THE LITERATURE OF
AERONAUTICS, ASTRONAUTICS, AND
AIR POWER

Richard P. Hallion
Air Force Flight Test Center

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USAF WARRIOR STUDIES

Richard H. Kohn and Joseph P. Harahan
General Editors
Foreword

The publication of *The Literature of Aeronautics, Astronautics, and Air Power* is part of a continuing series of historical studies from the Office of Air Force History in support of Project Warrior.

Project Warrior seeks to create and maintain within the Air Force an environment where Air Force people at all levels can learn from the past and apply the warfighting experiences of past generations to the present. When General Lew Allen, Jr. initiated this project in 1982, he called for the “continuing study of military history, combat leadership, the principles of war and, particularly, the applications of air power.” All of us in the Air Force community can benefit from such study and reflection. The challenges of today and the future demand no less.

CHARLES A. GABRIEL, General, USAF
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Introduction

Since its inception in 1982, Project Warrior has revived interest inside the Air Force in using history to sharpen professional knowledge of air power. Project Warrior has also expanded interest in the heritage of the U.S. Air Force in peace and in war. The bibliographical essay published here as *The Literature of Aeronautics, Astronautics, and Air Power* is meant to provide readers with a guide to the vast collections of books and articles available today in libraries and from publishers.

It was written originally in early 1982 by Dr. Richard P. Hallion as a Project Warrior monograph at the Air Force Systems Command’s Edwards Flight Test Center, California. Drawing on his experience as an author, a curator at the Smithsonian Institution’s National Air and Space Museum, and as a history professor at the University of Maryland, Dr. Hallion recognized the need of scientists and engineers for a guide to the research and technical literature on the history of aeronautics and astronautics. Publication here of a revised, reorganized, and expanded version reflects our belief that what was so valuable to the flight test community will, in different form, be of similar use to the rest of the Air Force, to civilian scholars, and to aviation enthusiasts generally.

Dr. Hallion’s essay, while revised in size, scope, and emphasis, retains the flavor of its original purpose and reflects the author’s interests, background, and professional judgments. In part, the essay also reflects suggestions made by the editors, especially on the growth and development of air power in the twentieth century.

The publishing of this work in book form was made possible by several individuals in the Office of Air Force History. Joseph P. Harahan served as general manuscript editor, checking virtually every citation in the text. Richard H. Kohn interweaved some titles on air power from an earlier bibliographic effort of his own. Herman Wolk and Colonel John F. Shiner, USAF, critiqued the essay and provided excellent advice at critical points.

R. H. K.
J. P. H.
THE LITERATURE OF AERONAUTICS,
ASTRONAUTICS, AND AIR POWER

General Reference Sources

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Technical Development (London: Peter Owen, Vision Press, 1965) is a generally useful introduction to the history of aerospace technology. Oliver Stewart, Aviation: The Creative Ideas (New York: Praeger, 1966) is a thoughtful and well-written series of essays on one man’s perspective on the history of aviation, but readers are cautioned that his chapter on the Wrights and Clement Ader (a French pioneer) is dangerously misleading. Ader did not, as Stewart claims, understand aeronautical concepts anywhere near the depth of the Wrights. Richard P. Hallion, “The Rise of Air and Space,” in Astronautics and Aeronautics, 19, No. 5, (May 1981) furnishes an introductory overview to the general history of aeronautics and astronautics.

The field of aerodynamics is one that requires a good historical survey bringing it up to date. Theodore von Karman’s, Aerodynamics (New York: McGraw-Hill, 1963), a collection of six lectures he presented at Cornell University in 1953, is still the best introduction to the history of aerodynamics. A highly technical and exhaustive survey of aerodynamics history through 1930 is an essay by R. Giacomelli and E. Pistolesi in William F. Durand’s series, Aerodynamic Theory: A General Review of Progress, Vol 1, (New York: Dover Publications, 1963). This series, incidentally, has itself taken on major importance to the understanding of the evolution of aerospace technology. The Dayton-Cincinnati Section of the American Institute of Aeronautics and Astronautics (the national professional organization of aerospace engineers, scientists, and technologists) has issued two compilations of papers relating to the technical development of aviation. Though the papers vary in quality, the works are very useful as references: Jay D. Pinson, compiler, Diamond Jubilee of Powered Flight: The Evolution of Aircraft Design (Dayton: AIAA, 1978), and The Evolution of Aircraft Wing Design (Dayton: AIAA, 1980). Both works resulted from historical symposia.

The International Academy of Astronautics of the International Astronautical Federation has sponsored an annual historical symposium since 1967; the papers presented at these symposia have been from a truly international body of pioneers and distinguished historians, and, as such,

The industrial and “think tank” perspectives on aeronautical and astronautical development are ones that have traditionally been slighted. Two uncritical but nevertheless valuable looks at aerospace from the corporate and laboratory environment are William A. Schoneberger, *et al.*, *Seven Decades of Progress: A Heritage of Aircraft Turbine Technology* (Fallbrook, Calif.: Aero Publishers, 1979), which examines the gas turbine work of General Electric, and Everett T. Welmers, *et al.*, *The Aerospace Corporation—Its Work: 1960–1980* (Los Angeles, Calif.: Aerospace Corporation, 1980), which is a history of the role one major American aerospace think tank has played in recent aerospace development.

