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Equivalent Longitudinal Area Distributions of the B-58 and XB-70-1 Airplanes for Use in Wave Drag and Sonic Boom Calculations

Ana F. Tinetti
NCI Information Systems, Inc., Hampton, Virginia

Domenic J. Maglieri, Cornelius Driver, and Percy J. Bobbitt
Eagle Aeronautics, Inc., Hampton, Virginia

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ABSTRACT

A detailed geometric description, in wave drag format, has been developed for the Convair B-58 and North American XB-70-1 delta-wing airplanes. These descriptions have been placed on electronic files at the NASA Langley Research Center, the contents of which are described in the present paper. They are intended for use in wave drag and sonic boom calculations.

Included on the electronic file and in the present paper are photographs and three-view drawings of the two airplanes, tabulated geometric descriptions of each vehicle and its components, and comparisons of the electronic file outputs with existing data. The comparison includes a pictorial of the two airplanes based on the present geometric descriptions contained on the electronic files and a comparison of the cross-sectional area distributions for both the normal Mach cuts and oblique Mach above and below the vehicles. Good correlation exists between the area distributions generated in the late 1950s and 1960s and the present files.

The availability of the present electronic files allows for further validation of existing sonic boom prediction codes through the use of two existing experimental data bases on these two airplanes. These data bases were acquired in the early and mid 1960s time period and, to date, have not been fully exploited. These two data bases consist of in-flight measurements of the supersonic flow-fields above and below the B-58 and XB-70-1 airplanes, acquired in 1963 and 1966, respectively, at distances of from about 10 to 95 body lengths.

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INTRODUCTION

In 1963, the USAF and NASA conducted flight tests to define the supersonic flow field above and below a B-58 delta-wing bomber airplane. A specially instrumented F-106 aircraft was used to "probe" the B-58 flow field at distances of about 14 to 95 body lengths from the B-58 (ref. 1). During the 1966-1967 EAFB National Sonic Boom Evaluation Program (ref. 2), the USAF and NASA conducted flight tests of an F-104 probing above and below the supersonic flow-field of the much larger XB-70-1 delta-wing bomber at distances of about 10 to 42 body lengths. The purpose of these in-flight measurements was to add to the sonic boom data base being used to validate existing sonic boom prediction codes.

Little use was made of the 1963 and 1966 probe measurements of the B-58 and XB-70 flow-field signatures in terms of sonic boom theory validation. This was due, primarily, to the lack of sufficient details of the B-58 and XB-70-1 geometric and aerodynamic descriptions and, in part, to the availability of the details of the XB-70-1 probe measurements. The B-58 probe tests, however, were reported in full detail in reference 1. Although the XB-70-1/F-104 in-flight probe measurement effort was successfully completed, the results were never formally documented. They appeared only briefly in a few reports in preliminary form to reflect the general nature of the flight test results.

The need to formally document the 1966 XB-70-1 probe flight tests and to provide geometric details of the B-58 and XB-70-1 airplanes was identified within the NASA High Speed Research (HSR) Program and funds were made available to accomplish these two tasks. Formal documentation of the 1966 XB-70-1 probe tests has been completed and reported in reference 3.

Detailed geometric descriptions of the B-58 and XB-70-1 airplanes have been completed and are presently available in a wave drag format on electronic file at the NASA Langley Reseaarch Center (LaRC). The purpose of this report is to provide an overview and description of the information contained on these electronic files. Included are photographs and three-view drawings of the two airplanes, tabulated geometric descriptions of each vehicle and its components, and comparisons of the electronic file outputs with existing data. These comparisons include a pictorial of the two aircraft as generated by the present geometric description file, normal cross-sectional areas of the complete airplane and each component, and total cross-sectional areas above and below the vehicles at oblique Mach cuts corresponding to the flight test data. These results are compared with those generated in the late 1950s and early 1960s time period prior to the existence of the present computational capability.

SYMBOLS

A Cross-sectional area of airplane obtained by normal or oblique cuts, sq. ft.

l Airplane reference length, ft

M Airplane Mach number

X Cylindrical coordinate measured along body axis, ft

θ Angle measured from horizontal (-90^o under airplane, $+ 90^o$ above)

TEST AIRCRAFT

Photographs of the USAF Convair B-58 and North American XB-70-1 delta-wing airplanes are presented in figure 1; three-view drawings of each aircraft are shown in figure 2. Detailed geometric characteristics of the B-58 airplane based upon the 1/5- and 1/40-scale wind tunnel models described in references 4 to 7 are provided in Table I. The geometric characteristics of the XB-70-1 airplane taken from reference 8 are presented in Table II. Information contained in Tables I and II, along with aerodynamic dimensional data contained in references 8 to 10 allow for an accurate and detailed geometric description of the B-58 and XB-70-1 airplanes.

The Convair B-58 delta-wing airplane (figs. 1a and 2a) has a length of 96.8 feet (from nose to tip of tail), a wing span of 56.8 feet, and a total wing area of 1542 square feet. Aircraft weight at brake release for the in-flight probe tests of reference 1 ranged from about 135,000 pounds to 145,000 pounds. During the actual probe runs, the B-58 gross weight ranged from 84,000 pounds to 115,000 pounds. For all the probe flights of reference 1, the aircraft was configured with the MB-1 fuselage pod as shown in figures 1a and 2a. Engines were at 104 percent RPM and exhaust nozzles were in partial afterburner. The aircraft was powered by four GE-J-79 turbojet engines, each producing 15,600 pounds of thrust with full afterburner.

The North American XB-70-1 delta-wing airplane (figs. 1b and 2b) has a length of 189 feet (including noseboom), a wing span of 105 feet, and a total wing area of 6297.8 square feet. Aircraft weight at brake release for the three probe flights of reference 3 ranged from about 529,000 pounds to 536,000 pounds. During the actual probe runs, the XB-70-1 gross weight ranged from about 320,000 pounds to 350,000 pounds, wing tips were full down at 65 degrees and the nose ramp windshield was in the down position. The bypass was set at 400 square inches, all six engines were at 100 percent RPM and the exhaust nozzles were in partial afterburner. The aircraft was powered by six YJ93-GE-3 turbojet engines, each producing 31,000 pounds thrust with full afterburning.

INPUTS TO ELECTRONIC FILES DESCRIBING AIRPLANE GEOMETRIES

Data from references 4 to 7 and 8 to 10 were used, respectively, to describe the geometries of the B-58 and XB-70-1 aircraft in the wave drag format of reference 11. In the case of the B-58, the details of the airplane geometry are based upon 1/15-scale wind tunnel (ref. 4), free-flight models (ref. 5), and 1/40-scale wind tunnel models (refs. 6 and 7). Geometric descriptions were obtained from three-view dimensional drawings, cross-sections, and from tabulations contained in the reports.

With the exception of the MB-1 pod and the tail, only the left half of the aircraft has been described. The fuselage was described using 23 radial locations per side at 20 longitudinal stations; the wing using 17 chord stations at 7 spanwise stations; the nacelles using 37 radial locations at 14 longitudinal stations; the MB-1 pod using 37 radial locations at 21 longitudinal stations; pod fins using 23 chord stations at 2 spanwise locations; and the airplane vertical tail using 23 chord stations at 4 spanwise locations. Nacelle pylons and main landing gear fairings were also defined.

In the case of the XB-70-1, the details of the airplane geometry are based upon the documentation of the full-scale vehicle in references 8 to 10. Geometric descriptions were obtained from the three-view dimensional drawings, cross-sections, and from tabulations contained in the reports. Only the left half of the aircraft has been described. Because of the lack of cross-sectional information, the fuselage was described using elliptical contours with 19 radial locations at 30 longitudinal stations. The wing was described using 20 chord stations at 7 spanwise stations (9 spanwise stations for the wing with tips drooped 65^{o}), the canard using 24 chordwise stations at exposed root and tip; the vertical tail using 23 chord stations at 3 span stations; and the duct body using 33 radial locations at 11 longitudinal stations. The lower wedge was also described.

COMPARISONS OF ELECTRONIC FILE OUTPUTS

Figures 3 through 10 have been generated from the present electronic files that describe the detailed geometries of the B-58 and XB-70-1 airplanes. These figures are intended to illustrate the capability and accuracy of the present electronic files in providing the geometric inputs required to perform wave drag or sonic boom calculations.

Airplane Description

Pictorials of the B-58 and XB-70-1, as generated from the current electronic files containing their geometric descriptions, are presented in figures 3a and 3b, respectively. The NASA Langley "Viewer" program (ref. 12) was used to generate these isometrics. "Viewer" is an Open Windows based XView application that displays and prints geometries from multiple formats. Good comparison is noted between the airplane pictorials of figure 3 and the photographs and three-views of these aircraft shown in figures 1 and 2, respectively. Note, too, the details of the various airplane components such as inlets and nacelles, the fuselage pod, and the vertical tails.

B-58 Cross-Sectional Area Distributions

Wind tunnel model. - A comparison of the normal cross-sectional area distribution for the 1/40 scale wind tunnel model of reference 6, using the present vehicle geometric description, is given in figure 4. Shown on the two plots are the area distributions of the wind tunnel model components (fuselage, wing, nacelles, pod, etc.). The uppermost curve represents the total cross-sectional area distribution of all the components. In figure 4a, from reference 6, the total area curve is a sequential buildup of each of the model components, beginning with the fuselage, wing, nacelles, vertical tail, landing gear fairings, and the MB-1 pod. Prior to the availability of computational means, the cross-sectional area distributions of aircraft configurations were generated by immersing each of the model components and then the complete model into a tank and measuring the liquid displacement. Another method was to build the model and components out of balsa wood and then make normal or oblique saw cuts and measure the resulting cross-sectional areas.

In figure 4b, generated using the present electronic file of the vehicle geometric description, normal cross-sections are shown for each wind tunnel model component. The current wave drag program (ref. 11), however, does not provide for the sequential buildup of the components in forming the total area distribution. Note, too, that the area developments of the fuselage and nacelles were truncated at their end termination points to simulate the base areas associated with the fuselage sting support and nacelle exits of the wind tunnel model.

Good correlation is seen to exist between the area development generated in 1956 (fig. 4a) and the present electronic file data base (fig. 4b). This can be readily seen by directly comparing the area distributions for the fuselage, wing, and the total area curves. In fact, if an overlay is made of the two data sets, nearly complete correlation exists when the curves of figure 4b are shifted to the left by about one-half inch, in the abscissa.

