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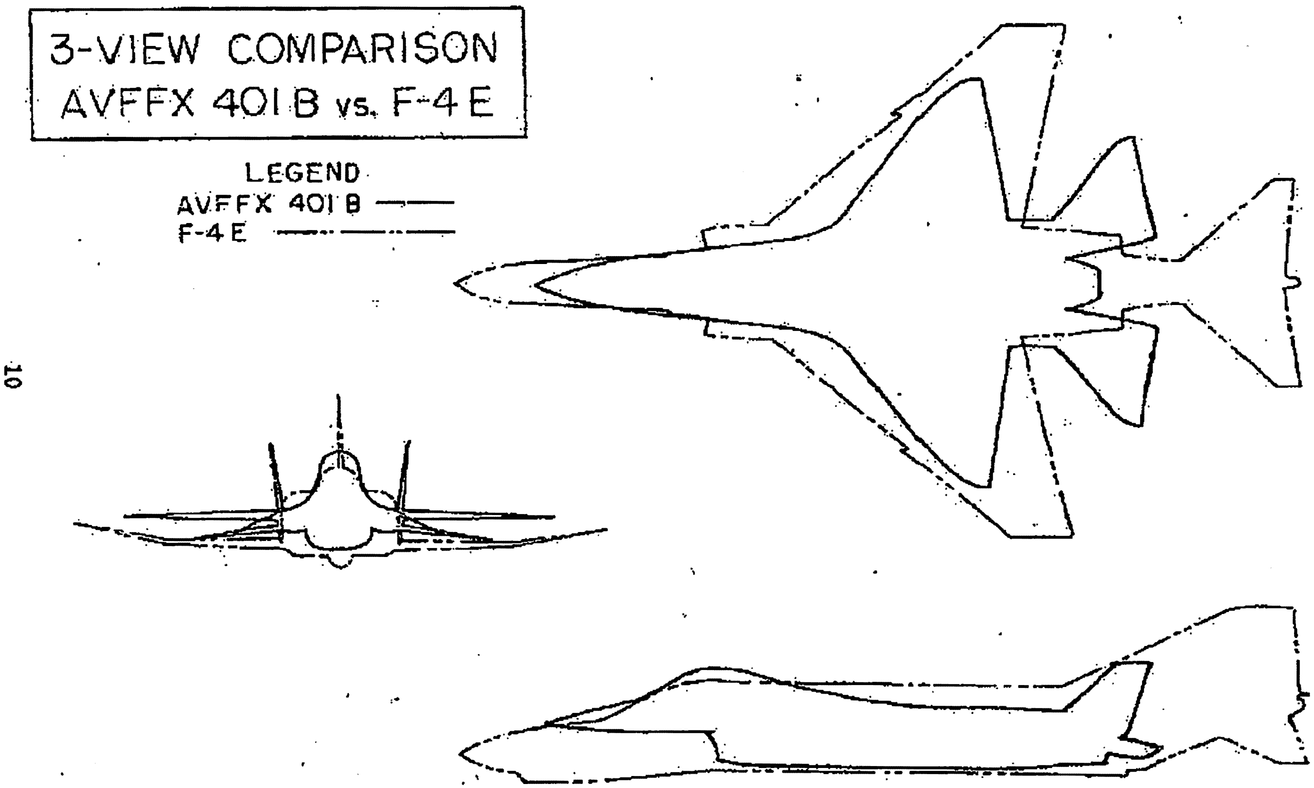


~~(S)~~ Figure 2.1-3 Relative Size Comparison, Single-Engine 401B vs F-4E (U)

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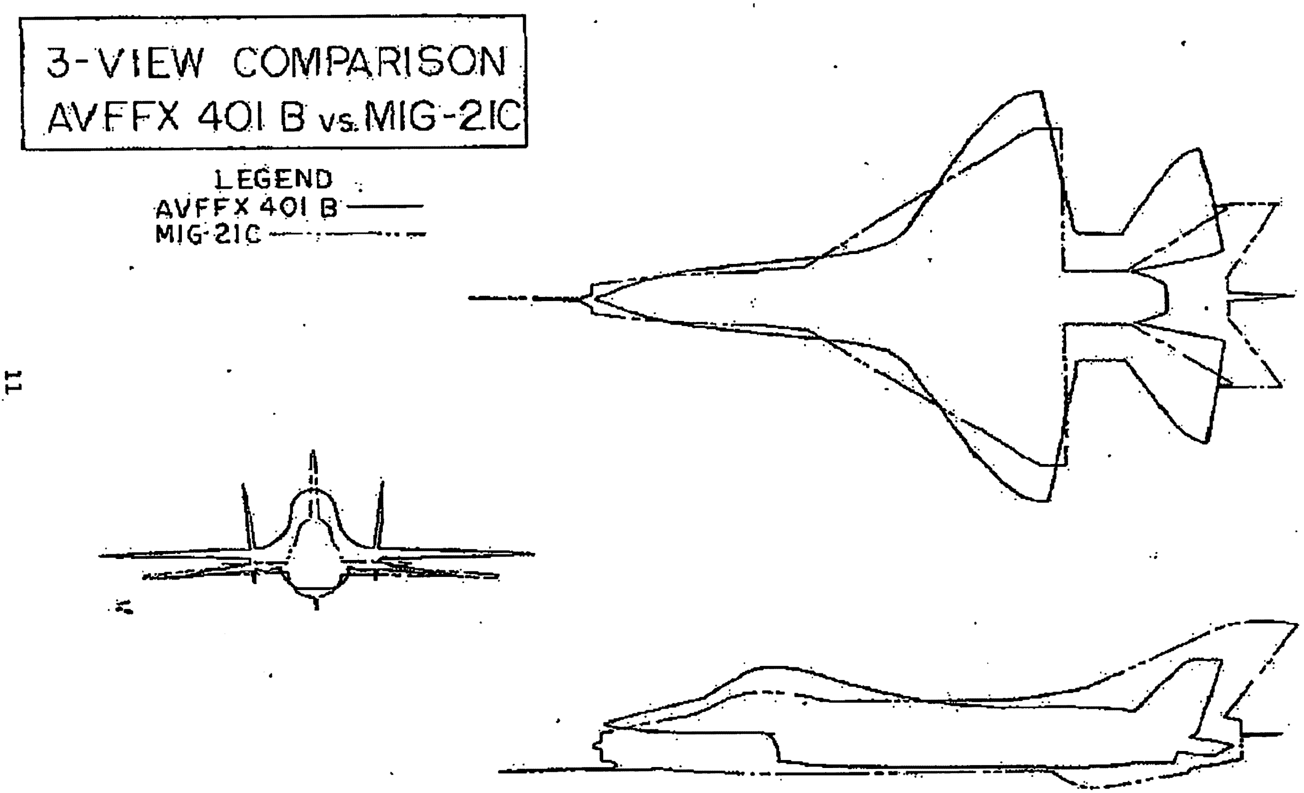


~~(S)~~ Figure 2.1-4 Relative Size Comparison, Single-Engine 401B vs MIG-21C (U)

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~~(S)~~ a single J101-GE-100 engine (rated thrust of 14,295 lb). The basic point-design layout was made at a size of 13,000 lb, and design data were also generated for a 10,000-lb and a 16,800-lb version. This provided a T/W variation of 1.43, 1.10, and 0.85.



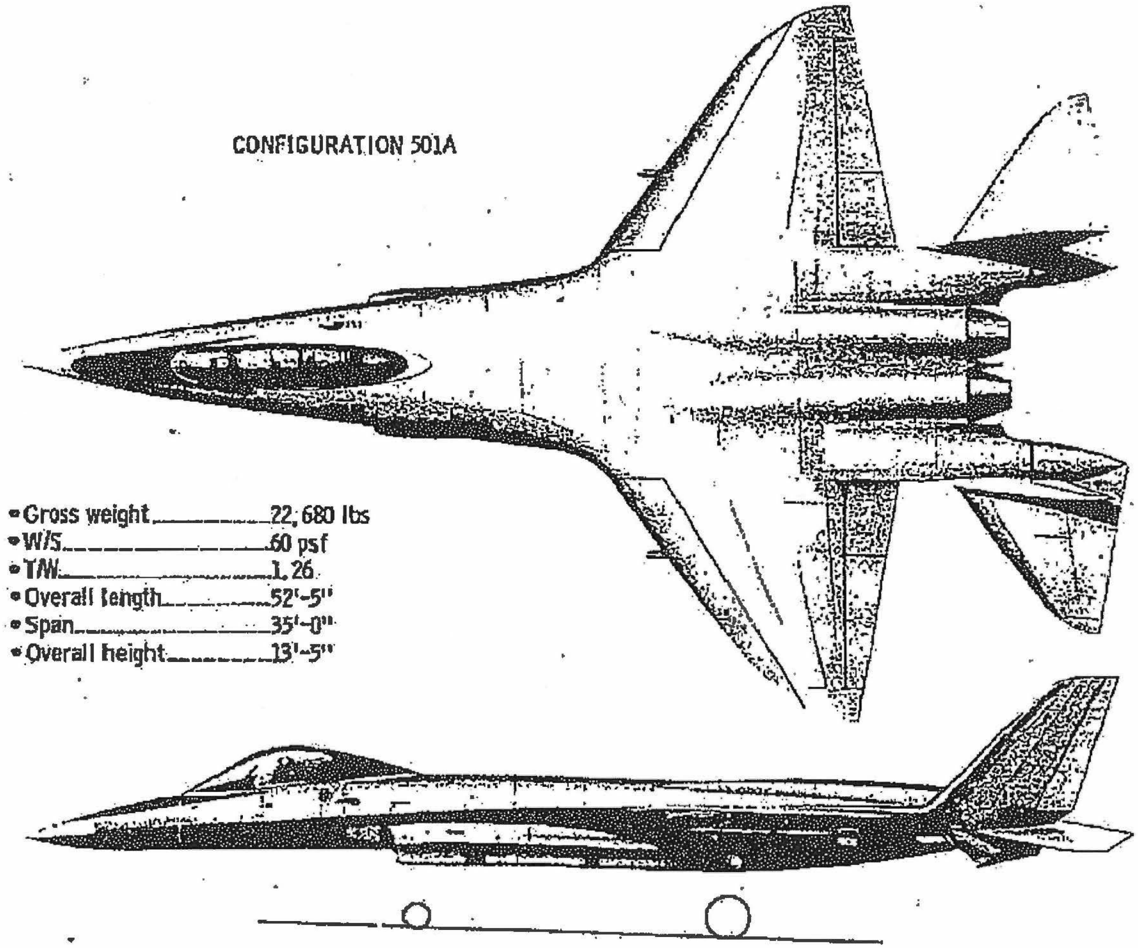
(U) The results show that no airplane size within the constraints of the design objectives can be made to perform the design mission when using only one of these small engines. At the smaller sizes (10,000 and 13,000 lb) the basic problem is simply insufficient fuel. As the size is increased to achieve higher fuel fractions, the combat fuel allowance required increases disproportionately because of the reduced T/W. Finally, at about 18,500 lb there is insufficient thrust to perform the acceleration requirement of the mission. Technical data for this concept are presented in Section 4.

## 2.3 LARGE TWIN-ENGINE CONCEPT (501A/J101-GE-100)

~~(S)~~ The 501A aircraft (Concept 3) is a single-place, twin-engine, fixed-wing design that utilizes J101-GE-100 engines and as many of the design features of the single-engine concepts as possible that are consistent with good twin-engine design (Figures 2.3-1 and 2.3-2). The gross weight of the initial design is 19,000 lb. Growth data for final sizing are also established by use of design gross weights of 16,800, 22,000, and 24,000 lb, resulting in a T/W variation of 1.7 to 1.2 (rated thrust is 14,295 lb per engine).



~~(S)~~ The aircraft, when sized to perform the LRASM (750 n.mi), requires a gross weight of 22,680 lb, resulting in a T/W of 1.26. The LRASM requires two 450-gal external fuel tanks for the outbound portion of the mission. The SRASM capability (no external fuel tanks) has a radius of 244 n.mi. The ferry mission capability when carrying a reasonable upper limit of external fuel (two 600-gal and one 150-gal tanks) is only 2166 n.mi with tanks retained. Summary mission capabilities of the 22,680-lb twin-engine aircraft are tabulated below. Detailed design, performance, aerodynamics, handling qualities, weight, and propulsion data are presented in Section 5.




~~(S)~~ Figure 2.3-1 Twin-Engine 501A, Top and Side Views (U)

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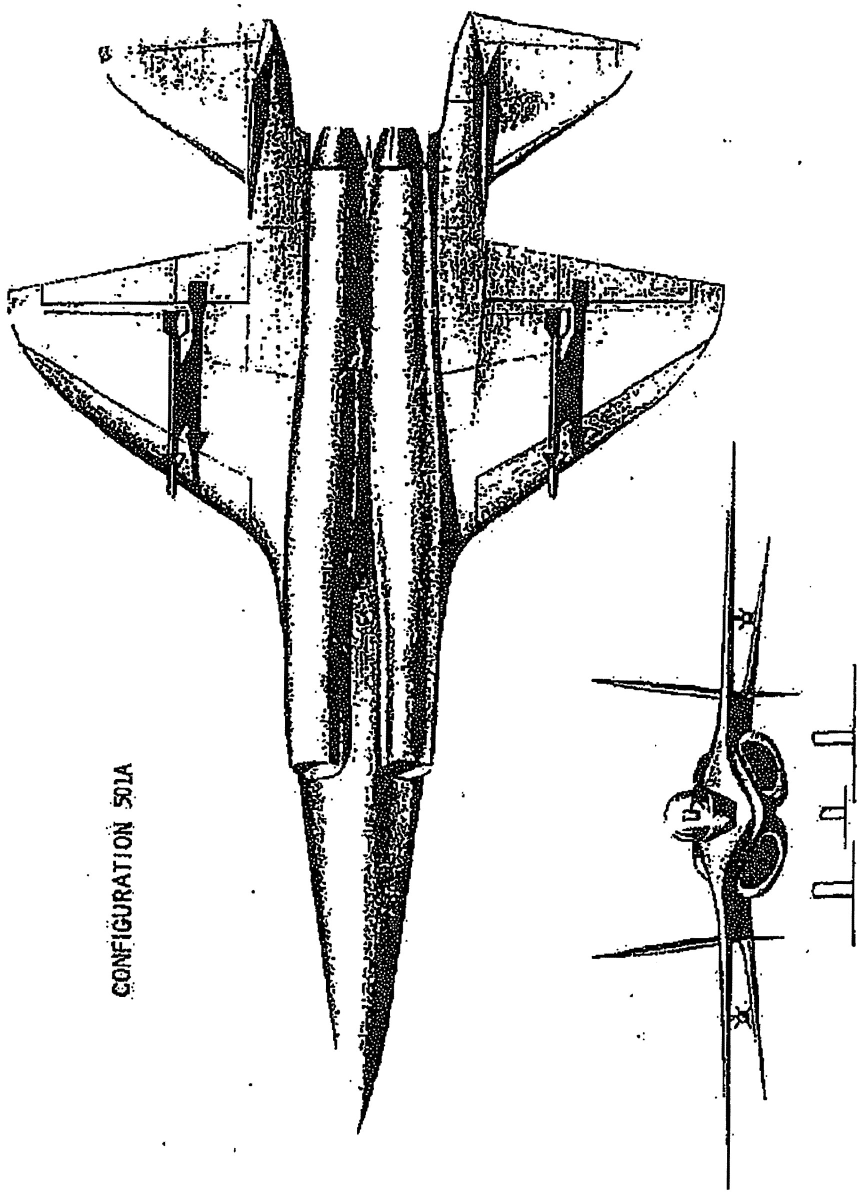


~~(S)~~ Figure 2.3-2 Twin-Engine 501A, Bottom and Front Views (U)

501A MISSION SUMMARY
(22,680-lb A/P)

| Mission | Range (n.mi) | Radius (n.mi) | $\dot{\theta}_{M.8}$ (deg/sec) | $\dot{\theta}_{M1.2}$ (deg/sec) | Accel. Time (sec) |
|---|---|---|---|---|---|
| LRASM | - | 750 | 9.5 | 6.9 | 51.4 |
| SRASM | - | 244 | 10.5 | 7.6 | 46.1 |
| Ferry | 2166 | - | - | - | - |

Silhouettes of the 22,680-lb version of 501A are superimposed on equal-scale outlines of the F-4 and MIG-21 aircraft in Figure 2.3-3 and 2.3-4 to show relative sizes.

## 2.4 0.4 TAPER RATIO WING ON 401B

~~(S)~~ The Concept 1 aircraft (the large single-engine 401B concept) was also designed with a contract-specified wing geometry: wing loading of 60 psf, aspect ratio of 3.0, taper ratio of 0.4, thickness/chord ratio of 4 percent, fixed leading-edge sweep of 35 degrees, straight leading and trailing edges, and manually selectable single-hinge leading-edge high-lift devices. This wing differs from the selected wing used on the Concept 1, 2, and 3 designs in two respects: taper ratio of 0.4 versus 0.20, and squared rather than rounded wing tips.



~~(S)~~ If the wing t/c is a constant 4 percent, the configuration when sized for a 16,800-lb airplane has a dry-weight penalty of 270 lb as compared to the Concept 1 401B. This is primarily due to taper ratio. However, because of the higher taper ratio, a tapered t/c can be utilized to minimize the weight penalty; therefore, the wing was redefined to have a tip t/c of 2.5 percent and an inboard t/c (at beginning of thickened wing root) of 4.84 percent, which results in an exposed RMS t/c of 4.0 percent. This change reduces the dry-weight penalty from 270 lb to 119 lb.

~~(S)~~ When sized to meet the LRASM, this airplane has a gross weight of 17,735 lb. Summary mission capabilities at this weight are tabulated below. Detailed technical data are presented in Section 6.

