



Aero 2050

A Symposium and Webcast
October 12, 2017



Aeronautics and Space Engineering Board
50 Years: 1967-2017

*The National
Academies of* SCIENCES
ENGINEERING
MEDICINE

About the Meeting



In this one-day symposium and webcast on the future of aeronautics, speakers from government, industry, and academia will discuss the last 100 years of advances in aeronautics, current challenges and opportunities, and new directions for aviation. The meeting will feature unique perspectives on important issues and emerging technologies in civil aviation such as unpiloted aircraft and propulsion efficiency.

AERONAUTICS AND SPACE ENGINEERING

50 YEARS: 1967–2017



This event celebrates the 50th anniversary of the Aeronautics and Space Engineering Board of the National Academies of Sciences, Engineering, and Medicine. This event is sponsored by NASA and the ASEB 50th Anniversary Fund (supported by Lockheed Martin Corporation).

Event Webcast

This event will be webcast at livestream.com/NASEM/events/7673823. Webcast recordings will be posted on our vimeo channel approximately 2 weeks after the event. If you'd like to receive an email when the recordings are available, please register for the webcast at aero2050.eventbrite.com.

Planning Committee

Special thanks to the symposium planning committee, who are also members of the Aeronautics and Space Engineering Board: Alan H. Epstein, Elizabeth R. Cantwell, Brian M. Argrow, Michael P. Delaney, Nicholas D. Lappos, Mark J. Lewis, Valerie Manning, Parviz Moin, Robie I. Samanta Roy, and Agam N. Sinha.

OPENING SESSION

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| 8:30 am | Meeting Convenes Michael Moloney, <i>National Academies, Director for Space and Aeronautics</i> |
| 8:35 am | Welcoming Remarks Marcia McNutt, <i>NAS President</i> Alan Epstein, <i>ASEB Chair</i> |
| 8:45 am | Opening Remarks Robert Lightfoot, <i>NASA Acting Administrator</i> |

SESSION 1: 60 YEARS OF AVIATION AND AERONAUTICS IN THE JET AGE (1958-2017)

- 9:00 am **Introductions and Opening Comments**
Moderator: Robie Samanta Roy, *ASEB*
- 9:05 am **Introduction to the Theme**
Richard Hallion, *Florida Polytechnic University*
- 9:20 am **NASA Perspective**
Jaiwon Shin, *NASA ARMD*
- 9:30 am **Additional Panelist Joins the Discussion**
Bob van der Linden, *NASM*
- 9:50 am **Audience Joins the Discussion**
- 10:15am **Break** – Coffee Available in East Court

SESSION 2: CURRENT CHALLENGES FOR AVIATION

- 10:45 am **Introductions and Opening Comments**
Moderator: Valerie Manning, *ASEB*
- 10:50 am **Introduction to the Theme**
John Hansman, *MIT*
- 11:05 am **Additional Panelists Join the Discussion**
John-Paul Clarke, *Georgia Tech*
Carl Burleson, *FAA*
Nancy Young, *A4A*
- 11:30 am **NASA Commentary**
Jay Dryer, *NASA ARMD*
- 11:35 am **Audience Joins the Discussion**

LUNCH

- 12:00 pm **Lunch Served** – East Court (please obtain lunch and return to Lecture Room)
- 12:15 pm **Keynote Address – Lecture Room**
Richard Aboulafia, *Teal Group*

SESSION 3: FUTURE VISIONS – COMMERCIAL AIR TRAVEL

- 1:15 pm **Introductions and Opening Comments**
Moderator: Mark Lewis, *ASEB*
- 1:20 pm **Introduction to the Theme**
Pierre Chao, *Renaissance Strategic Advisors*
- 1:35 pm **Additional Panelists Join the Discussion**
Juan Alonso, *Stanford University*
Robert Liebeck, *Boeing*
Graham Warwick, *Aviation Week*
- 2:00 pm **NASA Commentary**
Bob Pearce, *NASA ARMD*
- 2:05 pm **Audience Joins the Discussion**
- 2:30 pm **Break** – Coffee Available in East Court

SESSION 4: FUTURE VISIONS – NEW DIRECTIONS FOR AVIATION

- 3:00 pm **Introductions and Opening Comments**
Moderator: Nick Lappos, *ASEB*
- 3:05 pm **Introduction to the Theme**
Ilan Kroo, *Stanford University*
- 3:20 pm **Additional Panelists Join the Discussion**
Atherton Carty, *Lockheed Martin*
Pradeep Fernandes, *Boeing HorizonX*
John Langford, *Aurora Flight Sciences*
- 3:45 pm **NASA Commentary**
Ed Waggoner, *NASA ARMD*
- 3:50 pm **Audience Joins the Discussion**

SYMPOSIUM SUMMARY DISCUSSION

- 4:15 pm **Summary Thoughts on Key Themes and Issues Raised During the Symposium**
Jaiwon Shin, *NASA ARMD*
Alan Epstein, *ASEB, Chair*
- 4:30 pm **Closing Discussion**
- 4:45 pm **Reception** – Refreshments available in East Court

