Summary Report for Advanced Composites Workshop

May 1-2, 2012 – NASA Langley Research Center

Stephen Scotti, Lynn Bowman, Brian Jensen, Kevin O'Brien, Dan Perey, Martin Annett, and Marc Schultz

Background:

It is inevitable that highly efficient fiber-reinforced composite structures will see increased use due to pressure for higher vehicle efficiency (e.g., lower aircraft fuel burn, higher automotive MPG standards, etc.). The present approach for the development and certification of composites is largely based on testing so it is slow and expensive; this is a cautious, but safe design approach. A new NASA-sponsored Advanced Composites Initiative has been proposed to shorten the timeline for bringing innovative composite materials and structures to market. It is envisioned that this initiative will be a public-private partnership with the goal of reducing the current 10-20 year timeline for development and certification to 3-5 years. The initiative will require engaging key players from government (NASA, FAA, DoD), industry and academia to mature and verify the methodology, to transition it to forms usable by industry, and to assure it can be proven safe for use by certification authorities such as the FAA. A white paper has been generated that provides the motivation, objectives, research and development focus areas, and investment and advocacy strategy for the Advanced Composites Initiative (Ref 1). As a follow up to this white paper, the Advanced Composites Workshop was held at NASA Langley on May 1-2, 2012. This report is a summary of this Workshop.

Workshop Overview

The purpose of the Advanced Composite Workshop was to engage key decision makers and subject matter experts to better define scope and focus so that the Advanced Composites Initiative would most effectively meet its goal. Participation included 24 companies in 8 industry segments (Transport/Fighter Airframe OEM, Propulsion OEM, Specialty Structures/Tier 1 suppliers, Small Jet OEM, Helicopter OEM, Automotive OEM, Shipbuilding OEM, and Commercial Space OEM), certification experts from FAA and DoD, and selected participants from NASA Mission Directorates, NASA Office of Chief Technologist, NASA Office of Chief Engineer, and academia. The outcome of this workshop, of which this report is one component, will be used to better define the framework of an effective plan, and to obtain industry buy-in for a future public-private partnership. Guided by the Workshop-developed framework, more detailed plans involving numerous partners from industry, government, and academia will be crafted, taking into account the varied interests and constraints. The agenda for the workshop is given in attachment A, and the list of attendees is given in attachment B.

The Advanced Composites Workshop was held over two days. During the first day, presentations were given by selected industry and government groups representing a cross section of the industries and government agencies participating, and during the second day, small group discussions were held. The first-day presenters were requested to provide the general experience for their industry and the particular experience for their organization (e.g., experiences, examples, and lessons learned) on the development of high performance composite structures relative to the goal of a 3-year design/development/certification cycle with emphasis on the following areas:

1) Composite development challenges in the SOA approach and the "long poles" in this approach
2) Focus areas where application of new technology would have high payoff
3) Non-technical challenges (e.g., IP, regulatory, etc.)
4) Suggestions for a public-private partnership framework to achieve the goal

This first day served to provide a shared understanding of the issues and challenges from this broad-based group, and to provide a basis for more detailed discussions on the second day.

During the second day, the participants were organized into three groups, each of which was led by a Langley subject matter expert in materials, mechanics, or measurement sciences. These groups had facilitated discussions that were focused on the 4 points enumerated above. In addition, they were asked to discuss and identify shortfalls and areas where NASA can leverage with industry, FAA, and DoD change the present paradigm, and what would facilitate acceptance of any changes to the present paradigm by OEM's, regulators, and customers and operators. These groups reported out summaries of their discussions to the entire Workshop attendance at the end of the formal program. Informal tours of some specific NASA research and facilities followed in the afternoon of day 2.

