LONG-TERM INVESTMENT IN TECHNOLOGY DEVELOPMENT AND TRANSITION

Background: In 2005 HR 2862 called for the creation of a national aeronautics policy and a national R&D infrastructure plan that would address, among other issues, the extent to which federal laboratories should focus on long-term, high-risk research. The policy was issued in December 2006 and was followed by the National Aeronautics R&D Plan in December 2007 and the National Aeronautics R&D Infrastructure Plan in December 2008. While the policy calls for the advancement of U.S. technological leadership in aeronautics, neither plan addresses the high-risk research, critical research infrastructure, and long-term financial commitments required to demonstrate effectively the stated goals and objectives for NASA and other federal agencies as stated in the legislation. With mounting national debt and decreasing R&D budgets, our federal laboratories have become increasingly focused on short-term research investments have become more risk-averse. Willingness to accept failure is a normal, accepted, and necessary part of understanding the capability potential and limits of a technology, and is vital to the successful demonstration of technology readiness. The effective transition of aeronautics-related technologies from federal laboratories to civil and military aircraft systems hinges on successful demonstration of the technology readiness level (TRL) required to enable and expedite timely system development and acquisition. Since technology readiness is highly dependent on anticipated operational environments, demonstration in such environments is vital to successful technology transition. A disciplined assessment methodology must be employed at critical milestones throughout the technology and system development processes to validate technology readiness and uncover capability shortfalls that can have detrimental impacts on program cost, risk, and/or schedule.

Aeronautics expertise is critical to U.S. understanding of the potential and limits of revolutionary new aeronautics technologies. However, aeronautics technology development and demonstration programs are becoming increasingly more short-term focused and risk-averse, which impacts U.S. defense capabilities and economic competitiveness. A 2013 report by the Science & Technology Policy Institute (STPI) concluded that “complacency and risk aversion has cost the United States its global leadership more than once since its invention of flight.” The report identified almost 70 barriers to effective technology transition.

Fundamental changes must be made in how civil aeronautics technologies are matured and transitioned from federal laboratories to civil aircraft development programs. To meet the goals of the National Aeronautics Plan and to transition new technology to industry end users effectively, the nation must make a commitment to long-term investment in R&D and the requisite critical infrastructure.

Recommendations: The American Institute of Aeronautics and Astronautics recommends that:

- Congress support technology investments that specifically include a balanced risk portfolio of aeronautics research with demonstration “off-ramps” for technology transition that can be infused into new fielded systems.
- Congress and the Administration support “X-plane”–style competitions and capability demonstrations to enhance technology transition and inspire the next-generation workforce.
- The Administration requires programs to include frequent demonstration through simulations, ground tests, and flight tests that provide adequate validation of new technologies.

ASSURING THE VIABILITY OF THE U.S. AEROSPACE AND DEFENSE INDUSTRIAL BASE

Background: Continued stability of the U.S. aerospace and defense (A&D) industrial base is critical to our economy, national security, infrastructure, and future workforce. The A&D industry is facing one of its greatest challenges in history as Congress and the Administration deal with mounting national debt and the need to balance the federal budget. All federal agencies face significant budget reductions, with the Department of Defense (DoD) potentially bearing the biggest burden. While all areas must be examined to identify unnecessary spending that can be reduced or eliminated, we must make sure that the nation's future is not mortgaged to address today's crisis.

The A&D industry is the nation's largest manufacturing exporter and contributes 2.23% of the Gross Domestic Product. A&D small business generates almost half of private sector jobs, 64% of net new private sector jobs, 43% of high-tech employment, and is responsible for 33% of exports.* The industry's workforce is highly skilled and leads our nation in global competitiveness, providing current and future opportunities for young people to have high-paying careers that will keep the industry strong for the future while advancing our national and economic security.