RICHARD L. ABOULAFIA is vice president of Analysis at Teal Group. He manages consulting projects in the commercial and military aircraft field and analyzes broader defense and aerospace trends and has advised numerous aerospace companies, including most prime and many second- and third-tier contractors in the US, Europe and Asia. He also advises numerous financial institutions on aerospace market conditions. Richard writes and edits Teal Group's World Military and Civil Aircraft Briefing, a forecasting tool covering over 135 aircraft programs and markets. He also writes publicly about aviation and defense, with regular columns in Aviation Week and Space Technology, AIAA's Aerospace America, and at Forbes.com. His articles have also appeared in the Wall Street Journal, Financial Times, Professional Pilot, and other publications. Frequently cited as an aviation industry authority by trade and news publications, Richard has also appeared on numerous television news and radio programs including ABC, BBC, Bloomberg, Reuters, CBS, CNN, NBC, NPR and PBS. He has spoken at numerous conferences, including ATRIF, NAFA, NARA, Network for Aerospace Management in Europe (NAME), and Speednews. He presents a yearly lecture to the National Defense University/Industrial College of the Armed Forces and has served as an expert witness in aerospace markets. Before he joined Teal Group in 1990, Richard analyzed the jet engine market at Jane's Information Group, served as an aerospace industry consultant for an international trade advisory company and supported research projects at the Brookings Institution. He has a M.S. in war studies from King's College, University of London and a B.S. from George Washington University.

JUAN J. ALONSO is a professor of aeronautics and astronautics at Stanford University. Prof. Alonso is the founder and director of the Aerospace Design Laboratory (ADL) where he specializes in the development of high-fidelity computational analysis and design methodologies to enable the creation of realizable and efficient aerospace systems. He is the author of over 200 technical publications on the topics of computational aircraft and spacecraft design, multi-disciplinary optimization, fundamental numerical methods, and high-performance parallel computing. During the period spanning 2006-09, Prof. Alonso was the Director of the NASA Fundamental Aeronautics Program in Washington, DC. In that position he was responsible for the entire portfolio of aerospace vehicle and vehicle technology research for the agency in the subsonic rotary wing, subsonic fixed wing, supersonic, and hypersonic regimes, with particular emphasis on the energy and fuel efficiency of the aviation enterprise and its environmental impact. He is the recipient of several AIAA Best Paper Awards, the NASA Exceptional Public Service Medal, the NASA ARMD Associate Administrator Award, and the AIAA Stanford Chapter Professor of the Year award (8 times). Prof. Alonso has served in the NASA Advisory Council, the Secretary of Transportation's Future of Aviation Advisory Committee, the FAA Administrator's Management Advisory Council, and as an Independent Expert in the ICAO/CAEP fuel burn, noise, and emissions technology goals evaluation. He currently serves in the FAA Drone Advisory Council and as general chair of the AVIATION 2018 conference. Prof. Alonso and the ADL are responsible for the development of the open-source SU2 analysis and design environment, intended for use by the worldwide community to advance the state-of-the-art in numerical optimization of fluid flows. Prof. Alonso earned his Ph.D. in mechanical and aerospace engineering at Princeton University and his B.S. at the Massachusetts Institute of Technology.

CARL BURLESON is the deputy assistant administrator for Policy, International Affairs, and Environment at the Federal Aviation Administration (FAA). His office leads the agency's efforts to increase the safety and capacity of the global aerospace system in an environmentally sound manner. Dr. Burleson leads the FAA's strategic policy and planning efforts, coordinating the agency's reauthorization before Congress, and national and international aviation policies and strategies regarding environment and energy. In 2010, he was a finalist for the Science and Environment Public Service to America Award. Mr. Burleson has held several positions at the FAA, including director of the Office of Environment and Energy, the FAA Administrator's Chief of Staff, and the FAA's Senior Representative for Northern Europe. During his career with the FAA, he contributed to the creation of several programs such as the Commercial Aviation Alternative Fuels Initiative and the Next Generation Air Transport System.

PIERRE CHAO is a founding partner of Renaissance Strategic Advisors and a co-founder of Enlightenment Capital. He is also a guest lecturer at the National Defense University and the Defense Acquisition University. Mr. Chao brings three decades of aerospace/defense strategy management consulting, investment banking, equity analysis, investing and policy analysis expertise. Prior to establishing RSAdvisors, Mr. Chao was the director of Defense-Industrial Initiatives at the Center for Strategic and International Studies, a Washington D.C.-based, non-partisan defense and foreign policy think tank, where he still remains as a senior associate. Before joining CSIS, Mr. Chao was a managing director and senior aerospace/defense analyst at Credit Suisse First Boston, where he was responsible for following the U.S. and global aerospace/defense industry. He remained a CSFB independent senior adviser from 2003-2006. Prior to joining CSFB, Pierre was the senior aerospace/defense analyst at Morgan Stanley Dean Witter. He served as the senior aerospace/defense industry analyst at Smith Barney and as a director at JSA International, a Boston/Paris-based management consulting firm that focused on the aerospace/defense industry. Mr. Chao was also a co-founder of JSA Research, an equity research boutique specializing in the aerospace/defense industry. Before signing on

with JSA, he worked in the New York and London offices of Prudential-Bache Capital Funding as a mergers and acquisitions banker focusing on aerospace/defense. Mr. Chao earned dual B.S. in political science and management science from M.I.T. He has served on multiple Defense Science Board task forces and was a member of the Defense Business Board.

