



# Smithsonian National Air and Space Museum

## Apollo Flight Guidance Computer Software Collection [Hamilton]

Elizabeth C. Borja

2017

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TAPE HEAD RUN 6 VERIFICATION C4-L8A TEST RUN DATE 10/23/68 EDIT DATE 2/8/74 SCS TIME 1640 ASC TIME 1639.56 ID 777 PAGE 1
PROGRAM VERB 21 NRUN 15 R1 37777 R2 R3 00095 FLAGH 0 DSPTAB #81 00000
SDS REFERENCE MATRIX
**+1232394 *+7979084 *+4514113 *+4422224 *7325281 *4810513 **8/C ATTITUDE MATRIX
**0002095 **9491866 **8689022 **0004205 **14941686 **8689423 **0202166 **4949224 **8689049
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REFORMAT ER CIPHAL ANGLES SDS COU ASC COU ASC SHAFT SDS SHAFT SDS TIME LOS DR LOS ALT LOS CR
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Zx *+000 A8Rz *+00 *+00 *+00 *+00 *+00 *+00 *+00 *+00 *+00
Xx *+000 A8Gz *+01 *+01 *+01 *+01 *119.35 *+00 *+00 *+00
STATE VECT RZ BY RZ RBS VY VZ TIME
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ASC CR 872833R-1 2918736+6 *+166192+7 663373+3 *+391+80 582187 *+317+07 778.94 1640+42
DECTA *+0 *+0 *+0 *+0 *+0 *+0 *+0 *+0
SDS LR 872668R-1 294820S-8 *+1676134+6 665584+8 *+391+80 5787.80 *+3297+01 7740+17 1640+42
ASC LR 872668R-1 294820S-8 *+1676134+6 665584+8 *+391+80 5787.80 *+3297+01 7740+17 1640+42
DECTA *+0 *+0 *+0 *+0 *+0 *+0 *+0 *+0
POSITION LAT LONG ALT AHDISE PERIDCE AZIMUTH ELEVATION RANGE RANGE RATE
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SDS LR *+14+4S *+18+6E 279740+9 28271+0 27649+4
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FLAGND 8 00000 FLAGND 9 00000
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CHAN 13 00100 CHAN 14 00000 CHAN 30 37373 CHAN 31 37777 CHAN 32 77777 CHAN 33 67767
CDU
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THEAD X *+5163974 THEAD Y *+4436650 THEAD Z 10+83868 TIG 2372+820 BEST 1 *+0000000
BEST J *+6466667 HRKTIMEZ *+9849141 STAR X1 *+118294E+03 STAR Y1 *+282702E+01 STAR Z1 *+0000000
STAR RS1 *+0437776 HRKTIMEZ *+368+990 STAR X2 *+118294E+03 STAR Y2 1+219480 STAR Z2 *+0000000
STAR RES 1+219480 HMR *+0000000 HMR *+0709370 QR HMR *+0000000 HMR *+0000000
VOTIG Y *+0467225 VOTIG Z 1078+989 ADPT/ *+3012188 ADPT/SEP *+123663N ADPT/SEBY *+907979
AX *+0000000 AX *+0747933 AX *+0000000 AX *+0000000 THEAD X *+5163974 THEAD Y *+4436650
THEAD Z 10+83868 THEAD X *+0000000 THEAD Y *+0000000 THEAD Z *+0000000
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ERRRZ *+1200252 WBO/MCR *+3908782 WBO/RCP *+1280+999 WBO/RCY *+601408E+01 THEAD X 9.778609
THEAD Y *+11+4453 THEAD Z 10+81913 S/C PASS 1788+971 X CS *+8+66000 Y CS *+3071489
Z CS *+0774738 SET FUEL 3+000386 SLSH AR *+886368 IXX 11119+44 IYY 79300.74
IIZ *+9710+18 IZY 2038+133 IZL 086+8823 IYV 183+454 W/ DEVS *+134702E+02
WY DEVS *+104911E+01 NZ DEVS *+997057E+02 CNFIG 1+0000000 AVSCW/SZ *+998740E+03 AVSCW/SZ *+139155E+02
AVSCW/SZ *+860409E+02 AVSRM/SZ *+0000000 AVSRM/SZ *+0000000 ZENRMLT *+0000000 AVSRM/SZ *+038303E+03
AVSRM/SZ *+133349E+02 AZSRM/SZ *+814544E+02 ARSRM/SZ *+893284E+02
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National Air and Space Museum Archives  
14390 Air & Space Museum Parkway  
Chantilly, VA 20151  
NASMRefDesk@si.edu  
<https://airandspace.si.edu/archives>

