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Glide Path to Irrelevance

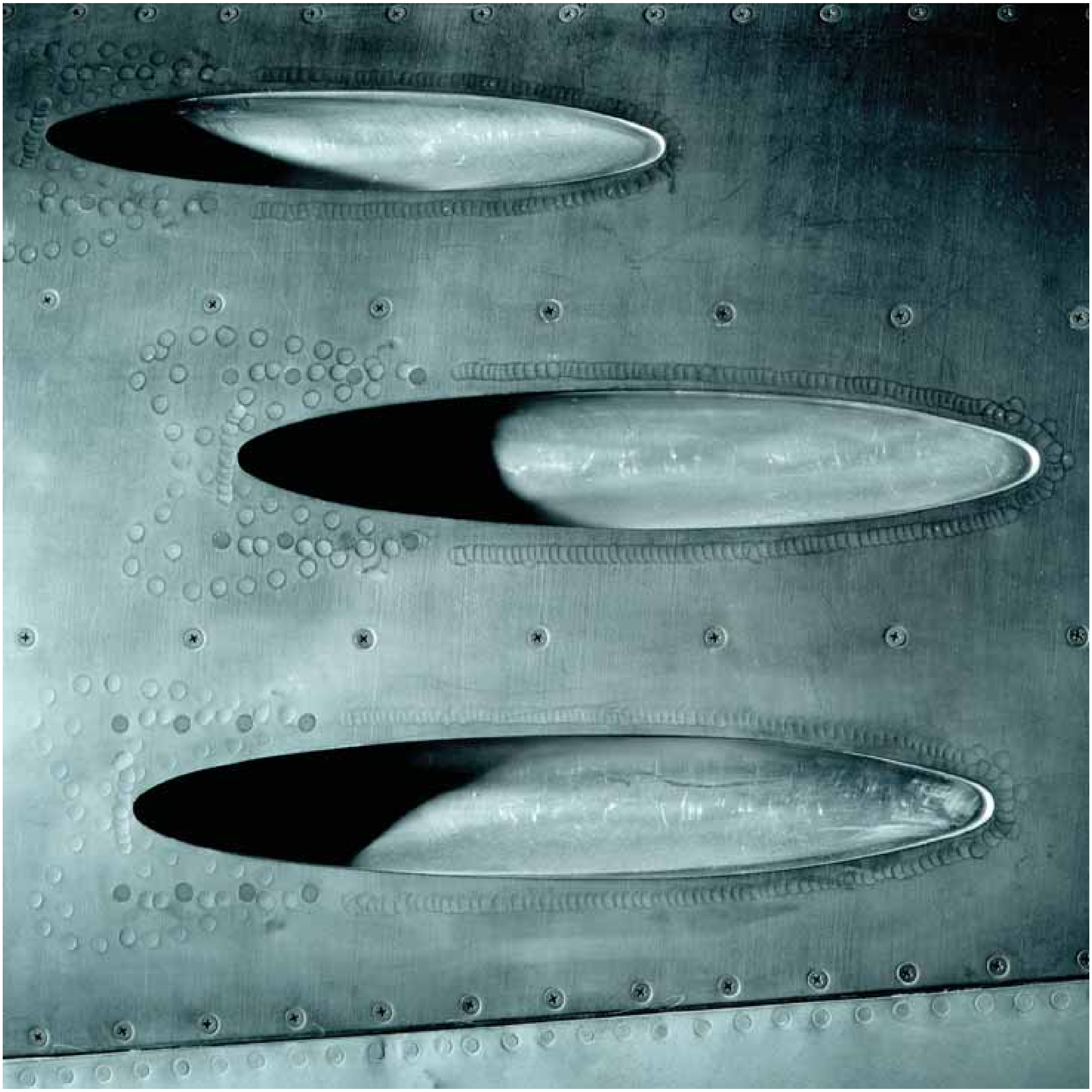
Federal Funding for Aeronautics

Aeronautics within NASA is too important to neglect in favor of space. But that is just what the federal government is doing.

The nation's 100-year preeminence in aviation is in serious jeopardy. So, too, are the medium- and long-term health and safety of the U.S. air transportation system. The peril stems from a lack of national consensus about the federal government's role in civilian aviation generally and about the National Aeronautics and Space Administration's (NASA's) role in aviation technology development in particular. Aeronautics—the first "A" in NASA—is now vastly overshadowed in resources, managerial attention, and political support by the agency's principal mission of space exploration and discovery. Indeed, most people have no idea that NASA is the leading, and essentially the only, agency that is organizationally and technically capable of supporting the nation's leadership in air transportation, air safety, and aircraft manufacturing.