The Promise of Composites

The Background section of this report and the white paper of Reference 1 both describe the value of composites for performance improvements as a forcing function for their greater adoption. The workshop presentations and participant discussions supported that claim, but also highlighted additional benefits that are envisioned as part of the end state that the Advanced Composites Initiative would help make a reality. For example, the promise of greater affordability for composites, relative to current metallic airframe development and production practices, was described by several participants. This affordability results from the greater unitization of the structure – creating larger and more complex components, which reduce the number of drawings, parts, and assembly steps – which is synergistic with greater utilization of automation to reduce the cost of touch labor in production. The strong tie to simulation for all stages of development including manufacturing and certification was also highlighted as key to reducing the development time and cost. Benefits would result from a significant reduction in empirical testing – for example, virtual testing in place of physical testing – as well as integration of the development, manufacturing and certification processes. Significantly, one of the presentations showed data that supported the white paper's proposition of achieving a drastically reduced development cycle. This presentation described the example of an aircraft prototype being developed and flown with an 18 month span from concept to flight. While this streamlined development template was not for an aircraft meeting rigid certification standards, it demonstrated the feasibility of the 3-year development goal (more nuances on development time are discussed in subsequent sections). However, it was commonly agreed that reducing development and certification time requires a paradigm shift from our present iterative and empirical approach to an approach where there is greater concurrence (e.g., manufacturing modeled concurrently with the structural modeling rather than sequentially), and which incorporates more simulation and less testing.

Technical Challenges for Composites that Must Be Addressed

The participants at the workshop were asked to describe the "long poles" that prevent the more rapid development and certification for advanced composite structures. The challenges are best understood

in relation to the present development and certification paradigm that is shown in figure 1. This figure is a simplified schematic that is most applicable to aircraft though it will be similar for other industries. It was synthesized from the Workshop industry presentations without including the internal and external business interactions that are a necessary part of the process, and it is focused on the materials, structures, and manufacturing aspects of product development and certification. It illustrates that going from "test tube" to delivery of the first flight ready production article can be a 20-year effort, and that there are interactions among the four principle areas of materials, manufacturing, design development, and design certification with significant overlap in time. Some of the "long poles" that prevent achieving the rapid development goals are intrinsic in present approaches used in these four principle areas. These approaches are largely empirical, requiring extensive testing (e.g., to create design and certification information), or iterative, "trial-and-error," processes (e.g., those presently used to develop manufacturing processes that provide acceptable quality, repeatability, and throughput). In addition, the way these four areas interact or are integrated within the larger process is presently inefficient and is an impediment to achieving the goal. As an example of this interaction challenge, today the ability to develop a material to meet specific product needs is very limited (e.g., arrow A in figure 1), which can lead to selecting a well-known but suboptimal material, or to a Material–Design Development iteration that can be very time consuming. Figure 1 does not appear specific to composites, but an inherent characteristic of composites that makes the four principle areas tightly coupled (and which is less of an issue for metals) is that with composites the material is not made until the finished product is made. That characteristic and the following unique aspects of composites contribute to the long timeline: 1) the proliferation of materials, of product forms, and of processing approaches (e.g., resins, fibers, prepregs, fiber preforms, and infusion, consolidation, and cure approaches) being marketed without the necessary characterization and generation of material properties (i.e., lack of standard materials-and-processes databases), and without adequate methodology to measure property "equivalence" to existing materials, processes, and databases; 2) the lack of experience in taking advantage of the significant design flexibility for composites (i.e., lack of design guidelines); 3) the immaturity and lack of validation for prediction of composite failure (i.e., existing models lack sufficient physical basis so they are not predictive which results in a heavy dependence on testing and its associated high costs); 4) concerns with structure durability and damage tolerance throughout system life (leading to conservative design and testing approaches); 5) manufacturing processes scale up, which is performed empirically and in an iterative manner; 6) manufacturing producibility being determined late in the design process (issues with dimensional tolerance achievable, effects on design properties and allowable defects from manufacture); 7) bonded structure process sensitivity, and bond integrity validation during manufacture and in service (i.e., inadequate NDE capability); 8) tooling designs being needed early in the development cycle (because of long lead times) and which are expensive to change; and 9) low manufacturing throughput.