Full-scale airplane. - Normal cross-sectional areas distributions for the full-scale B-58 airplane, with and without the MB-1 fuselage pod, are presented in non-dimensional form in figure 5. The curves shown in figure 5a, taken from reference 13, were generated in 1961 at LaRC. The curves of figure 5b were generated using the present electronic files. Total cross-sectional area distributions for the airplane with and without the MB-1 pod are provided since sonic boom signatures have been obtained on each configuration. The in-flight flow-field pressure signature measurements reported in reference 1 are taken with the pod on the airplane and the ground level sonic boom signatures reported in reference 13 are with the pod off. Adding the pod to the airplane increases the total cross-sectional area; however, it also results in a much smoother curve of the total area buildup. Good agreement exists between the curves of figure 5a, calculated in 1961 and representing the normal cross-sectional areas for the B-58 airplane with and without the MB-1 pod, and those shown in figure 5b, obtained using the present electronic files of the B-58 geometric description.

Oblique Mach cut. - Area distributions based on an oblique cut for positions above and below the B-58 airplane with the MB-1 pod are presented in figure 6. The oblique cut, made for a Mach number of 1.65, is representative of the flight conditions of the B-58 during the in-flight probe experiments of reference 1. Figure 6a and 6b, respectively, represent the total area distributions for positions directly above ($\theta = 90^{o}$) and below ($\theta = -90^{o}$) the airplane. The solid curves on each plot were calculated in 1963 and are taken from reference 1. The dashed curves are based on the electronic files of the present report.

It should be noted that these oblique cut area distribution plots are in non-dimensional form. This format is usually applied to "normal" Mach cuts, where both the "physical" and "effective" length of the aircraft are the same. For oblique cuts, the "physical" and "effective" aircraft lengths will be different. In fact, for the Mach 1.65 cut on the B-58, the "effective" length is larger than the "physical" length for positions below the aircraft and shorter for positions above the aircraft. In order to make comparisons with the 1963 probe flight measurements (ref. 1), the physical length of the airplane was used. Another feature to be observed in the 1963 curves of figure 5 is that the area distribution goes to zero at $X/l = 1.0$. This results from the fact that the inlet capture area was not included.

XB-70 Cross-Sectional Area Distributions

Wind tunnel model. - A comparison of the normal cross-sectional area distribution for the 0.000454 scale wind tunnel model of reference 14 to that generated using the present vehicle geometric description is given in figure 7. The plot is in non-dimensional format. Inlet capture area is not included and wing tips are drooped to 65°. Very good correlation is seen to exist between the total area development of the 1963 wind tunnel model (solid curve) and that resulting from the present electronic file data base. It should also be noted that the curves do not close to zero at X/l = 1.0. This is because inlet capture area is not included in the area developments, and results in a base drag at the end of the engine exhaust pack.

Full scale airplane. - In figure 8 is presented a comparison of the total normal cross-sectional area distribution of the XB-70-1 airplane, as generated in 1961 and reported in reference 10, with that obtained using the present vehicle geometric description contained in the electronic files. The plots are in dimensional format. Inlet capture area is included and wing tips are not deflected. Good correlation is seen to exist between the shape for the total area development generated by North American in 1961 (ref. 10) and that resulting from the present geometry. A difference exists in the absolute values because of the manner in which the present method calculates the capture area. Also note that the curves close to zero area since the inlet capture area is included in the total area development.

Figure 9 compares of the XB-70-1 normal cross-sectional area distributions for the complete airplane and each of its major components for the configuration generated in 1961 by North American (ref. 10), and the configuration from the present electronic file description. Shown on both plots are the area distributions of each vehicle component and a total airplane curve representing the summation of all these components. Note that, unlike the comparison of the normal cross-sections for the B-58 (see fig. 4), the area distributions for the wing and ducts (and thus the totals) obtained from reference 10 (fig. 9a) are quite different from those generated using the present geometric description (fig. 9b). The former include only the exposed wing in the wing cross-sectional area. The rest of the area and the inlet capture area (non-flow-through ducts) is attributed to the ducts. The latter includes the portion of the wing area covered by the duct body in the wing geometric definition instead of assigning it to the ducts, thus greatly reducing the effort needed for properly defining the entire aircraft. In addition, the inlet capture area was removed from the total duct area. The areas associated with the remaining components (fuselage, canards, tails, lower wedge) compare well.

Oblique Mach cut. - Area distributions based on an oblique cut for a position above and to the side ($\theta = 25^{\circ}$) and for positions below ($\theta = -90^{\circ}$) the XB-70-1 airplane are presented in figure 10. The oblique cut, made for a Mach number of 1.5, is representative of the flight conditions of the XB-70-1 during the in-flight probe experiments of reference 3. Unlike the previous curves shown for the B-58 airplane (see fig. 6), the XB-70-1 curves are in dimensional form. The abscissa represents the "effective" length of the vehicle.

As seen in figure 10, the area developments are quite different for a position above and to the side of the airplane as compared to a position below the airplane in their shape, total area, and location of the maximum area value. It is also of interest to note the difference in area distributions between a Mach 1.5 oblique cut and that associated with a normal Mach 1.0 cut (see figs. 7 and 8).

During the generation of the oblique cut total area distributions of figure 10 it was found that, for the $\theta = -90^{\circ}$ position (below the aircraft), a sharp discontinuity (spike) appeared on the area development aft of the maximum area at an affective fuselage length of about 2000 inches. This "spike" is believed to occur when the area cuts become coincident with some portion of the vehicle (for example, the wing leading edge). Discussion with NASA Langley personnel who are familiar with the wave drag program (ref. 11) noted that such a peculiarity is not uncommon. When it occurs, the area curve is "faired" through the "spike", as was done in the present case, or re-run at a slightly different Mach number.

The wave drag program provides the inputs required to calculate the sonic boom due to the vehicle "volume" effects. Vehicle "lift" can also play a significant role in the prediction of the sonic boom signature, depending upon the vehicle weight and operating conditions. Determination of the boom due to lift requires knowledge of the load distribution on all the vehicle lifting surfaces for the specific flight conditions being investigated.

DESCRIPTION OF ELECTRONIC FILE CONTAINING AIRCRAFT GEOMETRY AND WAVE-DRAG DEFINITIONS OF THE CONVAIR B-58 AND XB-70-1 AIRPLANES

Both geometries were originally formatted for, and tested in, the arbitrary geometry wave drag program of reference 11. All results presented in this report were obtained using this format. For compatibility with users of the Harris wave drag program, the files are also given in Hess format.

A total of three geometries (B-58, and XB-70-1 with wing tips at 0^o and 65^o down) are described in the six electronic files contained in the compact disc (CD) provided to the NASA LaRC. File names for geometries given in the arbitrary wave drag format are of the form xxxxgeo.arb, and file names for geometries given in Hess format are of the form xxxxgeo.hes. A Portable Document Format (PDF) file of the present report is also included in the compact disc.

SUMMARY REMARKS

A detailed geometric description, in wave drag format, has been developed for the Convair B-58 and North American XB-70-1 delta-wing airplanes. These descriptions have been placed on electronic files at the NASA Langley Research Center. The contents of the files are described in the present paper and are intended for use in wave drag and sonic boom calculations.

Included with the electronic files, a PDF file of the present report was also made available. The file contains photographs and three-view drawings of the two airplanes, tabulated geometric descriptions of each vehicle and its components, and comparisons of the electronic file outputs with existing data. The comparison includes a pictorial of the two airplanes based on the present geometric descriptions on the electronic files, and a comparison of the cross-sectional area distributions for both the normal Mach cuts and oblique Mach cuts above and below the vehicles. Good correlation exists between the area distributions generated in the late 1950s and 1960s and the present files.

The availability of the present electronic files allows for further validation of existing sonic boom prediction codes through the use of two existing experimental data bases on these two airplanes. The data bases were acquired in the early and mid 1960s time period and, to date, have not been fully exploited. These two data bases consist of in-flight measurements of the supersonic flow-fields above and below the B-58 and XB-70-1 airplanes, acquired in 1963 and 1966 respectively, at distances of from about 10 to 95 body lengths.

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TABLE I. - GEOMETRIC CHARACTERISTICS OF THE CONVAIR B-58 AIRPLANE

(Scaled from Table I of ref. 7)

[All wing dimensions defining spanwise locations or chord lengths are true dimensions in the chord plane unless otherwise specified. Station numbers are in feet]

Wing:	
Span, ft.	56.8
Total area, sq ft.	1542
Exposed area, sq ft	1317
Aspect ratio	2.096
Taper ratio	0
Airfoil section parallel to root chord:	
Root chord	NACA 0003-46
Outboard of span station 0.565b/2.	NACA 0004-08
Camber	.0286b/2 offset tangent at 0.85b/2
Leading-edge sweepback, deg	60
Trailing-edge sweepback, deg	-10
Incidence, deg	3
Dihedral, deg	2.23
Tip-chord length, ft	0
Root-chord length, ft.	54.3
Distance above parting plane at root chord:	
Leading edge, ft.	3.0
Trailing edge, ft	0.6
Hinge line, ft	0.6
Airplane station of root chord at:	
Leading edge	29.4
Trailing edge	83.6
Hinge line	75.5
25 percent $\bar{c}$	54.8
37.5 percent $\bar{c}$	59.4
Length of $\bar{c}$, ft	36.2
Span station of $\bar{c}$, ft	9.5
Elevon:	
Hinge line at airplane station, ft	75.9
Inboard end of elevon at span station	4.7
Outboard end of elevon at span station	19.7
Area of one elevon, sq ft	88.9
Fuselage:	
Overall length, ft	89.6
Overall length from nose to tip of vertical tail, ft	96.8
Maximum height, ft	6.5

TABLE I.- Continued.