The aeronautics community supports an expansive public R&D program, with NASA playing a lead role. But during the past seven or eight years, successive administrations and Congresses have reduced NASA's aeronautics budget without articulating how the program should be scaled back. In these circumstances, NASA has tried to maintain a sprawling program by spreading diminishing resources across existing research establishments and many objectives and projects—too many to ensure their effectiveness and the application of their results.

With its plans to return humans to the Moon and eventually send them to Mars, the Bush administration has added to the problem by further reducing the aeronautics budget. The budget request for fiscal year (FY) 2006 and succeeding years anticipates a 50% reduction in NASA's aeronautics R&D spending and personnel by 2010. The current NASA management understands that such resources will not support an expansive program and proposes to refocus efforts on fundamental research, avoiding costly demonstration projects. That may appear to be a reasonable strategy given the current outlook for funding, but it risks losing the



Carolyn Russo, *North American F-86A Sabre*, Giclée print, 24 x 24 inches, 2006.

support of industry stakeholders and other intended users of NASA-developed technologies. They operate in a risk-averse environment and often depend on outside suppliers to deliver well-proven technologies. This is especially the case in public goods research, such as safe, efficient air-traffic management and environmentally benign aviation operations, in which the argument for NASA involvement is strongest. Thus, with either its previous peanut-butter-spreading approach or its current fundamental research focus, we believe that the agency is on a glide path progressively leading to the irrelevance of the first A in NASA.

The administration's 2006 budget proposal exposed the lack of agreement between the government and the aeronautics community about the federal government's role in aeronautics. NASA's former associate administrator, Victor Lebacqz, acknowledged as much in defending the president's budget request before the House Science Committee. He said that there currently are two contending points of view. One point of view, reflected in a host of remarkably consistent blue-ribbon commissions and national panel reports, is that the aviation sector is critically important to national welfare and merits government support to ensure future economic growth and national competitiveness. This view implies an expansive public and private R&D program. The other view, reflected in the administration's budget submission, is that the aviation industry is approaching maturity, with aviation becoming something of a commodity, and that the government can therefore retrench and leave technology development to the private sector. Lebacqz neglected to mention what in our view is the most compelling case for reinvigorating national investment in aerospace technologies: clear public-good objectives—mobility, safety, and environmental protection—served by NASA's R&D involvement.

At any rate, the proposed retrenchment had a galvanizing effect. Congress rejected the proposed cut and restored NASA's Aeronautics Research Mission Directorate (ARMD) budget. At the same time, Congress passed the NASA Authorization Act, which called on the administration to prepare a policy statement on aeronautics as a basis for further discussion with Congress. A new NASA administrator and associate administrator withdrew proposed plans to scale back support for aeronautics and set to work on a new plan for ARMD.

These were encouraging signs that a potentially fatal retrenchment could be avoided. But in his FY 2007 budget proposals for NASA, the president proposed a further 18%

Carolyn Russo

Artist's statement:

"Defining a curve on the human face or abstracting elements on aircraft and spacecraft technology—it's the same to me. It all comes down to revealing the simple beauty in all that is seen.

I have walked by the aircraft in the Smithsonian's collection thousands of times and have seen them just as most people do—flying structures made of metal and rivets. The magic happens when you sit alone with them—as I have done during my photography sessions at night. It's as if the aircraft come to life and their personal features surface. I strive to capture the art within them that may otherwise pass away unnoticed."

The iconic aircraft and spacecraft in the Smithsonian's collections embody a century of historical and technological milestones, from breaking the sound barrier to landing on the moon. However, a new photography exhibition from the Smithsonian shifts the focus from the achievements of flight to the aesthetic attributes of these flying machines. *In Plane View: Abstractions of Flight* will feature 55 color photographs taken by Carolyn Russo that redirect our attention to the simple beauty of aircraft design. Visit www.sites.si.edu for exhibition tour information. A companion publication will be available from powerHouse Books in 2007.