In 2011, as part of the deal that allowed for the increase in the national debt ceiling while recognizing the unsustainability of the national debt, Congress passed the "Budget Control Act of 2011". The act included automatic triggers that mandate across-the-board spending cuts. Legislative proposals to allow for more flexibility among the agencies have been met with mixed outcomes. In April 2013, when faced with the growing reality of widespread flight delays caused by sequestration-related Federal Aviation Administration (FAA) staffing shortages, Congress acted swiftly to provide flexibility within the FAA to continue core operations while shifting sequestration impacts to lower priorities within the agency. However, other agencies have been prevented from employing the same priority-based shifting, and have continued to cut operations and programs across the board indiscriminately.

The A&D industrial base possesses unique capabilities and expertise required to address the unique and diverse missions required by their civil and military customers. However, future U.S. space operational capabilities face industrial base challenges, both from reduced production capability and loss of supporting human expertise. Small business is the backbone of the American economy and technology innovation. The domino effect of reduced federal budgets will undoubtedly force some companies out of business and still others to scale back significantly, resulting in single-source suppliers or even no domestic supplier for items on the critical development path. If those capabilities are allowed to erode in this lean budget environment, this nation could become technologically bankrupt and unable to address future threats to our national security or economic stability.

Recommendations: The American Institute of Aeronautics and Astronautics recommends that:

- Congress and the Administration carefully consider the impact of budget cuts on the continued viability of the aerospace and defense industrial base as well as their impact on U.S. national and economic security in their budget reduction deliberations.
- Congress and the Administration must address the impending threat of sequestration by eliminating the automatic "across-the-board" defense budget reductions that will severely impact research, development, testing, evaluation, and acquisitions programs; allow agencies the flexibility of discretion to prioritize programs, capabilities, and functionality when determining where statutory cuts should be made; and provide assurances of continuity and sustainability to federal contractors, the small businesses that support these programs, and university and federal laboratories that provide national security RDT&E.
- Congress should reform federal acquisitions and procurement and associated program processes to allow for multi-year appropriations for complex systems similar to DoD contracts for shipbuilding and fleet acquisitions.
- Congress must meet constitutional budget obligations to return program stability and economic certainty to the development of complex systems.

*AIA Second to None, 9/19/12

DEVELOPING A SEAMLESS NATIONAL CYBERSECURITY POLICY

Background: Cybersecurity continues to be a continually and rapidly evolving arena where our policy decisions have significant implications in both the commercial and military world. Beyond economic losses attributed to stolen Personally Identifiable Information (PII), the risks associated with loss of Intellectual Property (IP), especially from the aerospace and defense industry, pose a national security risk. The risks become even greater when cyber attacks target critical infrastructure, including air traffic management (ATM) and space-based assets, such as GPS, weather monitoring, and even the International Space Station (ISS). The presence of ground-based systems in the communication path adds additional portals for access that must also be protected. The risk to the system, both space and ground based, is amplified when the introduction of malicious hardware and code through the supply chain is also considered.

Cybersecurity presents a significant challenge to the "business as usual" approach when it comes to not only Con Ops (concept of operations) of our systems, but also the ways in which we design, build, and acquire them. The rapid growth in cybersecurity service companies also presents a new area of concern relative to ITAR issues: transfer of technology and "know how" to other nation-states and parties that may be using that same technology and capability against the United States and its interests. Additionally, the move to mobile and portable platforms with a rapidly growing catalog of "apps" (applications) that users can install on their devices and inadvertently provide backdoor access to networks and databases introduces another possible breach point.

Recommendations: The American Institute of Aeronautics and Astronautics recommends that:

- Congress should require the Administration to assess vulnerabilities throughout the supply chain relative to space-based and ground-based equipment, especially considering recent relaxing of ITAR restrictions in the area of satellites.
- Congress should require the Administration to develop a roadmap for protection of critical space-based and related ground-based assets that are vital from both a national security and critical infrastructure perspective.
    - This roadmap should include a review and propose guidelines related to cybersecurity skills, software, and hardware provided to companies and nation-states that could be used against the United States and our interests here and abroad.
    - Specific protocol for protecting GPS and other vital hardware should be included as part of the roadmap.
- Congress should increase the emphasis of STEM initiatives for the purpose of developing a "cyber cadre" that can address skill shortages and the growing need for cyber-capable individuals. Considering the sensitive nature of the work, this must be done in a manner that reflects the need for proper background assessment protocols and provides standardized training requirements.
- Congress should develop policies that encourage public/private cooperation to forge viable strategies that address the multiple areas of cybersecurity that ensure the integrity of global positioning systems technology and other space-based assets, national air traffic management systems, supply chain, etc.

