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LAWRENCE LIVERMORE LABORATORY

University of California/Livermore, California

MODEL OF SM-2 (ER)

(Unclassified)

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October 14, 1974

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MODEL OF SM-2 (ER)

At the request of the AEC, General Dynamics (Pomona Division) prepared a model of SM-2 which could be used to study systems effects.⁽¹⁾ This model was subsequently improved by General Dynamics⁽²⁾ and interpreted by the authors for use by the AEC. The resulting SM-2 (ER) model is presented in Figure 1 and Table I.

The construction of this model was guided by the intent to: (1) insofar as possible, within the constraint of a reasonably simple geometry, correctly locate the correct amount of each element, and (2) be internally consistent. It must be emphasized that the model presented here is a MODEL. The number of significant figures presented in Figure 1 and Table I are not to be considered so much as a measure of perfect knowledge but as an attempt to make the available information internally consistent.

It should be pointed out that this model is symmetric about the longitudinal axis of the missile. Consequently it was necessary to homogenize various missile components over fictitious volumes. By far the most extreme example of this is provided by the homogenization of the dorsal fins and control surfaces of the missile. In each case where such a homogenization was necessary, the mass of the components was considered inviolate, and consequently the density of the modeled components were adjusted appropriately.

(1) L. Friemel, General SM-2 Hardware Composition for Utilization in Determining Missile Shadowing Effects When Configured with a Special Warhead, General Dynamics (Pomona Division) Rept. GM-6-335-SM2-242 (April 5, 1974).
(Confidential)

(2) L. Friemel, T. Rollins, D. Kisner, Private communication (July 1974).

NOTE: ALL DIMENSIONS ARE IN CENTIMETERS.

Fig.1a GEOMETRY OF SM-2(ER) MODEL
FORWARD SECTION

NOTE: ALL DIMENSIONS ARE IN CENTIMETERS.

Fig.1b GEOMETRY OF SM-2 (ER) MODEL
CENTER SECTION

TABLE I

ELEMENTAL DESCRIPTION OF EACH MAJOR COMPONENT OF
SM-2 (ER) DEPICTED IN FIG. 1

1. Radome Tip

Volume = 1.407 cm³Average Density = 7.930 g/cm³

Element	Mass (g)
Fe	10.712
Ni	0.223
Co	0.111
C	0.056
Mn	0.056
Total	11.158

2. Van Karman Ogive

Volume = 3197.739 cm³Average Density = 2.61000 g/cm³

Element	Mass (g)
Ti	49.999
Mg	686.987
Al	1524.252
Si	1983.703
O	4101.159
Total	8346.100

3. Forward Guidance Section Shell

Volume = 330.515 cm³Average Density = 2.69900 g/cm³

Element	Mass (g)
Al	838.536
Cu	44.603
Mn	8.921
Total	892.060

TABLE I (Continued)

4. Central Guidance Section Shell & S/X Antennas

Volume = 756.263 cm³Average Density = 2.90852 g/cm³

Element	Mass (g)
H	9.747
C	114.714
O	325.397
Mg	36.738
Al	1443.079
Si	179.193
Ti	3.749
Cu	72.492
Mn	14.498
Total	2199.607

5. Aft Guidance Section Shell

Volume = 425.869 cm³Average Density = 2.69900 g/cm³

Element	Mass (g)
Al	1080.456
Cu	57.471
Mn	11.494
Total	1149.421

6. Antenna Assembly

Volume = 380.880 cm³Average Density = 2.59617 g/cm³

Element	Mass (g)
Al	587.521
Cu	232.849
Zn	12.369
H	8.149
C	63.495
N	1.587
O	34.711
Fe	47.621
Si	0.529
Total	988.831

TABLE I (Continued)

7. Gimballed Platform

Volume = 2319.675 cm³Average Density = 0.682439 g/cm³

Element	Mass (g)
Fe	903.737
Al	488.800
Cu	26.000
Mn	5.200
W	59.300
C	80.000
O	15.000
H	5.000
Total	1583.037