Carolyn Russo is a staff photographer at the National Air and Space Museum. She received her BFA in photography at the Massachusetts College of Art and has exhibited her work in solo and group shows nationally. In 1997, she was the regional chairperson for the Women's Committee of the National Press Photographers Association and resides in Washington, D.C.

cut in aeronautics, to $724 million. This is in comparison to the $16.8 billion total NASA request, mostly targeted on space. If enacted, the resulting aeronautics budget in real terms would be less than one-half what it was in 1994.

Thus, it is long past time for a sustained high-profile national dialogue about the public value of national investments in aeronautics, distinct from space, and the very real continuing threat to NASA's unique role and capabilities in aeronautics.

World leadership in air transportation and aircraft manufacturing is widely viewed as a cornerstone of U.S. economic welfare and national security. Department of Transportation statistics are revealing. U.S. residents already have the highest per capita level of air travel in the world, and use is rising steadily. Domestic commercial flights, the backbone of the U.S. travel industry, carried 660 million passengers in 2005. The Federal Aviation Administration predicts one billion passengers by 2015. General aviation already flies 150 million more passengers than do commercial flights. Air cargo has grown 7% annually since 1980, by far the fastest-growing mode of freight transportation during the past two decades. It now accounts for more than one-quarter of the overall value of U.S. international merchandise trade, steadily gaining ground on the maritime sector, which has a two-fifths share. JFK International Airport alone handled $125 billion worth of international air cargo in 2004; this total ranks ahead of the value of cargo through the Port of Los Angeles, the nation's leading maritime port.

Aviation's national economic impact does not stop with the air transport system. Aerospace exports in 2005 made up nearly 30% of all U.S. exports in the category that the Department of Commerce labels "advanced technology products." Census Bureau trade figures indicate that aerospace, mainly airplanes and parts, delivered a surplus to the United States of nearly $37 billion in 2005, which significantly defrayed an $82 billion deficit in all other advanced technology categories. Indeed, for years aerospace has regularly logged the widest positive trade margin among U.S. manufacturing industries.

As for aeronautics' military significance, the Department of Defense's (DOD's) guiding doctrine relies significantly on air superiority and aircraft rapid strike and force-deployment capabilities. Moreover, a variety of aeronautics technologies, such as stealth and unpiloted remote-sensing aircraft and airborne command and control systems, have transformed military operations not only in the air but on the ground and at sea. The centrality is reflected in procurement strategy: A 2005 RAND analysis found that the DOD spends on the order of a third of its procurement budget on aerospace, including about $40 billion every year to buy aircraft and other air systems.

Nonetheless, recent signs that the nation's preeminence in aviation may be imperiled have occasioned deep concern. At least 12 studies of U.S. activity in aeronautics published during the past half decade by the National Academies and various industry and government bodies have called attention to the vulnerability of the United States' traditional leading position. In its final report, the Commission on the Future of the United States Aerospace Industry, widely known as the Walker Commission, stated that "the critical underpinnings of this nation's aerospace industry are showing signs of faltering" and warned bluntly, "We stand dangerously close to squandering the advantage bequeathed to us by prior generations of aerospace leaders." In 2005, the National Aerospace Institute, in a report commissioned by Congress, declared the center of technical and market leadership to be "shifting outside the United States" to Europe, with a loss of high-paying jobs and intellectual capital to the detriment of the United States' economic well-being.

The clear message is that the United States must overcome a series of major challenges—to the capacity, safety, and security of the nation's air transportation system, to the nation's ability to compete in international markets, and to the need to reduce noise and emissions—if the nation's viability in this sector, let alone international leadership, is to be ensured.

National needs fall into four broad areas. The first three involve classic public or quasi-public goods in which there is little disagreement that the federal government should play a central role. These categories are air traffic control, emissions and noise reduction, and air safety and security. In practice, the central federal role falls to NASA. No other organization remotely has the capabilities. Were it not for NASA, little R&D would be performed, key supporting infrastructure would not exist, and new technologies would not be developed because the benefits appropriable by private enterprise are too limited or too widely diffused to attract investment. The fourth category centers on commercial competitiveness. Here, there is much more policy debate about the role of the federal aeronautics enterprise. And the ideological tone of this debate carries over to, and dwarfs and distorts, discussion of the other three areas.

The following discussion highlights the four categories and the related policy debates.

