Available online at www.sciencedirect.com
ScienceDirect
ELSEVIER
Space Policy 24 (2008) 140–147
Space Policy
www.elsevier.com/locate/spacepol

Accelerating entrepreneurial space: The case for an NACA-style organization

Glenn E. Bugos*, John W. Boyd

NASA Ames History Office, NASA Ames Research Center, MS 207-1, Moffett Field, CA 94035, USA

Available online 18 July 2008

Abstract

The entrepreneurial space industry today faces challenges similar to those facing the commercial aircraft industry in the early part of the last century. At that time the National Advisory Committee for Aeronautics (NACA) helped develop many of the key technologies that enabled air travel to become effective, economical and safe. Today, in discussing how best to support the realization of a commercial space economy, we suggest revisiting what an NACA-style organization can contribute. This paper outlines the key concepts that made the NACA so successful: a committee structure, open source publication, a willingness to try any useful experimental method, and a focus on problem definition.

Over the past few years, at many meetings of the entrepreneurial space community, discussion arises about the need for an ''NACA-style'' organization for space. Space entrepreneurs seem to want to ask NASA for engineering help. Thus far, and very quickly, they have done well piecing together existing components into viable spacecraft. Nevertheless, the entire industry seems to face generic problems that no one firm can afford to tackle alone. Foremost is the problem of designing and testing thermal protection systems for return capsules or for light spacecraft. Other technology needs include non-chemical means of reaching orbit, nano-materials, life support systems, and in situ use of lunar resources. These sorts of space technologies are the modern day equivalents of the aircraft components—airfoils, cowlings, landing gear, swept wings, jet inlets—developed in the 1920s and 1930s by the National Advisory Committee for Aeronautics (NACA). The NACA did fundamental engineering and testing on the then most intractable aircraft problems. An ''NACA-style'' organization, the entrepreneurs seem to think, would allow NASA to help from a respectful distance without inviting the red tape and regulation that entrepreneurs fear most.

For its part, NASA would like to help the entrepreneurial space industry and has a largely unfulfilled legislative mandate to do so. The NASA Authorization Act of 2005 (Section 108) explicitly asks the Administrator to develop a commercialization plan to support all facets of space exploration, and to encourage collaboration on many levels between NASA and private industry. The Commercial Orbital Transportation Services (COTS) program shows that NASA intends to be a committed launch customer. NASA engineers have expertise in engineering for space environments, as well as access to space-qualified research and testing facilities. But NASA has its own programs to work on first, and some in NASA think a separate NACA-style organization might let NASA help space entrepreneurs without distracting it from its main mission.

Furthermore, basic or component-oriented engineering of the sort the NACA did for the aircraft industry is what space entrepreneurs most want from NASA, not mission planning or systems design. NASA has not done well recently managing its own reusable launch vehicles. The Lockheed Martin X-33, the Orbital Sciences X-34, the Boeing X-37, the X-38 crew return vehicle, and the X-43 hypersonic test bed each have been canceled or languish in hiatus. While each program has generated dramatic new technologies, space entrepreneurs generally no longer seek to emulate NASA methods of systems engineering and program management.

*Corresponding author. Tel.: +1 650 604 6436.
E-mail address: Glenn.E.Bugos@nasa.gov (G.E. Bugos).

0265-9646/$ - see front matter r 2008 Elsevier Ltd. All rights reserved.
doi:10.1016/j.spacepol.2008.06.003

Thus, an NACA-style organization—perhaps even called a national advisory committee on astronautics—may suit the needs of both NASA and the entrepreneurial space community. It can provide balance between government incursion and industry independence, while keeping the focus on enabling engineering.

The Space Portal at the NASA Ames Research Center, launched in June 2005, was among the first groups to invoke the NACA as a paradigm for how it wants to support entrepreneurial space. An NACA model nicely fits the rolodex culture of Silicon Valley, encourages innovation through Space Act agreements, and fits the research culture of NASA Ames. Even after decades of reorganization to serve NASA goals, the NACA culture remains, today, woven into the fabric of many NASA facilities—notably the research centers like Ames, Glenn, Langley, and Dryden. As a result, whenever discussion turns to organizational models for some new technological initiative, there is much to learn by posing the question of how naturally the NACA might serve as such an organizational model.