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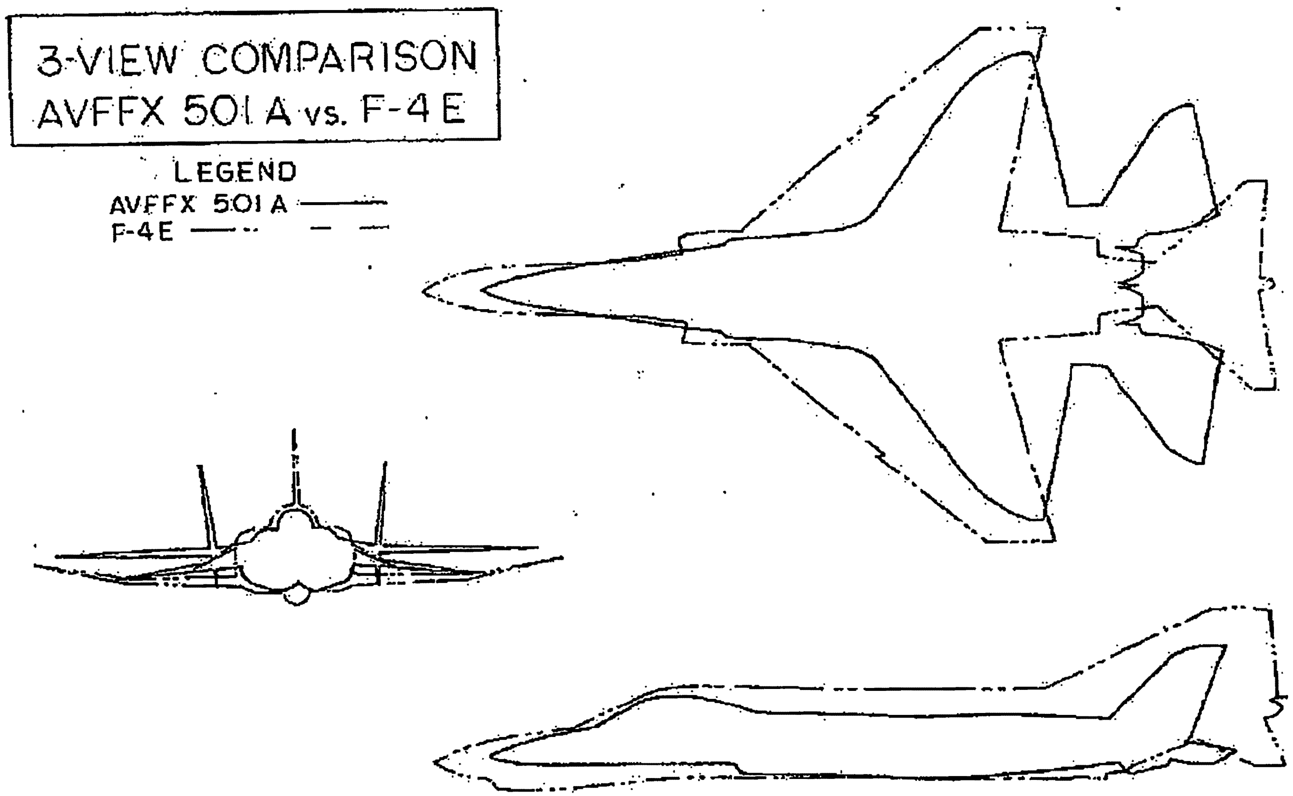


~~(S)~~ Figure 2.3-3 Relative Size Comparison, Twin-Engine 501A vs F-4E (U)

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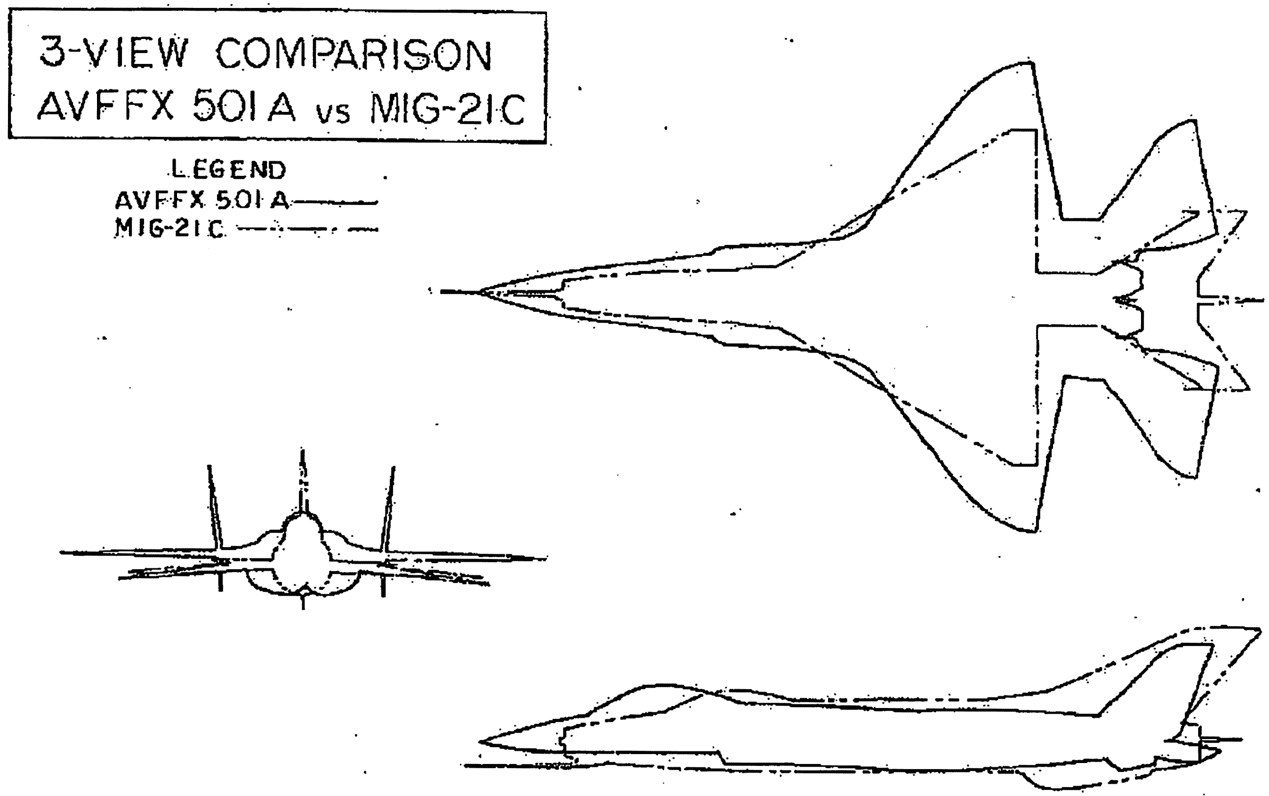


~~(S)~~ Figure 2.3-4 Relative Size Comparison, Twin-Engine 501A vs MIG-21C (U)

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401B λ=.4 MISSION SUMMARY
(17,735-lb A/P)

| Mission | Range (n.mi) | Radius (n.mi) | $\dot{\theta}_{M=.8}$ (deg/sec) | $\dot{\theta}_{M=1.2}$ (deg/sec) | Accel. Time (sec) |
|---|---|---|---|---|---|
| LRASM | - | 750 | 9.2 | 8.0 | 38.6 |
| SRASM | - | 244 | 10.1 | 8.7 | 35.2 |
| Ferry | 2478 | - | - | - | - |

## 2.5 SUPERCRITICAL WING STUDY ON 401B

(U) Effective utilization of the supercritical airfoil is attained only through proper selection of the wing planform. Merely to replace the biconvex airfoil with a supercritical airfoil on the Concept 1 planform is not sufficient. For example, a blunt-nosed airfoil on the Concept 1 planform is expected to have high wave drag that can be considerably reduced by increasing the wing sweep. Also, since the payoff of a supercritical airfoil is proportional to t/c, a slightly higher thickness of 6 percent was choosen to provide a useful supercritical payoff.

(U) The planform selection was made non-arbitrary by performing an abbreviated parametric study. The planform parameters investigated were wing sweep, wing loading, and aspect ratio. The effects of weight as well as aerodynamics were considered. From a weight standpoint, the thicker wing along with the elimination of leading-edge flaps provides a weight savings that can be translated into higher sweep, higher aspect ratio, or lower wing loading. The basis for comparison in the planform study was two representative maneuverability parameters: maximum sustained load factor between Mach 0.8 and 1.2 at 30,000 ft, and energy rate at Mach 0.9/10,000 ft/1g.



~~(S)~~ The results of the parametric study reveal that no single planform will be best for all flight conditions, and the final selected planform must necessarily be a compromise. Two planforms were selected for detailed analysis and mission performance, one favoring sustained turn rates and one favoring acceleration capability. Both have a leading-edge sweep of 45 degrees, wing loading of 60 psf, and thickness/chord ratio of 6 percent. The selected aspect ratios were 3.0 and 3.75, based on span of the average tip chord (or aspect ratios of 3.2 and 4.0 based on overall span where the tip is rounded in such a way as to hold constant wing area).

~~(S)~~ The SRASM radius objective was more critical than that of the LRASM and was therefore chosen as the sizing criterion. The higher-aspect-ratio wing requires a gross weight of 17,115 lb (coincidentally the same as the basic 401B). The lower-aspect-ratio wing requires a gross weight of 16,640 lb. Summary mission capabilities are tabulated below.

401 S/C AR 3.75 MISSION SUMMARY
(17,115-lb A/P)

| Mission | Range (n.mi) | Radius (n.mi) | $\dot{\theta}_{M=.8}$ (deg/sec) | $\dot{\theta}_{M=1.2}$ (deg/sec) | Accel. Time (sec) |
|---|---|---|---|---|---|
| LRASM | - | 794 | 11.0 | 7.6 | 62.6 |
| SRASM | - | 225 | 11.7 | 8.3 | 57.2 |
| Ferry | 3252 | - | - | - | - |

401 S/C AR 3.0 MISSION SUMMARY
(16,640-lb A/P)

| Mission | Range (n.mi) | Radius (n.mi) | $\dot{\theta}_{M=.8}$ (deg/sec) | $\dot{\theta}_{M=1.2}$ (deg/sec) | Accel. Time (sec) |
|---|---|---|---|---|---|
| LRASM | - | 767 | 10.6 | 7.5 | 55.8 |
| SRASM | - | 225 | 11.4 | 8.2 | 51.1 |
| Ferry | 3571 | - | - | - | - |

~~(S)~~ The general conclusions from these data are that supercritical airfoils, when used on fixed-wing supersonic airplanes, can be utilized to provide approximately 10-percent higher Mach 0.8 sustained turn rates but at the expense of reduced supersonic capability (10-percent lower Mach 1.2 sustained turn rate, and 70-percent or 25-second higher acceleration time from Mach 0.9 to 1.5). However, for speeds closer to the critical region, such as Mach 0.9, the sustained turn rate advantage becomes larger (13 percent over the Concept 1), and significant improvements in buffet limits are attained in the critical region. A side payoff of the supercritical wing designs is greatly improved ferry range. A side penalty of the supercritical wing designs is greatly reduced maximum speeds (from Mach 2.2 to 1.8). Detailed design data and performance, handling qualities, and weight data for the supercritical wing study are presented in Section 7.

88th ABW/PA FOIA (b)(1)
E.O. 13526 SEC. 3.3(b)(1)
1.4(a)(g)

(U) Through additional configuration shaping and development of thin-wing supercritical design, it is believed that the supersonic penalties can be reduced. Such studies were not possible within the scope of this study.

## 2.6 COMPOSITE MATERIAL STUDY ON 401B

~~(S)~~ A matrix of wing design variables were evaluated to determine whether the weight reductions attained through the use of composite materials should be used for increased aspect ratio, reduced wing loading, reduced aircraft size (higher T/W), or a combination of the three to maximize the maneuver capabilities. [The matrix of variables evaluated were: (1) aspect ratios of 3, 4, 5, and 6; (2) wing loadings of 45, 50, 55, and 60 psf; and (3) gross weights of 15,600, 16,800, and 18,000 lb, with corresponding thrust/weight ratios of 1.5, 1.4, and 1.3 when using the fixed-size F100-PW-100 engine. This matrix of variables was evaluated for four levels of composite usage: (1) none (all aluminum), (2) composite wing, (3) composite wing, tails, and duct, and (4) all composite.]



~~(S)~~ For each level of composite usage and for each combination of aspect ratio and wing loading, the aircraft was sized to perform the 750-n.mi-radius LRASM. Two types of energy-maneuverability were selected to show the payoff of composite usage: [(1) sustained turn rate at Mach 0.8 and 30,000 ft as being representative of a high-lift turning condition, and (2) acceleration time from Mach 0.9 to 1.5 at 30,000 ft as being representative of a low-lift accelerating capability or 1-g energy rate. The Mach 0.8 turn rate was then plotted versus acceleration time for the matrix of AR and W/S to establish the maximum capabilities for each level of composite usage.]



~~(S)~~ The composite trade study results along with backup data are presented in Section 8. As an example, if it is desired to utilize all of the benefits of composites to increase subsonic turning capability (within constraints of equal acceleration capability and equal mission radius), [airplane sustained turn rates at Mach 0.8 can be increased over an aluminum airplane by 12 percent with a composite wing or 36 percent with maximum composite usage. Energy-maneuverability plots, including maximum maneuver diagrams, for various selected combinations of variables are needed] to allow comparisons over the whole maneuvering flight spectrum before the optimum combinations of variables can be selected.

## 2.7 INLET TRADE STUDY ON 401B

~~(S)~~ Four inlet designs were evaluated during the study to assess the payoff and penalties associated with inlet sophistication. The inlet configurations selected and evaluated are:

| Inlet | Design Mach | Capture Area, $A_i$ (in.$^2$) | Variable Geometry | Bypass |
|---|---|---|---|---|
| (1) Open-nose (401B basic) | 1.6 | 740 | No | No |
| (2) Half-axisymmetric, fixed-spike | 2.0 | 1020 | No | Yes |
| (3) Half-axisymmetric, variable-diameter | 2.2 | 890 | Yes | No |
| (4) Two-dimensional, variable-ramp | 2.2 | 840 | Yes | No |

(U) The inlet designs were evaluated against Concept 1 as the basic vehicle. Each inlet was incorporated into the 401B airframe and lines were generated in sufficient detail to determine aircraft cross-sectional and wetted-area changes, structural and control system weights, inlet pressure recoveries, and drags.

~~(S)~~ A performance comparison in terms LRASM radius, aircraft gross weight required to achieve a 750-n.mi radius, mission maneuver capability, supersonic $P_s$, and Mach 2.2 ceiling was made between each inlet configuration. The variable-geometry inlets have significantly better performance above Mach 1.6, as expected, but with a significant degradation in mission radius, which requires increasing the aircraft size. For example, the 2-D variable-ramp-inlet airplane achieves 136 n.mi less mission radius, which requires resizing to 17,790 lb (from the basic 17,115-lb airplane). At speeds less than

~~(S)~~ Mach 1.2, the aircraft with the basic open-nose inlet has maneuver capabilities slightly better than aircraft with any of the alternate inlets. This is a result primarily of the 4-percent-higher T/W of the smaller airplane size.

(U) The fixed-spike inlet with bypass was not competitive with the variable-geometry inlets in terms of either energy maneuverability or mission radius.

(U) Configuration layouts, performance comparisons, and supporting data are presented in Section 9.

## 2.8 OTHER TRADES AND CONSIDERATIONS

~~(S)~~ The various tradeoff effects established during the course of the study are presented in Section 10. Some of the summary results are listed below in terms of aircraft size required to perform the 750-n.mi mission.

| Trade | Gross Weight (lb) |
|---|---|
| Concept 1 (401B) | 17,115 |
| Addition of tail hook | 17,320 |
| Self sealing of 100% fuel rather than only fuselage fuel | 17,277 |
| Increasing design load factor from 6.5g to 8.0g at 80% fuel | 17,693 |
| Increasing design load factor from 6.5g to 8.0g at constant nw | 17,191 |
| Increasing landing R/S from 10 fps to 15 fps (fuselage structure only) | 17,196 |
| Applying 1.05 factor to fuel flows | 17,520 |
| Applying 1.05 factor to fuel flows and adding 5% fuel reserve | 18,075 |

## 2.9 ENERGY MANEUVERABILITY PLOTS

~~(S)~~ One of the purposes of this study is to provide data for use in validating the integration of Col. J. R. Boyd's Advanced Energy-Maneuverability Theory with tradeoff analyses. The methods used with Col. Boyd's theory for displaying and comparing the capabilities of different design concepts are described in Armament Memorandum Report 71-2.* Examples of the energy-maneuverability plots generated by Convair under this study are presented in Figure 2.9-1 through 2.9-3. These data are for Configuration 401B, the single-engine concept with the F100-PW-100 engine and having a mission weight of 17,115 lb.

~~(S)~~ The combat arena plot (Figure 2.9-1) displays the region of the flight envelope for various types of maximum maneuver capabilities:

1. The top line is the basic 1-g ceiling.

2. The quickest/tightest turn line is the highest altitude for limit load factor (i.e., the "corner velocity" of v-n diagrams). To the left of this line, maximum turn rates are aerodynamically limited; to the right, structurally limited.

3. The top line of the Maximum Maneuver Corridor is the Best Energy Climb path (or the maximum 1-g energy rate ($P_s$) for each level of energy ($E_s$).

4. The bottom line of the Maximum Maneuver Corridor is the maximum energy rate for each level of energy while turning at structural limit load factor.

5. The Maxinum Maneuver Corridor is the region of maximum turn rate for any energy rate, or the maximum energy rate for any turn rate.

88th ABW/IPI (1)
FOIA (b)(1)
EO 13526 SEC 3.3
(b)(4)
1.4 (a)(g)

*Boyd, J. R., Col., USAF, Christie, T. P., and Drabant, R. E., Capt., USAF, Maximum Maneuver Concept, Armament Memorandum Report 71-2, August 1971.

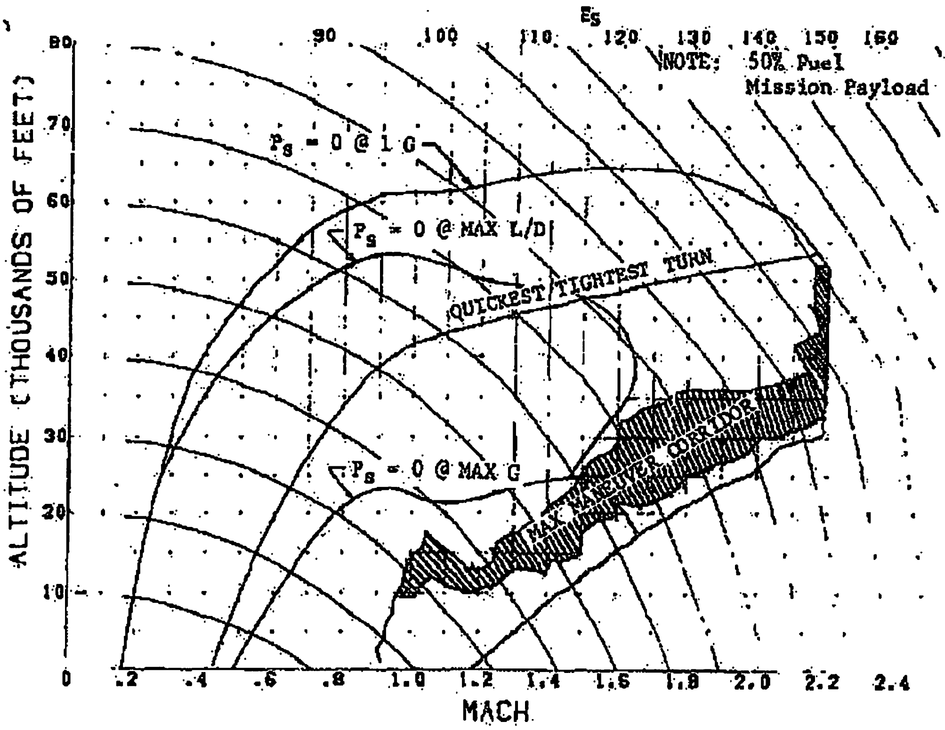
6. The maximum sustained maneuver region is identified by the contour line of zero energy rate at limit load factor.