One of the most significant international organizations in the development of aviation technology was the National Advisory Committee for Aeronautics (1915–1958), the predecessor of the present-day National Aeronautics and Space Administration. The NACA and its operations are rich subjects for historical research, although an administrative and organizational study by Professor Alex Roland of Duke University is forthcoming. George W. Gray, *Frontiers of Flight: The Story of NACA Research* (New York: Knopf, 1948) was an early attempt to discuss the work of the NACA, and, though flawed by a generally uncritical tone, the book is very valuable. Frank W. Anderson, *Orders of Magnitude: A History of NACA and NASA, 1915–1980* (Washington: NASA, 1981) provides a good introductory look at the two agencies. Jerome Hunsaker, “Forty Years of Aeronautical Research,” in the *Smithsonian Report for 1955* (Washington: Smithsonian Institution Press, 1956) gives a good overall survey of the


Chronology can be said to be the framework of history. Fortunately for those interested in the history of aviation there have already been some well executed chronologies tracing the development of flight. A very useful introductory chronology can be found in the first volume of Michael J. H. Taylor, *et al., Jane's Encyclopedia of Aviation*, 5 vols (London: Jane's
Publishing Company, 1980), though, it must be noted, neither the chronology nor the subjects covered are treated as exhaustively as the title of this five-volume series suggests. A truly significant chronological effort has been that of the NASA History Office, with a series of NASA-sponsored publications that have presented a detailed, world-wide chronology of flight ranging from 1915 through 1976. The first of these is Eugene M. Emme’s *Aeronautics and Astronautics: An American Chronology of Science and Technology in the Exploration of Space, 1915–1960* (Washington: NASA, 1961). Two subsequent chronologies, *Aeronautical and Astronautical Events of 1961* (Washington: Government Printing Office, 1962), and *Aeronautical and Astronautical Events of 1962* (Washington: Government Printing Office, 1963), were published as NASA reports to the U.S. House of Representatives’ Committee on Science and Astronautics. Since then, the NASA History Office has issued an annual *Astronautics and Aeronautics* (Washington: NASA, 1964–present) volume, which includes a detailed, annotated international chronology of events relevant to the history of aerospace.


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Army Air Forces in World War II: Combat Chronology, 1941–1945 (Washington: Office of Air Force History, 1973) is, as the title implies, an exhaustive chronological accounting of the day-to-day activities of the AAF at war. Finally, the American Institute of Aeronautics and Astronautics has supported an extensive chronological effort by Frank H. Winter of the National Air and Space Museum, in conjunction with Richard P. Hallion and Frank Robert Van Der Linden. Each month, in the AIAA journal Astronautics and Aeronautics, the AIAA publishes a column entitled “Out of the Past,” treating events that occurred in aviation and aerospace 25, 50, and 100 years previously. This column has been appearing regularly since 1972, and is especially valuable because it references its entries to applicable sources.

Oddly, there have been very few biographical guides to the individuals who have made aviation what it is today. Howard S. Wolko, In the Cause of Flight: Technologists of Aeronautics and Astronautics (Washington: Smithsonian Institution Press, 1981) is an excellent reference, with short biographical sketches and lengthy and incisive surveys of the various fields within aviation technology, together with their “players.” Shirley Thomas, Men of Space, 8 vols (Philadelphia: Chilton, 1960–) is a useful guide to the pioneers of the space age, written in a breezy, anecdotal style. Aside from these, however, one must look to contemporary reference sources and to the few published biographies of specific individuals cited earlier. G. Edward Pendray, The Guggenheim Medalists: Architects of the Age of Flight (New York: The Guggenheim Medal Board of Award of the United Engineering Trustees, Inc, 1964) is a handy reference to some of the key technologists, scientists, practitioners, and managers of aviation’s early days, who received the prestigious Daniel Guggenheim Medal for great achievement in the cause of flight. Three “Who’s Who” books are especially good references: Lester D. Gardner, Who’s Who in American Aeronautics (Los Angeles: Floyd Clymer Publications, 1925, reissued, 1974), also called The Blue Book of American Airmen; the Writers’ Program of the Work Projects Administration, Who’s Who in Aviation, 1942–43 (New York: Ziff-Davis Publishing Co, 1942); and Wayne W. Parrish, Who’s Who in World Aviation, 1955 (Washington: American Avia-
tion Publication, 1955). The National Aeronautical Institute, *Who's Who in Aviation and Aerospace* (Boston: National Aeronautical Institute, 1983) is a voluminous recent guide to individuals working in the field, many of whom started their careers in the mid-to-late 1940s. Finally, one useful reference that can contribute to knowledge of distinguished individuals who worked within the aerospace profession is by the National Air and Space Museum Library, *International Handbook of Aerospace Awards and Trophies* (Washington: Smithsonian Institution Press, 1978), prepared under the direction of Catherine D. Scott.

So-called “coffee table” books often can be a surprisingly good source of both information and visual references. They must be used with care, however, for a number exist that are misleading or incorrect. Three are considered especially reliable and useful: Charles H. Gibbs-Smith, *Flight Through the Ages* (New York: Crowell, 1974) combines chronology with excellent illustrations to provide the reader with a thorough and accurate account of aviation history; John W. R. Taylor and Kenneth Munson, *History of Aviation* (New York: Putnam, 1978); and *The Lore of Flight* (Gothenburg, Sweden: Tre Tryckare Cagner & Co, 1970), which is an excellent introduction into the functional uses of aircraft and spacecraft, as well as their history. As mentioned earlier, there still is no single reference or group of references that, in a concise form, furnishes a useful overview of the history of aeronautics and astronautics. Time-Life Books’ *Epic of Flight* series, cited where appropriate throughout this essay, constitutes a good attempt at such a work, but still does not address post-1945 aviation in detail.