JOHN-PAUL CLARKE is a College of Engineering Dean's Professor at the Georgia Institute of Technology (Georgia Tech), where he has appointments in the Daniel Guggenheim School of Aerospace Engineering and the School of Industrial and Systems Engineering, and serves as director of the Air Transportation Laboratory. Dr. Clarke is a leading expert in aircraft trajectory prediction and optimization, especially as it pertains to the development of flight procedures that reduce the environmental impact of aviation. His research has been instrumental in changing both the theory and the practice of flight procedure design, and has spurred the global effort to reduce the environmental impact of aviation via changes in operational procedures. He is also an expert in the development and use of stochastic models and optimization algorithms to improve the efficiency and robustness of airline, airport, and air traffic operations. Dr. Clarke received the S.B., S.M., and Sc.D. degrees from the Massachusetts Institute of Technology (MIT) in 1991, 1992, and 1997, respectively. His many prior honors include the 1999 AIAA/AAAE/ACC Jay Hollingsworth Speas Airport Award, the 2003 FAA Excellence in Aviation Award, the 2006 National Academy of Engineering Gilbreth Lectureship, and the 2012 AIAA/SAE William Littlewood Lectureship. He is a Fellow of the AIAA, and is a member of AGIFORS, INFORMS, and Sigma Xi. Professor Clarke was co-chair of the National Academies Committee that developed the US National Agenda for Autonomy Research related to Civil Aviation, and a member of the National Academies Committee that reviewed the Next Generation Air Transportation System. He is currently co-chair of the Joint Planning Committee for the AIAA-AAAF Aviation Noise and Emissions Reduction Symposium (ANERS) and a member of the NASA Advisory Council Aeronautics Committee. Over the years, he has chaired or served on advisory and technical committees chartered by the AIAA, EU, FAA, ICAO, NASA, the National Academies, the U.S. Army, and the U.S. DOT.

ALAN H. EPSTEIN (ASEB Chair) is responsible for setting the direction for and coordinating technology across Pratt & Whitney. He also provides strategic leadership in the investment, development, and incorporation of technologies that reduce the environmental impact of Pratt & Whitney's world-wide products and services. Prior to joining Pratt & Whitney, Dr. Epstein was the R.C. Maclaurin Professor of Aeronautics and Astronautics and director of the Gas Turbine Laboratory at the Massachusetts Institute of Technology, and currently holds an appointment there as professor emeritus. His research at MIT included gas turbines, power and energy, aerospace propulsion, and micro-mechanical and electrical systems (MEMS). Dr. Epstein has served on many panels and committees advising the U.S. Government and is currently the Chair of the Aeronautics and Space Engineering Board of the National Academy of Engineering. He has won many international awards for his work in propulsion heat transfer, turbomachinery, instrumentation and controls, gas turbine technology, and MEMS. These include the American Society of Mechanical Engineering Gas Turbine Award, the American Institute of Aeronautics and Astronautics Dryden Lectureship in Research, the International Gas Turbine Institute Gas Turbine Technology Award, and the Canadian Aeronautics and Space Institute Turnbull Lectureship. Dr. Epstein is a member and past chair of the Aerospace Section of the U.S. National Academy of Engineering, a Fellow of the American Institute of Aeronautics and Astronautics, of the American Society of Mechanical Engineers, and of the Royal Aeronautical Society. He received his B.S., M.S., and Ph.D. degrees in aeronautics and astronautics from the Massachusetts Institute of Technology.

PRADEEP FERNANDES is the managing director of the Disruptive Horizons organization of the newly formed Boeing HorizonX unit. He is responsible for exploring and implementing non-traditional business opportunities for the Boeing Company. Prior to this role, Pradeep was the managing director of product strategy for Boeing Commercial Airplanes. In this role, he was responsible for setting the product strategy for the business unit and making recommendations for launch of new products and/or major upgrades to existing products -- launch of 737MAX, 777X and 787-10. Prior to this role, he was part of the BCA Supply Chain Strategy group, leading the effort to develop an overall supply chain strategy and key supplier strategies. Earlier, he was the product manager for the Boeing 737 and led marketing and strategy efforts to launch the Boeing Sky Interior. Pradeep also spent three years in the Corporate Audit organization, where he was part of the Enterprise Auditor Program. As part of the program, he managed program, engineering, financial, operational and compliance audits across business units and international sites. Prior to Audit, he worked in the Configuration Engineering and Analysis and Fleet Support Engineering groups contributing to airplane performance analysis and early configuration development for new airplanes. He holds a B.S. in aerospace engineering from Polytechnic Institute of New York University, a M.S. in aeronautics and astronautics from Massachusetts Institute of Technology and a M.B.A. from The Wharton School at the University of Pennsylvania.