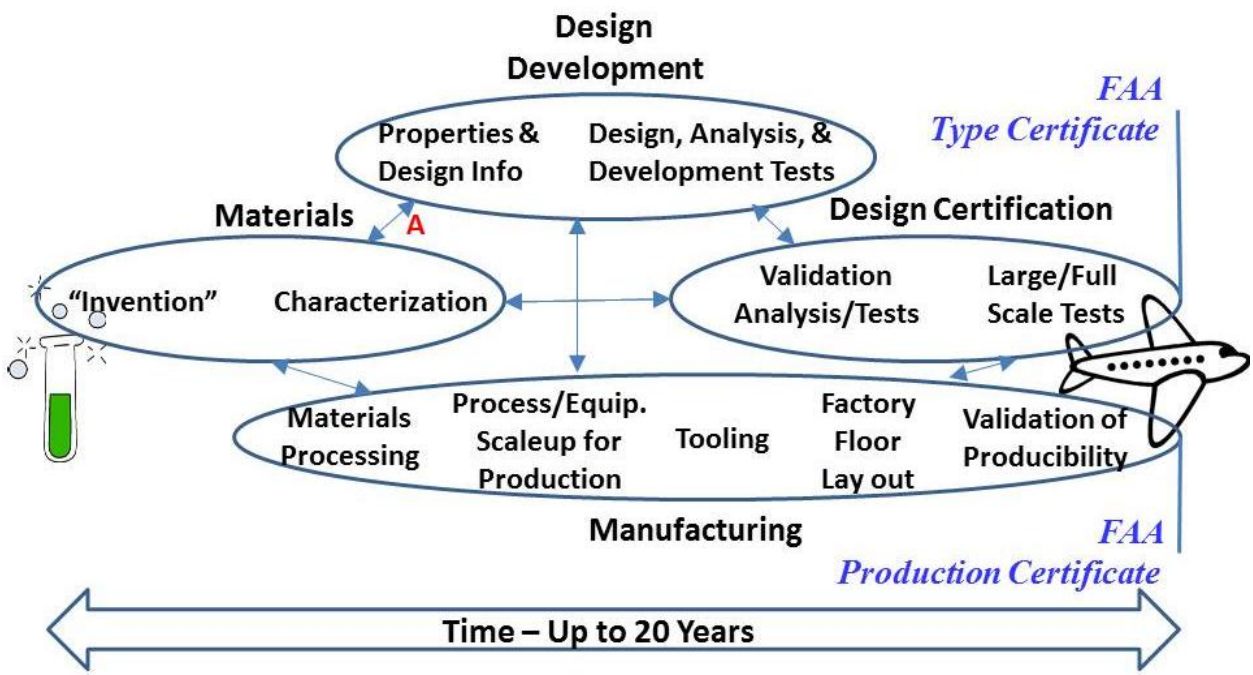

Figure 1 – Schematic of present development and certification paradigm (most directly applicable to aircraft)

Non-technical Challenges for Composites that Must Be Addressed

The participants at the workshop were asked to identify and discuss the non-technical challenges that either contribute to the long development time or that may become constraints that limit the ability of participants of the proposed composites initiative to come together to address the technical challenges described previously. One significant challenge that was brought up in the small group discussions was to frame the initiative so that there is a clear framework where potential participants can understand the ground rules and weigh the advantages and disadvantages so that the business case for participation is clearly understood. Success of any initiative cannot be expected unless it is advantageous to participate (and it is possible that each company may wish to participate differently depending on their unique position and competitive advantages). Aspects of this business case are finding common ground for collaboration, handling IP within the initiative, and defining which aspects are precompetitive and readily shared among participants. Other non-technical challenges identified were the limited workforce talent pool familiar with composites, the difficulty in changing established culture (existing experience base is primarily with heritage fastened metallic structures), risk aversion (i.e., paying costs of being first adopter of technology in both tech developments and potential corporate liability), government contracts where databases are not specified as a deliverable (leading to situations where the same material is characterized multiple times because the data are not shared), excessive ITAR and export control (especially of things that are already globally known), the perception that the Initiative will be a subsidy (with political implications and/or trade agreement concerns), regulatory constraints that prescribe the materials qualification approach (e.g., CMH-17 for material allowables testing, building block approach in FAA guidance and DoD JSSG-2006) and a no-growth certification requirement for damage tolerance (including full fatigue-life testing prior to ultimate load testing), lack of sufficient product demand to influence material suppliers, high capital equipment investment costs and long lead

times (especially an issue since certification components must be produced on a qualified production system), and the limited opportunities to develop new systems in aerospace. There was significant discussion in small groups about the TRL 4-5-6 "valley of death" between new technology push and manufacturing pull. Manufacturing groups consider many aspects of composite material systems as high risk, but are unwilling to invest resources to bridge this gap in TRL level. An overarching concern for both the technical as well as non-technical aspects is that the high standards for safety throughout the life cycle need to be maintained as new composite technologies are utilized.