7. The zero-energy-rate ($P_s = 0$) line for maximum excess L/D bounds the transient maneuver region where the most efficient turns may be sustained. Maneuvering combat outside this region will most likely be hit-and-run attacks. These data show the configuration 401B to have efficient maneuvering capability up to the upper limits of the anticipated air-to-air combat region (Mach 1.6).

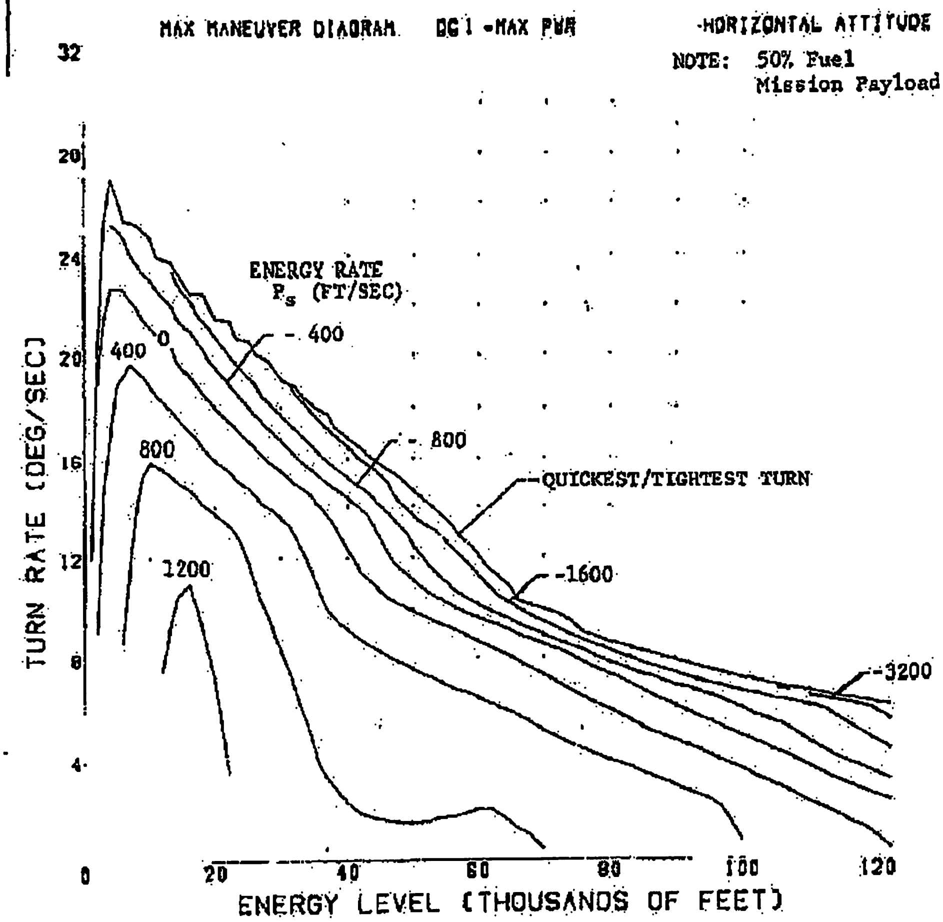
88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC 3.3(b)(4)
1.4(a)(g)
FOIA (b)(1)(x4)
EO 13526
SEC 3.3(b)(9)
SEC 1.4(a)(g)

(U) The Maximum Maneuver Diagrams, Figures 2.9-2 and 2.9-3, for Configuration 401B display data of the same type - one displaying turn rate versus energy level ($E_s$) with energy-rate contours, the other displaying energy rate versus energy level with turn-rate contours. As shown in Figure 2.9-2, the quickest/tightest turn boundary is the top line. The Mach/altitude combination for this boundary at any energy level can be obtained from Figure 2.9-1. Energy rates associated with the Best Energy Climb are located on the longitudinal axis. The energy-rate ($P_s$) contours represent the maximum energy rate for any turn rate available for any energy-rate/energy-level combination.

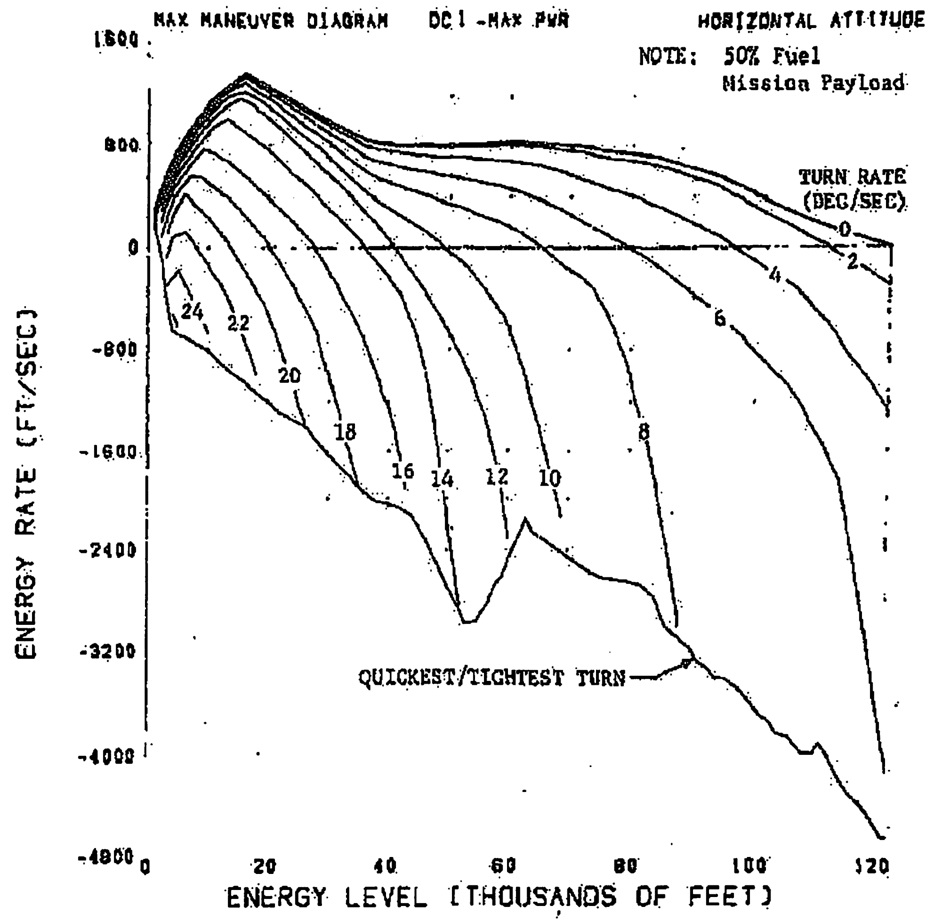
COMBAT ARENA    OC1 -MAX PWR    HORIZONTAL ATTITUDE




~~(S)~~ Figure 2.9-1  Configuration 401B Combat Arena (U)




~~(S)~~ Figure 2.9-2 Configuration 401B Max Maneuver Diagram - Turn Rate vs Energy Level (U)




~~(S)~~ Figure 2.9-3 Configuration 401B Max Maneuver Diagram - Energy Rate vs Energy Level (U)

# SECTION 3

## LARGE SINGLE-ENGINE CONCEPT
(401B/F100-PW-100)

### 3.1 VEHICLE DESIGN

(U) In this subsection, a description is presented of the large single-engine concept, a brief explanation is given of the overall configuration rationale, and the configuration growth data that were generated to provide the basis for structure, aerodynamic, and performance analyses required to size the vehicle are summarized.

#### 3.1.1 Vehicle Description

~~(S)~~ The large single-engine fighter concept (Concept 1) has been designated Configuration 401B. The general arrangement of the point design aircraft, a vehicle with a 17,115-lb mission weight is presented in Figure 3.1-1. The basic lines, inboard profile, and general arrangement of the 401B-type vehicle at a mission weight of 16,800 lb are shown in Figures 3.1-2, -3, and -4, respectively. This vehicle size was initially developed and used as a data point in generating the growth data which formed the basis for sizing the final point-design aircraft. The data sheets on which the basic geometry characteristics, area distribution, etc., are defined for Configuration 401B (at 16,800 lb) are presented along with the growth data in Subsection 3.1.3.2.

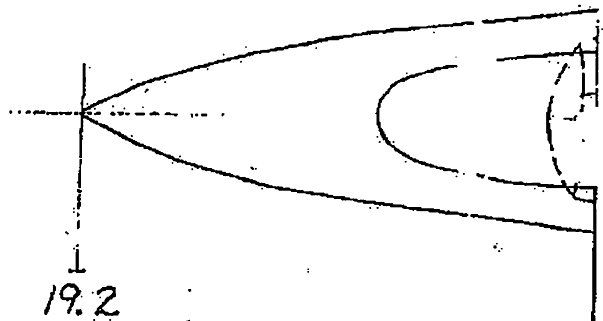
~~(S)~~ Configuration 401B is a small high-performance fighter [with a wing loading of 60 psf and a thrust-to-weight ratio of 1.37 (uninstalled). The basic features of the configuration arrangement are summarized in Figure 3.1-5.]

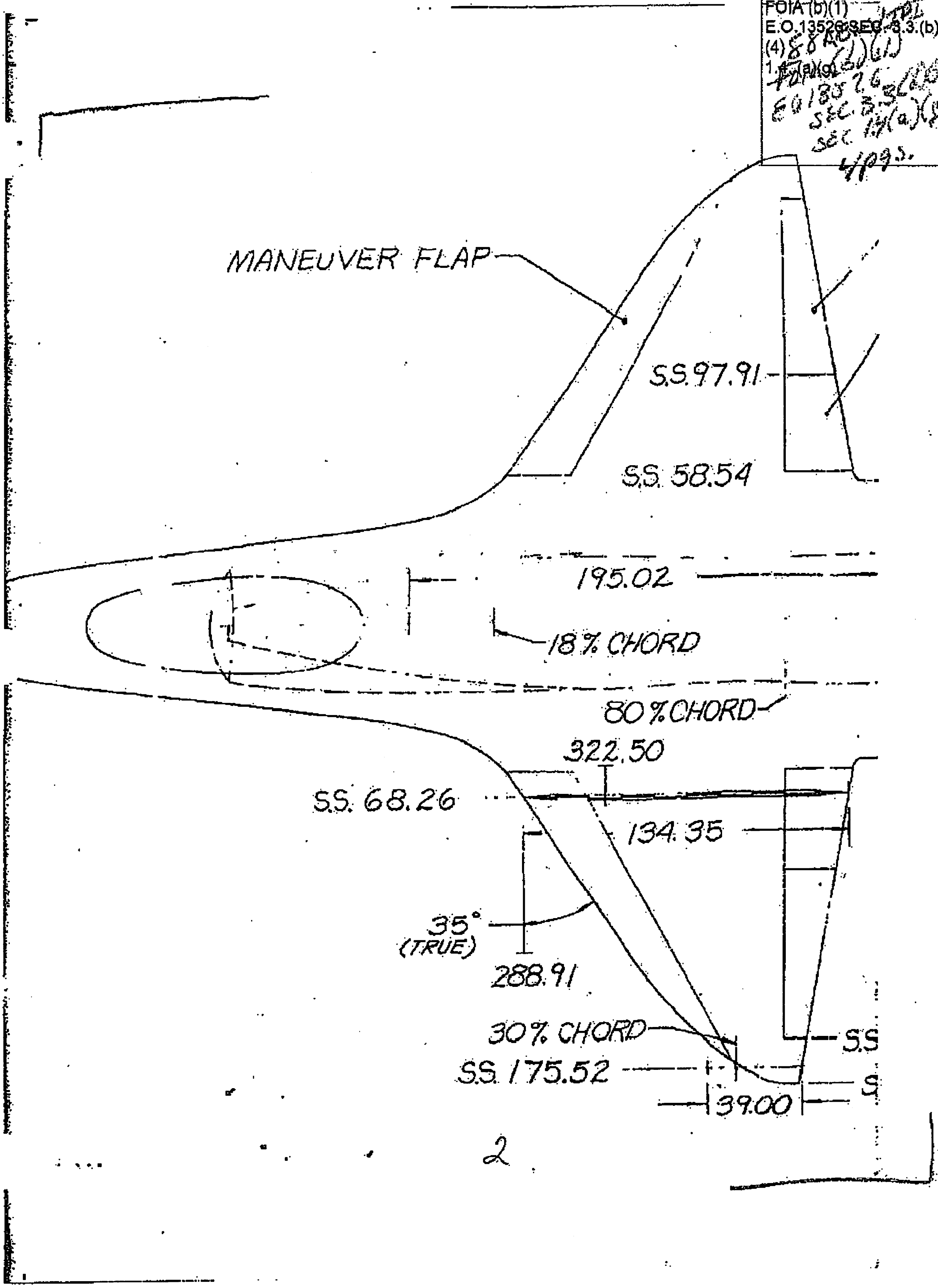
88th ABW/IP FOIA (b)(1) E.O. 13526 SEC. 3.3. (b)(4) 1.4 (a)(g) SEC. 1.1 (a)(g)

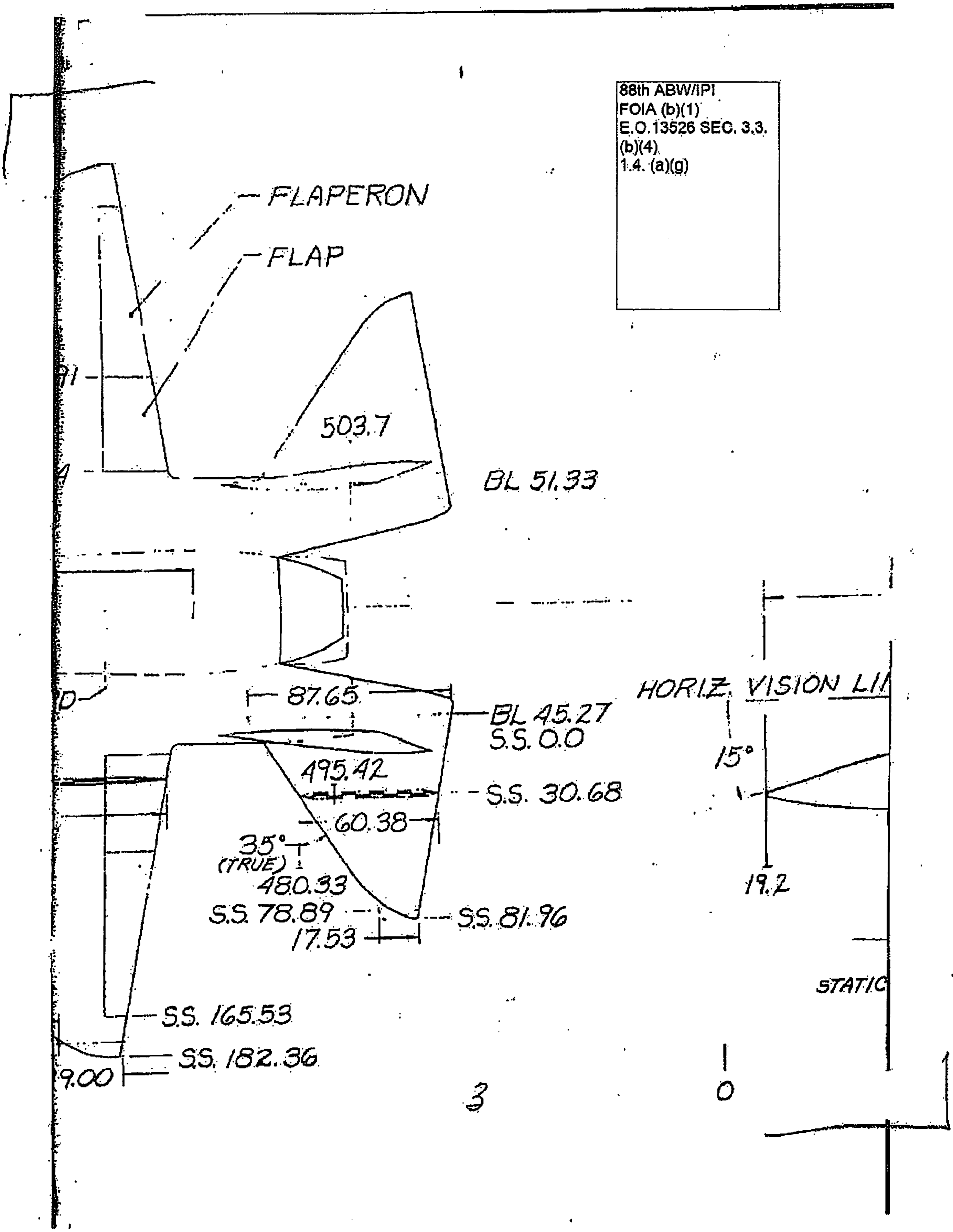
(U) Four major elements comprise the 401B configuration: (1) the fuselage, (2) the wing, (3) the empennage, and (4) the landing gear. These components are described briefly in the following subsections along with a description of the external stores capability of the airplane.

(U) 3.1.1.1 <u>Fuselage</u>

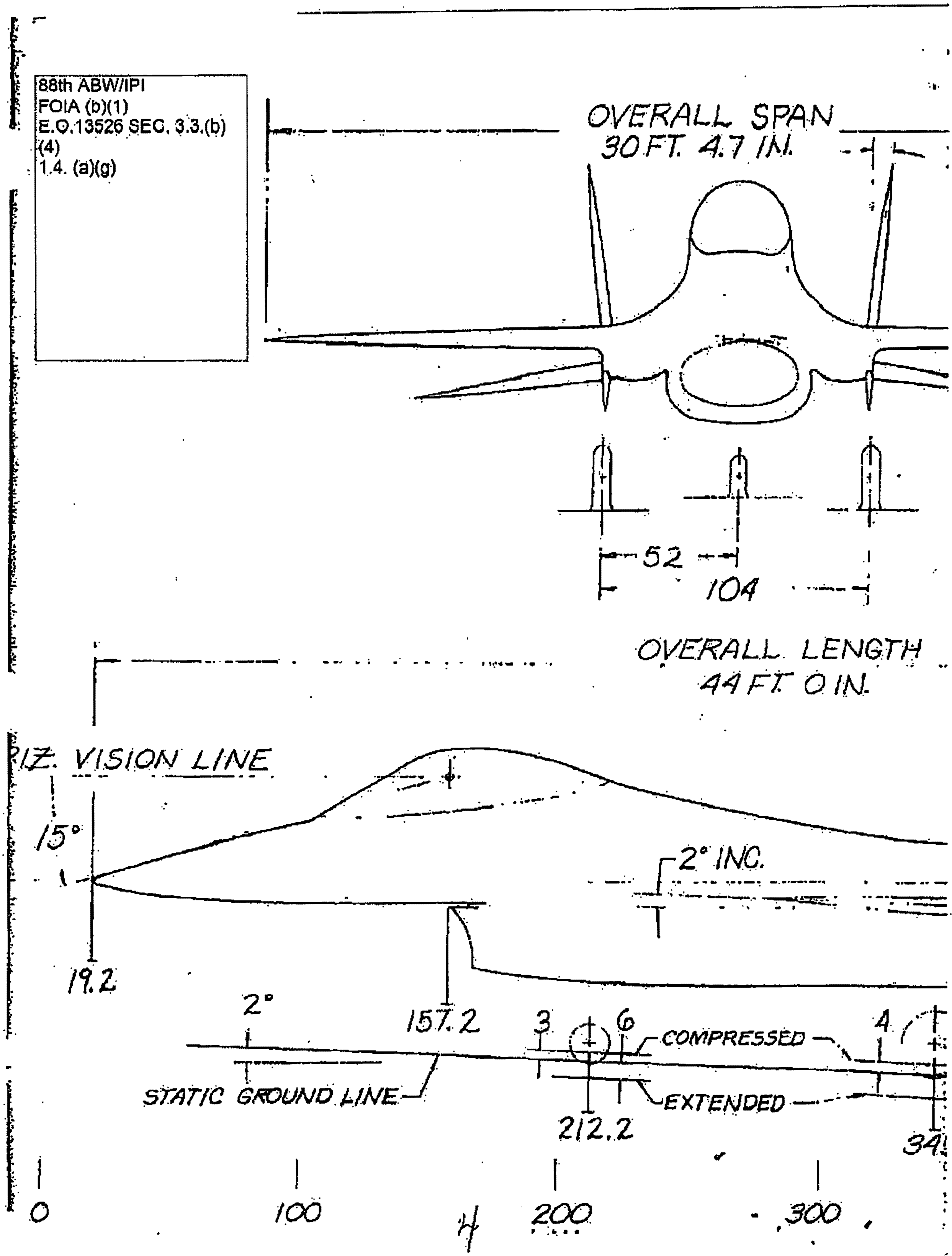
The fuselage of 401B contains the cockpit, equipment bay, armament, fuel tanks, and propulsion system.

