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EXTERNAL STORE EFFECTS ON THE STABILITY OF FIGHTER AND INTERCEPTOR AIRPLANES

By M. Leroy Spearman and Wallace C. Sawyer

Langley Research Center
Hampton, Va. 23665

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16. Abstract

The purpose of this paper is to consider some criteria for external carriage of missiles for fighter aircraft intended for aerial combat missions and for fighter-interceptor missions. The mission requirements discussed include the short-range fighter-interceptor, the short-range interceptor, the medium-range interceptor, and the long-range interceptor. Missile types considered to be compatible with the various point mission designs include the short-range missile, the medium-range missile, and the long-range missile. From the study, it appears that point mission design aircraft can be arranged in such a way that the required external-store arrangement will not impair the stability of the aircraft. An extensive reference list of NASA external store research is included.

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SUMMARY

The purpose of this paper is to consider some criteria for external carriage of missiles for fighter aircraft intended for aerial combat missions and for fighter-interceptor missions. The mission requirements discussed include the short-range fighter-interceptor, the short-range interceptor, the medium-range interceptor, and the long-range interceptor. Missile types considered to be compatible with the various point mission designs include the short-range missile, the medium-range missile, and the long-range missile. From the study, it appears that point mission design aircraft can be arranged in such a way that the required external-store arrangement does not impair the stability of the aircraft.

INTRODUCTION

A continuing research program has been underway at the National Aeronautics and Space Administration for several years to evaluate the effects of external stores on aircraft. An extensive list of this activity is presented in references 1 to 109. The summary data presented in reference 109 consider many varying criteria for the external carriage of stores on fighter aircraft. The present paper summarizes store effects on fighters intended for aerial combat missions and for fighter-interceptor missions. Among the mission requirements considered are those for the short-range fighter-interceptor, the short-range interceptor, the medium-range interceptor, and the long-range interceptor. Missile types considered to be compatible with these various point mission designs include the short-range missile, the medium-range missile, and the long-range missile. The aircraft and missile concepts considered are shown in figures 1 to 5. The primary differences in the aircraft considered have to do with a progressive increase in aircraft size when progressing from the short-range to the long-range aircraft. This change in size is, of course, mainly generated by fuel requirements and, to some extent, by electronics space requirements. The primary differences in the missiles are again in size and again are related primarily to propulsion requirements and, to some extent, to guidance and warhead requirements. Some geometric missile and aircraft ratios are listed in Table I for the configurations used in this paper.

Table I - Missile and Aircraft
Geometric Ratios for Current Investigation

Missile-length—diameter ratio for -	
Short-range missile (SRM)	22.5
Medium-range missile (MRM)	14.8
Long-range missile (LRM)	16.4
Missile-length—airplane-length ratio for -	
Short-range fighter-interceptor (SRF/I) with SRM	0.21
Short-range fighter-interceptor (SRF/I) with MRM	0.24
Short-range interceptor (SRI) with MRM	0.19
Medium-range interceptor (MRI) with MRM (short nose)	0.24
Medium-range interceptor (MRI) with MRM (long nose)	0.22
Long-range interceptor (LRI) with LRM	0.19

SYMBOLS

C_D drag coefficient

C_L lift coefficient

C_{ℓ_β} effective dihedral parameter

C_{n_β} directional stability parameter

L/D lift-drag ratio

M Mach number

α angle of attack, deg

DISCUSSION

For the airplane and missile arrangements considered, there were no significant effects of store carriage on the control effectiveness or the aerodynamic-center location. Obviously, some effects on drag would be expected and two cases are shown in figure 6 for the short-range fighter-interceptor with two short-range missiles and the medium-range interceptor with four medium-range missiles at a Mach number of 1.60 (unpublished data). The primary drag effect is at zero lift with a diminishing effect as the lift increases. For the short-range fighter with a relatively small missile, the lift coefficients at which maneuvering flight occurs are such that the drag of the missiles is relatively small and there is little effect on the lift-drag ratio. For the medium-range interceptor with four missiles, there is a large increase in drag at zero lift but in the lift range for cruise, the effect of missiles on the lift-drag ratio is relatively small.

The more pronounced effects of external stores occur in the lateral-directional stability characteristics. Two examples are shown in figure 7 for the short-range fighter-interceptor at M = 1.6 with two short-range missiles mounted inboard and a case with two medium-range missiles mounted outboard (unpublished data). Both installations resulted in an increase in directional stability. The short-range missiles mounted inboard had little effect on the effective dihedral, whereas the medium-range missiles mounted outboard substantially reduced the effective dihedral. Similar characteristics are indicated in figure 8 for the short-range interceptor at a Mach number of 1.60 with two medium-range missiles (ref. 108). For both the short-range fighter-interceptor and the short-range interceptor, the increase in directional stability resulting from the store installation is primarily a result of the store and pylon being located aft of the center of gravity. The changes in effective dihedral are opposite to those that would be caused by the side force on the missile pylon and must result from lift induced by the pressure fields of the store-pylon arrangement which appears to cause a reduction in lift on the inboard section of the windward wing and an increase in lift on the inboard section of the downwind wing. Such changes in lift are consistent with the changes in local interference pressure fields that would be expected. For the highly maneuverable fighter aircraft, the increase in directional stability and lower values of effective dihedral are desirable characteristics.