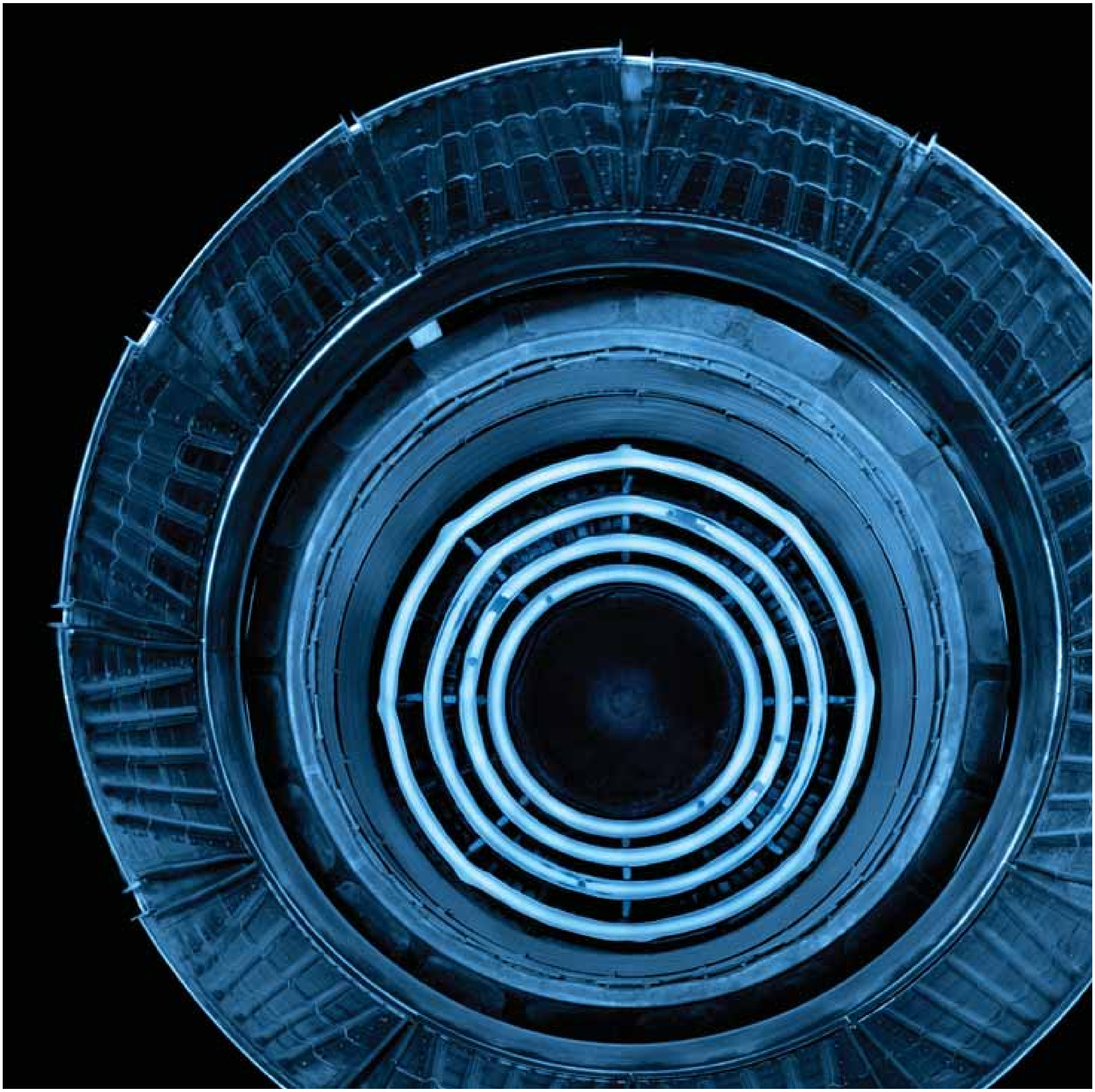
Modernizing a strained air transportation system. Air transportation in the United States has, in a sense, fallen victim to its own popularity. The system is severely strained because of capacity limits, delaying tens of millions of passengers and many billions of dollars in cargo. In the face of growing demand, passenger airlines' on-time records have been deteriorating. Only slightly more than three-quarters of all flights on major U.S. carriers in 2005 arrived within 15 minutes of being on time. To improve on-time performance records, airlines have extended scheduled flight times. Over short-haul routes (less than 500 miles), air travel is essentially no longer faster than earthbound alternatives: door-to-door travel times amount to between 35 and 80 miles per hour. The Walker Commission calculated that barring transportation system improvements, the delays will cost the U.S. economy $170 billion between 2002 and 2012, with annual costs exceeding $30 billion by 2015.

