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10.3 STRUCTURAL CRITERIA TRADES

~~(S)~~ Several trades were conducted to define the effect of structural criteria changes on aircraft structural weight. Since the Configuration 401B growth studies showed that each pound of additional dry weight results in an increase of 2.25 pounds in gross weight, dry-weight data from the trade studies would allow the effect of changes in structural criteria on airplane gross weight to be determined. The reference airplane for the structural criteria studies was Configuration 401B with a gross weight of 16,800 pounds.

10.3.1 Load-Factor/Design-Weight Trade

~~(S)~~ [Structural criteria are based on a 6.5-g load factor at an 80% fuel weight. In the case of the 16,800-pound airplane, the maximum design nw is 6.5 x 15,960 = 103,740 pounds. The purpose of this study is to show the structural weight impact of structural design gross weight in terms of percent fuel at the 6.5-g and 8.0-g load factors.] These weight increments were calculated with the previously described analytical-statistical weighing methods (see Section 3.5). The results of this study are shown in Figure 10.3-1.

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SEC 1.4(a)(g)

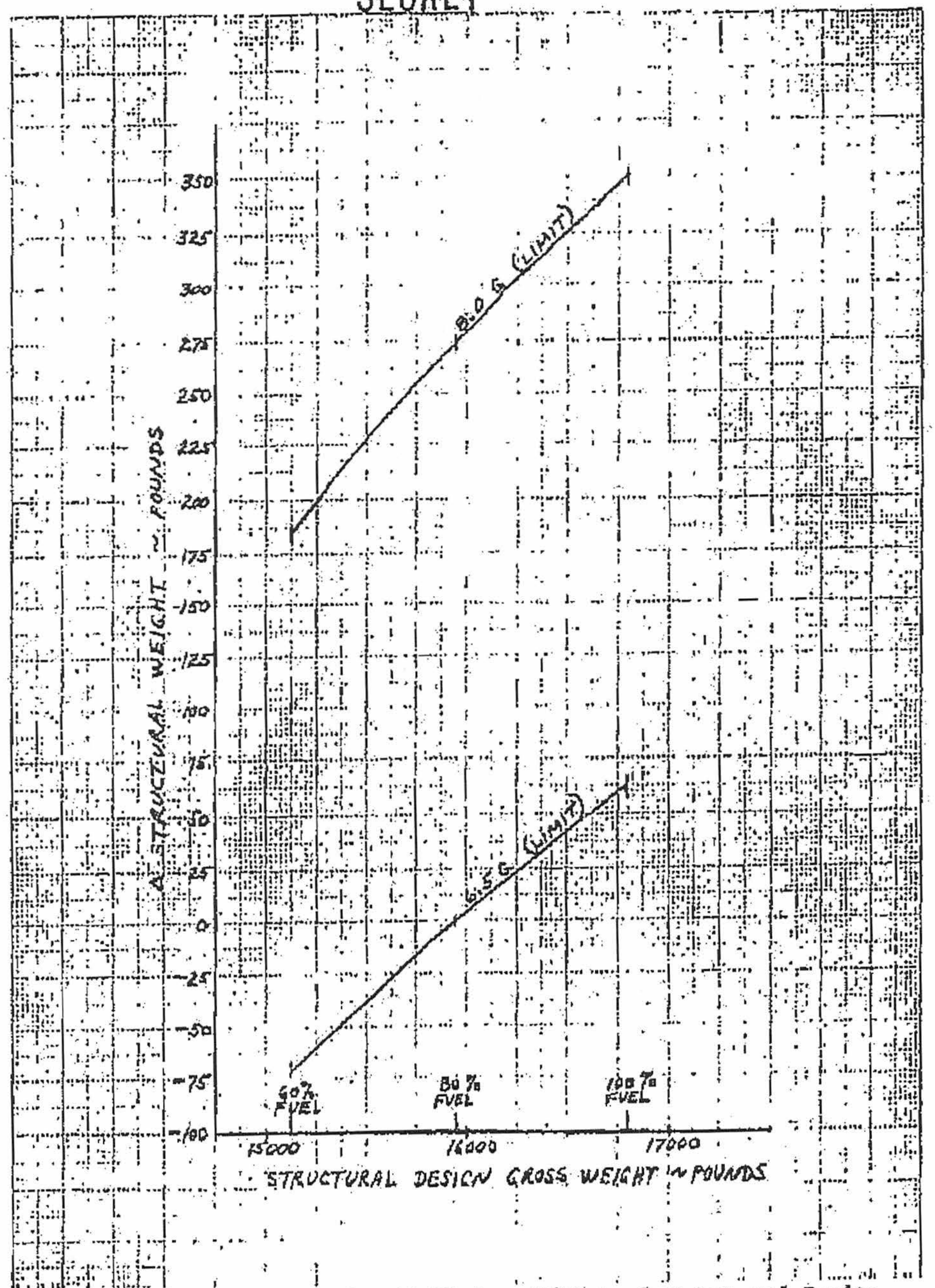
10.3.2 Load Factor/Constant nw Trade

(U) The purpose of this study is to define the weight impact of increasing the structural design load factor while holding the maximum nw constant. The major weight impacts in this trade are in the fuselage inertia items since the wing loads are primarily a function of nw. The weight impace for this trade study is shown plotted in Figure 10.3-2 against design load factor and percent remaining fuel. These weights were calculated by the previously described analytical-statistical weight equations.

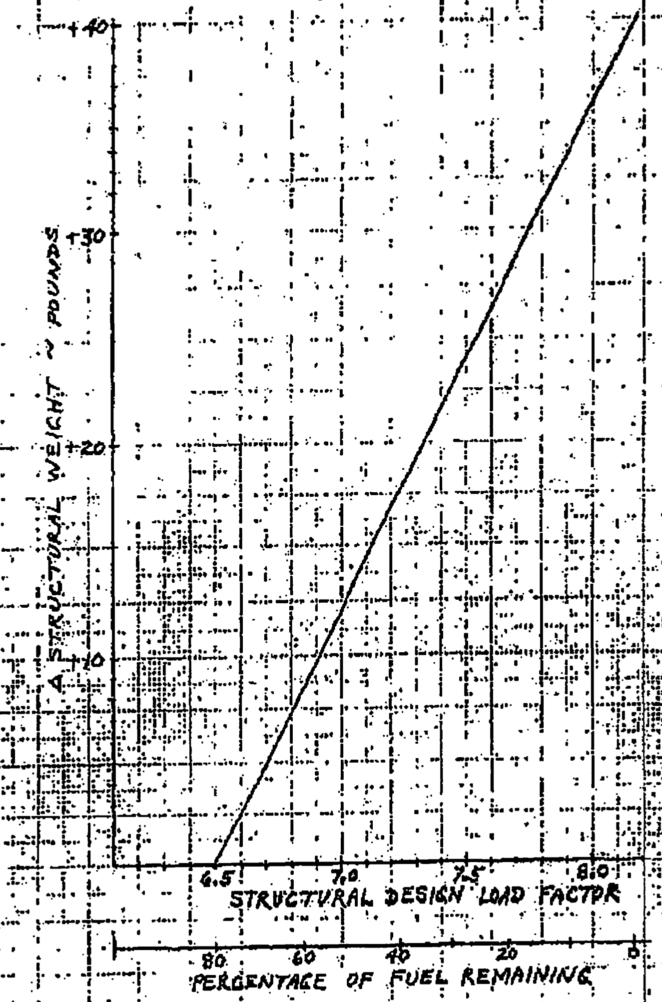
10.3.3 Landing Rate-of-Sink Growth Trade

(U) Many of the problems of fighter-type aircraft occur in landing gear backup structure. Since this backup structure is normally buried within the airplane, it becomes a major retrofit effort to either replace or strengthen the structure. As a result, it is desirable to design the backup structure for a higher sink speed than the gear since the

