set was very light in intensity and transitioned to a light intensity along the skid. The entire skid mark length measured 734 feet from point of initiation to the point of departure from the west runway edge. The left skid mark set departed the west edge of the runway about 2,624 feet from the threshold.

A third skid mark, consistent with the position of the right wheel on the nose landing gear (NLG), initiated about 2,015 feet north of the threshold of runway 34R. Specifically, the skid mark initiated 103 feet, 8 inches north of the right and left skid mark sets and 7 feet, 11 inches west of the runway centerline. This skid mark width measured between 3 and 7.5 inches along the length of the skid mark. About 147 feet from the initiation point, the skid mark began to converge with the left set of MLG skid marks. A second skid mark consistent with the left tire of the NLG became evident about 120 feet from the west runway edge. The two distinct NLG skid marks diverged from the left set of MLG skid marks and remained a distance of about 7 inches from those skid marks for the remainder of the length. At initiation, the NLG right skid mark was very light in intensity and gradually became darker. The last 80 feet of the NLG right skid mark increased to a heavy intensity. The NLG left skid mark was light in intensity at the initiation and increased to a heavy intensity at the runway edge. The two NLG skid marks converged towards each other along the length of the skid. The entire length of the NLG right skid mark was 652 feet from the point of initiation to the point it departed the west edge of the runway.

All three sets of skid marks departed the runway to the left (west) side. Snow and ice was scattered to the right of the departure point back onto the runway. No other debris, ice, or snow was noted or observed on the runway on the night of the accident. No damage was noted to runway signs or lights.

The left and right MLG skid marks changed to ground scars at the edge of the runway when the tires left the paved surface and entered the grass, snow, and dirt. The ground scars continued from the west edge of the runway into the adjacent grass in a north/northwestern direction for about 1,010 feet. The two scars were characterized by ruts formed in the dirt, snow, and grass consistent again with the right and left MLG tires. The left set of ruts appeared wider than the right set of ruts. There was no distinct set of NLG ground scars conclusively identified due to the numerous airport vehicle tracks in this area. The two sets of ruts varied from less than one inch in depth to five inches in depth and a distance of 14 feet was measured between the two sets of ruts. This area of the terrain was snow covered with three to five inches of snow on the night of the accident.

The ground scars transitioned to skid marks as they crossed taxiway WC. The skid marks were very light in intensity and a distance of 14 feet was measured between the right and left MLG skid mark sets on the taxiway. There were no discernable NLG skid marks. The skid marks transitioned back to ground scars as they continued off of the north end of taxiway WC. The right and left ground scars continued for an additional 70 feet and terminated at the edge of a terrain drop off. The left ground scar appeared wider than the right. The terrain abruptly decreased in elevation at this point and was about 13 feet below the taxiway elevation.

Two sets of parallel ruts were formed in the snow and grass 168 feet from the termination of the previous set of ground scars. These ruts were parallel and consistent with the MLG on the aircraft. The right rut measured 33 feet in length and the left rut measured 32 feet in length. The distance between the two ruts measured 16.7 feet. See Figures 3 and 4 for aerial views of the ground scars.

Adjacent to the termination of the two parallel skid marks, two additional ground scars initiated, consistent with the right and left engine nacelles. These scars were approximately 29 feet apart, 4.5 feet each at their widest point, and continued from their initiation point for about 90 feet to the airport service road (Kewaunee Street). The initiation of these ground scars was accompanied by the initiation of the debris field. Debris located within the first 90 feet included torn metal, fiberglass, paint chips, and honeycomb material consistent with the engine cowling and nacelles.

Dirt and debris continued up a four foot incline and across Kewaunee Street. Several green reflector polls along the street were bent in the direction of airplane travel. The ground scars continued down a three to four foot slope and transitioned into one wide scar, approximately 20 feet wide at its widest point, for approximately 250 feet to the main wreckage. Debris within this ground scar included torn metal, honeycomb composite material, the right MLG assembly, a portion of the left MLG, and tubing, hoses, and wires consistent with engine components and accessories.