8. Antenna Center Support

Volume = 529.387 cm³Average Density = 2.69900 g/cm³

Element	Mass (g)
Al	1343.087
Cu	71.441
Mn	14.288
Total	1428.816

TABLE I (Continued)

9. Head Control

Volume = 3462.737 cm³Average Density = 1.13963 g/cm³

Element	Mass (g)
Ni	204.120
Fe	2098.281
Cr	408.240
Mn	68.040
Cu	106.129
Pb	74.474
Sn	74.474
H	69.509
C	511.391
N	10.639
O	271.654
Si	43.202
Al	3.284
Au	1.407
Ag	<u>1.407</u>
Total	3946.251

10. Base Plate

Volume = 683.518 cm³Average Density = 1.32723 g/cm³

Element	Mass (g)
Al	852.754
Cu	45.359
Mn	<u>9.072</u>
Total	907.185

TABLE I (Continued)

11. Plate #1

Volume = 5530.232 cm³Average Density = 1.01131 g/cm³

Element	Mass (g)
Al	3291.970
Fe	840.101
Cu	579.110
Si	380.594
C	163.170
O	136.249
H	25.380
Pb	46.958
Sn	46.958
Au	6.576
Ag	21.167
Ni	11.816
Cr	23.633
F	16.749
Mn	2.363
Total	5592.794

12. Plate #2

Volume = 2414.198 cm³Average Density = 0.697055 g/cm³

Element	Mass (g)
Al	785.012
Fe	101.573
Cu	185.098
Si	328.684
C	56.753
O	104.682
H	7.019
Ni	4.111
Cr	8.222
Mn	1.404
Pb	41.111
Sn	41.111
Au	9.024
Ag	9.024
Total	1682.828

TABLE I (Continued)

13. Plate #3

Volume = 4372.595 cm³Average Density = 1.25208 g/cm³

Element	Mass (g)
Al	1984.318
Fe	170.604
Cu	1763.327
Si	1096.332
C	141.771
O	79.794
H	3.448
Ag	91.289
Au	91.289
F	4.789
Pb	9.579
Sn	9.579
Ni	8.621
Cr	17.242
Mn	2.874
Total	5474.856

14. Plate #4

Volume = 1931.358 cm³Average Density = 0.767981 g/cm³

Element	Mass (g)
Al	718.015
Fe	119.298
Cu	209.474
Si	255.625
C	39.863
O	68.986
H	5.515
Ni	3.967
Cr	7.837
Mn	1.355
Pb	23.221
Sn	23.221
Au	5.805
Ag	1.064
Total	1483.246

TABLE I (Continued)

15. Plate #5

Volume = 2607.334 cm³Average Density = 1.18959 g/cm³

Element	Mass (g)
Al	1175.216
Fe	292.585
Cu	707.344
Si	578.291
C	99.797
O	134.952
H	13.079
Ni	3.100
Cr	6.124
Mn	7.862
Pb	23.815
Sn	23.815
Au	17.842
Ag	17.842
Total	3101.664

16. Autopilot Battery Section Shell

Volume = 3260.353 cm³Average Density = 2.69900 g/cm³

Element	Mass (g)
Al	8271.711
Cu	439.985
Mn	87.997
Total	8799.693

TABLE I (Continued)

17. Power Change Over Circuit

Volume = 917.399 cm³Average Density = 3.35225 g/cm³

Element	Mass (g)
Cu	1495.292
Si	473.768
Al	688.775
Au	15.608
Ag	15.608
Ni	5.369
Fe	77.244
Cr	10.739
Mn	8.730
Pb	13.798
Sn	13.798
H	12.161
C	132.074
O	<u>112.390</u>
Total	3075.354

18. Autopilot Battery Section Shell Sleeve

Volume = 226.796 cm³Average Density = 3.84001 g/cm³

Element	Mass (g)
Al	319.783
Cu	17.010
Mn	3.402
C	334.343
Ni	31.842
O	122.062
H	31.842
Si	<u>10.614</u>
Total	870.898

TABLE I (Continued)