Some unpublished results for a medium-range interceptor at a Mach number of 1.60 indicate a reduction in directional stability at low angles of attack that apparently result from the missile installation being somewhat closer to the center of gravity. (See fig. 9.) This reduction in directional stability diminishes with increasing angle of attack and does not impair the stability in the angle-of-attack range for which a medium-range interceptor aircraft might be expected to cruise or maneuver. The effective dihedral is reduced by the store installation - the reduction being somewhat greater with four medium-range missiles than with two medium-range missiles. This effect might be expected since the installation of four missiles would tend to interfere with the lift over a greater part of the wing. There are essentially no differences in directional stability at angle of attack between the short- and long-nose versions. This result is a particularly interesting one in that the longer nose, which might be expected to produce some inherent directional instability, could be used to provide more volume for electronic equipment, and the center of gravity would most likely be farther forward so that the net effect might be an interceptor with additional volume and no adverse stability effects.

Results are shown in figure 10 for a large long-range interceptor with four long-range missiles at a Mach number of 1.70 (unpublished data). The installation of the four missiles indicates some reduction in directional stability since the stores are located close to the center of gravity and, in fact, the inboard store is forward of the center of gravity. This reduction in directional stability, however, does not appear to impair the aircraft in the angle-of-attack range at which a long-range interceptor aircraft would be expected to cruise or maneuver. The effective dihedral is reduced by the installation of the store, but the reduction is small, apparently because of the more inboard location of the missiles. Thus, it is indicated that the effective dihedral reductions are limited to pressure changes in the immediate vicinity of the pylon, the more outboard installations providing greater moment arms to the regions of lift change and thus greater changes in roll. An effective way of exploring this phenomenon is by means of local surface measurements on the wing in the vicinity of the pylon and such investigations are currently being made.

CONCLUDING REMARKS

It appears that point mission aircraft utilizing external store carriage can be designed in such a way that the required external store arrangement does not impair the stability of the aircraft. For fighter or fighter-interceptors required to maneuver, store arrangements can be achieved in which the stability characteristics are improved under maneuvering conditions. For interceptor aircraft where cruise is important and maneuvering is of less importance, some deterioration in directional stability can be tolerated without impairing the mission. In addition, the drag increments near zero lift appear to be of limited importance and in the range for which fighters would be expected to maneuver or the interceptor would be expected to cruise, there is relatively little drag or lift-drag penalty to impair the performance.

Langley Research Center,
National Aeronautics and Space Administration
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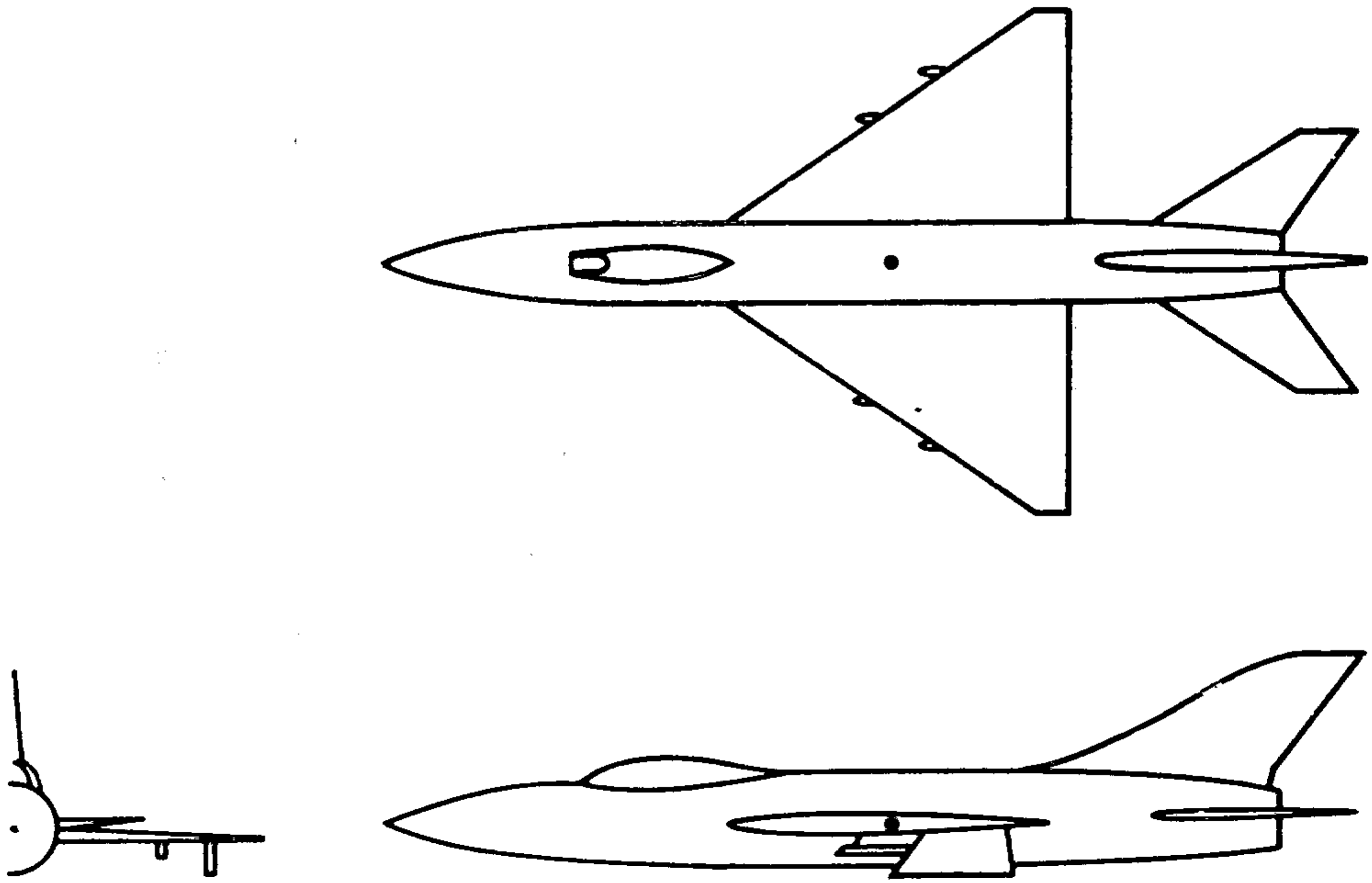

Figure 1. Short-range fighter/interceptor (SRF/I).