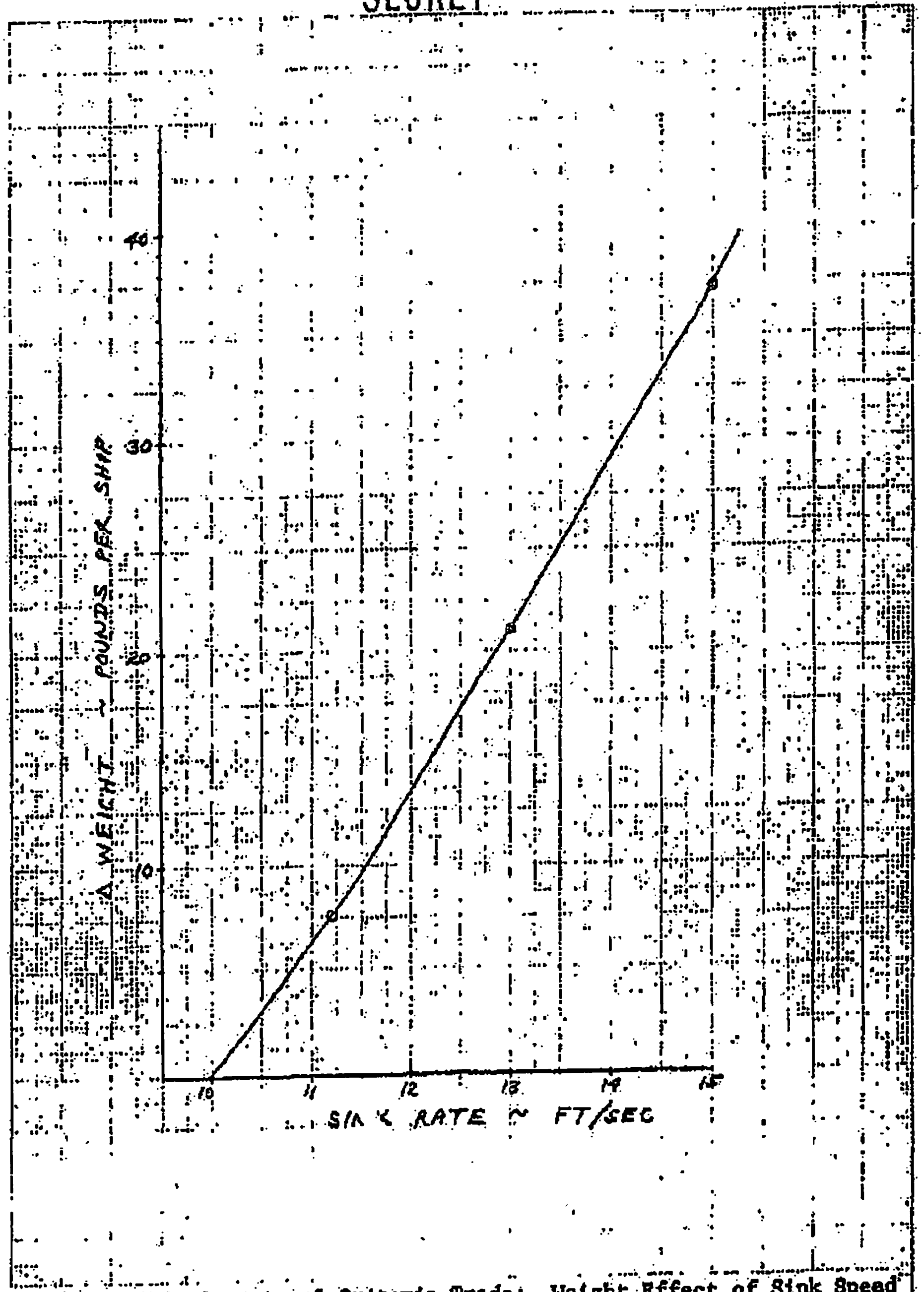
(U) gear can be redesigned and replaced fairly easily. The weight penalty associated with increasing the sink-speed loads on the understructure only are shown in Figure 10.3-3. These weights were calculated through the use of stress analysis methods,



~~(S)~~ Figure 10.3-1 Structural Criteria Trade: Effect of Structural Design Gross Weight and Design Load Factor on Structural Weight (U)



~~(S)~~ Figure 10.3-2 Structural Criteria Trade: Effect of Design Load Factor on Structural Weight at Constant nw (U)



~~(S)~~ Figure 10.3-3 Structural Criteria Trade: Weight Effect of Sink Speed on Landing Gear Backup Structure (U)

10.4 TAIL-HOOK TRADE

(U) This subsection contains the results of the study conducted to determine the impact of a tail-hook installation on the large single-engine airplane (401B). A brief description is presented of the installation, the effects on airplane performance, and the aerodynamic and structural penalties that were used to determine these performance effects.

