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AFFDL-TR-67-104
PART II

DEMONSTRATION OF A SUPERSONIC BOX METHOD FOR UNSTEADY AERODYNAMICS OF NONPLANAR WINGS

PART II. APPLICATION TO THE AGARD PLANFORMS

JAMES J. OLSEN

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FOREWORD

This report was prepared by the Aerospace Dynamics Branch, Vehicle Dynamics Division, Air Force Flight Dynamics Laboratory, Wright-Patterson Air Force Base, Ohio. The work was conducted under Project No. 1370, "Dynamic Problems in Flight Vehicles", Task No. 137003, "Prediction and Prevention of Aerothermoelastic Instabilities". Mr. James J. Olsen (FDDS) was the Project Engineer.

The report is published in two parts: Part I, "General Applications"; Part II, "Application to AGARD Planforms". The calculations were performed on the IBM 7094 at WPAFB, using a computer program developed by North American Aviation, Inc. and described in FDL-TDR-64-152, Part IV, "Unsteady Aerodynamics for Advanced Configurations". Recently, improvements have been made to this supersonic unsteady aerodynamic method. The improved methods are described in reports FDL-TDR-64-152, Part VI, "A Supersonic Mach Box Method Applied to T-Tails, V-Tails, and Top-Mounted Vertical Tails", and AFFDL-TR-68-30, "Supersonic Unsteady Aerodynamics for Wings With Trailing Edge Control Surfaces and Folded Tips".

The research covered by this report was conducted from 1 March to 15 April 1967. The report was completed in September 1968.

This report has been reviewed and is approved.

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ABSTRACT

This report is published in two parts: Part I, "General Applications," and Part II, "Application to the AGARD Planforms."

Part I presents and interprets the calculations of the unsteady aerodynamic prediction method known as the "Nonplanar Mach Box" method. It contains examples of data input and output for the associated computer program and explains the program's interpretation of the user's modal data. Also included are summaries of convergence properties, comparison with exact linearized theory, and a brief outline of the calculations for the Advisory Group for Aeronautical Research and Development (AGARD) planforms. A small part of the extensive tables of Part II is included in Part I.

Part II contains a tabulation of the "Nonplanar Mach Box" results for unsteady generalized force coefficients for the planforms, Mach numbers, mode shapes, and frequencies recommended by AGARD. The tabulation uses the AGARD coordinate system and format. Not all the desired cases could be included because of the program's current limitation to supersonic trailing edges (leading edges can be supersonic or subsonic).

The method was found to be fully workable and constitutes a valuable research and design tool. Convergence and accuracy were found to be comparable to steady-state, planar methods. The computer program is available with sample problems from the Air Force Flight Dynamics Laboratory.

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NOMENCLATURE

A_{ij}	coefficient of a polynomial in X and Y
A_t	coefficient of a polynomial in X and Y
a	speed of sound
b	box length
C_R	root chord
C_T	tip chord
C_{F_α}	slope of second pitching moment curve
C_{L_α}	slope of lift curve
C_{M_α}	slope of pitching moment curve
CPS	cycles per second
f	frequency in CPS
f_i	nondimensional mode shape in AGARD notation
i	$\sqrt{-1}$
i,j	summation indices
k	reduced frequency, $\frac{C_R \omega}{V}$
k_s	reduced frequency, $s\omega/V$
M_∞	Mach number
P_L, P_U	pressure on lower, upper surface
P_j	$(P_L - P_U)$ in the j^{th} mode
Q_{ij}	generalized force coefficient
Q^*_{ij}	generalized force coefficient as printed out by the Mach Box Program
Q'_{ij}	real part of generalized force coefficient in AGARD notation
Q''_{ij}	imaginary part of generalized force coefficient in AGARD notation
q	dynamic pressure, $\rho V^2/2$
r,s	summation indices
r,t	powers

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NOMENCLATURE (CONTD)

R	upper limit on r summation
R_{ij}	ratio of generalized force coefficients Q_{ij} between two successive computer runs
s	semispan
S	wing planform area
V	airspeed
X	dimensional coordinate
x	$x = X$, dimensional coordinate
x_1	x/b, nondimensional coordinate
x_{l_e}	position of leading edge in AGARD coordinate system
x_{t_e}	position of trailing edge in AGARD coordinate system
X_{cp}	dimensional position of center of pressure
Y	dimensional coordinate
y	βY, transformed dimensional coordinate; also nondimensional spanwise distance in AGARD coordinate system
y_1	y/b, transformed nondimensional coordinate
Z	dimensional coordinate
z	βZ, transformed dimensional coordinate
z_1	z/b, transformed nondimensional coordinate
α	angle of attack, radians
β	$\sqrt{M_\infty^2 - 1}$
$\tilde{\zeta}$	dimensional coordinate
ζ	$\beta\tilde{\zeta}$, transformed dimensional coordinate
ζ_1	ζ/b, transformed nondimensional coordinate
$\tilde{\eta}$	dimensional coordinate
η	$\beta\tilde{\eta}$, transformed dimensional coordinate
η_1	η/b, transformed nondimensional coordinate

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NOMENCLATURE (CONTD)

λ	$\Delta P/2q$, nondimensional pressure in AGARD notation
$\tilde{\xi}$	dimensional coordinate
ξ	$\xi = \tilde{\xi}$, dimensional coordinate
ξ_1	ξ/b, nondimensional coordinate
ρ	air density
ω	frequency, radians/second

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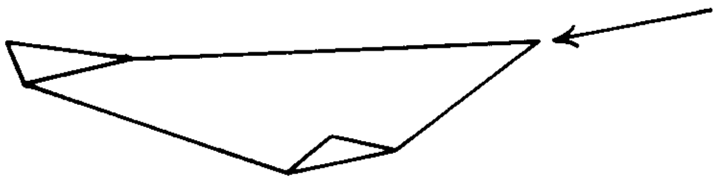
SECTION I

INTRODUCTION

Moore and Andrew (Reference 1) developed a numerical method of calculating the velocity potentials and generalized forces on symmetrically vibrating, nonplanar wings at supersonic speeds. The method is based on Ashley's source distribution approach to mutual interference effects in linearized supersonic theory (Reference 2). The method has since been extended to quite general arrays of lifting surfaces (Reference 3). The configuration of interest in the initial computer program and in this report, however, is restricted to a lifting surface consisting of three intersecting planes, as in the sketch below. (The planes need not intersect at right angles.)



Practical examples of this type of lifting surface are the XB-70 and the F-4 aircraft. The complete theoretical development and some applications of the method are given in Reference 1. However, as is often the case, there was not sufficient time for the authors to fully demonstrate the method to potential users and to elaborate on the intricacies of data handling and interpretation. This report is intended to fulfull that need by serving as a handbook for users of the computer program, by dwelling at length on convergence, correlation, and interpretation of results, and by applying the method to the AGARD planforms (Reference 4).

Part I summarizes the initial work which examined the program's interpretation of the user's modal data; presents the convergence effects of Mach number, sweep, frequency, and folded-tip interference; and outlines the application to the standard AGARD planforms. Part II contains an extensive tabulation of generalized force coefficients for the planforms, Mach numbers, frequencies and mode shapes recommended by AGARD. A small sample of the extensive tables of Part II is included in Part I to illustrate the method.

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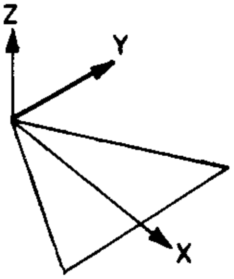
SECTION II

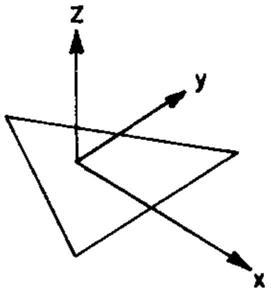
APPLICATION TO THE AGARD PLANFORMS

At the 20th meeting of the AGARD Panel on Structures and Materials, the NATO countries were invited to perform unsteady aerodynamic calculations on a set of standard planforms. The AGARD coordinate system and the definition of generalized forces to be used differ from those normally used for the Mach box method so that some interpretation is necessary. Further, the existing program is capable only of performing calculations of symmetric modes of vibration so that all values of Y should be interpreted as $|Y|$.

The standard AGARD format requires the use of a nondimensional coordinate system which is denoted by x, y, z. The origin of coordinates is at the center of the root chord, and all coordinates are made nondimensional by dividing by the semispan s. The Mach box program uses a dimensional coordinate system, originating at the apex.



Mach Box



AGARD

Hence we have the transformations

$$y = Y/s \qquad z = Z/s \qquad x = \left(X - \frac{C_R}{2}\right)/s$$

The AGARD definition of a generalized force coefficient is

$$Q_{ij} = -\int_{y=-1}^{+1} \int_{x=x_{l_e}}^{x_{t_e}} f_i(x,y)\, \lambda_j(x,y)\, dx\, dy$$

where

$$\lambda_j(x,y) = \Delta P_j(x,y)/2q$$

$$f_i(x,y) = Z_i(x,y)/s$$

Then in the Mach box notation we have

$$Q_{ij} = -\int_{y=-1}^{+1} \int_{x=x_{l_e}}^{x_{t_e}} \frac{Z_i(x,y)}{s} \, \frac{\Delta P_j(x,y)}{2q}\, dx\, dy$$

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Returning to the dimensional X, Y, Z coordinate system

$$Q_{ij} = \frac{-1}{2qs^3} \int_{Y=-s}^{+s} \int_{X=X_{l_e}}^{X_{t_e}} Z_i\,(X,Y)\ \Delta P_j\,(X,Y)\ dX\ dY$$

In terms of the Mach box program definition (call it Q^*_{ij})

$$Q_{ij} = \frac{-1}{2qs^3}\,(Q^*_{ij})^T\ qS = -\,(Q^*_{ij})^T\ \frac{(C_R + C_T)}{2s^2}$$

where the superscript T denotes "transpose" and we have taken the area definition of any trapezoidal wing $S = (C_R + C_T)s$. Then for a given set of mode shapes, to put the data in the AGARD format we must (1) change the sign and transpose Q_{ij}, and (2) multiply by the average chord and divide by the semispan, squared.

A convenient way to aid the changes automatically is to choose dimensions so that

$$\frac{C_R + C_T}{2s^2} = 1.0$$

This will occasionally necessitate the dimensions to vary from those of AGARD, but since the AGARD generalized force coefficients are nondimensional, they should be unaffected.

A final note in this regard is that the reduced frequency is defined as $k_s = s\omega/V$ in the AGARD format and that the generalized force coefficients are broken into real and imaginary parts:

$$Q_{ij} = Q'_{ij} + ik_s\ Q''_{ij}$$

1. THE ASPECT RATIO 2.0 RECTANGULAR WING

Figure 1 depicts the aspect ratio 2.0 rectangular wing. Both the root chord and the semispan can be set equal to 1.0 which is the value specified by AGARD. The Mach box program can be used at the desired Mach numbers of 1.05, 1.20, and 2.0. Figure 2 shows the Mach box program's approximation of the wing and diaphragm areas for the three Mach numbers used in these calculations. The necessary oscillatory frequencies to yield the desired values of k can be obtained from

$$k_s = \frac{s\omega}{V} = \frac{2\pi s f}{M_\infty a}$$

Hence for a = 1000 ft/sec and s = 1 ft, we have

$$f_{cps} = 159.16\,(M_\infty k_s)$$

Table I illustrates the frequencies required at each Mach number and reduced frequency. Table II gives the mode shapes in the AGARD and Mach box coordinate systems. Tables III and IV summarize the generalized force coefficients for all cases.

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2. THE ASPECT RATIO 1.45 TAPERED, SWEPT-BACK WING

Figure 3 depicts the aspect ratio 1.45 tapered, swept-back wing. We find that interpretation of the Mach box output in terms of the AGARD requirements are facilitated if we change the semispan from 1.0 to 1.379. Therefore

$$s = 1.379$$

$$C_R = 2.224$$

$$C_T = 1.579$$

Then $\frac{C_R + C_T}{2s^2} = 1.0$ and the AGARD generalized force matrix can again be obtained from the Mach box output by a simple change of sign and transposition. The desired Mach numbers are 2.0, 1.2, and 1.04, however, to obtain a supersonic trailing edge the minimum Mach number must be 1.057. Figure 4 shows the Mach box program's approximation of the wing and diaphragm areas for the three Mach numbers used. The desired values of reduced frequency are 0, 0.5, and 1.4. The necessary oscillatory frequencies required to obtain the desired values of k_s can be obtained from

$$f = \frac{M_\infty a k_s}{2\pi s}$$

Since s = 1.379 and a = 1000.0, f = 115.4 ($M_\infty k_s$).

Table V illustrates the frequencies required at each Mach number and reduced frequency while Table VI gives the mode shapes in the AGARD and Mach box coordinate systems. Tables VII and VIII contain the AGARD generalized force coefficients Q'_{ij} and Q''_{ij}.

3. THE ASPECT RATIO 4.0 ARROWHEAD WING

Figure 5 depicts the AGARD aspect ratio 4.0 arrowhead wing. The root chord has the same length as the semispan and the tip chord is zero. Therefore, to force $\frac{C_R + C_T}{2s^2} = 1.0$, we must change s from the AGARD value of 1.0 to 0.5. The Mach box program can be run at the desired Mach numbers of 2.0, 1.5621, and 1.25. However, at the desired Mach number of 1.1 the trailing edge is subsonic, therefore the program must be run at a minimum Mach number of 1.12 to insure a supersonic trailing edge. Figure 6 shows the Mach box program's approximation of the wing and diaphragm areas at the four Mach numbers used. The oscillatory frequencies necessary to yield the desired values of k_s can be obtained from

$$f_{cps} = \frac{M_\infty a k_s}{2\pi s} = 318.3\ (M_\infty k_s)$$

Table IX gives the frequencies required at each Mach number and reduced frequency. Table X gives the mode shapes in the AGARD and Mach box coordinate systems. Tables XI and XII give Q'_{ij} and Q''_{ij}.

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SECTION III

CONCLUSIONS

1. The user of the folded tip Mach box computer program need only work in a physical, dimensional, coordinate system.

2. The generalized force coefficients are defined in the program by

$$Q_{ij} = \frac{1}{qS} \iint_S (P_L - P_U)_i \; Z_j \; dX \, dY$$

3. If the user chooses dimensional scaling so that $\frac{C_R + C_T}{2S^2} = 1.0$, the Mach box program's generalized force coefficients are easily related to the AGARD generalized force coefficients by a change of sign and a transposition of subscripts.

4. The results of the report are applicable only to symmetric vibration modes; therefore, any mode given by an odd power of Y should be interpreted in terms of $|Y|$, the absolute value. Exact duplication of the antisymmetric AGARD modes is not possible.

REFERENCES

1. Moore, M. and Andrew, L., Unsteady Aerodynamics for Advanced Configurations, Part IV, Application of the Supersonic Mach Box Method to Intersecting Planar Surfaces, FDL-TDR-64-152, Part IV, Air Force Flight Dynamics Laboratory, Wright-Patterson Air Force Base, Ohio, May 1965.

2. Ashley, H., Supersonic Airloads on Interferring Lifting Surfaces by Aerodynamic Influence Coefficient Theory, Boeing Report D2-22-67, November 1962.

3. Andrew, L., Unsteady Aerodynamics for Advanced Configurations, Part VI, Application of the Supersonic Mach Box Method to T-Tails, V-Tails, and Top-Mounted Verticals, FDL-TDR-64-152, Part VI, Air Force Flight Dynamics Laboratory, Wright-Patterson Air Force Base, Ohio, 1967.

4. Woodcock, D., Dat, R., Bergh, H., and Lashka, B., Planforms for Calculations of Unsteady Airforces, Report of Working Party Appointed at 19th AGARD Structures and Materials Panel Meeting, May 1965.