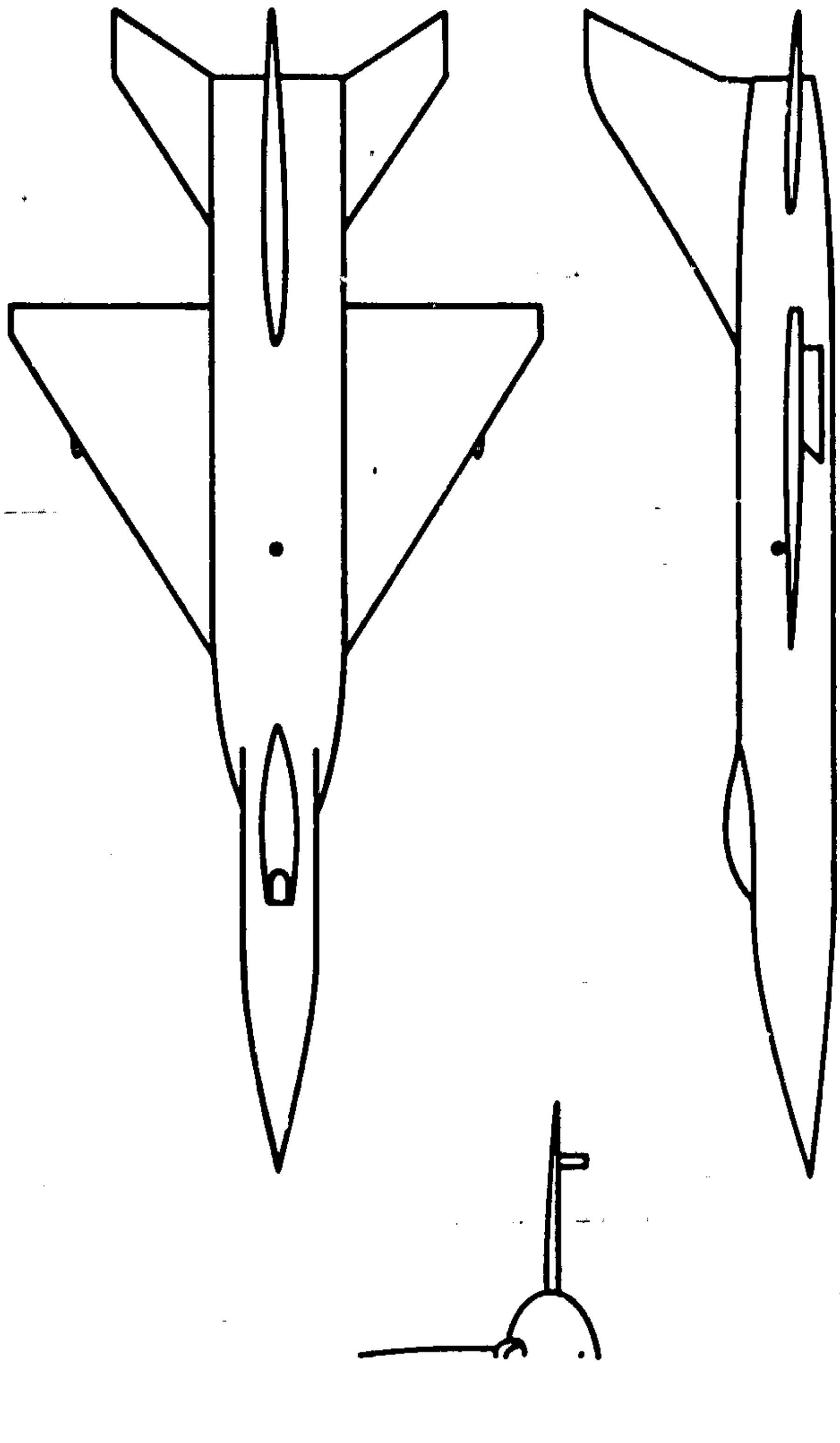

Figure 2. Short-range interceptor (SRI).

