Unique Document # SAB200087890006

SANDIA REPORT

Enclosure 1: #66

SAND88—0360
Specified External Distribution Only*
Printed March 1988

ASP RAP-200 Data and Trajectory Analysis

DEPARTMENT OF ENERGY DECLASSIFICATION REVIEW
1ST REVIEW-DATE: 4-18-08
AUTHORITY: ☐ DC ☒ DD
NAME: Eric Holzer
2ND REVIEW-DATE: 4/18/08
AUTHORITY: [illegible]
NAME: [illegible]
DETERMINATION [CIRCLE NUMBER(S)]
1. CLASSIFICATION RETAINED
2. CLASSIFICATION CHANGED TO:
3. CONTAINS NO DOE CLASSIFIED INFO
4. COORDINATE WITH:
5. CLASSIFICATION CANCELED
6. CLASSIFIED INFO BRACKETED
7. OTHER (SPECIFY): DOD BRACKETS (MCTL) [redacted]
PER LETTER DTD. 10/2/97

Walter P. Wolfe, Christine E. Hailey

Prepared by
Sandia National Laboratories
Albuquerque, New Mexico 87185 and Livermore, California 94550
for the United States Department of Energy
under Contract DE-AC04-76DP00789

WARNING This document contains technical data whose export is restricted by the Arms Export Control Act (22 USC 2751 et seq) or the Export Administration Act of 1979, as amended (50 USC 2401 et seq). Violations of these export laws are subject to severe civil and criminal penalties.

***Only those recipients external to SNL as listed under "Distribution" are authorized to receive copies of this report. They are not authorized to further disseminate the information without permission from the originator.**

SF2900Q(8-81)

95SA20B000277

SAND88-0360
Specified External Distribution Only
Printed March 1988

ASP RAP-200 Data and Trajectory Analysis

Walter P. Wolfe and Christine E. Hailey
Aeroballistics Division
Sandia National Laboratories
Albuquerque, New Mexico 87185

ABSTRACT

DOD
MCTL
b(3)

WARNING: This document contains technical data whose export is restricted by the Arms Export Control Act (22 U.S.C. 2751 et seq) or the Export Administration Act of 1979, as amended, (50 U.S.C. 2401 et seq). Violations of these export laws are subject to severe civil and criminal penalties.

Contents

Nomenclature **9**

1 Introduction **11**

2 ASP Development Program **12**

3 Mathematical Modeling **14**

4 Instrumentation **16**

5 Flight Test Summary **18**

6 RAP-201 Data Analysis **20**
- 6.1 Recorded Data 20
- 6.2 Axial Accelerometers 24
- 6.3 Lateral Accelerometers 34
- 6.4 Pressure Transducers 39
- 6.5 Gyro Data 43

7 Trajectory Analyses **50**
- 7.1 RAP-202 Trajectory 51
- 7.2 RAP-203 Trajectory 51
- 7.3 RAP-103 Trajectory Re-evaluation 51
- 7.4 Recovery System Deployment 55

8 Conclusions **61**

9 Recommendations **63**

10 References **64**

List of Figures

1 ASP Geometry 13
2 Unfiltered Axial Accelerometer Data, AX2 22
3 Axial Accelerometer Data, AX2, with Overwrite 23
4 Filtered Axial Accelerometer Data, AX2 23
5 Filtered Axial Accelerometer Data, AX1 24
6 Comparison of AX1 and AX2 Data 25
7 Comparison of AX2 Data and Point Mass Acceleration Prediction . 27
8 Early Time Comparison of AX2 and Theory 28
9 Comparison of Integrated AX2 Data and Prediction–Velocity vs. Time 30
10 Comparison of Integrated AX2 Data and Prediction–Depth vs. Time 30
11 Comparison of Integrated AX2 Data and Prediction–Depth vs. Down Range 31
12 Comparison of Integrated AX2 Data and Prediction–Flight Path Angle vs. Time 31
13 Extension of AX2 Integration Compared with Pinger Data – Depth vs. Time 32
14 Extension of AX2 Integration Compared with Pinger Data – Depth vs. Down Range 32
15 Comparison of Drag Coefficient from AX2 Data with SANDRAG-H Results 34
16 AY1, Lateral Accelerometer Data 35
17 AY2, Lateral Accelerometer Data 35
18 AY3, Lateral Accelerometer Data 36
19 AY4, Lateral Accelerometer Data 36
20 AZ1, Lateral Accelerometer Data 37
21 AZ2, Lateral Accelerometer Data 37
22 AZ3, Lateral Accelerometer Data 38
23 AZ4, Lateral Accelerometer Data 38
24 Comparison of P1 Pressure Data and SANDRAG-H Prediction . . . 40
25 Comparison of P1 Pressure Data with Pinger Data 41
26 P5 Pressure Data 42
27 P7 Pressure Data 42
28 P8 Pressure Data 43
29 Pitch Gyro Data 45
30 Yaw Gyro Data 45

