Sep 28th, 9:00 AM - 10:00 AM

The Wright Brothers, Government Support for Aeronautical Research, and the Progress of Flight

Roger D. Launius

National Aeronautics and Space Administration (NASA) Historian

The Wright Brothers, Government Support for Aeronautical Research, and the Progress of Flight

Presented by Roger D. Launius
National Aeronautics and Space Administration (NASA) Historian, Washington, DC

Introduction

In Stephen E. Ambrose's best-selling biography of Meriwether Lewis, *Undaunted Courage*, he makes the point that at the beginning of the 19th century everything moved at the speed of a horse. "No human being," he observed, "no manufactured item, no bushel of wheat, no side of beef (or any beef on the hoof, for that matter), no letter, no information, no idea, no order, or instruction of any kind moved faster. Nothing ever had moved faster, and, as far as [Thomas] Jefferson's contemporaries were able to tell, nothing ever would. And except on a racetrack, no horse moved very fast." [1]

It is an insightful comment, both at once obvious and secluded. But the 19th century portended enormous changes in transportation. Those living in it saw the movement from horsepower to steam-driven trains, then the rise of the internal combustion engine and the automobile, and finally at century's end the dawning of a new age of flight. Thanks to the invention of the airplane by the two brothers from Dayton, for the first time in human history the people of the 20th century would enjoy the thrill of flying. In the process their lives would fundamentally change, and in ways that no one could have foreseen as the airplane became a *sine qua non* of a modern, mobile, magnificent, and sometimes monstrous way of life.

Historians of 500 years hence may well characterize successful human flight, and all that followed in both air and space, as the most significant single technology of the 20th century. It has fundamentally reshaped our world, at once awesome and awful in its affect on the human condition. It has made easy, even luxurious, movement about the globe a commonplace. At the dawn of the 20th century, which I would remind you also had mechanized means of transportation, everyone had to allow multiples of days and sometime weeks for travel. Jules Verne's character Phineas Fogg of *Around the World in Eighty Days* was a creature of railroad and steamship timetables that took him throughout the globe with some ease, but certainly on a much longer schedule. [2] At the dawn of the 21st century, when one plans a transcontinental or even trans-Atlantic trip, one may allow only one day for travel. We rightfully scoff at 80 days being required to circle the Earth; after all, anyone can do it in a few hours by airplane and in a few minutes by spacecraft.

Anyone and anything can be virtually anywhere in the world within one day's travel. This is both a blessing and a curse. Lifesaving personnel and equipment and supplies can reach a region of the world just as easily as bombs and destructive viruses. High priority passengers and cargo can be almost effortlessly transported wherever they are required, but as the events of September 11, 2001, demonstrated the destructive power of an airplane in the wrong hands is enormous. At a level both sublime and unambiguous the capability of human flight has wrought enormous changes to the human condition that had never been necessary to deal with before.

So how did we get to this point? I would suggest that the importance of aerospace technology was recognized even before the point that the Wright brothers first flew. The Wrights were an exceptionally unique pair of brothers who undertook cutting edge research-building very well on what had already been accomplished-without any government involvement whatsoever. [3] No doubt they deserve our sustained celebration for their contributions as lone inventors. And as Americans we love that kind of ingenuity. It's the same kind of ingenuity we have seen throughout our history as enterprising individuals ranging from Eli Whitney to David Packard to Steve Jobs accomplished great technological breakthroughs. [4] And of course at the same time the Wrights were undertaking their work Samuel Langley had significant dollars from the military for his aerodrome and failed to achieve any success whatsoever. Consequently, the Wright's story is a variation of the Horatio Alger phenomenon in American life. [5]

But it seems that in something as complex as aeronautics and space, for marked progress to take place significant investment beyond the capability of most individuals or even corporations is necessary. Various European governments invested heavily in the technology and the result was that their airplanes far outstripped American capabilities by the time of World War I. And it required significant U.S. government investment to advance aeronautics in this country. I want to trace that investment and to show the government role in fostering the technology of flight. I also want to note that since the 1930s a consistently positive balance of trade has been possible in the aerospace industry and this is largely because of government investment. I will comment on the relationship between government investment and R&D advances in aeronautics.

Finally, to bring it back to the Wrights, I want to speculate a little using counterfactual methodologies about what might have been the result had a well-organized R&D establishment been in existence in the latter 19th century. Would the Wrights have still been the first to fly? Would they have been completely frozen out of the R&D process by well-financed research institutions? Would the U.S. have been better of worse off in this environment?

Lone Inventors versus Standing Armies of Researchers

If there is folklore in the public mind about the history of engineering, it is the story of genius and its role in innovation. Americans love the idea of the lone inventor, especially if that inventor strives against odds to develop some revolutionary piece of technology in a basement or garage. There have been enough instances of this in U.S. history to feed this folklore and allow it to persist. The "Renaissance man" who with broad background can build a technological system from the ground up permeates this ideal. And it is a uniquely compelling vision for a nation of overachievers such as the United States.