Yet demand represents only one side of the equation. The air-traffic management system, although generally judged to be safe, reliable, and generally capable of handling today's traffic flow, largely relies on 1960s technology and operational concepts and resists innovation. The system's limitations, along with other factors such as airport runway capacity, place severe constraints on future expansion. The skies and landing patterns will become even more cluttered as hundreds of air taxis join the fleets annually during the next decade, thanks to the introduction of relatively inexpensive so-called microjets. In a 2003 report, a National Academies' committee was emphatic: "Business as usual, in the form of continued, evolutionary improvements to existing technologies, aircraft, air traffic control systems, and operational concepts, is unlikely to meet the challenge of greatly increased demand over the next 25 to 50 years."

Significant technical hurdles remain:

- The need to accommodate an increased variety of vehicles and venues. Such aircraft include air taxis, unpiloted aircraft, aircraft that use tilt-rotor propulsion systems to achieve nearly vertical takeoff and landing, "lighter-than-air" aircraft, and other aircraft that do not need runways.
- Heightened security and reliability of voice, data, and video connections to in-flight aircraft.
- Increased use of automation and satellites in handling traffic flow.
- Use of synthetic vision, cockpit display of traffic information, and controller displays to improve awareness of aircraft separation.
- Systems engineering and real-time information man-

CAROLYN RUSSO
Top: *Mercury Spacecraft* Friendship 7, Giclée print, 24 x 24 inches, 2006.
Middle: *North American X-15*, Giclée print, 24 x 24 inches, 2006.
Bottom: *Homing Overlay Experiment Test Vehicle*, Giclée print, 36 x 36 inches, 2006.



Carolyn Russo, *Lockheed SR-71A Blackbird–Pratt and Whitney J-58 Engine*, Giclée print, 24 x 24 inches, 2006.

THE UNITED STATES MUST OVERCOME A SERIES OF MAJOR CHALLENGES—TO THE CAPACITY, SAFETY, AND SECURITY OF THE NATION'S AIR TRANSPORTATION SYSTEM; TO THE NATION'S ABILITY TO COMPETE IN INTERNATIONAL MARKETS; AND TO THE NEED TO REDUCE NOISE AND EMISSIONS.

agement and communication for moving from local traffic control to regional and nationwide traffic flow control and optimization.

• Prediction and direct sensing of the magnitude, duration, and location of wake vortices.

• Safety buffers against monitoring failures and late detection of potential conflicts.

Curtailing environmental degradation. Efforts during the past half century, primarily supported by the federal government, have paid off in significant reductions of both the noise and emissions emanating from turbine engines. But the growth of air traffic over the period has more than offset technological progress. In fact, objections to aircraft noise and emissions have been the primary barriers to building new airports or adding new runways at existing airports. These two steps are key to relieving pressure on the nation's overburdened air transportation system, simultaneously increasing system capacity and travel speeds.

Technical needs here include:

• Low-emission combustors to reduce emissions of nitrogen oxide and particulate matter

• Alternative energy sources

• Structures and materials to reduce drag and improve aerodynamics

• Understanding aviation's effect on climate and the need to balance nitrogen oxide and carbon dioxide emissions

• Improved dispersion models, which look at how pollutants disperse in, react with, and interact with the atmosphere

• Standardized methods for measuring particulate emissions

• Improved engine and airframe noise-reduction technologies

• Reducing sonic boom to enable a new generation of commercial supersonic transports

Enhancing safety and security. The air transportation system has an excellent safety record. From 2002 to mid-May 2006, U.S. commercial aviation, both passenger and cargo, saw a total of 59 fatalities resulting from eight events, yet carried well more than 2 billion domestic passengers on more than 40 million flights. However, as forecast demand accelerates during the next 25 to 50 years, there is little assurance that historical trends will continue. Indeed, National Transportation and Safety Board Chairman Mark Rosenker released a report in late 2005 suggesting that near-misses between passenger jets at the nation's most congested airports occur "with alarming frequency." At least 326 "runway incursions," close calls that could have led to accidents, occurred at U.S. airports in 2004. Rosenker put much of the blame on the technologies currently in use. Moreover, the 9/11 terrorist attacks did more than show the vulnerabilities of the air transportation system; they focused attention on new homeland security requirements that call for system capabilities not previously anticipated.