High-Payoff Technical Focus Areas

The technical issues and challenges identified by the participants covered all of the constituent efforts shown in figure 1, and there was general agreement that modeling and simulation improvements within each of these individual efforts coupled with improved integration of these tools would be a strong component of achieving the Initiative goal. However, with such a broad range of potential efforts and also the large variation of technical maturity (TRL) of modeling and simulation among these efforts, the proper breath of scope of the initiative quickly surfaced in the small group discussions. Referring to figure 1, it was felt that computational modeling as a method of material design in the "Invention" part of Materials development was out of scope for the Advanced Composite Initiative. The maturity of modeling and simulation tools for "design of materials" is presently low, and it is unlikely that sufficient progress could be made during a 5-year effort to bring them to a level where they could be incorporated in a production environment. So computational design of material may be better suited to the Material Genome Initiative than the Advanced Composites Initiative. Similarly, the characterization part of materials development may be addressed within the Advanced Composites Initiative for only selected, high-payoff technologies.

The high-payoff focus areas that had significant common agreement among the participants can be organized into several categories shown below. These categories are shown as if they are a shopping list of technologies. However, the Initiative will not achieve its goal if it only focuses on improving technologies in an uncoordinated manner. A critical step in formulation of the Advanced Composites Initiative is to determine the best suite or suites of technologies from this list, and the most appropriate system engineering processes to integrate them to achieve the Initiative goals.

Table I – High-Payoff Technology Focus Areas

1. Material development and qualification leading to the creation of standard material databases
    a. Material development addressing broadly based material requirements and various product forms (such as Tape, cloth, 3-D Preforms with RTM –VARTM –RFI, etc.)
    b. Accelerated testing and characterization combined with computational methods to streamline allowables development ("National Center for Advanced Materials Performance (NCAMP) on steroids")
    c. Include higher levels of building block complexity in a standard material spec (e.g., component in addition to laminate that is in NCAMP)
    d. Materials equivalency methodology
    e. Identification and creation of databases needed to support computational methods and modeling
    f. Constituent property modeling methodology (including effects of aging, hygro-thermal, strain-rate, creep, end-of-life properties)

2. Progressive damage modeling
    a. Failure prediction for various product forms (such as tape, cloth, 3-D preforms with RTM, VARTM, RFI, etc.)
    b. Dynamic modeling for fatigue, impacts and crash
    c. Durability and damage tolerance methods validation (including NDE needed for validation damage formation and growth data)
    d. Integration of tools into design allowables development methodology
3. Design coupled to manufacturing (including incorporating metrics of throughput, quality, and cost)
    a. Component design tools for large, near-net-shape components
    b. Manufacturing process simulations (tape/autoclave, preform/RTM , VARTM, RFI, etc.)
    c. Robust/reconfigurable processes
    d. In-process NDE
    e. Probabilistic analyses and design methods incorporating process variations
    f. Quality linked back to analysis and design (e.g., process variations, effects of defects, etc.)
4. Bonding and bond qualification
    a. In-process NDE and in-field NDE/health monitoring for joints
    b. End of life bond durability
5. Manufacturing tooling and molds
    a. Rapid manufacturing modeling
    b. Additive manufacturing of tools
    c. Ability to modify molds (e.g., additive manufacturing approaches)
6. Accelerated certification approaches and processes (to include issues with metal and composites mixed within a system)
    a. Validated simulations for structural performance and failure
    b. Probabilistic approaches to quantifying and managing risk (e.g., determine high risk “hot spots” and focus on them)
    c. End-of-life simulation/testing methodology
    d. Durability and Damage Tolerance modeling used for certification
7. Material durability and aging
8. Education of workforce (fresh outs not good enough for composites now)
    a. Often classes are using texts from 30 years ago - need next generation information
    b. Need training for educated user (not a black box)
    c. Train tradesmen as well as engineers
    d. Working groups to develop best practices and the path forward (e.g., a composite computational working group)

There was also discussion of the need for better tool integration and establishing standardization of data required for modeling and simulation as well as standardization of formats and interfaces to facilitate the integration.