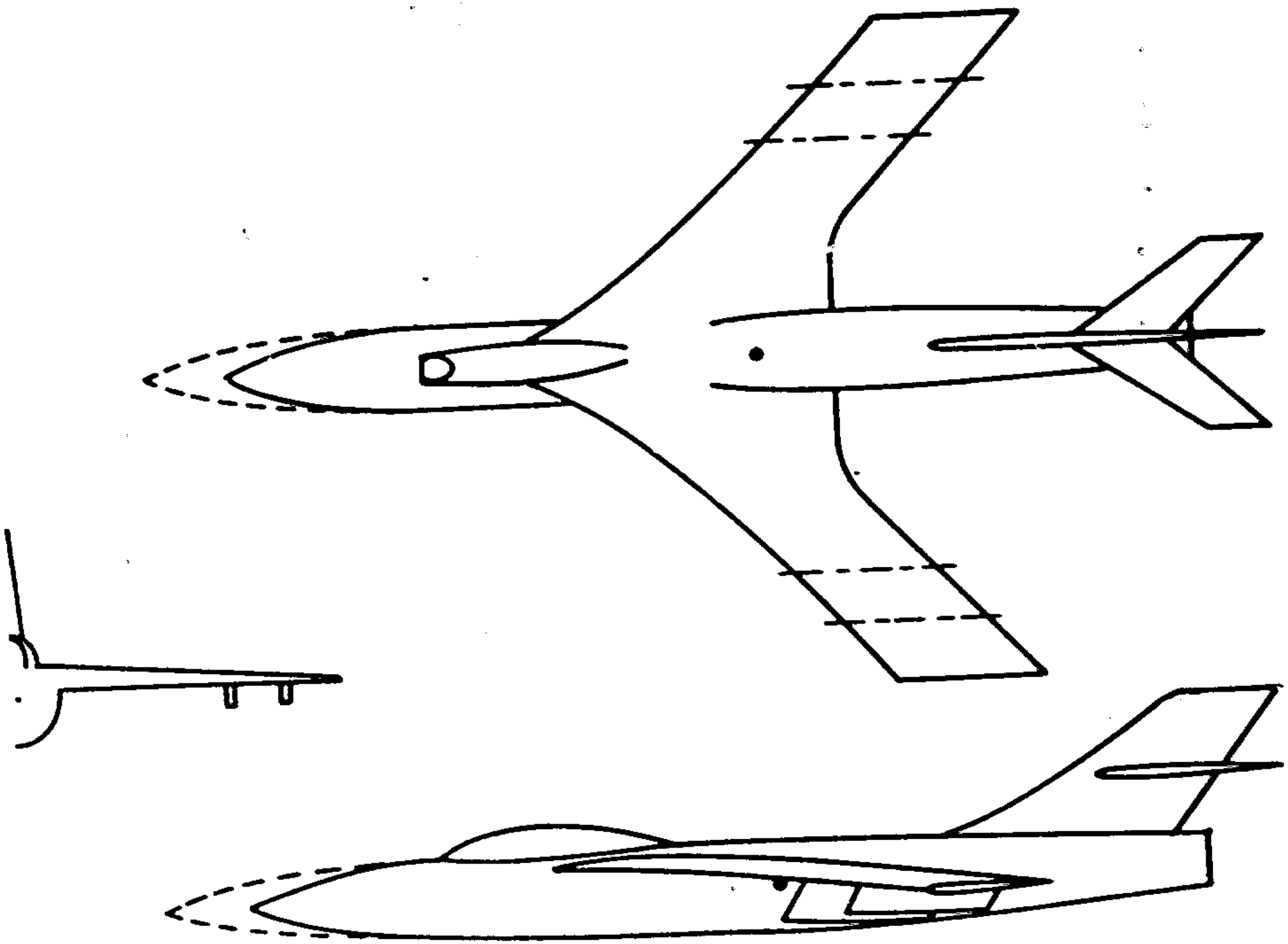

Figure 3. Medium-range interceptor (MRI).