10.4.1 Hook Installation

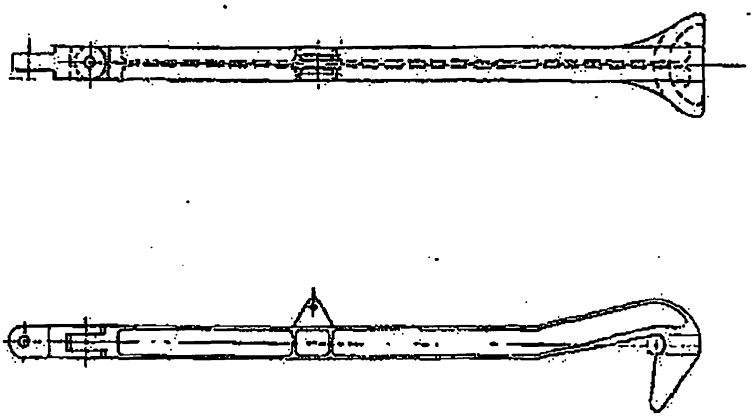
(U) In the Figure 10.4-1 drawing, a standard arresting hook is shown installed on Configuration 401B. The hook is attached to the rear wing-spar frame at the lower fuselage centerline and is stowed in a recess along the centerline of the panel located aft of this frame. The frame to which the hook is attached is the most-aft continuous ring member around the engine. The lower section of all frames aft of this station become part of the lower fuselage panel, which is hinged along one side to allow for engine removal. The shear pins that attach the hook to the fuselage frame must be removed prior to engine removal. In this arrangement the hook is hinged aside, along with the panel in which it is stowed, during the engine removal and installation process. This configuration allows the region beneath the fuselage to be free so that the engine loading cart can be positioned without any restrictions imposed by the hook arrangement.

10.4.2 Performance

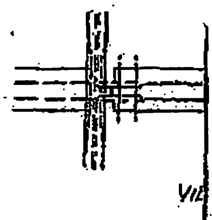
~~(S)~~ The performance evaluation of the addition of a tail hook to Configuration 401B yielded the following results:

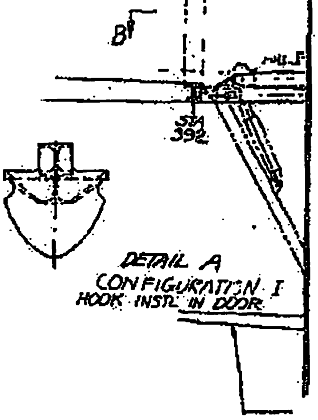
1. A 43-n.mi-radius loss for the LRASM if aircraft size is held constant.
2. A 205-pound increase in aircraft size (to 17,320 lb) if the LRASM radius is held constant.

(U) The performance evaluation was made through use of the sensitivity data of Section 3.3 and the incremental weight and drag data presented in the following subsections.