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## Collection Overview

<b>Repository:</b>	National Air and Space Museum Archives
<b>Title:</b>	Apollo Flight Guidance Computer Software Collection [Hamilton]
<b>Identifier:</b>	NASM.1986.0158
<b>Date:</b>	1965-1986 (bulk 1965-1972)
<b>Extent:</b>	1.22 Cubic feet (2 legal document boxes; 1 slim legal document box)
<b>Creator:</b>	Hamilton, Margaret Heafield, 1936-
<b>Language:</b>	English .
<b>Summary:</b>	The Apollo Flight Guidance Computer Software Collection [Hamilton] consists of reports, memoranda, and related material documenting the Apollo flight guidance software developed by Margaret Hamilton's team at the Charles Stark Draper Laboratory (CSDL) in the late 1960s and early 1970s. The collection also includes Hamilton's 1986 handwritten notes on selected documents.

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## Administrative Information

### Acquisition Information

Donated by Margaret Hamilton, gift, 1986-1987.

### Processing Information

Arranged, described, and encoded by Elizabeth C. Borja, 2017.

### Preferred Citation

Apollo Flight Guidance Computer Software Collection [Hamilton], Accession 1986-0158, National Air and Space Museum, Smithsonian Institution.

### Restrictions

No restrictions on access.

### Conditions Governing Use

[Permissions Requests](#)

## Biographical Note

Margaret H. Hamilton (b. 1936) was the Director of Software Engineering Division at Charles Stark Draper Laboratory (CSDL), Massachusetts Institute of Technology (MIT) and was responsible for the onboard flight software for NASA's Apollo and Skylab missions. She became known as the "Rope Mother," an apt description for her role and referred to the unusual way that computer programs were stored on the Apollo guidance computers.

Hamilton received a BA in Mathematics from Earlham College in Richmond, Indiana, and postponed her Ph.D. work when she was offered the opportunity to work on the Apollo project. She has published over 130 papers and reports on her areas of expertise in system design and software development. In 1986, she became the founder and CEO of Hamilton Technologies, Inc. in Cambridge, Massachusetts. On November 22, 2016, President Barack Obama awarded Hamilton the Presidential Medal of Freedom for her contribution that led to Apollo 11's successful landing.

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## Scope and Contents

This collection consists of reports, memoranda, and related material documenting the Apollo flight guidance software developed by Margaret Hamilton's team at the Charles Stark Draper Laboratory (CSDL) in the late 1960s and early 1970s. Documents include a printout from an Apollo guidance computer software simulation; software program change routing slips; reports from Apollo Guidance, Navigation, and Control (formerly Apollo Guidance and Navigation); a preliminary flight plan for Apollo 7; memoranda for the submission of MIT/IL Software Development Plan, critiquing each new official version of the flight system; guidance system documents using assorted programs, including Sundisk, Skylark, and Luminary; and an oversized Charles Stark Draper Laboratory brochure. When she donated the collection in 1986, Hamilton composed handwritten notes on the history of selected documents, which are included with each document and identified in the finding aid as "[Note from Margaret Hamilton]."

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## Arrangement

The materials are arranged chronologically.