The actual flight vehicles of aerospace history have held a fascination for writers for years, and the literature on individual airplanes is so voluminous as to actually clutter the field. *Jane’s All the World’s Aircraft* (London: Jane’s Publishing Co, 1909–present) has long been the standard yearly reference on aircraft development; some issues, such as its 1919 and 1945 issues, are classic references. Later (post-1945) editions of Jane’s offer considerably more detail than earlier ones. Two other Jane’s publica-
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tions, one by Horace F. King and John W. R. Taylor, *Jane's 100 Significant Aircraft, 1909-1969* (London: Jane's Publishing Co, 1969), and the previously mentioned five-volume *Jane's Encyclopedia of Aviation* are significant. The latter work, despite its title, is really a guide to the world's air forces, airlines, and the various aircraft built by nations through the years. It is, unfortunately, flawed by minor errors of fact and interpretation, and thus must be used with caution. John W. R. Taylor, *Combat Aircraft of the World* (New York: G. P. Putnam's Sons, 1969) is a comprehensive introduction to the combat aircraft produced from 1909 through the late 1960s, and is very useful. Ray Wagner, *American Combat Planes*, 3rd revised edition (Garden City, N.Y.: Doubleday, 1982) is an excellent introduction to the American perspective of military aircraft development. An authoritative reference work is F. Gordon Swanborough and Peter M. Bowers, *United States Military Aircraft Since 1909* (London: Putnam, 1971). Claudia Oakes, *Aircraft of the National Air and Space Museum* (Washington: Smithsonian Institution Press, 1981) is an excellent guide to the holdings of the Smithsonian Institution, one of the world's great aircraft collections, and contains excellent aircraft "biographies" written by the NASM's curatorial staff. A special mention must be made of the *Putnam Aeronautical Books* series published since the early 1960s by Putnam & Company, Ltd, 9 Bow Street, London, England. This series consists of individual volumes, often running to many hundreds of pages on aircraft developed by specific manufacturers, such as McDonnell-Douglas and Bristol. The books are heavily illustrated with photographs and drawings, and contain much useful information on the growth of the world aircraft industry. The *Profile Publication* series (London: Hills and Lacy, 1965-1975), a collection of over 250 heavily illustrated pamphlets on individual aircraft types (such as the Fokker D–VII or the Douglas DC–3), is an excellent detailed source of information on particular aircraft. Each pamphlet was written by an authority on the particular aircraft. This series was issued in several volumes in the United States by Doubleday & Co. and, though now long out of print, is still available as a library reference. Finally, Bill Gunston's *The World's Greatest Airplanes: The Story of the Men Who Built Them and How They Came to Be* (New York: Elsevier-Dutton Publishing Co, 1980) is a good popular introduction told with style.
and with a goodly number of anecdotes about the world's great aircraft companies, and how they evolved.


The Prehistory of Flight, Antiquity to 1783

Practical aviation as it is known today began with the first balloon flights of the Montgolfier brothers and J. A. C. Charles in the year 1783. The social impact of these flights was considerable; it was reflected in art, literature, and interior design. “Balloonmania” resulted in references to 1783 as the “Year of Miracles,” and the appearance of balloon prints, chandeliers, chairs, and the like. For the first time, humanity was able to

The Era of Discovery, 1783–1903

During the nineteenth century, a technological base was established that enabled the development of the first heavier-than-air flying machines. This work began with the theoretical and practical experiments and studies of Sir George Cayley, continued through such individuals as Stringfellow
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also contains Orville Wright’s own account of the brothers’ preparations for flight, and is a useful introduction to the Wrights and their accomplishments. A colorful and reliable history of efforts leading to the Wrights’ triumph at Kitty Hawk is by Valerie Moolman, *The Road to Kitty Hawk* (Alexandria, Va.: Time-Life Books, 1980). This book, part of the Time-Life *Epic of Flight* series, is, like most of the works in the series, replete with numerous photographs and drawings and a heavily anecdotal text, being particularly suited to those needing a readable and popular introduction to the subject.

The Development of Practical Airplanes, 1903–1918

The time period running from the Wrights through the First World War was a particularly challenging and fruitful time in aeronautics. Critical advances were made in aerodynamics, propulsion, structures, and controls technology, enabling a four-fold increase in aircraft flight speeds. By the end of the First World War, aircraft design technology had advanced to the point where operators could confidently plan long-range flights across the North Atlantic and through Southeast Asia to Australia. The airplane had proven itself a major military weapon, forcing military planners to rethink strategy and tactics in light of its capabilities. Charles Gibbs-Smith, *The Rebirth of European Aviation, 1902–1908* (London: Her Majesty’s Stationary Office, 1974) offers a clear analysis of the Wrights’ impact upon a European aeronautical community suddenly shocked into awareness of its technological inferiority. Several useful popular accounts of aviation’s pioneering days exist, notably, Walter T. Bonney, *The Heritage of Kitty Hawk* (New York: Norton, 1962); Henry Serrano Villard, *Contact: The Story of the Early Birds* (New York: Crowell, 1968); and Sherwood Harris, *The First to Fly: Aviation’s Pioneer Days* (New York: Simon & Schuster, 1970). Sir Geoffrey de Havilland’s reissued autobiography, *Sky Fever* (Shrewsbury, England: Airlife Publications, 1979), offers an often amusing and informative look at the trials and tribulations of an early British aircraft builder and pilot. Constance Babington-Smith’s *Testing Time: The Story of*

Owen S. Lieberg, The First Air Race: The International Competition at Reims, 1909 (Garden City, N.Y.: Doubleday & Co, 1974) is a popularly written and informative account of the first great air meet, enabling critical comparisons of technological approaches to be made. Tom D. Crouch, Bleriot XI: The Story of a Classic Aircraft (Washington: Smithsonian Institution Press, 1982) is a valuable account of the work of French pioneer Louis Bleriot, developer of one of early aviation’s most significant flying vehicles. Interestingly, Allen Wheeler, Building Aeroplanes for “Those Magnificent Men” (London: G. T. Foulis & Co, 1965) wrote an account of constructing flying replicas for the film Those Magnificent Men in Their Flying Machines. It is one of the best sources of information on the design, construction techniques, flying, and handling qualities of early airplanes. The actual pioneers of the early days have not received the biographical treatment that is their due, though Claudia Oakes, United States Women in Aviation Through World War I (Washington: Smithsonian Institution Press, 1978) and Howard S. Wolko, In the Cause of Flight: Technologists of Aeronautics and Astronautics, cited previously, are useful steps towards remedying this situation. Overall, Curtis Prendegast, The First Aviators (Alexandria, Va.: Time-Life Books, 1980), part of the Time-Life series, is a reliable and well-written popular introduction to the people of the period.

The First World War in the air has been the subject of so many works that it is virtually impossible to discuss all of them in a coherent essay.

The interwar years through the mid-1930s were a particularly critical time for aeronautics. It was in this decade that the first practical air transport aircraft were developed, leading to the emergence of widespread air passenger and freight service. Also, military airpower doctrine was refined, and the roles and missions of military aircraft types more closely defined. The basic technology of flight underwent a revolution, with the development of powerful piston engines, efficient wing shapes, a variety of specialized devices for improved aerodynamic performance, the emergence of the monoplane (one-wing) configuration, and the appearance of the all-metal airplane. The profession of aerospace engineer also underwent a significant upgrading in skill level and training with the appearance of schools and departments of aerospace engineering, usually drawing upon the field of mechanical engineering and fluid mechanics for their technical and scientific background. An excellent introduction to this period can be found in Roger E. Bilstein, Flight Patterns: Trends in American Aviation 1918–1929 (Athens, Ga.: University of Georgia Press, 1983).