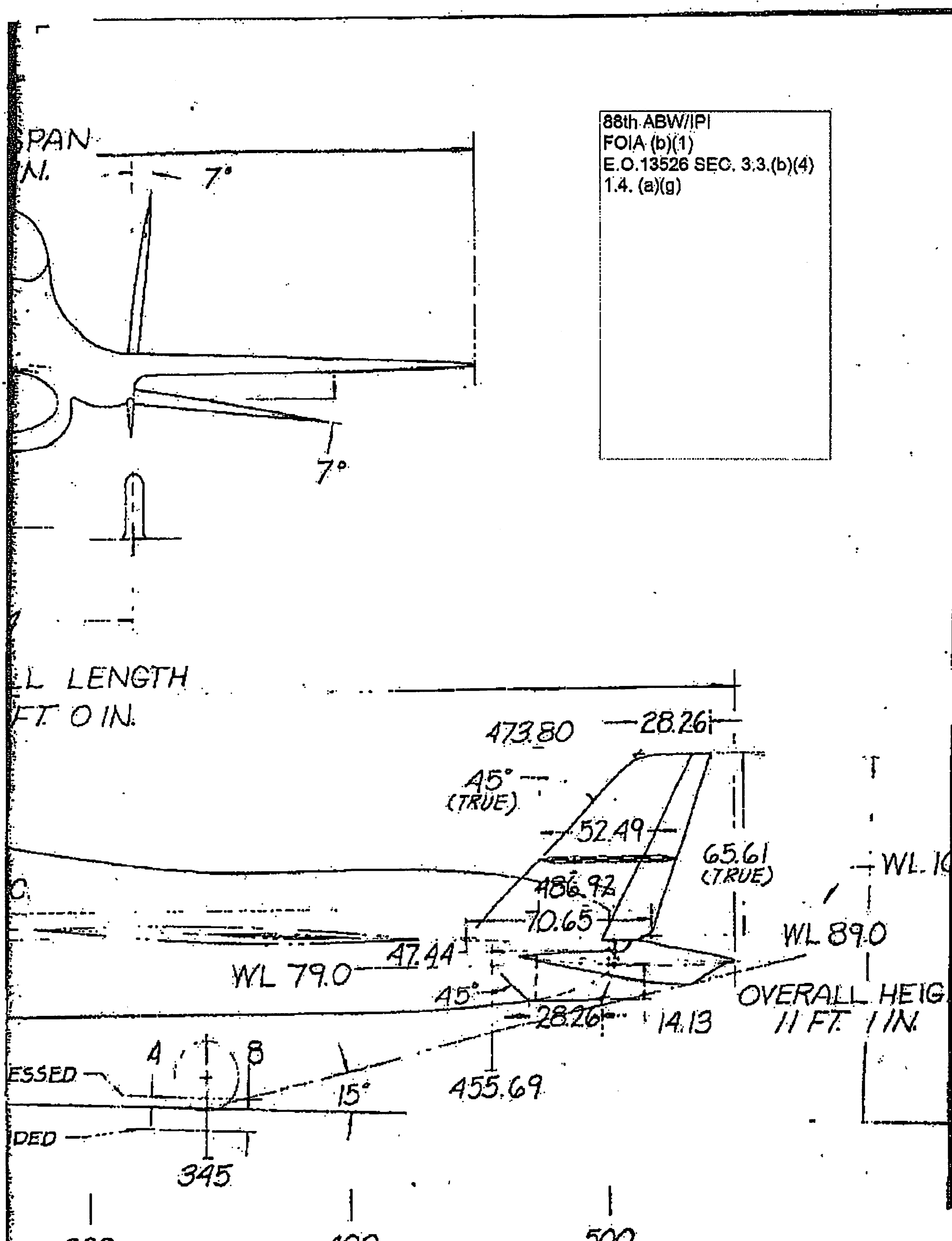

19.2


MANEUVER FLAP
S.S. 97.91
S.S. 58.54
195.02
18% CHORD
80% CHORD
322.50
S.S. 68.26
134.35
35°
(TRUE)
288.91
30% CHORD
S.S. 175.52
39.00

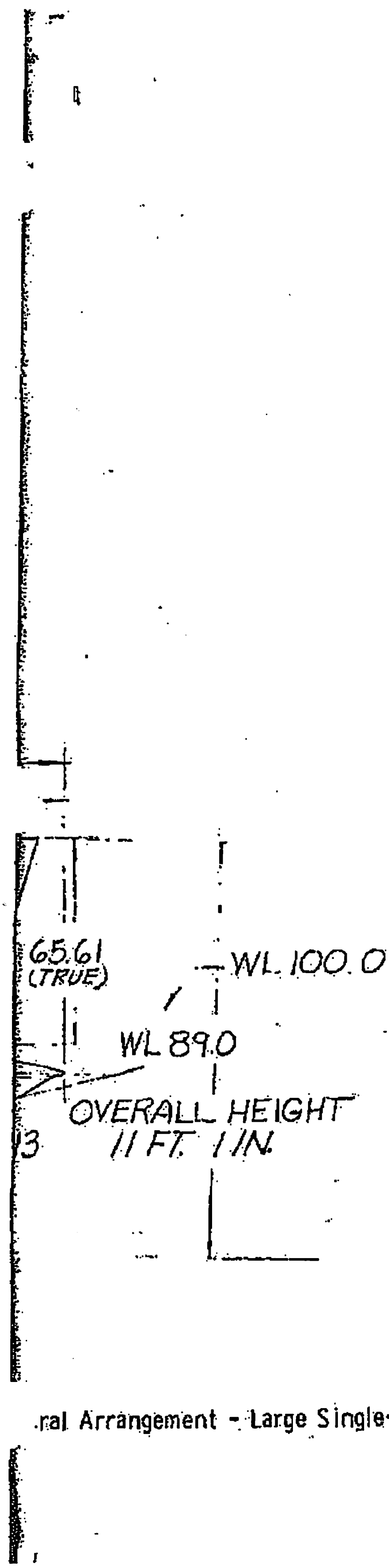

FLAPERON
FLAP
503.7
BL 51.33
87.65
BL 45.27
S.S. 0.0
495.42
S.S. 30.68
60.38
35°
(TRUE)
480.33
S.S. 78.89
S.S. 81.96
17.53
S.S. 165.53
S.S. 182.36
9.00
HORIZ. VISION LI
15°
19.2
STATIC
0
3

88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC. 3.3.(b)(4)
1.4. (a)(g)






~~(S)~~ Figure 3.1-1 General Arrangement - Large




~~SECRET~~

**WING (REFERENCE)**

| | |
|---|---|
| AREA | [illegible] SQ FT |
| ASPECT RATIO | [illegible] |
| TAPER RATIO | [illegible] |
| SPAN | [illegible] FT |
| SWEEP-LEADING EDGE | [illegible] |
| ROOT CHORD | [illegible] |
| TIP CHORD | [illegible] |
| M.A.C. | [illegible] |
| AIRFOIL SECTION | [illegible] |
| INCIDENCE | [illegible] |
| DIHEDRAL | [illegible] |

**[illegible] FLAP**

| | |
|---|---|
| TYPE | PLAIN |
| TOTAL AREA | [illegible] FT |
| SPAN-PER SIDE | 11' 6 IN |
| ROOT CHORD | [illegible] IN |
| TIP CHORD | [illegible] IN |
| DEFLECTION | 25° |
| HINGE LINE | |
| ROOT | [illegible] |
| TIP | [illegible] |

**FLAPS**

| | |
|---|---|
| TYPE | PLAIN |
| TOTAL AREA - INCLUDING FLAPERON | [illegible] SQ. FT |
| ROOT CHORD | [illegible] IN |
| TIP CHORD | [illegible] IN |
| FLAPERON | |
| TOTAL AREA | [illegible] SQ FT |
| SPAN - PER SIDE | [illegible] IN |
| ROOT CHORD | [illegible] IN |
| TIP CHORD | [illegible] IN |
| DEFLECTION | [illegible] |
| FLAP DEFLECTION - MAX | [illegible] |
| FLAP [illegible] | [illegible] |

**VERTICAL TAIL**

| | |
|---|---|
| AREA-TOTAL | [illegible] SQ FT |
| ASPECT RATIO | [illegible] |
| TAPER RATIO | [illegible] |
| SPAN | [illegible] IN |
| SWEEP-LEADING EDGE | [illegible] |
| ROOT CHORD | [illegible] IN |
| TIP CHORD | [illegible] IN |
| AIRFOIL SECTION | [illegible] ROOT, [illegible] TIP BICONVEX |

**RUDDER**

| | |
|---|---|
| AREA - TOTAL | [illegible] SQ. FT |
| SPAN | [illegible] IN |
| ROOT CHORD | [illegible] IN |
| TIP CHORD | [illegible] IN |
| DEFLECTION | [illegible] |

**VENTRAL FIN**

| | |
|---|---|
| AREA - TOTAL | [illegible] SQ FT |
| ASPECT RATIO | [illegible] |
| TAPER RATIO | [illegible] |
| SPAN | [illegible] IN |
| SWEEP-LEADING EDGE | [illegible] |
| ROOT CHORD | [illegible] IN |
| TIP CHORD | [illegible] IN |
| AIRFOIL SECTION | [illegible] BICONVEX |

**HORIZONTAL TAIL** [illegible]

| | |
|---|---|
| AREA | [illegible] SQ FT |
| ASPECT RATIO | [illegible] |
| TAPER RATIO | [illegible] |
| SPAN - EXPOSED | [illegible] IN |
| SWEEP - LEADING EDGE | [illegible] |
| ROOT CHORD | [illegible] IN |
| TIP CHORD | [illegible] IN |
| M.A.C. | [illegible] IN |
| INCIDENCE | [illegible] |
| AIRFOIL SECTION | [illegible] TIP - BICONVEX |
| DIHEDRAL | [illegible] |
| DEFLECTION | [illegible] |

**POWERPLANT**

[illegible] TURBOFAN ENGINE

**LANDING GEAR**

| | |
|---|---|
| MAIN GEAR TIRE | [illegible] |
| NOSE GEAR TIRE | [illegible] |

**TAIL LENGTHS**

| | |
|---|---|
| ¼ WING TO ¼ VERTICAL TAIL | [illegible] FT. [illegible] IN |
| ¼ WING TO ¼ HORIZONTAL TAIL | [illegible] FT [illegible] IN |

Aircraft Mission Weight -- 17,115 lb

**PRELIMINARY DESIGN DRAWING**

GENERAL ARRANGEMENT -
LARGE SINGLE ENGINE CONCEPT
POINT DESIGN, A.I FX PP [illegible]

GENERAL DYNAMICS
Convair Aerospace Division
Fort Worth Operation

FW. 7 [illegible] 4136

29/30 ~~SECRET~~ 6

[Gene]ral Arrangement - Large Single-Engine Concept Point Design Configuration 401B (U)

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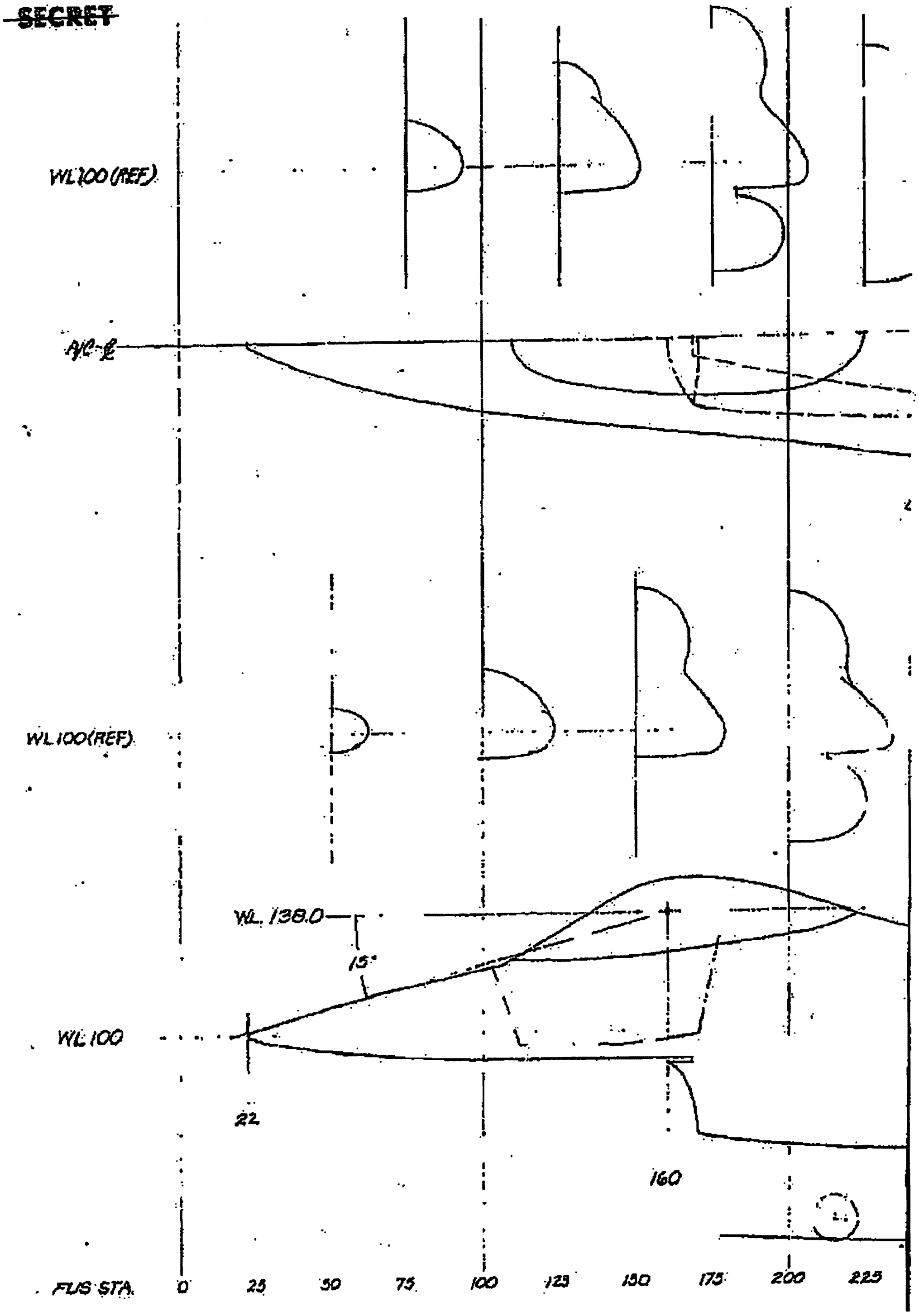


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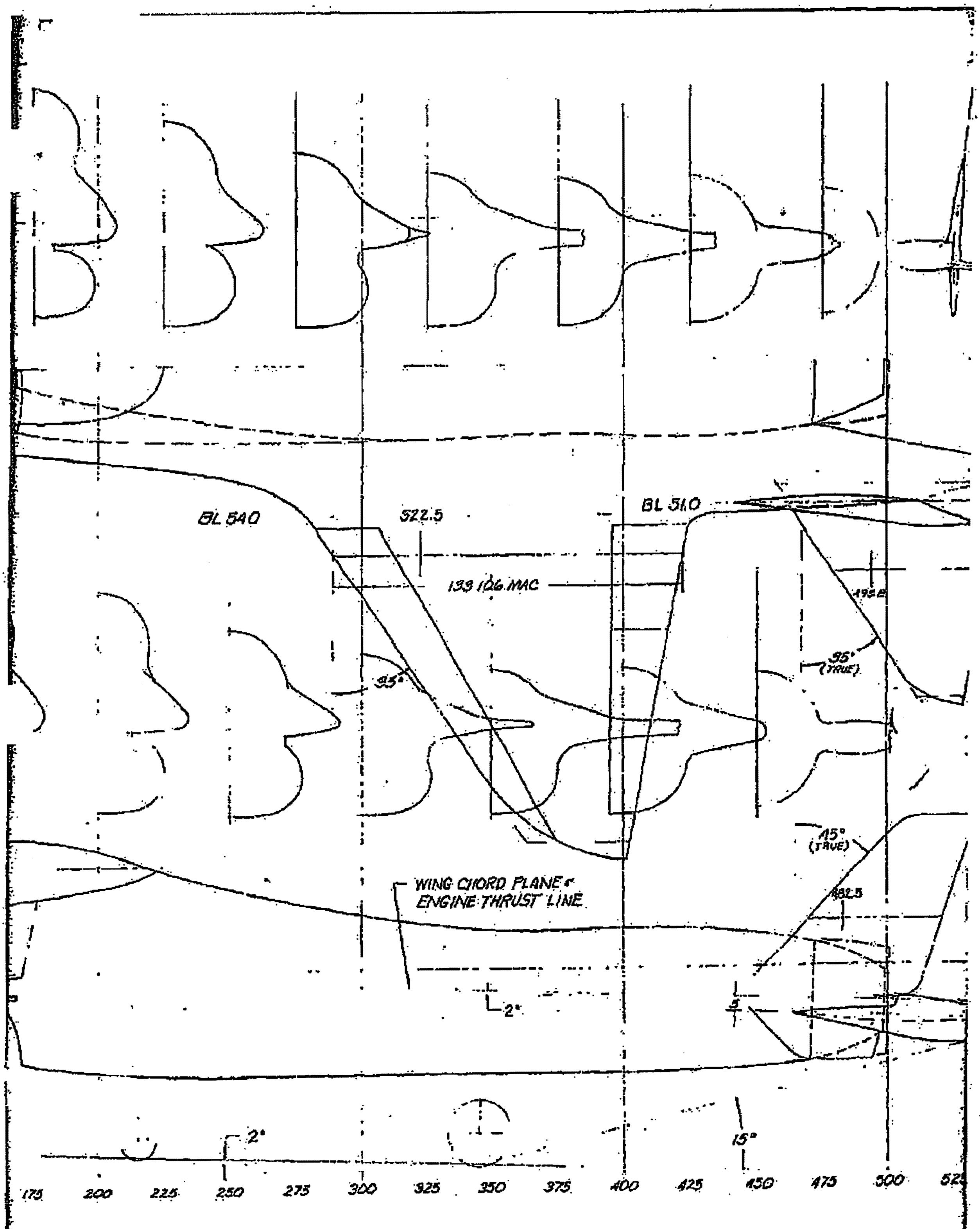