In the 50 years since it was merged into NASA, many people have advocated resurrecting the NACA as it once existed to support commercial aviation in the face of European competition. Especially in the 1970s, some NASA observers suggested that an independent NACA, free from the space-focused NASA, might give aeronautics research the freedom needed to set a more utilitarian agenda and garner support. The USA's aircraft and airline industry could benefit from greater agreement on a broader research and engineering agenda, and focus on solving lingering problems with quiet supersonic business jets and with cleaner jet engines. Resurrecting the NACA as it was might provide such focus. Here, however, we are not advocating resurrection of the historical NACA to address problems in aviation and air travel.

What we hope to do in this paper, instead, is to channel the NACA spirit. We will explore how an organization inspired by the NACA might serve a different nascent industry almost a century later—the entrepreneurial space industry. Specifically, we want to illuminate the essence of the NACA model, more generally and historically, as a way of reaching some consensus on which elements of its model need more exploration and explanation in order to be useful to policy makers today. The focus of our paper is on how to help a new organization, perhaps like the NASA Ames Space Portal, embody some of what was best about the NACA. Much as the NACA so effectively enabled the rapid growth of the entrepreneurial commercial air travel industry, perhaps a new NACA-style organization can enable the growth of an entrepreneurial commercial space industry.

1. Why reconsider the NACA?

Why is the NACA a good starting point for discussions about an appropriate organization for government support of entrepreneurial space? The NACA was formed in 1915, and was merged into NASA on 1 October 1958. Even though it has now been dead longer than it was active, it still evokes favorable feelings. The NACA then, and today, enjoys a good reputation, and thus carries forward some goodwill. The NACA organizational structure was unique, transparent, and understandable, both then and to observers today. There were few indiscernible social and cultural forces underlying its effectiveness. It was known as being non-bureaucratic. And while it had impressive leaders, the NACA was not the lengthened shadow of any individuals.

The NACA used its appropriations effectively, with no waste or pork barrel spending (although that may have to do less with its structure and more with the penny-pinching attitude of its longtime executive secretary, John Victory). And it also used its labor force wisely, in that it developed a strong safety culture that originated in the Committee and was imposed by the Laboratory directors. ''Faster, better, cheaper'' and safe will be important in the entrepreneurial space arena. The NACA proved flexible enough to provide usable technologies across the entirety of the aviation industry during its rapid entrepreneurial growth. It also proved successful in setting technology policy that was agreeable to those working on the shop floor, in forging broad consensus on the major problems and opportunities in aircraft technology.

2. Four concepts for understanding the NACA

NACA history can be roughly divided into three periods. First, we can combine the two world war periods, which hopefully will remain anomalous and irrelevant to us as we plan for the future. They are marked by an acceleration of problem-solving work, of which good examples are the solution to the duct rumble in the P-51 and the patching together of thermal de-icing systems. Second, the classical period, the 1920s and 1930s, is when the NACA had only one laboratory, had few competitors for research funds, and had a clear role in the broad development of aeronautical technology. Comparatively the postwar period, the late 1940s and 1950s, is marked by NACA involvement in a greater variety of new technologies and the creation of two new NACA labs and one research station, which in turn required a larger NACA headquarters.

During all three periods, certain key concepts are important to grasp the essence of the NACA. First, it was a committee—not a working group, or a board, or a council, or a federation. The committee had executive powers, a discretionary budget, and when it needed to bring in help it set up subcommittees. Alex Roland has written a very useful history of the NACA as a functioning committee [1]. While there is a fair amount of literature on the engineering work of the NACA laboratories, Roland's book Model Research focuses on the Committee itself and how it processed information and reached decisions.

Anyone wishing to invoke the name of the NACA today should start by reading this book.

Second, the concept of basic research, within the linear view of research policy, did not reach prominence until the 1950s during Vannevar Bush's efforts to create a National Science Foundation (NSF). One cannot understand the NACA by thinking of a linear model—of basic research feeding applied research which then feeds industry through a process of technology transfer. The NACA did all those things, but only in the order that most made sense. That is, the NACA considered itself to be comprised of engineers rather than scientists, and would use any research tool available to solve a practical problem. That said, historians have not yet created a better way to define generically what research process the NACA did use. Historians of the three NACA laboratories—James Hansen, Edwin Hartman, and Virginia Dawson—have written several useful case studies on how the NACA laboratories attacked important issues [2]. Notably, Hansen portrays the NACA cowling work as a story of basic research and technology transfer [3]. The NACA was usually first into a topic (because the primary job of the Committee was defining new topics) but, once there, NACA researchers used any method available to start structuring the engineering conversation.