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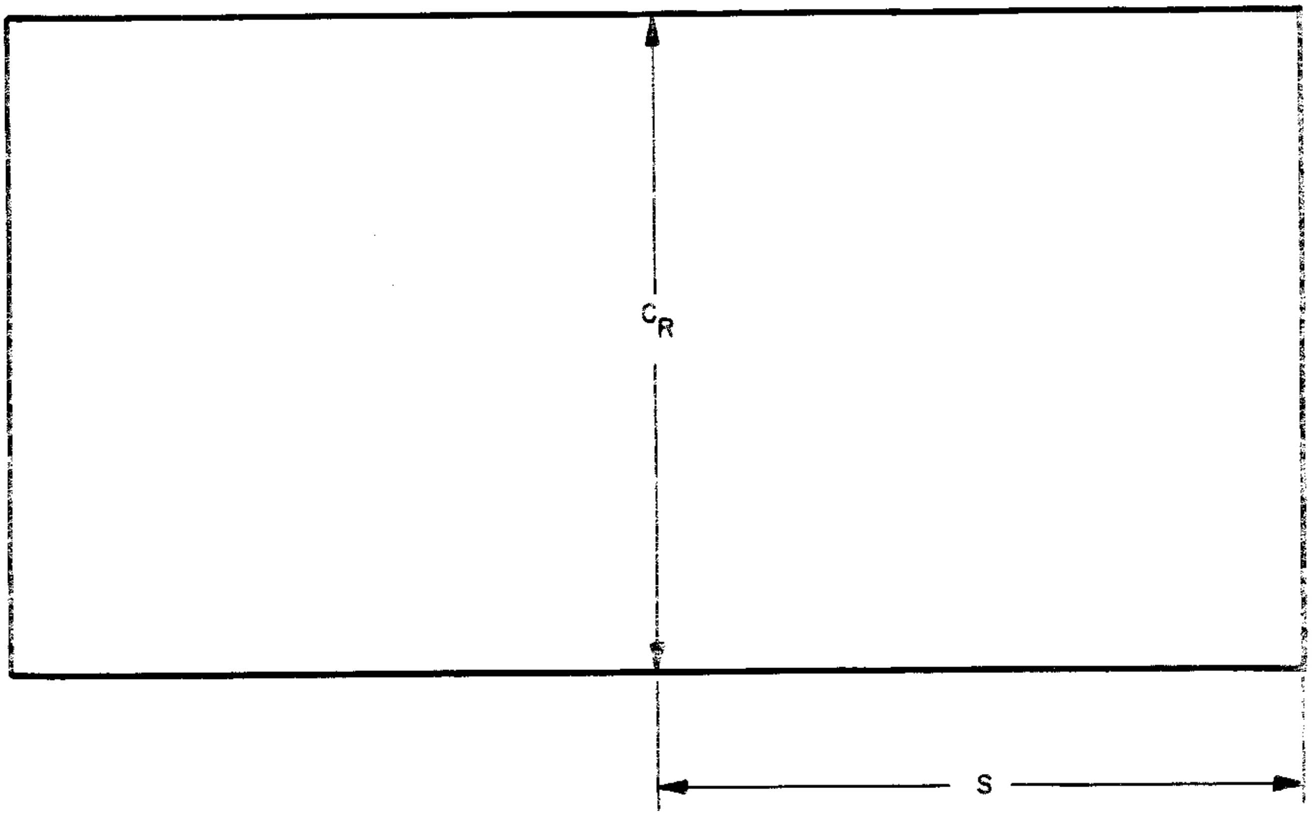

Figure 1. AGARD Aspect Ratio 2.0 Rectangular Wing, $C_R = 1.0$, $s = 1.0$

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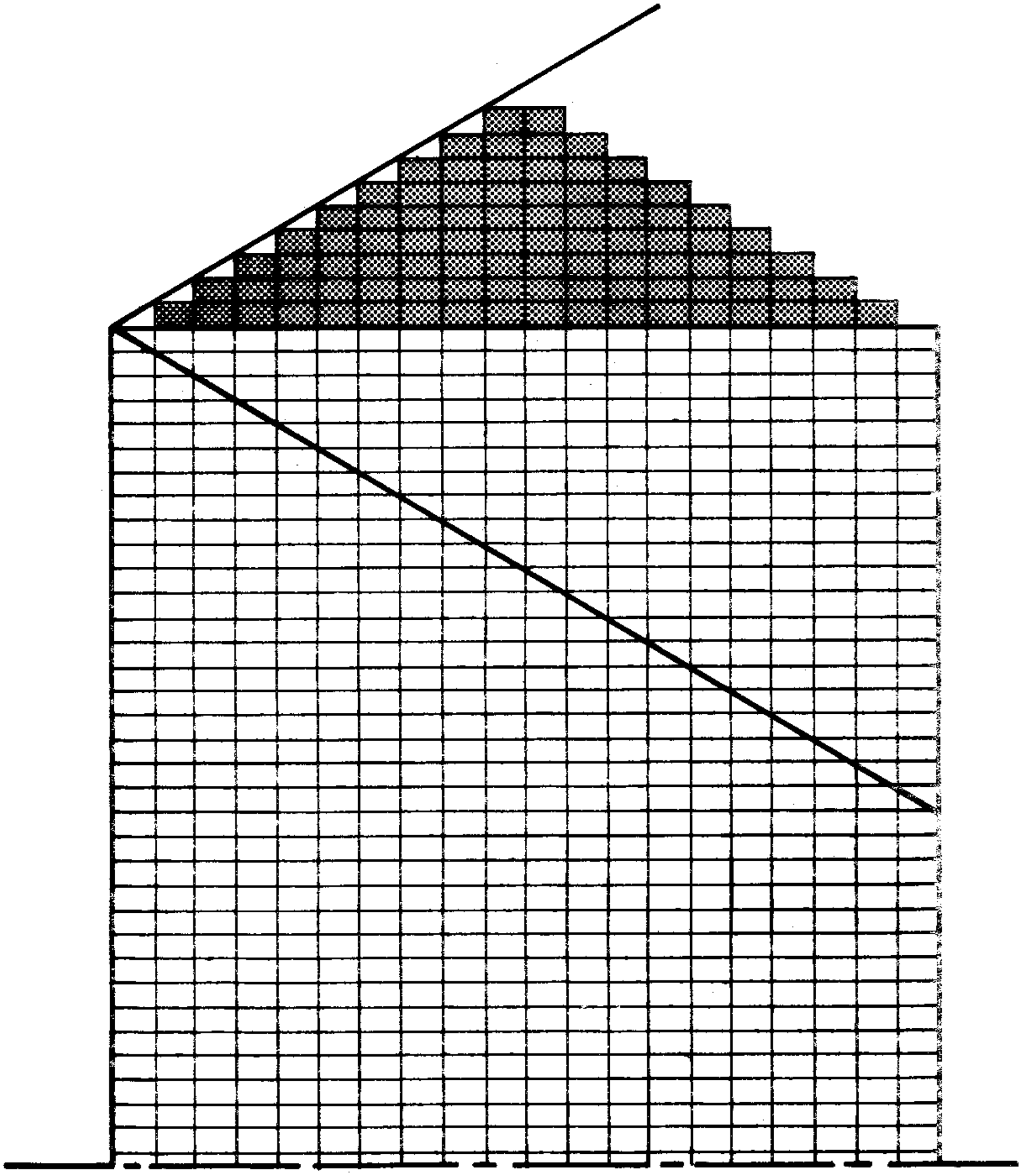

(a) $M_\infty = 2.0$

Figure 2. Mach Box Approximation to the Aspect Ratio 2.0 Rectangular Wing

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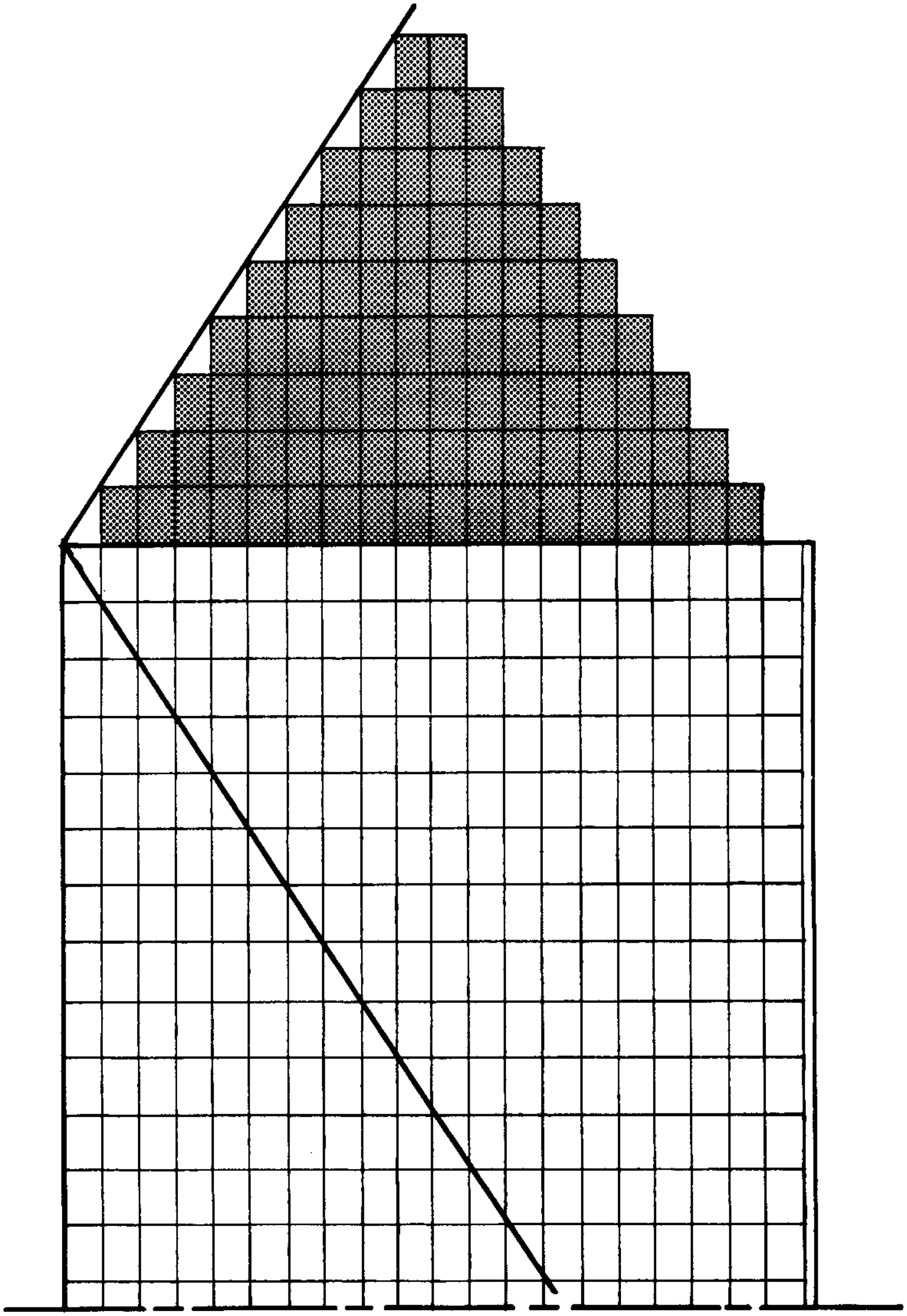

(b) $M_\infty = 1.20$

Figure 2. Mach Box Approximation to the Aspect Ratio 2.0 Rectangular Wing

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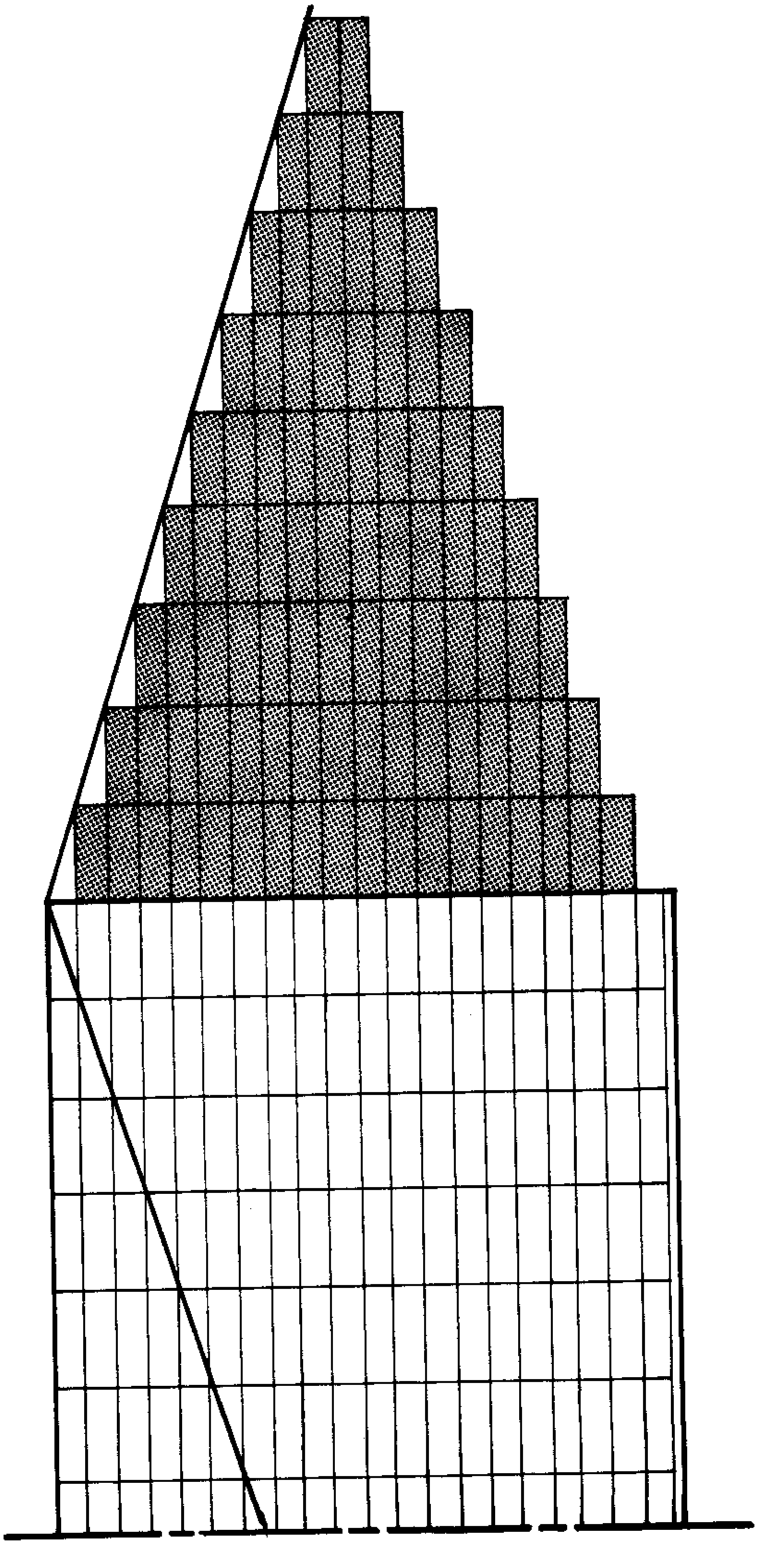

(c) $M_\infty = 1.05$

Figure 2. Mach Box Approximation to the Aspect Ratio 2.0 Rectangular Wing

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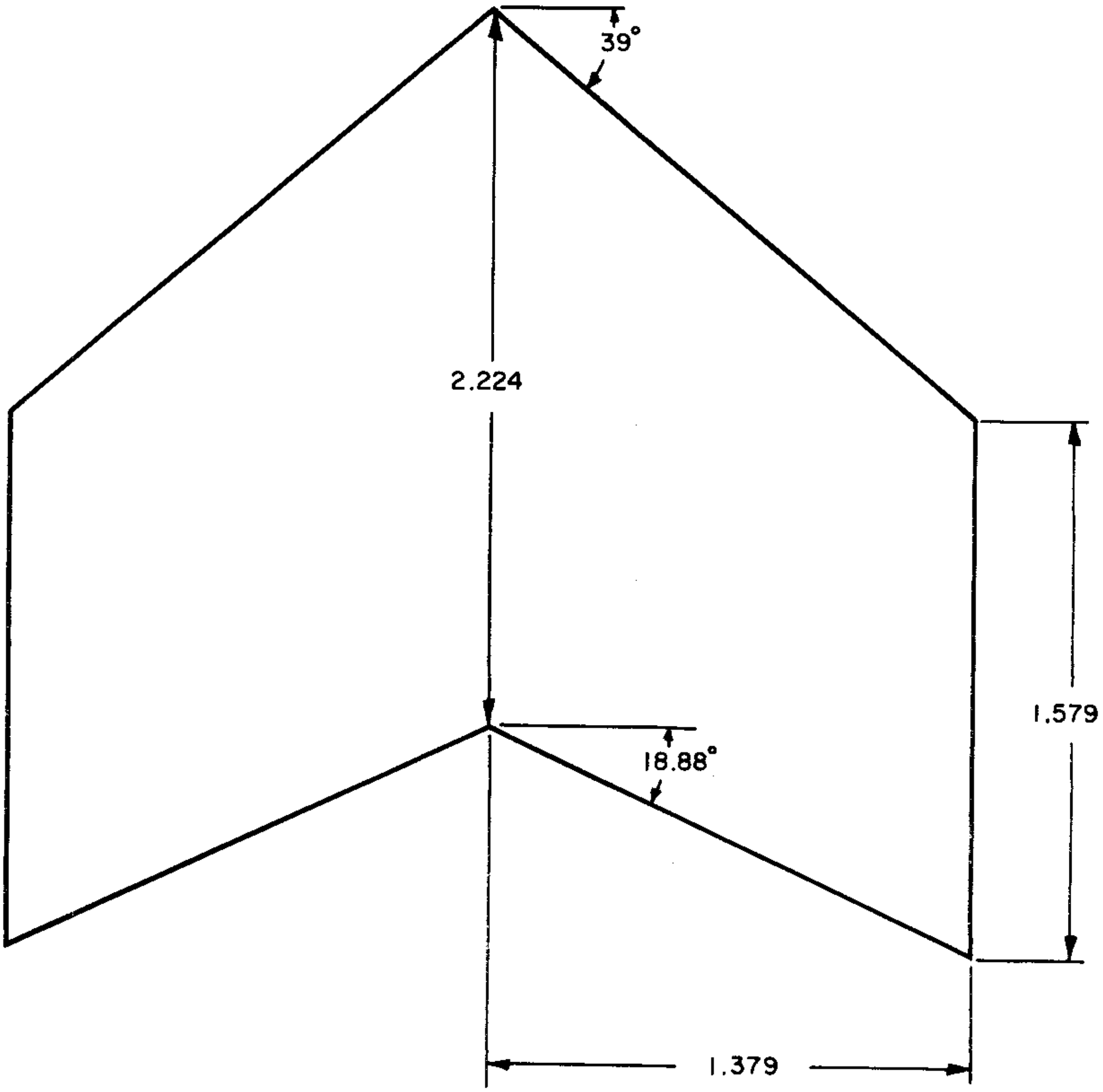

