EFFECTS OF NOSE BLUNTNESS
ON AERODYNAMIC CHARACTERISTICS
OF CRUCIFORM-FINNED MISSILE
CONFIGURATION AT MACH 1.50 TO 2.86

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An investigation was conducted to determine the effects of various magnitudes of spherical nose bluntness on model stability. The effectiveness of a forward-protruding nose spike in reducing the axial-force coefficient of a blunt-nose configuration was also investigated. Data were obtained at angles of attack up to about 22° at sideslip angles of approximately 0° and 4° and roll angles of 0° and 45°. The tests were conducted over a Mach number range of 1.50 to 2.86 at a Reynolds number of 2.5 × 10^6 per foot (8.2 × 10^6 per meter).
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SUMMARY

An investigation has been conducted in the Langley Unitary Plan wind tunnel to determine the effects of spherical nose bluntness on the aerodynamic characteristics of a typical cruciform-finned short-range missile configuration for roll angles of 0° and 45° and Mach numbers from 1.50 to 2.86. Also investigated was the effectiveness of a forward-protruding nose spike in reducing the axial-force coefficient of a blunt-nose configuration.

The results indicated that the effects of nose bluntness and nose spike on the longitudinal stability were small. For roll angles of both 0° and 45°, the greatest effects of nose bluntness on the aerodynamic-center location near zero angle of attack occurred at a Mach number of 2.86, where for each roll position, a rearward shift of approximately 3.5 percent of the body length occurred as bluntness was increased. Although large magnitudes of nose bluntness were accompanied by high axial-force coefficients, significant reductions in the axial-force coefficient of a blunt-nose configuration were achieved with the use of the nose spike.

There were no noteworthy effects of nose bluntness on either the directional stability or side-force parameters. However, for high angles of attack at a Mach number of 1.50 increased nose bluntness generally resulted in decreased effective dihedral.

INTRODUCTION

The use of electronic guidance systems in the forebodies of missiles and aircraft usually requires the incorporation of a considerable amount of nose bluntness in order to minimize electronic signal distortion. Increasing the bluntness, of course, results in increased drag and may also affect the lift and stability characteristics. The purpose of the present investigation is to determine the effects of nose bluntness on the aerodynamic characteristics of a typical cruciform-finned short-range missile configuration at Mach numbers from 1.50 to 2.86. Spherical bluntness was progressively applied to an ogive nose until a hemispherical forebody was attained. Also investigated was the effectiveness...
of a forward-protruding nose spike in reducing the axial-force coefficient of a blunt-nose configuration.

Reference 1 presents the results of tests in which nose shapes (identical to three of the nose shapes studied herein) were investigated as forebodies of two cruciform-finned missile configurations at a Mach number of 2.01. The results of other investigations concerned with the effects of nose bluntness and/or nose spikes are reported in references 2 to 7.

SYMBOLS

The data are referred to the body-axis system. The moment center is located as shown in figure 1.

\( A \)  
model cross-sectional area

\( C_A \)  
axial-force coefficient, \( \frac{\text{Axial force}}{qA} \)

\( C_{A,0} \)  
axial-force coefficient at \( \alpha = 0^\circ \)

\( C_m \)  
pitching-moment coefficient, \( \frac{\text{Pitching moment}}{qAd} \)

\( C_{m\alpha} \)  
slope of pitching-moment curve at \( \alpha \approx 0^\circ \), \( \frac{\partial C_m}{\partial \alpha} \), per degree

\( C_N \)  
normal-force coefficient, \( \frac{\text{Normal force}}{qA} \)

\( C_{N\alpha} \)  
slope of normal-force curve at \( \alpha \approx 0^\circ \), \( \frac{\partial C_N}{\partial \alpha} \), per degree

\( C_n \)  
yawing-moment coefficient, \( \frac{\text{Yawing moment}}{qAd} \)

\( C_l \)  
rolling-moment coefficient, \( \frac{\text{Rolling moment}}{qAd} \)

\( C_{l\beta} \)  
effective-dihedral parameter, \( \frac{\Delta C_l}{\Delta \beta} \), per degree

\( C_{n\beta} \)  
directional stability parameter, \( \frac{\Delta C_n}{\Delta \beta} \), per degree

\( C_Y \)  
side-force coefficient, \( \frac{\text{Side force}}{qA} \)

\( C_{Y\beta} \)  
side-force parameter, \( \frac{\Delta C_Y}{\Delta \beta} \), per degree

\( d \)  
body diameter
\[ l \] length of model with ogive nose

\[ M \] Mach number

\[ q \] dynamic pressure

\[ r_b \] body radius

\[ r_n \] radius of spherical segment of nose

\[ x_{ac} \] location of aerodynamic center from apex of ogive nose

\[ \alpha \] angle of attack of model center line, degrees

\[ \beta \] angle of sideslip of model center line, degrees

\[ \phi \] angle of roll (zero with fins in horizontal and vertical planes, positive for right roll), degrees

**APPARATUS**

**Model**

Details of the model are shown in figure 1. The basic configuration consisted of an ogive forebody, a cylindrical afterbody, and cruciform delta-planform fins. The ogive nose was modified by applying spherical bluntness in various magnitudes until a hemispherical nose was attained. An additional configuration consisted of the addition of a forward-protruding nose spike to one of the blunt-nose configurations.