Looking forward, the roadmap of safety-related technology needs involves:

• Fault-detection and control technologies to enhance aircraft airworthiness and resiliency against loss of control in flight

• Prediction, detection, and testing of propulsion system malfunctions

• Technologies to reduce fatalities from in-flight fires, post-crash fires, and fuel tank explosions, including self-extinguishing fuels

• On-board weather and hazard identification

• Systems using synthetic vision and digital terrain recognition to allow all-weather visibility

• Technologies to reduce weather-related accidents and turbulence-related injuries

• Understanding human error in maintenance and air-traffic control

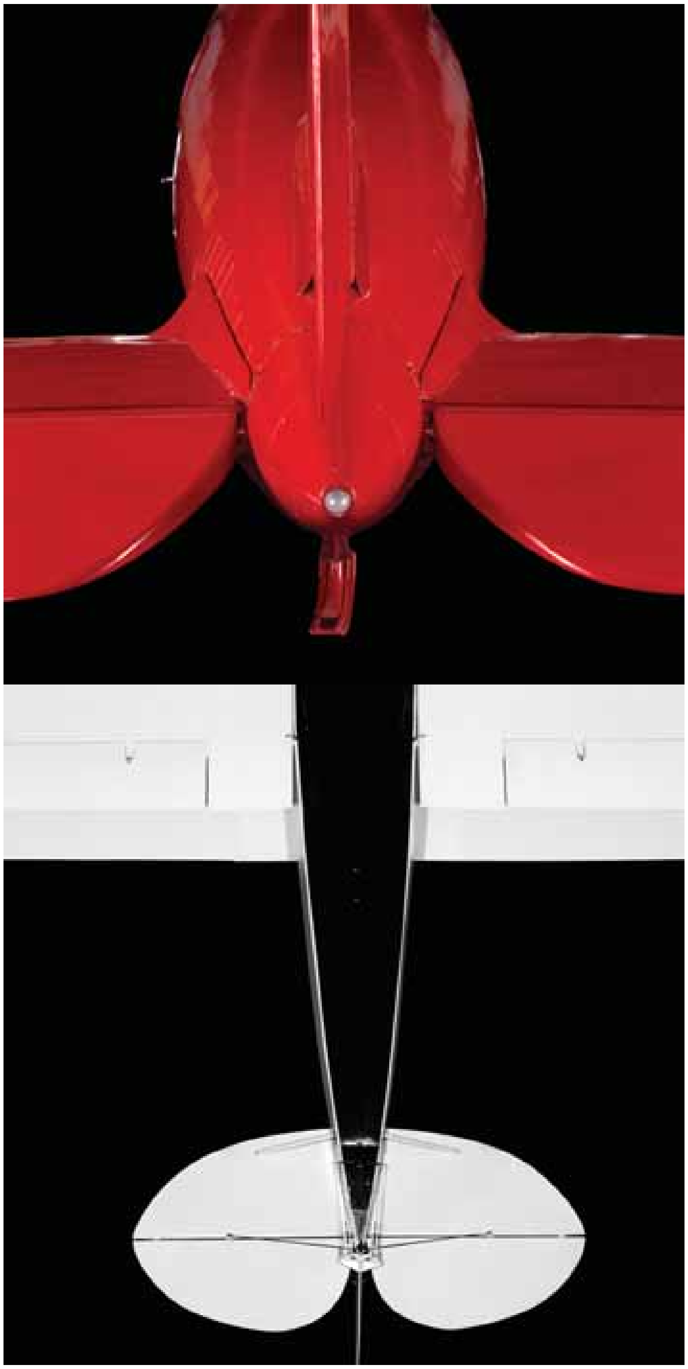
• Blast-resistant structures and luggage containers

• More sensitive, accurate, and faster technology for passenger screening

• Intelligent autopilots able to respond to anomalous flight commands

• Reduced vulnerability of Global Positioning System guidance

Increasing the performance and competitiveness of



CAROLYN RUSSO
Top: *Lockheed 5B Vega (flown by Amelia Earhart)*, Giclée print, 24 x 24 inches, 2006.
Bottom: Kreider-Reisner KR-34C, Giclée print, 24 x 24 inches, 2006.