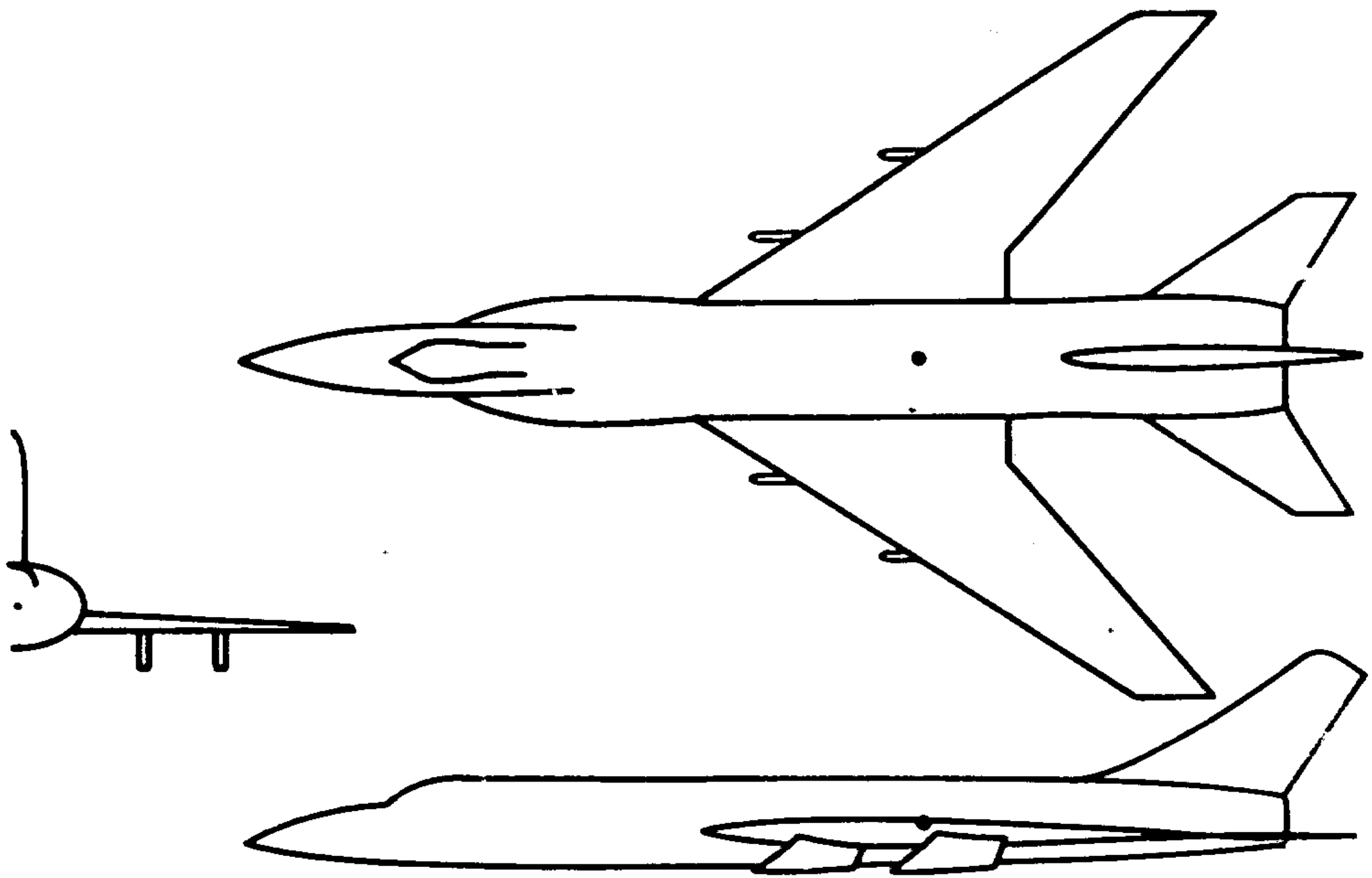

Figure 4. Long-range interceptor (LRI).

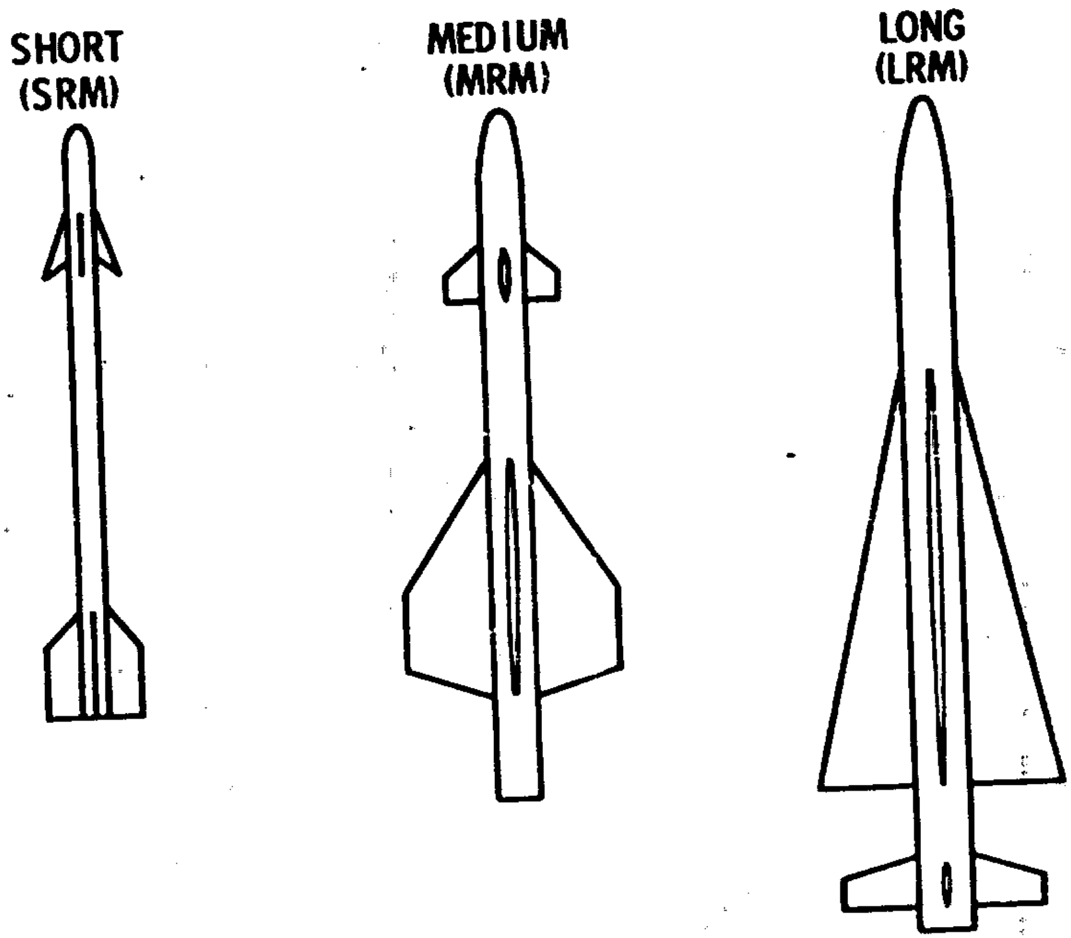

Figure 5. Missile concepts for various ranges.