Third, 'reverse salient' is a term popularized by historian of technology Thomas Parke Hughes [4]. With a military force advancing in a great expanding arc, reverse salients are parts of its front line that cannot keep up with the advance. What made the NACA most effective was developing new technologies (often by stepping back and applying new insight) in areas lagging the general advance of the aircraft firms. Understanding how the NACA identified reverse salients is key to understanding how it set its research agenda.

Fourth is the notion of epistemology, explained best by historian Walter Vincenti in his book What Engineers Know and How They Know It [5]. Vincenti worked at Ames from 1940 to 1958, then went to Stanford where he had two careers, as a professor of astronautics and of the history of technology. As Vincenti describes it, epistemology is that branch of philosophy that deals not with what you know, but how you know it. Those working in the NACA culture did not focus on inventing or blazing new theory. They focused on knowing, and made the experimental apparatus of the wind tunnel their primary tool. They were always attuned to the limits of the knowledge they were generating, and were unafraid to make sure NACA management and clients were aware of those limits to what they knew for sure. Within the literature on organizational behavior, committees are usually characterized as conservative in how they accept new information and act on it. A focus on epistemology may help us understand that tendency.

3. The essence of the NACA: a committee

The structure of the NACA was relatively simple. The Main Committee met twice a year and served without compensation. It started with 12 members; that number had grown to 17 by 1958. Most of them were appointed because of their positions in government agencies. Initially there were two from the War Department, two from the Navy, plus the Secretary of the Smithsonian Institution and the directors of the Weather Bureau and of the National Bureau of Standards. These members were the highest-ranking people in those agencies dealing with aeronautics. Because of the short tenures of military officers in their positions, their appointments to the NACA overlapped so that military representatives were not at a disadvantage to the longer-serving non-government members. In the classical period of the 1920s and 1930s, the discretionary appointments were mostly of university or consulting engineers. In the postwar period, more members worked for industry. They were all appointed by the president, with nominations informally coming from the outgoing Committee.

An Executive Committee met monthly, and signed most correspondence. It was made up of Main Committee members who lived near Washington, DC, and thus was weighted toward members with government jobs.

There were five to ten standing committees that dealt with specific technical issues. Their titles evolved, but their topics included operational problems, power plants, airframes, aerodynamics, manpower training, or missiles. These were chaired by members of the Main Committee, though subcommittee members could be drawn from anywhere except the NACA laboratories. NACA employees often attended the meetings, however, to facilitate communication about what NACA engineers already knew on a topic. Subcommittees and special committees came and went to address specific problems.

The Headquarters staff was small, led by the Director of Research, first George Lewis and later Hugh Dryden. John Victory served as Executive Secretary during the entire history of the NACA. In the postwar period, as laboratories and programs proliferated, Dryden created a staff of division directors to help him administer the research work. By 1957, the NACA had 276 headquarters staff managing 7889 field staff.

4. The essence of the NACA: communication

The NACA was also very effective at communicating the results of its work. Nothing it did was proprietary, although it could have security classification. Nor did it patent, even though much of its work was patentable. The NACA Main Committee was, in fact, a primary proponent of the Manufacturer's Aircraft Association, which compelled cross-licensing of aircraft patents during World War I. Furthermore, NACA publications were all government publications, deposited at most major libraries or available for the cost of postage. No NACA results were controlled by for-profit publishers; none were restricted from export.

(Indeed, the equivalent European laboratories were also then very open about their results.)

The NACA publication system was rigorous [6]. Peer-review was usually done inside the NACA, as part of one's paid duties, by a competing branch, although university or military engineers often commented. Every assumption would be questioned and data were frequently recalculated. In the postwar period, as peer-review was expanded to the new laboratories, it became even more competitive, and experiments were often re-run during the review process. There is little evidence that such competition was wasteful. Because the Committee assured that only the most significant questions were addressed, even small refinements were useful to the aircraft industry.

Publications were tiered. Thus, preliminary results were published quickly, for example, as a Technical Memorandum. As the research progressed, and as peer-review and technical editing became more intense, results were presented in more polished publications, like an NACA Technical Report. The result was that aircraft manufacturers felt they could absolutely rely on data or an equation printed in an NACA report. Or, they felt that the NACA would be very transparent about any limits to the data they generated.