Maximum width, ft	5.3
Maximum cross-sectional area, sq ft	28.1
Vertical tail:	
Span, ft	14.5
Total area, sq ft	160.0
Exposed area, sq ft	156.8
Area of control surface (rudder), sq ft	40.0
Leading-edge sweepback, deg	52
Trailing-edge sweepback, deg	26.71
Hinge line sweepback, deg	35.51
Aspect ratio	2.628
Taper ratio	0.324
Tip-chord length, ft	5.4
Root-chord length, ft	16.7
Airplane station of root chord at leading edge, ft	77.9
Distance of root chord above parting plane, ft	5.2
Mean aerodynamic chord, ft	12.0
Fuselage station at leading edge of mean aerodynamic chord, ft	85.6
Distance of mean aerodynamic chord above parting plane, ft	11.2
Airfoil section parallel to root chord	NACA 0005-64
Nacelle:	
Overall length, ft	24.2
Maximum height above thrust plane	1.9
Maximum depth below thrust plane, ft	2.5
Maximum width, ft	3.7
Nacelle lip radius, in	0.08
Duct inlet area including spike area (1 duct), sq ft	4.03
Duct area at exit (1 duct), sq ft	3.73
Spike apex angle, deg	50
Location of inboard nacelle:	
Longitudinal location of nacelle inlet at thrust center line:	
Airplane station	32.7
Distance from wing chord plane to thrust center line:	
Nacelle station 0	5.4
Nacelle station 17.7	4.8
Nacelle station 24.2	4.5
Wing span station of nacelle center line	12.2
Angle between wing chord plane and nacelle center line, deg	-2
Leading-edge angle, deg	13.03
Trailing-edge angle, deg	9.62

TABLE I.- Concluded.

Location of outboard nacelle:	
Longitudinal location of nacelle inlet at thrust center line:	
Airplane station	558
Distance from wing chord plane to thrust center line:	
Nacelle station 0, ft	3.6
Nacelle station 11.1 ft	2.9
Nacelle station, 24.2 ft	2.0
Wing span station of nacelle center line, ft	21.7
Angle between wing chord plane and nacelle center line, deg	-4
Pylon:	
Leading-edge sweepback, deg	75
Trailing-edge sweepback, deg	75
Main landing gear fairings:	
Span station of fairing center line	6.7
Maximum width, upper fairing, ft	3.9
Maximum width, lower fairing, ft	4.1
Maximum height above chord plane, ft	1.0
Maximum depth below chord plane, ft	1.2
Store	
Overall length (from pod nose), ft	50.9
Overall length (from pod station 0) ft	57.6
Maximum diameter, ft	5.0
Maximum cross-sectional area, sq ft	19.6
Pod nose at airplane station	18.3
Distance from parting plane to pod center line, ft	2.7
Angle between pod center line and parting plane, deg	0
Base area, sq ft	5.0
Fineness ratio	11.392
Store fins:	
Span, ft	8.8
Area per fin, sq ft	22.5
Exposed area per fin, sq ft	10.7
Aspect ratio	1.734
Leading-edge sweepback, deg	60
Taper ratio	0.111
Trailing-edge sweep forward, deg	6.42
Length of fin mean aerodynamic chord, ft	6.2
Pod station at leading edge of root chord	41.8
Pod station at trailing edge of root chord	51.0
Airfoil section parallel to root chord	NACA 0005-64

TABLE II. - GEOMETRIC CHARACTERISTICS OF XB-70-1 AIRPLANE
(from reference 8)

Total wing	
Total area (includes 230.62 m^2 (2482.34 ft^2) covered by fuselage but not 3.12 m^2 (33.53 ft^2) of the wing ramp area), m^2 (ft^2)	585.07 (6297.8)
Span, m (ft)	32 (105)
Aspect ratio	11.751
Taper ratio	0.019
Dihedral angle, deg	0
Root chord (wing station 0), m (ft)	35.89 (117.76)
Tip chord (wing station 16m (630 in.)), m (ft)	0.67 (2.19)
Mean aerodynamic chord (wing station 5.43 m (17.82. (ft)), m (ft)	23.94 (78.532)
Fuselage station of 25-percent wing mean aerodynamic chord, m (ft)	41.18 (135.10)
Sweepback angle, deg:	
Leading edge	65.57
25-percent element	58.79
Trailing edge	0
Incidence angle, deg:	
Root (fuselage juncture)	0
Tip (fold line and outboard	-2.60
Airfoil section (modified hexagonal):	
Root to wing station 4.72m (186 in.) (thickness-chord ratio, 2 percent)	0.30 to 0.70
Wing station 11.68 m (460 in.) to 16.00 m (630 in.) (thickness-chord ratio, 2.5 percent)	0.30 to 0.70
Inboard wing -	
Area (includes 230.62 m^2 (2482.34 ft^2)covered by fuselage but not 3.12 m^2 (33.53 ft^2) wing ram area, m^2 (ft^2)	488.28 (5256.0)
Span, m (ft)	19.34 (63.44)
Aspect ratio	0.766
Taper ratio	0.407
Dihedral angle, deg	0
Root chord (wing station 0), m (ft)	35.89 (117.76)
Tip chord (wing station 9.67 m (380.62 in.)), m (ft)	14.61 (47.94)
Mean aerodynamic chord (wing station 4.15 m (163.58 in.)), m (in.)	26.75 (1053)
Fuselage station of 25-percent wing mean aerodynamic chord, m (in)	39.07 (1538.29)
Sweepback angle, deg:	
Leading edge	65.57
25-percent element	58.79
Trailing edge	0
Airfoil section (modified hexagonal):	
Root (thickness-chord ratio, 2 percent)	0.30 to 0.70
Tip (thickness-chord ratio, 2.4 percent).	0.30 to 0.70

TABLE II.- Continued.

Mean camber (leading edge), deg:		
Butt plane 0		0.15
Butt plane 2.72 m (107 in.)		4.40
Butt plane 3.89 m (153 in.)		2.75
Butt plane 6.53 m (257 in.)		2.60
Butt plane 9.32 m (367 in.) to tip		0
Outboard wing -		
Area (one side only), m^2 (ft^2)		48.39 (520.90)
Span, m (ft)		6.33 (20.78)
Aspect ratio		0.829
Taper ratio		0.046
Dihedral angle, deg		5
Root chord (wing station 9.67 m) (380.62 in.)), m (ft)		14.61 (47.94)
Tip chord (wing station 16.00 m) (630 in.)), m (ft)		0.67 (2.19)
Mean aerodynamic chord (wing station 11.87 m) (467.37 in.)), m (in.)		9.76 (384.25)
Sweepback angle, deg:		
Leading edge		65.57
25-percent element		58.79
Trailing edge		0
Airfoil section (modified hexagonal):		
Root (thickness-chord ratio, 2.4 percent)		0.30 to 0.70
Tip (thickness-chord ratio, 2.5 percent)		0.30 to 0.70
Down deflection from wing reference plane, deg		0,25,65
Skewline of tip fold, deg:		
Leading edge in		1.5
Leading edge down		3
	Wing tips	
	Up	Down
Elevons (data for one side):		
Total area aft of hinge line, m^2 (ft^2)	18.37 (197.7)	12.57 (135.26)
Span, m (ft)	6.23 (20.44)	4.26 (13.98)
Inboard chord (equivalent), m (in.)	295 (116)	(116) 2.95
Sweepback angle of hinge line, deg	0	0
Deflection, deg:		
As elevator		-25 to 15
As aileron with elevators at $\pm 15^{o}$ or less		–15 to 15
As aileron with elevators at -25^{o} or less		-5 to 5
Total		-30 to 30
Canard -		
Area (includes 13.96 m^2 (150.31 ft^2) covered by fuselage), m^2 (ft^2)		38.61 (415.59)
Span, m (ft)		8.78 (28.81)

TABLE II.- Continued.

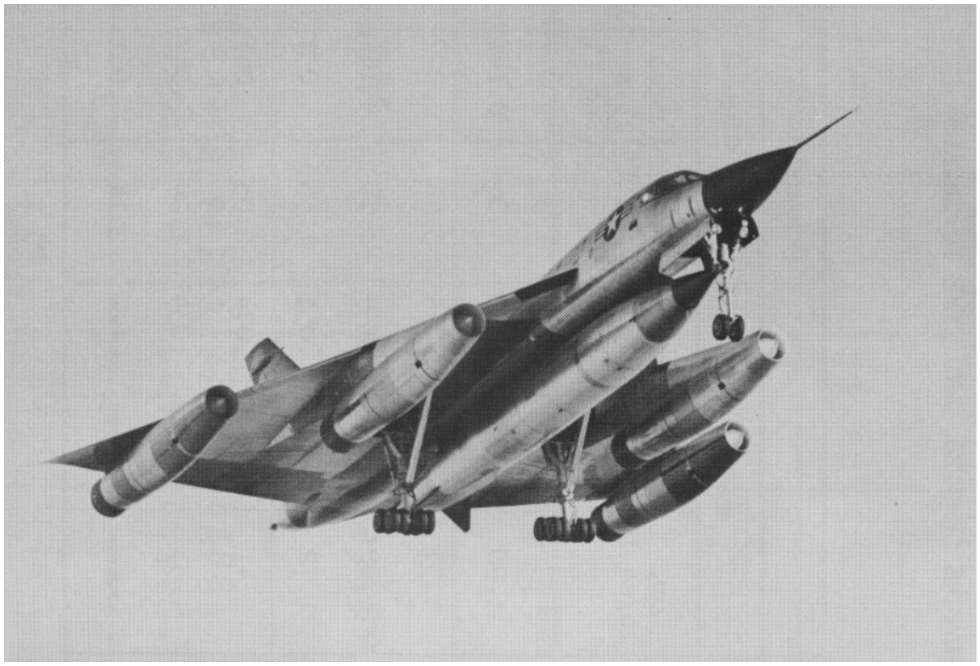
Aspect ratio	1.997
Taper ratio	0.388
Dihedral angle, deg	0
Root chord (canard station 0), m (ft)	6.34 (20.79)
Tip chord (canard station 4.39 m (172.86 in.)), m (ft)	2.46 (8.06)
Mean aerodynamic chord (canard station 1.87 m (73.71 in.)), m (in.)	4.68 (184.3)
Fuselage station of 25-percent canard mean aerodynamic chord, m (in.)	14.06 (553.73)
Sweepback angle, deg:	
leading edge	31.70
25-percent element	21.64
trailing edge	-14.91
Incidence angle (nose up), deg	0 to 6
Airfoil section (modified hexagonal):	
root (thickness-chord ratio 2.5 percent)	0.34 to 0.66
tip (thickness-chord ratio 2.52 percent)	0.34 to 0.66
Ratio of canard area to wing area	0.066
Canard flap (one of two):	
Area (aft of hinge line), m^2 (ft^2)	5.08 (54.69)
Ratio of flap area to canard semiarea	0.263
Vertical tail (one of two) -	
Area (includes 0.83 m^2 (8.96 ft^2) blanketed area), m^2 (ft^2)	21.74 (233.96)
Span, m (ft)	4.75 (15)
Aspect ratio	1
Taper ratio	0.30
Root chord (vertical-tail station 0), m (ft)	7.03 (23.08)
Tip chord (vertical-tail station 4.57 m (180 in.)), m (ft)	211. (6.92)
Mean aerodynamic chord (vertical-tail station 1.88 m (73.85 in.)), m (in.)	5.01 (197.40)
Fuselage station of 25-percent vertical-tail mean aerodynamic chord, m (in.)	55.59 (2188.50)
Sweepback, angle, deg:	
Leading edge	51.77
25-percent element	45
Trailing edge	10.89
Airfoil section (modified hexagonal):	
Root (thickness-chord ratio 3.75 percent)	0.30 to 0.70
Tip (thickness-chord ratio 2.5 percent)	0.30 to 0.70
Cant angle, deg	0

TABLE II.- Continued.