**Tunnel**

The investigation was conducted in the low Mach number test section of the Langley Unitary Plan wind tunnel, which is a variable-pressure, continuous-flow facility. The test section is 4 feet (1.22 meters) square and approximately 7 feet (2.13 meters) in length. The nozzle leading to the test section is of the asymmetric sliding-block type, which permits a continuous variation in Mach number from about 1.47 to 2.86.

**MEASUREMENTS, CORRECTIONS, AND TEST CONDITIONS**

Aerodynamic forces and moments were measured by means of a sting-supported, six-component, strain-gage balance mounted within the model. The tests were conducted
at Mach numbers of 1.50, 1.90, 2.36, and 2.86 and at a Reynolds number of $2.5 \times 10^6$ per foot ($8.2 \times 10^6$ per meter). The angle-of-attack range was from about $-4^\circ$ to $22^\circ$ at angles of sideslip of approximately $0^\circ$ and $4^\circ$ and angles of roll of $0^\circ$ and $45^\circ$.

The angles of attack and sideslip have been corrected for tunnel flow angularity and for the deflection of the model support system due to load. The axial-force coefficient has been adjusted to a condition of free-stream static pressure at the base of the model. The stagnation dewpoint was maintained below $-30^\circ$ F ($239^\circ$ K) to avoid moisture condensation effects. A transition strip 0.06 inch (0.15 cm) wide and composed of No. 50 carborundum grains embedded in a plastic adhesive was affixed around the nose 1.20 inches (3.05 cm) rearward of the nose apex (measured along the surface). For the blunt-nose configurations, the measurement was made from the stagnation point. Similar transition strips were applied to the fins 0.40 inch (1.02 cm) rearward (streamwise) of the leading edge.

**DISCUSSION**

The basic longitudinal aerodynamic characteristics of the model with various degrees of nose bluntness are presented for roll angles of $0^\circ$ and $45^\circ$ in figures 2 and 3, respectively. All pitching-moment data reflect considerable longitudinal stability. This result is expected since the longitudinal position of the moment center corresponds to that of the juncture of the fin leading edge with the body. (See fig. 1.) Neither the pitching-moment nor normal-force coefficients exhibit any large nonlinear variations with angle of attack. Throughout the angle-of-attack range, the pitching-moment and normal-force coefficients for both roll angles reflect relatively small changes due to increased nose bluntness; this result indicates that the effects of bluntness on the longitudinal stability are small.

Figure 4 presents the longitudinal aerodynamic characteristics of the model with nose configuration $\frac{r_n}{r_b} = 0.70$ and the spike for a roll angle of $\phi = 0^\circ$. The trends of the normal-force and pitching-moment data are similar to those of the model without the spike (fig. 2(d)). This similarity indicates negligible effects of the spike on the longitudinal stability.

The normal-force and pitching-moment data of figures 2 to 4 are summarized in figure 5 for an angle of attack of approximately zero. The effects of nose bluntness on the parameters presented in this figure are relatively small. For roll angles of both $0^\circ$ and $45^\circ$, the greatest effect of nose bluntness on the aerodynamic-center location occurs at $M = 2.86$, where, for each roll position, a rearward shift of approximately 3.5 percent of the total body length occurs as bluntness is increased. The data for the model equipped with the nose spike, represented by the point symbols, indicate minor effects of the spike on $C_{m_{0\phi}}$, $C_{N_{0\phi}}$, and the aerodynamic-center location.
The effects of the various nose configurations on the axial-force coefficients at $\alpha = 0^\circ$ are summarized in figure 6. Spherically blunting the ogive nose initially has little effect on the axial-force coefficient. However, for $r_n/r_b$ greater than approximately 0.2, the $C_{A\alpha}$ begins to increase rapidly. The effect of bluntness also becomes greater as Mach number is increased. The effect of adding the spike to nose configuration $r_n/r_b = 0.70$ is indicated by the point symbols. It will be noted that with the addition of the spike the increase in the axial-force coefficient due to bluntness (over that of the ogive nose) is reduced approximately 50 percent at $M = 1.50$. The magnitude of this reduction increases to about 80 percent at $M = 2.86$.

The lateral stability derivatives of the model are presented for roll angles of $0^\circ$ and $45^\circ$ in figures 7 and 8, respectively. For both roll positions, the data show no noteworthy effects of nose bluntness on either the directional stability parameter $C_{n\beta}$ or the side-force parameter $C_{Y\beta}$. For $\phi = 0^\circ$ at Mach numbers of 1.50 and 1.90, there is a noticeable decrease in the directional stability as the angle of attack is increased above approximately $10^\circ$. At the higher Mach numbers, however, the directional stability is not significantly affected by change in angle of attack. Unlike the data for $\phi = 0^\circ$, the directional stability at $\phi = 45^\circ$ generally exhibits an increase as the angle of attack is increased, particularly at the lower Mach numbers. Data at both roll angles reflect a decrease in directional stability with increasing Mach number except for $\phi = 0^\circ$ at the higher angles of attack where there is little Mach number effect.