Perspectives on NASA role

There was broad consensus that the Advanced Composites Initiative is needed because a radical change in the present development and certification approach is necessary for US industries to compete internationally in the future. Also, the sense of the participants at the Workshop was that NASA should

take a leadership role; in addition to being a technology developer and contributor, NASA needs to become the "honest broker" for technologies and certification approaches. In the technology area, coordinating working groups for the high payoff areas that were described previously would be an important NASA role. For example, it was suggested that NASA organize a composite computational tools working group whose function would be to validate new tools and their integration in design processes in addition to developing training in the use of these tools. Other suggestions were for NASA to sponsor round-robin evaluations of technologies such as equivalency procedures (e.g., the methodology for accelerated materials characterization for similar but slightly different materials) or analytical tools, and approach similar to what has been done previously for developing testing standards. NASA's role in leading a public-private partnership would facilitate developing standardized databases and standardized methodologies. As an honest broker in this partnership, NASA could help develop the business case for Initiative partners to share (e.g., IP) so that each company will benefit. An example of this approach is the National Center for Advanced Materials Performance (NCAMP), which evolved from the Advanced General Aviation Transport Experiments (AGATE) program to develop sharable materials data, but as mentioned previously, the scope of sharable databases needs to be greater than that presently in NCAMP. However, an alternative suggestion was for the government to outright buy the IP and data to make them publicly available. Though this approach sounds unworkable because of expense, it was noted that modifying the present government procurement processes to include delivery of material, manufacturing and component data as part of NASA and DoD development contracts could be an excellent source of data that could be shared. An additional value of this "honest broker" role for NASA would be to instill greater confidence by certification agencies in the application of new technologies as part of the certification process (Note: during the Workshop it was highlighted that products are what is certified, not test/analysis methodologies. However, methodologies require validation for them to be used as a basis for certification). A related recommendation from an FAA participant was that NASA help establish an industry/FAA/NASA "International User/Regulator Review Team" that would identify and evaluate technology advances, and in collaboration with academia and standards organizations, would facilitate standardization, training, and technology transfer into engineering practice.

The Next Steps

The Advanced Composites Workshop was a good initial start in helping develop the focus and scope of the Advanced Composites Initiative to best achieve the accelerated development/certification goal. The elements of the state-of-the-art approach that contribute to the long development template were clearly described. The technical and non-technical challenges have been identified. There was broad consensus among the participants that 1) standardization and modeling, 2) flexible manufacturing processes and tooling, and 3) certification are necessary aspects of the Initiative. Several categories of technology that can help reduce the cycle time have been proposed, and their maturation, validation and adoption would, along with improved integration of the four principle areas of the development process (in figure 1), create a new development and certification paradigm that has the potential to achieve the goal of a 3 to 5 year cycle time. However, the Initiative will not achieve its goal if it only focuses on improving a shopping list of technologies in an uncoordinated manner. A critical need is to develop descriptions of alternative future states that can achieve the 3 to 5 year development/ certification goal, and perform an analysis of the technology gaps to define the high payoff areas to be worked in Initiative. This gap analysis may necessitate additional workshops on the specific areas identified as high payoff to define path forward for each area.

Perhaps the greatest challenge in establishing the Initiative is developing the necessary broad-based business case for industry. The participants stressed that the business case for them participating in the Initiative needs to be clearly developed. Several technology areas were presented and were discussed in small groups which could be precompetitive and be beneficial for them to cooperatively mature. However, each company may see their business case differently, so it is important that the Initiative be tailorable so that it can accommodate these different business cases and is not a "one size fits all" approach. Also, the workshop highlighted the need for defining the specific framework under which the work can proceed (i.e., the specifics of the public-private partnership) to get the industry buy-in. For example, one framework discussed was an Advanced Composites Consortium – one that would be cross-industry as opposed to one specific to one industry such as automotive or helicopter. Potential partners need to know what it would look like, how it would function, and how its contractual and legal framework is structured.