Figure 3. The AGARD Aspect Ratio 1.45 Tapered Swept-Back Wing

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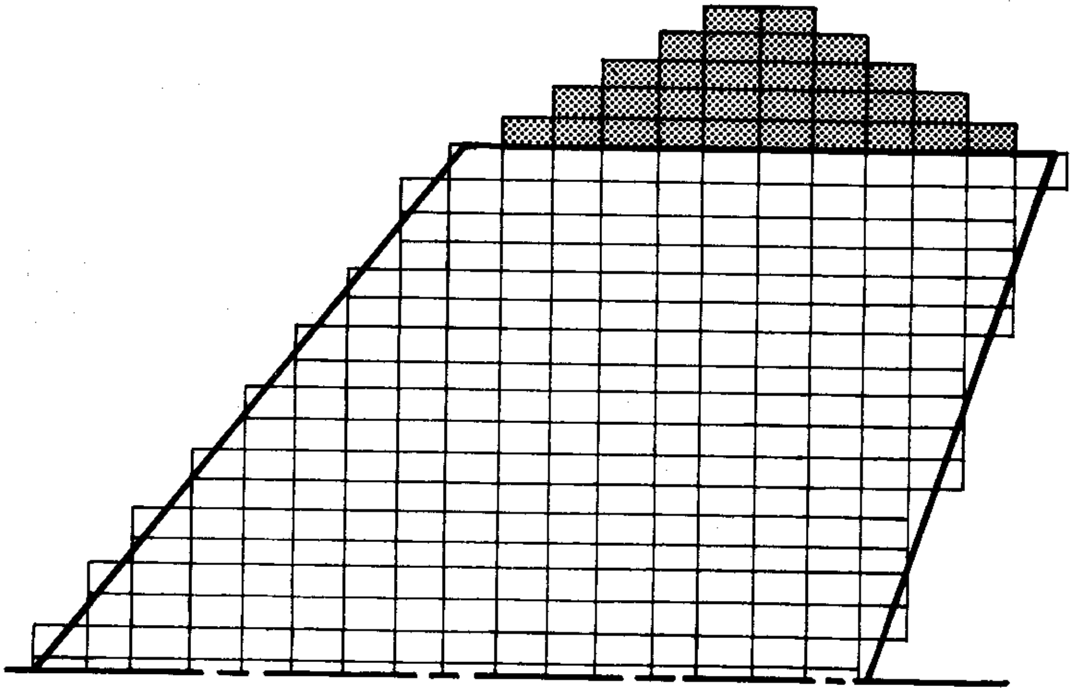

(a) $M_{\infty} = 2.0$

Figure 4. The Mach Box Approximation to the AGARD Aspect Ratio 1.45 Tapered Swept-Back Wing

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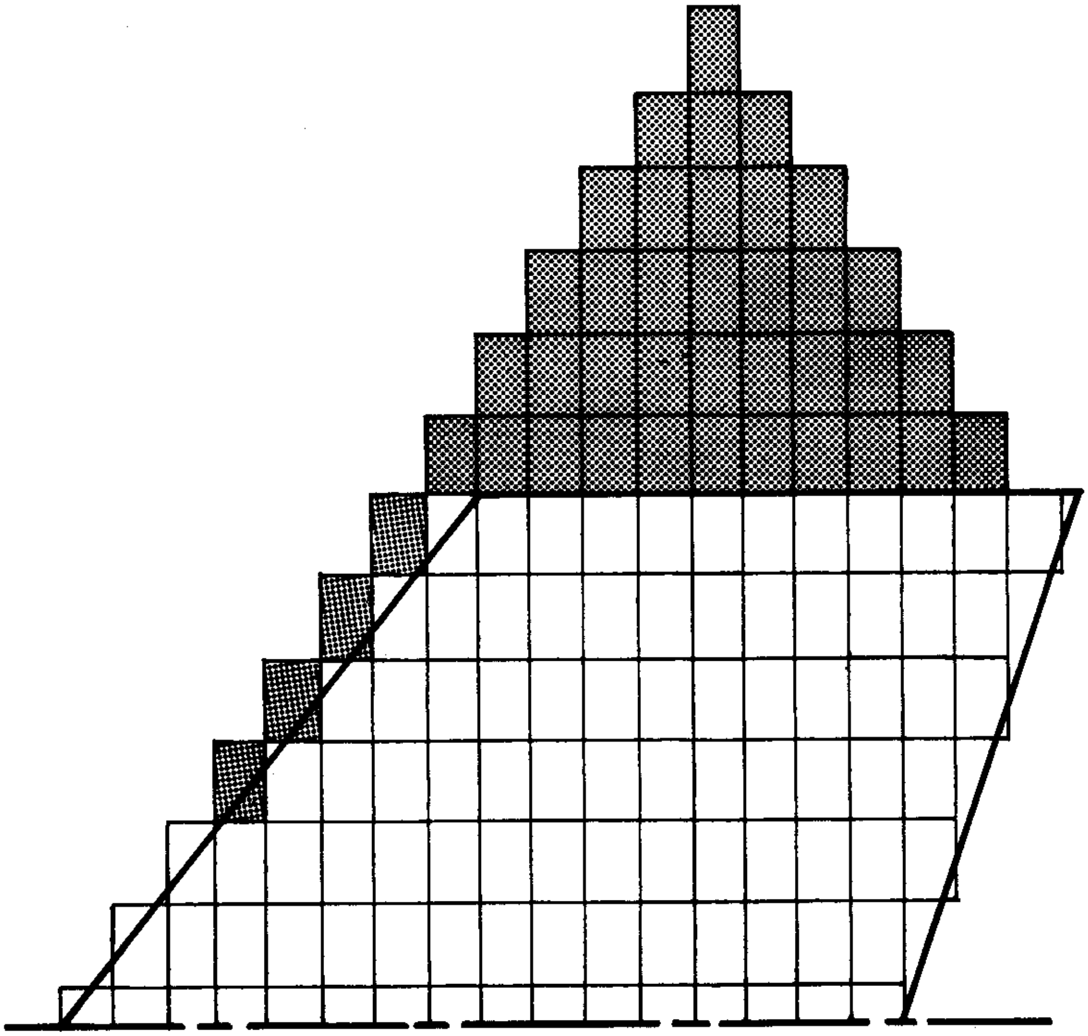

(b) $M_{\infty} = 1.2$

Figure 4. The Mach Box Approximation to the AGARD Aspect Ratio 1.45 Tapered Swept-Back Wing

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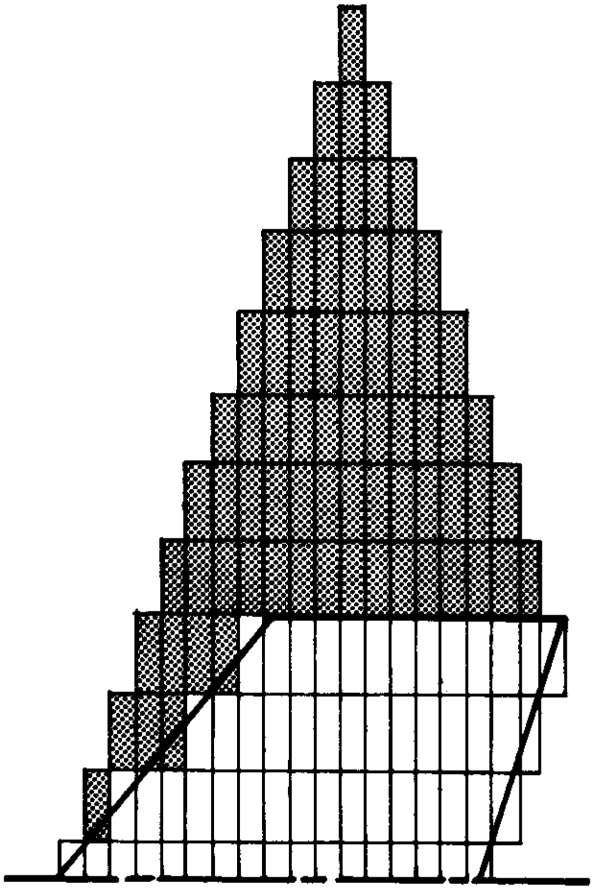

(c) $M_\infty = 1.057$

Figure 4. The Mach Box Approximation to the AGARD Aspect Ratio 1.45 Tapered Swept-Back Wing

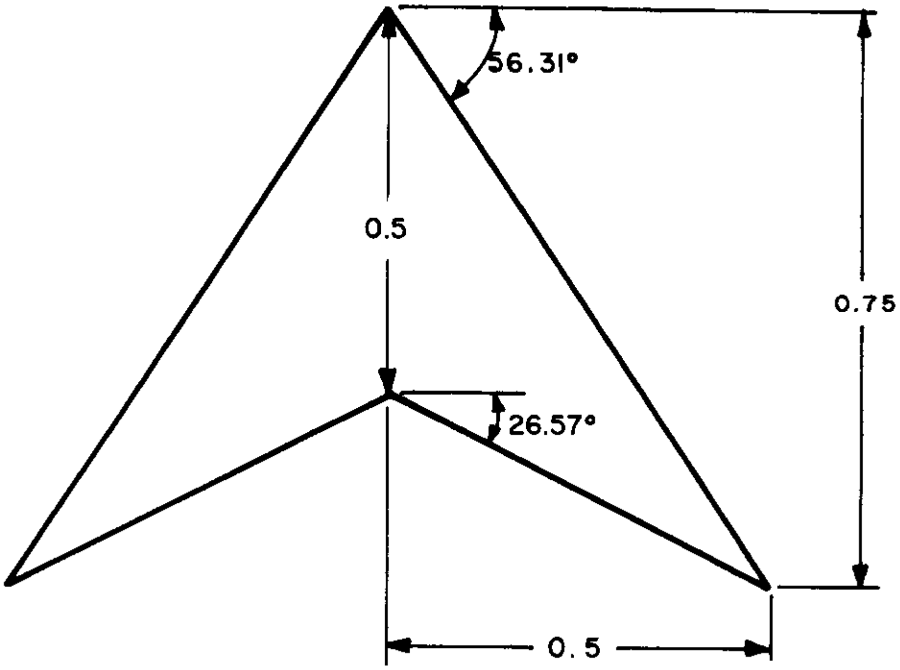

Figure 5. The AGARD Aspect Ratio 4.0 Arrowhead Wing

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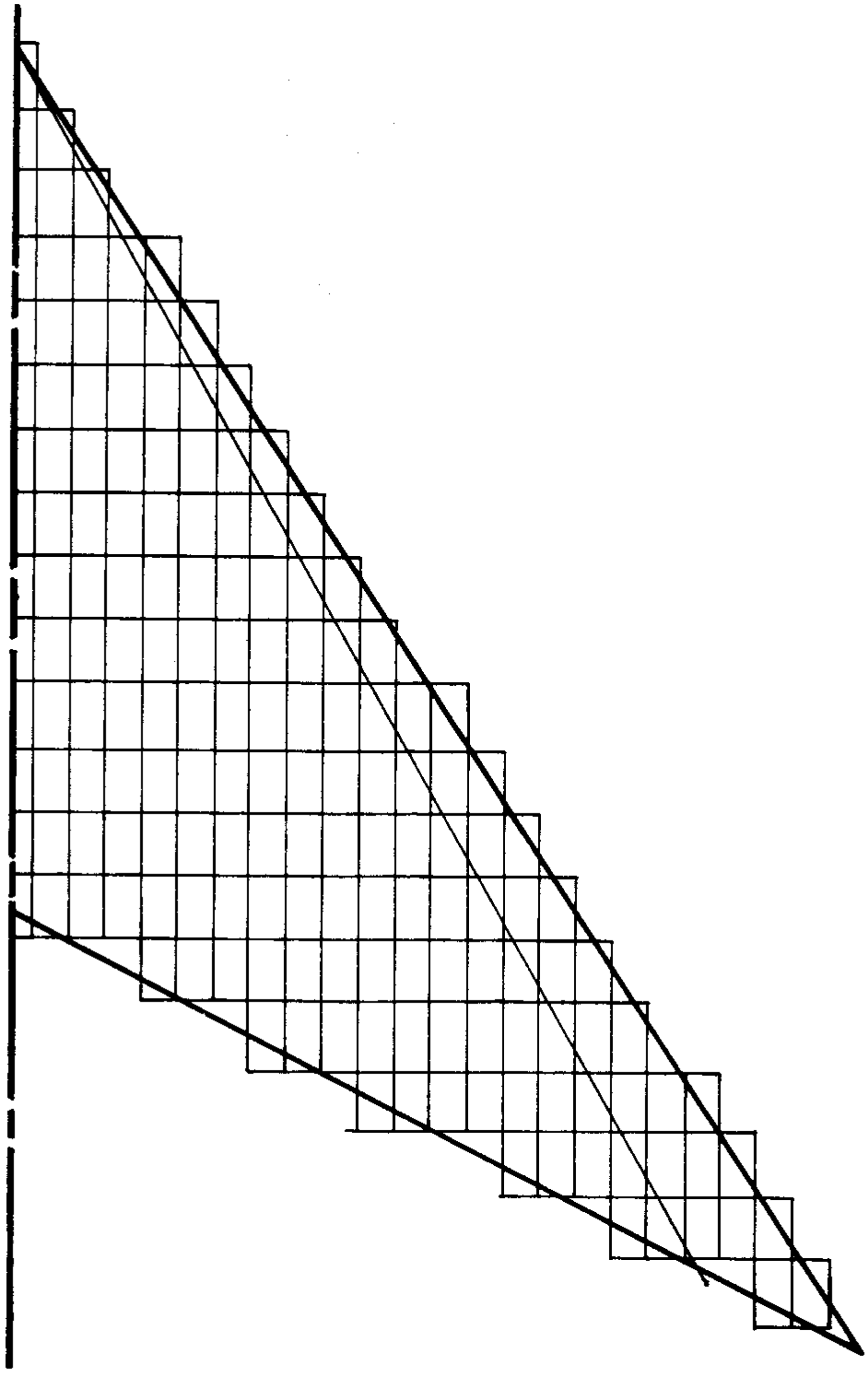

(a) $M_\infty = 2.0$

Figure 6. The Mach Box Approximation to the AGARD Aspect Ratio 4.0 Arrowhead Wing