Again, each NACA committee fed information to the laboratories about the state-of-the-art in the aircraft industry. Members were attuned to the role of the NACA in the ecosystem of technical knowledge in the industry, and they understood that committee efforts at problem definition would be as significant as their proposed solution to the problem. In addition, the NACA had support offices, in New York, Paris, and Los Angeles, staffed by aeronautical engineers who persistently visited every organization working in air travel: universities, component manufacturers, airlines, military air bases. Their memoranda to headquarters painted a detailed picture of the vast industrial infrastructure that made air travel possible. Also, because the NACA distributed its results openly, not through any formal product licenses, factory tours were often the only good way for the NACA to collect data on which of its innovations were of most use to manufacturers. Quite simply, the NACA gave manufacturers ideas to improve aircraft, and those firms made money off them. Whenever the NACA leadership heard that some work in a laboratory had a direct benefit to an aircraft manufacturer, the kudos went to the researcher to reinforce their focus on practical solutions.

Likewise, the only real promotion the NACA did was in person, by welcoming visitors to its laboratories. Open houses, annual inspections, conferences were all ways that NACA people learned how to make their work more valuable. Although NACA engineers were given these opportunities to share their ideas and capabilities, any formal requests for work were communicated and authorized through the laboratory Director. The Director served as a formal gatekeeper on any activity involving funds. Even the roads at Ames—as at Langley, Lewis, and Dryden—were built so that a visitor to the laboratory literally had to drive around the Director's office to get inside.

It is important to note, however, that the committees did not disseminate knowledge. Committee membership offered no privileged access to information or use of resources. The ideas emanating from the laboratories were available to all comers, through a variety of publications. Committee members were expected to bring experience to the meetings, and to work to fashion an agenda for useful work.

5. The essence of the NACA: laboratory culture

It would be hard to image a funding system as simple as that for the NACA today. It had three pots of money, which were filled each year. Every year, Congress appropriated a general discretionary fund to the Committee. The Committee then decided how to apportion this to the Laboratories. Most of it went as research and program management (RPM) funds, which the Directors spent on personnel (within the confines of civil service laws) and on discretionary research to try out new lines of inquiry. The Committee also took from the annual appropriations some funds for Research Authorizations, which brought visibility to a research effort and could continue over many years but were not a significant source of funds [7]. Most ''construction of facility'' funds were appropriated for specific, large facilities. At times these funds came from other defense agencies to the NACA. The Navy, for example, funded construction of the Ames 6 x 6 ft wind tunnel. In the early years, the military services also transferred funds to do simple wind tunnel work, like drag clean-up, on their aircraft. Later that service work was written into the NACA annual appropriation. Whenever NACA did tests for a completely private aircraft, the money it collected went straight into the US Treasury without benefit to the laboratory. The result of such simple funding was that the laboratory Directors did not need to manage or raise many separate pots of money, and had tremendous discretion in how to build their research programs to satisfy the questions raised by the NACA committees.

Of course, many people think the organization of the NACA itself had much less to do with its success than did the organization of its laboratories. Indeed, each NACA laboratory was unique, formidable, and well run. The NACA charter allowed it to create laboratories as it felt they were needed. And, if one reads the vast opus of work produced by the laboratories, it is clear that it reflects the text chartering the NACA: ''to supervise and direct the scientific study of the problems of flight, with a view to their practical solution, and to determine the problems which should be experimentally attacked, and to discuss their solution and their application to practical questions''[8].[1] The terms it uses seem quaint, today, but in fact were very relevant to the work of the laboratories: determine problems, scientific study of problems, experimental attack on problems, practical solution.

While each NACA wind tunnel branch had a different organizational culture, they all shared some more universal character traits. Some of the most charismatic and paradigmatic research leaders in the NACA labs (like Eastman Jacobs and John Stack at Langley and Harvey Allen at Ames) ran their branches somewhat like an NACA committee [9]. Everyone had an equal say, at least around the lunch table, while they worked to define the really big problems. There was an expectation that any researcher could and should make use of many experimental tools. Although the branches were often organized according to the wind tunnels they had at their disposal, the researchers in them were not limited to wind tunnel work.

NACA work was about engineering, not science. They wanted to control airflow, and if they actually understood airflow they were willing to treat that understanding like an intuition or a sense rather than a scientific principle. (R.T. Jones' use of aerodynamic theory was a good example of this [10].) NACA researchers were often the first into a new problem, and they used all the tools available to them to start generating some usable data. The result was that a branch usually verified a proposed engineering solution in several ways—tunnel data, flight test, correspondence with theory, and statistics on its success in use. The data were layered and cross-checked.