Ratio of vertical tail to wing area	0.037
Rudder travel, deg:	
With gear extended	±12
With gear retracted	±3
Fuselage (includes canopy) -	
Length, m (ft)	56.62 (185.75)
Maximum depth (fuselage station 22.30 m (878 in.)), M (in.)	2.72 (106.92)
Maximum breadth (fuselage station 21.72 m (855 in.)), m (in.)	2.54 (100)
Side area, m^2 (ft^2)	87.30 (939.72)
Planform area, m^2 (ft^2)	110.07 (1184.78)
Center of gravity:	
Forward limit, percent mean aerodynamic chord	19.0
Aft limit, percent mean aerodynamic chord	25.0
Duct -	
Length, m (ft)	31.96 (104.84)
Maximum depth (fuselage station 34.93 m (1375 in.)), m (in.)	2.31 (90.75)
Maximum breadth (fuselage station 53.34 m (2100 in.)), m (in.)	9.16 (360.70)
Side area, m^2 ($ft^{2)}$	66.58 (716.66)
Planform area, m^2 (ft^2)	217.61 (2342.33)
Inlet captive area (each), m^2 ($in^{2)}$ 3.61 (5600)	3.61 (5600)
Surface areas (net wetted), m^2 (ft^2) -	
Fuselage, canopy, boundary layer gutter, and tailpipes	264.77 (2850.0)
Ducts	318.71 (3430.6)
Wing, wing tips, and wing ramp	864.71 (9307.7)
Vertical tails (two)	87.12 (937.7)
Canard	49.47 (532.5)
Total	1584.79 (17,058.5)
Engines (six)	YJ93-GE-3
Boattail angle, deg -	
Upper surface	6
Lower surface	5
Side	6
Base areas, m^2 (ft^2) -	
Total	12.7 (137)
Total (all engines on, minimum exit area)	10 (107.2)
Total (all engines on, maximum exit area)	4.5 (48.5)
Projected thickness (height) of base, m (in.)	1.47 (58)

TABLE II.- Concluded.

Width of propulsion package, cm (in.)	914 (360)
Engine -	
Jet-exit area (minimum), cm^2 (in^2)	4613 (715)
Jet-exit area (maximum), cm^2 (in^2)	13,678 (2120)
Jet-exit diameter (minimum), cm (in.)	77 (30.2)
Jet-exit diameter (maximum), cm (in.)	132 (52)



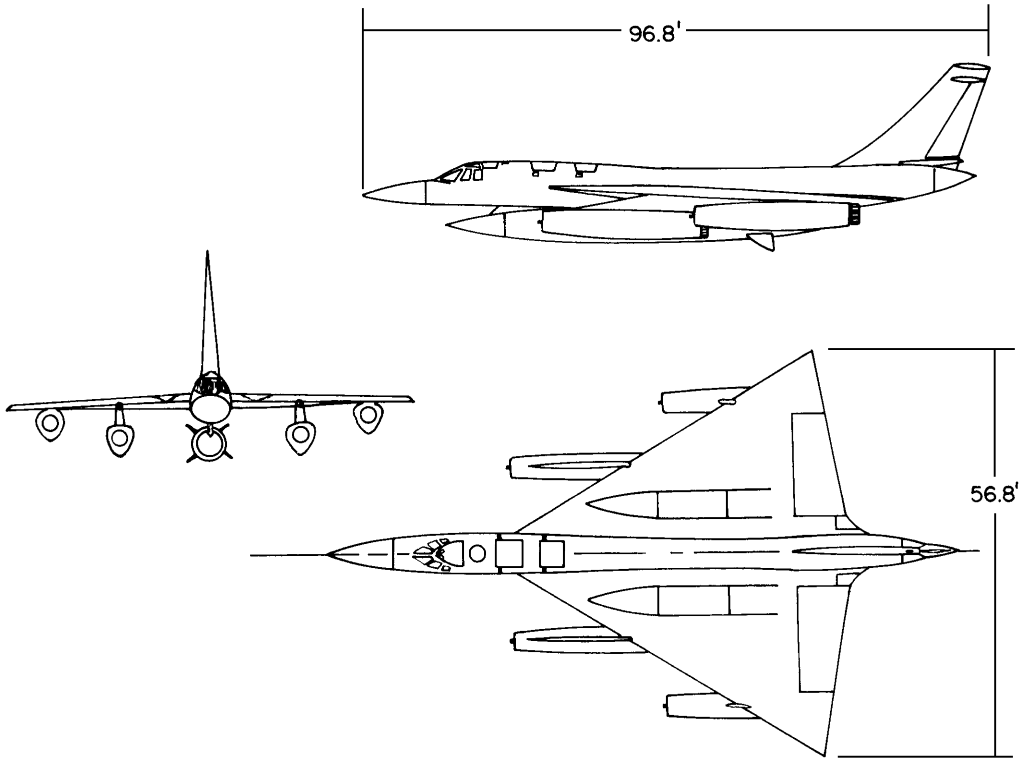
(Courtesy of U.S. Air Force)

(a) Convair B-58

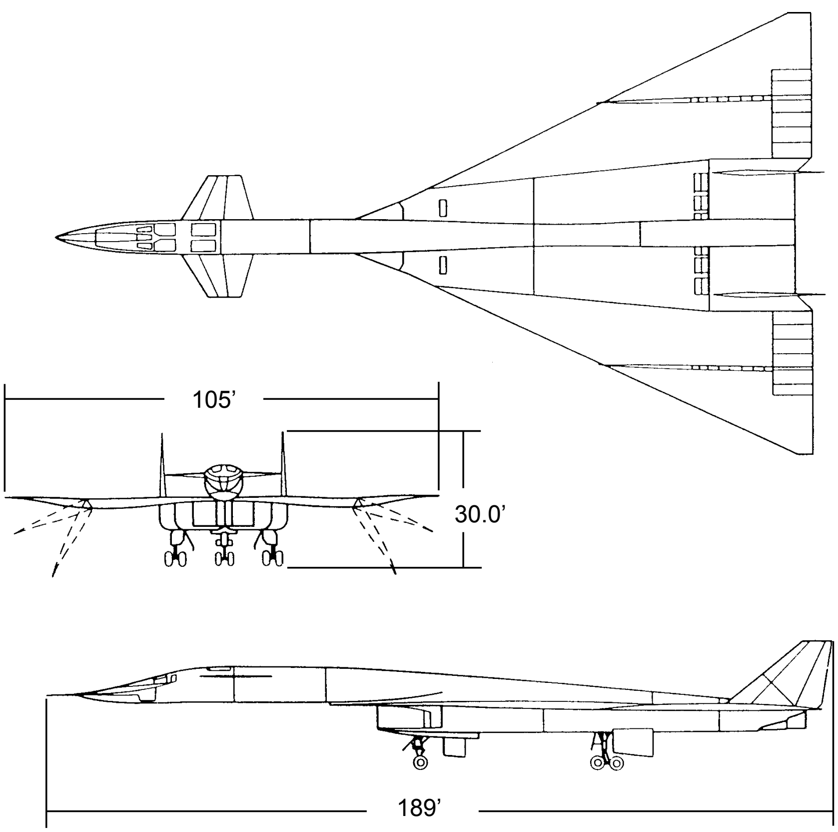
(Courtesy of NASA Flight Research Center)

(b) North American XB-70-1

Figure 1.- Photographs of delta-wing airplanes to be geometrically described.

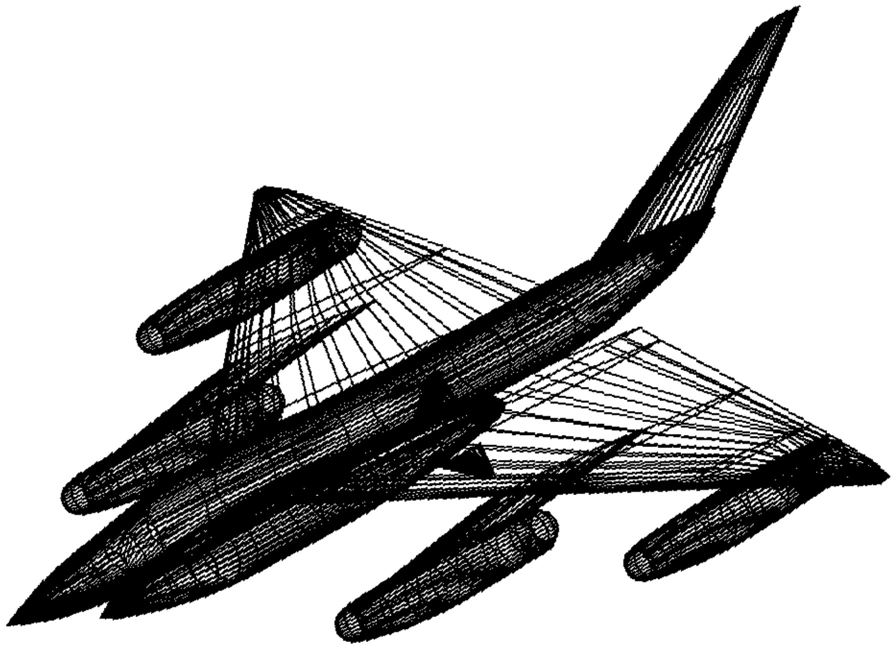


(a) Convair B-58 (total wing area = 1542 sq. ft.)