The above mentioned next steps will be initiated in the coming weeks and subsequently many of the participants will be contacted to obtain feedback on future state/technology gap analysis, public-private partnership framework and on the following topics:

a) Which technical focus areas do you feel can be worked in Public-Private partnership? (Is the workshop list right? Where do you see yourself participating and how? What are your IP concerns?)
b) What is your view of the most appropriate public-private partnership structure(s) and NASA role(s)? (An Advanced Composites Consortium (perhaps modeled after other consortia such as the Vertical Lift Consortium or the Edison Welding Institute)? An International User/Regulator Review Team as suggested by FAA? Other NASA roles as the "honest broker" in technology development, validation, and interaction with certification agencies?)

References:

1. "Advanced Composites Initiative: accelerating the design/development/manufacturing life cycle for advanced composite materials for civil aviation vehicles", Charles Harris and Stephen Scotti, Research Directorate, NASA Langley Research Center, January 2012.

Attachment A – Workshop Agenda (to be attached)

National Aeronautics and
Space Administration

Langley Research Center
Hampton, VA 23681

AGENDA

Advanced Composites Workshop

NASA Langley Research Center
Hampton, VA

May 1 - 2, 2012

Tuesday, May 1, 2012

7:30 – 8:30 Greet Visitors in NASA Langley's Badge & Pass Office .....Cheryl Cleghorn
Protocol, LaRC (757) 864-2497 (office) (757) 272-6127 (cell)

7:30 – 8:45 Registration .....Lena Little
Reid Conference Center *Protocol, LaRC (757) 864-9464*

Welcome and Overview

8:45 Meeting Goals and Announcements

8:55 Langley Welcome .....Lesa Roe
Director, LaRC

9:00 Welcome Message.....The Honorable Mark Warner
United States Senate

9:10 Langley Perspective .....Lesa Roe
Director, LaRC

9:20 Office of Chief Technologist Perspective..... Dr. Mike Gazarik
Director, Space Technology Programs, NASA HQ

9:30 Aeronautics Research Mission Directorate Perspective .....Thomas Irvine
Deputy Associate Administrator, NASA HQ

9:45 Logistics and Meeting Format

9:50 Break

Composite Industry Perspective Presentations 1

10:00 Composite Trends and Challenges..... Jerry Young
Director, Materials and Fabrication Technology, Boeing Research & Technology

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10:30 Composites Development and Technology Transition ..... Dr. John Fish
Senior Manager, Airframe Design, Test Verification & Flight Operations, Lockheed Martin Aeronautics

11:00 Aerospace Propulsion OEM Perspective ..... Dr. Rajiv Naik
Fellow, Pratt & Whitney

11:30 Specialty Structures Manufacturer Perspective ..... Carl Madsen
Chief Scientist, ATK Aerospace Structures Division

12:00 Lunch in Reid Conference Center

Composite Certification/DOD Perspective Presentations

1:00 FAA Perspectives: Composite Safety and Certification Initiatives ..... Dr. Larry Ilcewicz
Chief Scientific and Technical Advisor for Advanced Composite Materials, FAA

1:30 ASIP View on Certification of Advanced Composite Structures ..... Charles Babish
Technical Advisor, Aircraft Structural Integrity, USAF AFMC ASC/EN

2:00 DoD Lessons Learned in Composite Airframe R&D ..... Dr. John Russell
Program Manager, Defense-Wide Manufacturing Science and Technology, AFRL/RXMT

2:30 Break

Composite Industry Perspective Presentations 2

2:45 Challenges to Composite Technology Insertion on Business Jets ..... Andrew Foose
Director, Composites Engineering, Gulfstream Aerospace Corporation

3:15 Helicopter Composite Perspective ..... Dr. Michael Urban
Chief Structural Methods and Prognostics, Sikorsky Aircraft Corporation

3:45 Challenges Facing the Automotive Applications of Composites ..... Dr. Hamid Kia
Lab Group Manager – Polymer Composites Group, Global Research & Development, General Motors

4:15 Composites in Naval Shipbuilding: Experience, Successes and Challenges ..... John Sullivan
Naval Architect, Ingalls Shipbuilding