RICHARD P. HALLION is a founding Trustee of Florida Polytechnic University. He also serves as an advisor to the Royal Air Force Centre for Air Power Studies (RAF-CAPS) and as a consultant to various organizations,

including the Mitchell Institute of the Air Force Association, and the Science and Technology Policy Institute (STPI) of the Institute for Defense Analyses (IDA). Previously, Dr. Hallion was a founding museum curator at the National Air and Space Museum of the Smithsonian Institution; served as a Historian with the National Aeronautics and Space Administration and the U.S. Air Force; held the General Harold Keith Johnson Chair of Military History at the U.S. Army War College; ran the USAF History and Museums Program; and was a senior advisor on aerospace technology and policy for the Secretary of the Air Force. He has flying experience as a mission observer (not pilot) in a wide range of military and civil aircraft, and is a Fellow of the American Institute of Aeronautics and Astronautics, the Royal Aeronautical Society, and the Royal Historical Society. Dr. Hallion received a Ph.D in history from the University of Maryland, and completed postgraduate executive study programs at the Federal Executive Institute and the John F. Kennedy School of Government at Harvard University. He has served on several National Academies projects, including the Committee on Future Air Force Needs for Defense Against High-Speed Weapon Systems and the Committee on Examination of the U.S. Air Force's Science, Technology, Engineering, and Mathematics Workforce Needs in the Future and Its Strategy to Meet Those Needs.

R. JOHN HANSMAN is the T. Wilson Professor of Aeronautics & Astronautics at Massachusetts Institute of Technology, where he is the director of the MIT International Center for Air Transportation. He conducts research in the application of information technology in operational aerospace systems. Dr. Hansman holds 6 patents and has authored over 250 technical publications. He has over 6000 hours of pilot in-command time in airplanes, helicopters and sailplanes including meteorological, production and engineering flight test experience. Professor Hansman chairs the U.S. Federal Aviation Administration Research Engineering & Development Advisory Committee (REDAC) as well as other national and international advisory committees. He is a member of the U.S. National Academy of Engineering (NAE); is a fellow of the AIAA and has received numerous awards including the AIAA Dryden Lectureship in Aeronautics Research, the ATCA Kriske Air Traffic Award, a Laurel from Aviation Week & Space Technology, and the FAA Excellence in Aviation Award. Dr. Hansman earned his A.B. in physics from Cornell University; and an S.M. and Ph.D. in physics from the Massachusetts Institute of Technology. Dr. Hansman has participated in many National Academies activities, including the Board on Army Science and Technology and the Committee on Aviation Safety Assurance, and he previously served as a member of the Aeronautics and Space Engineering Board.

ILAN KROO is the Thomas V. Jones Professor of Engineering in the Department of Aeronautics and Astronautics at Stanford University. Professor Kroo's research involves work in three general areas: multidisciplinary optimization, unconventional aircraft, and aerodynamic design. He has participated in the design and development of UAV's, high-speed research aircraft, and personal aircraft. In addition to his research and teaching interests, Dr. Kroo was a co-founder of Zee.Aero, a Silicon Valley start-up company focusing on bringing new technologies to personal aviation, and Aerion Corporation, developing efficient supersonic business aircraft. He joined the Stanford University faculty in 1986 after earning a B.S. in physics and a Ph.D. in aeronautics from Stanford. Professor Kroo is a member of the National Academy of Engineering and has participated in many National Academies projects, including the Committee on Assessment of Aircraft Winglets for Large Aircraft Fuel Efficiency and the Aeronautics and Space Engineering Board.

JOHN S. LANGFORD, III is the chairman and CEO of Aurora Flight Sciences Corporation, which he founded in 1989. Prior to Aurora, Langford worked for the Institute for Defense Analyses in Alexandria, Virginia. While at MIT, Langford organized and led a series of human-powered aircraft projects, culminating in the Daedalus Project, which in 1988 shattered the world distance and endurance records for human-powered flight with a 72 mile flight between the Greek islands of Crete and Santorini. Earlier, Langford worked for the Lockheed Corporation as an engineer on the development of the F-117 stealth fighter, and as an intern at the White House Office of Science and Technology Policy. In 2014, the National Aeronautics Association (NAA) awarded Langford the Cliff Henderson Trophy for "significant and lasting contributions to the promotion and advancement of aviation and aerospace in the United States". He has also received the DeFlorez Prize from MIT (1979), the Kremer Speed Prize from the Royal Aeronautical Society (1984), the Young Engineer of the Year award from the AIAA National Capital Section (1989), the National Tibbets Award for outstanding contributions to the SBIR Program (1996), the Barry M. Goldwater Educator Award from the AIAA (2000), Virginia's Outstanding Industrialist award from the Commonwealth of Virginia (2004), and the President's Award for Exceptional Service (2008) and the Howard Galloway Award (2014) from the National Association of Rocketry. Langford is a Fellow in the American Institute of Aeronautics and Astronautics (AIAA) and was elected President for the 2018-20 term. He is also a Fellow in the Royal Aeronautical Society (RAeS), and has served on academic advisory boards at MIT, the University of Maryland, and Mississippi State University. He has served on the board of directors of the NAA, the Executive Committee of the Aerospace Industries Association (AIA) (2012-2015), and the Institute Development Committee (IDC) of the AIAA. Langford served on the NASA Advisory Council (NAC) (2011-2015) and chaired its Subcommittee on Unmanned Air Systems. He has served on several study committees for the National Academies. In 2015 he was named by the Governor of Virginia to chair the Virginia Commission on Unmanned Systems. Dr. Langford earned his Ph.D. in

aeronautics and public policy from the Massachusetts Institute of Technology. He has participated in several National Academies projects, including the Committee to Assess NASA's Aeronautics Flight Research Capabilities and the Committee on Autonomous Vehicles in Support of Naval Operations.