That also meant the NACA invested in developing cutting edge instrumentation, since it wanted data to be reliable and commensurate across a great many types of experimentation. From the perspective of NASA today, it is important to note that the NACA successfully developed technology in advance of the needs of any specific aircraft project. It sought to develop technology that could be of use in multiple types of aircraft built by many different companies.

Furthermore, the NACA developed substantial expertise in program management and did contract much of its work. However, NACA projects were grounded rather than flying. The tunnels and simulators the NACA built were among the most complex facilities of their times. Wind tunnels and other simulators embodied enormous hulls, often built by naval contractors, to withstand incredible stress. Yet, the NACA also relied upon very precise instrumentation and sophisticated protocols for data management. By comparison, most aircraft built then were less complex or risky then the tools the NACA needed to study them.

6. Further research into the NACA as a model

What additional work can historians do to clarify the essence of the NACA? Perhaps the best case study, to understand how an NACA-style organization can enable a successful commercial spacecraft, is to look retrospectively at what the NACA did to undergird the design of the Boeing 247 [11]. The 247, which first flew in February 1933, is widely recognized as one of the first aircraft to include all elements of the airframe revolution—airfoils, cowlings, stressed metal manufacture, flush riveting, variable pitch propellor, recessed wheels, drag clean-up on protuberances—that gave us streamlined metal aircraft. The 247 was also the first airliner to truly make air travel viable, and was an important predecessor to the Douglas DC-3. Historian Jim Hansen has compiled an interesting set of documents on the role of the NACA in this reinvention of the airplane in the 1930s [12]. The NACA left it to aircraft manufactures to pick from the component technologies and design guidance it made available to them, and Boeing picked well.

During the late 1930s, as manufactures began building more airliners, like the 247 and the DC-3, the weight of NACA attention shifted to operational issues. A perception that air travel was unsafe did more to limit the development of the industry than aircraft performance and the economic efficiency of air travel. That is, the NACA set about figuring out what technologies were required at all airports for navigation, assessed which weather data was most useful, studied why aircraft crashed (in a statistical way, like the Aviation Safety Reporting System does today), invented new methods of de-icing and fire suppression, then developed technologies to make air travel more regular. Throughout its history, the NACA always made passenger safety a key part of its agenda.

[1] Within 25 pages of legislative text was the two paragraphs that defined the NACA for its entire history: ''An Advisory Committee for Aeronautics is hereby established, and the President is authorized to appoint not to exceed 12 members, to consist of two members from the War Department, from the office in charge of military aeronautics; two members from the Navy Department, from the office in charge of naval aeronautics; a representative each of the Smithsonian Institution, of the United States Weather Bureau, and of the United States Bureau of Standards; together with not more than five additional persons who shall be acquainted with the needs of aeronautical science, either civil or military, or skilled in aeronautical engineering or its allied sciences: provided, that the members of the Advisory Committee for Aeronautics, as such, shall serve without compensation: provided further, that it shall be the duty of the Advisory Committee for Aeronautics to supervise and direct the scientific study of the problems of flight, with a view to their practical solution, and to determine the problems which should be experimentally attacked, and to discuss their solution and their application to practical questions. In the event of a laboratory or laboratories, either in whole or in part, being placed under the direction of the committee, the committee may direct and conduct research and experiment in aeronautics in such laboratory or laboratories: and provided further, that rules and regulations for the conduct of the work of the committee shall be formulated by the committee and approved by the President.

That the sum of $5,000 a year, or so much thereof as may be necessary, for five years is hereby appropriated, out of any money in the Treasury not otherwise appropriated, to be immediately available, for experimental work and investigations undertaken by the committee, clerical expenses and supplies, and necessary expenses of members of the committee in going to, returning from, and while attending meetings of the committee: provided, that an annual report to the Congress shall be submitted through the President, including an itemized statement of expenditures.''

It may be possible to do the same sort of case study to look at how NACA design guidance and component technologies made possible the Century series of supersonic Air Force fighter aircraft in the 1950s, or the Boeing 707, the first successful jet-powered airliner [13]. Again, the NACA developed theories and component technologies, and the defense services and aircraft manufactures picked from them to design individual aircraft. It might also make sense to look at how the NACA initially failed to anticipate the significance of two other postwar technologies, the jet engine and helicopters.