And it does exist in unique personalities and situations. Individualism and versatility characterizes this concept of engineering. Its quintessential expression in American history came in the work of Thomas A. Edison, whose many accomplishments in technology have been recognized as seminal to modern life. These same virtuoso expressions of engineering mastery have also been recognized in the work of U.S. rocket pioneer Robert H. Goddard, who spent most of his career as a lone researcher designing and testing rockets on a piece of isolated land near Roswell, New Mexico. [6]

This tale of the lone inventor, working in solitude, coming up with a hugely significant invention without either assistance or hindrance from others is especially legitimate when thinking of the Wright brothers and the process of invention that led to the airplane. [7] At the same time, the "Renaissance man" has never been very common in the history of science and technology. The kinds of lone wolves that make up the folklore, reinforced by the reality of a few bona fide geniuses, are rare indeed. This has especially been the case in 20th century aerospace engineering. It is in part the logical consequence of the increasing depth of information in the individual disciplines. No one person can master the multifarious skills necessary in the research, design, development, and building of a piece of aerospace hardware.

Accordingly, the vast majority of breakthroughs in aerospace technology have been the result not of the Wrights or of other independent inventors but of well-heeled R&D organizations usually funded by government largesse. Great leaps forward in technological capability almost always require significant long-term investment in research and development -- research and development that does not have explicit short-term return to the "bottom line" and may not yield even long-term economic return. Without that large-scale investment in aerospace technology, however, the United States will become a second-class aerospace power. I would suggest that today we are on the road to becoming one. That is the result of two related perspectives. First, since the end of the Cold War, and the belief that the United States stood alone as the world's only superpower, there has been an erosion in the level of R&D investment that the Federal government made in the technology of flight. It was no longer viewed as necessary for national defense. Second, many public officials believe-mistaken though they are-that aerospace technology is mature and that private industry should be able to sustain aerospace advances without significant government investment.

A Breathless Survey of the U.S. Government's R&D Investment

Although the Wrights invented the airplane without external assistance, we should not forget that other researchers were well-funded by government. For instance, in the United States the Smithsonian Secretary Samuel P. Langley received $100,000 from the War Department for his experiments at virtually the same time that the Wrights were inventing the airplane. [8] He undertook tests in the Potomac River just a few days before the Wrights' first successful flight at Kitty Hawk -- tests that ended in discouraging failure. These discouraging results raised doubts over the propriety of spending government money on Langley's experiments. [9] Langley, it seems, was not only a scientist but also a government agent supplied with public monies for the purpose of building a machine that the Federal government might use as a military weapon. [10]

In the aftermath of the Langley fiasco there was no public clamor to devote more government money in the uncertain quest for elusive innovation. Nor was any government agency eager to begin a new project that might call to mind the previous waste. Langley's research organization was soon closed down, and stood for years as "a silent monument to the political hazards of aeronautical research." [11] The ghost of Langley reminded men in Washington of the uncertain outcome of research aimed at innovation and the political vulnerability of government patronage for such research. For years after Langley's death in 1906, whenever aeronautics was mentioned in Congress, "some gray-haired Senator would whisper 'Remember Langley,' and that ended the talk about all things aerial at the Capitol." [12] As one influential report stated, even though the U.S. led the world into the air age, by 1915 it was "the only first class nation in the world that does not have an Advisory Committee or Board on Aeronautics, and one of more aeronautical laboratories devoted to the solution of problems which the manufacturer and practical aviator meet with in connection with the advancement of aerial flight." [13]

To a very real extent, the result of Langley's lack of success-I hesitate to call it failure for aerospace R&D is at a fundamental level a process of trial and error, build-test-retest, that ultimately leads to an advancing of a state of the art-served to stunt the development of the airplane in America. Although the United States invented the airplane, by the time of World War I it was obvious that the knowledge required to fly efficiently, to do much of anything with airplanes, had moved offshore and resided in Europe. This was true for two reasons.

First, European governments, as well as industrial firms, tended to be more supportive of what might be called "applied research." As early as 1909, the internationally known British physicist, Lord Rayleigh, was appointed head of the Advisory Committee for Aeronautics; in Germany, Ludwig Prandtl and others were beginning the sort of investigations that soon made the University of Göttingen a center of theoretical aerodynamics. Additional programs were soon underway in France and elsewhere on the continent. As Smithsonian Institution secretary Charles D. Walcott wrote to Congress in 1915:

> As soon as Americans demonstrated the feasibility of flight by heavier-than-air machines, France took the matter up promptly, and utilized all the available agencies, including the army, navy, and similar establishments, both public and private. Large sums were devoted to the research work by wealthy individuals, and rapid advance was made in the art.

Germany quickly followed, and a fund of one million seven hundred thousand dollars was raised by subscription, and experimentation directed by a group of technically trained and experienced men.