NICHOLAS D. LAPPOS is a senior technical fellow for Advance Technology at Sikorsky, a Lockheed Martin Company. He is also chairman of the board of the Vertical Lift Consortium, an industry consortium established to work collaboratively with the U.S. Government to develop and transition innovative vertical lift technologies to rapidly and affordably meet warfighter needs. He was elected to the Academy of Distinguished Engineering Alumni of Georgia Tech in 2004 and awarded the Sir Barnes Wallis Medal by the UK Guild of Air Pilots and Navigators, 2013. He is an honorary fellow and technical fellow of the American Helicopter Society (2013) and received the Frederick Feinberg Award as most outstanding pilot and the Society of Experimental Test Pilots Tenhoff Award, 1988. Mr. Lappos holds 23 U.S. patents and three FAI world speed records. He has authored numerous technical papers for the American Helicopter Society, the Royal Aeronautical Society and the SAE and written articles for magazines such as Rotor and Wing, Interavia, and has a regular column in HeliOps Magazine. Mr. Lappos was elected chairman of the board of directors of the Vertical Lift Consortium in 2010 and again in 2012. Mr. Lappos is a U.S. Army Vietnam veteran, and served as a Cobra attack helicopter pilot. He was awarded the Bronze Star and the Republic of Vietnam's Cross of Gallantry. Serving as a test pilot for Sikorsky for over 27 years, he has flown over 70 different helicopter types. With over 7,500 hours flight time, Mr. Lappos served as chief R&D test pilot for over 12 years. Mr. Lappos has served on numerous technical committees for NASA, the American Helicopter Society, the FAA and NATO's Advisory Group for Aerospace Research and Development committees and working groups. Mr. Lappos has participated in the development of several flight systems such as the S76, UH-60, RAH-66, ABC, Fantail, Shadow, Fly-by-wire demonstrator, CH-53E, S92. He was the program manager for the S-92 program during its development, certification and introduction into production. During that time, the National Aeronautic Association awarded the S-92 Industry Team the Robert J. Collier Trophy in 2002. He has a B.S. in aerospace engineering from the Georgia Institute of Technology in 1973. He has served on the National Academies Aeronautics Research and Technology Roundtable.

MARK J. LEWIS is the director of the IDA Science and Technology Policy Institute, a federally-funded research and development center that supports the white house and other executive branch agencies. Previous to that he was the Willis Young, Jr., professor and chair of the Department of Aerospace Engineering at the University of Maryland. He has also served as the chief scientist of the U.S. Air Force. He is the past president of the American Institute of Aeronautics and Astronautics (AIAA). Dr. Lewis has been teaching and conducting basic and applied research in the fields of hypersonic aerodynamics, advanced propulsion, and space vehicle design and optimization. His work has spanned the aerospace flight spectrum from the analysis of conventional jet engines to entry into planetary atmospheres at hypervelocity speeds, with a specialty in the integration of high-speed engines with highly-efficient airframes. Dr. Lewis is the author of more than 300 technical publications, and he has been adviser to more than 70 graduate students. A recipient of both the Department of Defense Meritorious Civilian Service Award and Exceptional Civilian Service Award, Dr. Lewis received the IECEC/AIAA Lifetime Achievement Award and was named an Aviation Week and Space Technology Laureate in 2007. He is a fellow of the American Society of Mechanical Engineers, a fellow of AIAA, and a president's fellow of the Royal Aeronautical Society. Dr. Lewis received a B.S. in aeronautics and astronautics and in Earth and planetary science and M.S. and Ph.D. in aeronautics and astronautics at the Massachusetts Institute of Technology. He is currently a member of the Academies Air Force Studies Board and has previously served as a member of Panel B: Robotic Access and Human Planetary Landing Systems and the Panel to Review Air Force Office of Scientific Research Proposals in Fluids.

ROBERT H. LIEBECK is a senior fellow at The Boeing Company and a professor of mechanical and aerospace engineering at the University of California, Irvine. Dr. Liebeck is a world-renowned authority in the fields of aerodynamics, hydrodynamics, and aircraft design. In his long and distinguished career, he has held top positions at Boeing/McDonnell Douglas and has taught and conducted research at the University of Southern California. Dr. Liebeck attained world recognition starting in the 1970s with his novel designs for high-lift airfoils, referred to by the aeronautics community as the "Liebeck airfoils." He has made substantial contributions to a variety of related fields, including propeller design, windmill analysis, wing design for supersonic transports, and the design of high-altitude unmanned aircraft. He is co-developer of the Blended-Wing-Body, widely considered as the next revolution in subsonic commercial transportation. Dr. Liebeck earned a Ph.D. in aeronautical and astronautical engineering from the University of Illinois. He is a member of the National Academy of Engineering and has participated in several National Academies projects, including the Aerospace Engineering Peer Committee and on Panel A: Aerodynamics and Aeroacoustics of the Decadal Survey of Civil Aeronautics.