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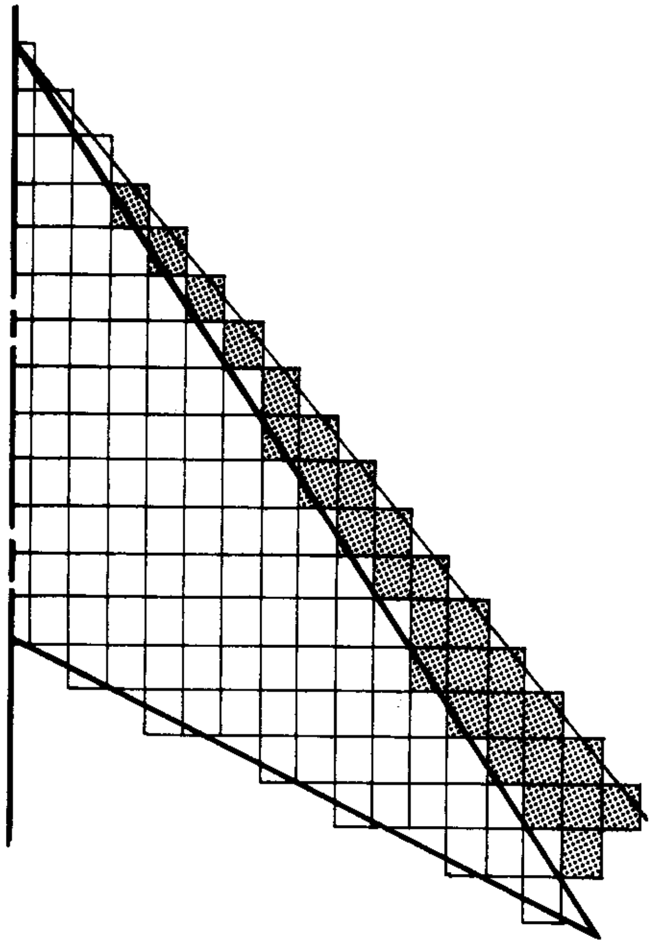

(b) $M_{\infty} = 1.5621$

Figure 6. The Mach Box Approximation to the AGARD Aspect Ratio 4.0 Arrowhead Wing

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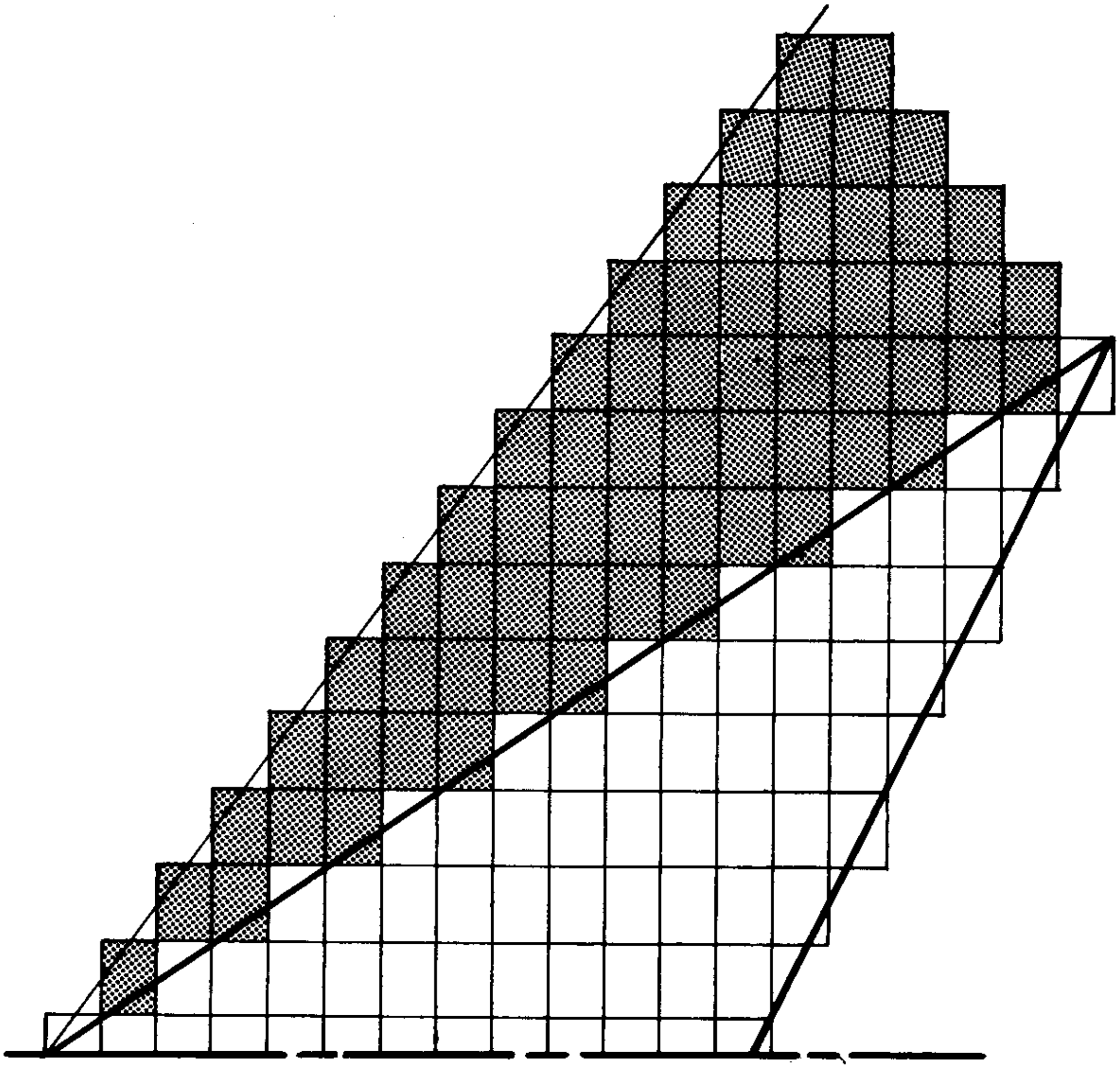

(c) $M_{\infty} = 1.25$

Figure 6. The Mach Box Approximation to the AGARD Aspect Ratio 4.0 Arrowhead Wing

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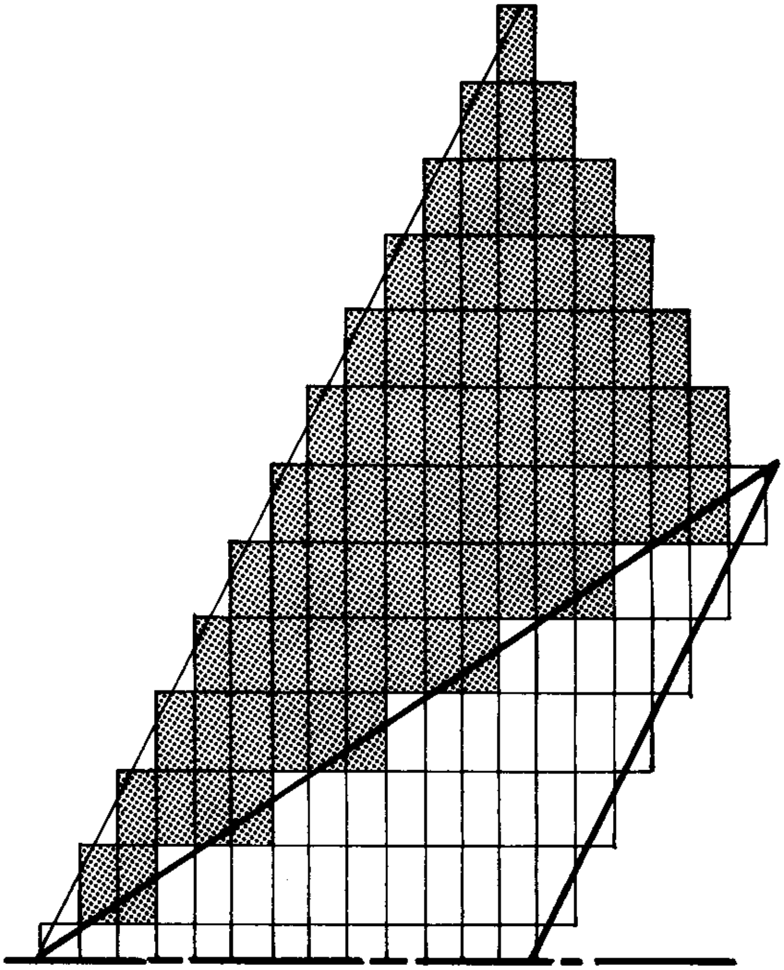

(d) $M_\infty = 1.12$

Figure 6. The Mach Box Approximation to the AGARD Aspect Ratio 4.0 Arrowhead Wing

TABLE I

MACH NUMBER, k_s, AND FREQUENCY FOR THE AGARD ASPECT RATIO 2.0 RECTANGLE

M	k_s	f (cps)
1.05	0	0
	0.3	50.14
	0.6	100.3
	1.0	167.1
	2.0	334.2
1.20	0	0
	0.3	57.30
	0.6	114.6
	1.0	191.0
	2.0	382.0
2.00	0	0
	0.3	95.51
	0.6	191.0
	1.0	318.4
	2.0	636.6

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TABLE II

MODE SHAPES FOR THE ASPECT RATIO 2.0 RECTANGULAR WING IN AGARD AND MACH BOX COORDINATE SYSTEMS

Mode	$f(x,y)$	$Z(X,Y)$
1	1	1
2	x	$-0.5 + X$
3	x^2	$0.25 - X + X^2$
4	y^2	Y^2
5	x^2y^2	$0.25Y^2 - XY^2 + X^2Y^2$
6	$\|y\|$	$\|Y\|$
7	$x\|y\|$	$-0.5\|Y\| + X\|Y\|$

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TABLE III

Q'_{ij} IN AGARD NOTATION, ASPECT RATIO 2.0 RECTANGLE

(a) $M_\infty = 2.0$, $k_s = 0.0$

I	J=1	J=2	J=3	J=4	J=5	J=6	J=7
1	0.0	1.988,0	1.123,-1	0.0	7.554,-2	0.0	8.478,-1
2	0.0	-5.579,-2	3,864,-1	0.0	1.235,-1	0.0	-5.105,-2
3	0.0	1.660,-1	5.713,-3	0.0	2.792,-3	0.0	7.142,-2
4	0.0	4.631,-2	2.165,-1	0.0	1.199,-1	0.0	3.709,-2
5	0.0	-7.542,-2	3.870,-2	0.0	1.521,-2	0.0	-4.369,-2
6	0.0	-1.704,-1	4.184,-1	0.0	1.621,-1	0.0	8.621,-3
7	0.0	4.809,-1	2.424,-2	0.0	4.818,-2	0.0	1.914,-1

(b) $M_\infty = 2.0$, $k_s = 0.3$

I	J=1	J=2	J=3	J=4	J=5	J=6	J=7
1	1.746,-2	1.971,0	1.202,-1	-1.748,-4	7.614,-2	1.737,-3	8.444,-1
2	1.454,-3	-5.829,-2	3.873,-1	-8.062,-4	1.234,-1	-9.221,-4	-5.108,-2
3	1.163,-3	1.646,-1	6.245,-3	-1.427,-4	2.792,-3	-7.518,-5	7.125,-2
4	-1.695,-2	5.456,-2	2.121,-1	-9.927,-3	1.174,-1	-1.267,-2	4.334,-2
5	-4.409,-3	-7.299,-2	3.743,-2	-1.966,-3	1.470,-2	-2.762,-3	-4.221,-2
6	-3.563,-2	-1.515,-1	4.085,-1	-1.340,-2	1.586,-1	-1.923,-2	1.859,-2
7	1.931,-2	4.685,-1	3.042,-2	3.821,-3	4.931,-2	6.921,-3	1.871,-1

(c) $M_\infty = 2.0$, $k_s = 0.6$

I	J=1	J=2	J=3	J=4	J=5	J=6	J=7
1	6.173,-2	1.927,0	1.410,-1	-2.279,-3	7.737,-2	4.212,-3	8.360,-1
2	3.519,-3	-6.420,-2	3.892,-1	-3.637,-3	1.228,-1	-4.411,-3	-5.065,-2
3	3.763,-3	1.614,-1	7.511,-3	-7.305,-4	2.731,-3	-5.803,-4	7.093,-2
4	-6.739,-2	7.921,-2	1.992,-1	-3.931,-2	1.101,-1	-5.021,-2	6.187,-2
5	-1.728,-2	-6.586,-2	3.373,-2	-7.708,-3	1.319,-2	-1.083,-2	-3.789,-2
6	-1.407,-1	-9.567,-2	3.791,-1	-5.302,-2	1.480,-1	-7.606,-2	4.807,-2
7	7.394,-2	4.338,-1	4.785,-2	1.455,-2	5.247,-2	2.642,-2	1.749,-1

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TABLE III (CONTD)

(d) $M_\infty = 2.0$, $k_s = 1.0$

I	J=1	J=2	J=3	J=4	J=5	J=6	J=7
1	1.240,-1	1.851,0	1.746,-1	-1.546,-2	7.725,-2	-4.154,-3	8.261,-1
2	-3.342,-3	-6.981,-2	3.890,-1	-1.239,-2	1.206,-1	-1.628,-2	-4.699,-2
3	5.394,-3	1.568,-1	8.798,-3	-2.912,-3	2.280,-3	-3.164,-3	7.120,-2
4	-1.842,-1	1.367,-1	1.691,-1	-1.065,-1	9.347,-2	-1,363,-1	1.045,-1
5	-4.578,-2	-5.012,-2	2.558,-2	-2.042,-2	9.894,-3	-2.867,-2	-2.837,-2
6	-3.790,-1	3.119,-2	3.124,-1	-1.434,-1	1.240,-1	-2.055,-1	1.154,-1
7	1.855,-1	3.616,-1	8.301,-2	3.610,-2	5.865,-2	6.589,-2	1.504,-1

(e) $M_\infty = 2.0$, $k_s = 2.0$

I	J=1	J=2	J=3	J=4	J=5	J=6	J=7
1	-5.952,-2	1.838,0	1.503,-1	-1.588,-1	4.421,-2	-1.890,-1	8.879,-1
2	-1.452,-1	-9.681,-3	3.438,-1	-6.792,-2	1.037,-1	-9.918,-2	-5.992,-3
3	-2.859,-2	1.682,-1	-2.035,-3	-1.870,-2	-2.320,-3	-2.564,-2	8.149,-2
4	-6.559,-1	3.729,-1	4.586,-2	-3.718,-1	2.866,-2	-4.770,-1	2.734,-1
5	-1.447,-1	4.217,-3	-2.142,-3	-6.501,-2	-1.103,-3	-9.084,-2	4.213,-3
6	-1.283,0	5.145,-1	5.970,-2	-4.941,-1	3.193,-2	-7.052,-1	3.757,-1
7	4.789,-1	1.753,-1	1.685,-1	9.041,-2	7.173,-2	1.680,-1	8.987,-2

(f) $M_\infty = 1.20$, $k_s = 0.0$

I	J=1	J=2	J=3	J=4	J=5	J=6	J=7
1	0.0,-0	3.836,-0	7.603,-1	0.0,-0	3.439,-1	0.0,-0	1.180,-0
2	0.0,-0	-3.783,-1	1.021,-0	0.0,-0	2.800,-1	0.0,-0	-2.559,-1
3	0.0,-0	3.264,-1	4.290,-2	0.0,-0	7.144,-3	0.0,-0	1.202,-1
4	0.0,-0	-3.603,-2	4.916,-1	0.0,-0	2.200,-1	0.0,-0	-7.159,-2
5	0.0,-0	-1.552,-1	6.702,-2	0.0,-0	9.345,-3	0.0,-0	-6.860,-2
6	0.0,-0	-6.793,-1	1.005,-0	0.0,-0	3.368,-1	0.0,-0	-2.380,-1
7	0.0,-0	9.670,-1	1.201,-1	0.0,-0	1.120,-1	0.0,-0	2.591,-1

Contrails

TABLE III (CONTD)

(g) $M_\infty = 1.20$, $k_s = 0.3$

I	J=1	J=2	J=3	J=4	J=5	J=6	J=7
1	1.952,-1	3.439,-0	9.064,-1	3.275,-3	3.428,-1	7.615,-3	1.137,-0
2	-3.213,-3	-4.262,-1	1.016,-0	-9.463,-3	2.716,-1	-1.539,-2	-2.477,-1
3	1.010,-2	2.989,-1	4.632,-2	-3.740,-4	5.836,-3	-5.921,-4	1.186,-1
4	-2.869,-2	-4.382,-2	4.846,-1	-2.056,-2	2.135,-1	-2.894,-2	-5.654,-2
5	-1.455,-2	-1.414,-1	5.790,-2	-3.786,-3	7.940,-3	-6.119,-3	-6.340,-2
6	-9.735,-2	-6.257,-1	9.560,-1	-3.528,-2	3.220,-1	-5.324,-2	-2.013,-1
7	8.534,-2	8.355,-1	1.780,-1	9.104,-3	1.165,-1	1.542,-2	2.366,-1