Walcott added that England and Russia followed suit, leading the way into the air age. He noted that when World War I began in 1914, about 1,400 military aircraft existed, of which only 23 belonged to the United States. [14]

Second, fueled by military necessity the nations of Europe invested heavily in aeronautical technology and built flying machines of great complexity and significant capability, capability far outstripping anything that the U.S. could accomplish in the mid-1910s. [15] As a result of the First World War the small, fast, maneuverable, and heavily armed fighter emerged as a major component of the battlefield. Although powered-flight had been possible since 1903, as late as 1914 there was little understanding of what might be possible in warfare by extending it into three dimensions with the use of the airplane. European combatants on both sides transformed airplanes into "warplanes," evolving these vehicles through five essential generations during the Great War. Each stage represented a major technological breakthrough and was dominated by one side of the belligerents. It also forced the development of fighter tactics to make aerial combat more effective. In turn, each stage was made obsolete by its successor, and while vestiges of aircraft types and tactics might remain throughout the rest of the war, they became less significant as they were passed by later developments. [16]

Similar progress in the United States was slow in coming. Aware of European activity, Secretary Walcott of the Smithsonian obtained funds to dispatch two Americans on a fact? finding tour overseas. Dr. Albert F. Zahm taught physics and experimented in aeronautics at Catholic University in Washington, D.C., while Dr. Jerome C. Hunsaker, a graduate of the Massachusetts Institute of Technology, was developing a curriculum in aeronautical engineering at the institute. Their report, submitted to Congress early in 1915, emphasized the galling disparity between European progress and American inertia. The visit also established European contacts that later proved valuable to the NACA. [17]

The United States developed no comparable capability, as American flying lagged far behind European aviation. This was particularly galling to many aviation advocates in the United States, the home of the Wright brothers. The European success was documented not only in a growing record of achievements but also underscored by a lack of organized research in the United States. The best the U.S. could do in the war was build the Liberty Engine. [18] Indeed, as late as 1914 the United States stood fourteenth in total funds allocated by nations to military aviation, far behind even Bulgaria and Greece.

Well into the 20th century there was in the United States little appreciation of scientific and technical research and even less inclination to allocate government funding for such an uncertain activity. But because of this truly poor response at the time of World War I, the U.S. decided to create the National Advisory Committee for Aeronautics (NACA) in 1915. Sentiment for some sort of center of aeronautical research had been building for several years. At the inaugural meeting of the American Aeronautical Society, in 1911, some of its members discussed a national laboratory with federal patronage. But the American Aeronautical Society's dreams were frustrated by bureaucratic in?fighting and questions about the appropriateness of government investment in technological R&D. Something drastic had to be done, and it was through the passage of enabling legislation for the NACA on 3 March 1915 as a rider to the Naval Appropriations Act. [19]

The NACA had emerged by 1920 as a small, loosely organized, and elitist non-bureaucracy that provided aeronautical research services on an equal basis to all. An exceptionally small headquarters staff in Washington-so small in fact that it could be housed in a corner of the Navy Building-oversaw the political situation and secured funding for research activities. It was governed by a committee of appointees who served without pay, making it one of the most nontraditional organizations in Washington. [20] Moreover, its small Langley Memorial Aeronautical Laboratory with only 100 employees by 1925, collocated with the Army Air Corps near Hampton, Virginia, conducted pure research, mostly related to aerodynamics, receiving advice and support from the headquarters Director of Research, Dr. George W. Lewis. [21] Those who remember the agency between the two world wars speak of it in idyllic terms. They were able to develop their own research programs along lines that seemed to them the most productive, handle all test details in-house, and carry out experiments as they believed appropriate. They issued "Technical Notes" partway through many investigations containing interim results and "Technical Reports" with major research conclusions at the end of the effort. No one and no political issue, the old NACA hands recollected, infringed upon their work. Thus they believed that partly for this reason the organization was the premier aeronautical research institution in the world during the 1920s and 1930s. [22]

At the same time, the U.S. military began to perceive, albeit reluctantly, the significance of aircraft in the conduct of modern warfare. This led to a rapid expansion of federal spending for aeronautics. When the U.S. entered World War I in April 1917, this process accelerated and the government made significant investments in the aviation industry and expanded procurement of military aircraft from 350 on order to an ambitious program to develop and produce 22,000 modern military aircraft by July 1918. Even without achieving this goal-U.S. manufacturers delivered 11,950 planes to the government during the war-the massive military appropriations gave the nascent aviation industry a huge boost. [23]

Even with its efforts during World War I the United States refused to make a significant sustained investment in aeronautical technology thereafter. Many people found reason to question these government expenditures virtually as soon as the war was won. The comments of Glenn L. Martin come to mind in considering this situation:

> Only a failure of the United States government to place orders with our successful airplane designers and builders will cause our aircraft industrial strength to slip back into the position it occupied three years ago. A vital point

> is being overlooked by the American people. It is immediately evident that the industrial strength of the United States must be at the war strength all the time....The government must stimulate and aid in the application of aircraft industrially, and also aid in foreign trade, furnishing sufficient outlet for industrial aviation and guaranteeing a continuity of production at the required rate.