19. Battery

Volume = 8288.877 cm³Average Density = 1.34074 g/cm³

Element	Mass (g)
Ni	458.824
Fe	3568.629
Cr	917.647
Mn	152.941
Zn	3663.893
Ag	915.973
K	538.179
O	355.995
H	30.700
Cu	<u>510.417</u>
Total	11113.198

20. Autopilot Instrument/Electrical Assembly

Volume = 6582.344 cm³Average Density = 1.13703 g/cm³

Element	Mass (g)
Al	2611.576
Cu	2108.736
Mn	18.666
Si	309.360
Au	11.349
Ag	11.349
Fe	992.299
Ni	10.898
Cr	38.143
Pb	64.559
Sn	64.559
C	953.130
O	222.151
H	<u>67.516</u>
Total	7484.291

TABLE I. (Continued)

21. Autopilot Battery Section Dorsal Fins

Volume = 24364.524 cm³Average Density = 0.0744677 g/cm³

Element	Mass (g)
Al	1705.507
Cu	90.718
Mn	<u>18.144</u>
Total	1814.369

22. Rocket Motor Forward End Shell

Volume = 507.360 cm³Average Density = 7.93000 g/cm³

Element	Mass (g)
Fe	3862.430
Ni	80.467
Co	40.234
C	20.117
Mn	<u>20.117</u>
Total	4023.365

23. Rocket Motor Forward End Wall

Volume = 2173.583 cm³Average Density = 7.93000 g/cm³

Element	Mass (g)
Fe	16547.051
Ni	344.730
Co	172.365
C	86.183
Mn	<u>86.183</u>
Total	17236.512

TABLE I (Continued)

24. Rocket Motor Center Section Shell

Volume = 3076.764 cm³Average Density = 7.93000 g/cm³

Element	Mass (g)
Fe	23422.786
Ni	487.975
Co	243.987
C	121.994
Mn	121.994
Total	24398.736

25. Rocket Motor Dorsal Fins

Volume = 270605.061 cm³Average Density = 0.126638 g/cm³

Element	Mass (g)
Fe	32898.150
Ni	685.378
Co	342.689
C	171.345
Mn	171.345
Total	34268.907

26. Rocket Motor Rear Wall

Volume = 686.395 cm³Average Density = 7.93000 g/cm³

Element	Mass (g)
Fe	5225.384
Ni	108.862
Co	54.431
C	27.216
Mn	27.216
Total	5443.109

TABLE I (Continued)

27. Spacer

Volume = 1680.594 cm³Average Density = 2.69900 g/cm³

Element	Mass (g)
Al	4263.769
Cu	226.796
Mn	<u>45.359</u>
Total	4535.924

28. Spacer Dorsal Cover

Volume = 14702.532 cm³Average Density = 0.0740431 g/cm³

Element	Mass (g)
Al	1023.304
Cu	54.431
Mn	<u>10.886</u>
Total	1088.621

29. Steering Control Section Shell - Forward

Volume = 853.946 cm³Average Density = 2.69900 g/cm³

Element	Mass (g)
Al	2166.513
Cu	115.240
Mn	<u>23.048</u>
Total	2304.801

TABLE I (Continued)

30. Steering Control Section Shell - Center and Actuators

Volume = 12515.451 cm³Average Density = 2.09627 g/cm³

Element	Mass (g)
Fe	18200.123
Al	4424.051
Cu	571.208
C	1149.380
Sn	457.584
Pb	114.396
H	114.396
O	457.584
Si	686.376
Mn	28.145
Ni	21.682
Co	<u>10.841</u>
Total	26235.766

31. Steering Control Section Shell - Rear

Volume = 1289.633 cm³Average Density = 2.6990 g/cm³

Element	Mass (g)
Al	3271.877
Cu	174.036
Mn	<u>34.807</u>
Total	3480.720

TABLE I (Continued)

32. Rocket Motor Rear Wall Liner

Volume = 793.969 cm³Average Density = 3.99908 g/cm³

Element	Mass (g)
H	139.412
C	1181.024
N	113.912
O	1023.281
Mg	318.366
Al	53.683
Si	<u>345.469</u>
Total	3175.147