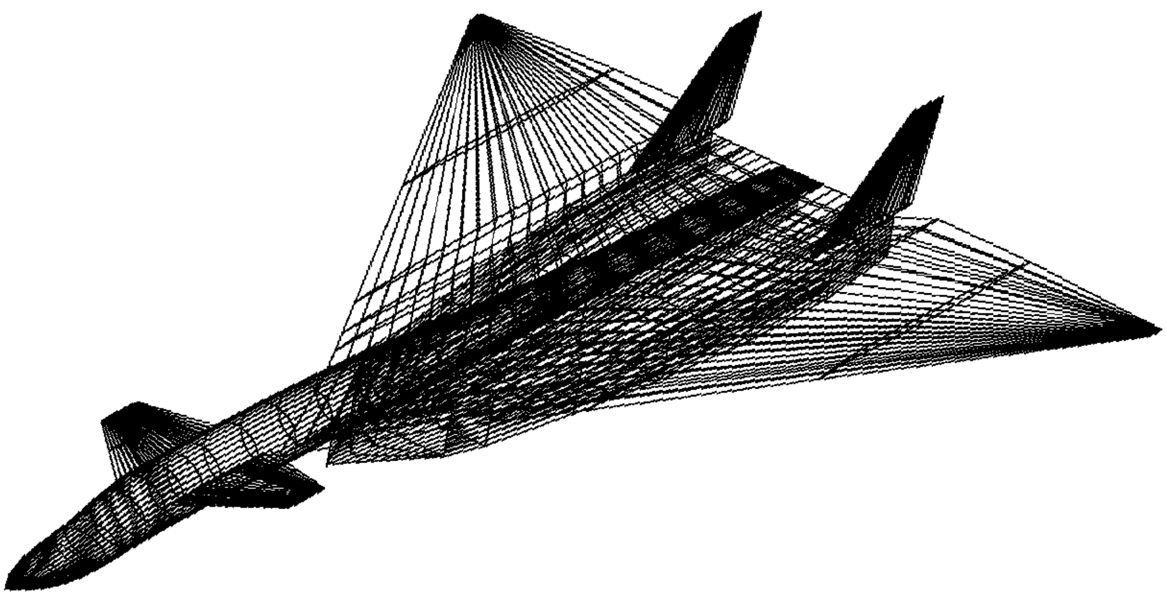


(b) North American XB-70-1 (total wing area = 6297.8 sq. ft.)

Figure 2.- Three-view drawings of delta-wing airplanes to be geometrically described.

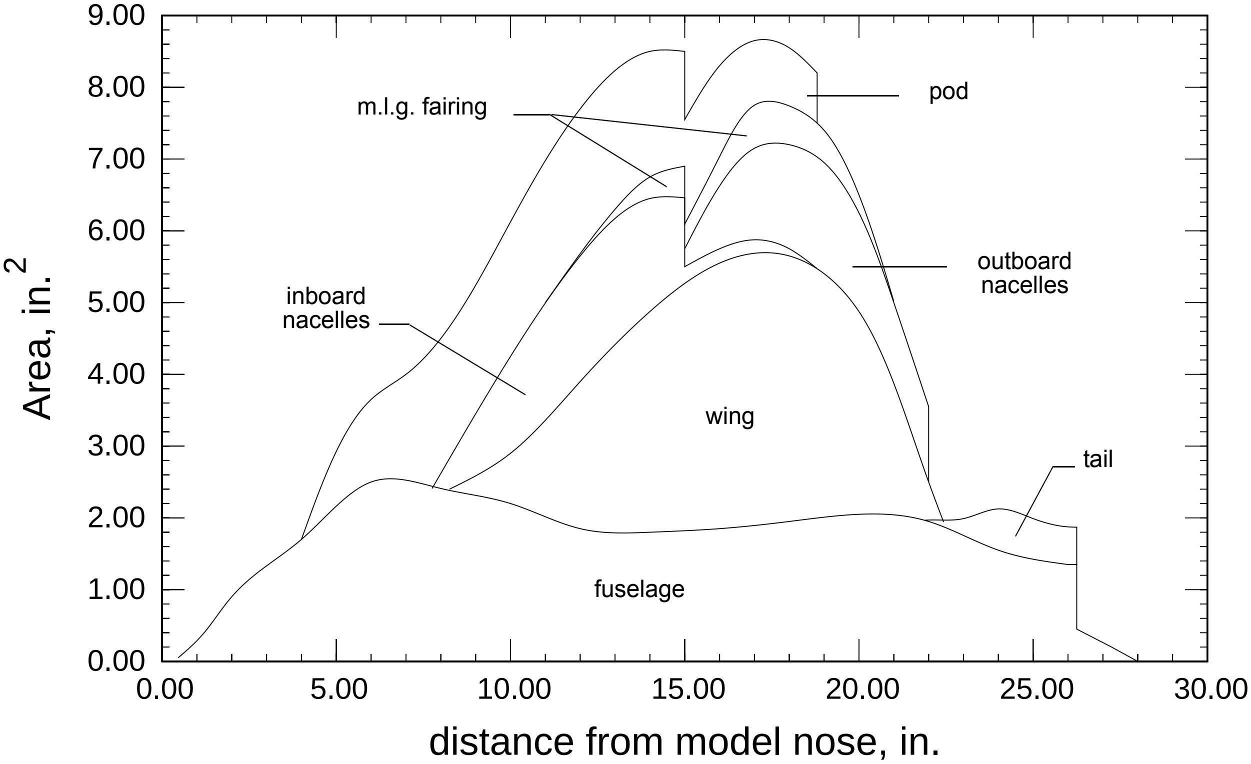


(a) Convair B-58

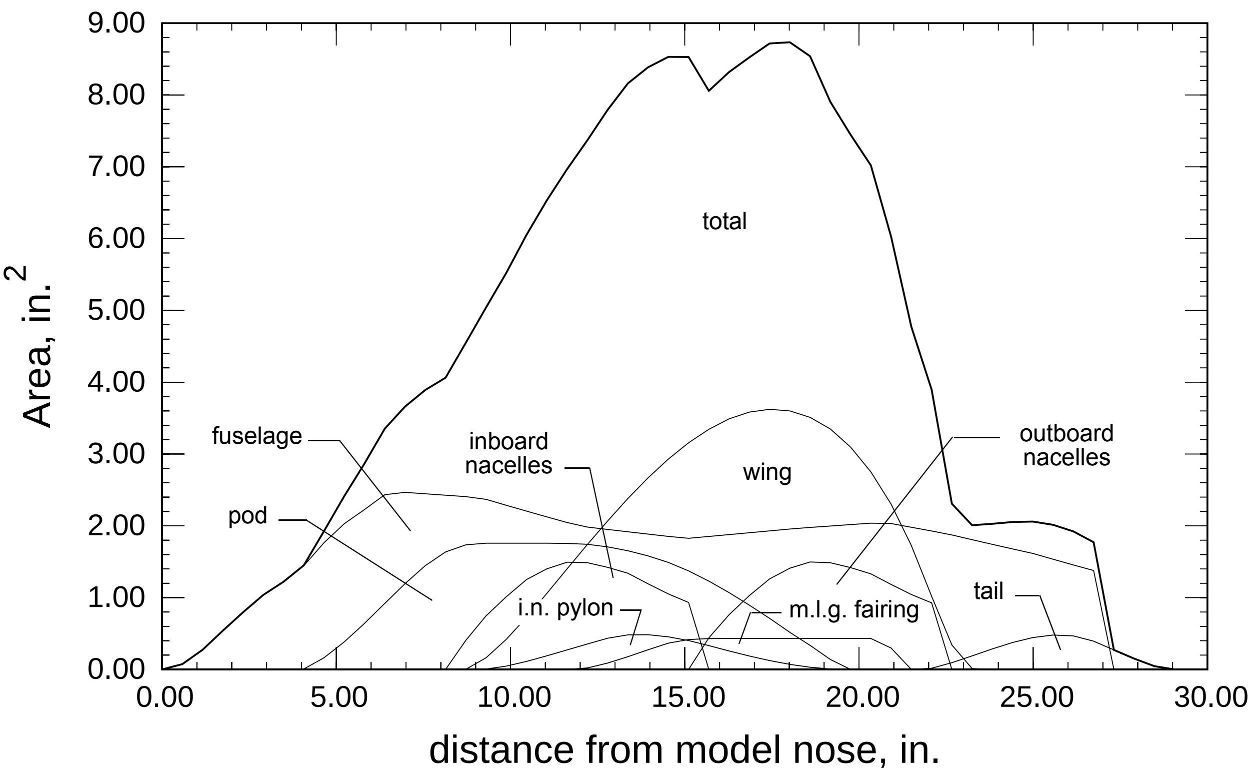


(b) North American XB-70

Figure 3.- Pictorials of B-58 and XB-70 as generated from current electronic files containing geometric descriptions of both airplanes.

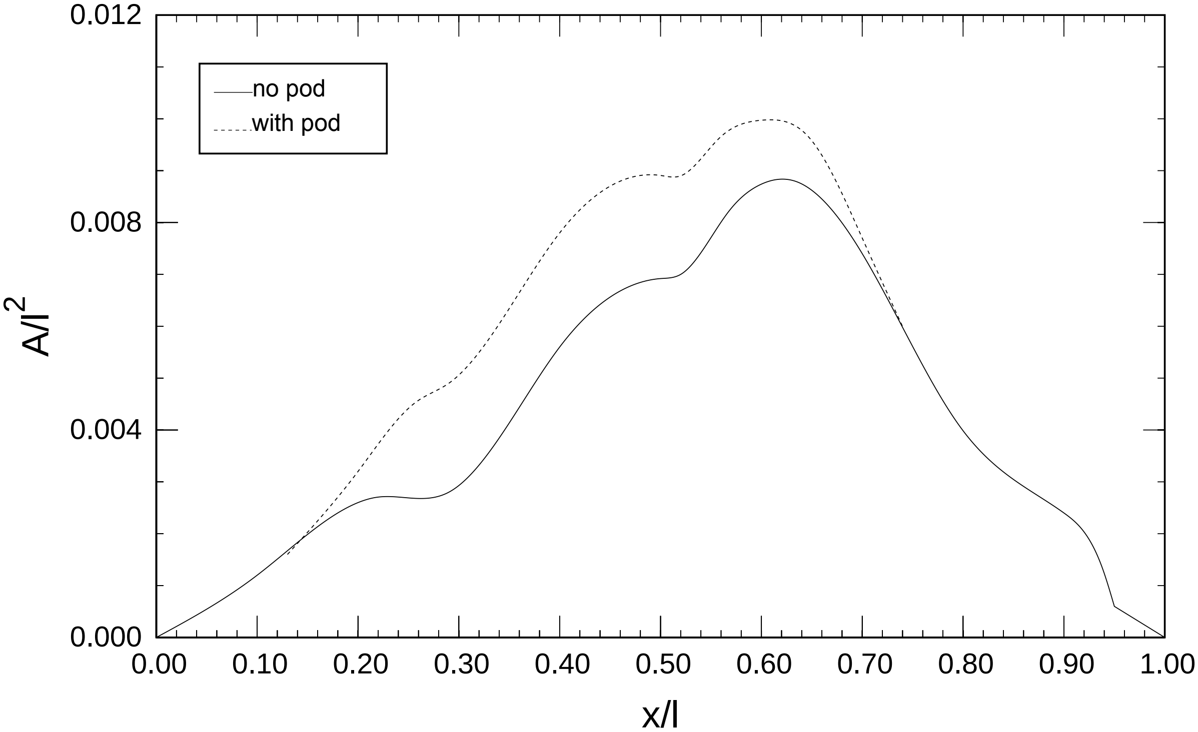


(a) As generated in 1956 (ref. 6)