ACCESS FOR UNMANNED AERIAL VEHICLES IN THE NATIONAL AEROSPACE SYSTEM

Background: The FAA Modernization and Reform Act of 2012 directed the FAA to address the rapidly evolving issue of accommodating UAVs (Unmanned Aerial Vehicles, i.e., drones) in the national airspace. The recent (Fall 2013) publication of its "Integration of Civil Unmanned Aircraft Systems (UAS) in the National Airspace System (NAS) Roadmap" attempted to lay out its systematic approach to what is an admittedly challenging issue from both a technical and policy perspective.

While the roadmap is successful in capturing the complexity of the task in front of the FAA and other involved groups/agencies, the broad timelines included indicate a system that is literally decades away from maturity. Recent efforts by the FAA to solicit proposals for and selection of six (6) test sites for UAV testing (a key early step) were delayed beyond the originally announced milestone date. Additionally, political issues, namely the recent government shutdown, have halted work and remain before the FAA as possible future impediments to integration efforts.

Beyond impacts from external forces, the report itself indicates concerns over the FAA's ability to meet the milestones and dates it has set out for itself in its own roadmap. In Appendix C (page 50), the report states "Some of the target dates are aggressive and will require additional industry or government resources if they are to be met." Considering that the roadmap contains both serial and parallel efforts relative to its phased approach to "accommodate, integrate, and evolve" UAVs into the NAS, there is significant risk to the overall roadmap. And while some aspects of the roadmap may be implemented, the FAA's stated focus that it must be done "…without reducing existing capacity, decreasing safety, negatively impacting current operators, or increasing the risk to airspace users..." leaves little doubt that even a small delay in an integration task could have significant ripples throughout the overall effort.

The rapid growth of the UAV industry, the limited ability to operate commercially under the current system (Certification of Authorization, or COA), and the ambiguity that currently exists as to what the final FAA oversight will look like and what restrictions it will pose on developers and users of UAVs will all need to be considered.

Recommendations: The American Institute of Aeronautics and Astronautics recommends that:

- Congress should direct the Federal Aviation Administration to shorten its "mid-term" and "long-term" task period of performance from "5–10 years" and "2022–2026", respectively, to timelines that reflect the importance of the crossroads that the UAV/UAS industry is at within the United States. Significant technical and business implications could result from decisions by the FAA and other regulatory bodies and there is significant risk that companies/investors will choose to NOT enter the UAV/UAS market while ambiguity could possibly exist for another decade.
    - The FAA and its UAS Technical Community Representative Group (TCRG) should accelerate the effort to define the required sensors and approved approach (ABSSA, GBSSA, etc.) that will allow for safe vehicle operation within the NAS. The roadmap indicates an expectation of no major progress until the mid-term timeframe, between 5 and 10 years. This timeline could hamper efforts for vehicle development as FAA-mandated technology could impact vehicle design and costs downstream of decisions made 5–10 years out.
- Congress require the FAA to review and issue a report, within 180 days, addressing the planning and progress on NextGen being able to accommodate UAV/UAS, specifically its ability to deal with the required secure Control and Communications (C2).
- Congress should identify areas of concern that risk delays because of either insufficient federal funding or resources and work to create public/private partnerships that can be leveraged to minimize impacts to the overall integration effort.
- The FAA should look to international examples of functioning UAV/UAS integration (Israel, Canada, etc.) to leverage both their Lessons Learned and to avoid U.S. regulations being overly burdensome on U.S. manufacturers and thereby impede their ability to compete for international business (this requires a balance between safety and competitiveness).