ROBERT M. LIGHTFOOT JR. became NASA's acting administrator effective Jan. 20, 2017. His permanent title is associate administrator for NASA, the agency's highest-ranking civil servant position, effective since Sept. 25, 2012. He previously was director of NASA's Marshall Space Flight Center in Huntsville, Ala. Named to the position in August 2009, he headed one of NASA's largest field installations, which plays a critical role in NASA's space operations, exploration and science missions. Lightfoot managed a broad range of propulsion, scientific and space transportation activities contributing to the nation's space program. He served as acting director of the center from March 2009 until his appointment as director. From 2007 to 2009, Lightfoot was deputy director of the Marshall Center. Lightfoot served as manager of the Space Shuttle Propulsion Office at Marshall from 2005 to 2007, where he was responsible for overseeing the manufacture, assembly and operation of the primary shuttle propulsion elements: the main engines, external tank, solid rocket boosters and reusable solid rocket motors. From 2003 to 2005, he served as assistant associate administrator for the Space Shuttle Program in the Office of Space Operations at NASA Headquarters in Washington. His responsibilities included space shuttle Return to Flight activities following the Columbia tragedy, technical and budgetary oversight of the \$3 billion annual budget and initial transition and retirement efforts for shuttle infrastructure. In 2002, Lightfoot was named director of the Propulsion Test Directorate at NASA's Stennis Space Center. He served as deputy director of the organization beginning in 2001, until his appointment as director. Lightfoot began his NASA career at the Marshall Center in 1989 as a test engineer and program manager for the space shuttle main engine technology test bed program and the Russian RD-180 engine testing program for the Atlas launch vehicle program. Lightfoot received a B.S. in mechanical engineering in 1986 from the University of Alabama. In October 2007, he was named Distinguished Departmental Fellow for the University of Alabama, Department of Mechanical Engineering. He was selected as a University of Alabama College of Engineering fellow in 2009. Lightfoot serves on the University of Alabama Mechanical Engineering Advisory Board. In 2010, he was inducted into the State of Alabama Engineering Hall of Fame. Lightfoot has received numerous awards during his NASA career, including a NASA Outstanding Leadership medal in 2007 for exemplary leadership of the Shuttle Propulsion Office, assuring safety for the return to flight of the space shuttle. In 2006, he was awarded the Presidential Rank Award for Meritorious Executives, and in 2010 and 2016, he received the Presidential Rank Award for Distinguished Executives -- the highest honors attainable for federal government work. In 2000, Mr. Lightfoot received a Spaceflight Leadership Recognition Award, which recognizes leaders who exemplify characteristics necessary for success. In 1999, NASA's astronaut corps presented him with a Silver Snoopy Award, which honors individuals who have made key contributions to the success of human spaceflight missions. He also received the NASA Exceptional Achievement Medal in 1996 for significant contributions to NASA's mission.

VALERIE M. MANNING is the senior vice president of Customer Support at Airbus, where she is responsible for the relationship and interaction between Airbus and all aircraft owners, operators, and maintainers of the more than 9,000 Airbus aircraft in service around the world. As such, Dr. Manning leads a large team of professionals residing globally—including the worldwide field service team, the customer support directors, the Airbus warranty program, credit and cash management, and all support or services contracts from initial aircraft sale until aircraft decommissioning. Dr. Manning has more than 25 years of service in government and civilian roles at Airbus, the United States Air Force, and McKinsey and Company. Prior to her current role, Dr. Manning served as vice president and head of Airbus Upgrade Services, where she led the sale, development, certification, and delivery of optional modifications to airframes, cabins, and systems for the Airbus fleet. At the parent company of Airbus, EADS (now merged with Airbus), Dr. Manning has served as the vice president and chief of staff to the Chief Technical Officer (CTO). She has also served on A380 and A400M technical assessment teams and has managed an EADS technology development and commercialization program. In her first role with EADS, Dr. Manning served as director of strategy and mergers & acquisitions in North America. This position was preceded by employment as a consultant with McKinsey & Company, concentrating on Aerospace and high-tech (internet) consulting. She also consulted privately in multidisciplinary optimization and supersonic design. Before McKinsey, Dr. Manning was employed General Motors as an aerodynamics engineer. She began her career in the United States Air Force and has served continuously on active duty or in the reserves since her commission upon graduation from university. This has included assignments in Manpower at Kelly AFB, Acquisitions Security at the Space and Missile Systems Center at Los Angeles Air Force Base, the Air Force Scientific Advisory Board Secretariat, the Joint Reserve Directorate within the Office of the Secretary of Defense, and as a member of the USAF World Class Athlete Program where she represented the Air Force around the world in athletics competitions and competed in two Olympic Trials. Dr. Manning graduated from Princeton University with a B.S. in mechanical and aerospace engineering, going on to earn an M.S. and Ph.D. in aeronautics and astronautics from Stanford University with concentrations in supersonic aircraft design, natural laminar flow, and multidisciplinary optimization. She complemented these degrees with a minor concentration in Orthopaedic Biomechanics. Additionally, Dr. Manning is a graduate of Air War College and completed Advanced Joint Professional Military Education at National Defense University's Joint Forces Staff College. Dr. Manning, currently residing in Toulouse, France, is an active instrument-rated pilot, and an associate fellow of the American Institute of Aeronautics and Astronautics.