(h) $M_\infty = 1.20$, $k_s = 0.6$

I	J=1	J=2	J=3	J=4	J=5	J=6	J=7
1	3.588,-1	2.886,-0	9.927,-1	-3.142,-2	3.039,-1	-4.298,-2	1.125,-0
2	-1.077,-1	-3.975,-1	9.115,-1	-4.408,-2	2.406,-1	-7.175,-2	-1.968,-1
3	3.124,-3	2.838,-1	2.303,-2	-4.517,-3	-6.179,-4	-7.228,-3	1.248,-1
4	-1.542,-1	8.845,-3	4.240,-1	-8.335,-2	1.917,-1	-1.179,-1	-7.136,-5
5	-5.251,-2	-1.022,-1	3.316,-2	-1.348,-2	4.688,-3	-2.159,-2	-5.005,-2
6	-4.106,-1	-3.912,-1	7.759,-1	-1.377,-1	2.773,-1	-2.077,-1	-8.353,-2
7	2.245,-1	6.082,-1	2.573,-1	2.251,-2	1.193,-1	3.877,-2	2.034,-1

(i) $M_\infty = 1.20$, $k_s = 1.0$

I	J=1	J=2	J=3	J=4	J=5	J=6	J=7
1	6.904,-2	2.993,0	5.613,-1	-1.460,-1	1.866,-1	-2.164,-1	1.293,0
2	-3.578,-1	-9.119,-2	6.170,-1	-9.989,-2	1.863,-1	-1.616,-1	-8.052,-2
3	-1.799,-2	3.367,-1	-4.564,-2	-7.861,-3	-9.549,-3	-1.176,-2	1.408,-1
4	-4.365,-1	2.330,-1	2.587,-1	-2.104,-1	1.512,-1	-2.929,-1	1.218,-1
5	-1.015,-1	-4.513,-2	2.551,-3	-2.830,-2	2.553,-3	-4.397,-2	-3.313,-2
6	-9.817,-1	1.417,-1	4.269,-1	-3.278,-1	2.030,-1	-4.876,-1	1.396,-1
7	3.152,-1	4.871,-1	2.376,-1	3.277,-2	1.097,-1	5.950,-2	1.948,-1

Contrails

TABLE III (CONTD)

(j) $M_\infty = 1.20$, $k_s = 2.0$

I	J=1	J=2	J=3	J=4	J=5	J=6	J=7
1	-5.088,-1	3.263,0	2.262,-1	-4.451,-1	6.116,-2	-6.480,-1	1.568,0
2	-5.829,-1	1.172,-1	5.034,-1	-1.912,-1	1.530,-1	-3.050,-1	3.309,-2
3	2.283,-4	2.849,-1	-2.923,-3	-1.866,-2	-4.488,-3	-2.523,-2	1.355,-1
4	-1.116,0	6.094,-1	8.660,-2	-6.302,-1	7.084,-1	-8.335,-1	3.995,-1
5	-1.981,-1	2.517,-3	-2.935,-3	-7.990,-4	6.990,-4	-1.154,-1	-4.649,-3
6	-2.213,0	9.120,-1	9.414,-2	-8.904,-1	7.434,-2	-1.277,0	5.911,-1
7	5.860,-1	3.118,-1	2.646,-1	7.177,-2	1.115,-1	1.415,-1	1.594,-1

(k) $M_\infty = 1.05$, $k_s = 0.0$

I	J=1	J=2	J=3	J=4	J=5	J=6	J=7
1	0.000,0	3.776,0	2.693,0	0.000,0	6,095,-1	0.000,0	1.008,0
2	0.000,0	-1.348,0	1.921,0	0.000,0	3.527,-1	0.000,0	-4.343,-1
3	0.000,0	3.770,-1	8.046,-2	0.000,0	-1.440,-2	0.000,0	1.782,-1
4	0.000,0	-4.093,-1	9.456,-1	0.000,0	2.687,-1	0.000,0	-1.640,-1
5	0.000,0	-2.442,-1	7.697,-2	0.000,0	-5.394,-3	0.000,0	-6.413,-2
6	0.000,0	-1.604,0	1.737,0	0.000,0	3.967,-1	0.000,0	-4.060,-1
7	0.000,0	1.036,0	5.357,-1	0.000,0	1.742,-1	0.000,0	2.113,-1

(l) $M_\infty = 1.05$, $k_s = 0.3$

I	J=1	J=2	J=3	J=4	J=5	J=6	J=7
1	3.090,-2	3.990,0	1.354,0	-3.147,-2	4.672,-1	-4.943,-2	1.160,0
2	-1.824,-1	-5.801,-1	1.136,0	-2.531,-2	2.968,-1	-4.021,-2	-3.146,-1
3	1.087,-2	4.944,-1	-7.466,-2	3.683,-3	-1.549,-2	5.994,-3	1.786,-1
4	-1.155,-1	-2.762,-2	5.373,-1	-3.172,-2	2.323,-1	-4.663,-2	-8.112,-2
5	-2.817,-2	-1.286,-1	1.689,-2	-3.176,-3	-4.038,-3	-4.821,-3	-5.479,-2
6	-2.789,-1	-7.216,-1	1.000,0	-5.350,-2	3.409,-1	-8.154,-2	-2.572,-1
7	6.952,-2	9.512,-1	2.954,-1	2.732,-3	1.467,-1	4.407,-3	2.287,-1

Contrails

TABLE III (CONTD)

(m) $M_\infty = 1.05$, $k_s = 0.6$

I	J=1	J=2	J=3	J=4	J=5	J=6	J=7
1	1.422,-1	3.818,0	8.502,-1	-9.146,-2	3.612,-1	-1.425,-1	1.304,0
2	-3.325,-1	-2.391,-1	8.625,-1	-6.427,-2	2.633,-1	-1.027,-1	-2.155,-1
3	3.449,-2	4.228,-1	-4.465,-2	7.578,-3	-9.947,-3	1.231,-2	1.644,-1
4	-2.584,-1	1.786,-1	3.694,-1	-1.010,-1	2.037,-1	-1.458,-1	9.356,-3
5	-6.274,-2	-7.981,-2	9.351,-3	-1.080,-2	-1.996,-3	-1.652,-2	-4.783,-2
6	-6.330,-1	-1.832,-1	6.892,-1	-1.662,-1	2.966,-1	-2.510,-1	-9.174,-2
7	2.060,-1	7.794,-1	2.305,-1	1.337,-2	1.310,-1	2.158,-2	2.292,-1

(n) $M_\infty = 1.05$, $k_s = 1.0$

I	J=1	J=2	J=3	J=4	J=5	J=6	J=7
1	2.711,-1	3.655,0	5.690,-1	-1.849,-1	2.761,-1	-2.818,-1	1.448,0
2	-3.953,-1	-5.033,-2	7.010,-1	-1.078,-1	2.417,-1	-1.722,-1	-1.362,-1
3	9.334,-2	3.573,-1	-2.119,-2	1.411,-2	-9.543,-4	2.289,-2	1.445,-1
4	-4.417,-1	3.212,-1	2.737,-1	-2.288,-1	1.835,-1	-3.215,-1	1.099,-1
5	-9.003,-2	-5.018,-2	4.215,-3	-2.322,-2	1.745,-3	-3.560,-2	-4.292,-2
6	-1.056,0	2.308,-1	4.775,-1	-3.624,-1	2.592,-1	-5.383,-1	9.781,-2
7	4.013,-1	5.874,-1	2.367,-1	3.640,-2	1.310,-1	5.979,-2	2.065,-1

(o) $M_\infty = 1.05$, $k_s = 2.0$

I	J=1	J=2	J=3	J=4	J=5	J=6	J=7
1	-3.300,-1	3.749,0	2.976,-1	-5.421,-1	1.065,-1	-7.902,-1	1.810,0
2	-6.166,-1	1.214,-1	5.970,-1	-2.250,-1	2.007,-1	-3.469,-1	3.886,-3
3	1.126,-1	2.839,-1	2.017,-2	2.682,-3	6.641,-3	1.229,-2	1.309,-1
4	-1.237,0	6.896,-1	1.288,-1	-7.328,-1	1.054,-1	-9.700,-1	4.279,-1
5	-1.987,-1	-8.731,-3	3.847,-3	-8.151,-2	3.961,-3	-1.170,-1	-1.752,-2
6	-2.449,0	1.019,0	1.612,-1	-1.048,0	1.277,-1	-1.488,0	6.258,-1
7	6.707,-1	3.432,-1	3.095,-1	6.950,-2	1.381,-1	1.349,-1	1.707,-1

Contrails

TABLE IV

Q''_{ij} IN AGARD NOTATION, ASPECT RATIO 2.0 RECTANGLE

(a) $M = 2.0$, $k = 0.3$

I	J=1	J=2	J=3	J=4	J=5	J=6	J=7
1	1.973,-0	-1.344,-1	1.966,-1	5.202,-1	2.637,-2	8.436,-1	3.318,-2
2	-5.918,-2	1.776,-1	-2.228,-2	-3.795,-2	-1.148,-2	-5.182,-2	1.062,-1
3	1.646,-1	-9.840,-3	2.482,-2	4.453,-2	5.706,-3	7.110,-2	3.233,-3
4	4.989,-2	2.953,-1	-9.677,-2	3.041,-2	-5.134,-2	3.997,-2	2.178,-1
5	-7.410,-2	6.790,-2	-2.576,-2	-2.909,-2	-9.162,-3	-4.286,-2	4.173,-2
6	-1.613,-1	6.019,-1	-2.282,-1	2.939,-2	-7.518,-2	1.330,-2	3.283,-1
7	4.727,-1	-2.024,-1	1.322,-1	1.096,-1	2.624,-2	1.884,-1	-4.836,-2

(b) $M_\infty = 2.0$, $k_s = 0.6$

I	J=1	J=2	J=3	J=4	J=5	J=6	J=7
1	1.930,0	-1.028,-1	1.801,-1	5.138,-1	2.366,-2	8.315,-1	4.266,-2
2	-6.830,-2	1.851,-1	-2.604,-2	-3.888,-2	-1.196,-2	-5. 374,-2	1.081,-1
3	1.608,-1	-6.820,-3	2.331,-2	4.409,-2	5.500,-3	7.022,-2	4.023,-3
4	6.073,-2	2.902,-1	-9.408,-2	3.717,-2	-4.958,-2	4.856,-2	2.135,-1
5	-7.013,-2	5.675,-2	-2.457,-2	-2.736,-2	-8.667,-3	-4.040,-2	4.036,-2
6	-1.342,-1	5.876,-1	-2.205,-1	3.896,-2	-7.253,-2	2.728,-2	3.210,-1
7	4.489,-1	-1.848,-1	1.242,-1	1.049,-1	2.466,-2	1.798,-1	-4.282,-2

(c) $M_\infty = 2.0$, $k_s = 1.0$

I	J=1	J=2	J=3	J=4	J=5	J=6	J=7
1	1.848,0	-3.924,-2	1.473,-1	5.025,-1	1.855,-2	8.097,-1	6.105,-2
2	-8.435,-2	1.993,-1	-3.297,-2	-3.996,-2	-1.269,-2	-5.636,-2	1.113,-1
3	1.541,-1	-1.105,-3	2.053,-2	4.350,-2	5.172,-3	6.894,-2	5.395,-3
4	8.698,-2	2.778,-1	-8.747,-2	5.311,-2	-4.542,-2	6.896,-2	2.034,-1
5	-6.113,-2	6.062,-2	-2.188,-2	-2.345,-2	-7.553,-3	-3.484,-2	3.728,-2
6	-7.091,-2	5.541,-1	-2.026,-1	6.146,-2	-6.633,-2	6.016,-2	3.039,-1
7	3.991,-1	-1.522,-1	1.073,-1	9.487,-2	2.142,-2	1.620,-1	-3.129,-2

Contrails

TABLE IV (CONTD)

(d) $M_\infty = 2.0$, $k_s = 2.0$

I	J=1	J=2	J=3	J=4	J=5	J=6	J=7
1	1.692,-0	1.043,-1	7.699,-2	4.968,-1	1.181,-2	7.881,-1	9.273,-2
2	-8.921,-2	2.175,-1	-3.953,-2	-3.140,-2	-1.106,-2	-4.579,-2	1.100,-1
3	1.495,-1	7.248,-3	1.736,-2	4.580,-2	5.545,-3	7.171,-2	5.656,-3
4	2.094,-1	2.165,-1	-5.485,-2	1.223,-1	-2.707,-2	1.591,-1	1.572,-1
5	-2.613,-2	4.077,-2	-1.137,-2	-8.435,-3	-3.304,-3	-1.336,-2	2.531,-2
6	1.977,-1	4.088,-1	-1.251,-1	1.584,-1	-3.914,-2	2.020,-1	2.283,-1
7	2.514,-1	-5.453,-2	5.782,-2	6.817,-2	1.293,-2	1.123,-1	1.307,-3

(e) $M_\infty = 1.2$, $k_s = 0.3$

I	J=1	J=2	J=3	J=4	J=5	J=6	J=7
1	3.435,0	-1.721,0	2.042,-1	6.920,-1	-1.653,-1	1.119,0	1.879,-1
2	-4.481,-1	5.454,-1	-5.053,-1	-1.646,-1	-1.344,-1	-2.577,-1	3.899,-1
3	2.951,-1	-8.935,-2	-2.637,-2	7.373,-2	-4.838,-3	1.168,-1	1.247,-2
4	-5.864,-2	5.295,-1	-3.150,-1	-4.092,-2	-1.112,-1	-6.550,-2	4.737,-1
5	-1.454,-1	1.911,-1	-8.834,-2	-3.657,-2	-7.248,-3	-6.445,-2	7.625,-2
6	-6.631,-1	1.565,0	-8.572,-1	-1.187,-1	-2.180,-1	-2.179,-1	8.340,-1
7	8.462,-1	-8.624,-1	3.103,-1	1.358,-1	2.040,-2	2.364,-1	-8.865,-2

(f) $M_\infty = 1.2$, $k_s = 0.6$

I	J=1	J=2	J=3	J=4	J=5	J=6	J=7
1	2.777,0	-5.008,-1	-3.433,-1	6.493,-1	-1.920,-1	1.048,0	3.642,-1
2	-4.968,-1	7.644,-1	-5.599,-1	-1.504,-1	-1.224,-1	-2.342,-1	3.944,-1
3	2.636,-1	2.553,-3	-5.065,-2	7.441,-2	-2.558,-3	1.183,-1	2.004,-2
4	-5.548,-2	6.483,-1	-3.371,-1	-2.047,-2	-1.033,-1	-3.399,-2	4.642,-1
5	-1.153,-1	1.642,-1	-6.808,-2	-3.333,-2	-3.495,-3	-5.310,-2	6.521,-2
6	-5.348,-1	1.549,0	-8.003,-1	-7.223,-2	-1.940,-1	-1.441,-1	7.877,-1
7	6.215,-1	-5.024,-1	1.328,-1	1.127,-1	4.929,-3	1.985,-1	-2.471,-2

Contrails

TABLE IV (CONTD)

(g) $M_\infty = 1.2$, $k_s = 1.0$

I	J=1	J=2	J=3	J=4	J=5	J=6	J=7
1	2.633,0	2.215,-1	-4.137,-1	6.950,-1	-1.290,-1	1.121,0	3.684,-1
2	-2.911,-1	6.795,-1	-3.703,-1	-9.707,-2	-7.112,-2	-1.462,-1	3.112,-1
3	3.076,-1	-9.697,-3	9.894,-3	8.400,-2	1.136,-2	1.344,-1	1.829,-3
4	9.036,-2	5.819,-1	-2.451,-1	3.272,-2	-7.520,-2	4.938,-2	3.998,-1
5	-6.312,-2	1.046,-1	-2.728,-2	-2.371,-2	1.917,-3	-3.644,-2	4.650,-2
6	-1.456,-1	1.232,0	-5.315,-1	2.848,-2	-1.340,-1	1.662,-2	6.436,-1
7	4.766,-1	-2.080,-1	3.602,-2	1.027,-1	4.999,-3	1.824,-1	1.168,-2

(h) $M_\infty = 1.2$, $k_s = 2.0$

I	J=1	J=2	J=3	J=4	J=5	J=6	J=7
1	2.675,0	2.423,-1	-2.565,-2	7.771,-1	-1.802,-2	1.246,0	2.228,-1
2	-1.187,-1	4.030,-1	-1.043,-1	-4.424,-2	-2.231,-2	-6.176,-2	1.985,-1
3	2.686,-1	-1.262,-2	3.890,-2	8.073,-2	1.288,-2	1.280,-1	-4.515,-4
4	3.425,-1	3.573,-1	-8.631,-2	1.542,-1	-3.795,-2	2.226,-1	2.738,-1
5	-2.157,-2	5.221,-2	-5.100,-3	-9.611,-3	1.708,-3	-1.434,-2	3.132,-2
6	4.037,-1	6.745,-1	-1.911,-1	2.246,-1	-6.223,-2	3.091,-1	4.054,-1
7	3.278,-1	-4.576,-2	4.401,-2	8.785,-2	1.213,-2	1.528,-1	2.895,-2