Charles A. Lindbergh and his solo flight across the North Atlantic in May 1927 inspired countless journalists and writers to write about the lanky airman. Unfortunately, most have written in a sensationalist fashion, ignoring the careful and methodical planning that went into the flight. Tom D. Crouch, ed, *Charles A. Lindbergh: An American Life* (Washington: Smithsonian Institution Press, 1977), a series of essays by experts in the field, has an excellent introduction to Lindbergh, his accomplishments, and the political controversy that surrounded him later in life. Lindbergh has been the subject of three general biographies: Kenneth Davis, *The Hero: Charles A. Lindbergh and the American Dream* (Garden City, N.Y.: Doubleday & Co, 1959); Walter S. Ross, *The Last Hero: Charles A. Lindbergh* (New York: Harper & Row, 1968); and Leonard Mosley, *Lindbergh: A Biography* (Garden City, N.Y.: Doubleday & Co, 1976). Davis and Ross are still the best; Lindbergh preferred the Ross work. Additionally, Wayne S. Cole, *Charles A. Lindbergh and the Battle Against American Intervention in World War II* (New York: Harcourt Brace Jovanovich, 1974) is the most reliable and authoritative study on Lindbergh's controversial political stand in the years before Pearl Harbor. Lindbergh himself was the author of numerous books and articles during his life, and these offer a rich treasury of materials on his life and wide breadth of interests. Especially recommended are: *We* (New York: Putnam, 1927), his account of the Paris flight written just after his return; *The Spirit of St. Louis* (New York: Scribner, 1953), and *Autobiography of Values* (New York: Harcourt Brace Jovanovich, 1978), the latter published following his

which details this Russian-American pioneer’s work with flying boats. Sikorsky’s work in the 1920s and 1930s, as well as his subsequent development of the helicopter, is examined in detail in Frank Delear, *Igor Sikorsky: His Three Careers in Aviation* (New York: Dodd, Mead & Co., 1976). Warren R. Young, *The Helicopters* (Alexandria, Va.: Time-Life Books, 1982) is also an informative account of the “chopper’s” development and subsequent service.

Significantly, the 1920s were a time in which the profession of aeronautical engineering advanced rapidly. Critical to this development were the activities of the Daniel Guggenheim Fund for the Promotion of Aeronautics (1926–1930), a remarkable philanthropic activity that endowed schools of aeronautical engineering across the United States, established aeronautical research facilities dealing with safety in aviation and so-called “blind” flying, and helped create a “Model Air Line” run by Western Air Express between Los Angeles and San Francisco. Guggenheim activities have been examined by Richard P. Hallion in *Legacy of Flight: The Guggenheim Contribution to American Aviation* (Seattle: University of Washington Press, 1977). Theodore von Karman’s memoir, written with Lee Edson, *The Wind and Beyond: Theodore von Karman, Pioneer in Aviation and Pathfinder in Space* (Boston: Little, Brown, and Co., 1967), provides an interesting personal account of one key individual’s role in advancing aerospace engineering and education during the early years of aviation. Von Karman, the foremost aeronautical scientist of his time, immigrated to the United States to escape the increasingly anti-intellectual climate of Germany on the eve of Hitler’s rise to power, and became director of the Guggenheim Aeronautical Laboratory at the California Institute of Technology. The transfer of the European laboratory tradition in aeronautical research and the role von Karman played are the subjects of Paul A. Hanle’s *Bringing Aerodynamics to America* (Cambridge: MIT Press, 1982).

The 1920s and 1930s were marked by the emergence of practical air transportation. By the mid-1930s the first airplane capable of making a

Peter W. Brooks' classic study, *The Modern Airliner: Its Origins and Development* (London: Putnam, 1961) is still the best survey of the growth of air transport technology and the driving factors of airline operating
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Equally useful for understanding the technological climate from which the transport aircraft of the 1920s and 1930s sprang is Thomas Foxworth, The Speed Seekers (New York: Doubleday & Co, 1976) the definitive history of air racing during the 1920s and 1930s. Elsbeth E. Freudenthal, The Aviation Business: From Kitty Hawk to Wall Street (New York: Vanguard, 1940) is an informative and highly critical study of the growth of the aircraft manufacturing and air transport industry. Monte Duane Wright, Most Probable Position: A History of Aerial Navigation to 1941 (Lawrence, Kans.: University Press of Kansas, 1972) is an in-depth study of the development of air navigation instruments and techniques. It was, of course, from the air mail era that commercial aviation blossomed, and, interestingly, the air mail period is one that has received too little detailed attention. Aside from Jackson’s Time-Life book mentioned earlier,
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During the 1930s, the pace of aeronautical technology accelerated rapidly. This challenged such areas as aerospace medicine, propulsion

The development of military aviation in the 1920s and 1930s was marked by the emergence of doctrines emphasizing long-range strategic air power, tactical aviation, and naval aviation. The seeds for the employment of air power in the Second World War were planted and nurtured during the 1920s. Two useful introductions to the military aviation issues of the interwar years are Nevin’s Time-Life book *Architects of Air Power* cited earlier, and Sir Arthur Hezlet’s excellent survey of naval aviation, *Aircraft and Sea Power* (New York: Stein and Day, 1970). The evolution of the aircraft carrier as a capital ship has been examined in detail by Charles M. Melhorn in *Two Block Fox: The Rise of the Aircraft Carrier, 1911–1929* (Annapolis: U.S. Naval Institute Press, 1974). The major event affecting public perceptions of air power in the United States during the 1920s was the court-martial of Billy Mitchell, an outspoken and often incautiously intemperate airpower zealot. Mitchell has been the subject of numerous articles and works, but Alfred F. Hurley, *Billy Mitchell: Crusader for Air Power* (New York: Franklin Watts, 1964), new edition (Bloomington, Ind.: Indiana University Press, 1975) remains the most reliable source for information on this controversial figure. Mitchell was surrounded by a
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coterie of bright, ambitious, and dedicated junior officers who did much to advance the cause of a separate and independent air arm that eventually came to fruition with the creation of the United States Air Force in 1947. The contribution of one pioneer, not particularly friendly to Mitchell, is covered in John F. Shiner's penetrating Foulois and the U.S. Army Air Corps, 1931–1935 (Washington: Office of Air Force History, 1983). The interwar years and many of these men are the subject of a major study by DeWitt S. Copp, A Few Great Captains: The Men and Events that Shaped the Development of U.S. Air Power (Garden City, N. Y.: Doubleday, 1980) sponsored by the Air Force Historical Foundation.