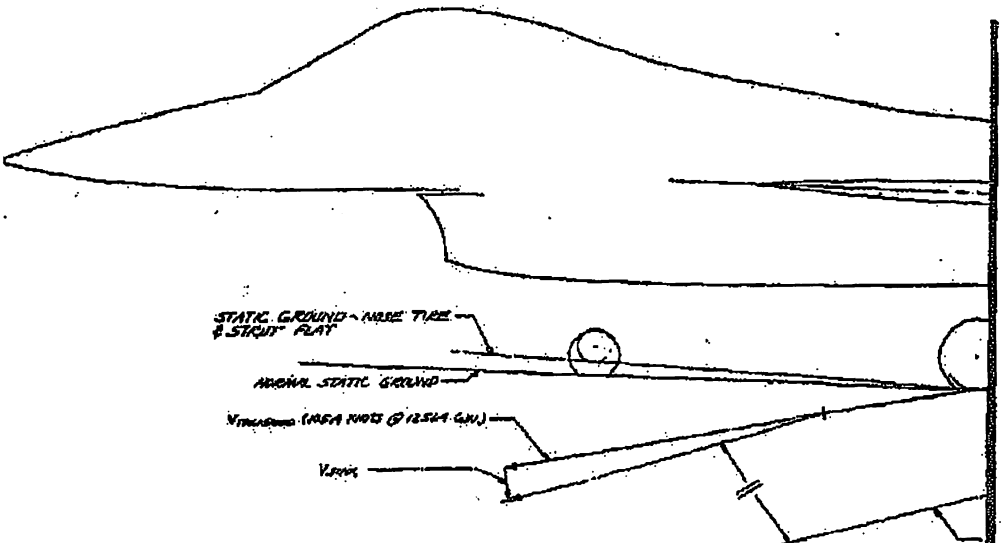


TAIL ARRESTING HOOK
1/4 SCALE





DETAIL A
CONFIGURATION I
HOOK INSTL IN DOOR



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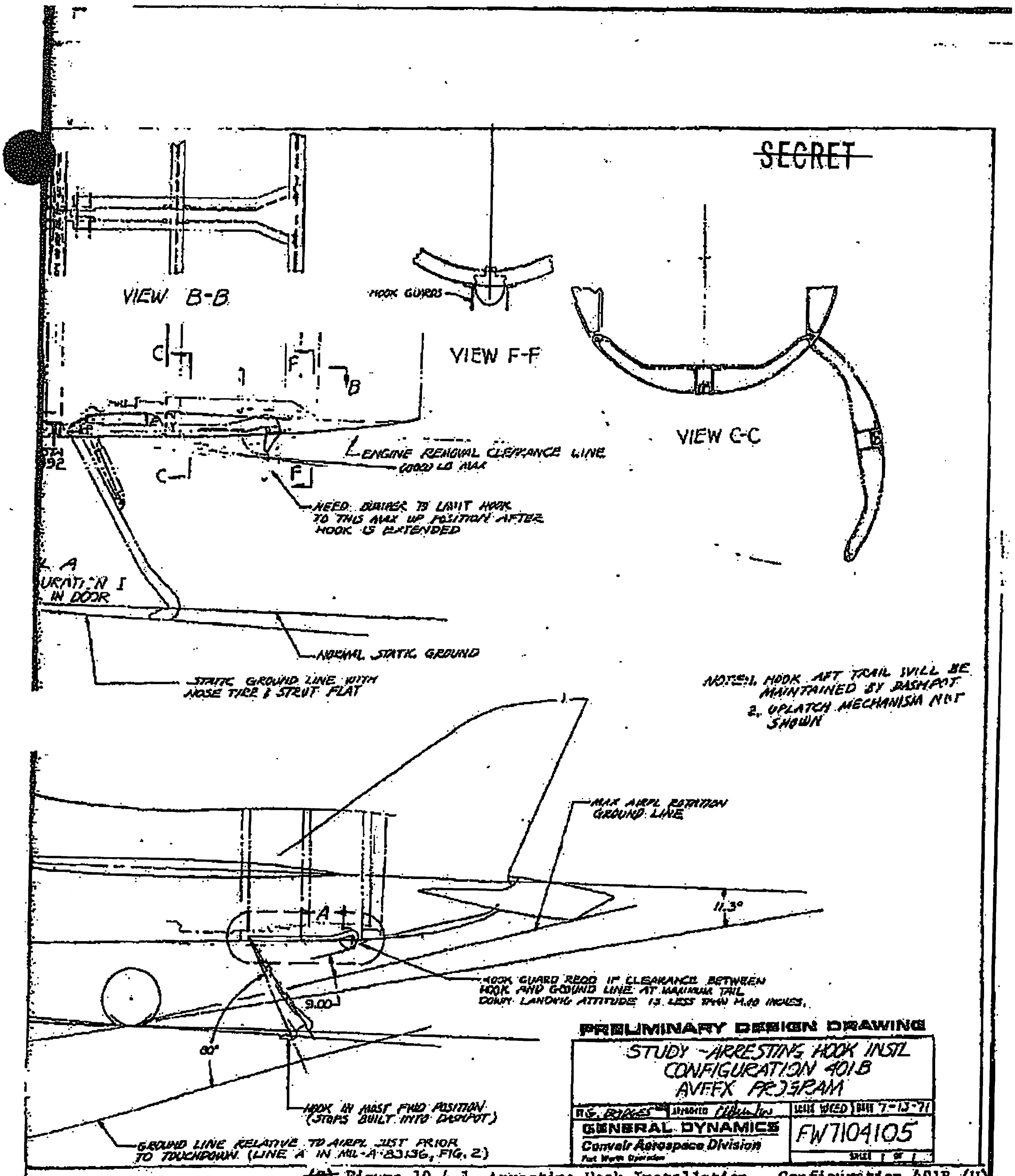