31 Pitch and Yaw Gyro Data 46
32 Estimated Roll Angle 48
33 Estimated Roll Rate 48
34 Estimated Roll Deceleration 49
35 Estimated Roll Damping Coefficient 49
36 Predicted Nominal Trajectory and Hydrophone Data, RAP-202, Depth versus Time 52
37 Predicted Nominal Trajectory and Hydrophone Data, RAP-202, Depth versus Down Range 52
38 Predicted Nominal Trajectory and Hydrophone Data, RAP-203, Depth versus Time 53
39 Predicted Nominal Trajectory and Hydrophone Data, RAP-203, Depth versus Down Range 53
40 Predicted Nominal Trajectory and Hydrophone Data, RAP-103, Depth versus Time 54
41 Predicted Nominal Trajectory and Hydrophone Data, RAP-103, Depth versus Down Range 54
42 Experimental and Theoretical Depth vs. Time for RAP-201, Parachute Deployed when Fully-Wetted Flow Predicted, when Accelerometer Data Indicate Deployment, and at Nominal Time 56
43 Experimental and Theoretical Depth vs. Down Range for RAP-201, Parachute Deployed when Fully-Wetted Flow Predicted, when Accelerometer Data Indicate Deployment, and at Nominal Time 56
44 Experimental and Theoretical Depth vs. Time for RAP-202, Parachute Deployed when Fully-Wetted Flow Predicted and at Nominal Time 58
45 Experimental and Theoretical Depth vs. Down Range for RAP-202, Parachute Deployed when Fully-Wetted Flow Predicted and at Nominal Time 58
46 Experimental and Theoretical Depth vs. Time for RAP-203, Parachute Deployed when Fully-Wetted Flow Predicted and at Nominal Time 59
47 Experimental and Theoretical Depth vs. Down Range for RAP-203, Parachute Deployed when Fully-Wetted Flow Predicted and at Nominal Time 59
48 Experimental and Theoretical Depth vs. Time for RAP-103, Parachute Deployed when Fully-Wetted Flow Predicted and at Nominal Time 60

49 Experimental and Theoretical Depth vs. Down Range for RAP-103, Parachute Deployed when Fully-Wetted Flow Predicted and at Nominal Time 60

List of Tables

1 LDRS Channel Assignments 17
2 Water Impact Conditions 20
3 Coefficients of Non-linear Fit to RAP-201 Gyro Data 47
4 Predicted Dynamic Pressures at Fully-Wetted Flow 61

Nomenclature

a	Acceleration
B	Buoyancy (138 lbf for ASP)
C_D	Drag coefficient $= D/(qS)$
C_ℓ	Roll moment coefficient $= \ell/qSd$
C_{ℓ_p}	Roll damping coefficient $= \partial C_\ell/\partial\frac{pd}{2V}$
$C_1 \ldots C_7$	Coefficients of fit for gyro data - Eqs. 8 – 10
d	Base diameter = 14.7 inches
D	Drag force
g	Acceleration due to gravity
h	Depth
ℓ	Rolling moment
m	Vehicle mass = 789 lbm
p	Roll rate
p_c	Cavity pressure
p_{hs}	Hydrostatic pressure, in psf - Eq. 7
q	Free stream dynamic pressure $= \rho V^2/2$
S	Reference area = 1.179 ft^2
t	Time from water impact
V	Velocity
x	Horizontal distance
z	Vertical distance
γ	Flight path angle, measured from horizontal
θ	Pitch angle for fit - Eq. 9
ρ	Salt water density = 1.989 slug/ft^3
σ	Cavitation number $= (p_{hs} - p_c)/q$
ϕ	Roll angle for fit - Eq. 8
Φ	Roll angle from zero reference point - Eq. 11
ψ	Yaw angle for fit - Eq. 10

