N91-10900

AEROASSIST FLIGHT EXPERIMENT AERODYNAMICS AND AEROTHERMODYNAMICS

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Abstract

The problem is to determine the transitional flow aerodynamics and aerothermodynamics, including he base flow characteristics, of the Aeroassist Flight Experiment (AFE). The justification for the CFD Application stems from MSFC's system integration responsibility for the AFE. To insure that the AFE objectives are met, MSFC must understand the limitations and uncertainties of the design data.

Perhaps the only method capable of handling the complex physics of the rarefied high energy AFE trajectory is Bird's Direct Simulation Monte Carlo (DSMC) technique. The three-dimensional code used in this analysis is applicable only to the AFE geometry. It uses the Variable Hard Sphere (VHS) collision model and five specie chemistry model available from Langley Research Center.

The code will be benchmarked against the AFE flight data and used as an Aeroassisted Space Transfer Vechicle (ASTV) design tool. Meanwhile, the code is being used to understand the AFE flow field and verify or modify existing design data. Continued application to lower altitudes is testing the capability of the Numerical Aerodynamaic Simulation Facility (NASF) to handle three-dimensional DSMC and its practicality as an ASTV/AFE design tool.

AFE AEROTHERMODYNAMIC LOADS

OBJECTIVE:

DEVELOP A CODE TO CALCULATE THE AERODYNAMICS AND AEROTHERMODYNAMICS OF THE AFE IN HYPERSONIC RAREFIED NONEQUILIBRIUM FLOW WITH CHEMICAL REACTIONS.

APPROACH:

THE DIRECT SIMULATION MONTE CARLO (DMSC) IS THE ONLY TECHNIQUE WHICH CAN HANDLE THE TRANSITIONAL FLOW ENVIRONMENT. THE VARIABLE HARD SPHERE (VHS) COLLISION MODEL OF G.A. BIRD IS BEING USED IN THIS DEVELOPMENT.

COMPUTER RESOURCES:

500 HOURS ON THE NUMERICAL AERODYNAMIC SIMULATION (NAS) FACILITY AT NASA'S AMES RESEARCH CENTER WAS USED DURING THE NAS OPERATIONAL YEAR (MARCH 1988 THROUGH FEB. 1989).

IMPACT:

NASA'S AFE GOAL IS TO OBTAIN THE PHYSICAL DATA BASE REQUIRED TO BENCHMARK COMPUTATIONAL CODES APPLICABLE TO THE DESIGN OF THE AERO ASSISTED SPACE TRANSFER VEHICLE (ASTV). AFE DESIGN IS RELYING ON CFD CALCULATIONS TO AN UNPRECEDENTED EXTENT DUE TO THE LACK OF WIND TUNNEL FACILITIES WHICH SIMULATE THE RAREFIED/REAL GAS PHYSICS.

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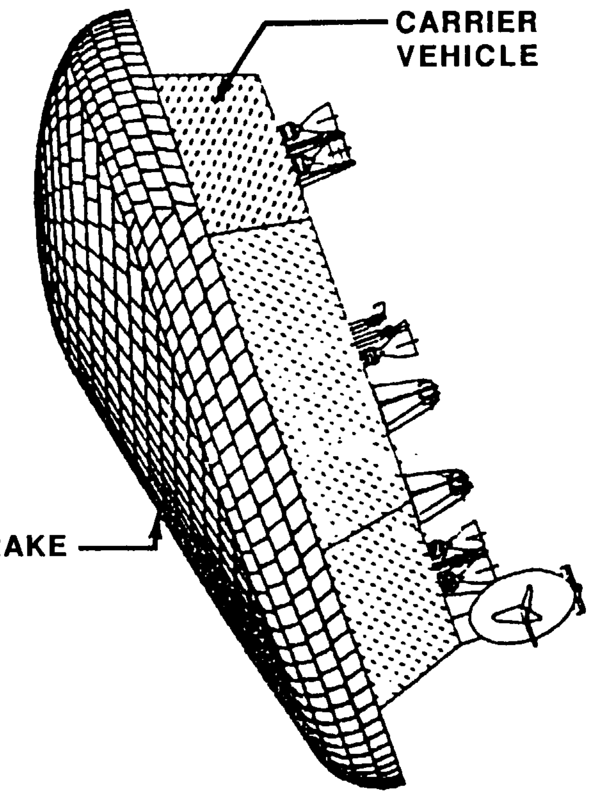
ORGANIZATION: ED32	MARSHALL SPACE FLIGHT CENTER	NAME: E. BREWER
CHART NO.:	**AFE AEROPASS CONFIGURATION SIDE VIEW**	DATE:



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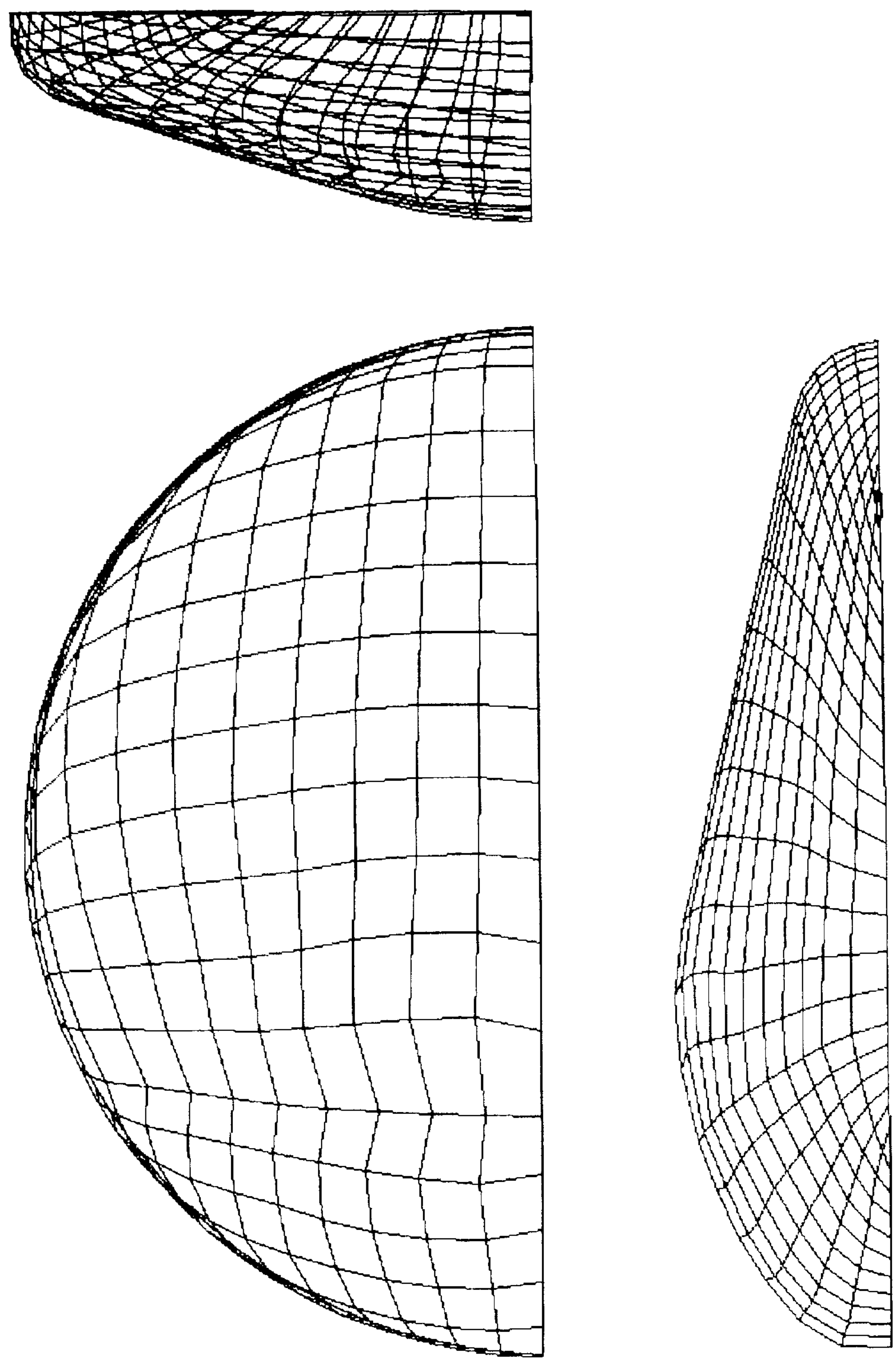