~~(S)~~ Figure 10.4-1 Arresting Hook Installation - Configuration 401B (U)

2

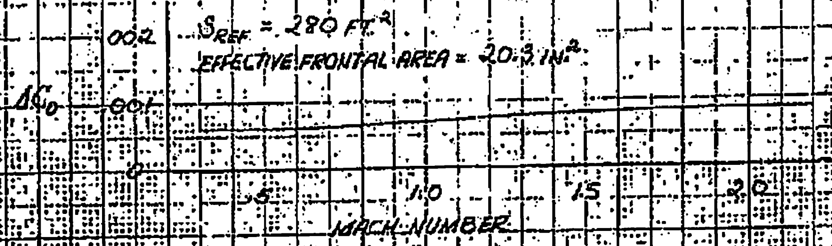
10.4.3 Aerodynamics

(U) The drag increment due to the tail hook in the retracted position is plotted in Figure 10.4-2. This prediction is based on drag data for flat-faced short bodies presented in Reference 7. An effective frontal area of 20.3 sq in. is used.

10.4.4 Structures and Weights

~~(S)~~ The structural weight increment for the installation of the tail hook on Configuration 401B was determined by stress analysis methods. The primary structural weight increments are due to the tail hook and to the local load introduction effects. Sufficient capacity exists to handle these loads, and additional strength is not required. The tail hook design load is 94,900 pounds-ultimate, obtained from data in MIL-A-83136. This load is introduced into integral fittings on the major rear-spar aft-engine-mount frame. This frame, together with a lower centerline stub longeron running forward, redistributes the load into the basic fuselage shell-longeron structure. The results of the weight integration of the added material thicknesses and areas together with the additional systems and equipment weight required is as follows:

	Pounds
Local Load Introduction Material	9
Tail Hook	32
Systems and Equipment	25
Total Additional Weight	66