2 ~~(S)~~ Figure 3.1-2 Lines – Large Sing

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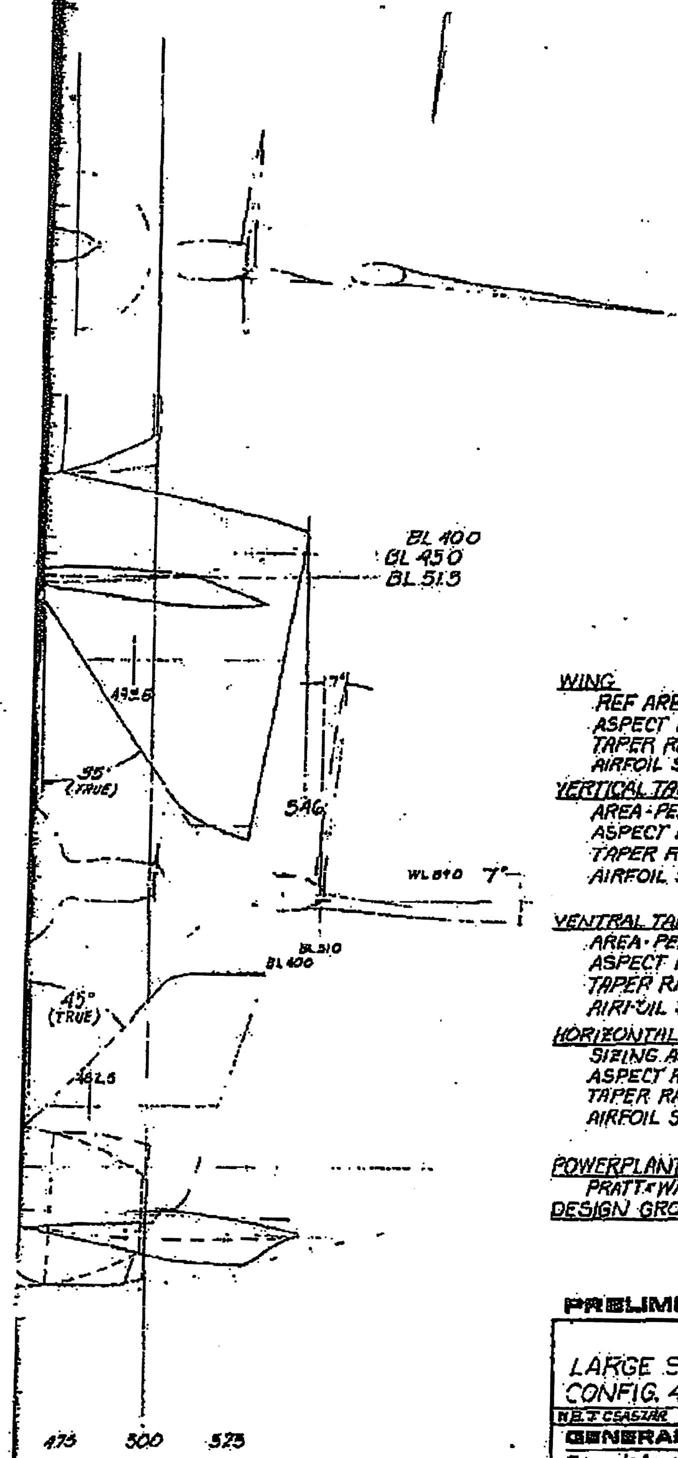


BASIC DATA

| | | |
|---|---|---|
| **WING** | | |
| REF AREA | | 280 SQ.FT |
| ASPECT RATIO | | 3.0 |
| TAPER RATIO | | 0.2 |
| AIRFOIL SECTION | | 4% BI-CONVEX |
| **VERTICAL TAIL** | | |
| AREA - PER TAIL | | 22.12 SQ.FT |
| ASPECT RATIO | | 1.3265 |
| TAPER RATIO | | 0.4 |
| AIRFOIL SECTION | ROOT | 6% BI-CONVEX |
| | TIP | 4% BI-CONVEX |
| **VENTRAL TAIL** | | |
| AREA - PER FIN | | 3.646 SQ.FT |
| ASPECT RATIO | | 0.3733 |
| TAPER RATIO | | 0.5957 |
| AIRFOIL SECTION | | 6% BI-CONVEX |
| **HORIZONTAL TAIL** | | |
| SIZING AREA | | 56.56 SQ.FT |
| ASPECT RATIO | | 3.0 |
| TAPER RATIO | | 0.2 |
| AIRFOIL SECTION | TIP | 4% BI-CONVEX |
| | BL 51.5 | 6% BI-CONVEX |
| **POWERPLANT** | | |
| PRATT & WHITNEY F-100-PW-100 ENGINE | | |
| **DESIGN GROSS WEIGHT** | | 16,800 LBS |

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PRELIMINARY DESIGN DRAWING

— LAYOUT —
LARGE SINGLE ENGINE CONCEPT
CONFIG. 401B ; AVFFX PROGRAM

BY E.J. CSASZAR | SCALE 1/20 | DATE 6-16-71

GENERAL DYNAMICS
Convair Aerospace Division
Fort Worth Operation

FW7104066

es - Large Single-Engine Concept Configuration 401B Type (U) 31/32

3

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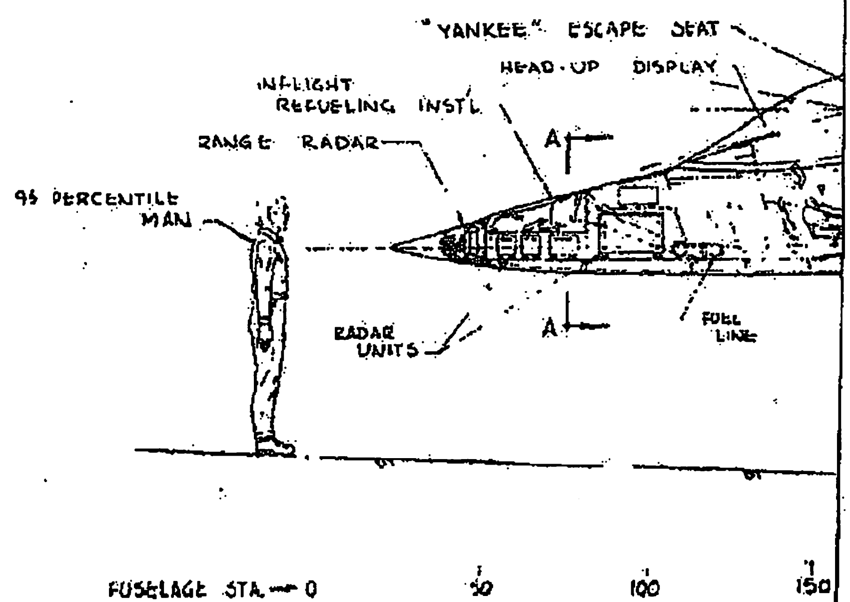


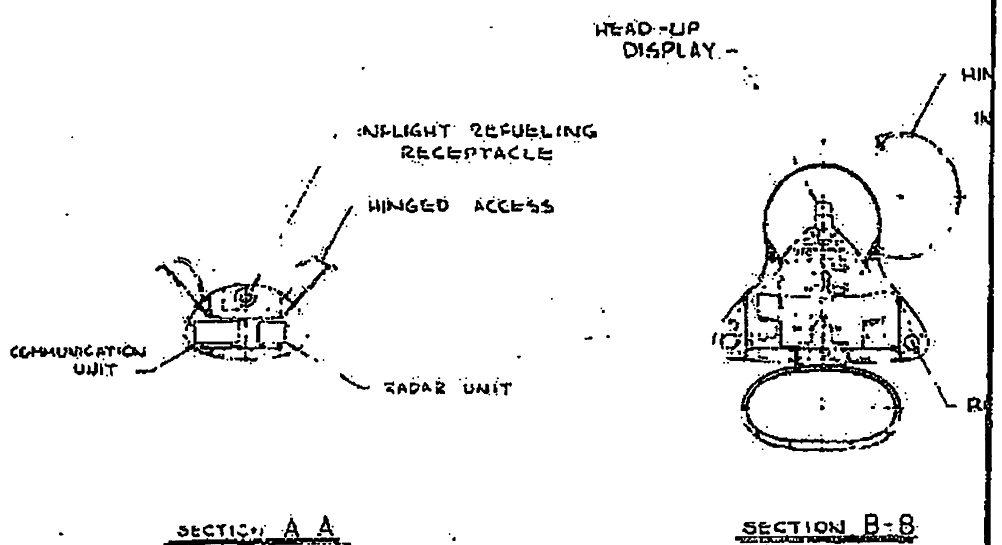


SECTION A-A

SECTION B-B

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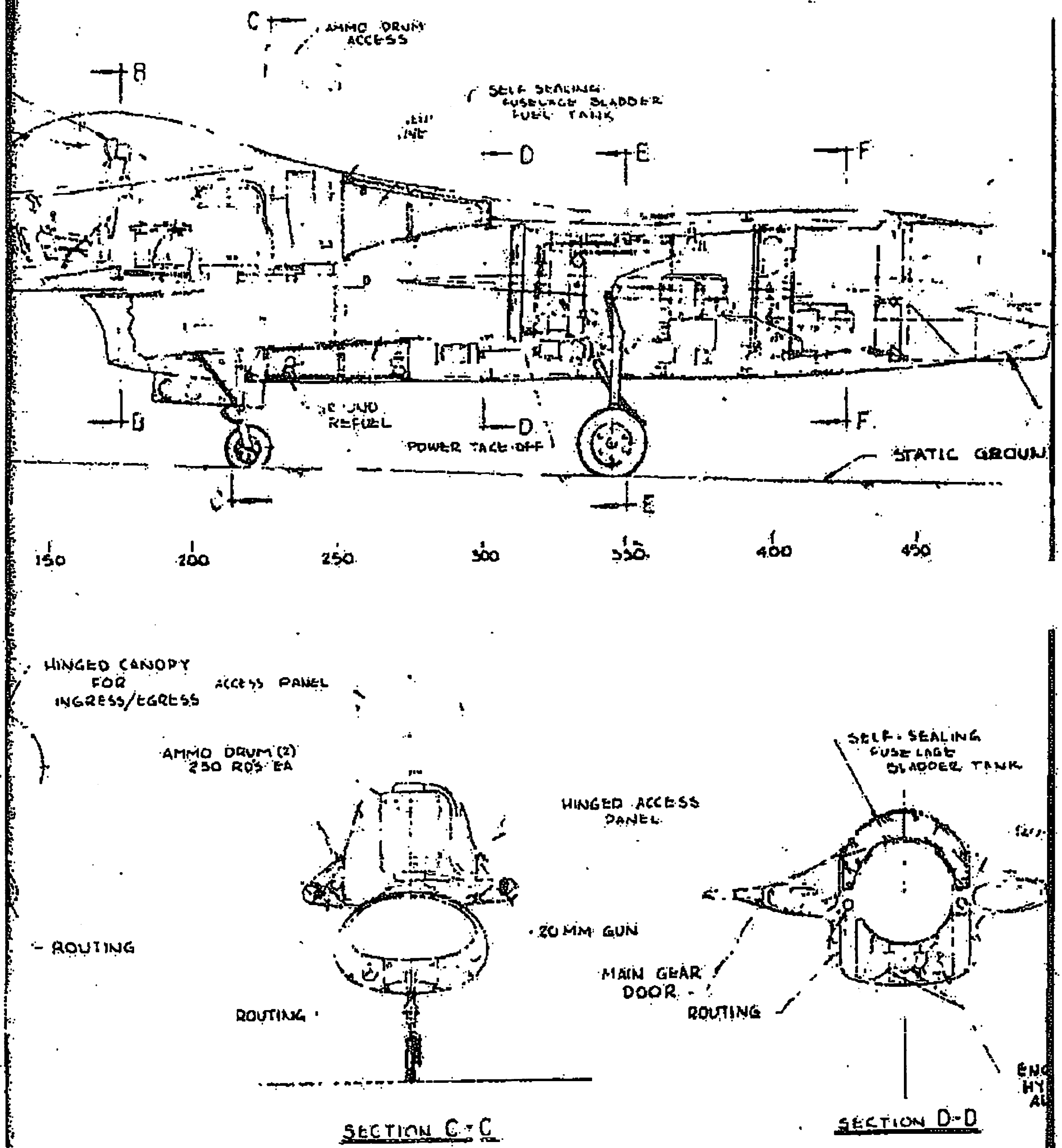
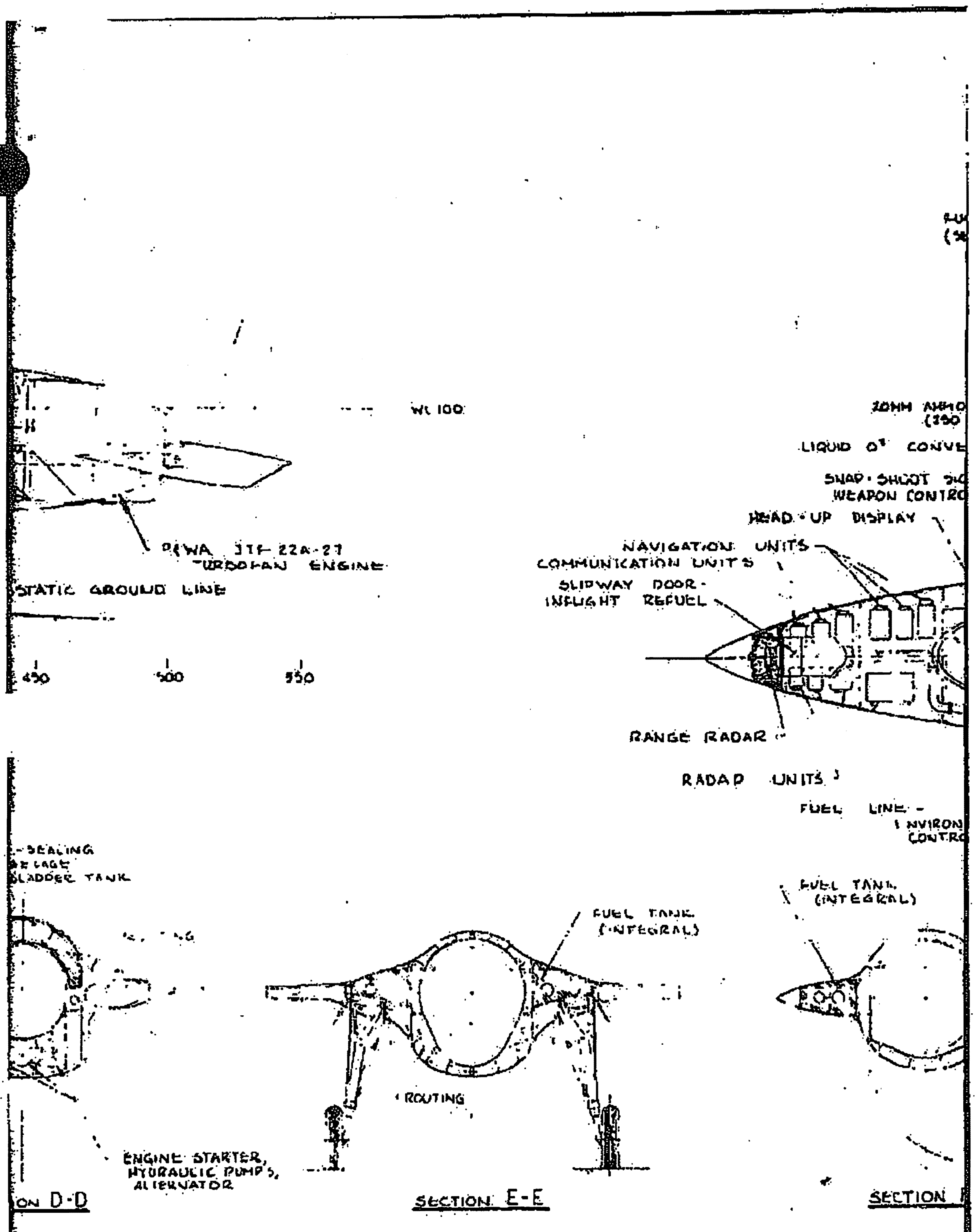
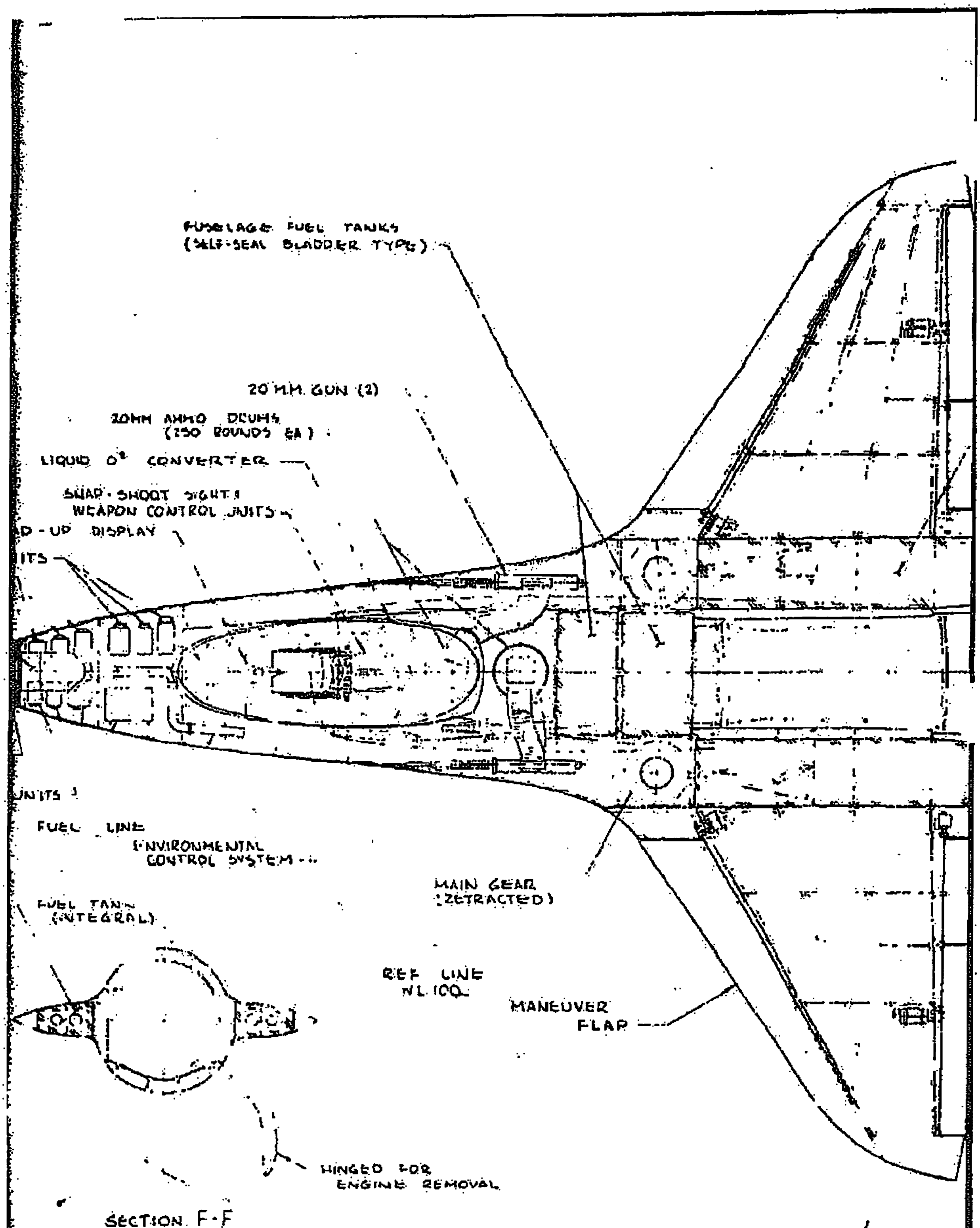