3.0 Wreckage

The airplane came to rest in a drainage basin west of runway 34R about 40 feet below the runway elevation. The airplane was on a 315º magnetic heading. Both MLG and the left engine were separated from the airframe. The NLG remained attached to the airplane and was collapsed aft into the NLG wheel well and Electronic Equipment bay aft of the wheel well. There was a post crash fire on the right side of the airplane. See Figures 5 and 6 for photos of the left (LH) and right (RH) side of the wreckage, respectively.

See Figures 7-11 for the Boeing 737-500 station diagrams. The fuselage was broken into two pieces in the vicinity of fuselage station 727B. The lower fuselage sustained significant scraping, denting, and buckling damage along its length. The right side of the fuselage sustained heavy fire damage from station 291 to station 887. A large section of the right fuselage was entirely consumed by fire. The forward and aft doors on the right side were open and reportedly opened by the first responders. The left side of the fuselage exhibited only buckling and denting damage but no fire damage. The forward and aft doors on the left side and the left overwing exit were in the open position.

The left wing was intact and attached to the fuselage. The trailing edge flaps, leading edge slats, leading edge Kreueger flaps, 5 spoilers, aileron and winglet remained attached to the left wing. The center and inboard leading edge slats and both Krueger flaps exhibited crushing, denting, and buckling damage and deformation in the area around where the engine was installed. The inboard trailing edge flap and inboard ground spoiler were bent and

buckled aft of the area where the left MLG is normally installed. The left engine pylon area was crushed, buckled, and torn in the vicinity of nacelle station (NAC STA) 196.840. The section of the pylon above approximately NAC waterline (WL) 132.15 remained attached to the lower surface of the wing. The left wing forward spar at the pylon attachment location exhibited very little damage. The front spar clevis fitting, inboard lobe, which holds the fuse pin to the upper link assembly, was sheared off.

The right wing was intact and attached to the fuselage. The right wing was deformed downward about 20º between the pylon and fuselage. The outboard trailing edge flaps, leading edge slats, 3 outboard spoilers, aileron, and winglet remained attached to the right wing. The Krueger flaps, upper wing skin inboard of the pylon, inboard flaps, and 2 inboard spoilers were consumed by fire. The inboard half of the outboard trailing edge flaps and the lower wing skin inboard of the pylon exhibited moderate to heavy fire damage. The engine and pylon remained attached to the wing with moderate buckling and tearing damage.

The empennage was intact and exhibited little damage. The right side of the vertical stabilizer exhibited light fire damage and charring while the left side was essentially normal. The left horizontal stabilizer was undamaged. The right horizontal stabilizer exhibited tearing and crushing damage between stations 203 and 221 that penetrated about 27 inches aft of the leading edge.

Both MLG were recovered in the debris field between Kewaunee Street and the airplane. Examination of the MLG revealed that on each, the fused trunnion bolts had separated at the the forward trunnion links. The bolts are designed to fail at this section to allow for a controlled breakaway of the MLG under certain aft loading conditions.

According to the dispatch paperwork the airplane was loaded with 20,000 pounds of fuel for the flight, 10,000 pounds in each wing. During the recovery and removal of the wreckage, about 4,700 pounds of fuel was removed from the left wing tank.

4.0 Winglets

The airplane underwent modification at AAR Aircraft Services in Miami, Florida, during November 2008 to install Aviation Partners Boeing (APB) Blended Winglets per Supplemental Type Certificate (STC) ST01219SE[2]. The modification work was performed in accordance with Continental Airlines Engineering Authorization EA 5730-02222 Rev F and was FAA approved per an FAA form 337 dated December 6, 2008[3].