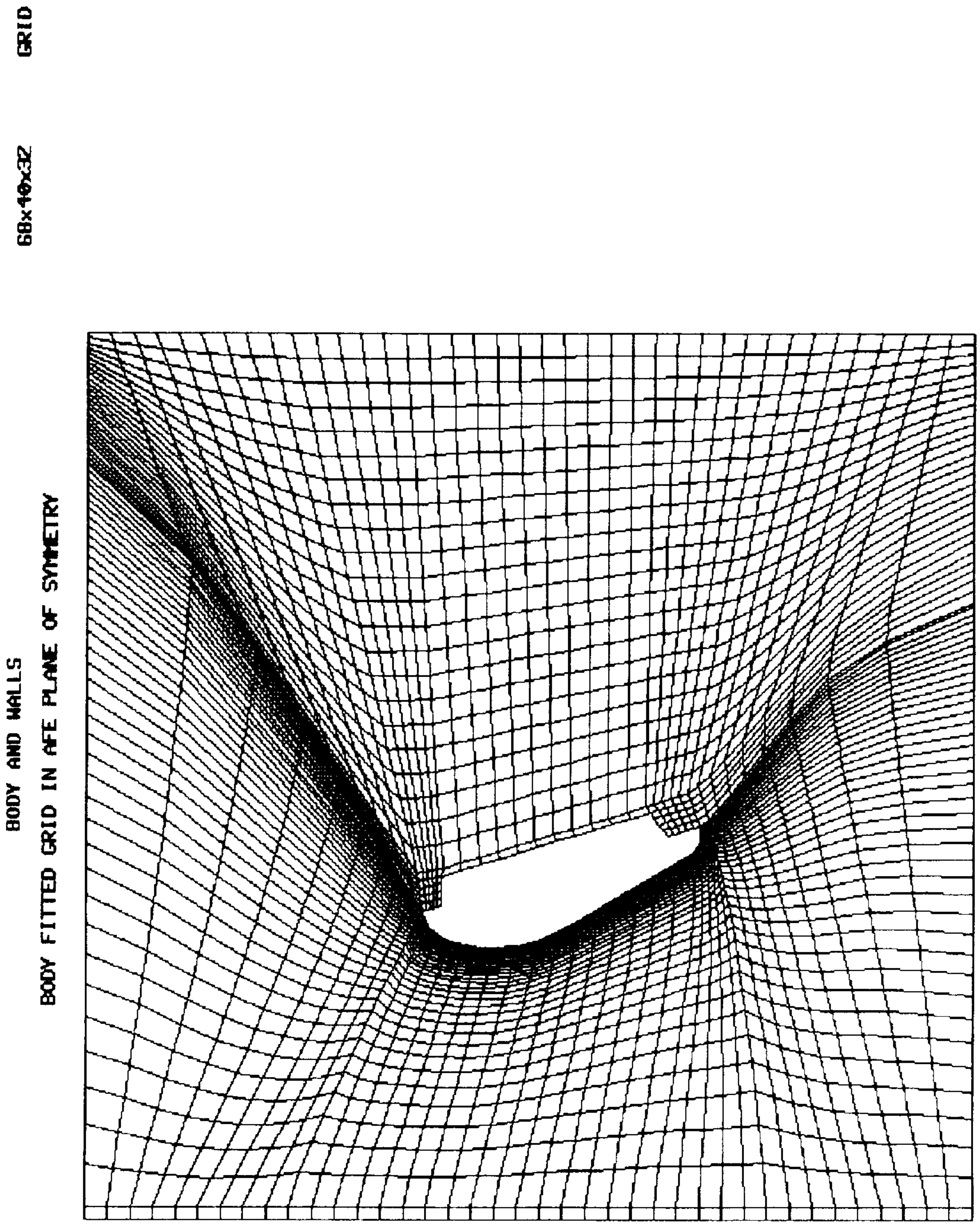
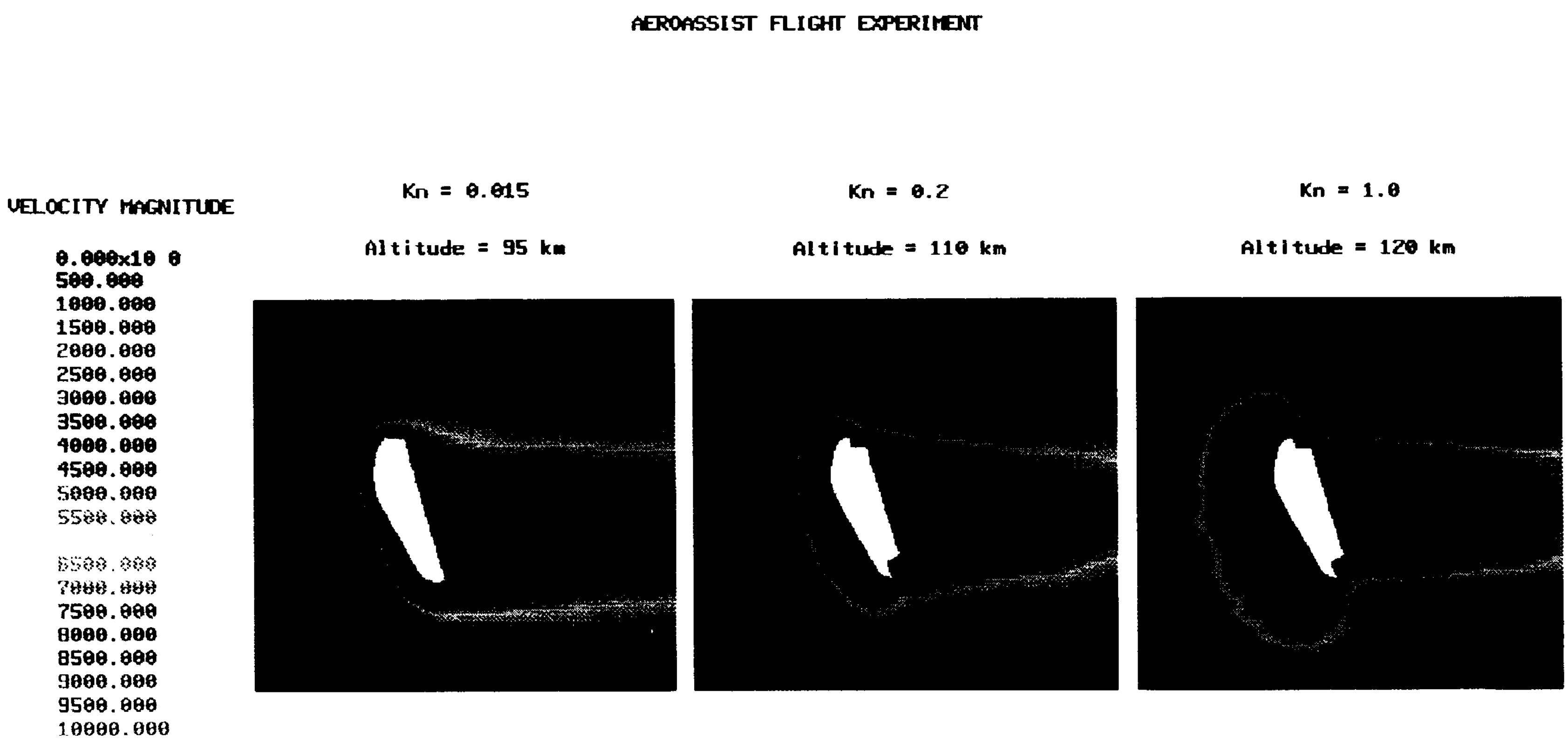