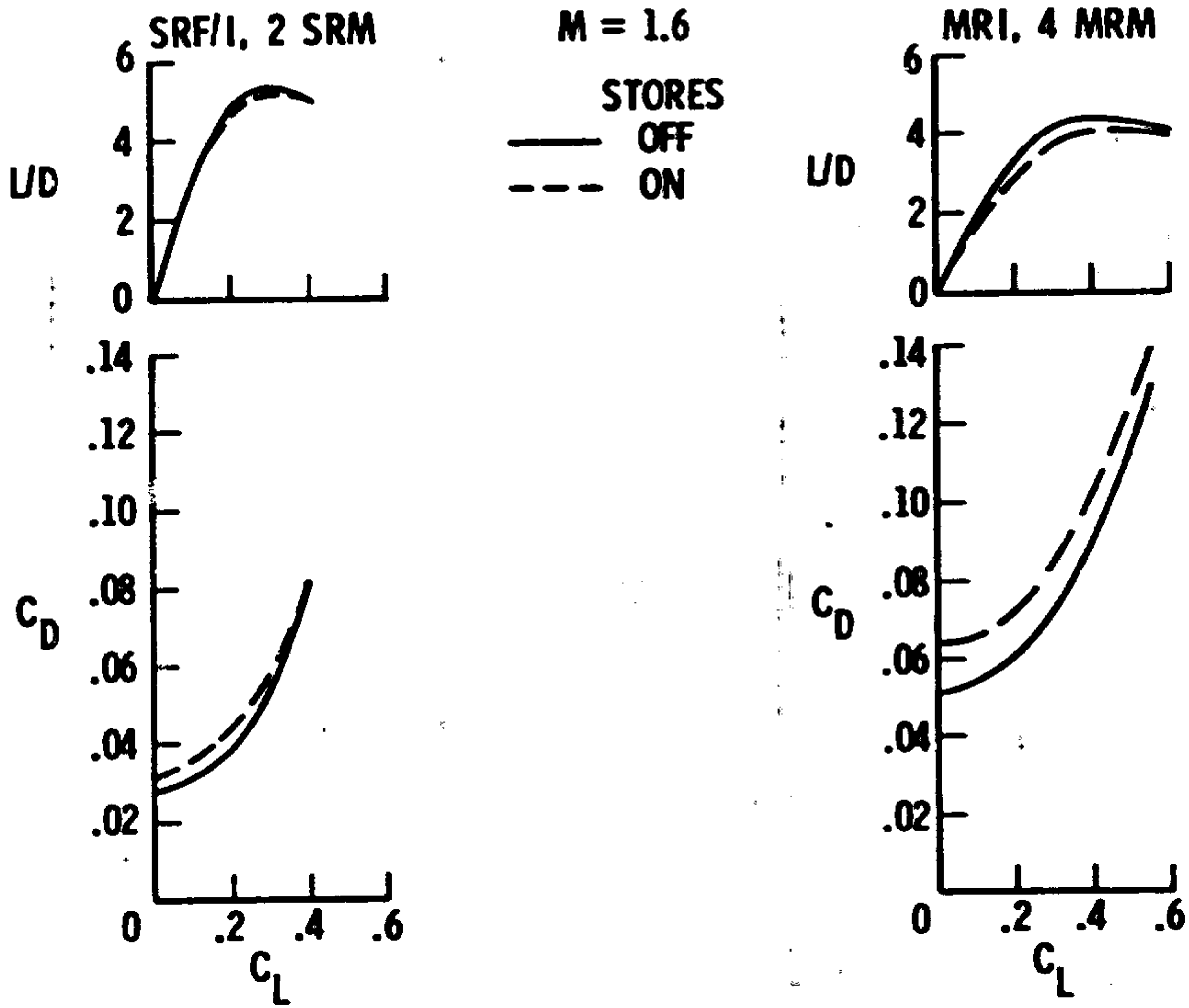

Figure 6. Drag characteristics, M = 1.6.