The Ascendency of the Propeller-Driven Airplane, 1936–1945

From the late 1930s through 1945, aviation underwent many profound changes, in part because of the demands of wartime activities and requirements. Chief among these changes were the turbojet revolution, which reached its fulfillment after 1945, and the conscious recognition that the world would never quite be the same as a result of blending advanced long-range aircraft with the capabilities of modern military weapons, especially the atomic bomb. By 1945, propeller-driven long-range aircraft were flying across the world's oceans to deliver cargo and to attack targets. Yet, such
was the pace of aeronautical development that their technology was already obsolescent in the face of the turbojet revolution. Truly, by the end of 1945, the dominance of the propeller-driven airplane had already begun to decline; by 1958, with the arrival of the first practical intercontinental jet transports, it would be totally swept away from the mainstream of long-range air operations.

World War II proved a tremendous “forcing function” in the evolution of military and civil aviation. In many respects, however, this was more evolutionary than revolutionary, in that the scope of wartime activities had more or less been determined by the respective development of aviation in the major combatant nations during the 1920s and 1930s.


U.S. Army Air Forces’ operations have been the subject of numerous popular works. However, they are often characterized by a “gee whiz” approach to the subject that obscures, or even supplants, more serious interpretations and discussions. Readers thus should choose very carefully among available sources, being especially cautious when dealing with books written immediately after the war and even into the 1950s and early 1960s. One major study that furnishes useful insights on the U.S. Army Air Forces is by DeWitt S. Copp, *Forged in Fire: Strategy and Decisions in the Air War Over Europe, 1940–1945* (Garden City, N.Y.: Doubleday & Co, 1982).

Nothing was as symbolic of the role air power played in the Second World War as the massive Anglo-American bombing raids launched against Axis targets. There is a wealth of literature on this subject, but
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One of the critical periods of the war was the Battle of Britain in 1940, which resulted in a clear British victory and the thwarting of Hitler’s plans for an invasion of the British Isles. The literature and pilot memoirs on both sides of this conflict are extensive. Derek Wood and Derek Dempster, *The Narrow Margin* (London: Hutchinson, 1961) is the standard historical account. Peter Townsend’s later, *Duel of Eagles* (New York: Simon and Schuster, 1970) is a masterful blend of memoir and history. Francis K. Mason’s encyclopedic *Battle Over Britain* (Garden City, N.Y.: Doubleday & Co, 1970) is the best source for statistical data, as well as giving a blow-by-blow daily account of the struggle. The depth of Mason’s research is remarkable.


have written dozens, if not hundreds, of memoirs which, for the most part, are well-written and highly informative. The strategic war waged by the RAF is covered in the excellent official history by Sir Charles K. Webster and Noble Frankland, *The Strategic Air Offensive Against Germany, 1939–1945*, 4 Vols (London: Her Majesty’s Stationary Office, 1961).

The Luftwaffe has continued to fascinate popular writers and historians through the years. Two “insider” accounts that avoid many of the self-serving generalizations used in other memoirs of the Nazi era are: Adolf Galland, *The First and the Last* (London: Fontana, 1970) by the former chief of German fighter forces; and Werner Baumbach, *The Life and Death of the Luftwaffe* (New York: Coward-McCann, 1960), written by the former chief of Germany’s Bomber Command. David Irving, *The Rise and Fall of the Luftwaffe: The Life of Field Marshal Erhard Milch* (Boston: Little, Brown & Co, 1974) is a provocative, absorbing, and insightful examination of the Luftwaffe from the perspective of its chief architect. Finally, W. H. Tantum, IV and E. J. Hoffschmidt, *The Rise and Fall of the Luftwaffe 1933–1945*, (Old Greenwich, Conn.: WE, Inc, 1969) provides an excellent summary history of that ineptly led and confused organization. Smaller air forces have not received their fair due, though Jerzy Cynk, *History of the Polish Air Force, 1918–1968* (Reading, U.K.: Osprey Publishing, 1972) is an exception, and a study that could serve as a model for others to follow.

One of the truly significant aspects of aviation from 1936 through 1945 was the development of global air transport networks. While the Allied nations had a keen awareness of the importance of air transport, the Axis nations did not: Germany, for example, ignored military air transportation, with the loss of Stalingrad offering clear evidence of this critical weakness in Nazi strategic doctrine. Some good works exist on Allied air transport operations. Oliver LaFarge, *The Eagle in the Egg* (Boston: Houghton, 1949) is a popular and reliable history of the U.S. Army Air Forces Air Transport Command written shortly after the war. William H. Tunner, the wartime manager of America’s famed “Hump” aerial supply route to China, has written an excellent memoir of his work and the lessons
learned from the Hump (lessons subsequently applied during the Berlin Airlift after the war), *Over the Hump* (New York: Duell, Sloan and Pearce, 1964).

Various works have been written on specific aspects of aeronautics during the Second World War. David Irving, *The Mare's Nest: The German Secret Weapons Campaign and British Countermeasures* (London: William Kimber, 1964) is an excellent study of the development of German "robot" weapons, the V-1 "buzz bomb" cruise missile and the V-2 ballistic missile. R.V. Jones, *The Wizard War: British Scientific Intelligence, 1939–1945* (New York: Coward, McCann and Geoghegan, 1978) while a memoir is the most complete description to date of the scientific duel in the air war between the British and the Germans. It is likely this book will become a classic. Brian Johnson, *The Secret War* (New York: Methuen, 1978) is a good introduction to the wartime scientific research of both the Allies and Axis, most of which was related to aviation. Leslie Simon, *German Research in World War II, An Analysis of the Conduct of Research* (New York: J. Wiley & Sons, 1947) is the standard reference on Nazi Germany's scientific war, and James Phinney Baxter, III, *Scientists Against Time* (Boston: Little, Brown and Co, 1946), reprinted (Boston: MIT Press, 1968) is an excellent study of the workings of the wartime Office of Scientific Research and Development, which conducted numerous aviation-related programs. Constance Babington-Smith, *Evidence in Camera: The Story of Photographic Intelligence in World War II* (London: Chatto and Windus, 1958) is a remarkably complete survey of wartime work by an individual who was herself a distinguished practitioner. Glenn Infield, *Unarmed and Unafraid* (New York: Macmillan Co, 1970) is an anecdotal survey history of aerial reconnaissance, with much useful material on the Second World War.