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## Names and Subject Terms

This collection is indexed in the online catalog of the Smithsonian Institution under the following terms:

Subjects:

Charles Stark Draper Laboratory  
Project Apollo (U.S.)  
Space vehicles -- Guidance systems

Names:

Hamilton, Margaret Heafield, 1936-

## Container Listing

- Box 1, Folder 1      Sakkappa, Balraj G. "On Optimal Steering to Achieve 'Required Velocity.'" Report R-491, April 1965
- Box 1, Folder 2      "Guidance System Operations Plan for Manned CM Earth Orbital Mission Using Program Sundisk. Section 6: Control Data." Report R-547 Rev. 1 [Note from Margaret Hamilton], December 1967
- Box 1, Folder 3      "Guidance System Operations Plan for Manned CM Earth Orbital Mission Using Program Sundisk. Section 5: Guidance Equations" Report R-547 Rev. 2, March 1968
- Box 1, Folder 4-6    "Guidance System Operations Plan for Manned LM Earth Orbital and Lunar Missions Using Program Luminary. Section 4: PGNCS Operational Modes." Report R-567 [Note from Margaret Hamilton], March 1968
- Box 1, Folder 7      NASA, Preliminary Flight Plan Apollo 7, AS 205/101, May 31, 1968
- Box 1, Folder 8      Hamilton, M. MIT/IL. COLOSSUS Revision Memos. [Note from Margaret Hamilton], May 1968 - July 1968
- Box 4, Item 2        Apollo Guidance Computer Software Simulation - [computer printout] (command module test run simulation in a powered flight program demonstrating parameter during an error detection and recovery process. Bailout during burn.) [Note from Margaret Hamilton], October 23, 1968
- Box 2, Folder 1      Instrumentation Laboratory, MIT, Apollo Project Memorandum #2038, Submission of MIT/IL Software Development Plan, December 20, 1968
- Box 2, Folder 2      Battin, Richard H. and Gerald M. Levine. "Application of Kalman Filtering Techniques to the Apollo Program." Report E-2401, April 1969
- Box 2, Folder 3      Schmidt, George T. and Larry D. Brock. "General Questions on Kalman Filtering in Navigation Systems." Report E-2406., April 1969
- Box 2, Folder 4      Memo, To: FS55/Head, Apollo Guidance Program Section, From: FS55/Head, Program Support Group, Subject: Apollo Mission G Post-flight Summary - AGC support (console 37, Flight Dynamics SSR), September 19, 1969
- Box 2, Folder 5      MIT/Charles Stark Draper Laboratory. Stubbs, G., A. Penchuk, and R. Schlundt. "A Digital Autopilot for Thrust Vector Control of Apollo CSM and CSM/LM Vehicles." Report R-670, November 1969
- Box 2, Folder 6-8    Apollo Guidance Program Symbolic Listing Information for Block 2, Revision 2, November 20, 1969

- Box 2, Folder 9 MIT/Draper Laboratory Program Change Routing Slips [Note from Margaret Hamilton], February to July 1969
- Box 2, Folder 10 AC Electronics, Apollo 13 Guidance and Navigation Summary, circa 1970
- Box 2, Folder 11 [Note from Margaret Hamilton, placed in AC Electronics, Apollo 13 book], circa 1986
- Box 3, Folder 1 Delco Electronics. Apollo Command Module. Primary Guidance, Navigation and Control System. Student Study Guide. CM Digital Autopilot., June 2, 1969; revised April 15, 1971
- Box 3, Folder 2 [Note from Margaret Hamilton, placed in Delco Electronics. Apollo Command Module. Primary Guidance, Navigation and Control System. Student Study Guide.], circa 1986
- Box 3, Folder 3 Hamilton, Margaret. Charles Stark Draper Laboratory. Software Shuttle Memo #29. Management of APOLLO Programming and its Application to the Shuttle. [Note from Margaret Hamilton], May 20, 1971
- Box 3, Folder 4 "Guidance System Operations Plan Manned CM Earth Orbital Missions Using Program Skylark 1. Section 2: Data Links." Report R-693 [Pre-Release Copy], December 1971
- Box 4, Item 1 The Charles Stark Draper Laboratory [promotional material], circa 1971
- Box 3, Folder 5 Hamilton, Margaret. Charles Stark Draper Laboratory. Shuttle Management Note #14. First Draft of a Report on the Analysis of Apollo System Problems During Flight., October 23, 1972
- NASM-9A12593-45506-A: Apollo Project, Simulations, October 23, 1968  
[Image\(s\)](#)  
Page (45506-A) from an example of a command module test run simulation in a powered flight program demonstrating parameters during an error detection and recovery process. Run date: 10/23/1968.