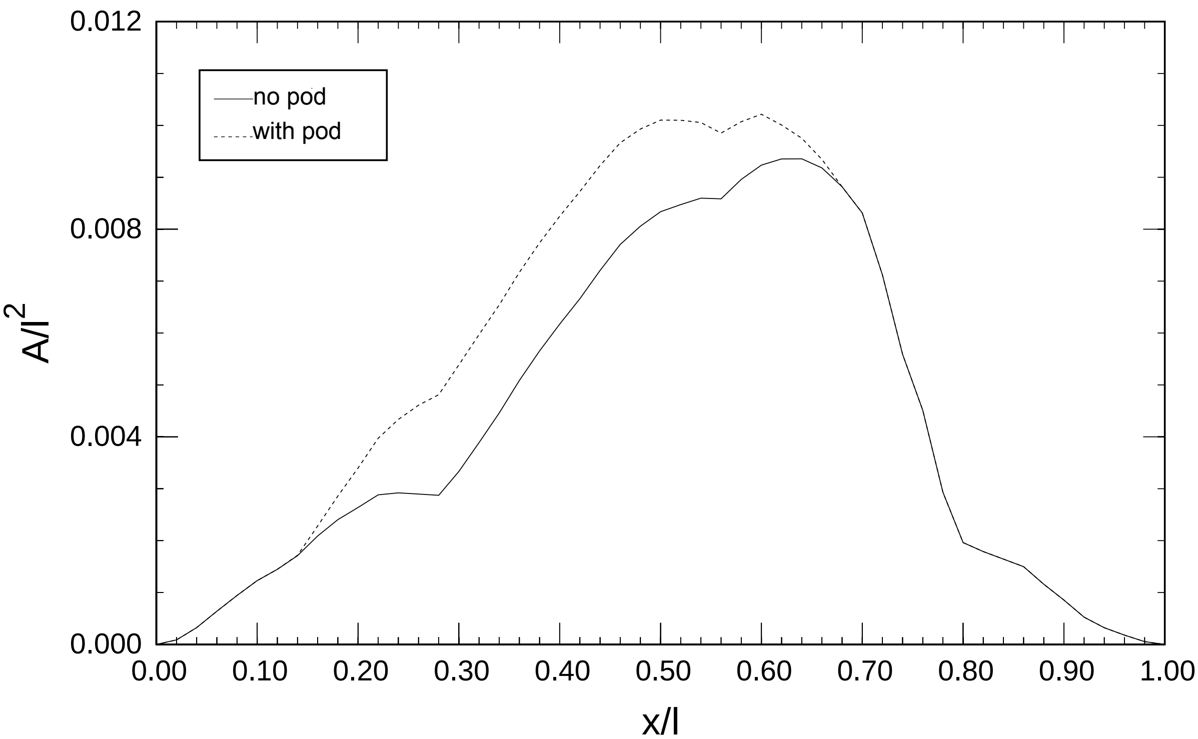


(b) As generated using present vehicle geometric description

Figure 4.- Comparison of normal cross-sectional area distributions of B-58 wind tunnel model and components (inlet capture area not included).

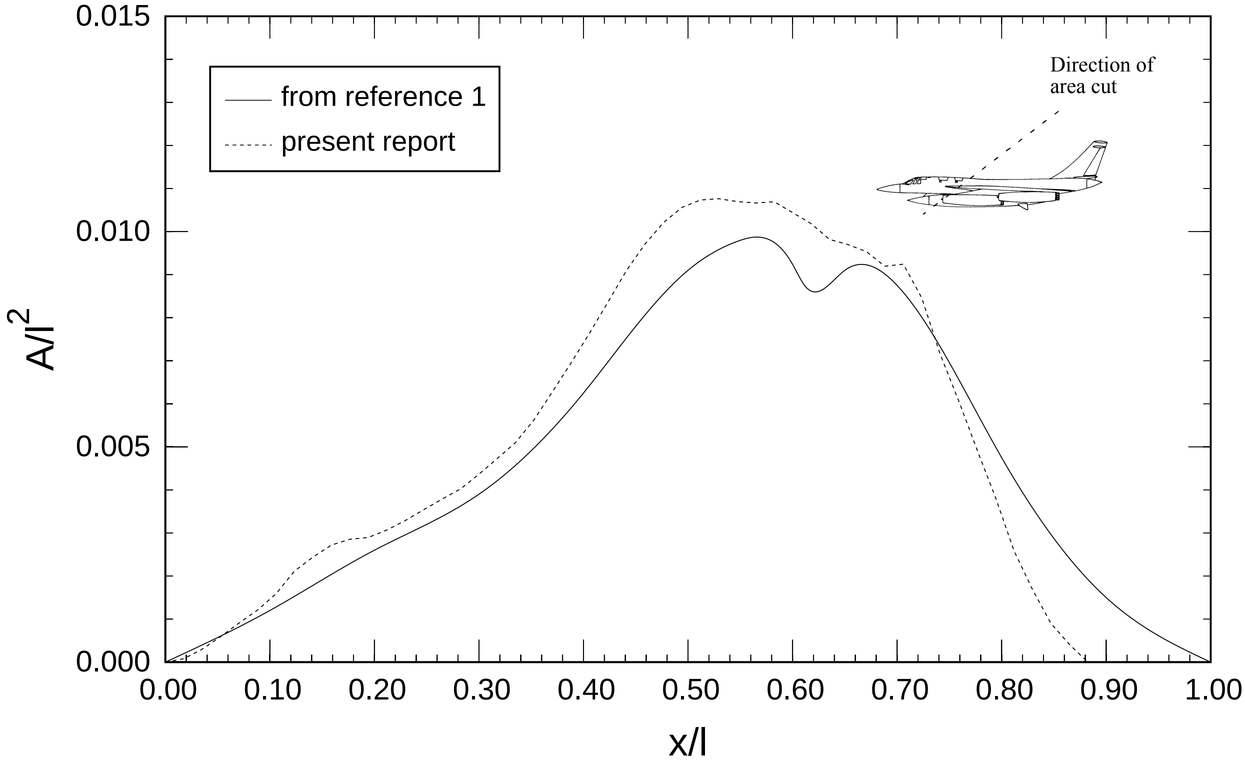


(a) As generated in 1961 (ref. 13)

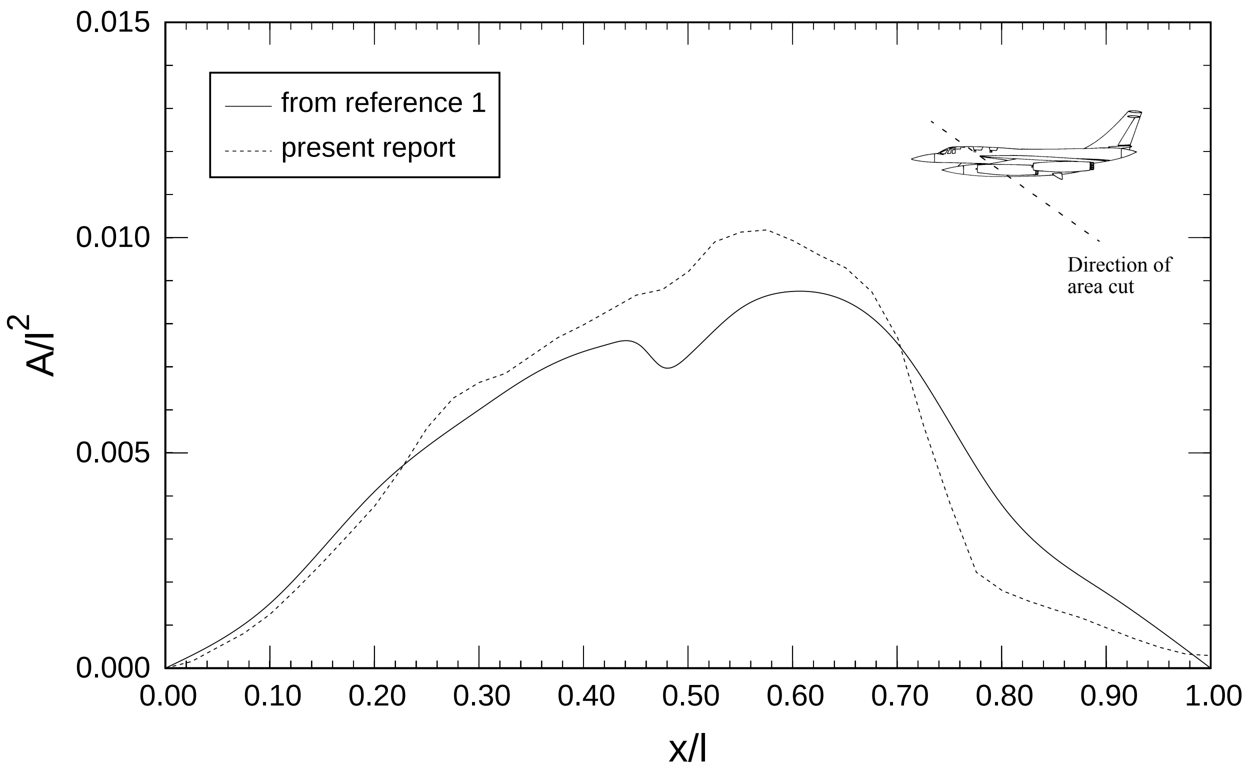


(b) As generated using present vehicle geometric description

Figure 5.- Comparison of normal cross-sectional area distributions of B-58 with and without MB-1 fuselage pod (inlet capture area not included).