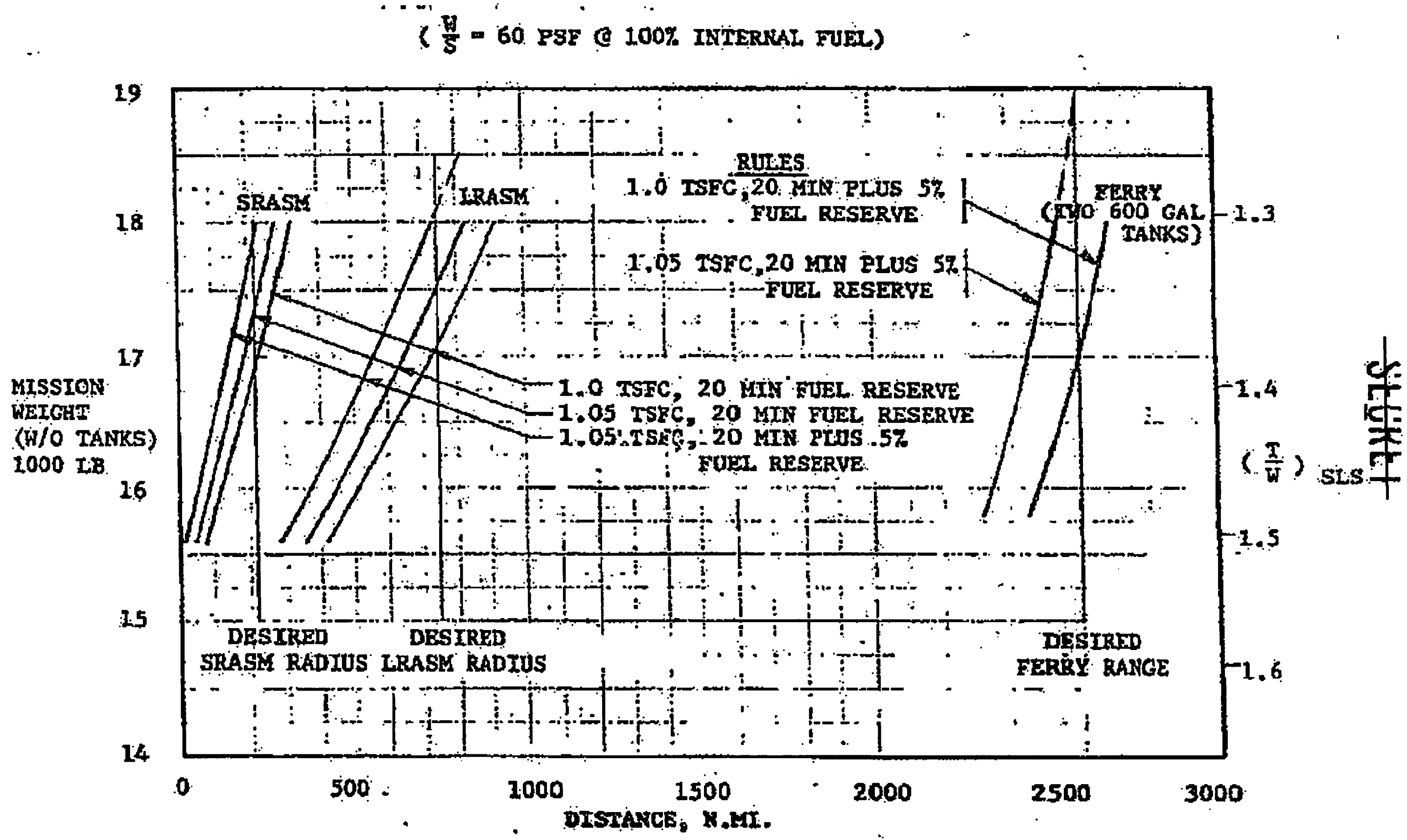


~~(S)~~ Figure 10.4-2 Drag Due to Hook in Retracted Position (U)

10.5 MISSION RULES TRADES

(U) The effect of changes in mission rules on the aircraft size required to accomplish a given mission has been evaluated for changes in the rules regarding fuel flow and landing reserve. The results of the evaluation, presented in Figure 10.5-1, show a 405-lb increase in aircraft size when the fuel flow (or TSFC) is increased 5 percent as a service tolerance to allow for practicable operation. An additional 555-lb increase in aircraft size results, with a requirement for 5 percent fuel reserve in addition to the fuel for 20 minutes maximum endurance at sea level.

~~(S)~~ These effects were evaluated to determine the increase in aircraft size that would result if the mission rules were changed. The mission rules used for the overall study did not require a service tolerance on fuel flow, and the additional 5 percent fuel reserve was required for the ferry mission only. With these rules, the aircraft was sized to 17,115 lb (without external tanks) to meet the Long-Range Air-Superiority Mission required radius of 750 n.mi. Incorporating both changes to the rules would increase the aircraft size to 18,075 lb.