(i) $M_\infty = 1.05$, $k_s = 0.3$

I	J=1	J=2	J=3	J=4	J=5	J=6	J=7
1	3.808,0	3.287,-1	-3.569,0	7.052,-1	-5.202,-1	1.115,0	9.166,-1
2	-6.703,-1	2.595,0	-1.955,0	-2.114,-1	-1.748,-1	-3.280,-1	6.804,-1
3	4.917,-1	-1.640,-1	5.218,-2	1.146,-1	5.591,-2	1.807,-1	-7.937,-2
4	-7.982,-2	1.554,0	-1.108,0	-5.726,-2	-1.441,-1	-9.301,-2	6.825,-1
5	-1.315,-1	3.209,-1	-5.305,-2	-3.342,-2	2.408,-2	-5.357,-2	5.165,-2
6	-8.150,-1	3.605,0	-2.043,0	-1.554,-1	-2.337,-1	-2.756,-1	1.158,0
7	9.230,-1	-6.280,-1	-5.143,-1	1.312,-1	-5.826,-2	3.333,-1	5.651,-2

Contrails

TABLE IV (CONTD)

(j) $M_\infty = 1.05,\ k_s = 0.6$

I	J=1	J=2	J=3	J=4	J=5	J=6	J=7
1	3.487,0	1.334,-2	-1.437,0	7.492,-1	-3.050,-1	1.188,0	6.761,-1
2	-4.074,-1	1.358,0	-9.002,-1	-1.631,-1	-1.099,-1	-2.504,-1	4.912,-1
3	4.156,-1	-1.275,-1	4.560,-2	1.060,-1	3.414,-2	1.671,-1	-4.432,-2
4	7.627,-2	9.085,-1	-5.166,-2	-1.370,-2	-9.543,-2	-2.454,-2	5.482,-1
5	-8.775,-2	1.786,-1	-3.470,-2	-2.843,-2	1.358,-2	-4.594,-2	4.574,-2
6	-3.767,-1	2.120,0	-1.034,0	-7.357,-2	-1.655,-1	-1.464,-1	9.169,-1
7	7.426,-1	-4.675,-1	-1.138,-1	1.272,-1	-1.450,-2	2.165,-1	3.032,-2

(k) $M_\infty = 1.05,\ k_s = 1.0$

I	J=1	J=2	J=3	J=4	J=5	J=6	J=7
1	3.258,0	-3.211,-2	-4.295,-1	7.853,-1	-1.582,-1	1.248,0	4.905,-1
2	-2.387,-1	7.388,-1	-3.470,-1	-1.263,-1	-6.013,-2	-1.904,-1	3.578,-1
3	3.688,-1	-1.219,-1	9.432,-2	9.556,-2	2.915,-2	1.509,-1	-2.887,-2
4	1.887,-1	5.844,-1	-2.116,-1	2.947,-2	-6.064,-2	4.425,-2	4.499,-1
5	-5.543,-2	9.197,-2	-1.025,-3	-2.463,-2	1.127,-2	-3.941,-2	3.797,-2
6	-3.664,-2	1.317,0	-4.812,-1	1.104,-2	-1.127,-1	-1.144,-2	7.319,-1
7	5.756,-1	-3.083,-1	4.882,-2	1.122,-1	1.029,-2	1.944,-1	2.400,-2

(l) $M_\infty = 1.05,\ k_s = 2.0$

I	J=1	J=2	J=3	J=4	J=5	J=6	J=7
1	3.127,0	1.772,-1	2.409,-3	8.953,-1	3.590,-2	1.417,0	2.856,-1
2	-9.708,-2	4.353,-1	-9.164,-2	-6.330,-2	-2.621,-2	9.029,-2	2.388,-1
3	3.138,-1	4.518,-2	6.876,-2	8.755,-2	1.814,-2	1.384,-1	-6.193,-3
4	4.048,-1	4.024,-1	-8.811,-2	1.592,-1	-4.223,-2	2.336,-1	3.316,-1
5	-2.133,-2	5.345,-2	1.772,-3	-1.302,-2	4.327,-3	-2.003,-2	3.404,-2
6	4.901,-1	7.572,-1	-1.922,-1	2.309,-1	-7.104,-2	3.194,-1	4.952,-1
7	3.630,-1	-5.886,-2	5.081,-2	9.245,-2	1.263,-2	1.616,-1	4.469,-2

Contrails

TABLE V

MACH NUMBER, k_s, AND FREQUENCY FOR THE AGARD ASPECT RATIO 1.45 TAPERED, SWEPT-BACK WING

M	k_s	f (cps)
2.0	0.0	0.0
	0.5	115.4
	1.4	323.2
1.2	0.0	0.0
	0.5	69.3
	1.4	193.9
1.057	0.0	0.0
	0.5	61.0
	1.4	171.0

Contrails

TABLE VI

MODE SHAPES FOR THE ASPECT RATIO 1.45 TAPERED, SWEPT-BACK WING IN AGARD AND MACH BOX COORDINATE SYSTEMS

Mode	f (x,y)	Z(X,Y)
1	1.0	1.379
2	x	$-1.112 + X$
3	x^2	$0.8967 - 1.613X + .7252X^2$
4	y^2	$0.7252Y^2$
5	$\|y\|$	$\|Y\|$
6	$x\|y\|$	$-0.8064\|Y\| + 0.7252X\|Y\|$

Contrails

TABLE VII

Q'_{ij} IN AGARD NOTATION, ASPECT RATIO 1.45 TAPERED, SWEPT- BACK WING

(a) $M_\infty = 2.0$, $k_s = 0.0$

I	J=1	J=2	J=3	J=4	J=5	J=6
1	0.000,0	2.667,0	1.527,0	0.000,0	0.000,0	9.742,-1
2	0.000,0	4.866,-1	1.533,0	0.000,0	0.000,0	1.988,-1
3	0.000,0	5.629,-1	8.727,-1	0.000,0	0.000,0	1.722,-1
4	0.000,0	-1.875,-1	4.201,-1	0.000,0	0.000,0	-8.662,-2
5	0.000,0	-8.714,-1	8.355,-1	0.000,0	0.000,0	-2.251,-1
6	0.000,0	1.974,0	6.996,-1	0.000,0	0.000,0	7.383,-1

(b) $M_\infty = 2.0$, $k_s = 0.5$

I	J=1	J=2	J=3	J=4	J=5	J=6
1	6.007,-2	2.572,0	1.566,0	-1.934,-2	-2.409,-2	9.735,-1
2	-1.025,-3	4.566,-1	1.533,0	-2.136,-2	-3.023,-2	2.062,-1
3	-2.990,-3	5.422,-1	8.699,-1	-1.891,-2	-2.608,-2	1.791,-1
4	-1.180,-1	-1.348,-1	3.856,-1	-5.113,-2	-7.342,-2	-6.422,-2
5	-2.722,-1	-7.135,-1	7.330,-1	-7.267,-2	-1.176,-1	-1.811,-1
6	2.424,-1	1.774,0	8.172,-1	1.854,-2	4.840,-2	7.093,-1

(c) $M_\infty = 2.0$, $k_s = 1.4$

I	J=1	J=2	J=3	J=4	J=5	J=6
1	-1.529,-1	2.501,0	1.480,0	-1.863,-1	-2.665,-1	1.034,0
2	-3.306,-1	5.708,-1	1.357,0	-1.774,-1	-2.610,-1	2.846,-1
3	-2.473,-1	6.291,-1	7.360,-1	-1.496,-1	-2.118,-1	2.428,-1
4	-7.363,-1	1.201,-1	2.283,-1	-3.423,-1	-4.752,-1	4.491,-2
5	-1.620,0	1.767,-2	2.856,-1	-4.800,-1	-7.495,-1	3.622,-2
6	1.054,0	1.124,0	1.144,0	7.808,-2	2.217,-1	6.139,-1

Contrails

TABLE VII (CONTD)

(d) $M_\infty = 1.2$, $k_S = 0.0$

I	J=1	J=2	J=3	J=4	J=5	J=6
1	0.000,0	4.185,0	4.265,0	0.000,0	0.000,0	1.061,0
2	0.000,0	4.800,-2	3.574,0	0.000,0	0.000,0	-1.748,-1
3	0.000,0	6.378,-1	1.911,0	0.000,0	0.000,0	1.222,-2
4	0.000,0	-6.576,-1	8.724,-1	0.000,0	0.000,0	-3.018,-1
5	0.000,0	-2.144,0	1.492,0	0.000,0	0.000,0	-6.584,-1
6	0.000,0	3.258,0	2.128,0	0.000,0	0.000,0	8.911,-1

(e) $M_\infty = 1.2$, $k_S = 0.5$

I	J=1	J=2	J=3	J=4	J=5	J=6
1	1.197,-2	3.801,0	3.532,0	-8.949,-2	-1.705,-1	1.200,0
2	-2.695,-1	2.272,-1	2.852,0	-9.833,-2	-1.820,-1	1.015,-2
3	-1.474,-1	7.242,-1	1.444,0	-6.925,-2	-1.183,-1	1.361,-1
4	-3.301,-1	-3.376,-1	6.071,-1	-9.783,-2	-1.580,-1	-1.970,-1
5	-7.295,-1	-1.353,0	9.798,-1	-1.588,-1	-2.711,-1	-4.516,-1
6	4.321,-1	2.577,0	1.933,0	1.051,-2	2.148,-2	8.742,-1

(f) $M_\infty = 1.2$, $k_S = 1.4$

I	J=1	J=2	J=3	J=4	J=5	J=6
1	-8.473,-1	4.452,0	2.374,0	-4.872,-1	-7.973,-1	1.532,0
2	-1.076,0	1.042,0	2.153,0	-4.274,-1	-6.957,-1	2.944,-1
3	-5.409,-1	1.045,0	1.190,0	-2.939,-1	-4.486,-1	2.462,-1
4	-1.299,0	2.669,-1	3.359,-1	-5.471,-1	-7.925,-1	-3.456,-2
5	-2.711,0	5.817,-2	4.902,-1	-8.125,-1	-1.274,0	-9.408,-2
6	1.209,0	2.004,0	1.627,0	-1.259,-2	7.700,-2	8.465,-1

Contrails

TABLE VII (CONTD)

(g) $M_\infty = 1.057$, $k_s = 0.0$

I	J=1	J=2	J=3	J=4	J=5	J=6
1	0.000,0	3.680,0	6.419,0	0.000,0	0.000,0	8.929,-1
2	0.000,0	-9.459,-1	4.301,0	0.000,0	0.000,0	-3.309,-1
3	0.000,0	1.144,-1	2.178,0	0.000,0	0.000,0	2.817,-2
4	0.000,0	-9.734,-1	8.306,-1	0.000,0	0.000,0	-3.234,-1
5	0.000,0	-2.882,0	1.102,0	0.000,0	0.000,0	-7.118,-1
6	0.000,0	3.242,0	3.523,0	0.000,0	0.000,0	8.480,-1

(h) $M_\infty = 1.057$, $k_s = 0.5$

I	J=1	J=2	J=3	J=4	J=5	J=6
1	-1.772,-1	4.480,0	4.433,0	-1.357,-1	-2.259,-1	1.112,0
2	-4.256,-1	3.872,-1	3.332,0	-1.249,-1	-2.006,-1	-1.327,-1
3	-2.176,-1	8.919,-1	1.768,0	-6.816,-2	-9.685,-2	4.482,-2
4	-3.709,-1	-3.238,-1	7.596,-1	-1.018,-1	-1.526,-1	-2.471,-1
5	-8.029,-1	-1.512,0	1.160,0	-1.668,-1	-2.636,-1	-5.502,-1
6	3.611,-1	3.068,0	2.372,0	-9.564,-3	-5.301,-3	8.588,-1

(i) $M_\infty = 1.057$, $k_s = 1.4$

I	J=1	J=2	J=3	J=4	J=5	J=6
1	-1.062,0	5.157,0	2.925,0	-6.745,-1	-1.090,0	1.605,0
2	-1.187,0	1.117,0	2.629,0	-5.663,-1	-8.895,-1	2.193,-1
3	-6.026,-1	1.116,0	1.401,0	-3.804,-1	-5.624,-1	1.704,-1
4	-1.407,0	2.529,-1	5.094,-1	-5.950,-1	-8.631,-1	-1.026,-1
5	-2.935,0	-1.023,-1	7.860,-1	-9.028,-1	-1.392,0	-2.203,-1
6	1.273,0	2.373,0	1.839,0	-7.094,-2	-3.902,-2	9.150,-1

Contrails

TABLE VIII

Q''_{ij} IN AGARD NOTATION, ASPECT RATIO 1.45 TAPERED SWEPT-BACK WING

(a) $M_\infty = 2.0$, $k_s = 0.5$

I	J=1	J=2	J=3	J=4	J=5	J=6
1	2.565,0	5.374,-1	6.912,-1	5.779,-1	9.668,-1	5.498,-1
2	4.388,-1	7.695,-1	2.829,-1	1.302,-2	2.007,-1	4.755,-1
3	5.293,-1	4.457,-1	3.102,-1	1.028,-1	1.777,-1	3.482,-1
4	-1.415,-1	6.712,-1	7.844,-2	-3.105,-2	-6.010,-2	4.174,-1
5	-7.522,-1	1.472,-1	-2.045,-1	-7.171,-2	-1.806,-1	6.517,-1
6	1.809,0	-5.800,-1	7.920,-1	4.252,-1	7.074,-1	1.223,-1

(b) $M_\infty = 2.0$, $k_s = 1.4$

I	J=1	J=2	J=3	J=4	J=5	J=6
1	2.350,0	8.112,-1	5.726,-1	6.014,-1	9.978,-1	5.589,-1
2	4.262,-1	8.512,-1	2.858,-1	1.791,-1	2.634,-1	4.587,-1
3	5.411,-1	4.906,-1	3.294,-1	1.413,-1	2.364,-1	3.289,-1
4	1.362,-1	5.232,-1	1.796,-1	6.249,-2	9.620,-2	3.578,-1
5	-9.469,-2	1.054,0	7.830,-2	7.703,-2	7.686,-2	5.400,-1
6	1.179,0	-4.510,-2	4.712,-1	3.068,-1	5.900,-1	1.972,-1

(c) $M_\infty = 1.2$, $k_s = 0.5$

I	J=1	J=2	J=3	J=4	J=5	J=6
1	3.473,0	1.681,0	-1.185,0	7.021,-1	1.143,0	1.441,0
2	-1.650,-2	2.475,0	-1.055,0	2.259,-2	-2.209,-2	1.254,0
3	5.895,-1	1.276,0	-2.269,-1	6.474,-2	1.272,-1	7.905,-1
4	-3.883,-1	1.627,0	-1.516,-1	-1.118,-1	-1.863,-1	7.821,-1
5	1.454,0	3.421,0	-5.461,-1	-2.298,-1	-4.425,-1	1.297,-0
6	2.448,0	-8.049,-1	-1.298,-1	5.122,-1	8.451,-1	4.215,-1

Contrails

TABLE VIII (CONTD)

(d) $M_\infty = 1.2$, $k_s = 1.4$

I	J=1	J=2	J=3	J=4	J=5	J=6
1	3.816,0	1.507,0	5.773,-1	8.753,-1	1.462,0	1.065,0
2	7.156,-1	1.542,0	3.723,-1	2.093,-1	3.101,-1	8.412,-1
3	9.419,-1	7.902,-1	5.548,-1	1.785,-1	3.084,-1	5.545,-1
4	2.938,-1	8.810,-1	2.893,-1	5.256,-2	9.273,-2	5.764,-1
5	7.772,-3	1.743,0	2.469,-1	5.613,-2	5.551,-2	8.904,-1
6	1.801,0	2.881,-2	5.003,-1	4.932,-1	8.002,-1	4.144,-1

(e) $M_\infty = 1.057$, $k_s = 0.5$

I	J=1	J=2	J=3	J=4	J=5	J=6
1	3.963,0	2.773,0	-2.005,0	6.898,-1	1.071,0	1.754,0
2	1.719,-1	3.271,0	-6.964,-1	-3.074,-2	-1.175,-1	1.352,0
3	7.786,-1	1.680,0	1.090,-1	3.912,-2	7.318,-2	7.133,-1
4	-3.300,-1	1.870,0	1.931,-1	-1.272,-1	-2.119,-1	7.723,-1
5	-1.478,0	3.828,0	3.423,-1	-2.679,-1	-4.959,-1	1.276,0
6	2.376,0	-3.925,-1	-9.444,-1	5.223,-1	8.266,-1	5.841,-1