A potpourri of other works have been published. Perry McCoy Smith, *The Air Force Plans for Peace, 1943–1945* (Baltimore, Md.: Johns Hopkins University Press, 1970) is an excellent administrative history of how the Air Force began adapting for its postwar roles even as fighting was
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Great Britain, and both offer a detailed perspective on the famous conflict between Sir Henry Tizard and Lord Cherwell.

As with other aspects of aviation history, the aircraft of the combatant powers have received coverage bordering on the repetitive and excessive. Kenneth Munson, *Bombers, Patrol, and Transport Aircraft, 1939–1945* (New York: Macmillan, 1969) and *Fighters, Attack, and Training Aircraft, 1939–1945* (New York: Macmillan, 1969) are reliable and informative. William Green is a well-known author of definitive reference works on World War II, and two of his best are the republished *Famous Fighters of the Second World War* (Garden City, N.Y.: Doubleday & Co, 1975) and *Famous Bombers of the Second World War* (Garden City, N.Y.: Doubleday & Co, 1976). Many other more specialized works, most of which deal with a single aircraft or “family” of aircraft also exist but are beyond the scope of this introduction to the field.

The Turbojet Revolution and the Supersonic Breakthrough, 1945–1957

Between 1945 and 1957, the scope of aviation changed radically. During this time period, civil long-range aviation became the dominant form of domestic and international passenger transportation, surpassing the accumulated accomplishments of a century of railroad and motor vessel transportation. Flight speeds quadrupled due to the development of refined high-speed aerodynamics and advanced propulsion by jet and rocket engines. The turbojet revolution permitted developing highly efficient high-speed aircraft; the attainment of flight faster than sound—supersonic flight—opened up a whole new range of speeds and altitudes to be explored.

The major technical development influencing the course of postwar aviation was the appearance of the gas turbine (turbojet) engine. It was
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largely the product of a few farsighted inventors who worked outside the mainstream of contemporary propulsion research and development. Only later was gas turbine technology seized upon by a propulsion industry previously totally committed to the piston engine and propeller. The early jet era is one that has not been as thoroughly examined as it should be. Nevertheless, a number of useful books are available for researchers. Schlaifer and Heron’s previously cited Development of Aircraft Engines and Fuels is excellent for the development of the jet engine in Britain, Germany, and the United States. Edward Constant, The Origins of the Turbojet Revolution (Baltimore: Johns Hopkins University Press, 1980) is a detailed examination of the actual evolutionary process that led to the jet engine. Sir Frank Whittle, Jet: The Story of a Pioneer (New York: Philosophical Library, 1954) is an autobiography which tells the trials and tribulations of how “The Father of the Jet Engine” went about winning support and actually designing and building the then radical powerplant. John Grierson’s rare but fascinating Jet Flight (London: Sampson Low, Marston & Co, Ltd, 1946) combines history and autobiography to trace the story of the jet engine and important wartime development work. Also Walter J. Boyne and Donald S. Lopez, The Jet Age: Forty Years of Jet Aviation (Washington: Smithsonian Institution Press, 1979) is a useful introductory reader, as is E. T. Wooldridge, Jet Aviation: Threshold to a New Era (Washington: Smithsonian Institution Press, 1981). Grover Heiman’s anecdotal Jet Pioneers (New York: Duell, Sloan and Pearce, 1963) is a good, readable popular reference. William Green and Roy Cross, The Jet Aircraft of the World (Garden City, N.Y.: Hanover House, 1955) remains the best single reference work on the wide range of experimental aircraft built during the first fifteen years of jet flight.

The supersonic breakthrough constituted the most important development in aeronautics since the time of the Wrights’ first flights, yet it has only been the subject of two books. Richard P. Hallion, Supersonic Flight: Breaking the Sound Barrier and Beyond (New York: Macmillan Co, 1972) discusses the problem of supersonic flight and how a specialized research aircraft program was established to confront it. Charles Burnet, Three Centuries to Concorde (London: Mechanical Engineering Publications
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Ltd, 1979) is equally thorough in examining British efforts to achieve flight faster than sound. The individuals most responsible for ensuring that reliable data on supersonic flight would be acquired were a group of highly skilled test and research pilots.

Test flying and flight research have often been the subject of misinterpretation and sensationalism. Only two books have been written that attempt to analyze the role of test pilots and their contributions to aerospace development: the previously cited Testing Time by Constance Babington-Smith, and Richard P. Hallion, Test Pilots: The Frontiersmen of Flight (Garden City, N.Y.: Doubleday & Co, 1981). In addition, an institutional history of a NASA Research Center, Richard P. Hallion’s, On the Frontier: Flight Research at Dryden 1946–1981 (Washington: NASA, 1984) reveals the complexity of making technological choices.

strictly about flight testing. Jacqueline Cochran, *The Stars at Noon* (Boston: Little, Brown, 1954) is an interesting memoir by the first American woman to fly faster than sound. Finally, while written for a young adult audience, Don Dwiggins, *Flying the Frontiers of Space* (New York: Dodd, Mead & Co. 1982) is a useful introductory overview of flight research from the first supersonic flights to the Space Shuttle.