~~(S)~~ Figure 10.5-1 Effect of Mission Rules for Configuration 401B on Growth Curves (U)

SECTION 11

CONCLUSIONS

~~(S)~~ The general conclusion of this study is that the trend toward achieving high unit effectiveness through sophistication and attendant high unit cost can be reversed through use of the design discipline approach. Specific conclusions are:

1. Visual air-to-air day fighters, at weights of less than one-half those of current air-superiority fighters, can be developed to have superior maneuvering performance with adequate mission range and combat fuel allowance without the use of advanced technologies.

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2. The design approach necessary to obtain superior energy rates and turn rates, while minimizing size and cost, is to use only minimum or mission-essential equipment and to optimize the design only for those capabilities that contribute directly and demonstratably to the visual air-to-air combat environment. The weight savings from this approach allow a tradeoff for more optimum wing loading and a significant increase in thrust/weight ratio.

3. Each of the many non-combat-relevant specifications and requirements that are normally considered do not, by themselves, impose significant penalties to the aircraft size or maneuverability; however, the collective effect of many small penalties destroys the potential of providing a truly superior air-to-air fighter. Each compromise that reduces the maximum attainable maneuverability in the primary air combat arena must be categorically questioned.

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4. Single-engine concepts are superior to twin-engine concepts by approximately 5000 pounds of gross weight when presently identified engines are used. Even with the higher thrust advantage of the twin-engine airplane, the

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single-engine airplane exhibits a 9-percent higher thrust/weight ratio when both aircraft are sized to perform the same mission.

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(4)
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5. Supercritical airfoils, used on fixed-wing supersonic aircraft, can be utilized to provide increased transonic capability but at the expense of supersonic capability. Sustained turn rates can be increased approximately 10 percent at Mach 0.8 and 13 percent at Mach 0.9. Buffet limits are significantly improved in the Mach 0.9-1.0 region. Ferry range capabilities are increased by 20-25 percent. However, sustained turn rates at Mach 1.2 are reduced 10 percent, time to accelerate from Mach 0.9 to 1.5 is increased 70 percent, and maximum supersonic speeds and altitudes are greatly reduced. Use of variable-sweep wings would allow utilization of the supercritical transonic benefits without the supersonic penalties; however, additional design work in configuration shaping and development of thin-wing supercritical technology is needed to reduce the supersonic penalties of fixed supercritical wing designs.

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(4)
1.4.(a)(g)
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6. The use of composite materials can significantly increase combat maneuverability. When constrained to maintain equal mission radius and equal acceleration capability, subsonic sustained turn rates can be increased by 12 percent through the use of composites in the wing only and by 36 percent through the use of maximum composites. The potential of composites can be utilized to provide improved subsonic or supersonic capabilities, accelerating or turning capabilities, or some of each. Energy-maneuverability comparisons, including maximum maneuver diagrams, over the maneuvering flight spectrum are needed before the most promising payoff can be determined.

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13. ABSTRACT

A number of air-superiority day-fighter concepts are synthesized so that low unit cost and high transonic maneuverability are paramount. The basic approach used to maximize fighting qualities while minimizing size and cost was to employ only minimum or mission-essential equipment and to optimize only on those capabilities that contribute directly and demonstratably to the visual air-to-air combat environment. The primary configuration tradeoff issues addressed are (1) single-engine versus twin-engine concepts, (2) aircraft size versus performance, and (3) effects of recent technology advancements in aerodynamic design and structural materials. Study results show that visual air-to-air day fighters utilizing current technology can be developed to have superior maneuvering performance, with adequate range and combat fuel allowance, at gross weights less than one-half that of current air-superiority fighters. Single-engine concepts provide greater maneuverability and 5000-pound lower gross weights than twin-engine concepts, when using presently identified engines. The use of smaller engines in the single-engine concepts to further reduce aircraft size results in prohibitive reductions in maneuverability or insufficient mission range. Composite materials can be utilized to increase combat maneuverability significantly. As an example, if it is desired to utilize all of the benefits of composites to increase turning capability (within constraints of equal acceleration capability and equal mission radius), airplane sustained turn rates can be increased over an aluminum airplane by 12 percent with a composite wing and 36 percent with maximum composite usage. Supercritical airfoils used on fixed-wing supersonic aircraft can be utilized to improve transonic capability but at the expense of supersonic capability.

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