(a) Area distribution based on oblique cuts for positions above the airplane ($\theta = 90^o$)



(b) Area distribution based on oblique cuts for positions below the airplane ($\theta = -90^o$)

Figure 6.- Comparison of total area distributions above and below B-58 airplane with MB-1 pod at M=1.65 (inlet capture area not included).

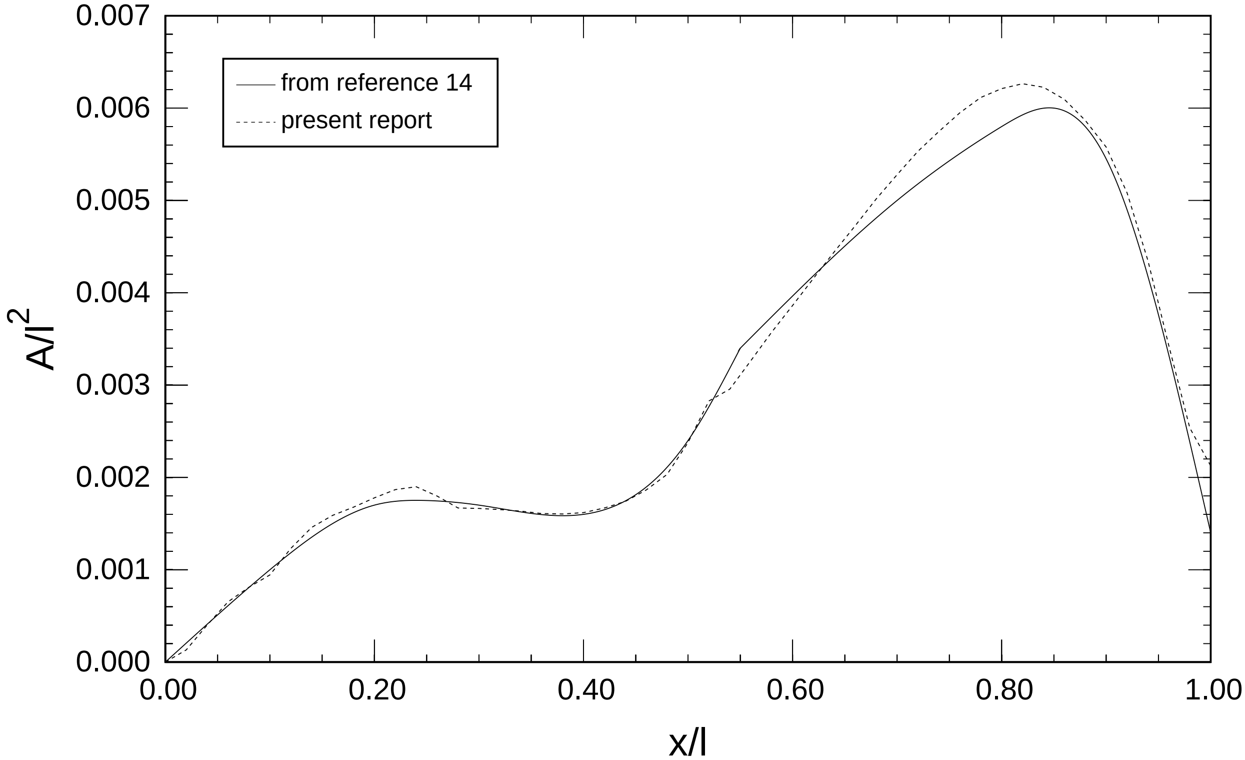


Figure 7.- Comparison of non-dimensional total normal cross-sectional area distributions of XB-70-1 airplane. Inlet capture area not included. Wing tips at 65^o

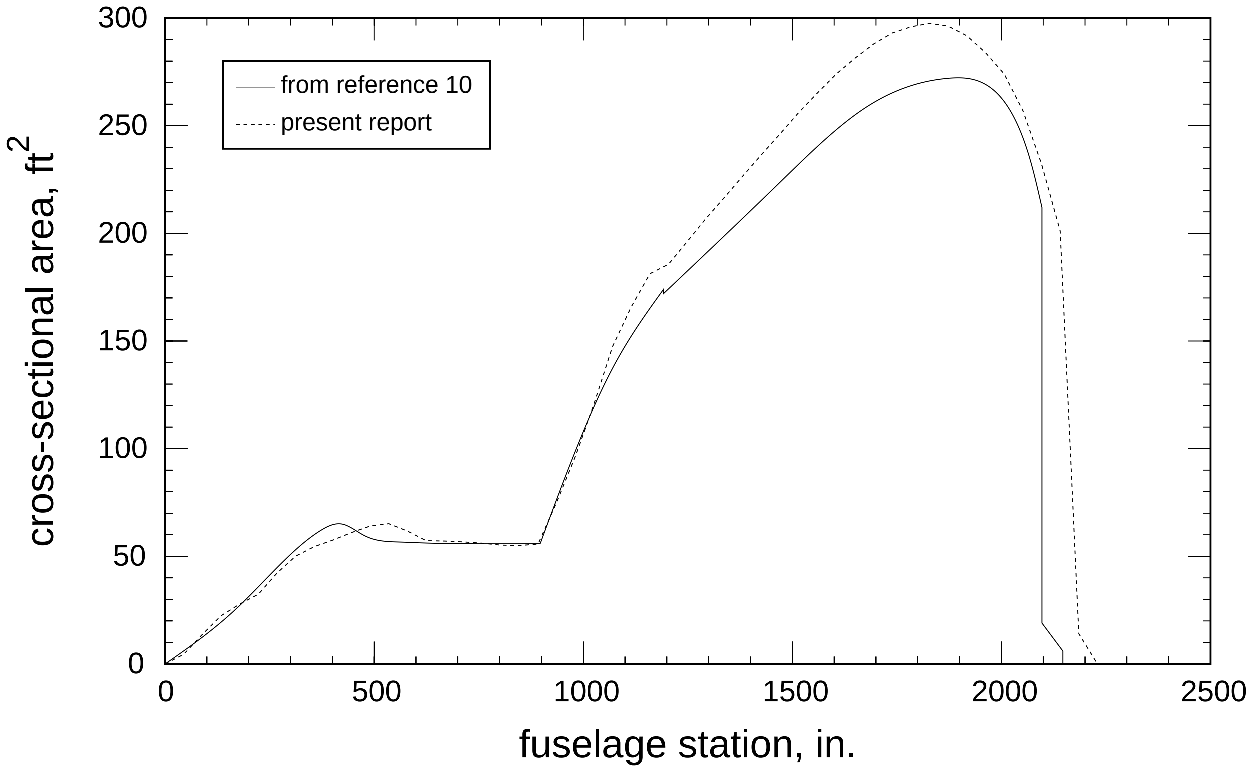
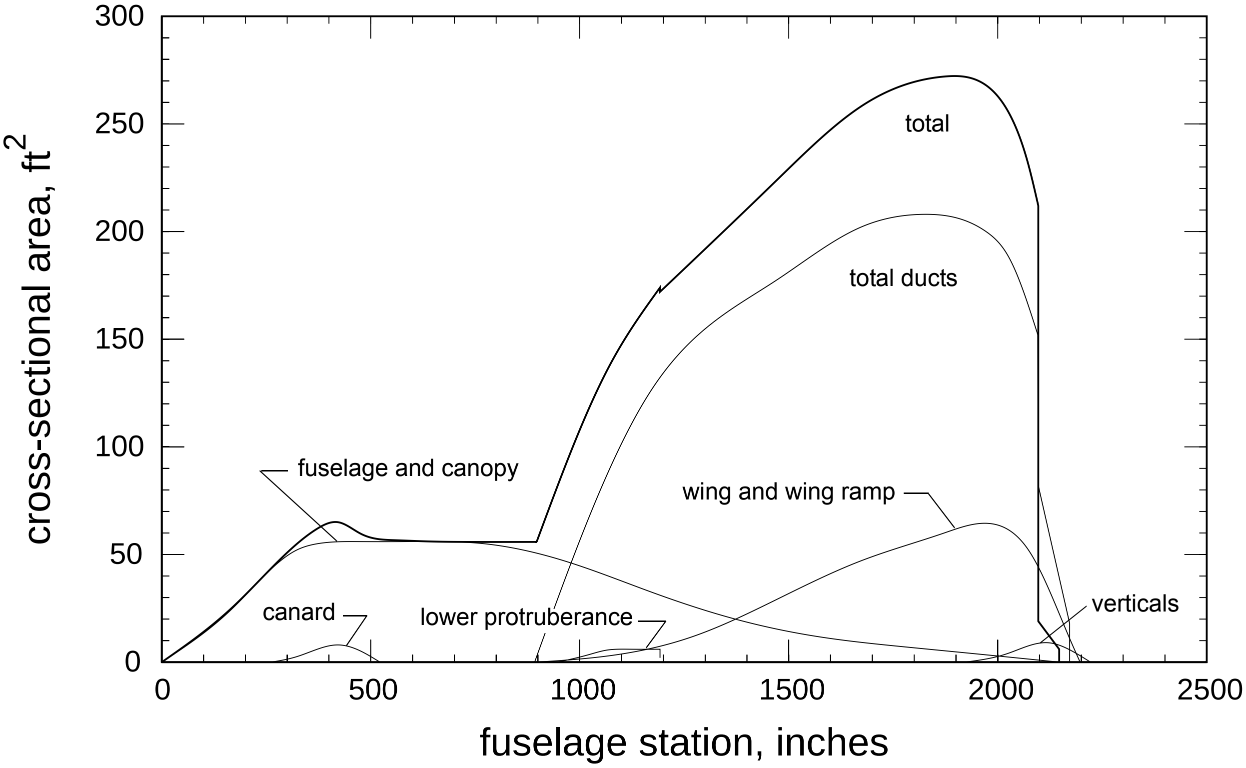
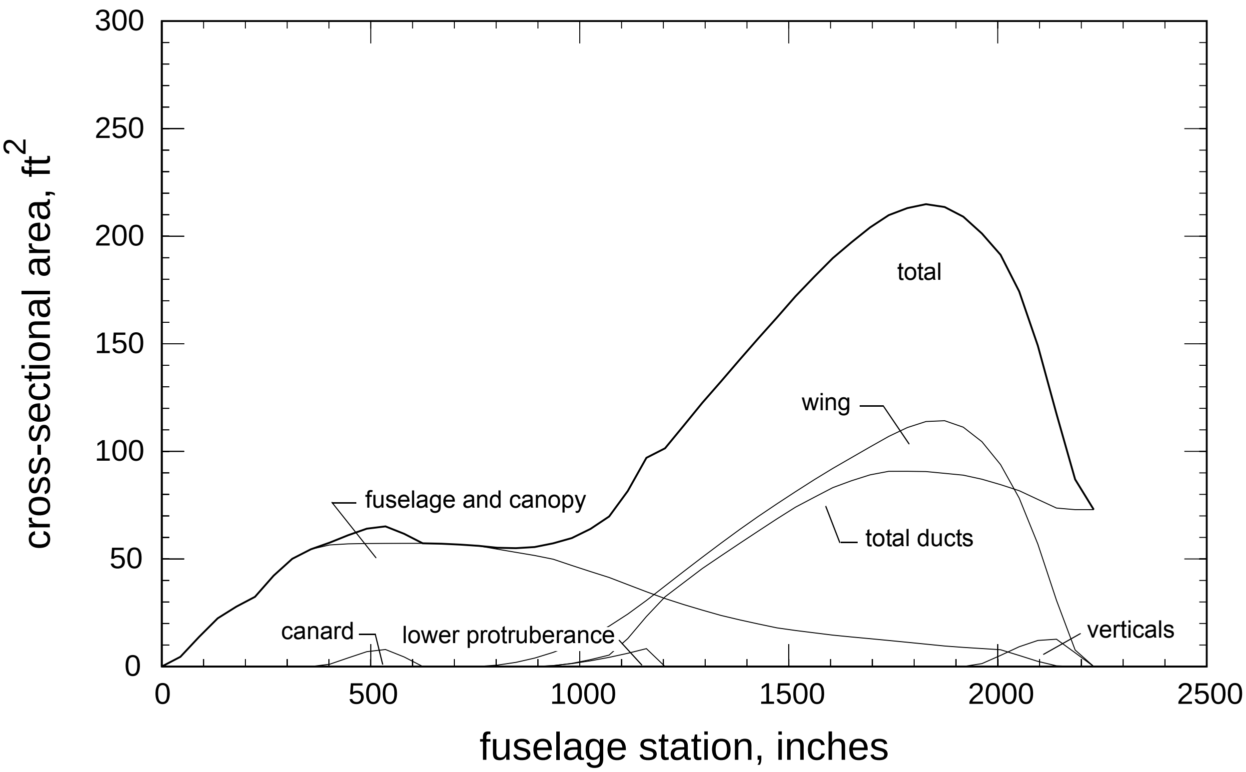