The Air Force itself underwent a variety of technological, administrative, strategic, and tactical changes during the period from 1945 through 1957. Alfred Goldberg’s previously cited *A History of the United States Air Force* offers a reliable account of key developments in this time

As with other aspects of aviation history, the aircraft of the 1945–1957 time period have been the subject of a variety of popular works. Again, the best introductory source works are: Kenneth G. Munson's, *Airliners Since 1946* (New York: Macmillan, 1972), and *Private Aircraft, Business and General Purpose, Since 1946* (New York: Macmillan, 1967); John R. and Michael J. H. Taylor's, *Jane's Pocket Book of Commercial Transport Aircraft* (New York: Macmillan, 1974), *Jane's Pocket Book of Military Transport and Training Aircraft* (New York: Macmillan, 1974), and *Jane's
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True vertical flight via helicopters was first achieved shortly before the Second World War, but it was not until the postwar years that the helicopter came of age, especially for search and rescue operations. The history of the helicopter is another subject that deserves greater attention; helicopter-like toys had appeared as early as the Renaissance. H. F. Gregory, Anything a Horse Can Do: The Story of the Helicopter (New York: Reynal & Hitchcock, 1944) is an entertaining and informative history of helicopters during the formative years of vertical flight. Paul Lambermont and Anthony Pirie, Helicopters & Autogyros of the World, rev ed (New York: A. S. Barnes & Co, 1970) is the definitive reference guide to rotorcraft through the years, though Kenneth G. Munson, Helicopters and Other Rotorcraft Since 1907 (New York: Macmillan, 1969) is a colorful and useful introductory work.

Cancelled (Indianapolis: Bobbs-Merrill, 1975), while suffering from a sometimes sensationalist approach, is a generally useful account of the near collapse of Britain's aircraft industry from mismanagement and misdirection in the late 1940s and 1950s.


The Space Age and the Maturation of Aeronautics, 1957–1982

The launching of Sputnik I in October 1957 had a profound impact upon American society. As a result of this event, American education was totally revamped, the NACA was replaced by the NASA, and a "space race" began between the United States and the Soviet Union. Competition and rivalry in science and technology was accompanied by big power rivalry for influence among the Third World nations. Traditional animosities flared into war in the Middle East and Southeast Asia. Aviation and aerospace development played crucial roles in all of these conflicts.
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Aeronautics since 1957 has not been the subject of too many substantial works; rather, developments in this time period have been examined in periodical literature. Three of the best periodical sources for information on aviation since 1957 have been McGraw-Hill's journal Aviation Week and Space Technology (New York: McGraw-Hill, weekly); Astronautics and Aeronautics, the professional journal of The American Institute of Aeronautics and Astronautics (New York: American Institute of Aeronautics and Astronautics, monthly); and Flight International (London: IPC Transport Press, Ltd, weekly), good for the European perspective. Many of the major aerospace development programs of the 1960s and 1970s were marked by controversy.


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planners. Written in a humorous and ironic style in the form of "laws," this book, by a former undersecretary of the Army and president of a major aerospace corporation, is a provocative and insightful analysis of the problems of weapons system procurement and the management of research and development.

The protracted war in Southeast Asia spawned volumes of popular studies of the bombing campaigns, air fighting, aircraft, and personalities involved. Much of this was of a "buff" nature, particularly the great body of literature concerning individual aircraft types. Nevertheless, as with other aspects of the conflict, there have been some useful studies produced, although the Vietnam era is clearly one that requires a well-integrated military, social, and political history volume of the kind the late Bernard B. Fall so eloquently produced on France's earlier experience in Indochina.


One of the more significant technological developments of the Vietnam era was the emergence and employment of precision-guided “smart”
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weaponry, and the use of unmanned remotely piloted vehicle (RPV) technology to undertake a variety of hazardous missions at minimal cost and risk to human lives. As a result of the Vietnam experience, and subsequent lessons learned from other conflicts, the RPV occupies a secure place as a tool in the military arsenals of many nations. Arthur Reed, *Brassey's Unmanned Aircraft* (London: Brassey’s Publishers Ltd, 1979) is a well-written reference on the development, current status, and projected future uses of military remotely piloted vehicles, popularly but often mistakenly called “drones.” William Wagner, *Lightning Bugs and Other Reconnaissance Drones* (Fallbrook, Calif.: Aero Publishers, Inc, 1982) is a generally useful and anecdotal account of the Ryan Corporation’s highly successful Firebee family of RPVs and their use in Southeast Asia, but it is marred by a lack of sources and a narrow internalist perspective. John W. R. Taylor and Kenneth G. Munson, *Jane’s Pocket Book of Remotely Piloted Vehicles* (New York: Collier Books, 1977) is an excellent reference to the various RPVs that have been developed, as well as a useful guide to their early history. Finally, Roger A. Beaumont, “Rapiers Versus Clubs: The Fitful History of ‘Smart Bombs,’” *Journal of the Royal United Services Institute* 126, No. 3 (Sep 1981) is an excellent reference for the history of precision guided weaponry and its influence on tactics and doctrine.

The war in Southeast Asia and various small “brushfire” conflicts have also been the subject of some popular studies, memoirs, and the like. One very useful reference is the Senator Mike Gravel edition of the so-called “Pentagon Papers”, first illegally released by antiwar activist Daniel Ellsberg, entitled *The Pentagon Papers: The Defense Department History of United States Decisionmaking on Vietnam* (Boston: Beacon Press, 1971), a five-volume work. Jack Broughton, *Thud Ridge* (Philadelphia: Lippincott, 1969) is a lively and excellent memoir by a combat pilot who is bitter over American bombing policy in the early years of the air war “up North.” Robinson Risner, *The Passing of the Night: My Seven Years as a Prisoner of the North Vietnamese* (New York: Random House, 1974) is an unforgettable and moving memoir of a POW’s struggle to survive. Benjamin Schemmer, *The Raid* (New York: Harper, 1976) is a thorough account of the ill-fated attempt to rescue POWs believed held in the Son Tay...

Unrelated to warfare and mercenary flying, but having many of the same “roughing it” aspects, is Arctic bush flying in Alaska and Canada. This is a subject rich in anecdotes and worthy of detailed treatment; Harmon Helmericks, *The Last of the Bush Pilots* (New York: Knopf, 1970) is a good introduction.