33. Collector Ring Assembly

Volume = 1619.963 cm³Average Density = 1.63241 g/cm³

Element	Mass (g)
Al	880.468
Cu	99.722
Mn	12.367
Fe	1521.998
Si	10.578
C	33.156
O	10.578
H	10.578
F	38.000
Ni	9.000
Cr	<u>18.000</u>
Total	2644.445

TABLE I (Continued)

34. Missile to Booster Connector

Volume = 1425.010 cm³Average Density = 1.17774 g/cm³

Element	Mass (g)
Al	1577.594
Cu	83.915
Mn	<u>16.783</u>
Total	1678.292

35. Blast Tube

Volume = 381.595 cm³Average Density = 7.93000 g/cm³

Element	Mass (g)
Fe	2905.007
Ni	60.521
Co	30.260
C	15.130
Mn	<u>15.130</u>
Total	3026.048

36. Nozzle

Volume = 144.743 cm³Average Density = 7.93000 g/cm³

Element	Mass (g)
Fe	1101.898
Ni	22.956
Co	11.478
C	5.739
Mn	<u>5.739</u>
Total	1147.810

TABLE I (Continued)

37. Control Surfaces

Volume = 150965.682 cm³Average Density = 0.0979502 g/cm³

Element	Mass (g)
Fe	14195.628
Ni	295.742
Co	147.871
C	73.940
Mn	<u>73.940</u>
Total	14787.121

38. Guidance Section Shell Sleeve

Volume = 1093.158 cm³Average Density = 2.00000 g/cm³

Element	Mass (g)
C	1377.379
Ni	131.179
O	502.853
H	131.179
Si	<u>43.726</u>
Total	2186.316

39. Gimballed Platform Counter Weight

Volume = 327.181 cm³Average Density = 7.93000 g/cm³

Element	Mass (g)
Fe	2490.766
Ni	51.891
Co	25.945
C	12.973
Mn	<u>12.973</u>
Total	2594.548

TABLE I (Continued)

40. Rocket Fuel

Volume = 71530.835 cm³Average Density = 1.74383 g/cm³

Element	Mass (g)
N	12193.256
H	5086.965
Cl	36538.991
O	59427.842
C	<u>11490.856</u>
Total	124737.910

41. Rocket Motor Center Section Liner

Volume = 5501.071 cm³Average Density = 3.99908 g/cm³

Element	Mass (g)
H	965.925
C	8182.806
N	789.251
O	7089.876
Mg	2205.820
Al	371.946
Si	<u>2393.607</u>
Total	21999.231

42. Rocket Motor Center Section Beef-up

Volume = 290.574 cm³Average Density = 7.93000 g/cm³

Element	Mass (g)
Fe	2212.079
Ni	46.085
Co	23.042
C	11.521
Mn	<u>11.521</u>
Total	2304.248

TABLE I (Continued)

43. Steering Control Section Forward Beef-up

Volume = 297.018 cm³Average Density = 4.18034 g/cm³

Element	Mass (g)
Al	753.552
Cu	40.083
Mn	10.216
Fe	422.385
Ni	8.800
Co	4.400
C	<u>2.200</u>
Total	1241.636

44. Steering Control Section Flange

Volume = 674.845 cm³Average Density = 1.34950 g/cm³

Element	Mass (g)
Al	856.061
Cu	45.535
Mn	<u>9.107</u>
Total	910.703

45. Blast Tube Liner

Volume = 945.692 cm³Average Density = 1.50065 g/cm³

Element	Mass (g)
C	<u>1419.157</u>
Total	1419.157

TABLE I (Continued)

46. Nozzle Liner

Volume = 330.656 cm³Average Density = 1.19279 g/cm³

Element	Mass (g)
C	<u>394.404</u>
Total	394.404

47. Aft Ring

Volume = 221.329 cm³Average Density = 2.69900 g/cm³

Element	Mass (g)
Al	561.525
Cu	29.868
Mn	<u>5.974</u>
Total	597.367

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