Martin probably had it pretty much right when he said this in 1920. He complained that the government required a strong aerospace industry as a guarantee of national defense and should put money into it as a matter of industrial policy. [24]

Well into the 20th century there was in the United States little appreciation of scientific research and even less inclination to allocate government funding for such an uncertain activity. Only with war clouds gathering for what became World War II did the federal government become a major patron of science. Again, only because of perceived needs in national defense.

To a very real extent the U.S. had to be jarred out of lethargy in supporting aeronautical R&D. In 1936 John J. Ide, the NACA's European representative since 1921, fired off an alarming report on the state of aeronautical science on that continent. Ide, the sometime technology expert, sometime intelligence analyst, and sometime expatriate socialite, reported on greatly increased aeronautical research activities in Great Britain, France, Italy, and especially Germany. He observed that new and quite modern wind tunnels were being erected to aid in the development of higher performing aircraft and suggested that the NACA review its own equipment to determine if it met contemporary demands. [25] Charles A. Lindbergh, a NACA executive committee member living in seclusion in England, confirmed Ide's report in a May 1936 letter to Committee chairman Dr. Joseph S. Ames. [26] Because of this Lewis inserted a deft warning to the government in the NACA's 1936 annual report. Commenting on the arms race in Europe Ames suggested that "increased recognition abroad of the value and of the vital necessity of aeronautical research has led to recent tremendous expansion in research programs and to multiplication of research facilities by other progressive nations. Thus has the foundation been laid for a serious challenge to America's present leadership in the technical development of aircraft." [27]

Because of these developments, in September-October 1936 George W. Lewis traveled to Europe via the Hindenberg to learn about aeronautical development firsthand. He toured with Dr. Adolph Baeumker, the German government's R&D head, several aeronautical facilities in Nazi Germany and was both impressed and disquieted by their activities. He learned that Luftwaffe chief and Hitler stalwart Hermann Goering was "intensely interested in research and development" and greatly expanded it. He decentralized it at three major stations: one for research on new aircraft, one for fundamental research without application to specific aircraft designs, and one for the development of new propulsion systems. Lewis remarked:

> It is apparent in Germany, especially in aviation, that everyone is working under high pressure. The greatest effort is being made to provide an adequate air fleet. Every manufacturer is turning out as many airplanes as possible, and the research and development organizations are working on problems that have an immediate bearing on this production program.

To ensure American competitiveness in aviation, Lewis advised, the nation should immediately start the expansion of R&D capabilities. [28]

These epistles of warning brought moderate action. In 1936 the Congress funded construction of another wind tunnel at Langley and the lengthening of a tank used for seaplane research. It provided the impetus for additional funding through a special "Deficiency Appropriation Act" to fund the construction of new facilities, all because of war sentiment in Europe. [29]

Once the United States got into a shooting war against the Axis, however, the treasury opened and funds flowed to advance the frontiers of flight. War was good business, proving a great boon both to advancement if the technology of flight and industry that developed it. It was the only time the aircraft industry really enjoyed exceptional success. As an example of what all the industry enjoyed, Douglas Aircraft made the decision in 1942 to expand its manufacturing greatly, opening plants in El Segundo, Santa Monica, and Long Beach, California; Tulsa and Oklahoma City, Oklahoma; and Chicago. By 1944, Douglas employed a total of 160,000 personnel, compared to less than a 2,000 when it started building the DC-3 aircraft in the 1930s. By 1945, Douglas Aircraft Company had built 29,385 aircraft in four years, and had become one of the largest aircraft firms in the nation. [30]

This success did not last long. Virtually every study of the aerospace industry in World War II speaks of its devastation with demobilization. From late 1943 on the Joint Chiefs of Staff was sure of eventual victory and began to trim defense contracts for aircraft and other war materiel. Between 1942 and 1945 an average of 138 airplanes rolled off the assembly lines each day. The result of this activity was that 1944 became the peak year of production, with 95,272 aircraft delivered, and another 48,912 delivered in the last year of the war. Even so, this was nearly half of the total of 316,495 aircraft produced during World War II. But this investment declined significantly, and in 1946 production was just over 36,000 aircraft, the vast majority of which were commercial aircraft purchased by air carriers after years of waiting for newer models. In 1947 the production declined by more than half of its 1946 level. Employment in the industry demonstrated similar declining trends, losing nearly 75 percent of its workforce during the last two years of the war and the first year of peace. [31]

Because of these trends the industry became much more dominated by a few mega-firms while less lucrative companies went out of business or merged with the giants of the industry. Indeed, the mobilization and demobilization of World War II made the aerospace manufacturing concerns that commanded the industry in the Cold War era. It also ensured the demise, merger, or consolidation of several weaker firms. The top fifteen manufacturers of aircraft, by numbers of aircraft delivered, included firms that are familiar to most of us. The top ten of these eclipsed all others in the postwar era, and some of the smaller ones shown here-notably Ford and Taylor-got out of the aerospace business altogether. And these were exceptionally healthy firms throughout the wartime period. Defense industry procurement patterns, at least for the World War II period, placed a heavy reliance on contracting with large, established firms that had a long history in the field. In essence, those with longstanding ties to the government and with exceptional resources already available got much richer. Those without those attributes may have survived but not in as lucrative a manner. All of that would change with demobilization, however, as every firm suffered enormous reductions in government contracts as soon as the war ended. [32]