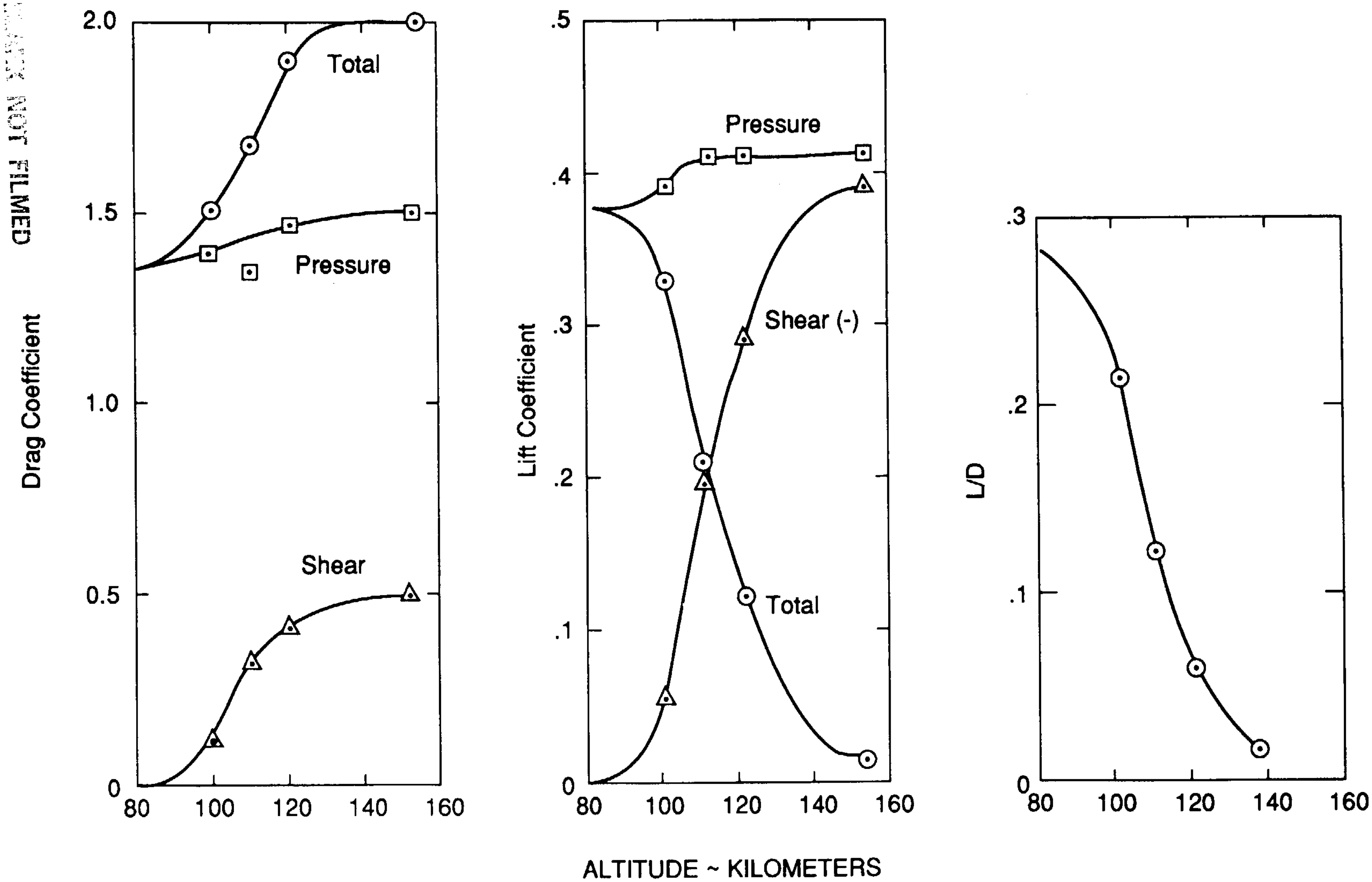