In some instances the trends of the effective-dihedral parameter $C_{l\beta}$ at $\phi = 0^\circ$ differ greatly from those at $\phi = 45^\circ$. For angles of attack above approximately $4^\circ$ the effective-dihedral parameter generally increases with $\alpha$ for $\phi = 0^\circ$, whereas the data at $\phi = 45^\circ$ generally exhibit a decrease in $C_{l\beta}$ as $\alpha$ is increased. For high angles of attack at $M = 1.50$, increased nose bluntness generally resulted in decreased effective dihedral.

**CONCLUSIONS**

An investigation has been conducted to determine the effects of spherical nose bluntness on the aerodynamic characteristics of a typical cruciform-finned short-range missile configuration for roll angles of $0^\circ$ and $45^\circ$ and Mach numbers from 1.50 to 2.86. Also investigated was the effectiveness of a forward-protruding nose spike in reducing the axial-force coefficient of a blunt-nose configuration. The conclusions are summarized as follows:

1. The effects of nose bluntness and nose spike on the longitudinal stability are small.
2. For roll angles of both $0^\circ$ and $45^\circ$, the greatest effects of nose bluntness on the aerodynamic-center location near zero angle of attack occur at a Mach number of 2.86, where for each roll position, a rearward shift of approximately 3.5 percent of the body length occurs as bluntness is increased.

3. Although large magnitudes of nose bluntness are accompanied by high axial-force coefficients, significant reductions in the axial-force coefficient of a blunt-nose configuration were achieved with the use of the nose spike.

4. There are no noteworthy effects of nose bluntness on either the directional stability or side-force parameters. However, for high angles of attack at a Mach number of 1.50 increased nose bluntness generally resulted in decreased effective dihedral.

Langley Research Center,
National Aeronautics and Space Administration,
Hampton, Va., April 24, 1970.

REFERENCES


Figure 1.- Model drawing. (Linear dimensions are given in inches and parenthetically in centimeters.)
Figure 2. Longitudinal aerodynamic characteristics of model with various degrees of nose bluntness; $\Phi = 0^\circ$.
Figure 2. Continued.

(b) $\frac{r_n}{r_b} = 0.15$

$\frac{r_n}{r_b}$

Figure 2. Continued.
Figure 2.- Continued.

(c) \( \frac{r_n}{r_d} = 0.45 \).

Figure 2.- Continued.
Figure 2.- Continued.

(a) $\frac{r_n}{r_b} = 0.70$.
Figure 2.- Concluded.
Figure 3.- Longitudinal aerodynamic characteristics of model with various degrees of nose bluntness; $\Phi = 45^\circ$. 

(a) $\frac{r_n}{r_b} = 0.00.$
Figure 3.- Continued.

(b) \( \frac{r_n}{r_b} = 0.15 \).

Figure 3.- Continued.
Figure 3.- Continued.

\( C_m \)

\( C_N \)

\( a, \text{ deg} \)

\[ \frac{r_n}{r_b} = 0.45. \]

Figure 3.- Continued.
Figure 3.- Continued.

(d) $\frac{r_m}{r_b} = 0.70$.
Figure 3. Concluded.

(e) \( \frac{r_m}{r_b} = 1.00 \).

Figure 3.- Concluded.
Figure 4.- Longitudinal aerodynamic characteristics of model with nose configuration $\frac{r_n}{r_b} = 0.70$ and spike; $\Phi = 0^\circ$. 
Figure 5: Summary of the longitudinal aerodynamic characteristics. $\alpha = \phi^0$. 

Nose spike

\begin{tabular}{cc}
On & Off \\
\bigcirc & 1.50 \\
\square & 1.90 \\
\Diamond & 2.36 \\
\triangle & 2.86 \\
\end{tabular}
Figure 6.- Effects of nose radius and spike on axial-force coefficient at $\alpha = 0^\circ$. 
(a) $r_n = 0.00$.

Figure 7.- Lateral stability derivatives of model with various degrees of nose bluntness; $\Phi = \phi^\circ$. 
Figure 7—Continued.

(b) \( \frac{r_n}{r_b} = 0.45 \)

Figure 7—Continued.
Figure 7.- Concluded.
Figure 8.- Lateral stability derivatives of model with various degrees of nose bluntness; $\Phi = 45^\circ$. 

(a) $\frac{r_n}{r_b} = 0.00.$
Figure 8.- Continued.

(b) $\frac{r_m}{r_b} = 0.45$

Figure 8.- Continued.
Figure 8.- Concluded.
"The aeronautical and space activities of the United States shall be conducted so as to contribute..., to the expansion of human knowledge of phenomena in the atmosphere and space. The Administration shall provide for the widest practicable and appropriate dissemination of information concerning its activities and the results thereof."

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