Figure 8.- Comparison of total normal cross-sectional area distributions of XB-70-1 airplane. Inlet capture area included. Wing tips at 0^o

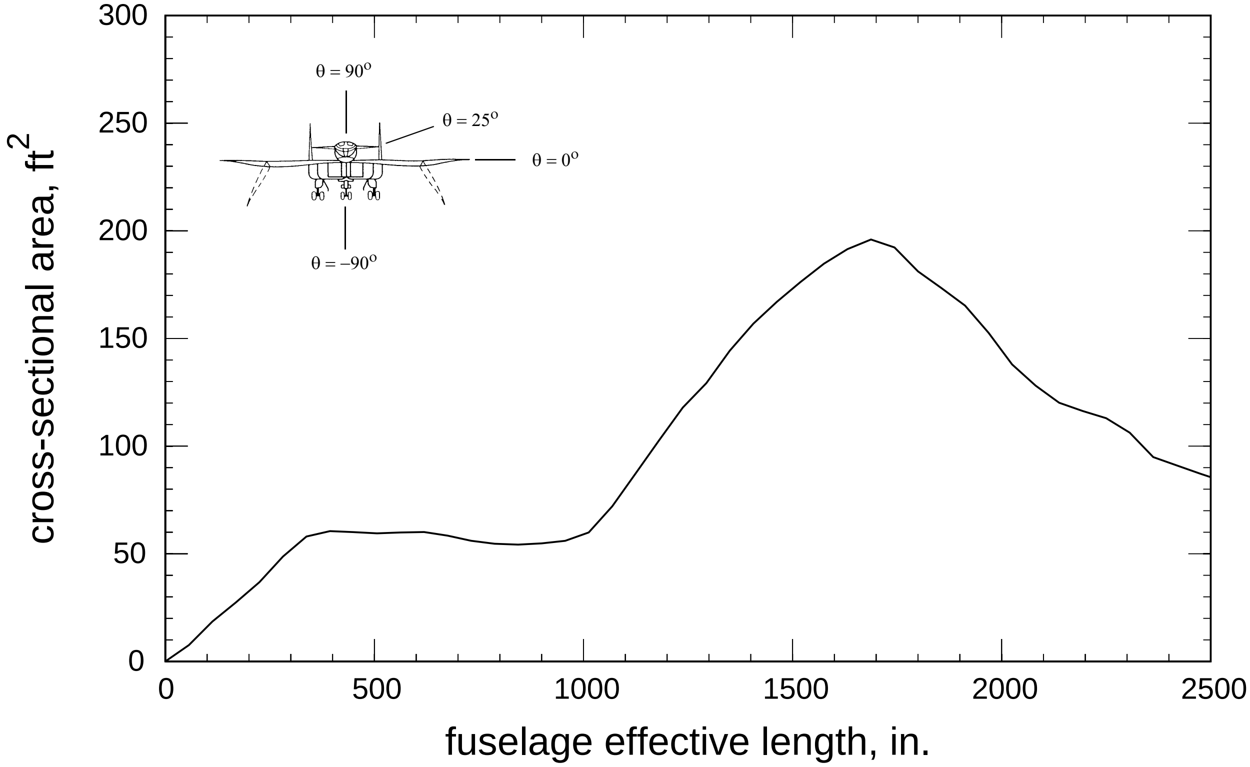


(a) As generated in 1961 (ref. 10). Inlet capture area included.

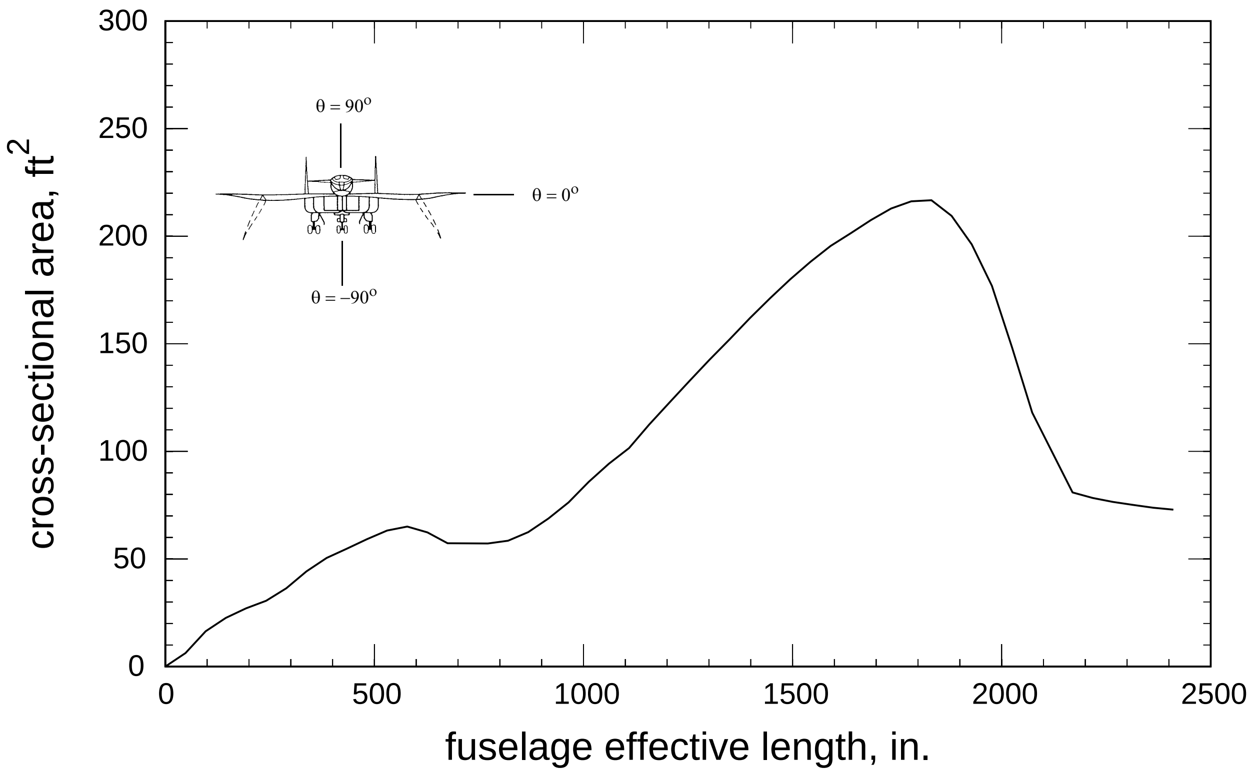


(b) As generated using present vehicle geometric description. Inlet capture area not included.

Figure 9.- Comparison of normal cross-sectional area distributions of XB-70-1 airplane and components. Wing tips at 0^{o}



(a) Total area distribution based on oblique cuts for a position above and to the side of the aircraft ($\theta = 25^{o}$)



(b) Total area distribution based on oblique cuts for a position below the aircraft ($\theta = -90^{o}$)

Figure 10.- Area distributions of XB-70-1 vehicle used as shock-wave generating airplane. Oblique cuts at Mach 1.5 (inlet capture area not included. Wing tips at 65^{o} down).

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14. ABSTRACT
A detailed geometric description, in wave drag format, has been developed for the Convair B-58 and North American XB-70-1 delta wing airplanes. These descriptions have been placed on electronic files, the contents of which are described in this paper
They are intended for use in wave drag and sonic boom calculations. Included in the electronic file and in the present paper are photographs and 3-view drawings of the two airplanes, tabulated geometric descriptions of each vehicle and its components, and comparisons of the electronic file outputs with existing data. The comparisons include a pictorial of the two airplanes based on the present geometric descriptions, and cross-sectional area distributions for both the normal Mach cuts and oblique Mach cuts above and below the vehicles. Good correlation exists between the area distributions generated in the late 1950s and 1960s and the present files. The availability of these electronic files facilitates further validation of sonic boom prediction codes through the use of two existing data bases on these airplanes, which were acquired in the 1960s and have not been fully exploited.

15. SUBJECT TERMS
Sonic boom,; Equivalent area distributions; Wave drag; Aircraft geometry

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