AFE Aerobrake Surface Grid
(22 x 12)


BODY AND WALLS
BODY FITTED GRID IN AFE PLANE OF SYMMETRY
68x40x32
GRID


AEROASSIST FLIGHT EXPERIMENT
VELOCITY MAGNITUDE
0.000x10 0
500.000
1000.000
1500.000
2000.000
2500.000
3000.000
3500.000
4000.000
4500.000
5000.000
5500.000
6500.000
7000.000
7500.000
8000.000
8500.000
9000.000
9500.000
10000.000
Kn = 0.015
Altitude = 95 km
Kn = 0.2
Altitude = 110 km
Kn = 1.0
Altitude = 120 km

AFE TRANSITIONAL FLOW AERODYNAMICS DETERMINED BY DSMC



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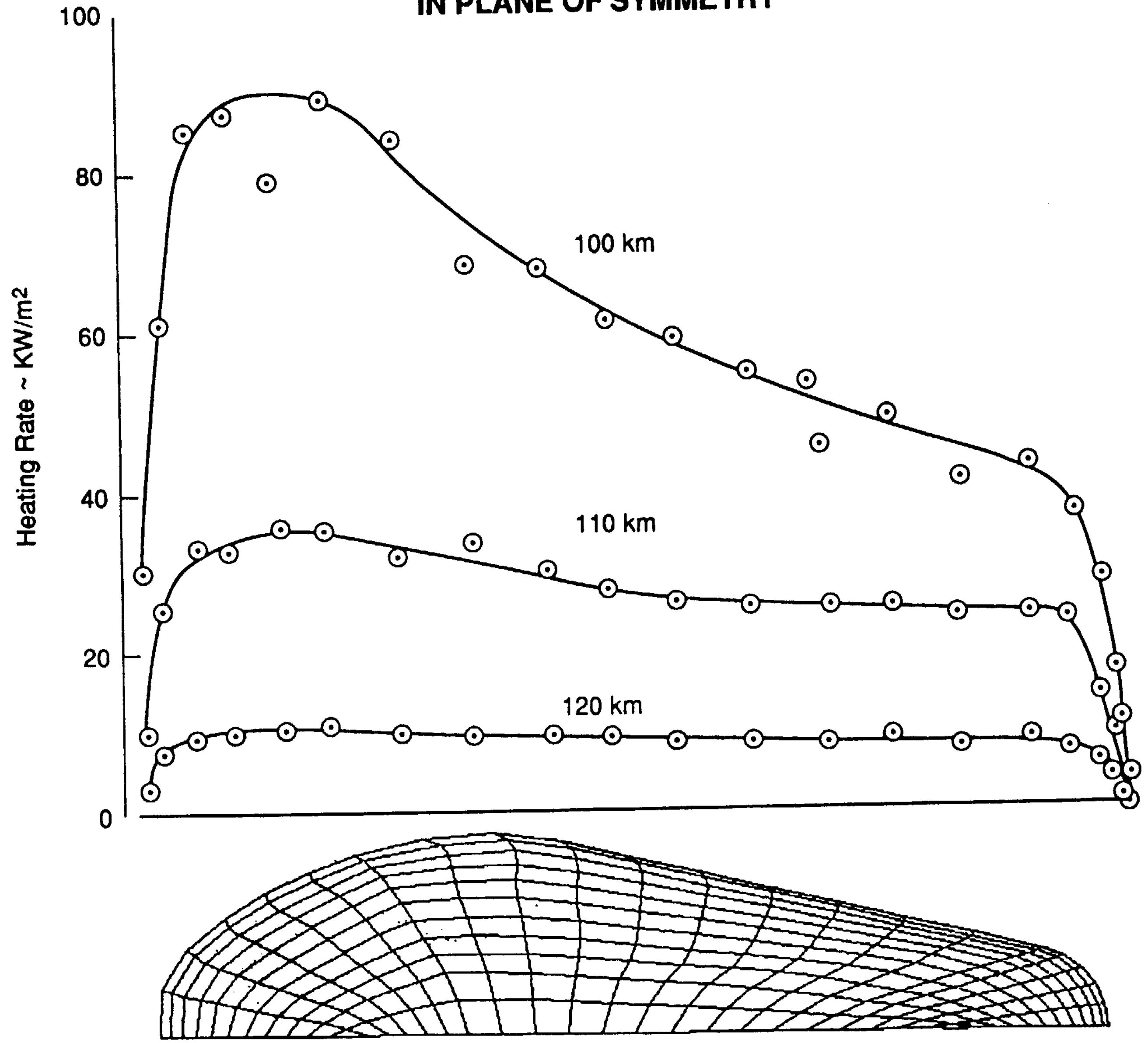
AFE SURFACE HEATING RATE DISTRIBUTION IN PLANE OF SYMMETRY