We might also look at how advisory committees for aeronautics operated in countries other than the USA. The NACA was itself modeled on the Advisory Committee for Aeronautics, established in Britain in 1909. Other similar efforts were, in France, L'Etablissement Central de l'Aé rostation Militaire at Chalais-Meudon, in Germany, the aerodynamical laboratory of the University of Gö ttin- gen and, in Russia, the Aerodynamic Institute of Koutch- ino.

Others have also discussed the value of using the NACA as a model for developing a technology base. Perhaps the most ardent student of the NACA was its one-time chairman, Vannevar Bush. He very explicitly used the NACA as the model for the National Defense Research Council (NRDC), which created some of the most notable new technologies of World War II, like radar, the proximity fuse, and the early Manhattan Project. Bush soon rolled the NRDC into the Office of Scientific Research and Development, which was more hierarchical, as a wartime expedient. In planning for peacetime support of basic research, Bush argued that the NSF should assume the NACA or NRDC model, but then considered the NSF that emerged in 1950 as a failed implementation of that idea [14].

To understand how the NACA worked so well, it might also make sense to revisit the entrepreneurial nature of the aviation industry when the NACA was founded in 1915. Jim Hansen has also compiled an interesting set of documents on this era in the history of the NACA [15]. This was an era when aircraft were designed and built one at a time, by young men enthralled with speed and fueled by ego, financed by venturers moving in from other industries, operating out of garages and looking for a purpose for their machines. Curtiss, Martin, Boeing, Loughead—these aircraft pioneers share much with the current faces of entrepreneurial space—Musk, Rutan, Bigelow, Bezos, Branson. However, when it came to populating the NACA it was not the egos that found a seat at the table, but rather their adult supervision—the professors who would train their employees, the military officers whose subordinates would fly their aircraft, and the agency bureaucrats who would decide the rules for how airplanes would fly.

And it was fortuitous that the more mature members of the NACA set the research agenda. Once the war ended aircraft needed to find a commercial use. While those who built and flew aircraft remained obsessed with speed, the NACA quietly and steadily fashioned an agenda to support what would become early aviation's ''killer ap'' (highly profitable application)—first flying airmail around the country, then flying airmail at night, then flying it across the Atlantic Ocean. This industry—airmail operations—attracted a new generation of entrepreneurial adventurers who came to rely on the work of the NACA.

7. The NACA becomes NASA

Given its successes, why does the NACA not survive today? There is no clear answer to this question, mostly because the NACA willingly disbanded itself. The NACA leadership thought, like most other Americans, that the USA needed a strong response to Sputnik. After quick efforts to craft legislation that moved the NACA into civil space research, the NACA leadership embraced the National Aeronautics and Space Act of 1958. Furthermore, the NACA leadership expected that they would continue to guide NASA—that NASA would be just the four NACA labs with JPL and von Braun's group thrown in. And for the first year or so, the old NACA did run NASA. Harry Goett, an old NACA hand, ran the new Goddard Center at Maryland, and NASA addressed the issues of spaceflight by setting up space-oriented technical committees. T. Keith Glennan spent most of his time protecting NASA's boundaries from defense department incursion, and charted a gradual program of science-driven exploration.

But when Kennedy announced the Apollo program in 1961, the old NACA was clearly subsumed within a program-driven NASA intent on building its own hardware through contract. The administrative needs of new Centers further reduced the effectiveness of committees in apportioning work. Most vestiges of the NACA leadership jumped on the Apollo gravy train rather than fight any battles of retrenchment. Nevertheless, Ames director Smith DeFrance continued to argue for the viability of NACA-style research to generate the technologies needed for a broad-based effort in space exploration. When Ames was asked to build a basic life sciences function within NASA in the mid-1960s, this group looked much like an NACA-inspired effort [16]. There were similar NACA overtones when NASA Ames built the discipline of computational fluid dynamics in the 1970s. Today, those involved in the NASA Astrobiology Institute and Lunar Science Institute might recognize some elements of NACA style in their virtual academies [17].

Some have questioned, counter-factually, whether the NACA, if so tasked, could have moved the USA into the Space Age, based on NACA history during the 1950s. During World War II, the NACA built three new laboratories—Ames and Lewis and Dryden—which were almost immediately and completely made busy solving the problems of aircraft going to war. As soon as the war ended, however, the NACA had to deal with its rapid expansion. Its budget jumped from $3.1 million in 1940, to $33 million in 1945, to $89 million in 1954. (Note that the budget then declined slightly to 1958.)