Post-World War II demobilization devastated the aircraft industry and only the beginnings of the cold war seemed to help it recover from a postwar depression. As historian Charles D. Bright appropriately concluded: "By the latter part of 1947 the industry had run out of money, ideas, courage, and hope." [33] Industry leaders began lobbying the government for relief, and it was not long in coming because rising tensions between the United States and the Soviet Union brought renewed military procurement in the latter 1940s. Despite the very real demobilization in 1945-1947, the United States' Cold War rivalry with the Soviet Union precipitated an arms race both desperate and tragic during the period between 1948 and 1989. [34] With it came an enormous expansion of military aerospace activities. Couple this defense increase, which also had an increasingly important component involving rocket development and space systems beginning in the 1950s, with the rise of commercial air travel, especially after the advent of the jet age in the 1950s and early 1960s, and the aerospace industry enjoyed a relatively stable existence for the next 40 years.

At the same time, the industry could be viewed as a tragic creature. As Charles Bright commented:

> The aerospace industry since Would War II, then, is the story of an increasingly capital-intensive business whose manufacturing function has steadily declined, and its product cost has risen so high that it has almost priced itself out of its market. It is an industry which has...not been able to diversify adequately to shelter itself from its captive status in relation to its dominant customer, the government.

The industry's reliance upon a dominant client, the U.S. government and its cold war aerospace needs, has ensured an industry that is over capacity and inefficient. [35]

In the last decade the situation has gotten worse. Market share in all major aerospace sectors has declined. In commercial space launch, which the United States dominated until the advent of the Ariane launcher built by the European consortium Aerospatiale in the early 1980s. The market collapsed for the U.S. in the aftermath of the Challenger and has not recovered. In passenger aircraft, Airbus Industrie's analysis suggests that to satisfy an expected average annual growth rate in passengers and cargo of 5.2 per cent during the next ten years, the number of passenger aircraft in service will increase from some 10,350 in 1999 to 14,820 in 2009 and 19,170 in 2019. Satisfying that requirement is Airbus' objective for the indefinite future. And they are showing remarkable staying power there. At the Paris airshow this last summer they nailed down 110 orders for new aircraft to Boeing's less than 40. [36]

Commercial aviation is quickly evolving, both technologically and in the context of the global business climate. Pacing world economic growth, air travel is evolving through profound changes to provide better service at lower cost. The world fleet is currently three times as large as it was 20 years ago, and today's fuel-efficient jetliners offer airlines greater choice in terms of range, passenger capacity, and operating economics. More than half of all flights are made on routes bounded by few, if any, regulatory constraints. Flag carriers are privatizing, "open skies" agreements are replacing bilateral air service agreements, and global alliances are on the rise. As a result, airlines now have unprecedented flexibility to pursue strategies that meet the needs of the next century's global community. They will not purchase American aircraft because we want them to do so. Indeed, with the growth of overseas carriers, there is an ideological reason to refrain from buying American if for no other reason than to thumb their noses at the last remaining superpower. Accordingly, U.S. technology must be clearly superior.

Reasons for Decline

During the period between the 1960s and the 1990s the share of the market enjoyed by American aerospace manufacturers has fallen sharply as foreign corporations-either private or state-run-gained greater portions of the market. In 1986, for example, United States high technology imports exceeded exports for the first time. The aerospace industry was one of the only remaining fields with a trade surplus, 90 percent of which was attributable to the sale of aircraft and aircraft parts. Compared to an overall U.S. trade deficit in manufactured goods of $136 billion in 1986, the aerospace industry had a surplus of $11.8 billion. But the U.S. lead in aerospace was shrinking rapidly. In 1980, the U.S. market share of large civil transport sales was 90 percent. By 1992, that percentage had dropped to 70 percent and was in danger of falling even further. The lead in the commuter aircraft market had already been lost. During the 1990s the U.S. lost its lead in the space launch market as well.

The reasons for this loss of market share are complex. From my perspective the aerospace community is in the doldrums for five key reasons.

First, there are the inherent difficulties of the aerospace marketplace. As aerospace technology became more complex and expensive, it was also more difficult for individual companies to shoulder the entire financial burden for researching and developing new technology and products themselves. It has always been a marginal economic enterprise in all its myriad permutations. Aerospace manufacturers literally bet the company on a new design because of the enormous cost associated with developing an aircraft or rocket. Malcolm Stamper, former president of Boeing Aircraft Corporation, remarked that "Locating the break-even point is like finding a will-o'-the-wisp." [37] Knowledgeable individuals have concluded that it is not until 20 to 35 production aircraft have actually been manufactured that production costs become predictable. For rockets and other space technology, which does not have large production runs the economics of manufacturing are even more problematic. [38]