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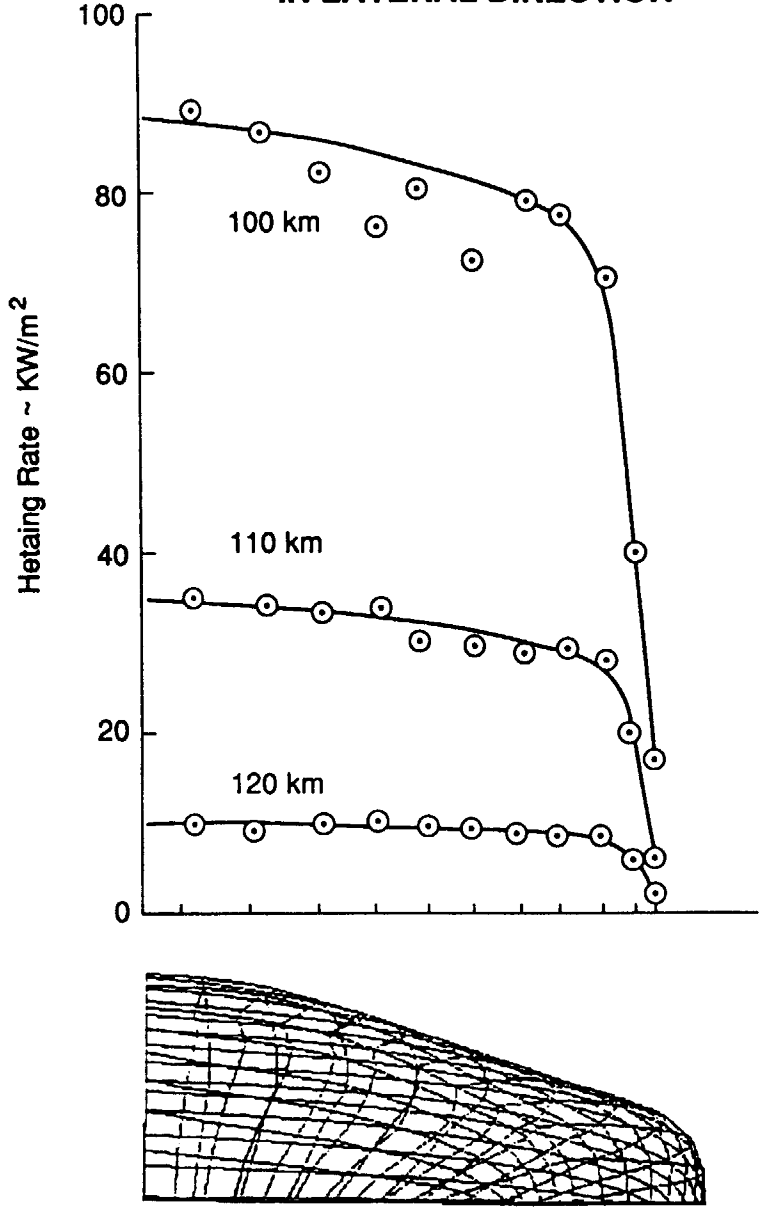
AFE SURFACE HEATING RATE DISTRIBUTION IN LATERAL DIRECTION



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SUMMARY OF AFE ENTRY AERODYNAMIC COEFFICIENTS CALCULATED BY DSMC

ALTITUDE	TOTAL			PRESSURE		SHEAR	
~(Km)	CL	CD	L/D	CL	CD	CL	CD
100	0.334	1.530	0.218	0.392	1.402	–0.058	0.128
110	0.214	1.688	0.127	0.413	1.363	–0.199	0.325
120	0.125	1.904	0.065	0.414	1482	–0.289	0.422
152.4	0.019	2.007	0.010	0.415	1.506	–0.396	0.501

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ATMOSPHERIC CONDITIONS USED BY DSMC (1976 US STD ATM)

ALTITUDE	DENSITY	TEMPERATURE	PRESSURE	SPECIES NO. DENSITY		
Km	Kg/m**3	Kelvin	Pascal	N2	O2	O
95	0.1393E–05	189.9	0.7596E–01	.7835	.2014	.0151
100	0.5604E–06	195.0	0.3201E–01	.7811	.1824	.03645
110	0.9708E–07	240.0	0.7104E–02	.7692	.12285	.10795
120	2.2220E–08	360.0	2.5380E–03	.7316	.0863	.1821
152.4	1.8200E–09	650.3	4.1070E–04	.5932	.05135	.3554