MARCIA MCNUTT (B.A. in physics, Colorado College; Ph.D. in Earth sciences, Scripps Institution of Oceanography) is a geophysicist and the 22nd president of the National Academy of Sciences. From 2013 to 2016, she was editor-in-chief of Science journals. McNutt was director of the U.S. Geological Survey from 2009 to 2013, during which time USGS responded to a number of major disasters, including the Deepwater Horizon oil spill. For her work to help contain that spill, McNutt was awarded the U.S. Coast Guard's Meritorious Service Medal. She is a fellow of the American Geophysical Union (AGU), Geological Society of America, the American Association for the Advancement of Science, and the International Association of Geodesy. McNutt is a member of the American Philosophical Society and the American Academy of Arts and Sciences, and a Foreign Member of the Royal Society, UK, and the Russian Academy of Sciences. In 1998, McNutt was awarded the AGU's Macelwane Medal for research accomplishments by a young scientist, and she received the Maurice Ewing Medal in 2007 for her contributions to deep-sea exploration.

MICHAEL H. MOLONEY is the director for Space and Aeronautics at the Space Studies Board and the Aeronautics and Space Engineering Board of the U.S. National Academies of Sciences, Engineering, and Medicine. Since joining the ASEP/SSB Dr. Moloney has overseen the production of more than 60 reports; including five decadal surveys—in astronomy and astrophysics, Earth science and applications from space, planetary science, microgravity sciences, and solar and space physics—prioritizations of NASA space technology roadmaps, a major report on the rational for and future direction of the U.S. human spaceflight program, as well as reports on issues such as NASA's Strategic Direction, lessons learned from the decadal survey processes, the science promise of cubesats, the challenge of orbital debris, the future of NASA's astronaut corps, NASA's aeronautical flight research program, and national research agendas for autonomy and low-carbon propulsion in civil aviation. Since joining the Academies in 2001, Dr. Moloney has also served as a study director at the National Materials Advisory Board, the Board on Physics and Astronomy (BPA), the Board on Manufacturing and Engineering Design, and the Center for Economic, Governance, and International Studies. Dr. Moloney has served as study director or senior staff for a series of reports on subject matters as varied as quantum physics, nanotechnology, cosmology, the operation of the nation's helium reserve, new anti-counterfeiting technologies for currency, corrosion science, and nuclear fusion. Before joining the SSB and ASEP in 2010, Dr. Moloney was associate director of the BPA and study director for the 2010 decadal survey for astronomy and astrophysics (New Worlds New Horizons in Astronomy and Astrophysics). In addition to his professional experience at the Academies, Dr. Moloney has more than 7 years' experience as a foreign-service officer for the Irish government—including serving at the Irish Embassy in Washington and the Irish Mission to the United Nations in New York. A physicist, Dr. Moloney did his Ph.D. work at Trinity College Dublin in Ireland. He received his undergraduate degree in experimental physics at University College Dublin, where he was awarded the Nevin Medal for Physics. Dr. Moloney is a corresponding member of the International Academy of Astronautics and a Senior Member of the American Institute of Aeronautics and Astronautics. He is also a recipient of a distinguished service award from the National Academies of Sciences, Engineering and Medicine.

ROBIE I. SAMANTA ROY is vice president of Technology Strategy and Innovation at Lockheed Martin. Dr. Samanta Roy's primary responsibilities include: 1) developing and providing technical intelligence and strategy for the corporation; 2) engaging the global S&T ecosystem outside the corporation – including government labs, universities, large and small businesses, and startups; and 3) fostering cross-enterprise innovation within the corporation. In this role, he works with leaders from across the Corporation to develop and actively manage enterprise technology roadmaps aligned with customer and business area needs. Dr. Samanta Roy also serves as a liaison with government and non-government organizations critical to the formation of S&T policy and the execution of research. Prior to joining Lockheed Martin, Dr. Samanta Roy was a professional staff member with the Senate Armed Services Committee from 2010 to 2014 with the portfolio of the Department of Defense's wide spectrum of science and technology-related activities. He came to that position from the White House Office of Science and Technology Policy where he was the assistant director for Space and Aeronautics from 2005 to 2009 and was responsible for space and aeronautics activities ranging from human space flight to the Next Generation Air Transportation System. Dr. Samanta Roy previously served as a Strategic Analyst at the Congressional Budget Office and as a Research Staff Member in the Systems Evaluation Division of the Institute for Defense Analyses in Alexandria, Virginia. Dr. Samanta Roy earned his Bachelor of Science, Master of Science and Ph.D. degrees in aeronautics and astronautics from MIT. He earned a master's degree in space policy from George Washington University and diplomas from the International Space University and Institut d'Etudes Politiques de Paris. Dr. Samanta Roy is an associate fellow and member of the Board of Trustees of the American Institute of Aeronautics and Astronautics and a member of the National Research Council's Aeronautics and Space Engineering Board. He also chairs the Industry Relations Committee of the International Astronautical Federation and serves on the Board of Visitors for the University of Maryland's College of Computer, Mathematical, and Natural Sciences and on the FAA's Drone Advisory Committee. Dr. Samanta Roy continues to serve in the U.S. Air Force Reserve.