During the 1950s, the NACA grew its headquarters staff, and created three assistants to the Director of Research. While competition between the laboratories pushed peer-review to an even greater intensity, it also prompted competition—not so much for resources as for who controlled program direction. Permanent staff rather than the committees increasingly took it upon themselves to decide which reverse salient they would attack. Furthermore, the aircraft industry, realizing the tremendous value in NACA work, argued for and got more seats on the NACA main committee. Academics and consulting engineers had less voice in NACA decision-making, and turned instead to organizations like the NSF which gave them more freedom to build their university programs. The NACA asserted no role in the satellite experiments for the International Geophysical Year. In addition, the military started to build their own laboratories. The Air Force built up Wright-Patterson and a new set of simulator facilities at the Arnold Engineering Development Center. Industry and the defense services bid up salaries for engineering talent. Competition for resources the NACA once commanded grew fierce.

More importantly, in 1954 the defense services shifted their missile and space work to a new generation of program managers—Bernard Schriever for the USAF Atlas, William Raborn for the Navy Polaris, and John Medaris for the Army Jupiter. And these program management groups got results quickly. By contrast, in the late 1940s the NACA had, for the first time, begun building its own aircraft—the X-series. These were meant to be civilian, experimental aircraft, although the defense procurement offices often managed the contracts. And while the research results were spectacular, the aircraft were often late and over budget. If American taxpayers (that is, with no entrepreneurs or corporations volunteering) were going to put a civilian rocket into space, by 1958 it seemed obvious that an administration-style of organization, with all decisions made by a bureaucrat with a direct line to the president, could do that more expeditiously than a Committee-style organization. There was simply not enough time to support the general state-of-the-art, hoping that a private rocket builder would build its own rocket from that broad base of technology.

Today, the only remaining organizational vestige of the NACA is the NASA Advisory Council (NAC). In 1967, Congress directed NASA to form an Aerospace Safety Advisory Panel to advise the administrator on safety in NASA's hardware programs. Congress also mandated a Space Program Advisory Council and a Research and Technology Advisory Council, reporting to the Administrator. In 1977, these were combined into the NAC. According to the current NASA website, the NAC continues the advisory tradition of the NACA Main Committee [18]. However, it has no executive functions. Other than living in the hearts of those knowledgeable about aviation history, the NACA no longer exists.

8. Applying the NACA model to entrepreneurial space

So what, more specifically, would an NACA-style organization look like today? To more formally structure an NACA-style organization to support entrepreneurial space, the conversation should first address issues of independence—not only independence from being captured by any element of the industry, but also from being captured by NASA or the Air Force. A national advisory committee for astronautics needs an independent federal charter. Once independence is assured, notable leaders will chose to help guide it. Membership might be drawn from the highest offices of NASA, the National Oceanic and Atmospheric Administration, the Defense Advance Research Projects Agency, the Federal Aviation Administration, the Air Force, the National Institute of Standards and Technology, and the NSF, and any other federal agency which might be a customer of entrepreneurial space products and services. Other members might come from university engineering departments. The main committee would exclude members of the entrepreneurial firms and their investors, although they might work on the subcommittees created to define specific technical tasks.

In terms of purview and agenda, a new NACA would recognize that significant private investment has poured into space business over the past decade. Its agenda would first try to identify which efforts are most likely to become operational first: tourism, commercial launch, small satellites, planetary exploration, spaceports, robotic lunar exploration, space solar power, use of the International Space Station as a laboratory. Then, they could narrow the search for the reverse salients in the emerging systems.

A new NACA would leave anything that looked like government regulation in the hands of the Federal Aviation Administration or other established authorities. The entrepreneurial space industry today has quietly but clearly stated that they hope the federal government will not invent new types of red tape and oversight to hobble their efforts. On the space tourism side of the industry, the Personal Spaceflight Federation includes many of the key players developing small spacecraft for private markets in suborbital commercial passenger travel. They have announced their intention to develop new and rigorous standards for safety, and moved to set up a ''voluntary personal spaceflight industry consensus standards organization'' to develop standards to implement the Commercial Space Launch Amendments Act of 2004. Unless there are compelling engineering questions about these safety standards, a new NACA should let others try to first come to some agreement.

A new NACA need not start with a lot of money, since its focus would not be on cutting metal but rather setting research agendas and conducting research. The former NACA's appropriation in 1958 of $117 million—even if unadjusted for inflation—would give it enough funds to start. Congress might give it an independent appropriation. Or it might be funded by something like a tax on the budgets of the Defense Department, NASA and other agencies that rely upon access to space and could benefit from an enlarged pool of suppliers. There should be some source of unrestricted operating funds which can be allocated by the committee. Most of this money would be spent on grants or contracts with federal or university laboratories, until the committee could decide which new research and testing facilities would support the entire entrepreneurial space effort.