ENSURING A ROBUST U.S. HUMAN SPACEFLIGHT PROGRAM

Background: Since the U.S. human spaceflight program was initiated in the early 1960s, the country has benefitted from the global space leadership, diplomatic opportunities, and inspiration that result from success in difficult human endeavors. The technologies that have been developed to enable human space exploration have resulted in great leaps in Earth-bound technological fields such as health care, communications, navigation, and environmental management.

The current Administration and Congress are in agreement that the ultimate destination for humans in space within the next 20–30 years is Mars. Currently, human space exploration is limited to travel to and from the International Space Station (ISS), located in low Earth orbit (LEO) approximately 250 miles above Earth. There is also strong agreement between the policymakers and the technical community that a stepping stone approach to human space exploration is necessary to demonstrate the human-rated spacecraft and critical technologies necessary to transport humans safely to and from Mars. NASA and its industry partners are developing a highly capable heavy lift launch vehicle and spacecraft that will enable deep-space human exploration to multiple destinations, and NASA and other international space agencies are jointly assessing options for milestone missions with the ultimate goal of landing humans on Mars. NASA is advancing the maturity of key technologies that will be necessary for future deep-space exploration, including such areas as in-space propulsion, in-space power generation and storage, cryogenic fuel management, crew health and safety, human-robotic systems, and other technologies crucial to deep-space human exploration.

Development of the Space Launch System (SLS) is also well underway. NASA and the agency's industry partners are maturing a design that maximizes the use of existing systems to reduce the launch vehicle cost and minimize schedule and technical risk. Currently the program is operating five months ahead of schedule. The initial test flight of the SLS integrated with the Orion spacecraft is scheduled for 2017.

The technologies and capabilities developed in support of human spaceflight also benefit other critical U.S. programs such as space science, Earth observation, weather forecasting, and national security space programs. Technologies developed to support astronauts in the constrained environment of space travel have been leveraged to improve methods for water filtration, agriculture, food storage, material manufacturing, communications, and energy management. Human spaceflight has the potential to provide economic opportunity as government and the private sector each contribute in unique ways.

A strong government human spaceflight program beyond Earth orbit inspires young people to join the scientific and technical workforce. The expanding human spaceflight industry is enabling the transport of humans, scientific instruments, and cargo to low Earth orbit, further enhancing educational, workforce, and commercial opportunities. Human exploration beyond Earth orbit also provides a platform for the U.S. to strengthen international relationships via collaboration. Historically the U.S. has been seen by other countries as the leader in human spaceflight, providing an opportunity to make the geopolitical links that will facilitate strong trade and security cooperation with established and emerging space-faring nations.

Recommendations: To ensure U.S. leadership in space and enable a robust human spaceflight program, the American Institute of Aeronautics & Astronautics recommends:

- Congress should adopt a NASA-endorsed roadmap of missions and milestones that leads to a human mission to Mars in the early 2030s.
- Congress should enable stable long-term funding for NASA to complete development of the SLS and Orion and to develop other systems necessary to execute a sustainable exploration roadmap, in conjunction with international partners.
- Congress and the Administration should provide for the uninterrupted development of NASA-defined technologies that are necessary to execute the exploration roadmap.
- Congress and the Administration should state clear priorities for linking NASA Human Spaceflight activity to national goals related to foreign relations, economic growth, education, and technological achievement.

ADDRESSING THE GROWING THREAT OF ORBITAL DEBRIS

Background: The tracking, prevention, and removal of orbiting debris is necessary to ensure that our nation's commercial, civil, and defense space assets achieve mission success throughout the originally designed mission lifetime. The largest population of debris in low Earth orbit (LEO) consists of 300,000 to 1 million objects between 0.1 cm and 10 cm. This debris is difficult to identify and track and poses a significant threat to space operations. Despite policy efforts to mitigate future space debris, there will continue to be on-orbit incidents that create small- to medium-sized debris in critical orbits. The Chinese anti-satellite test of 2007 and the Iridium 33/Cosmos 2251 collision in 2009 are examples of situations that are likely to recur. These two events alone likely doubled the amount of debris in critical sizes in orbit. While some debris naturally de-orbits over time, models indicate that we already have an unstable situation where debris is created faster than it naturally de-orbits, with an increasing collision frequency. Models indicate that even if all launch activity stopped, satellite collisions with existing debris would continue, with the debris population growing exponentially. Modeling studies indicate that removal of at least 5 large space objects per year in key orbits would be required to stabilize debris growth.