JAIWON SHIN is the associate administrator for the Aeronautics Research Mission Directorate (ARMD) at NASA. In this position, he manages the agency's aeronautics research portfolio and guides its strategic direction. This portfolio includes research in the fundamental aeronautics of flight, aviation safety, and the nation's airspace system. Previously, Shin served as deputy associate administrator for ARMD, where he was instrumental in restructuring NASA's aeronautics program to focus on fundamental research and better align with the nation's Next Generation Air Transportation System (NextGen). Prior to coming to work at NASA Headquarters, Shin served as chief of the Aeronautics Projects Office at NASA Glenn Research Center where he had management responsibility for all of the center's aeronautics projects. Prior to this he was Glenn's deputy director of aeronautics, where he provided executive leadership for the planning and implementation of Glenn's aeronautics program and interfaced with NASA Headquarters, other NASA centers, and external customers to explore and develop technologies in aeropropulsion, aviation safety and security, and airspace systems. Prior to this, Shin served as chief of the Aviation Safety Program Office, as well as the deputy program manager for NASA's Aviation Safety Program and Airspace Systems Program. He assisted both program directors in planning and research management. Shin co-chairs the National Science and Technology Council's Aeronautics Science and Technology Subcommittee. His honors include NASA's Outstanding Leadership Medal, NASA's Exceptional Service Medal, a NASA Group Achievement Award, the Lewis Superior Accomplishment Award, three Lewis Group Achievement Awards, and an Air Force Team Award. He is a graduate of the Senior Executive Fellowship Program at the Kennedy School of Government at Harvard University. He has extensive experience in high-speed and icing research, and has authored or co-authored more than 20 technical and journal papers. Shin received his Ph.D. in mechanical engineering from the Virginia Polytechnic Institute and State University, his B.S. from Yonsei University in Korea, and his M.S. in mechanical engineering from the California State University, Long Beach. He serves as a member of the Aeronautics Research and Technology Roundtable.

F. ROBERT VAN DER LINDEN is a curator and historian in the Aeronautics Department of the Smithsonian Institution's National Air and Space Museum, where he served two terms as Department Chair. He is currently the Curator of Air Transportation and Special Purpose Aircraft, the responsible curator for the Milestones of Flight gallery, the Hall of Air Transportation and the Golden Age of Flight gallery, and he is the lead curator for the award-winning America by Air gallery. Dr. van der Linden has authored and co-authored numerous books and articles on the history of civil and commercial aviation, including such titles as Chuck Yeager and the Bell X-1 and Airlines and Air Mail: The Post Office and the Birth of the Commercial Aviation Industry. He is a member of Phi Beta Kappa, Phi Alpha Theta history honor society, and the Society for the History of Technology. Dr. van der Linden holds a BA degree in History from the University of Denver, and an M.A. and Ph.D. in modern American, business, and military history from The George Washington University.

GRAHAM WARWICK is a senior aerospace journalist at Aviation Week, where he leads coverage of engineering and technology across the aerospace industry, with a special focus on identifying technologies of strategic importance to aviation, aerospace and defense. Born and educated in Scotland, he graduated in aeronautical engineering and worked in advanced design at Hawker Siddeley Aviation in the U.K. before becoming an aerospace journalist. Prior to joining Aviation Week, he spent almost 30 years with weekly aerospace news magazine Flight International, most recently as Americas Editor, based in the U.S. Warwick is a winner of the Decade of Excellence award for aviation journalism, the Aerospace Industries Association's Lauren D. Lyman Award for outstanding achievement in aerospace communications, and in 2013, the Jesse H. Neal award for Best Technical Content was awarded to Graham Warwick and Guy Norris for their Advanced Propulsion feature. Warwick is a Fellow of the Royal Aeronautical Society.

NANCY YOUNG is the Vice President of Environmental Affairs for Airlines for America (A4A). An environmental attorney, Ms. Young directs the A4A environmental sustainability programs, represents the A4A airlines in international negotiations regarding aircraft noise and emissions standards, and provides counsel on other environmental and sustainability issues of significance. She serves on the steering group and as environmental co-lead of the Commercial Aviation Alternative Fuels Initiative® (CAAFI), which is working to hasten the deployment of commercially viable, environmentally preferred alternative jet fuels, and participates in the working groups under the International Civil Aviation Organization's Committee on Aviation Environmental Protection. Previously, Ms. Young was a principal/partner at the law firm of Beveridge & Diamond, P.C., where she served as co-chair of the firm's climate change and waste management and recycling practices. She earned a J.D. cum laude from Harvard Law School. In 2015, Ms. Young was appointed by United Nations Secretary-General Ban Ki-moon to serve on his High-Level Advisory Group for Sustainable Transport. The Advisory Group concluded its work in late 2016 with the launch of its analysis and recommendations report, "Mobilizing Sustainable Transport for Development."



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