During the modification the outboard wing structure was modified to be able to install the winglets. The wingtip fairing was removed and discarded, the 4 outboard wing ribs were replaced including the wing end rib (560 Rib), the 2 inboard surge tank ribs were modified, and the outboard upper and lower skin panels were replaced. Two of the lower wing stringers were modified, 5 of the upper wing stringers were modified and one wing stringer was added

[2] See Attachment B to the Maintenance Records Group Chairman's Factual Report for a copy of the STC.
[3] See Attachment 1 to this report for a copy of the Form 337.

to the upper skin. The outboard front and rear wing spars were trimmed and fittings were installed. In addition, electrical wiring and spoiler controls were modified. The installed location of the winglet was determined by the location of the wing end rib (560 Rib) that was replaced as part of the modification. An Assembly Jig supplied by APB was used to locate the new 560 Rib per instructions and drawings supplied with the STC. The winglet was directly attached to the 560 Rib using 18 fasteners after the remainder of the modification work was performed. The work cards for the installation of the 560 Rib on the left and right wings of the accident airplane are presented in Attachment 2.

Clinton R. Crookshanks
Structures Group Chairman

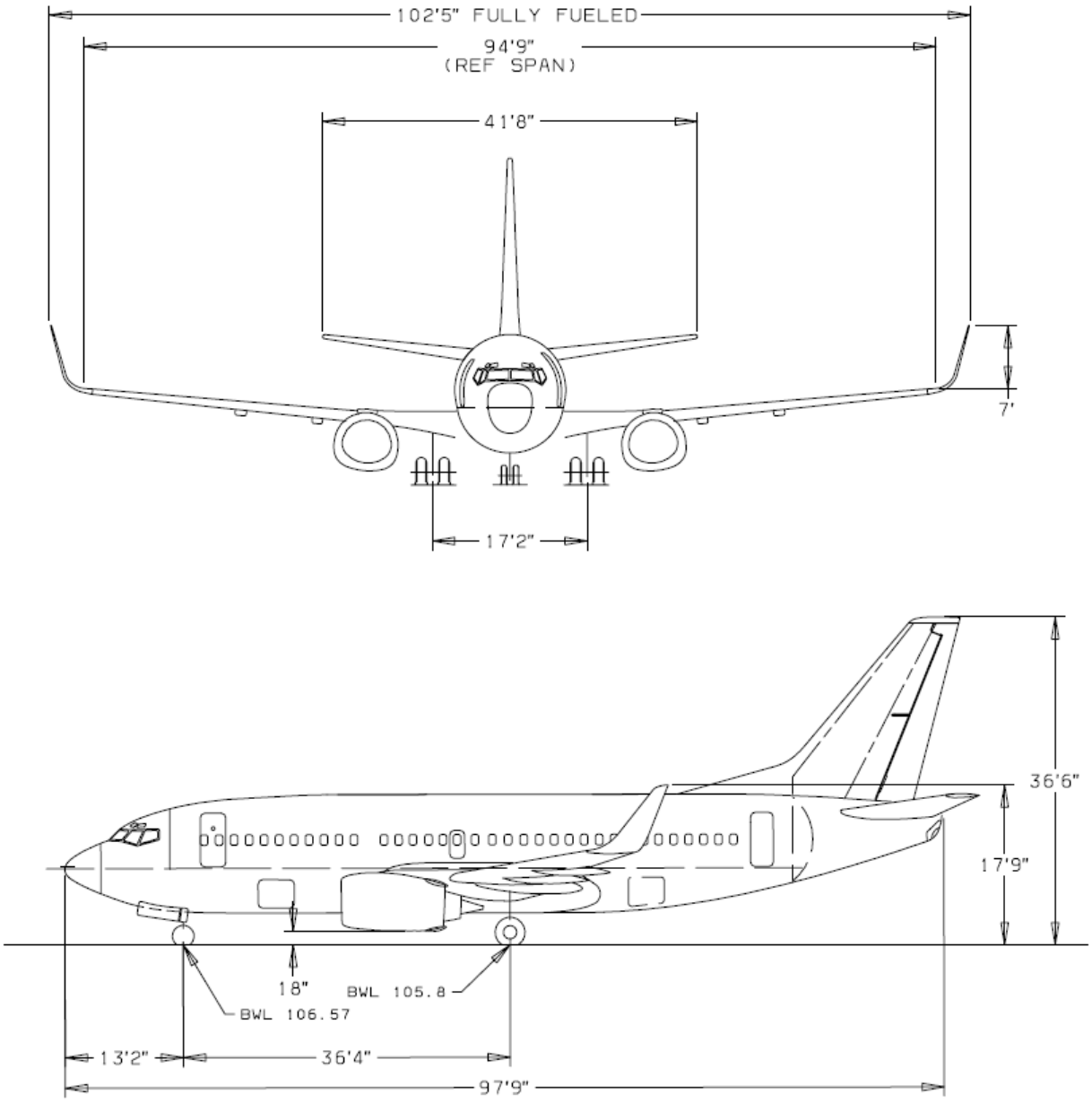

Figure 1 – Boeing 737-500 with Blended Winglets

Figure 2 – Aerial View of Runway Skid Marks

Figure 3 – Aerial View of Ground Scars at Terrain Drop-off

Figure 4 – Aerial View of Ground Scars and Wreckage

Figure 5 – LH Side of Wreckage

Figure 6 – RH Side of Wreckage

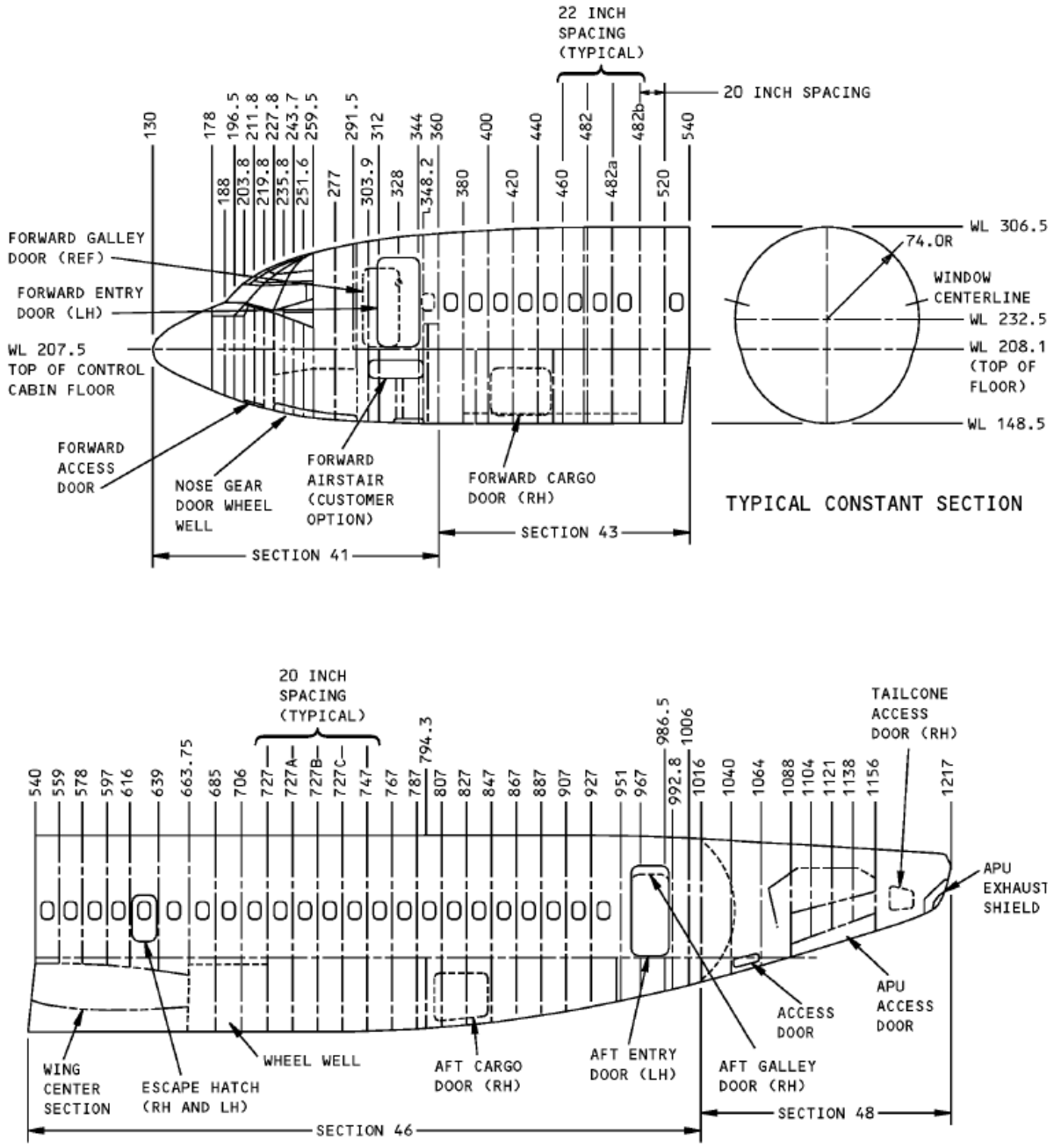

Figure 7 – Boeing 737-500 Fuselage Station Diagram

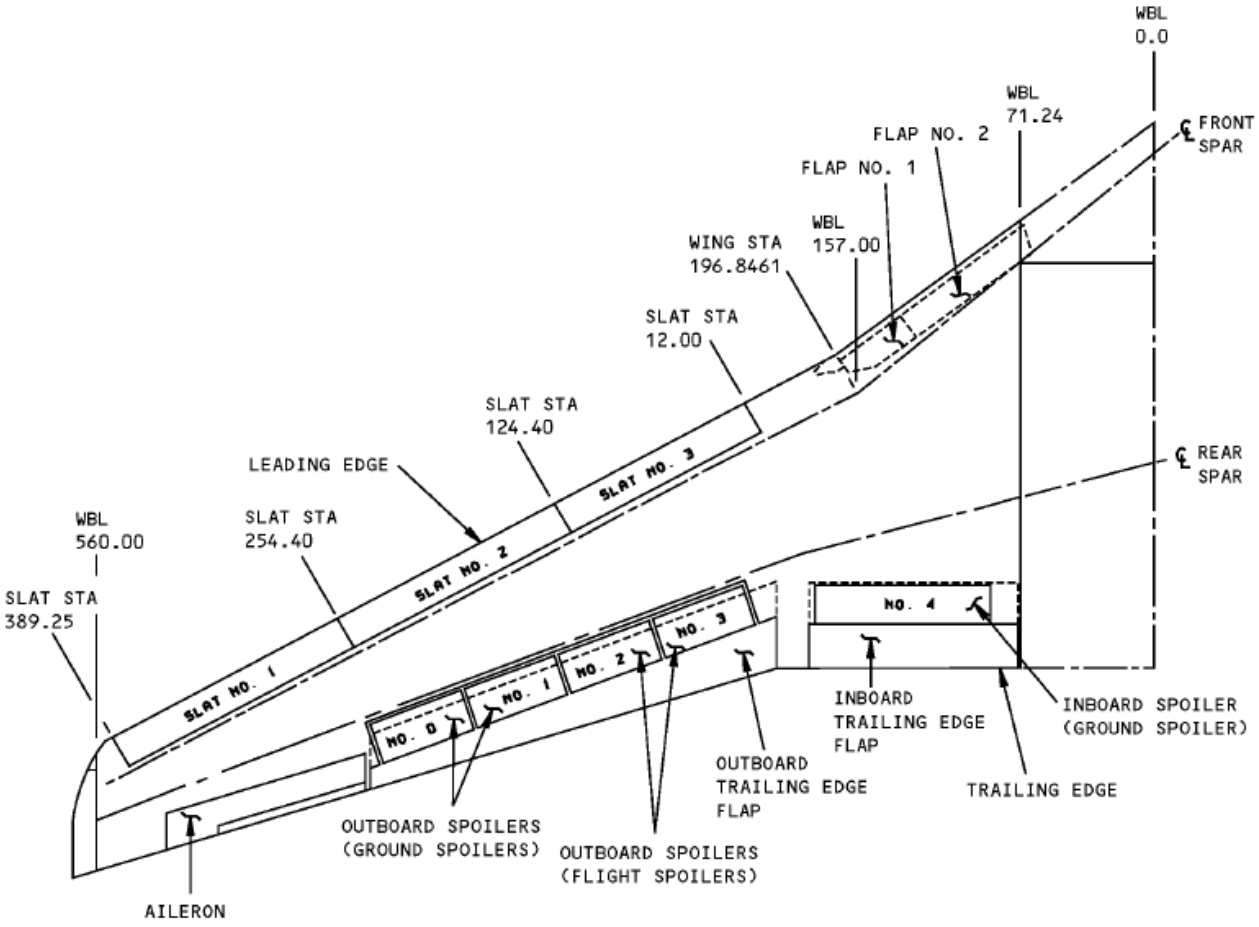

Figure 8 – Boeing 737-500 Wing Diagram (without winglets)