commercial aircraft. Several recent reports share the view that European competition, which already has eroded U.S. dominance of commercial large jet sales, threatens one of the nation's few standouts among value-added exports. The U.S. share of this global market plummeted from 71.l% in 1999 to about 50% today, with the U.S. company Boeing and the European company Airbus now trading the market leader spot from year to year. In 2005, Airbus took orders for more aircraft (1,055) than Boeing (1,002), though Boeing's aircraft were higher in total value. One positive note is that Boeing's new 787 Dreamliner appears to be competing well against the Airbus 350. U.S. companies that manufacture military airframes continue to dominate worldwide, in large part because of the sheer size of the Pentagon's procurement budgets. But these companies rely increasingly on foreign suppliers, particularly those in countries targeted for sales, squeezing the second and lower tiers of the U.S. defense industrial base.

Two indicators of industry health are employment and R&D. Trends in both areas are worrisome. In February 2004, total U.S. aerospace employment hit a 50-year low of 568,700 workers, the majority in commercial aircraft, engines, and parts. This level was more than 57% below the peak of 1.3 million workers in 1989. By the end of 2005, employment had nudged back up to 626,000 workers. Meanwhile, the aerospace share of R&D investments dropped from about 19% of the total in 1990 to only 5% in 2002. The comparable figure in Europe was 7%. Although the United States can obtain advanced aircraft and air-traffic management systems from foreign suppliers if U.S. manufacturers fail to remain competitive, the implications of such dependency are troubling well beyond the clear national security concerns and beyond the aeronautics industry itself. These sectors have the highest economic and jobs multipliers because they draw on a wider variety of other high-value sectors—computers, electronics, advanced materials, precision equipment, and so on—than nearly any other industry.

In terms of providing public goods, the technical issues in this category relate primarily to improving aircraft efficiency and performance. Technological advances may help increase high-technology employment and reduce imports. Other potential positive public externalities include transportation time savings, increased system capacity, reduced energy dependence, reduced environmental impact, and reduced public infrastructure needs. Related technical challenges include:

• Improved propulsion systems, both the evolution of high-bypass turbofan engines burning liquid hydrocarbon fuels and the development of engines using hydrogen as fuel

- New airframe concepts for subsonic transports, supersonic aircraft, runway-independent vehicles, personal air vehicles, and uninhabited air vehicles
- Composite airframe structures combining reduced weight, high-damage tolerance, high stiffness, low density, and resistance to lightning strikes
- High-temperature engine materials and advanced turbomachinery
- Enhanced airborne avionic systems
- The application of nanotechnology for advanced avionics and high-performance materials
- Passive and active control of laminar and turbulent flow on aircraft wings

Advances in each of these areas would be welcome. But given the severity of budget constraints, advancing every area is probably not possible. So where to set priorities? We urge focus on cross-cutting enabling technologies and on maintaining and upgrading NASA's unique national testbed faculties. Some technologies under development will have application primarily in one of the four major categories described above. Other technologies, crucial in more than one area, play enabling roles across the board. The interrelation is such that improvement or lack of it in each technology can affect improvements in one or more of the others. The following general technical capabilities or enabling technologies are particularly central:

Modeling and simulation. A 2003 National Research Council report provides a detailed set of recommendations that would provide "the long-term systems modeling capability needed to design and analyze evolutionary and revolutionary operational concepts and other changes to the air transportation system." Modeling and computer simulation are also significant factors in lowering manufacturing costs, which could help make commercial supersonic aircraft economically successful. Taking a broader view, modeling and simulation, among other information technology applications, will contribute not only to automating and integrating the air transportation system but also to reducing aviation transit time, fatal accident rates, noise and emissions, and the time-to-market product cycle times for new technologies.

Human factors. In aviation safety, human factors are critical and need more support. Air traffic controllers are central to the efficiency and safety of the airspace, especially during periods of inclement weather and poor visibility. Unfortunately, the stereotypical controller, harried and perhaps burned out, has a significant basis in aeromedical research reality. In addition, pilot errors, often related to fatigue, regularly lead to fatal crashes, including an American Connection commercial flight in late 2004 that left 13 dead. Such errors are particularly problematic in general aviation, leading to, for example, the accidents that killed U.S. Senator Paul Wellstone and John F. Kennedy Jr.