Second, American aerospace executives were too often complacent in maintaining their competitive technological edge. Aerospace corporations, like a lot of other organizations, have a decided "not invented here" syndrome. Ideas emanating from beyond the recognized corporate structure too often get short shrift. I can cite numerous examples ranging from Northrop Aircraft Corporation's hesitancy to embrace retractable landing gear in the 1920s to Boeing's rejection of the so-called "glass cockpit" technology in the 1980s. While the "glass cockpit" offered cutting-edge avionics displays, this American-made technology found its first use at Airbus Industry in Europe. Airbus made it a centerpiece of its newest generation of transports, in the process helping itself compete more effectively in the marketplace. Losing market share as a result, Boeing raced to adopt the new technology into its own designs. [39]

Third, there has been a lack-indeed a celebration of that lack-of coherent industrial policy in the United States. Because of the nature of our republic and citizenry, Americans have been loath to adopt anything approaching a centralized, rational, long-term industrial policy because of its inherently undemocratic and remarkably technocratic and elitist characteristics. Such a policy would recognize that the health of the American aerospace industry-and perhaps other industries-were important both for national security and economic competitiveness. Accordingly, it is something of a truism to suggest that anything other than what has passed for aerospace policy in this nation, a sub-unit of that largely non-existent industrial policy, has been both ad hoc and expeditious. [40]

Fourth, there has been the success of industrial policy by other nations aimed at securing greater market share for non-U.S. aerospace companies. Their governments, especially in command economies such as the communist bloc, often directly subsidized their national manufacturers. There is no question but that one of the major reasons for the European community to invest in aerospace technology has been to wrest economic market share from the United States. The Europeans have developed an industrial policy aimed at this goal, and they have been quite successful. [41] The Japanese, for instance, have long pursued policies, and directly subsidized key industries, to help move the fruits of basic research in to the marketplace for the purpose of gaining economic advantage vis-à-vis the United States. [42]

Finally, a major problem of the aircraft business was its cyclic nature, leading to boom and bust periods. Complicated by the enormous infrastructure necessary to support the design and manufacture of aircraft, these firms were exceptionally limited as to their markets and their capabilities. President Ronald Reagan's science advisor noted in 1982 that "aircraft are now the dominant common carrier for inter?city travel, and the safety and control of that travel are a federal responsibility." He recommended pressing hard for government support of basic research that could then be transferred to American private firms.

A Modest Proposal

So how do we get out of the current state of the doldrums? There are many things I could suggest but let me concentrate on one, that of ensuring the technical superiority of American aerospace technology. There is a direct correlation between R&D investment and excellence in technology. Since the 1960s the percentage of investment by the United States in aerospace technology has stabilized at about one percent of the Federal budget. The aerospace corporations and some universities invest in R&D as well, but that is a decidedly small amount and at least in the case of the private sector limited to almost entirely short term research. So let's do one thing that will yield a positive result. The American nation should decide to double this investment in aerospace R&D during the first decade of the 21st century. This is fully within the bounds of our capability, and it will help assure American economic, military, and cultural competitiveness in the new century. Not to do so would be to turn our backs, as we did in the 1900s on the legacy of the Wrights and their enormously significant invention.

Let me close with a comment made famous by Tom Hanks in the baseball film A League of Her Own-and no it's not "There's no crying in baseball"-but it is one that is equally insightful. He told the Geena Davis character that what they were doing was hard, and of course it had to be because otherwise "everyone would do it." Like baseball, flying is hard and flying with the latest technology is harder still. If it weren't everyone would do it. The United States is a nation with the high quality of economic, political, social, and knowledge base necessary to bring forward the next generation of aerospace technology. All it takes is will. All we have to do is make the decision to do so and follow that with the investment necessary to further the frontiers of flight. No one knows where that might lead but I believe it will lead to a hypersonic plane, jumbojets like we have never seen before, and trips beyond this planet. And we will do so in a safe and environmentally friendly manner.

Notes

1. Stephen E. Ambrose, *Undaunted Courage: Meriwether Lewis, Thomas Jefferson, and the Opening of the American West* (New York: Simon and Schuster, 1996), 52.

2. Jules Verne, *Le tour du Monde en quatre-vingts jours* (*Around the World in Eighty Days*), English translation by George Makepeace Towle (London, England: Porter and Coates, 1873).

3. That is certainly the position of the preeminent historian to write about the Wright brothers. See, Tom D. Crouch, *The Bishop's Boys: A Biography of the Wright Brothers* (New York: W.W. Norton and Co., 1989).

4. Thomas P. Hughes, *American Genesis: A Century of Invention and Technological*

Enthusiasm, 1870-1970 (New York: Viking, 1989), pp. 47-52, 92-95, 214-16.

5. Norriss S. Hetherington, "The Langley and Wright Aero Accidents: Two Responses to Early Aeronautical Innovation and Government Patronage," in Roger D. Launius, ed., *Innovation and the Development of Flight* (College Station: Texas A&M University Press, 199), pp. 18-51.