Given the need for open source publication, and our increasingly multinational business climate, there needs to be discussion of how to create and protect a national interest in the work of the committee. And those involved in the committee must be willing to envision a research program that is broad-based, fundamental, and not driven by the technology needs of only one rocket program. And above all there must be a publication strategy that is open source, meaning that the information is available to anyone and not controlled by any for-profit publisher. Finally, there should be some agreement on compulsory cross-licensing of patents. Any results must be quickly and clearly put into the public domain. Once the information is in the public domain, spacecraft manufacturers should be free to use it as they wish.

In the end, a new national advisory committee on astronautics might look little like the historical National Advisory Committee for Aeronautics. However, if a new NACA is shaped with respect for and understanding of the elements that made the historical NACA so successful, we believe it will be more likely to create a firm foundation for the private development of space.

Disclaimer

The opinions expressed are our own, and not necessarily those of NASA.

References

[1] Roland A. Model research: the National Advisory Committee for Aeronautics 1915–1958. Washington, DC: NASA SP-4103; 1985.

[2] Hansen JR. Engineer in charge: a History of the Langley Aeronautical Laboratory, 1917–1958. Washington, DC: NASA SP-4305; 1987;
See also Hartman EP. Adventures in research: a History of Ames Research Center, 1940–1965. Washington, DC: NASA SP-4302; 1970;
Dawson VP. Engines and innovation: Lewis Laboratory and American Propulsion Technology. Washington, DC: NASA SP-4306; 1991.

[3] Hansen JR. Engineering science and the development of the NACA low-drag engine cowling. In: Mack PE, editor. From engineering science to big science: the NACA and NASA Collier Trophy Research Project Winners. Washington, DC: NASA SP-4219; 1998. p. 1–28.

[4] Hughes TP. Networks of power: electrification in western society, 1880–1930. Baltimore, MD: Johns Hopkins University Press; 1983. p. 79–105.

[5] Vincenti WG. What engineers know and how they know it: analytical studies from aeronautical history. Baltimore, MD: Johns Hopkins University Press; 1990;
See also Bugos GE. Lew Rodert, epistemological liaison, and thermal de-icing at Ames. In: Mack PE, editor. From engineering science to big science: the NACA and NASA Collier Trophy Research Project Winners. Washington, DC: NASA SP-4219; 1998. p. 29–58.

[6] Roland A. Model research: the National Advisory Committee for Aeronautics 1915–1958, vol. II. Washington, DC: NASA SP-4103; 1985. p. 551–7.

[7] Roland A. Model research: the National Advisory Committee for Aeronautics 1915–1958, vol. II. Washington, DC: NASA SP-4103; 1985. p. 529–50.

[8] Public Law 271, 63d Congress, 3d session, passed 3 March 1915 (38 Stat. 930).

[9] Vincenti WG, Boyd JW, Bugos GE. H. Julian Allen: an appreciation. Annu Rev Fluid Mech 2007;39:1–17.

[10] Vincenti WG, Jones RT. Memorial tributes. Natl Acad Eng 2001;9:144–9.

[11] Van Der Linden FR. The Boeing 247: the first modern airliner. University of Washington Press; 1991.

[12] Hansen JR, editor. The wind and beyond: a documentary journey into the history of aerodynamics in America, vol. II. Washington, DC: NASA SP-2007-4409.

[13] Becker JV. The high speed frontier: case studies of four NACA programs, 1920–1950. Washington, DC: NASA SP-445; 1980.

[14] Gregory GP. Endless frontier: Vannevar Bush, engineer of the American century. Cambridge, MA: The MIT Press; 1990.

[15] Hansen JR, editor. The wind and beyond: a documentary journey into the history of aerodynamics in America, vol. I. Washington, DC: NASA SP-2003-4409.

[16] Bugos GE. Atmosphere of freedom: sixty years at the NASA Ames Research Center. Washington, DC: NASA SP-4314; 2000.

[17] Dick SJ, Strick JE. The living universe: NASA and the development of astrobiology. New Brunswick, NJ: Rutgers University Press; 2005. p. 202–20.

[18] /http://www.hq.nasa.gov/office/oer/nac/background.htmS; [accessed 27.03.08].