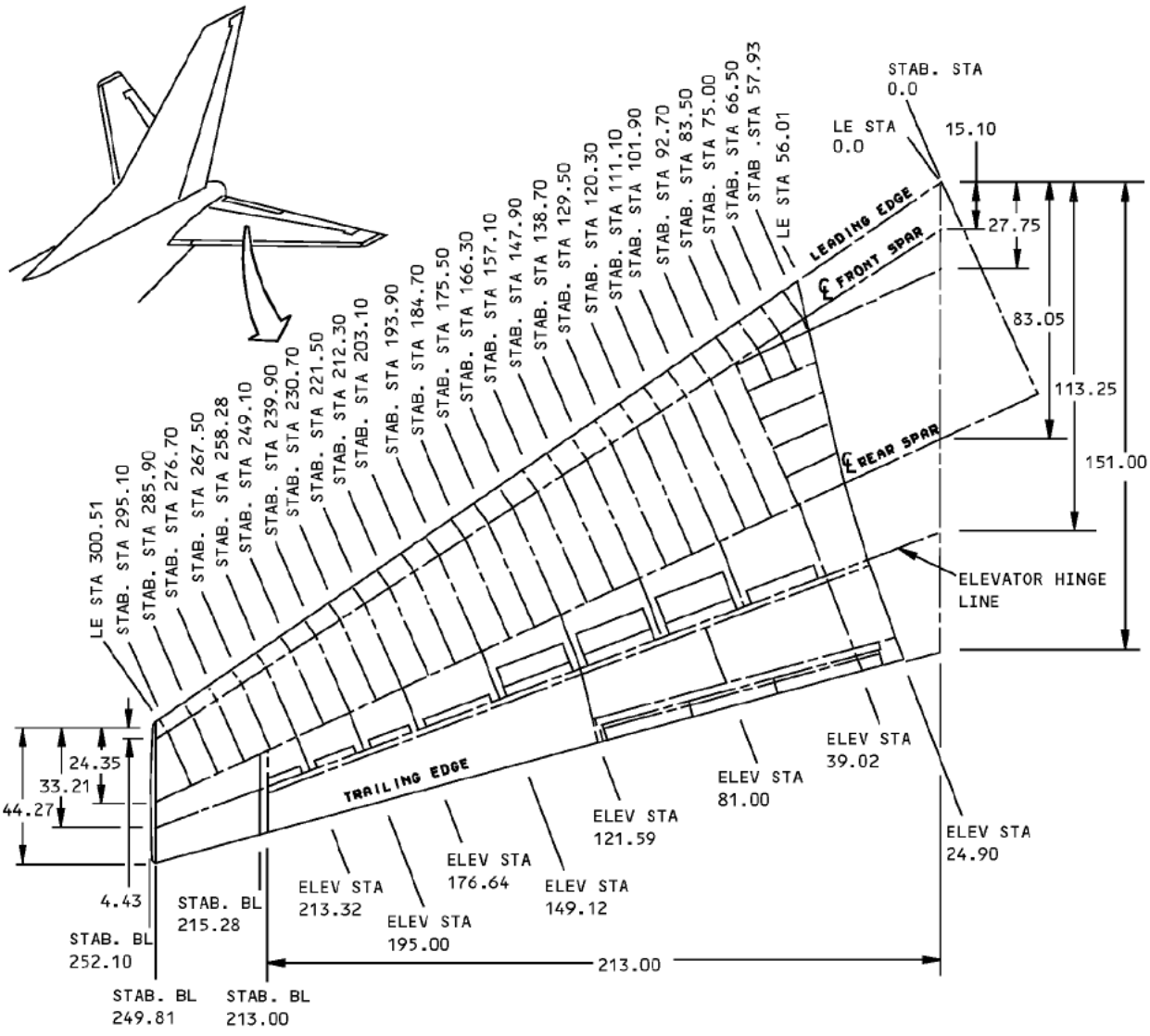

Figure 9 – Boeing 737-500 Horizontal Stabilizer Station Diagram