6. See Milton Lehman, *This High Man* (New York: Farrar, Straus, 1963); Neil Baldwin, *Edison: Inventing the Century* (Chicago: University of Chicago Press, 2001 ed.); Paul Israel, *Edison: A Life of Invention* (New York: John Wiley and Sons, 1998).

7. This heroic aspect of the Wrights is stated in two very fine books on the brothers: Tom D. Crouch, *The Bishop's Boys: A Biography of the Wright Brothers* (New York: W.W. Norton and Co., 1989); Peter Jakob, *Visions of a Flying Machine: The Wright Brothers and the Process of Invention* (Washington, DC: Smithsonian Institution Press, 1990).

8. Archibald D. Turnbull and Clifford L. Lord, *History of United States Naval Aviation* (New Haven, CT: Yale University Press, 1949), 1-3; Norriss S. Hetherington, "Langley's Aerodrome," *W. W. I Aero* 131 (February 1991): 3-16; Samuel P. Langley, edited by Charles M. Manly, *Langley Memoir on Mechanical Flight. Part II*. 1897 to 1903 (Washington, DC: Smithsonian Institution, 1911).

9. "Langley Wants More Money," *New York Times*, 20 September 1903, 10.

10. Letter to the editor, *ibid*., 30 August 1903, 9.

11. Alex Roland, *Model Research: The National Advisory Committee for Aeronautics 1915-1958, vol. 1* (Washington, DC: National Aeronautics and Space Administration, 1985), 2.

12. "Aeroplanes to be Put to a Government Test," *New York Times*, 28 June 1908, part 5, 8.

13. Charles D. Walcott, secretary of the Smithsonian Institution, to Senator Benjamin R. Tillman, chairman of the Committee on Naval Affairs, "Memorandum on a National Advisory Committee for Aeronautics," 1 February 1915, reprinted in, Alex Roland, *Model Research: The National Advisory Committee for Aeronautics, 1915-1958* (Washington, DC: NASA SP-4103, 1985), 2:593-97, quote from 594-95.

14. *Ibid*., 595.

15. John H. Morrow, Jr., *German Air Power in World War I* Lincoln: University of Nebraska Press, 1982), 3-13; John H. Morrow, Jr., *The Great War in the Air: Military Aviation from 1909 to 1921* (Washington, DC: Smithsonian Institution Press, 1993).

16. Richard P. Hallion analyzes this transformation in his masterful *Rise of the Fighter Aircraft, 1914-1918* (Baltimore, MD: The Nautical and Aviation Press, 1984).

17. Walcott to Tillman, "Memorandum on a National Advisory Committee for Aeronautics," 1 February 1915, reprinted in, Roland, *Model Research*, 2:593-97.

18. Rated at 410 hp., this engine weighed only two pounds per horsepower, far surpassing similar types of engines mass-produced by England, France, Italy, and Germany at that time. During the war, 20,478 Liberty 12s were produced by Packard, Lincoln, Ford, General Motors (Cadillac and Buick), Nordyke, and Marmon. They were used primarily in U.S.-built D.H.4s, the only American-made airplane to get into combat over the Western Front. Following the war, the engine was used by the Air Corps for more than a decade in

numerous types of airplanes. Some which were sold to civilians as war surplus were illegally used in speed boats for "rum running" during the Prohibition era of the 1920s; others were even used in Russian and British tanks during WWII.

19. The story of the NACA's creation is told in Roland, Model Research, 1:1-25; Roger E. Bilstein, *Orders of Magnitude: A History of the NACA and NASA* (Washington, DC: NASA SP-4404, 1989), chapter 1.

20. The NACA was a unique agency of the Federal government throughout the interwar period, but it must be acknowledged that much of Franklin D. Roosevelt's New Deal government was also loosely structured. His constant use of ex-officio diplomats and representatives is well documented. See Robert Dallek, *Franklin D. Roosevelt and American Foreign Policy, 1932-1945* (New York: Oxford University Press, 1979).

21. See also, George W. Gray, Frontiers of Flight: The Story of NACA Research (New York: Alfred A. Knopf, 1948); Arthur L. Levine, "United States Aeronautical Research Policy, 1915-1958: A Study of the Major Policy Decisions of he National Advisory Committee for Aeronautics," Ph.D. Diss., Columbia University, 1963; Ira H. Abbott, "A Review and Commentary of a Thesis by Arthur L. Levine entitled United States Aeronautical Research Policy, 1915-1958: A Study of the Major Policy Decisions of the National Advisory Committee for Aeronautics," April 1964, HHN-36, NASA History Division Reference Collection, Washington, DC.

22. William Phillips, "Recollections of Langley in the Forties," n.d., oral presentation, History Collection, Langley Research Center, VA; oral histories with Paul E. Purser, Walter S. Diehl, and W. Kemble Johnson by Michael D. Keller, all in NASA History Division Reference Collection.

23. Roger D. Launius, "Aerospace," in Donald C. Bacon, Roger H. Davidson, and Morton Keller, eds., *The Encyclopedia of the United States Congress* (New York: Simon & Schuster, 1995), 1:11-13.