With the expected increased automation in both individual aircraft and the total air transportation system, significantly better human interfaces and decision-aid technologies will be required to deal with the decisionmaking complexities and data overloads such systems will generate. The Walker Commission, concurring that human factors research could help "enhance performance and situational awareness . . . in and out of the cockpit," predicted it would be a "primary contributor" to tripling the capacity of the U.S. air transportation system by 2025. In addition, research on the impact on people (and structures) of the sonic boom pressure waves created by supersonic flight is needed to inform both vehicle design and safety regulations.

Distributed aeronautics communications networks. In the final analysis, the most complex problem of all may well be the integration of national and worldwide air, space, and ground communication networks. A highly automated, high-throughput, secure, and accident-free national airspace system will be extraordinarily information-dense and highly geographically (and spatially) distributed and will meet decisionmaker needs for essentially real-time data analysis and presentation with worldwide on-demand availability. Technologies currently in use have only just dented the needs. To help in moving ahead, the National Academies' Committee for the Review of NASA's Revolutionize Aviation Program recommended exploring "revolutionary concepts" related to distributed air-ground airspace systems, including the distribution of decisionmaking between the cockpit and ground systems and reorganization of how aircraft are routed, with significant implications for airspace usage and airport capacity.

Even if NASA aeronautics program expenditures were stabilized and focused along these lines, managers of ARMD will continue to face severe constraints. The first limitation is high fixed personnel costs. Total expenditures (salaries and fringe benefits) for aeronautics workers, including large contingents of civil service personnel as well as contractors, were slightly more than $400 million in fiscal 2006. This total is in the neighborhood of 45% of the aeronautics budget, even after assuming that NASA-projected workforce reductions occur. Yet even that assumption is in jeopardy, because the latest congressional authorization of NASA's budget restricted the agency's ability to reduce its workforce.

The second limitation is that certain fixed administrative costs incurred by the agency arise from its responsibilities as defined in the Space Act, obligating NASA to maintain certain critical national facilities (wind tunnels and the like) and aeronautics core competencies. Overhead such as general administrative costs (G&A) are normally determined for each center and applied as a percentage of labor cost involved in the program at that center. G&A costs in the proposed 2007 budget total more than $250 million alone at the four major aeronautics-related NASA labs: Ames, Glenn, Langley, and Dryden. G&A costs at the labs are high because of the obligation to support their aging facilities and equipment.

A third limitation is that an ever-growing part of NASA's extramural program is earmarked by Congress for particular projects. In the past decade, the number of earmarks in NASA's budget exploded more than 30-fold to 198. Earmarks totaled $568.5 million in fiscal 2006, fully eight times more in dollar terms than a decade before.

The issue is not so much whether any particular earmarked program or institution has technical merit or will substantially help a favored local constituency. Many surely do in isolation. But when it comes to effectively managing technology and ensuring maximum returns on public investments, NASA is rapidly losing the flexibility to optimize—by field, or level of risk, or potential users and suppliers, or time horizons, or national systemic needs, or core competencies, and so on—across its R&D portfolio. In our view, this risks making NASA's aeronautics activities not so much a coordinated strategic national portfolio but a hodgepodge collection of unrelated pet projects.

In short, after earmarks, personnel costs, and fixed G&A costs, NASA for fiscal year 2006 was left with roughly the same amount of money for discretionary R&D spending that several multinational high-technology firms each spend per week on R&D. At times, the results in the research trenches seem almost surreal. Langley administrators recently sent a memo to employees cutting all spending for gas on agency-related travel and for new wireless connectivity, as well as pushing back—again—roof repairs and badly needed information technology maintenance and upgrades. Outdated computers, no more wireless connectivity, and bad roofs at one of the nation's premier research institutions?

To us, this is stunning neglect of the national interest in the future of aeronautics technologies. At current and proposed funding levels, NASA and the nation cannot hope to come close to fulfilling national needs in the face of an already strained air transportation system; fierce and increasing international competition in aircraft markets; the environmental challenges of noise, emissions, and fuel efficiency; and demands for improved air safety and homeland security. NASA's ARMD is the nation's only organizationally and technically capable option for overall leadership in aeronautics technologies. Unfortunately, it is largely hidden from public view, structurally, financially, and politically buried in a space agency on a mission to Mars. How many additional hundreds of millions of delayed air travelers, or how many more national commissions warning about the perilous future of U.S. aeronautics, will it take to get policymakers to put the A back in NASA?

Recommended reading

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