ASP RAP-200 Data and Trajectory Analysis

1 Introduction

DOD
MCTL
b(3)

DCL
ACT 1
b(3)

DOD
MCTL
b(3)

NOD
MCTL
b(5)

DOD
MCTL
b(3)

DOD
MCTL
b3

DOD
NGA
b(3)

DOD
MCTL
d(5

DOD
MCTL
b(3)

DOD
MCTL
(3)

DOD
MCTL
b(3)

DOD
mc7L
b(3)

DOD

MC[illegible]

b(3)

DOD
MCTL
OLS

DoD
MCL
b(3)

DOD
MCTL
b(3)

DOD
MCTL
b(3)

DOD
MCTL
K/3

DOD
METL
(3)

DOD
MCTL
(3)
(2)

DOD
MCTL
B(3)

DOD
MCTL
LO

DOD
MCTL
b(3)

DOD
MCTL
V31

DoD
MCTL
V(3)

9 Recommendations

DOD
MCTL
b(3)

9 Recommendations

DoD
MCTL
b(3)

Specified External Distribution Only

Access to this document or its contents should be limited to employees of agencies specified on the distribution list. Distribution or announcement of this document outside the agencies listed may not be made without prior approval of the issuing organization.

Mr. Howard K. Steves
Naval Surface Warfare Center
White Oak, Code U12
Silver Spring, MD 20903-5000

Mr. J. Hager
Code 7311
Pacific Missile Range Facility
P.O. Box 128
Kekaha, HA 96752-0128

Boeing Aerospace Company
For: Sea Lance Program
R. Pearson
P. O. Box 3999
Seattle, WA 98124

Naval Sea Systems Command (4)
For: H. F. Masterson, Code PMS 414H
C. C. Roop, Code PMS 41T
Capt. J. T. Regan
Capt. J. Killian, Code PMS 423
Department of the Navy
Washington, DC 20362

Naval Underwater Systems Center
For: R. W. Trainor, Code 3693
Newport, RI 02841-5047

Naval Weapons Center
For: W. D. Sutherlen, Code 3909
China Lake, CA 93555

13. Benton, D. N., "Thermal Analysis of the Anti-Submarine Penetrator Surface Pressure Transducers," SAND87-0406, Sandia National Laboratories, Albuquerque, NM, March 1987.

14. Eklund, T. F., and Stoner, D. C., "Recoverable Data Acquisition System Designed and Developed for Penetrator Applications," SAND88-8208, Sandia National Laboratories, Livermore, CA, March 1988.

1510 J. W. Nunziato
1520 C. W. Peterson
1530 L. W. Davison
1550 R. C. Maydew
1551 J. K. Cole
1551 C. E. Hailey (5)
1551 W. P. Wolfe (5)
1552 D. D. McBride
Attn: D. W. Johnson
1553 S. McAlees, Jr.
Attn: D. N. Benton
D. W. Kuntz
1554 D. P. Aeschliman
1555 W. R. Barton
Attn: W. A. Millard
L. R. Rollstin
1556 W. L. Oberkampf
5100 H. W. Schmitt
5110 C. C. Burks
5112 L. J. Merrell
5120 W. R. Reynolds
5160 G. R. Otey
5161 K. D. Nokes
5165 S. D. Meyer
7500 D. M. Olson
7520 T. J. Hoban
7523 P. L. Walter
Attn: D. M. Talbert
7525 R. L. Eno
7526 L. W. Lathrop
8100 E. E. Ives
8131 W. R. Bolton
8140 J. F. Barham
8142 M. A. Gusinow
Attn: D. R. Baker
H. D. Sorensen
D. C. Stoner
T. F. Eklund
8150 J. B. Wright
8151 C. B. Layne
Attn: R. N. Everett
8152 J. C. Swearengen
Attn: R. E. Rychnovsky
8152 M. T. Ferrario
8282 S. G. Cain
Attn: J. Tootle
9142 E. W. Reece
Attn: J. P. Gallagher
3141 S. A. Landenberger (5)
3151 W. L. Garner (3)
8524 P. W. Dean