24. Quoted in Lt. Col. Ellen M. Pawlikowski, "Surviving the Peace: Lessons Learned from the Aircraft Industry in the 1920s and 1930s," Thesis, Industrial College of the Armed Forces, National Defense University, Fort McNair, Washington, DC, 1.

25. "John Jay Ide, 69, Air Pioneer, Dies," *New York Times*, 13 January 1962; NACA Executive Committee Minutes, 3 March 1936, 8-9, Record Group 255, National Archives and Records Administration, Washington, DC; Gray *Frontiers of Flight*, 22-23.

26. Charles A. Lindbergh to Dr. Joseph S. Ames, 20 May 1936; John F. Victory to Charles A. Lindbergh, 18 June 1936, both in NASA History Division Reference Collection.

27. *Twenty-Second Annual Report of the National Advisory Committee for Aeronautics, 1936* (Washington, DC: Government Printing Office, 1937), 3.

28. George W. Lewis, "Report on Trip to Germany and Russia, September-October, 1936," NASA History Division Reference Collection.

29. "Some Important Facts Regarding Expansion of NACA Research Facilities and War-time Status of NACA," 17 January 1946, NASA History Division Reference Collection; A Hunter Dupree, *Science in the Federal Government: A History of Policies and Activities to 1940* (Cambridge, MA: Harvard University Press, 1957), 363.

30. Frank Cunningham, *Sky Master: The Story of Donald Douglas and the Douglas Aircraft*

Company (Philadelphia, PA: Dorrance and Co., 1943), 57-65, 98-99; Denis Mulligan, *Aircraft Manufacture in Chicago* (Chicago: Aircraft Manufacturers Association, 1939), 32-33; Jeffrey A. Fadiman, "Dreamer of the Drawing Board: Donald Wills Douglas (1892-1981)," in Ted C. Hinckley, ed., *Business Entrepreneurs in the West* (Manhattan, KS: Sunflower University Press, 1986), 83-93.

31. See Irving B. Holley, Jr., *Buying Aircraft: Materiel Procurement for the Army Air Forces* (Washington, DC: Office of the Chief of Military History, 1964), 550-61.

32. Roger D. Launius, "End of a Forty Year War: Demobilization in the West Coast Aerospace Industry After the Cold War," *Journal of the West* 36 (July 1997): 85-96.

33. Charles D. Bright, *The Jet Makers: The Aerospace Industry from 1945 to 1972* (Lawrence: Regents Press of Kansas, 1978), 13.

34. On the Cold War generally three books stand out as excellent syntheses: Walter LeFeber, *America, Russia and the Cold War, 1945-1975* (New York: John Wiley, 1976); Stephen E. Ambrose, *Rise to Globalism: American Foreign Policy, 1938-1980* (New York: Penguin, 1980); and Adam B. Ulam, *The Rivals: America and Russia Since World War II* (New York: Viking, 1971).

35. *Bright*, Jet Makers, 22.

36. *Global Market Forecast, 2000-2019* (Blagnac, France: Airbus Industrie, 2000), 4-5.

37. Quoted in John Newhouse, *The Sporty Game* (New York: Alfred A. Knopf, 1982), 4.

38. Senate Committee on Armed Services, *Hearings*, *Weapons Systems Acquisition Process* (Washington, DC: Government Printing Office, 1972), 92d Sess., 1st Sess., 152.

39. See Walter G. Vincenti, "The Retractable Airplane Landing Gear and the Northrop 'Anomaly': Variation-Selection and the Shaping of Technology." *Technology & Culture 35* (January 1994): 1-33; Lane E. Wallace, *Airborne Trailblazer: Two Decades with NASA Langley's Boeing 737 Flying Laboratory* (Washington, DC: NASA SP?4216, 1994), 26-39.

40. The problem of aerospace policy is related to the larger theme of industrial policy. For discussions of this issue see, Malcolm L. Goggin, ed., *Governing Science and Technology in a Democracy* (Knoxville: University of Tennessee Press, 1986); Manfred Stanley, *The Technological Conscience: Survival and Dignity in an Age of Expertise* (New York: Free Press, 1978); Sylvia Doughty Fries, "Expertise Against Politics: Technology as Ideology on Capitol Hill, 1966-1972," *Science, Technology, & Human Values 8* (Spring 1983): 6-15; David McKay, *Domestic Policy and Ideology: Presidents and the American State, 1964-1987* (Cambridge, England: Cambridge University Press, 1989).

41. See, for example, the Convention for the Establishment of a European Space Agency (CSE.CD(73)19. rev.7: Paris, May 30, 1975). Article VII (I) (b) states: "The industrial policy which the Agency is to elaborate and apply by virtue of Article II (d) shall be designed in particular to:...b) improve the world-wide competitiveness of European industry by maintaining and developing space technology and by encouraging the rationalisation and development of an industrial structure appropriate to market requirements, making use in the first place of the existing industrial potential of all Member States."

42. Norman E. Bowie, *University-Business Partnerships: An Assessment* (Lanham, Maryland: Rowman & Littlefield Publishers, Inc., 1994), 19.