(f) $M_\infty = 1.057$, $k_s = 1.4$

I	J=1	J=2	J=3	J=4	J=5	J=6
1	4.165,0	1.118,0	3.677,-1	9.626,0	1.540,0	1.342,0
2	7.499,-1	1.775,0	3.964,-1	2.214,-1	3.007,-1	1.014,0
3	1.027,0	9.048,0	5.271,-1	1.860,-1	2.982,-1	6.597,-1
4	2.762,-1	1.028,0	3.086,-1	4.457,-2	6.816,-2	6.499,-1
5	-1.078,-1	2.021,0	2.251,-1	3.506,-2	6.780,-3	1.006,0
6	1.997,0	4.150,-2	4.327,-1	5.467,-1	8.614,-1	5.416,-1

Contrails

TABLE IX

MACH NUMBER, k_s, AND FREQUENCY FOR THE AGARD ASPECT RATIO 4.0 ARROWHEAD WING

M	k_s	f (cps)
2.0	0.0	0.0
	0.5	318.3
	1.0	636.6
	2.0	1273.3
	4.0	2546.6
1.5621	0.0	0.0
	0.5	248.6
	1.0	497.2
	2.0	994.5
	4.0	1989.0
1.25	0.0	0.0
	0.5	198.9
	1.0	397.9
	2.0	795.8
	4.0	1591.6
1.12	0.0	0.0
	0.5	178.3
	1.0	356.5
	2.0	713.0
	4.0	1426.1

Contrails

TABLE X

MODE SHAPES FOR THE ASPECT RATIO 4.0 ARROWHEAD WING IN AGARD AND MACH BOX COORDINATE SYSTEMS

Mode	f (x,y)	Z (X,Y)
1	1	0.5
2	x	$-0.25 + X$
3	x^2	$0.125 - X + 2.0\, X^2$
4	y^2	$2.0\, Y^2$
5	$\lvert y \rvert$	$\lvert Y \rvert$
6	$x \lvert y \rvert$	$-0.5 \lvert Y \rvert + 2.0\, X \lvert Y \rvert$

Contrails

TABLE XI

Q'_{ij} IN AGARD NOTATION, ASPECT RATIO 4.0 ARROWHEAD WING

(a) $M_\infty = 2.0$, $k_s = 0.0$

I	J=1	J=2	J=3	J=4	J=5	J=6
1	0.000,0	1.264,0	8.020,-1	0.000,0	0.000,0	4.063,-1
2	0.000,0	4.643,-1	5.162,-1	0.000,0	0.000,0	2.096,-1
3	0.000,0	3.164,-1	3.114,-1	0.000,0	0.000,0	1.472,-1
4	0.000,0	1.608,-1	2.073,-1	0.000,0	0.000,0	9.877,-2
5	0.000,0	9.266,-2	3.190,-1	0.000,0	0.000,0	1.176,-1
6	0.000,0	4.879,-1	3.259,-1	0.000,0	0.000,0	1.897,-1

(b) $M_\infty = 2.0$, $k_s = 0.5$

I	J=1	J=2	J=3	J=4	J=5	J=6
1	5.383,-2	1.238,0	8.090,-1	4.064,-3	1.125,-2	4.046,-1
2	3.126,-2	4.498,-1	5.202,-1	3.460,-3	8.007,-3	2.085,-1
3	2.104,-2	3.070,-1	3.141,-1	2.422,-3	5.536,-3	1.468,-1
4	7.988,-3	1.564,-1	2.087,-1	1.046,-3	2.302,-3	9.871,-2
5	-7.147,-3	9.280,-2	3.182,-1	4.847,-4	-3.534,-6	1.179,-1
6	4.120,-2	4.710,-1	3.320,-1	3.888,-3	9.564,-3	1.886,-1

(c) $M_\infty = 2.0$, $k_s = 1.0$

I	J=1	J=2	J=3	J=4	J=5	J=6
1	1.792,-1	1.177,0	8.233,-1	1.483,-2	3.972,-2	4.008,-1
2	1.034,-1	4.165,-1	5.281,-1	1.285,-2	2.863,-2	2.060,-1
3	6.952,-2	2.859,-1	3.195,-1	8.958,-3	1.973,-2	1.460,-1
4	2.485,-2	1.469,-1	2.112,-1	3.748,-3	7.908,-3	9.879,-2
5	-3.487,-2	9.640,-2	3.144,-1	1.443,-3	-1.383,-3	1.191,-1
6	1.454,-1	4.292,-1	3.465,-1	1.469,-2	3.528,-2	1.861,-1

(d) $M_\infty = 2.0$, $k_s = 2.0$

I	J=1	J=2	J=3	J=4	J=5	J=6
1	3.288,-1	1.097,0	8.195,-1	4.099,-2	9.563,-2	3.990,-1
2	1.873,-1	3.782,-1	5.246,-1	3.876,-2	7.404,-2	2.036,-1
3	1.250,-1	2.650,-1	3.166,-1	2.639,-2	5.016,-2	1.479,-1
4	2.598,-2	1.404,-1	2.077,-1	9.344,-3	1.603,-2	1.014,-1
5	-1.919,-1	1.347,-1	2.902,-1	-4.797,-4	-2.087,-2	1.256,-1
6	3.647,-1	3.530,-1	3.674,-1	4.741,-2	1.043,-1	1.829,-1

Contrails

TABLE XI (CONTD)

(e) $M_\infty = 2.0,\ k_s = 4.0$

I	J=1	J=2	J=3	J=4	J=5	J=6
1	-2.209,-2	1.182,0	7.278,-1	3.190,-2	3.389,-2	4.280,-1
2	6.930,-2	3.995,-1	4.901,-1	6.337,-2	7.824,-2	2.066,-1
3	4.063,-2	2.911,-1	2.906,-1	3.584,-2	4.281,-2	1.608,-1
4	-9.812,-2	1.589,-1	1.833,-1	-5.861,-3	-2.391,-2	1.113,-1
5	-6.183,-1	2.031,-1	2.410,-1	-4.354,-2	-1.393,-1	1.392,-1
6	4.908,-1	3.450,-1	3.561,-1	9.833,-2	1.794,-1	1.906,-1

(f) $M_\infty = 1.5621,\ k_s = 0.0$

I	J=1	J=2	J=3	J=4	J=5	J=6
1	0.000,0	1.584,0	1.099,0	0.000,0	0.000,0	4.837,-1
2	0.000,0	5.459,-1	6.555,-1	0.000,0	0.000,0	2.322,-1
3	0.000,0	3.506,-1	3.822,-1	0.000,0	0.000,0	1.478,-1
4	0.000,0	1.868,-1	2.412,-1	0.000,0	0.000,0	1.035,-1
5	0.000,0	8.154,-2	3.706,-1	0.000,0	0.000,0	1.176,-1
6	0.000,0	6.134,-1	4.215,-1	0.000,0	0.000,0	2.168,-1

(g) $M_\infty = 1.5621,\ k_s = 0.5$

I	J=1	J=2	J=3	J=4	J=5	J=6
1	8.901,-2	1.535,0	1.096,0	6.396,-3	1.859,-2	4.780,-1
2	4.473,-2	5.210,-1	6.521,-1	3.874,-3	1.031,-2	2.293,-1
3	2.965,-2	3.341,-1	3.801,-1	2.701,-3	6.922,-3	1.461,-1
4	1.407,-2	1.768,-1	2.400,-1	1.318,-3	3.205,-3	1.025,-1
5	-8.365,-3	7.920,-2	3.650,-1	3.944,-4	-3.191,-4	1.169,-1
6	6.332,-2	5.820,-1	4.242,-1	4.716,-3	1.303,-2	2.141,-1

(h) $M_\infty = 1.5621,\ k_s = 1.0$

I	J=1	J=2	J=3	J=4	J=5	J=6
1	2.557,-1	1.441,0	1.076,0	2.161,-2	5.907,-2	4.660,-1
2	1.221,-1	4.770,-1	6.375,-1	1.296,-2	3.197,-2	2.238,-1
3	8.111,-2	3.048,-1	3.698,-1	9.032,-3	2.142,-2	1.428,-1
4	3.437,-2	1.593,-1	2.339,-1	4.171,-3	9.100,-3	1.004,-1
5	-5.374,-2	8.389,-2	3.467,-1	3.004,-4	-5.323,-3	1.162,-1
6	2.004,-1	5.166,-1	4.246,-1	1.670,-2	4.414,-2	2.086,-1

Contrails

TABLE XI (CONTD)

(i) $M_\infty = 1.5621$, $k_s = 2.0$

I	J=1	J=2	J=3	J=4	J=5	J=6
1	2.972,-1	1.388,0	9.679,-1	4.584,-2	9.909,-2	4.552,-1
2	1.114,-1	4.657,-1	5.705,-1	2.641,-2	4.843,-2	2.215,-1
3	8.326,-2	2.933,-1	3.311,-1	1.856,-2	3.305,-2	1.421,-1
4	2.985,-3	1.514,-1	2.100,-1	5.877,-3	6.007,-3	9.900,-2
5	-2.901,-1	1.368,-1	2.954,-1	-1.053,-2	-4.984,-2	1.187,-1
6	3.984,-1	4.362,-1	4.011,-1	4.421,-2	1.032,-1	2.045,-1

(j) $M_\infty = 1.5621$, $k_s = 4.0$

I	J=1	J=2	J=3	J=4	J=5	J=6
1	-9.328,-2	1.388,0	8.612,-1	1.466,-2	-2.513,-3	4.413,-1
2	-6.265,-2	4.441,-1	5.257,-1	5.108,-3	-1.173,-2	2.105,-1
3	-5.834,-3	2.693,-1	3.055,-1	5.200,-3	-1.812,-3	1.327,-1
4	-1.335,-1	1.257,-1	1.872,-1	-1.811,-2	-4.695,-2	8.386,-2
5	-7.768,-1	1.534,-1	2.495,-1	-7.236,-2	-2.009,-1	9.958,-2
6	5.280,-1	3.827,-1	3.839,-1	6.780,-2	1.471,-1	2.023,-1

(k) $M_\infty = 1.25$, $k_s = 0.0$

I	J=1	J=2	J=3	J=4	J=5	J=6
1	0.000,0	1.940,0	1.834,0	0.000,0	0.000,0	6.308,-1
2	0.000,0	7.290,-1	1.075,0	0.000,0	0.000,0	3.233,-1
3	0.000,0	4.940,-1	6.762,-1	0.000,0	0.000,0	2.187,-1
4	0.000,0	3.041,-1	4.514,-1	0.000,0	0.000,0	1.621,-1
5	0.000,0	1.901,-1	6.180,-1	0.000,0	0.000,0	1.808,-1
6	0.000,0	8.072,-1	7.631,-1	0.000,0	0.000,0	3.001,-1

(l) $M_\infty = 1.25$, $k_s = 0.5$

I	J=1	J=2	J=3	J=4	J=5	J=6
1	1.337,-1	1.845,0	1.748,0	1.423,-2	3.737,-2	6.100,-1
2	7.174,-2	6.757,-1	1.020,0	8.898,-3	2.166,-2	3.111,-1
3	5.212,-2	4.546,-1	6.387,-1	6.499,-3	1.555,-2	2.100,-1
4	3.440,-2	2.741,-1	4.273,-1	4.291,-3	1.003,-2	1.558,-1
5	8.536,-3	1.666,-1	5.841,-1	3.512,-3	6.355,-3	1.740,-1
6	9.670,-2	7.463,-1	7.259,-1	9.219,-3	2.409,-2	2.892,-1

Contrails

TABLE XI (CONTD)

(m) $M_\infty = 1.25$, $k_s = 1.0$

I	J=1	J=2	J=3	J=4	J=5	J=6
1	2.482,-1	1.773,0	1.560,0	3.631,-2	8.386,-2	5.856,-1
2	1.200,-1	6.430,-1	9.081,-1	2.182,-2	4.511,-2	2.989,-1
3	9.132,-2	4.261,-1	5.651,-1	1.587,-2	3.231,-2	2.015,-1
4	5.563,-2	2.471,-1	3.813,-1	9.943,-3	1.920,-2	1.492,-1
5	-5.203,-2	1.670,-1	5.202,-1	5.195,-3	7.516,-4	1.686,-1
6	2.343,-1	6.750,-1	6.488,-1	2.573,-2	6.167,-2	2.762,-1

(n) $M_\infty = 1.25$, $k_s = 2.0$

I	J=1	J=2	J=3	J=4	J=5	J=6
1	1.977,-1	1.832,0	1.346,0	4.431,-2	7.940,-2	5.941,-1
2	8.729,-2	6.832,-1	8.055,-1	2.438,-2	3.423,-2	3.119,-1
3	8.017,-2	4.482,-1	5.031,-1	1.845,-2	2.649,-2	2.125,-1
4	6.764,-3	2.584,-1	3.401,-1	7.600,-3	3.787,-3	1.560,-1
5	-3.199,-1	2.379,-1	4.669,-1	-1.494,-2	-6.627,-2	1.805,-1
6	4.165,-1	6.382,-1	5.719,-1	4.730,-2	1.031,-1	2.839,-1

(o) $M_\infty = 1.25$, $k_s = 4.0$

I	J=1	J=2	J=3	J=4	J=5	J=6
1	-4.381,-1	1.805,0	1.194,0	-1.896,-2	-8.694,-2	5.684,-1
2	-1.782,-1	6.120,-1	7.549,-1	-1.267,-2	-5.415,-2	2.955,-1
3	-8.101,-2	3.961,-1	4.717,-1	-2.828,-3	-2.262,-2	2.021,-1
4	-1.825,-1	2.187,-1	3.146,-1	-2.150,-2	-6.083,-2	1.451,-1
5	-9.572,-1	2.392,-1	4.148,-1	-9.414,-2	-2.556,-1	1.593,-1
6	5.736,-1	5.464,-1	5.543,-1	6.804,-2	1.465,-1	2.893,-1

(p) $M_\infty = 1.12$, $k_s = 0.0$

I	J=1	J=2	J=3	J=4	J=5	J=6
1	0.000,0	2.353,0	2.539,0	0.000,0	0.000,0	8.202,-1
2	0.000,0	9.641,-1	1.497,0	0.000,0	0.000,0	4.455,-1
3	0.000,0	6.800,-1	9.726,-1	0.000,0	0.000,0	3.121,-1
4	0.000,0	4.225,-1	6.663,-1	0.000,0	0.000,0	2.269,-1
5	0.000,0	3.217,-1	8.810,-1	0.000,0	0.000,0	2.612,-1
6	0.000,0	9.949,-1	1.099,0	0.000,0	0.000,0	3.929,-1

Contrails

TABLE XI (CONTD)

(q) $M_\infty = 1.12,\ k_s = 0.5$

I	J=1	J=2	J=3	J=4	J=5	J=6
1	2.048,-1	2.152,0	2.212,0	3.335,-2	7.440,-2	7.516,-1
2	1.160,-1	8.428,-1	1.291,0	2.105,-2	4.433,-2	4.021,-1
3	8.674,-2	5.846,-1	8.292,-1	1.520,-2	3.195,-2	2.797,-1
4	5.234,-2	3.582,-1	5.689,-1	9.600,-3	1.951,-2	2.051,-1
5	2.974,-2	2.585,-1	7.530,-1	1.057,-2	1.850,-2	2.349,-1
6	1.264,-1	8.843,-1	9.462,-1	1.758,-2	3.965,-2	3.591,-1

(r) $M_\infty = 1.12,\ k_s = 1.0$

I	J=1	J=2	J=3	J=4	J=5	J=6
1	3.268,-1	2.017,0	1.885,0	6.329,-2	1.299,-1	6.926,-1
2	1.650,-1	7.635,-1	1.109,0	3.686,-2	6.884,-2	3.686,-1
3	1.192,-1	5.212,-1	7.097,-1	2.552,-2	4.727,-2	2.557,-1
4	5.672,-2	3.253,-1	4.914,-1	1.401,-2	2.337,-2	1.921,-1
5	-4.805,-2	2.378,-1	6.596,-1	1.112,-2	6.908,-3	2.193,-1
6	2.507,-1	8.058,-1	8.038,-1	3.463,-2	7.435,-2	3.351,-1