AMMO DRUM ACCESS
SELF SEALING FUSELAGE BLADDER FUEL TANK
REFUEL
POWER TAKE OFF
STATIC GROUND
150
200
250
300
350
400
450
HINGED CANOPY FOR INGRESS/EGRESS
ACCESS PANEL
AMMO DRUM (2) 250 RDS EA
HINGED ACCESS PANEL
20 MM GUN
ROUTING
ROUTING
SELF-SEALING FUSELAGE BLADDER TANK
MAIN GEAR DOOR
ROUTING
SECTION C-C
SECTION D-D

2


WL 100
P&WA JTF 22A-27
TURBOFAN ENGINE
STATIC GROUND LINE
450
500
550
20MM AMMO
LIQUID O
SNAP-SHOOT
WEAPON CONTR
HEAD-UP DISPLAY
NAVIGATION UNITS
COMMUNICATION UNITS
SLIPWAY DOOR-
INFLIGHT REFUEL
RANGE RADAR
RADAR UNITS
FUEL LINE
CONTR
SEALING
BLADDER TANK
FUEL TANK
(INTEGRAL)
FUEL TANK
(INTEGRAL)
ROUTING
ENGINE STARTER,
HYDRAULIC PUMPS,
ALTERNATOR
ON D-D
SECTION E-E
SECTION




4

~~(S)~~ Figure 3.1-3 Inboard Pro

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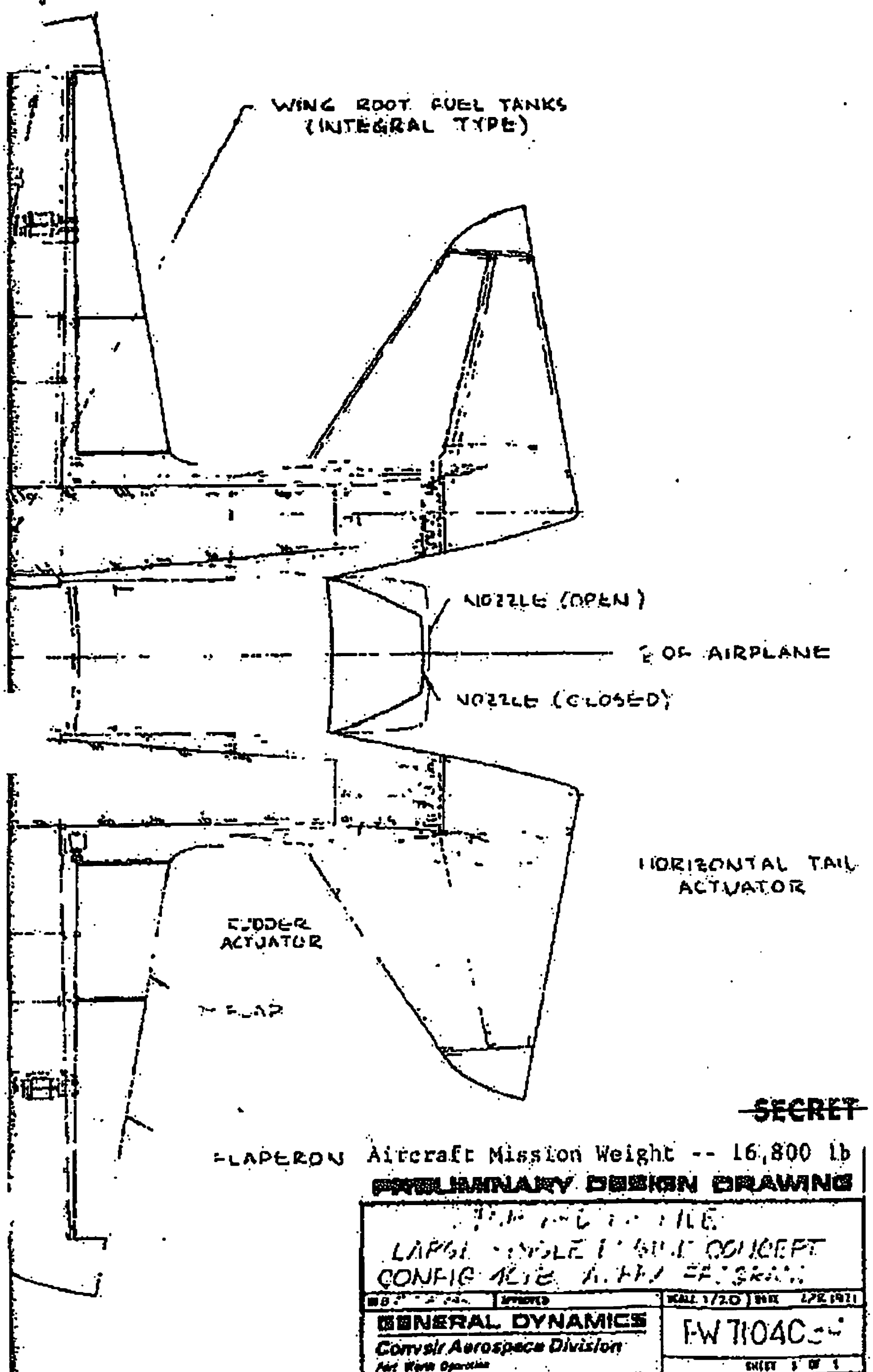



Profile - Large Single-Engine Concept Configuration 401B Type (U)

~~SECRET~~

WING

| | |
|---|---|
| AREA | 280.30 FT |
| ASPECT RATIO | 3.0 |
| TAPER RATIO | .020 |
| SPAN | [illegible] |
| SWEEP - LEADING EDGE | 35 |
| ROOT CHORD | 133.22 IN |
| TIP CHORD | 38.64 IN |
| MAC | [illegible] |
| AIRFOIL SECTION | [illegible] |
| INCIDENCE | [illegible] |
| DIHEDRAL | [illegible] |

[illegible] FLAP

| | |
|---|---|
| SPAN PER SIDE | [illegible] |
| ROOT CHORD | 27 IN |

HORIZONTAL TAIL (ALL MOVABLE)

| | |
|---|---|
| AREA | [illegible] |
| ASPECT RATIO | [illegible] |
| TAPER RATIO | [illegible] |
| SPAN EXPOSED | [illegible] |
| SWEEP - LEADING EDGE | [illegible] |
| ROOT CHORD | [illegible] |
| TIP CHORD | [illegible] |
| MAC | [illegible] |
| INCIDENCE | [illegible] |
| AIRFOIL SECTION | [illegible] |
| DIHEDRAL | [illegible] |
| DEFLECTION | [illegible] |

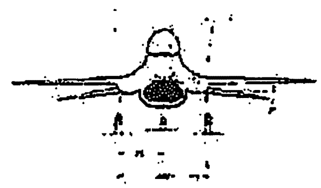
POWER PLANT

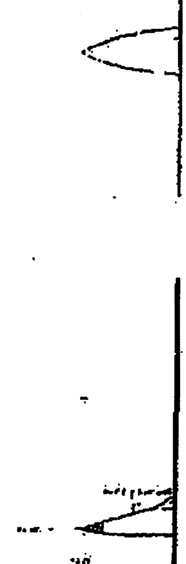
LANDING GEAR

MAIN GEAR TIRE

NOSE GEAR TIRE

TAIL LENGTHS





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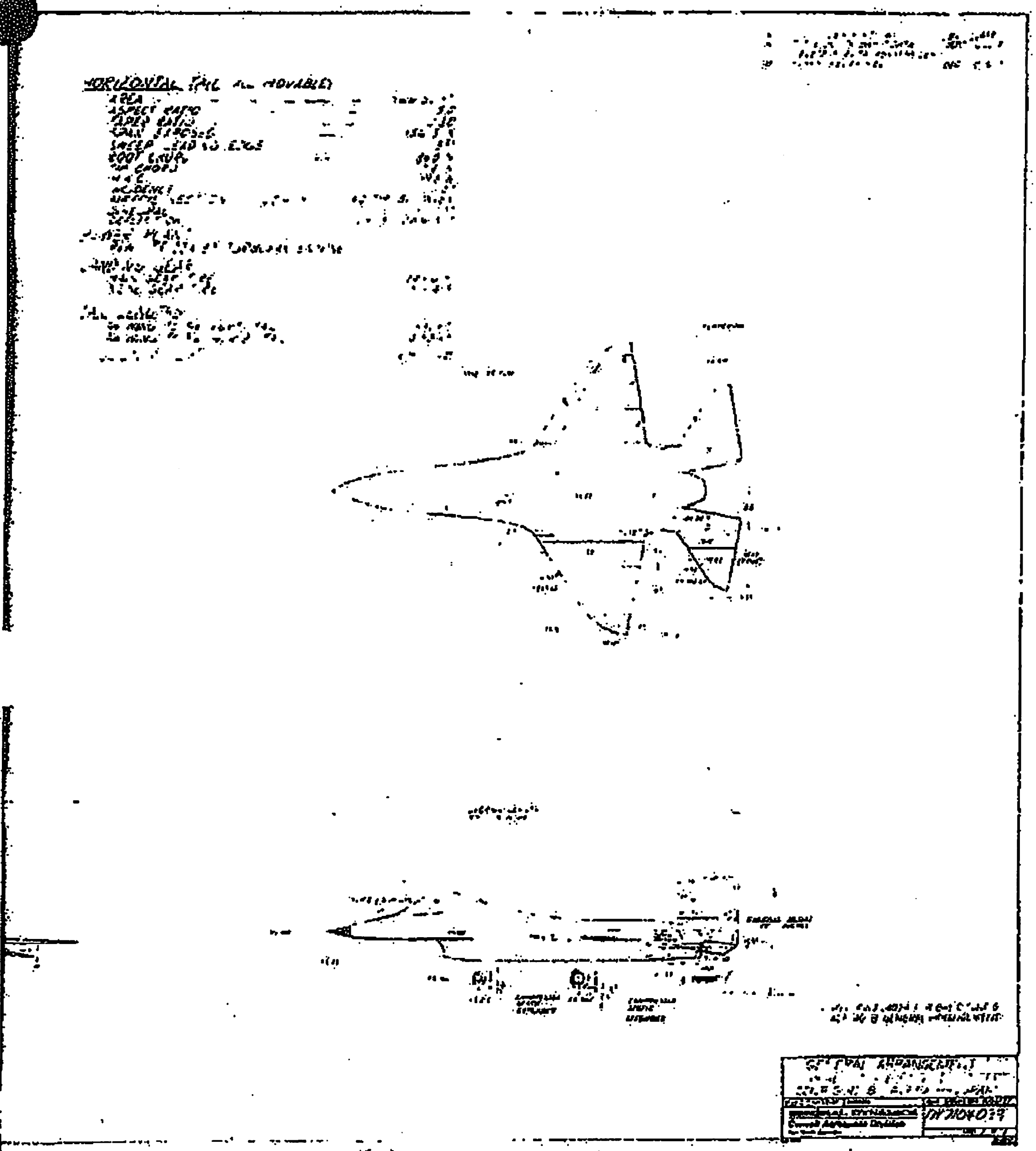

~~(S)~~ Figure 3.1-4 General Arrangement
Large Single-Engine Concept
Configuration 401B Type (U)

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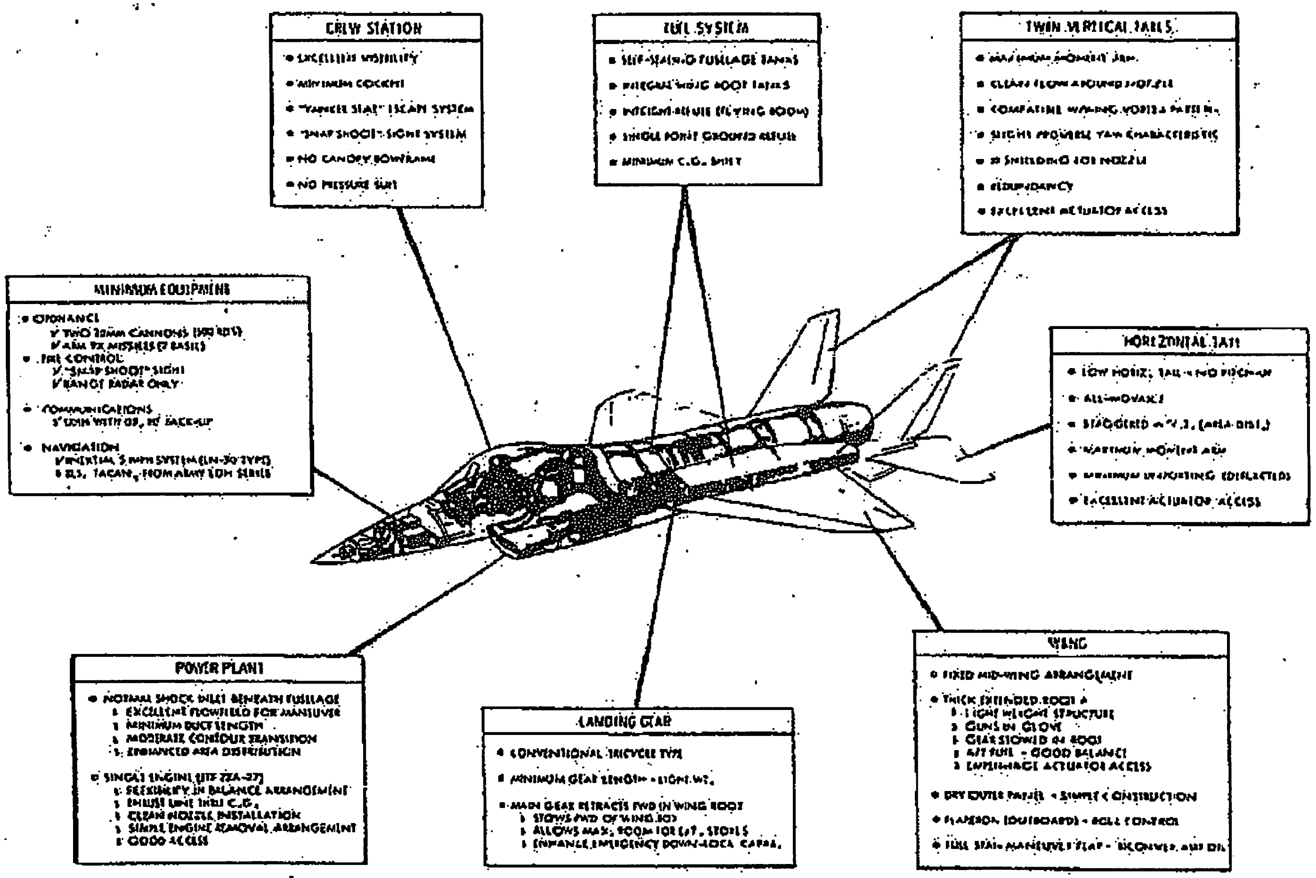


~~(S)~~ Figure 3.1-5 Configuration 401B Arrangement Features (U)

(U) The cockpit is arranged to provide excellent visibility, with special consideration given to the avoidance, where practical, of features which tend to restrict vision such as seats, inlet ducts, wing, etc. The following basic vision limits apply on 401B:

1. $15^{\circ}$ down vision over the nose ($0^{\circ}$ azimuth)

2. $40^{\circ}$ down vision over the side ($90^{\circ}$ azimuth)

3. $0^{\circ}$ down vision aft ($180^{\circ}$ azimuth).

(U) The canopy consists of a one-piece transparent bubble with full-vision capability (no bowframe vision obstruction). The canopy is hinged about the right-hand side and is manually operated for normal ingress and egress. Canopy jettison for pilot ejection is accomplished by a thruster, which rotates the canopy and frame about a hinge at the aft end as in most conventional fighter aircraft. A head-up display utilizes a thick transparent shield that provides blast protection for the pilot upon canopy ejection. A "snapshoot" sight is integrated with the head-up display. Configuration 401B employs the "Yankee 705" seat, which provides a simple, lightweight escape system. The cockpit dimensions are held to a minimum to provide a crew station envelope which is adequate without compromising cockpit visibility. The cockpit is pressurized, and no provision is made for a pressure suit.

(U) Equipment compartments are located forward and aft of the crew station. The forward (nose) bay contains the range radar, navigation, and communications equipment in compartments which are accessible through hinged panels located at eye level for ease of maintenance. The upper portion of the nose compartment contains the inflight refueling receptacle which is compatible with the USAF "Flying Boom" tanker refueling system. The aft equipment bay is divided into two sections. The forward section provides space for the environmental control system, the sight and weapon control units, and miscellaneous equipment. The aft section houses the ammunition drums for two 20mm cannons.

~~(S)~~ The basic armament consists of two 20mm cannons and two AIM-9X missiles. A single-barrel 20mm cannon is located on either side of the forward fuselage in the glove section of the body. The guns are situated aft and above the

~~(S)~~ engine inlet to preclude any adverse effect from the muzzle blast. Access to the guns for loading and maintenance is provided through hinged fuselage panels at shoulder level, within easy reach by ground personnel.

(U) Fuel is contained in three tanks: a forward fuselage tank and wing root tanks located on either side of the engine in the thickened root section where the wing blends into the fuselage. The forward tank is located above and below the inlet duct between the aft equipment bay and the engine firewall bulkhead.

