

Digital Apollo:

Human and Machine in Spaceflight

David A. Mindell

**The MIT Press
Cambridge, Massachusetts
London, England**

© 2008 Massachusetts Institute of Technology

All rights reserved. No part of this book may be reproduced in any form by any electronic or mechanical means (including photocopying, recording, or information storage and retrieval) without permission in writing from the publisher.

For information about special quantity discounts, please email special_sales@mitpress.mit.edu

This book was set in Stone Serif and Stone Sans on 3B2 by Asco Typesetters, Hong Kong.
Printed and bound in the United States of America.

Library of Congress Cataloging-in-Publication Data

Mindell, David A.

Digital Apollo : human and machine in spaceflight / David A. Mindell.

p. cm.

Includes bibliographical references and index.

ISBN 978-0-262-13497-2 (hardcover : alk. paper) 1. Human-machine systems. 2. Project Apollo (U.S.)—History. 3. Astronautics—United States—History. 4. Manned spaceflight—History.

I. Title.

TA167.M59 2008

629.47'4—dc22

2007032255

10 9 8 7 6 5 4 3 2 1

Preface and Acknowledgments

On June 14, 1966, a robotic spacecraft had just landed on the moon and begun transmitting images to NASA. Project Gemini was drawing to a close, Apollo hardware was beginning to emerge from factories, and Apollo software was experiencing a crisis. And on that day I was born.

I do not remember the first lunar landing of Apollo 11 or the drama of Apollo 13, but I do remember watching the later launches and landings on television. In that sense, I am among the first of a generation—those for whom lunar landings have always been a *fait accompli*—for whom the twentieth century's greatest technological spectacle was an accomplishment rather than a dream. Nevertheless, as a boy I was fascinated by images of Apollo. When my father brought home a book, *Apollo: Expeditions to the Moon*, filled with wonderful, complicated imagery, I pored through it hundreds of times. The book shaped my lifelong fascination with machinery and my later choice to become an engineer.

This book arises out of a later scholarly trajectory. It is the third in an unplanned trilogy, a series of books I have been writing since I chose to become a historian in 1991. For fifteen years, beginning with a study of the USS *Monitor* in the American Civil War, I have written about the relationship of humans and machines, the experiences of new technologies and their effects on human identity. My second book, *Between Human and Machine: Feedback, Control, and Computing before Cybernetics*, explored the history of human interfaces, control systems, and digital computing. That book included an episode during World War II when Charles Stark Draper (and his young associate Robert Seamans) collaborated on a gun sight project with James Webb, then a lawyer for the Sperry Gyroscope Company. These three men would play central roles in the Apollo program. As I completed that book I found more and more continuities between the earlier history and the lunar landings. A project funded by the Sloan Foundation and the Dibner Foundation on the History of Recent Technology on the World Wide Web provided early support for collecting documents and interviews (that website is available at <http://digitalapollo.mit.edu>). A senior research fellowship from the Dibner Institute supported early writing.

A number of colleagues, friends, and students have been patient interlocutors and have read manuscripts in various states: Alexander Brown, Stephen Cass, Paul Ceruzzi, Don Eyles, Slava Gerovitch, Jeff Hoffman, Thomas P. Hughes, Chihyung Jeon, Rich Katz, Alex Kosmala, Roger Launius, John Logsdon, Fred Martin, Larry McGlynn, Dava Newman, Jim Nevins, Chuck Oman, Wayne Ottinger, Philip Scranton, Sherry Turkle, John Tytko, and Rosalind Williams. Paul Fjeld made incisive readings and a variety of documents from the Grumman Archives available from his personal collection; John Knoll generously created the cover image with historical help from Fjeld. Eldon Hall also generously shared documents and photographs, as did Hugh Blair Smith and Jim Nevins. Victor McElheny, as always, proved an engaging friend and also provided access to his collection of documents from his reporting on Apollo for the *Boston Globe*. Sarah Fowler assisted the research for the final stages of the manuscript with energy and humor. Thanks to Jack Garman for granting permission to produce the image from his Apollo 11 program alarm “cheat sheet,” and to the Society of Experimental Test Pilots for providing access to their back issues of journals and newsletters (some of them dug out of a closet). A number of Apollo participants generously gave their time for a series of group oral history interviews: Ramon Alonso, Dave Bates, Hugh Blair-Smith, Ed Blondin, Herb Briss, Ed Copps, Ed Duggan, Cline Frasier, Joe Gavin, John Green, Eldon Hall, Margaret Hamilton, David Hanley, David Hoag, Alex Kosmala, Dan Lickly, Fred Martin, Jim Miller, John Miller, Jack Poundstone, Herb Thaler, and Bard Turner.

While writing this book I created a course at MIT, “Engineering Apollo: The Moon Project as a Complex System,” as an exploration of the project from numerous angles, from management techniques to software, from presidential policy to press coverage. I’ve been fortunate to teach in collaboration with Professor Larry Young from whom I have learned a great deal. We brought a wonderful mix of guests to class to create a unique educational experience for graduate students in engineering, management, and history: Buzz Aldrin, Dick Battin, Hugh Blair-Smith, Charlie Duke, Don Eyles, Joe Gavin, Eldon Hall, Sy Liebergot, John Logsdon, Victor McElheny, Ed Mitchell, Bob Parker, and Bob Seamans. A particularly interesting moment was attending a lunch with Chris Kraft, Bob Seamans, Aaron Cohen, and Jeff Hoffman. Each, through their generosity, memory, and insight, has contributed to my own thinking on Apollo.

I have also been fortunate to serve on the NASA Historical Advisory Committee and to work with the NASA historians, archivists, and librarians without whom books like this would not be possible. These include Nadine Andreassen, Steve Dick, Steve Garber, Christian Gelzer, Mike Gorn, Roger Launius, Peter Merlin, Jane Odom, Curtis Peebles, Jennifer Ross-Nazal, Rebecca Wright, and the numerous interviewers who have collected NASA history since the 1960s. The NASA History Office preserves and publishes a history that, in addition to being central to spaceflight, exemplifies the evolution of a large technological system. Open and well documented, NASA’s systems are more ac-

cessible to scholars than military or corporate ones, and hence provide crucial material for understanding the human evolution of technology.

Only the second time I met my wife's family, they accompanied me to the Cradle of Aviation Museum in Long Island and enjoyed a detailed tour of a lunar module. Their genuine interest and excitement made a warm welcome into the Getnick family that I will always remember.

Pamela, whom I met and married while writing this book, sang me through it. I dedicate the book to her, for laughing with me through every day and into our future.