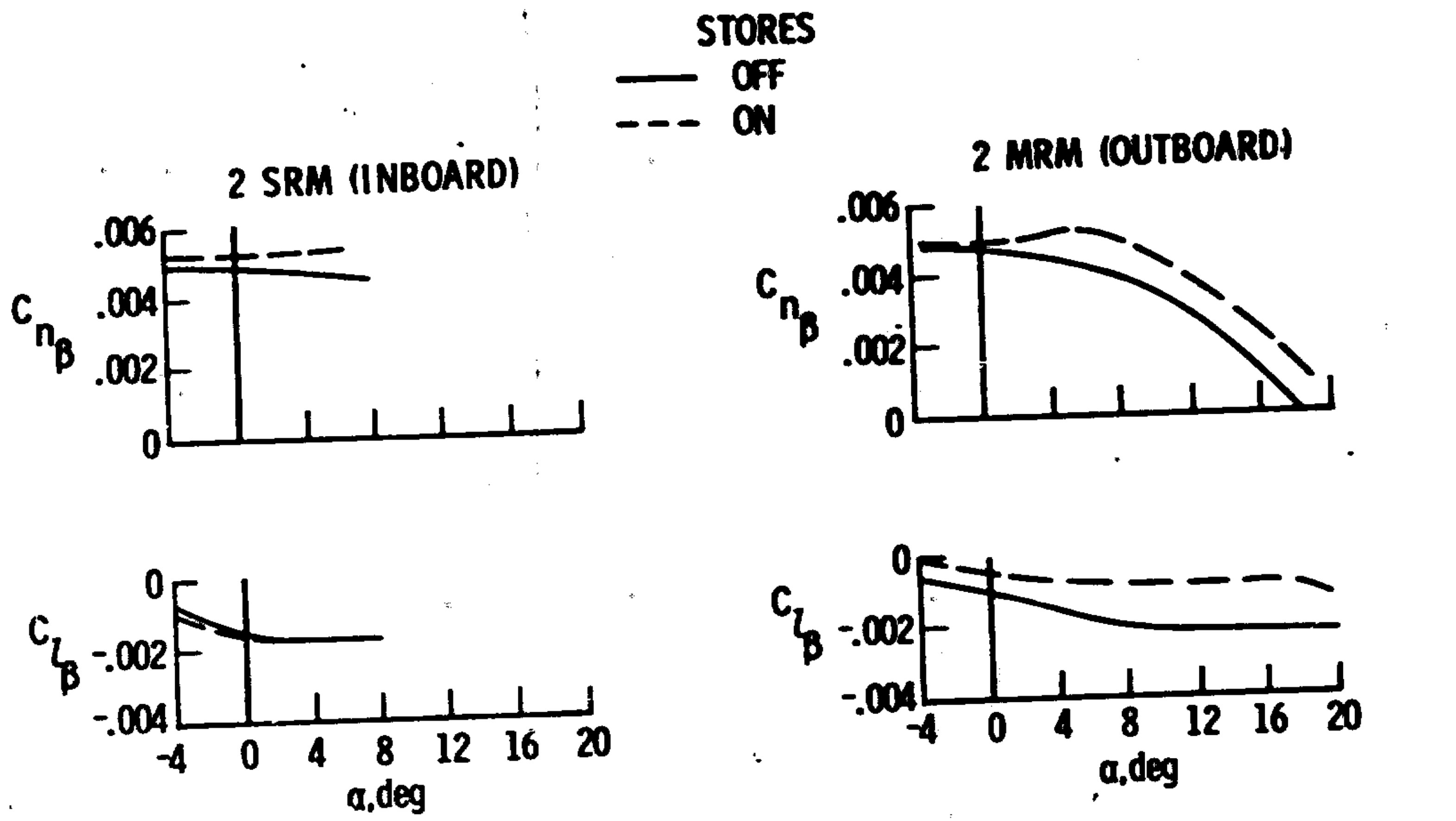

Figure 7. Lateral stability, SRF/I, M = 1.6.

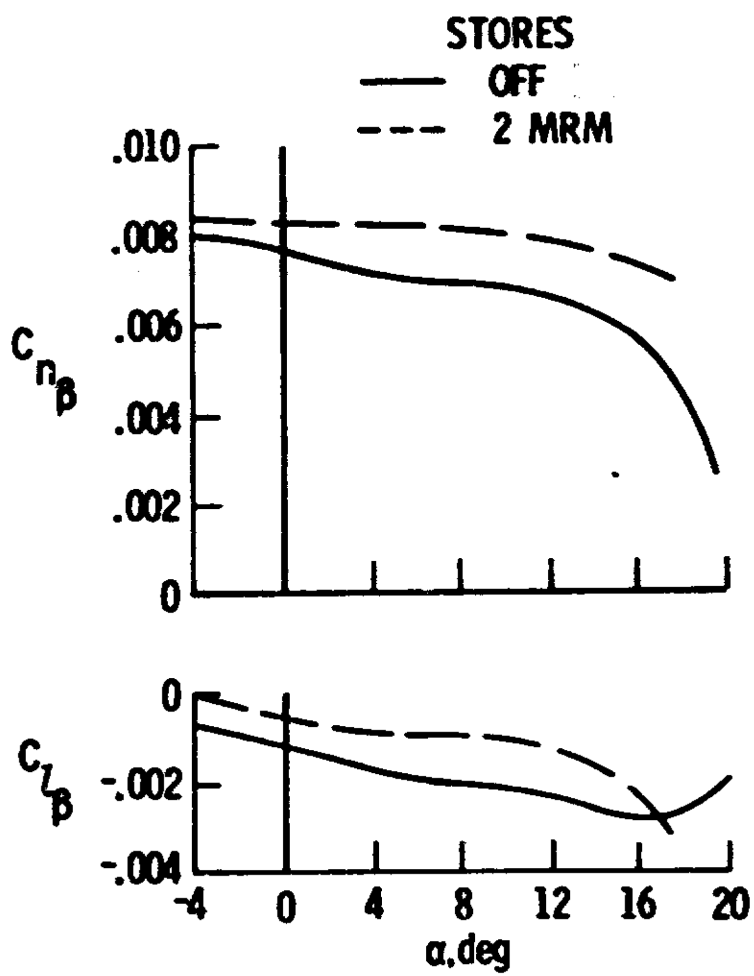

Figure 8. Lateral stability, SRI, M = 1.6.