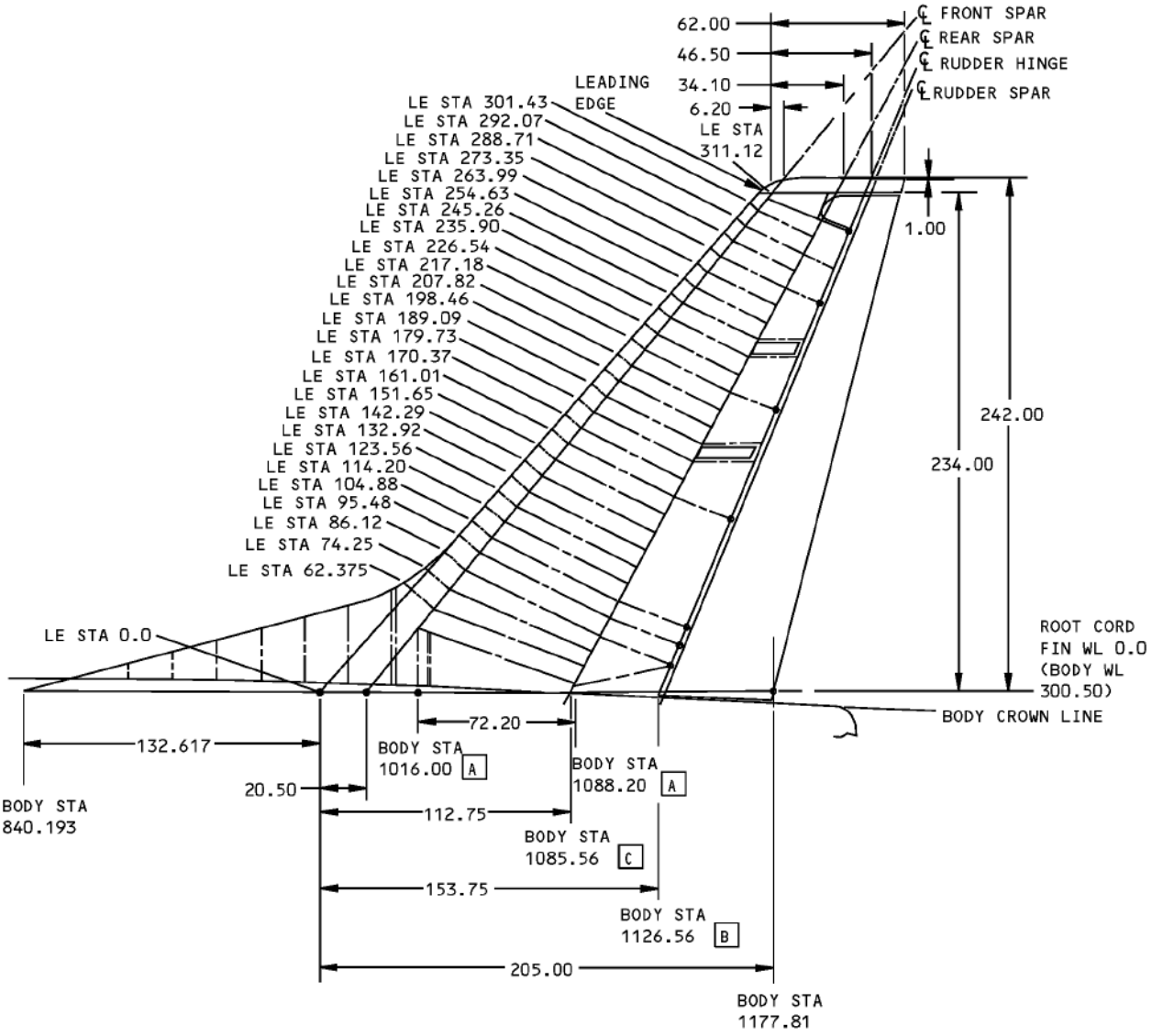

Figure 10 – Boeing 737-500 Vertical Stabilizer