(U) The fuselage tank is of the self-sealing bladder type and is so arranged that the engine fuel supply is taken from the lower section. Check valves are provided in the interconnect lines to ensure a full tank for all flight conditions. This portion of the tank also contains the single-point ground refuel receptacle, which is within easy reach of ground personnel.

~~(S)~~ The power plant for Configuration 401B is a single Pratt & Whitney Aircraft JTF22A-27 engine [(USAF Designation F100-PW-100) with a rated thrust of 23,470 pounds on maximum power. Engine accessories are mounted on the engine, and engine-driven aircraft accessories are airframe-mounted in the lower fuselage forward of the firewall bulkhead. A power take-off from the engine drives these accessories and is disconnected for engine removal. The engine is removed by sliding the unit aft along rails. The lower fuselage in the region aft of the rear spar bulkhead is hinged to allow for engine installation and removal. Primary air for the engine is supplied through a duct from an elliptically shaped, fixed, normal-shock inlet which is located beneath the crew station region of the forward fuselage. The inlet is positioned slightly away from the fuselage by a diverter that allows boundary layer air to be plowed off. A portion of this air is taken on-board by an inlet in the diverter leading edge to supply air for the environmental control system. The inlet lip is also shaped in profile in a manner designed to provide proper control of the inlet shock system throughout the operational envelope.]

88th ABW/IP
FOIA (b)(1)
E.O.13526 SEC.3.3.
(b)(4)
1.4.(a)(g)
SEC 3.3(b)(4)
SEC 1.4(a)

~~(S)~~ 3.1.1.2 Wing

Configuration 401B is a fixed, mid-wing airplane [with a wing loading of 60 psf, an aspect ratio of 3.00, a taper

88th ABW/IP
FOIA (b)(1)
E.O.13526 SEC. 3.3.
(b)(2) (b)(4)
1.4.(a)(g)
EO 3.3(b)
SEC 1.4(a)

~~(S)~~ ratio of 0.20, and a leading-edge sweep of 35.0 degrees. The wing tip is rounded in a manner that maintains constant wing area (280 sq. ft. for the 16,800-lb design) and results in an aspect ratio of 3.2. The wing employs a 4-percent biconvex airfoil with leading- and trailing-edge flaps. The full-span leading-edge flap is utilized both during landing and in maneuvering flight to provide the particular lift-drag characteristics required of these two portions of the operating envelope. For maneuvering flight, the leading-edge flap is a manually operated, three position, flap. A maximum setting of 25 degrees (leading edge down) is provided for the landing configuration. The outboard trailing-edge control surface is a flaperon, which provides for both the roll control and landing flap functions. A simple flap is also provided on the inboard section to provide lift augmentation for landing operations.

88th ABW/IP(U)
FOIA (b)(1)
EO 13526 SEC 3.3(b)(4)
1.4(a)(g)

(U) Four hardpoints are provided on the wing for external stores. The external stores capability is described in Subsection 3.1.1.5.

(U) As described in the previous subsection, the wing employs a thickened root section that blends into the fuselage centerbody. For the most part this root section contains the aft fuel tanks. These wing-root tanks are of the integral type and are located outboard of the engine compartment so that a double-wall section is provided to separate the fuel and engine compartments.

(U) Wing structural loads are distributed into the fuselage through four major spar bulkheads that are continuous around the fuselage.

(U) 3.1.1.3 Empennage

Configuration 401B utilizes twin vertical tails and ventral fins along with an all-movable horizontal tail arrangement. The horizontal and vertical tails are staggered longitudinally with respect to each other to provide a favorable area distribution effect and to gain maximum permissible tail moment arms.

(U) The vertical tail surface planform has a leading-edge sweep of 45 degrees, an aspect ratio of 1.33, and a taper ratio of 0.40. Each tail has a planform area of 22.12 $ft^2$ for a total of 44.24 $ft^2$ per airplane. The rudder comprises the aft 25 percent tail chord on each

(U) surface. The vertical surfaces are canted 7 degrees outboard to provide separation between them and to allow a proper relationship with the vortex which emanates from the wing-fuselage intersection at the wing leading edge. The vertical tails are located at the outer extremity of the aft outer-body extension.

(U) Ventral fins, located immediately beneath the upper vertical tails, also have a leading-edge sweep of 45 degrees. The exposed ventral fin aspect ratio is 0.37 and the taper ratio is 0.60.

(U) The horizontal tail is an all-movable control surface which provides trim and pitch control for the airplane. For tail sizing purposes, the surface is defined with a leading-edge sweep of 35 degrees, an aspect ratio of 3.00, and a taper ratio of 0.20. The portion of the horizontal tail outboard of the vertical tail has a negative dihedral angle of 7 degrees to allow maximum vertical separation distance between the wing and horizontal surface chord planes. This separation is important in the design of an airplane to provide linear pitch characteristics. The aft portion of the fuselage outer-body extension forms the inboard section of the horizontal tail. This feature allows for a maximum effective moment arm and, thus, a minimum surface-area requirement. The forward portion of the horizontal tail pivots about Fuselage Station 502 and fits flush alongside the outer surface of the vertical tail and ventral so that clean lines are maintained as the tail rotates through its deflection envelope, thus insuring good airflow over the surfaces under these conditions.

(U) 3.1.1.4 Landing Gear

Configuration 401B utilizes a conventional tricycle landing gear arrangement. The main gear employs a single-tire configuration which retracts up and forward into the wing root section just ahead of the front spar bulkhead. The wheels rotate approximately 90 degrees during the retraction sequence to fit flush within the wheel well. When the gear is in the retracted position, the struts are housed in the lower root fairing beneath the primary wing structure. The nose gear retracts up and forward into the lower fuselage section just aft of the engine inlet. The strut is compressed and the nose wheel is also rotated 90 degrees upon retraction to allow the nose gear to be stowed in the nose wheel well.

~~(S)~~ 3.1.1.5 External Stores

Capability is provided at the wing inboard hardpoints for pylons to accommodate two external fuel tanks up to a maximum of 600 gallons each (ferry mission). Capability at these hardpoints is also provided to carry two nuclear weapons as an alternate. The wing outboard hardpoints are designed to accommodate the basic missile complement of two AIM-9X weapons. Each outboard hardpoint is also capable of accommodating two AIM-9X weapons for a maximum of four missiles per airplane. Selected arrangements of the external stores capabilities are shown in Figures 3.1-6, -7, and -8. An alternate approach for carrying four AIM-9X missiles along with the two basic 300-gallon wing-mounted fuel tanks is shown in Figure 3.1-9.

### 3.1.2 Overall Design Rationale

(U) The overall design rationale for configuration 401B is described in the following paragraphs. Details of the rationale for selected specific features such as wing, inlet, etc., are covered in the subsequent sections of this report. The distinguishing features of Configuration 401B, as outlined in Figure 3.1-10, are

1. Forward engine location
2. Mid-wing
3. Outer blended body
4. Twin vertical tails
5. Under-fuselage inlet location
6. Bubble canopy.

(U) Results of design studies conducted prior to the contractural period indicated that for all configurations it was necessary to place the engine as far forward with respect to the wing as possible in order to provide appropriate balance characteristics and still maintain a reasonable tail moment arm. This situation results primarily from the nature of the dry-weight distribution inherent in this particular type of airplane (i.e., the dry weight forward consists primarily of crew station and armament since

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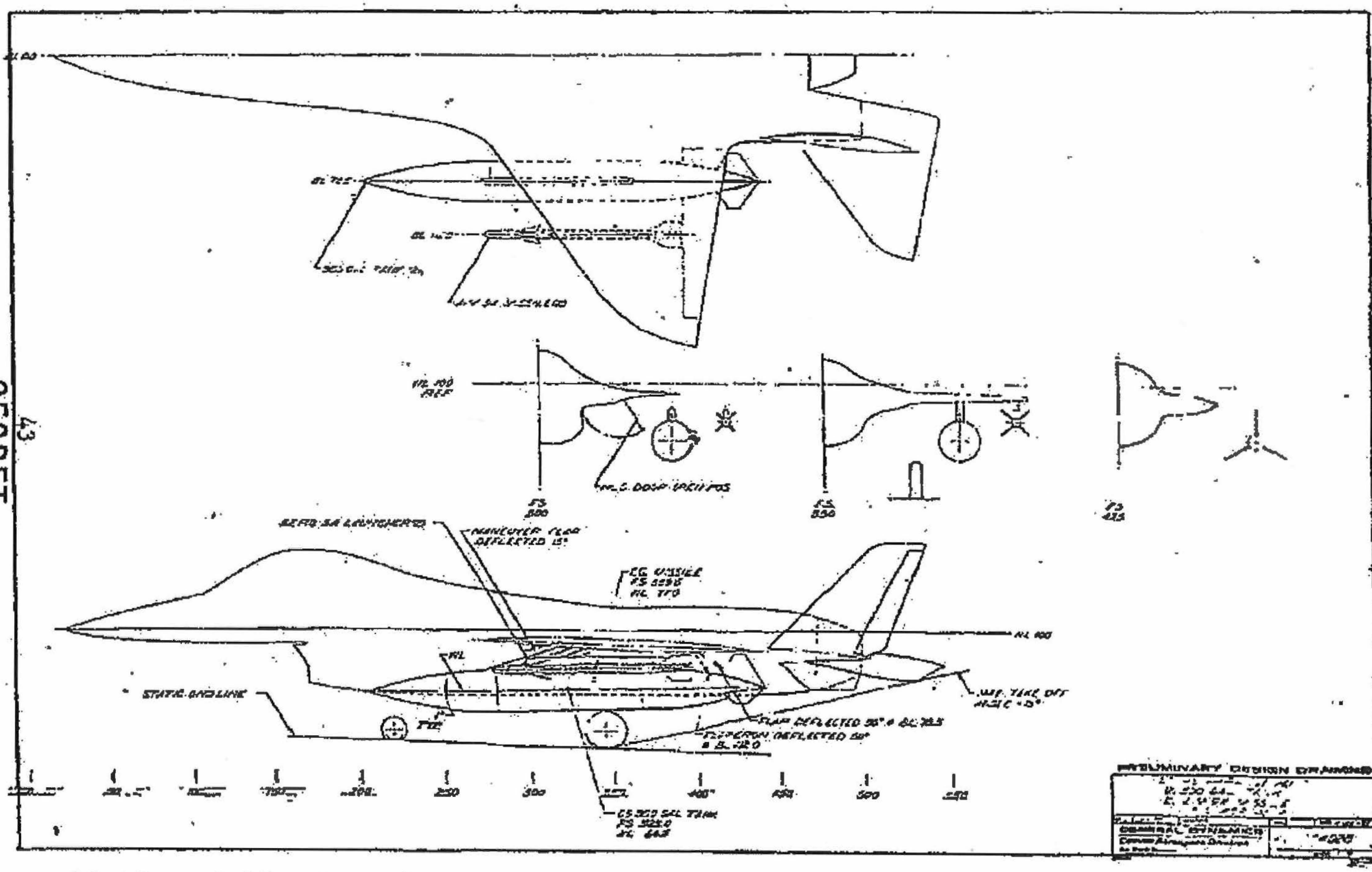


~~(S)~~ Figure 3.1-6 External Store Arrangement - Basic Long-Range Air-Superiority Mission (U)

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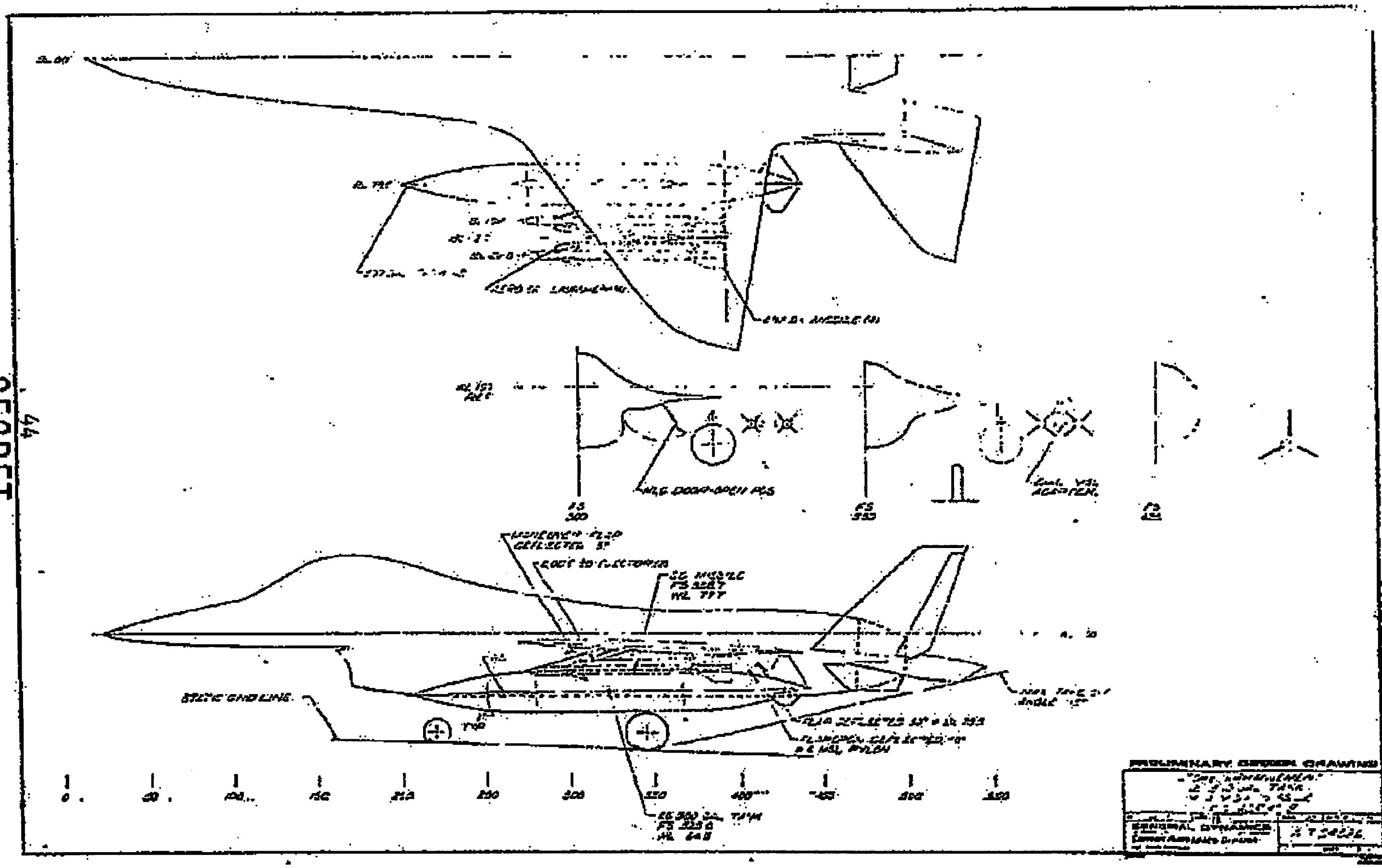
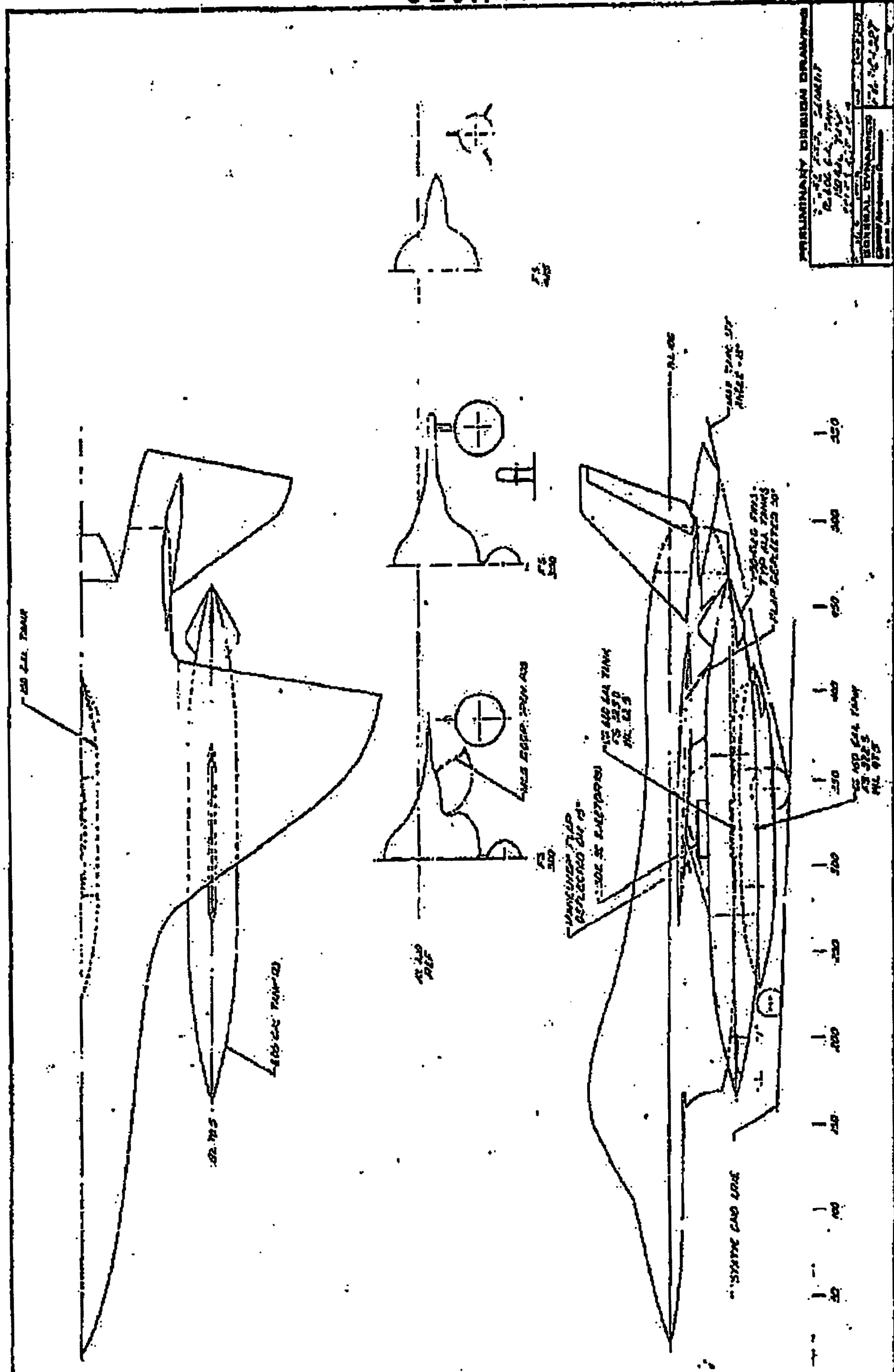



~~(S)~~ Figure 3.1-7 External Store Arrangement - Full Missile Load Capability (U)



~~(S)~~ Figure 3.1-8 External Store Arrangement - Ferry Mission (U)