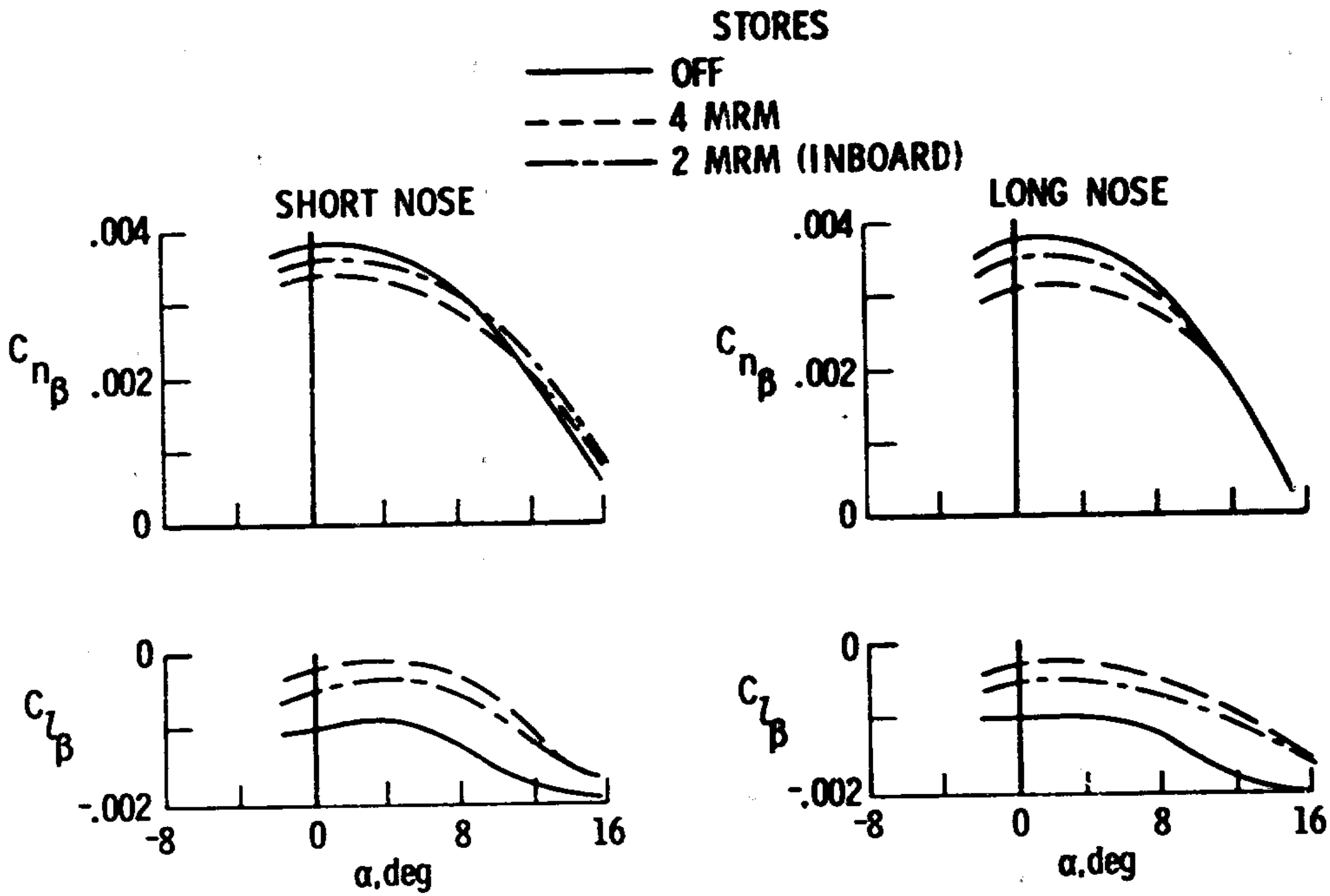

Figure 9. Lateral stability, MRI, M = 1.6.

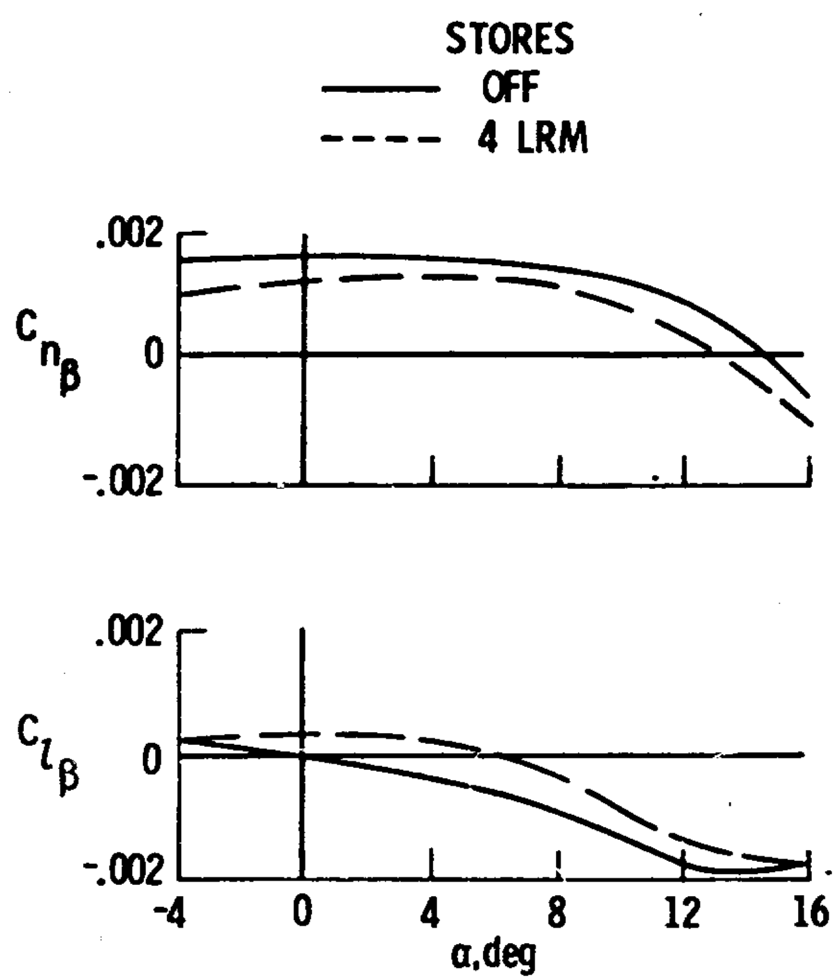

Figure 10. Lateral stability, LRI, M = 1.7.