

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

APOLLO

GUIDANCE AND NAVIGATION

Approved Milton B. Trageser Date 1/21/63
MILTON B. TRAGESER, DIRECTOR
APOLLO GUIDANCE AND NAVIGATION PROGRAM

Approved Roger B. Woodbury Date 1/21/63
ROGER B. WOODBURY, ASSOCIATE DIRECTOR
INSTRUMENTATION LABORATORY

J.E. Smart
MASA-SCB 71/70
9-21-71
CWS

E-1142 (REV. 4)

WEIGHT AND BALANCE REPORT

January 15, 1963

File



INSTRUMENTATION LABORATORY

CAMBRIDGE 39, MASSACHUSETTS

COPY # 45 OF 230 COPIES
THIS DOCUMENT CONTAINS 9 PAGES

ACKNOWLEDGMENT

This report was prepared under the auspices of DSR Project 55-191, sponsored by the Manned Spacecraft Center of the National Aeronautics and Space Administration through contract NAS9-153.

This document contains information affecting the national defense of the United States within the meaning of the Espionage Laws, Title 18, U.S.C., Sections 793 and 794, the transmission or the revelation of which in any manner to an unauthorized person is prohibited by law.

The publication of this report does not constitute approval by the National Aeronautics and Space Administration of the findings or the conclusions contained therein. It is published only for the exchange and stimulation of ideas.

ABSTRACT

Report E-1142 (Rev. 4) presents weight and center of gravity values for all components of the guidance and navigation equipment. Subsequent reports will include additional data on moments of inertia.

Only data pertaining to the guidance and navigation equipment of the command and service modules are, at present, included in this report.

E-1142 is prepared monthly and distributed on the 15th of each month.

Introduction

E-1142 (Rev. 4) is submitted in compliance with the documentation requirement for weight, center of gravity, and moment of inertia data for Apollo guidance and navigation equipment. At present, however, E-1142 pertains to only the command and service modules.

Weight evaluation and center of gravity data are included in this revision. Subsequent revisions will update this weight and center of gravity data and will also include moment of inertia data.

Weight

All weight items are grouped according to their specific location within the spacecraft modules. Subsystem weights are reported to the component level and to the nearest tenth of a pound.

Given component weights are identified as calculated, measured, or estimated. These terms are defined by North American Aviation, Inc. as follows:

Calculated weights (C) are weights based on detailed calculations made from final production drawings that will be used to build flyable equipment.

Measured weights (M) are the actual weights of equipment built to the production drawings.

Estimated weights (E) are rough calculations.

North American Aviation, Inc. will supply data on coldplate weights.

Centers of Gravity

The center of gravity of each weight component or packaged assembly is determined with respect to the basic X, Y, Z axes of the command module, that is, the established reference coordinates indicated on drawing V-16-930001

(NAA). The values given are to the nearest tenth of an inch.

Weight Status Reporting

The initial specification weights have not yet been established. On the basis of this revision, however, MIT/IL expects to supply NASA with more of the data necessary to establish specification weights.

This revision offers a comparison of present weight and center of gravity values with those values listed in the previous Weight and Balance Report, E-1142 (Rev. 3), December 1962. All changes in weight are explained.

Accuracy

The accuracy of numerical values reported in this revision should not be considered to be within the tolerances implied by the significant figures quoted. Numerical values will approach the established tolerances as design and development phases approach completion.

Explanation of Reported Weight Changes

D&C/NAV. Partial calculation of weights associated with D&C/NAV resulted in an eight pound weight reduction.

IMU. Weight increased due to an increase in flange weight which was required for additional strength.

Measured	31.4(M)
Calculated	19.8(C)
<u>Estimated</u>	<u>7.5(E)</u>
Total weight	58.7(E)

Electrical Load Requirements Data

In order to compute capacity requirements for the fuel cells and battery power supply system, subsequent reports will include electrical load requirements for guidance and navigation equipment.

Table 1. Current Weight Status

Items	Spec. Weight (lbs)	Changes to	Status 12/62	Changes to Current	Current Weight 1/63
<u>COMMAND MODULE</u>					
<u>Lower Equip. Bay-Forward</u>					
CDU	--	--	15.0(E)	0.0	15.0(E)
D&C/AGC	--	--	15.0(E)	0.0	15.0(E)
D&C/NAV	--	--	39.5(E)	-8.0	31.5(E)
M&DV	--	--	8.5(E)	0.0	8.5(E)
OPT SUBSYSTEM	--	--	40.0(E)	0.0	40.0(E)
IMU	--	--	58.4(E)	+0.3	58.7(E)
NVB	--	--	21.0(E)	0.0	21.0(E)
OPT EYE PIECES	--	--	5.0(E)	0.0	5.0(E)
CBL	--	--	40.0(E)	0.0	40.0(E)
BELLOWS ASSY	--	--	15.0(E)	0.0	15.0(E)
<u>Lower Equip. Bay-Middle</u>					
AGC	--	--	58.0(C)	0.0	58.0(C)
PSA*	--	--	29.0(E)	0.0	29.0(E)
JBX	--	--	11.0(E)	0.0	11.0(E)
<u>Main Panel</u>					
D&C/AGC	--	--	15.0(E)	0.0	15.0(E)
D&C/NAV	--	--	10.0(E)	0.0	10.0(E)
<u>SERVICE MODULE</u>					
RAD	--	--	15.0(E)	0.0	15.0(E)
<u>SPARES</u>	--	--	40.0(E)	0.0	40.0(E)
TOTAL			435.4	-7.7	427.7
<p>Notes: (C) Calculated; (E) Estimated; (M) Measured. *PSA weights are based on old CDU configuration.</p>					