(s) $M_\infty = 1.12,\ k_s = 2.0$

I	J=1	J=2	J=3	J=4	J=5	J=6
1	2.451,-1	2.126,0	1.649,0	7.380,-2	1.264,-1	7.142,-1
2	1.813,-1	8.350,-1	1.014,0	4.532,-2	7.010,-2	3.998,-1
3	1.826,-1	5.735,-1	6.546,-1	3.587,-2	6.005,-2	2.849,-1
4	1.150,-1	3.580,-1	4.605,-1	2.161,-2	3.390,-2	2.168,-1
5	-2.292,-1	3.437,-1	6.253,-1	-4.186,-4	-3.853,-2	2.537,-1
6	5.544,-1	7.987,-1	7.255,-1	6.721,-2	1.436,-1	3.623,-1

(t) $M_\infty = 1.12,\ k_s = 4.0$

I	J=1	J=2	J=3	J=4	J=5	J=6
1	-2.642,-1	2.226,0	1.485,0	9.668,-2	6.545,-2	7.643,-1
2	6.282,-2	8.293,-1	9.842,-1	8.649,-2	7.844,-2	4.493,-1
3	1.380,-1	5.697,-1	6.470,-1	8.446,-2	9.791,-2	3.311,-1
4	3.166,-3	3.520,-1	4.613,-1	5.003,-2	3.886,-2	2.533,-1
5	-7.789,-1	3.951,-1	5.986,-1	-8.927,-3	-1.415,-1	2.876,-1
6	8.498,-1	7.291,-1	7.322,-1	1.554,-1	2.715,-1	4.202,-1

Contrails

TABLE XII

Q''_{ij} IN AGARD NOTATION, ASPECT RATIO 4.0 ARROWHEAD

(a) $M_\infty = 2.0$, $k_s = 0.5$

I	J=1	J=2	J=3	J=4	J=5	J=6
1	1.232,0	1.869,-1	2.106,-1	1.998,-1	4.009,-1	1.552,-1
2	4.462,-1	1.333,-1	1.247,-1	1.212,-1	2.062,-1	1.022,-1
3	3.041,-1	7.167,-2	8.795,-2	9.012,-2	1.447,-1	7.070,-2
4	1.550,-1	7.181,-2	6.190,-2	6.732,-2	9.745,-2	6.209,-2
5	8.972,-2	1.874,-1	7.298,-2	8.526,-2	1.165,-1	9.690,-2
6	4.695,-1	-7.021,-4	1.057,-1	1.066,-1	1.863,-2	6.611,-2

(b) $M_\infty = 2.0$, $k_s = 1.0$

I	J=1	J=2	J=3	J=4	J=5	J=6
1	1.152,0	2.243,-1	1.975,-1	1.950,-1	3.864,-1	1.582,-1
2	4.000,-1	1.545,-1	1.173,-1	1.179,-1	1.968,-1	1.038,-1
3	2.727,-1	8.586,-2	8.280,-2	8.765,-2	1.380,-1	7.168,-2
4	1.404,-1	7.871,-2	5.905,-2	6.587,-2	9.389,-2	6.249,-2
5	8.388,-2	1.913,-1	7.162,-2	8.383,-2	1.137,-1	9.706,-2
6	4.207,-1	2.097,-2	9.710,-2	1.034,-1	1.770,-1	6.765,-2

(c) $M_\infty = 2.0$, $k_s = 2.0$

I	J=1	J=2	J=3	J=4	J=5	J=6
1	9.734,-1	3.061,-1	1.733,-1	1.810,-1	3.474,-1	1.648,-1
2	3.024,-1	2.977,-1	1.048,-1	1.080,-1	1.720,-1	1.070,-1
3	2.063,-1	1.143,-1	7.408,-2	8.016,-2	1.201,-1	7.342,-2
4	1.110,-1	9.205,-2	5.409,-2	6.142,-2	8.432,-2	6.305,-2
5	9.044,-2	1.919,-1	7.265,-2	7.982,-2	1.080,-1	9.656,-2
6	2.992,-1	7.234,-2	7.820,-2	9.334,-2	1.501,-1	7.115,-2

(d) $M_\infty = 2.0$, $k_s = 4.0$

I	J=1	J=2	J=3	J=4	J=5	J=6
1	9.447,-1	3.174,-1	1.877,-1	1.621,-1	3.156,-1	1.632,-1
2	2.996,-1	1.937,-1	1.164,-1	9.379,-2	1.512,-1	1.042,-1
3	1.992,-1	1.113,-1	8.105,-2	6.911,-2	1.040,-1	7.045,-2
4	1.170,-1	8.786,-2	5.798,-2	5.504,-2	7.656,-2	6.077,-2
5	1.858,-1	1.596,-1	8.817,-2	7.664,-2	1.147,-1	9.152,-2
6	2.066,-1	9.789,-2	7.415,-2	7.547,-2	1.144,-1	7.053,-2

Contrails

TABLE XII (CONTD)

(e) $M_\infty = 1.5621$, $k_s = 0.5$

I	J=1	J=2	J=3	J=4	J=5	J=6
1	1.515,0	1.884,-1	1.521,-1	2.260,-1	4.718,-1	1.657,-1
2	5.082,-1	1.446,-1	8.176,-2	1.284,-1	2.252,-1	1.084,-1
3	3.258,-1	6.964,-2	6.027,-2	8.601,-2	1.431,-1	7.255,-2
4	1.728,-1	6.278,-2	5.094,-2	6.825,-2	1.008,-1	6.242,-2
5	7.245,-2	2.153,-1	5.804,-2	8.513,-2	1.152,-1	1.035,-1
6	5.742,-1	-4.382,-2	7.603,-2	1.153,-1	2.101,-1	6.682,-2

(f) $M_\infty = 1.5621$, $k_s = 1.0$

I	J=1	J=2	J=3	J=4	J=5	J=6
1	1.361,0	2.691,-1	1.448,-1	2.170,-1	4.427,-1	1.745,-1
2	4.277,-1	1.869,-1	8.048,-2	1.228,-1	2.084,-1	1.130,-1
3	2.734,-1	9.728,-2	5.967,-2	8.212,-2	1.319,-1	7.545,-2
4	1.439,-1	7.927,-2	5.011,-2	6.591,-2	9.450,-2	6.397,-2
5	5.983,-2	2.249,-1	6.219,-2	8.289,-2	1.103,-1	1.047,-1
6	4.841,-1	2.549,-3	6.882,-2	1.100,-1	1.935,-1	7.105,-2

(g) $M_\infty = 1.5621$, $k_s = 2.0$

I	J=1	J=2	J=3	J=4	J=5	J=6
1	1.159,0	3.693,-1	1.711,-1	1.964,-1	3.886,-1	1.873,-1
2	3.395,-1	2.293,-1	1.029,-1	1.103,-1	1.794,-1	1.184,-1
3	2.170,-1	1.243,-1	7.429,-2	7.353,-2	1.129,-1	7.831,-2
4	1.183,-1	9.453,-2	5.833,-2	6.088,-2	8.455,-2	6.508,-2
5	9.671,-2	2.136,-1	8.472,-2	7.922,-2	1.080,-1	1.039,-1
6	3.362,-1	7.213,-2	7.078,-2	9.666,-2	1.588,-1	7.713,-2

(h) $M_\infty = 1.5621$, $k_s = 4.0$

I	J=1	J=2	J=3	J=4	J=5	J=6
1	1.165,0	3.755,-1	2.205,-1	1.822,-1	3.714,-1	1.861,-1
2	3.546,-1	2.262,-1	1.292,-1	1.021,-1	1.724,-1	1.152,-1
3	2.179,-1	1.260,-1	8.816,-2	6.740,-2	1.065,-1	7.578,-2
4	1.314,-1	9.527,-2	6.606,-2	5.801,-2	8.395,-2	6.327,-2
5	2.126,-1	1.828,-1	1.034,-1	8.238,-2	1.286,-1	9.906,-2
6	2.402,-1	1.072,-1	7.915,-2	8.125,-2	1.284,-1	7.648,-2

Contrails

TABLE XII (CONTD)

(i) $M_\infty = 1.25,\ k_s = 0.5$

I	J=1	J=2	J=3	J=4	J=5	J=6
1	1.765,0	3.245,-1	-1.414,-1	2.971,-1	5.903,-1	2.068,-1
2	6.278,-1	2.128,-1	-6.699,-2	1.786,-1	2.981,-1	1.432,-1
3	4.223,-1	1.031,-1	-3.425,-2	1.271,-1	2.006,-1	1.203,-1
4	2.540,-1	7.076,-2	-3.202,-3	1.042,-1	1.495,-1	8.612,-2
5	1.416,-1	2.514,-1	7.894,-3	1.248,-1	1.661,-1	1.372,-1
6	7.095,-1	-3.230,-2	-5.705,-2	1.605,-1	2.781,-1	8.939,-2

(j) $M_\infty = 1.25,\ k_s = 1.0$

I	J=1	J=2	J=3	J=4	J=5	J=6
1	1.540,0	4.840,-1	-1.024,-2	2.728,-1	5.249,-1	2.429,-1
2	5.105,-1	3.001,-1	2.170,-2	1.632,-1	2.597,-1	1.649,-1
3	3.390,-1	1.664,-1	2.775,-2	1.160,-1	1.735,-1	1.159,-1
4	1.946,-1	1.186,-1	3.654,-2	9.635,-2	1.306,-1	9.722,-2
5	1.051,-1	2.922,-1	6.425,-2	1.162,-1	1.485,-1	1.494,-1
6	5.692,-1	6.281,-2	2.829,-3	1.468,-1	2.413,-1	1.091,-1

(k) $M_\infty = 1.25,\ k_s = 2.0$

I	J=1	J=2	J=3	J=4	J=5	J=6
1	1.444,0	5.236,-1	1.840,-1	2.494,-1	4.818,-1	2.611,-1
2	4.862,-1	3.120,-1	1.340,-1	1.505,-1	2.418,-1	1.726,-1
3	3.191,-1	1.829,-1	9.868,-2	1.072,-1	1.619,-1	1.213,-1
4	1.847,-1	1.384,-1	7.941,-2	9.039,-2	1.236,-1	1.016,-1
5	1.711,-1	2.814,-1	1.219,-1	1.129,-1	1.544,-1	1.510,-1
6	4.544,-1	1.226,-1	8.177,-2	1.317,-1	2.099,-1	1.204,-1

(l) $M_\infty = 1.25,\ k_s = 4.0$

I	J=1	J=2	J=3	J=4	J=5	J=6
1	1.396,0	5.161,-1	2.758,-1	2.365,-1	4.588,-1	2.581,-1
2	4.463,-1	3.095,-1	1.771,-1	1.425,-1	2.288,-1	1.673,-1
3	2.779,-1	1.862,-1	1.244,-1	1.010,-1	1.504,-1	1.169,-1
4	1.772,-1	1.401,-1	9.611,-2	8.754,-2	1.211,-1	9.763,-2
5	2.622,-1	2.541,-1	1.443,-1	1.171,-1	1.728,-1	1.697,-1
6	3.200,-1	1.551,-1	1.130,-1	1.174,-1	1.782,-1	1.166,-1

Contrails

TABLE XII (CONTD)

(m) $M_\infty = 1.12,\ k_S = 0.5$

I	J=1	J=2	J=3	J=4	J=5	J=6
1	1.994,0	2.486,-1	-6.028,-1	3.542,-1	7.071,-1	1.554,-1
2	7.500,-1	1.550,-1	-3.170,-1	2.328,-1	3.733,-1	1.194,-1
3	5.217,-1	4.865,-2	-1.995,-1	1.702,-1	2.591,-1	8.622,-2
4	3.171,-1	6.174,-2	-1.127,-1	1.367,-1	1.911,-1	8.807,-2
5	2.085,-1	2.404,-1	-1.156,-1	1.649,-1	2.178,-1	1.382,-1
6	8.111,-1	-5.230,-2	-2.669,-1	2.030,-1	3.362,-1	8.086,-2

(n) $M_\infty = 1.12,\ k_S = 1.0$

I	J=1	J=2	J=3	J=4	J=5	J=6
1	1.683,0	5.220,-1	-1.235,-1	3.226,-1	5.930,-1	2.579,-1
2	5.803,-1	3.268,-1	-1.941,-2	2.008,-1	3.064,-1	1.863,-1
3	3.987,-1	1.916,-1	2.853,-3	1.477,-1	2.122,-1	1.377,-1
4	2.479,-1	1.595,-1	2.276,-2	1.228,-1	1.634,-1	1.234,-1
5	1.517,-1	3.405,-1	6.055,-2	1.476,-1	1.866,-1	1.804,-1
6	6.515,-1	1.031,-1	-4.638,-2	1.789,-1	2.829,-1	1.339,-1

(o) $M_\infty = 1.12,\ k_S = 2.0$

I	J=1	J=2	J=3	J=4	J=5	J=6
1	1.598,0	6.149,-1	1.774,-1	3.026,-1	5.553,-1	3.074,-1
2	5.693,-1	3.597,-1	1.475,-1	1.942,-1	2.991,-1	2.101,-1
3	3.941,-1	2.100,-1	1.133,-1	1.455,-1	2.117,-1	1.522,-1
4	2.475,-1	1.539,-1	9.306,-2	1.232,-1	1.670,-1	1.272,-1
5	2.390,-1	3.160,-1	1.428,-1	1.529,-1	2.075,-1	1.849,-1
6	5.488,-1	1.390,-1	8.724,-2	1.701,-1	2.622,-1	1.490,-1

(p) $M_\infty = 1.12,\ k_S = 4.0$

I	J=1	J=2	J=3	J=4	J=5	J=6
1	1.597,0	5.731,-1	3.004,-1	2.847,-1	5.322,-1	2.948,-1
2	5.370,-1	3.453,-1	1.994,-1	1.812,-1	2.818,-1	1.960,-1
3	3.464,-1	2.095,-1	1.434,-1	1.341,-1	1.934,-1	1.408,-1
4	2.222,-1	1.599,-1	1.110,-1	1.161,-1	1.563,-1	1.187,-1
5	3.172,-1	2.850,-1	1.388,-1	1.513,-1	2.167,-1	1.707,-1
6	3.835,-1	1.728,-1	1.284,-1	1.494,-1	2.197,-1	1.397,-1

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DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY *(Corporate author)* Air Force Flight Dynamics Laboratory (FDDS) Wright-Patterson Air Force Base, Ohio 45433	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE
DEMONSTRATION OF A SUPERSONIC BOX METHOD FOR UNSTEADY AERODYNAMICS OF NONPLANAR WINGS - Part II. Application To The AGARD Planforms

4. DESCRIPTIVE NOTES *(Type of report and inclusive dates)*
March 1967 - September 1968

5. AUTHOR(S) *(First name, middle initial, last name)*
Olsen, James J.

6. REPORT DATE February 1969	7a. TOTAL NO. OF PAGES 63	7b. NO. OF REFS 4
8a. CONTRACT OR GRANT NO. b. PROJECT NO 1370 c. Task No. 137003 d.	9a. ORIGINATOR'S REPORT NUMBER(S) AFFDL-TR-67-104 Part II 9b. OTHER REPORT NO(S) *(Any other numbers that may be assigned this report)*	

10. DISTRIBUTION STATEMENT
This document is subject to special export controls and each transmittal to foreign governments or foreign nationals may be made only with prior approval of the Vehicle Dynamics Division (FDD), Air Force Flight Dynamics Laboratory, Wright-Patterson AFB, Ohio.

11. SUPPLEMENTARY NOTES None	12. SPONSORING MILITARY ACTIVITY Air Force Flight Dynamics Laboratory (FDDS) Wright-Patterson Air Force Base, Ohio 4543

13. ABSTRACT

This report is published in two parts: Part I, "General Applications", and Part II, "Application to the AGARD Planforms".

Part I presents and interprets the calculations of the unsteady aerodynamic prediction method known as the "Nonplanar Mach Box" method. It contains examples of data input and output for the associated computer program and explains the program's interpretation of the user's modal data. Also included are summaries of convergence properties, comparison with exact linearized theory, and a brief outline of the calculations for the Advisory Group for Aeronautical Research and Development (AGARD) planforms. A small part of the extensive tables of Part II is included in Part I.

Part II contains a tabulation of the "Nonplanar Mach Box" results for unsteady generalized force coefficients for the planforms, Mach numbers, mode shapes, and frequencies recommended by AGARD. The tabulation uses the AGARD coordinate system and format. Not all the desired cases could be included because of the program's current limitation to supersonic trailing edges (leading edges can be supersonic or subsonic).

The method was found to be fully workable and constitutes a valuable research and design tool. Convergence and accuracy were found to be comparable to steady-state, planar methods. The computer program is available with sample problems from the Air Force Flight Dynamics Laboratory.

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UNCLASSIFIED
Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Unsteady Aerodynamics						
Supersonic Mach Box						
Interference						
AGARD Planforms						

UNCLASSIFIED
Security Classification