4:45 Questions & Answers Session/Wrap Up Day 1

5:00 Adjourn

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Space Administration

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Wednesday, May 2, 2012

8:00	Introductory Remarks/Session Logistics
8:15	Assemble in Breakout Rooms (3 parallel sessions)
8:30	Discussion
10:15	Break
10:30	Group Report Outs (15 minutes/group)
11:15	Wrap Up
11:30	Break/Board Buses for travel to NASA Langley Cafeteria for Lunch
1:00	Board buses at Cafeteria for facility tours
3:00	Tour will conclude with buses returning to Reid Conference Center

Each session will be a moderated, open table top discussion focused on these topics:

1) Given the present development process for your industry, identify critical technology challenges that must be overcome to enable the goal of a 3-year design/development/ certification cycle for advanced composite structures.
2) Focus areas for technology development to address these challenges.
3) Non-technical challenges that need to be addressed (e.g., IP, regulatory, etc.)
4) Suggestions for a Public-Private Partnership framework to achieve the goal.

Additional Guidelines for Participants:

- Discuss/identify shortfalls and areas where NASA can leverage with Industry/FAA/DoD
- Discuss what it would take to convince all parties to change the present development paradigm
    1. OEM acceptance
    2. Regulatory acceptance
    3. Customer/operator acceptance

Attachment B

List of Workshop Attendees

Prefix	Last Name	First Name	Company	Title
Ms.	Adelson	Beth	Senator Warner's Office	
Mr.	Annett	Martin	NASA Langley Research Center	Aerospace Engineer
Mr.	Arend	Greg	United Launch Alliance	Structure Development Manager
Mr.	Babish	Chuck	USAF	Technical Advisor, Aircraft Structural Integrity
Mr.	Beam	Brian	Sierra Nevada Corporation	Structural Engineer
Mr.	Boone	Richard	Cessna Aircraft	Sr. Project Engineer, Advanced Design
Mrs.	Bowman	Lynn	NASA Langley Research Center	Project Manager
Mr.	Browning	Jim	General Dynamics, ATP, Advanced Materials	Director of Engineering
Mr.	Charles	Stanton	Senator Webb's Office	
Ms.	Crisp	Vicki	NASA Langley Research Center	Director Aeronautics
Dr.	Dastoor	Minoo	NASA/OCT	Program Executive
Mr.	Davies	Curtis	FAA	Program Manager Advanced Composites and Structural
Mr.	Devereux	Nicholas	Senator Warners Office	
Mr.	Dickens	E. Dana	Hampton Roads Partnership	President and CEO
Dr.	Dragone	Tom	Orbital Sciences Corporation	Senior Scientist
Dr.	Fish	John	Lockheed Martin Aeronautics Co.	Senior Manager - Airframe Technology
Mr.	Foose	Andrew	Gulfstream Aerospace	Director, Composites Engineering
Mrs.	Froehlich	Rosemary	NASA Langley Research Center	Head, Science & Flight Projects Contracting Branch
Mr.	Fuhrmann	Barrett	Honeywell Aerospace	Engineer Fellow - Composites
Dr.	Gambone	Mary Lee	Rolls-Royce Corporation	Head, Materials Engineering
Dr.	Gazarik	Mike	NASA HQ	Associate Administrator for Science
Mr.	Greco	Giovanni	Blue Origin	Product Group Lead
Mr.	Grillos	Emmanuel	Blue Origin	Engineer
Dr.	Harris	Charles	NASA Langley Research Center	Director, Research Directorate