AFE ENTRY TRAJECTORY USED BY DSMC

ALTITUDE	VELOCITY	KNUDSEN NO.	MEAN-FREE-PATH	WALL TEMP	TWALL/TINF
Km	m/s		Meters	Kelvin	
95	9908	0.0136	0.0579	1000	5.266
100	9911	0.0334	0.142	866	4.441
110	9911	0.1855	0.788	500	2.083
120	9897	0.7794	3.31	295	0.819
152.4	9897	8.4768	37.	295	0.4536

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CONCLUSION

- THE AERODYNAMICS AND AEROTHERMODYNAMICS OF THE AFE HAVE BEEN OBTAINED IN THE TRANSITIONAL FLOW REGIME USING DIRECT SIMULATION MONTE CARLO. THESE CALCULATIONS ARE FOR A FIVE SPECIE REACTING AIR CHEMISTRY MODEL, INCLUDING THERMAL NONEQUILIBRIUM.

- DSMC IS A VERY POWER TOOL EVEN FOR COMPLEX THREE-DIMENSIONAL GEOMETRY. THIS HAS BEEN MADE FEASIBLE BY THE LARGE MEMORY AVAILABLE ON THE NAS CRAY-2. THREE-DIMENSIONAL NONVECTORIZED DSMC DOES REQUIRE TOO MUCH COMPUTER TIME TO CONDUCT PARAMETER STUDIES.

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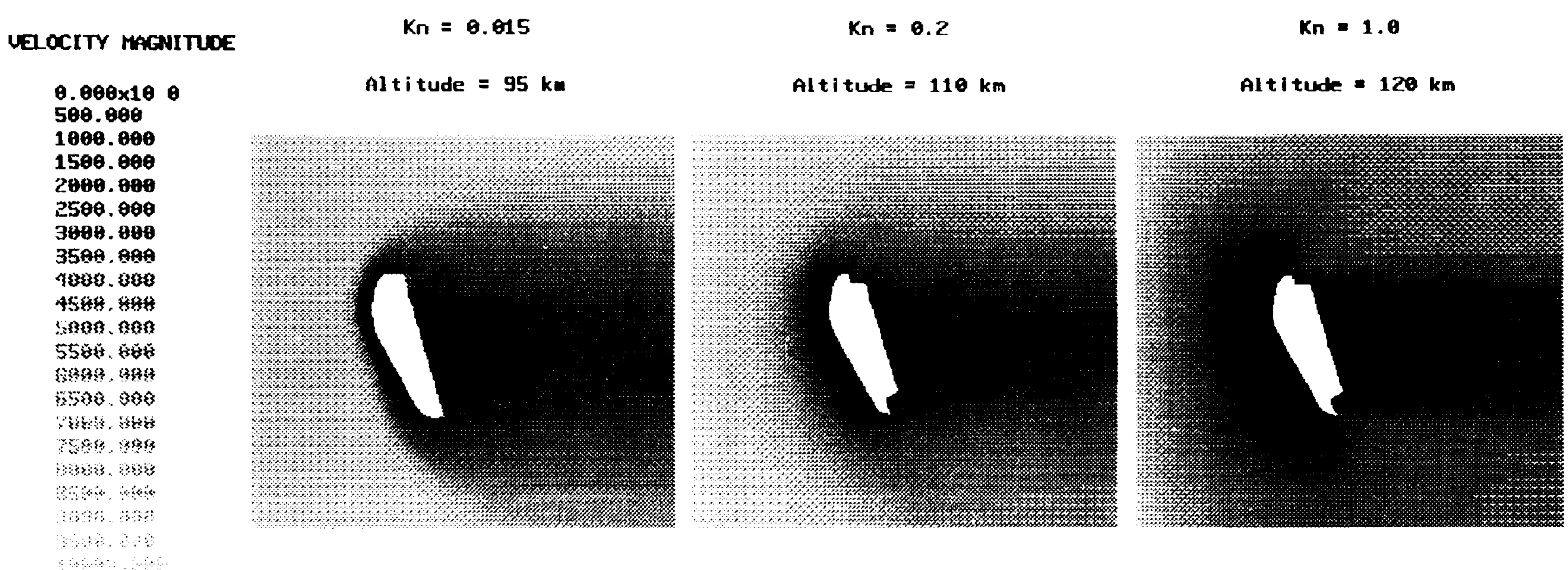
AEROASSIST FLIGHT EXPERIMENT



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