Station Diagram

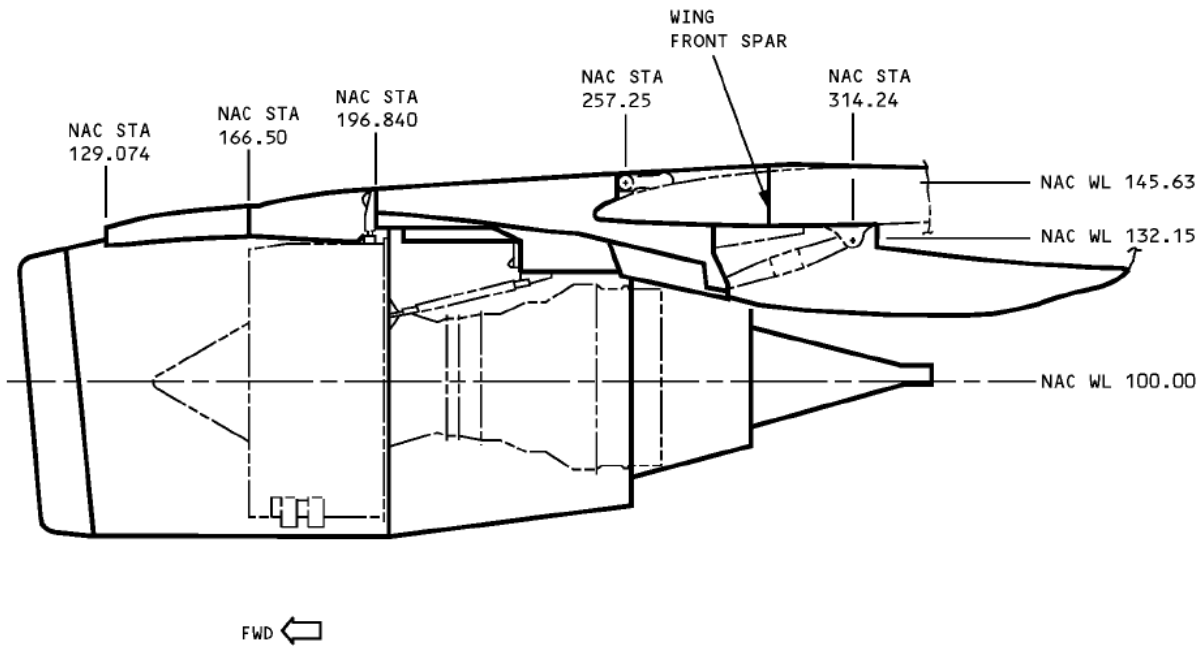

Figure 11 – Boeing 737-500 Nacelle Diagram