To the public, the greatest expression of aeronautics and astronautics in the 1960s and 1970s was found in the space programs of the United States and the Soviet Union. While not vast, a respectable body of literature concerned with manned and unmanned spaceflights already exists. Very few of the influential early theoreticians and pioneers have been the subject of biographies. A notable exception is Robert Goddard, an American physicist who launched the drive towards space with his firing of the world’s first liquid fuel rocket in 1926. Milton Lehman, *This High Man* (New York: Farrar, Straus, 1963) is a thoughtful and sympathetic biography of Goddard which examines the occasionally mystical and secretive nature of this somewhat tragic figure. Goddard’s own papers are available in the three-volume *The Papers of Robert H. Goddard* (New York: McGraw-Hill, 1970), edited by his widow Esther C. Goddard and rocket pioneer G. Edward Pendray. For other sources on the early days of rocketry, interested readers are advised to consult the following: Wernher von Braun and Frederick I. Ordway, *History of Rocketry and Space Travel*, 3rd rev ed (New York: Crowell, 1975), which features an excellent bibliography;
The growth of manned spaceflight reached such major proportions during the 1960s and 1970s that, understandably, social scientists attempted to place its development in the context of other developments in the history of technology. This led to a notable series of essays edited by Bruce Mazlish, *The Railroad and the Space Program: An Exploration in Historical Analogy* (Cambridge: MIT Press, 1965).

The international aspects of space—involving the rights of nations, the conduct of international affairs, and joint exploration and utilization of space—are receiving increasing attention. A useful introductory study on this important subject is Arnold W. Frutkin’s *International Cooperation in Space* (Englewood Cliffs, N.J.: Prentice-Hall, 1965), an examination of the various considerations that can influence the conduct of technology and science on a global scale. George S. Robinson, *Living in Outer Space* (Washington: Public Affairs Press, 1975) offers the legal perspective on spaceflight.

The history of rocketry can be arranged to reflect four major periods: the early years through mid-1957; Sputnik and its aftermath through the first utilization of space; the “heroic era” of manned spaceflight through the landing of Apollo 11 on the moon; and, finally, the post-Apollo years.

The early years of rocketry were most notable for the work of Goddard in America, and the German rocketeers in Nazi Germany. The best work on
Nazi Germany's rocketry efforts is Frederick I. Ordway and Mitchell R. Sharpe, *The Rocket Team* (New York: Thomas Y. Crowell, 1979). A slightly different but no less valuable perspective is that of David Irving's aforementioned *The Mare's Nest*. R. F. Pocock, *German Guided Missiles of the Second World War* (New York: Arco, 1967) is a well written technical reference to the specific weapon systems developed at Peenemunde and other German test sites.

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of remote sensing. Leonard Jaffe, *Communications in Space* (New York: Holt, Rinehart and Winston, 1966), while dated, is a useful introduction to the technology and history of communications satellite technology. A very different—and valuable—kind of work is Alfred Bester’s *The Life and Death of a Satellite* (Boston: Little, Brown, 1966) which treats the whole problem of how key individuals work together—sometimes at the expense of their health—to develop a successful space program.


John Logsdon’s *The Decision to Go to the Moon* (Cambridge: MIT Press, 1970) constitutes an insightful and important reference on the political environment surrounding the decision to undertake the Apollo lunar landing effort. A handy reference and introduction to the Apollo program and its social, political, technological, and scientific significance is Richard P. Hallion and Tom D. Crouch, eds, *Apollo: Ten Years Since Tranquility Base* (Washington: Smithsonian Institution Press, 1979), a series of essays by authorities in various fields ranging from rocket technology to space art and lunar geology. Also useful are two works: Kerry Joels, *Apollo to the Moon: A Dream of Centuries* (Washington: Smithsonian Institution Press, 1982), prepared as a Smithsonian exhibit gallery guide, and “The Moon Landing and Its Aftermath,” printed in a special issue of the *Michigan Quarterly Review*, 18, No. 2 (Spring 1979). Henry S. F. Cooper, *13: The Flight That Failed* (New York: Dial Press, 1973) is a gripping account of the Apollo mission that nearly failed disastrously and tragically in space, but which was rescued by creative decisionmaking and professional excellence. The scientific harvest gleaned from Apollo and especially the Apollo-Soyuz mission is the subject of Farouk El-Baz’s *Astronaut Observations from the Apollo-Soyuz Mission* (Washington: Smithsonian Institution Press, 1977), which offers the reader a good insight into the potentiality of remote sensing. Two noted artists, H. Lester Cooke and James D. Dean, who were administrators of NASA’s art program in which leading artists were invited to record their impressions of the space program, have collected a reflective and stimulating visual record of the American space effort in *Eyewitness to Space: Paintings and Drawings Related to the Apollo Mission to the Moon* (New York: Abrams, 1971).

Spaceflight has so far produced few good commentaries, but three are recommended. Norman Mailer, *Of a Fire on the Moon* (Boston: Little, Brown, 1970) discusses what Apollo meant to Mailer and the so-called “Aquarius Generation.” Tom Wolfe, *The Right Stuff*, previously cited,
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examines the world of the test pilot and astronaut, and the occasional tensions therein. Michael Collins, Carrying the Fire: An Astronaut's Journeys (New York: Farrar Straus Giroux, 1974) is a humorous, thoughtful, and lively recollection of the Gemini and Apollo programs and a host of other things, by the former command module pilot of Apollo 11. It is among the finest aviation memoirs written to date.

There is, of course, a very large body of literature that may be termed "space futurism." Much of this speculation falls between factual extrapolation from today's technology and outright science fiction. One glimpse that promises to be a landmark book in the literature of space utilization is physicist Gerard K. O'Neill's The High Frontier: Human Colonies in Space (New York: William Morrow, 1977) which postulates a future of high technology and cost-effective space colonies orbiting the earth, a vision that is hotly debated by technologists, scientists, enthusiasts, and social commentators.

edited essays, *Between Sputnik and the Shuttle: New Perspectives on American Astronautics* (San Diego, Calif.: American Astronautical Society, 1981), are volumes in the historical series of the American Astronautical Society, offering tentative interpretations on what the space program has meant to the United States and the Soviet Union. Paul A. Hanle and Von Del Chamberlin, *Space Science Comes of Age* (Washington: Smithsonian Institution Press, 1981), a series of edited essays, offers a quick perspective of the scientific impact of unmanned space exploration. Clearly, however, the field of space exploration is one that will continue to require incisive study and research.
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