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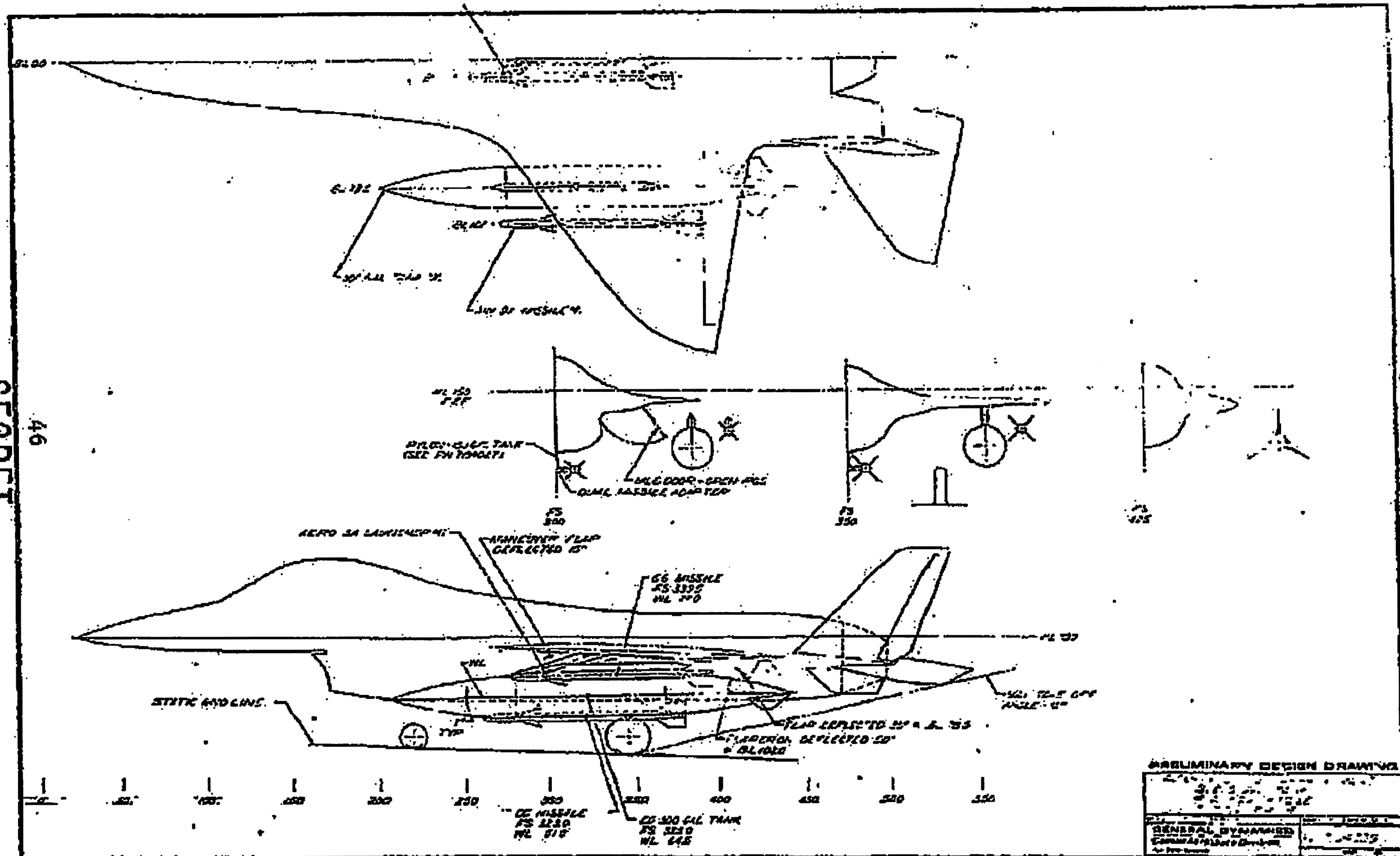


~~(S)~~ Figure 3.1-9 Alternate External Store Arrangement - Full Missile Load Capability (U)

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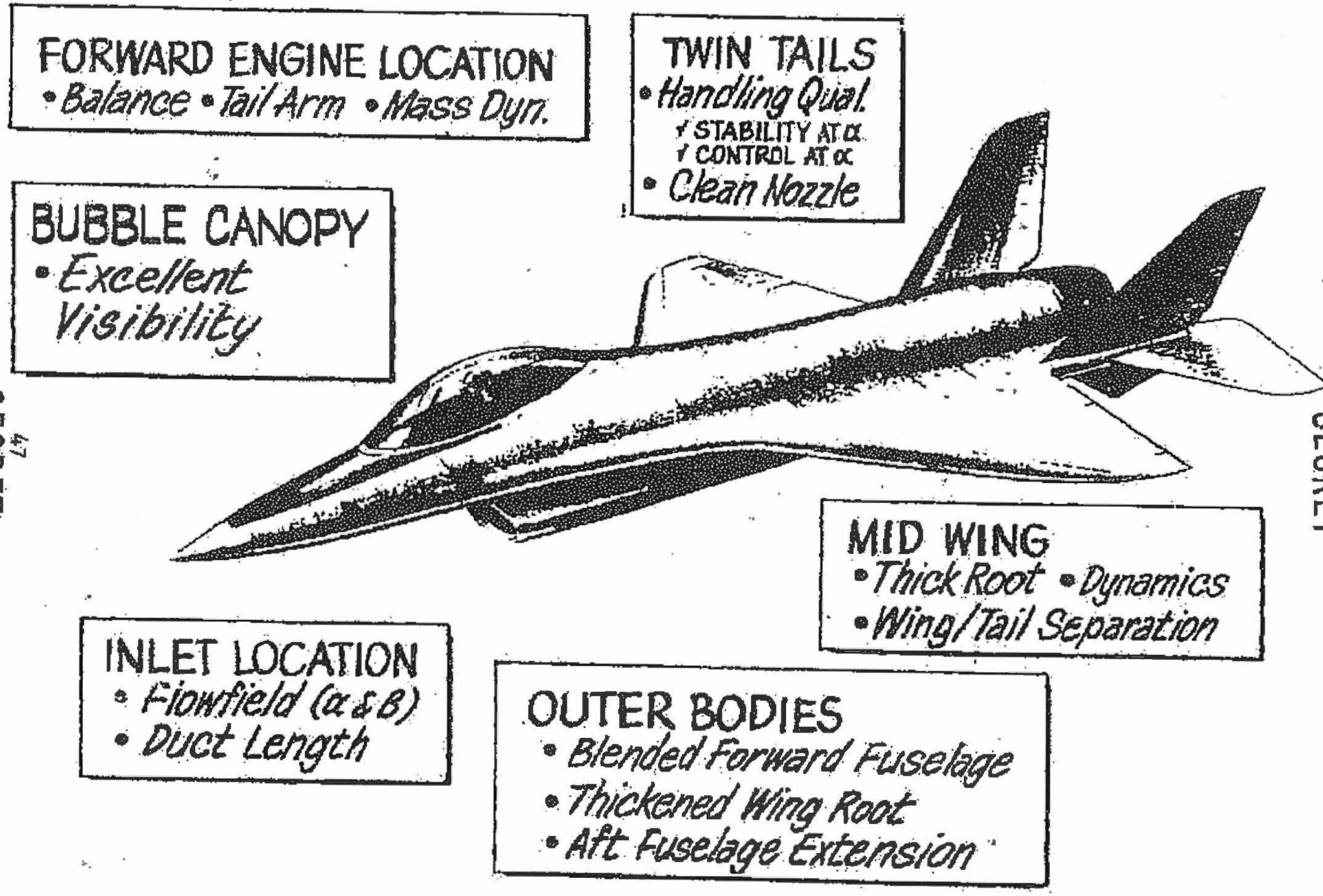


~~(S)~~ Figure 3.1-10 Distinguishing Features - Configuration 401B (U)

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(U) virtually no avionics systems are required). The combination of this lack of weight in the nose and the resultant engine/wing relationship leads to the conclusion that some kind of overhang beyond the engine nozzle is necessary so as to achieve a satisfactory balance arrangement.

(U) The three basic approaches that can be employed to provide such an overhang arrangement are

1. Single fuselage extension above the nozzle
2. Single fuselage extension below the nozzle
3. Twin fuselage extensions on either side of the nozzle.

(U) Approach 1 lends itself best to single vertical tail designs. The over-the-nozzle body extension also can incorporate cross-section shape variations anywhere from circular or elliptical to a wide-shelf arrangement and, thus, can also be adapted for twin vertical tail arrangements. Approach 2 has the potential for allowing increased horizontal arms; however, the vertical tail arm would still be limited by the nozzle, and it would require a single vertical tail concept. In this case, the horizontal tail ground clearance envelope at takeoff and landing would impose a constraint having considerable effect on gear length (i.e., weight). In addition, the lower-shelf structure would tend to make engine removal provisions complex or vice versa. Approach 3 allows the cleanest aft-end design in terms of providing a favorable flow field around the engine nozzle. This arrangement also has the capability to allow vertical separation between the wing and horizontal tail. Such a relationship has been shown by test and experience to be necessary to achieve the best handling qualities. Of the three approaches considered concerning fuselage overhang extension, the third approach offers the best arrangement.

(U) The selection of such an overhang concept with the horizontal tails mounted on side fuselage extensions requires that these extension elements be faired forward, making a mid-wing concept most logical. To make a mid-wing concept feasible (since loads must be carried around the engine and duct through bulkheads), there must be significant root thickening to allow a favorable structural load distribution from the wing to the fuselage. A thickened wing root thus affords a natural situation for fairing

(U) the contour aft into the outer body to which the horizontal tail is attached. Likewise, the thickened root, if incorporated, must be faired forward, either in the form of a thick glove or a wide, blended fuselage.

(U) The incorporation of the outer-body concept with its attendant wing root thickening, forward blended fuselage (or glove), and aft fuselage extensions thus provides many advantages from the standpoint of equipment arrangement. For example, the mid-wing concept allows a reasonably short landing gear that can be retracted into the thickened wing root region just forward of the front spar bulkhead. The retraction envelope traced by this arrangement allows the lower fuselage and a considerable portion of the wing to be free for the accommodation of external stores. The forward blended body (or glove) contributes a cross-sectional area fill at a region which enhances the transonic aerodynamic characteristics of the configuration. It also provides an ideal location for the two 20mm guns. The gun muzzles are thus positioned aft and above the inlet to preclude inlet ingestion problems. Accessibility to the gun compartments is at shoulder level, which affords an excellent arrangement for loading and maintanance operations. The aft portion of the outer body provides space for aft-located fuel to balance that of the forward fuselage tanks. This distribution arrangement is necessary to minimize c.g. shift during fuel burn; thus, proper c.g. control can be maintained with a minimum of trim. At the same time, this arrangement eliminates the need for the incorporation of self-sealing provisions in this portion of the fuel tankage. The aft portion of the outer body provides an ideal space for tail actuators (rudder and stabilizer) in that it affords sufficient volume and excellent accessibility.

(U) A configuration with after-body extensions on either side of the fuselage also lends itself quite readily to the twin-vertical tail concept. The adaptation of this tail arrangement geometry on Configuration 401B provides several primary advantages. First, it allows a reasonable tail moment arm and acts in concert with the after bodies to allow a clean flow field around the engine nozzle. The outboard placement enhances tail affectiveness at high angles of attack since the tails are essentially not blanked out by the fuselage forebody as a centerline tail would be. The outboard location also provides a relationship with the aileron which enhances neutral aileron yaw

88th ABW/IP
FOIA (b)(1)
E.O. 13526 SEC 3.3
(b)(4)
1.4(a)(g)

(U) characteristic for the airplane, a highly desirable feature for an aircraft requiring good handling qualities. The outward cant of the vertical tails on 401B provides maximum separation between the two surfaces and positions them properly in relation to the wing/fuselage vortex flow. Redundance and inherent I.R. shielding capability are also features which accrue from the twin vertical tail and matching ventrals.

~~(S)~~ The inlet location, below the forward fuselage, was selected to provide the most favorable flow field for the engine air supply. This placement provides the best inlet performance at high angles of attack and yaw, which is of paramount importance for a highly maneuverable fighter. A fixed-geometry inlet is employed to give the best performance in the combat arena (Mach 0.6 to 1.6) for the utmost in simplicity, reliability, and light weight. The aft location minimizes duct length (i.e., weight) and allows a fuselage forebody shape that enhances the directional stability of the configuration.

(U) A one-piece transparent bubble canopy with full-vision capability (no bow-frame vision obstruction) is utilized on Configuration 401B. This feature allows excellent pilot vision, which is so absolutely necessary for a highly maneuverable air-superiority fighter.

### 3.1.3 Configuration Growth Data

(U) Configuration 401B was developed and sized originally on the basis of preliminary growth studies conducted some time prior to the initiation of the contractual effort. A number of minor modifications to various elements of the configuration were made during the time between the development of the growth study data and the final completion of the configuration. In order to ensure that the selected single-engine concept sizing was still valid, a new growth curve was generated around 401B.

(U) The approach utilized to develop the configuration size variations is outlined below. Also, the basic parametric configuration design data generated to support the structure, aerodynamic, and performance analyses are summarized.

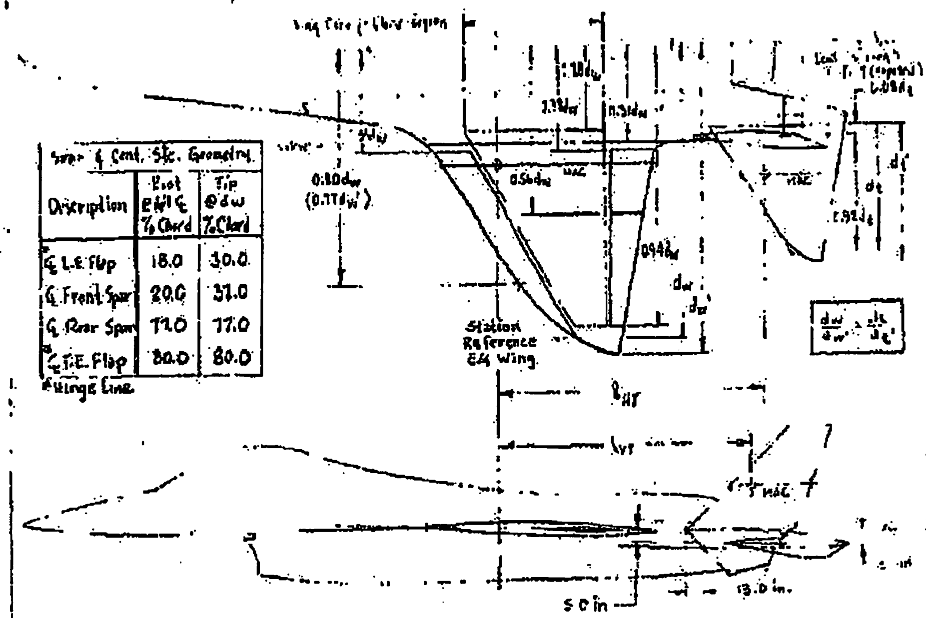
~~(S)~~ 3.1.3.1 Aircraft Sizing Approach

Mission weight of the 401B configuration was established at 16,800 pounds during the beginning of the contractual effort. The verification study was conducted by examining a gross-weight range extending 1200 pounds on either side of the baseline 16,800-pound value. Configuration data were developed by varying the airplane's basic component geometry as outlined in Figures 3.1-11 and 3.1-12.

~~(S)~~ Wing loading was held constant at 60 psf, and a family of configurations was developed in which the wing and tail sizing criteria shown in Figure 3.1-11 were utilized. Basic planform geometry for all surfaces was held constant, as shown, and surfaces were scaled according to the ground rules noted. In addition to these basic ground rules and constants, information on basic wing and tail dimensional constants and key ratios are also shown in the diagram of Figure 3.1-11. All dimensional relationships used in the development of the data are referenced to the quarter-chord point of the wing mean-aerodynamic-chord.

88th ABW/JPI FOIA (b)(1) EO 13526 SEC 1.4 3.3(b)(5)

(U) The scaling process utilized for the fuselage involved basically a variation in length since the engine size was fixed and 401B constituted a minimum attainable fuselage cross section. In Figure 3.1-12, the basic elements of the fuselage are outlined and the key constants and variables are shown. Crew station and equipment compartments remained fixed in size, as did the engine, accessories, and landing gear. Inlet location was held at a constant distance from the nose to retain the same geometric relationship between the nose, canopy, inlet, and nose gear. The basic fuselage variation then consisted of a length change in the center fuselage, which adjusted fuel tank volume and air inlet duct length. As shown in Figure 3.1-12, the variations were referenced to the quarter-chord position of the wing mean-aerodynamic-chord. The nose was lengthened and the engine was moved aft to provide appropriate balance characteristics, with the total linear increase sized to be proportional to the square root of the gross-weight ratio. In addition, the portion of the wing root that blends into the fuselage was increased in width in order to maintain a constant percent of wing span for this boundary. This relationship provided a change in wing-root fuel-tank volume, which balances that added in the fuselage fuel-tank length increase and, thereby, maintains the appropriate full-up balance characteristics.




| Span & Cent. Sec. Geometry | | |
|---|---|---|
| Discription | Root @W ℄ % Chord | Tip @dw % Chord |
| ℄ L.E. Flap | 18.0 | 30.0 |
| ℄ Front Spar | 20.0 | 31.0 |
| ℄ Rear Spar | 72.0 | 77.0 |
| *℄ T.E. Flap | 80.0 | 80.0 |

*Hinge Line

SCALING GROUND RULES

- Planform area of wing and horizontal tail scaled as a function of takeoff Gross Weight. $[S_2 = (G.W._2 / G.W._1)(S_1)]$
- Glove planform area in proportional to matching wing area.
- Vertical tail moment arm ($\ell_{VT}$) scaled as function of T.O. G.W. ($\ell_{VT_2} = \ell_{VT_1}\sqrt{GW_2/GW_1}$)
- Exposed ventral fin area proportional to vertical tail area. ($S_{VF}/S_{VT} = 0.115$)

BASIC CONSTANTS

| Description | Wing | Horiz. Tail | Vert. Tail | Ventral Fin |
|---|---|---|---|---|
| Wing Loading, lbs/ft² | 60.00 | — | — | — |
| Aspect Ratio | 3.00 | 3.00 | 1.33 | 0.37 |
| Taper Ratio | 0.20 | 0.20 | 0.40 | 0.60 |
| Tail Vol. Coefficient | — | 0.26 | * 0.037 | — |
| L.E. Sweep Angle, deg. | 35.0 | 35.0 | 45.0 | 45.0 |
| Airfoil @ root | 4% Biconvex | 6% Bicon. (exp. root) | 6% Biconvex | 6% Biconvex |
| Airfoil @ tip | 4% Biconvex | 4% Biconvex | 4% Biconvex | 6% Biconvex |

* Tail volume coefficient tabulated is value per side (Coeff. = 0.074 per airplane)

~~(S)~~ Figure 3.1-11 Parametric Configuration Scaling - Wing and Tail Criteria (U)