Mr.	Heinemann	Kurt	Pratt and Whitney Aircraft Engines	Compresssion Systems Methods Manager
Mr.	Homeyer	Ken	Triumph Aerostructures	Manager - Technology and Test
Prof.	Hyer	Michael	Virginia Tech	Professor Emeritus
Mr.	Ilcewicz	Larry	FAA	Chief Scientific and Technical Advisor
Mr.	Irvine	Thomas	NASA Headquarters	Deputy Associate Administrator for Aeronautics
Dr.	Jensen	Brian	NASA Langley Research Center	Senior Researcher, Advanced Materials
Dr.	Johnson	Ray	Lockheed Martin Corporation	Senior Vice President and Chief Technology Officer
Dr.	Kia	Hamid	General Motors R&D Center	Lab Group Manager
Mr.	Kysar	Randy	Spirit AeroSystems/Advanced Composites	Sr Manager
Mr.	Lally	Rick	Innovate Hampton Roads	Director
Dr.	Lavoie	Andre	Space Exploration Technologies	Senior Propulsion Engineer
Ms.	Lawson	Donna	NASA Langley Research Center	Government Relations Officer
Mr.	Madsen	Carl	ATK Aerospace Structures Div - R&D Engineering	Chief Scientist
Mr.	Maher	Michael	DARPA	Program Manager
Ms.	Marlowe	Jill	NASA Langley Research Center	Director, Engineering
Mr.	McLaughlin	Stephen	Sierra Nevada Corporation	Analysis Manager/ Structural DER
Mr.	McMurry	Tom	NASA Langley Research Center	Attorney
Mr.	Moore	Jason	Lockheed Martin Corporation	Technical Advisor to the Chief Technology Officer
Mr.	Morgans	Shawn	Ford Motor Company / Product Development	Technical Leader
Dr.	Naik	Rajiv	Pratt & Whitney	Fellow
Dr.	O'Brien	Thomas	NASA Langley Research Center	Aerospace Engineer
Mr.	Palm	Tod	Northrop Grumman Aerospace Systems	Manager Advanced Structures Development
Mr.	Perey	Daniel	NASA Langley Research Center	Engineer
Dr.	Piascik	Robert	NASA Engineering and Safety Center	NASA Technical Fellow for Materials

Mr.	Powers	William	Rolls-Royce North America Inc.	Executive Vice President, Chief Financial Officer
Dr.	Raju	Ivatury	NASA Engineering and Safety Center	NASA Technical Fellow for Structures
Mr.	Reese	Thomas	Virginia Modeling, Analysis and Simulation Center	Director, Business Development & Tech Transfer
Mr.	Rodgers	George	Northrop Grumman Aerospace Systems	Director, Technology Development
Ms.	Roe	Lesa	NASA	Director - NASA Langley
Mr.	Rogers	William	Navigation Ctr LaRC	Facilitator
Mr.	Roulo	Eric	SpaceX	Stress Analyst
Ms.	Runyan	Caitlin	Senator Warner's Office	
Dr.	Russell	John	Air Force Research Laboratory	Principal Materials Engineer
Mr.	Schmidt	Kip	Spirit AeroSystems/Technology Development	Director
Dr.	Schultz	Marc	NASA Langley Research Center	Aerospace Research Engineer
Congressman	Scott	Bobby	US House of Representatives	
Dr.	Scotti	Stephen	Research Directorate, NASA Langley Research Center	Chief Engineer for Structures and Materials
Dr.	Shahwan	Khaled	Chrysler	Engineering Specialist
Mr.	Simon	David	United Launch Alliance	Strength Engineer
Mr.	Smith	Stephen	Hamilton Sundstrand	Fellow-Composite Structures/Damage Tolerance
Mr.	Sullivan	John	Ingalls Shipbuilding	Naval Architect
Dr.	Sullivan	John	NASA	Senior Advisor
Mr.	Topper	Paul	Honeywell	Staff Engineer
Dr.	Turcotte	Rheal (ray)	NASA Langley Research Center	Partnership Manager
Ms.	Turner	Donna S.	NASA Langley Research Center	Senior Facilitator
Dr.	Tzeng	Jerome	Army Research Laboratory	Research Engineer
Dr.	Upadhyay	Ram	GE Global Research	Principal Engineer
Dr.	Urban	Michael	Sikorsky Aircraft	Chief, Structural Methods
Dr.	VanderHeiden	Bert	ATK/Aerospace Structures Division	VP Engineering
Mr.	Ward	Douglas	GE Aviation	Composite Consulting Engineer
Senator	Warner	Mark	US Senate	
Dr.	Weinstein	Edward	FAA	Section Manager

Dr.	Xie	Ming	GE Aviation	Senior Engineer
Mr.	Yaskowsky	Mike	Hampton Economic Development	Sr. Business Development Manager
Mr.	Young	Gerould	Boeing	Director Materials & Fabrication Technology
Dr.	Yuan	Fuh-Gwo	North Carolina State University	Professor