Current tracking systems primarily identify objects bigger than 10 cm. Active spacecraft with propellant reserves can maneuver away from threatening objects given sufficient warning, but collisions with objects smaller than 10 cm are difficult to avoid. Without debris mitigation and remediation, spacecraft life would be adversely affected and replacement costs will rise significantly. Furthermore, because LEO spans all geographic boundaries, debris is also an international legal challenge. There are no international regulations that limit actions that create debris; retired spacecraft and resulting debris remain the sovereign property of the nations that launched the spacecraft; and no means currently exist to raise the long-term funding required to develop and implement methods of debris mitigation. International and national laws are vague and still in their infancy, with many legal and technical hurdles that prevent active debris removal.

Recommendations: To address the threat of orbital debris, the American Institute of Aeronautics & Astronautics recommends the following actions should be taken by the Congress and the Administration:

- Sponsor development of space situational awareness (SSA) methods on a global cooperative basis to identify, track, and maintain a catalog of LEO debris objects down to 1 cm.
- Develop a clearinghouse of "best practices" for satellite and launch vehicle upper stage designers that limit debris generation and minimize orbital loiter after booster and satellite end of life. Provide international access with all space-faring nations to share these best practices.
- Establish international agreements that prevent intentional creation of hazardous debris.
- Continue to work through UNCOPUOS to develop international agreements to limit orbital debris, including transparency and confidence-building measures.
- Develop and demonstrate cost-effective technologies for debris remediation, and promote the resolution of legal issues of liability and other legal hurdles related to debris removal.

BUILDING OUR COMPETITIVE FOUNDATION: SUPPORTING K–12 STEM EDUCATION

Background: Science, Technology, Engineering, and Mathematics (STEM) education in our nation's classrooms provides the critical foundation needed for our future national security and economic competitiveness. Students need adequate preparation at the primary and secondary education levels if they are to advance to university study of STEM and onto careers in STEM fields. However, inadequate emphasis, funding, communication of resources, and teacher training has been provided, particularly for the critical technology and engineering (T&E) components of STEM, thus eroding this foundation. Additionally, a 2011 White House report on federally sponsored STEM programs suggests there may be significant overlap. If the nation is to reap fully the intended benefits of STEM education and its investment therein, we must remedy our current deficiencies in emphasis, funding, communication of resources, and teacher training in STEM areas.

Recommendations: To remain globally competitive, the American Institute of Aeronautics & Astronautics recommends that the U.S. must increase its emphasis, funding, and teacher training in STEM subjects at the primary and secondary education levels. Several policies and actions would make significant progress on this objective.

- Congress should provide incentives for states to adopt the new Next Generation Science Standards being developed by a multi-agency working group lead by the National Research Council. Incentives might include curriculum development grants, teacher training grants, or materials grants.
- Congress should provide direct funds specifically to support teacher training programs in technology and engineering areas. Engineering and technology-related learning opportunities are compounded exponentially for each teacher who is effectively trained.
- The Administration should pursue a research-based evaluation of existing teacher training programs in technology and engineering subjects to determine which training approaches are most successful and then deploy those approaches nationwide.
- Congress should create a centralized national STEM resource center/network that identifies, publicizes, coordinates with, and connects educators to STEM support opportunities throughout all federal government agencies.
- Congress should recommend language to the Federal Acquisition Regulations that requires private companies to perform a minimum amount of STEM outreach activities for all federally funded technical contracts. Research has shown that the most effective method of encouraging students to enter a STEM field is through local scientists and engineers volunteering in a classroom.
    - Reduces costs by eliminating, at a minimum, overhead of managing federal STEM funding for local STEM programs.
    - Encourages greater participation in STEM activities by private industry, which are the most effective at encouraging students.
    - Generates local community involvement.