Table 2. Center of Gravity and Moment of Inertia Data

Item	Weight (lbs)	Center of Gravity (inches)			Moment of Inertia (lb-in ²)		
		X	Y	Z	I _{xx}	I _{yy}	I _{zz}
<u>COMMAND MODULE</u>							
<u>Lower Equip. Bay, Forward</u>							
CDU	15.0(E)	63.5	-14.4	35.8			
D&C/AGC	15.0(E)						
D&C/NAV	31.5(E)						
M&DV	8.5(E)						
OPT. SUBSYSTEM	40.0(E)	69.0	1.7	32.3			
IMU	58.7(E)	56.6	0.0	41.7			
NVB	21.0(E)	60.6	0.0	44.0			
OPT. EYE PIECES**							
SXT	1.0(E)	65.1	-3.5	26.2			
SCT	4.0(E)	65.1	4.5	26.2			
CBL*	40.0(E)						
BELLOWS ASSY	15.0(E)	71.0	-0.2	35.6			
<u>Lower Equip. Bay, Middle</u>							
AGC	58.0(C)	39.2	0.0	50.0			
PSA	29.0(E)	44.7	0.0	41.3			
JBX	11.0(E)	44.9	0.0	50.0			
<u>Main Panel</u>							
D&C/AGC	15.0(E)						
D&C/NAV	10.0(E)						
<u>SERVICE MODULE</u>							
RAD*	15.0(E)						
SPARES	40.0(E)						

*C. g. values for these items not determined due to indefinite location
 **C. g. values for eyepieces in place in SXT and SCT.

Glossary

- AGC: Apollo Guidance Computer; complete computer, except display and keyboard, including all structure mounting rails.
- BELLOWS ASSY: Bellows Assembly: connection between command module and optical subsystem.
- CBL: Cabling: intrasubassembly cabling in lower equipment bay. (Interequipment cabling from lower equipment bay to other assemblies is assumed a spacecraft responsibility.)
- CDU: Coupling Display Units: five gear boxes used as an angle data interface among the optics, IMU, AGC, and spacecraft autopilot.
- D&C/AGC: Display and Control, Computer: letter and number readout, keyboard, control, relays, and support structure.
- D&C/NAV: Display and Control, Navigation: meters, switches, lights, etc. except as reported elsewhere. Weight includes display panel in lower equipment bay but does not include wire, clock, or optics controller gear train. The display clock is not considered as part of the G & N equipment even though it appears above the G & N display panel.
- IMU: Inertial Measurement Unit: gimbal assembly, inertial components, data transducers, and support structure.
- JBX: Junction Box: electrical interconnection center between subassemblies in lower equipment bay.
- M&DV: Map and Data Viewer: film viewer for display of maps, charts, procedures, etc.
- NVB: Navigation Base: rigid structure containing the IMU and the optical subsystem with its associated hardware and supported by three shock mounts.
- OPT. BASE: Optical Base: Base for SCT and SXT.

~~CONFIDENTIAL~~

OPT. EYE PIECES: Optical Eye Pieces: optical eye pieces for SXT and SCT.

OPT. SUBSYSTEM: Optical Subsystem: SXT, SCT, optical base, panel piece, and associated hardware.

PSA: Power Servo Assembly: IMU, SCT, and SXT servos, power supplies, CDU electronics, IMU backup mode electronics, and miscellaneous electronics.

RAD: Radar: Electromagnetic ranging equipment, located in service module, for lunar orbit rendezvous.

SCT: Scanning Telescope: single, line-of sight, wide-field, two-degree-of freedom telescope and its drive mechanism.

SHOCK MOUNTS: Three shock mounts that attach the NVB to the spacecraft.

SXT: Sextant: two, line-of-sight, narrow field, two-degree-of freedom sextant; and drive mechanism.

~~CONFIDENTIAL~~

DISTRIBUTION LIST

E-1142 Rev 4.

NASA (150 copies)

Participating Contractors (30 copies)

Apollo Limited Internal

Alonso, R.	Kupfer, W.
Barnard, J. (NASA)	Ladd, D.
Battin, R.	Laning, J.
Bean, W.	Lawton, T. J.
Bowditch, P.	Levy, J. (WESCO)
Boyce, A.	Lickly, D. J.
Bryant, P.	Mayo, G.
Copps, E. M.	Miller, James
Dahlen, J.	Miller, John
Duggan, E.	Nevins, J.
Felix, S.	Nugent, J.
North American Aviation, Inc.	Olsson, E. A.
Space & Systems Information Div.	Parker, C.
12214 Lakewood Boulevard	Rhine, W. (NASA)
Downey, California	Scholten, R.
Flanders, J.	Sciegienny, J.
Gates, W.	Sears, N.
Hall, E. C.	Smith, B.
Halzel, I.	Trageser, M.
Hanley, D.	Wheaton, Major C.
Hickey, E.	Wilk, L. (2)
Hoag, D.	Woodbury, R.
Houston, F.	Kramer, M.
Hursh, J. (2)	APOLLO Library
Koso, A.	