AIAA Ground Test Technical Committee

GTTC Website

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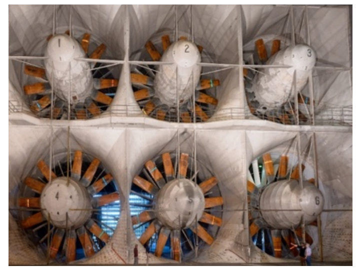
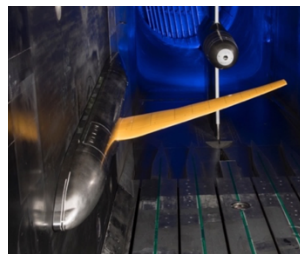
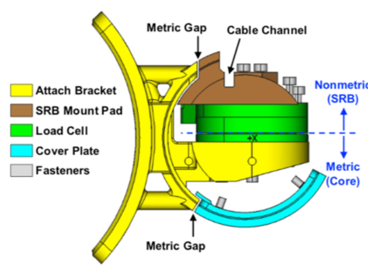
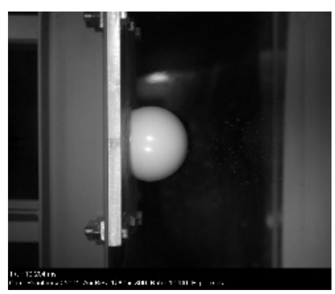
GTTC Newsletter

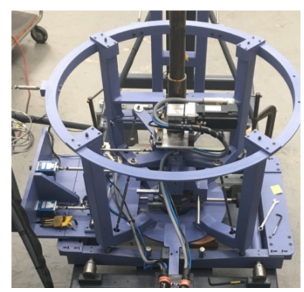
San Diego, CA
Winter 2019
Issue No. 46

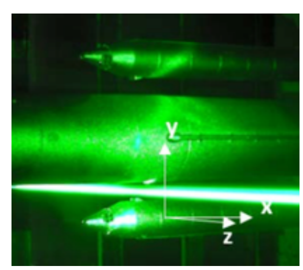












Chairman's Message

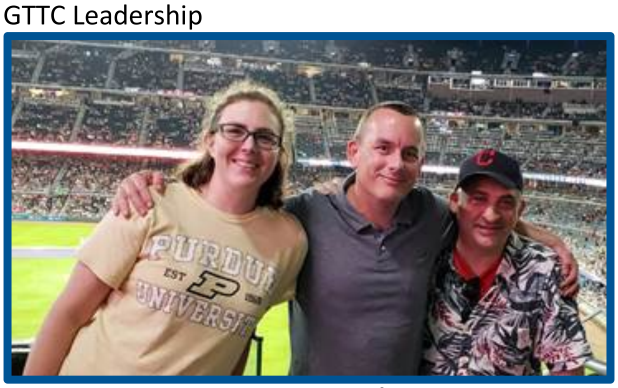
Thank you for reading through our Ground Test Technical Committee (GTTC) Newsletter. This newsletter is meant to keep AIAA members informed on GTTC activities with some highlights from across the industry. I hope you find it interesting and worth your time to read.

The GTTC is pleased to be part of the AIAA SciTech 2019 conference in San Diego, CA. We welcome a number of new members, and have many technical activities planned, including meetings about, awards, publications, standards, education, conference proceedings and student activities. Our active Technical Committee (TC) members also participate in a number of working groups in technical focus areas like internal balances, flow quality, wind tunnel model attitude/deformation, dual flow reference nozzle, uncertainty standards, the future of ground testing, and statistically defensible experiments.

We like to say we put the "T" in TC, so try to come to our technical sessions to see what kinds of testing activities are being presented and documented. GTTC technical sessions are listed in the conference program and all are welcome to attend the working group meetings and actively participate in this process. If you are interested in becoming a GTTC member, applications can be input through the AIAA web site, www.aiaa.org.

We are always looking for ways to improve the GTTC and our overall value to the aerospace community. Your ideas and participation are greatly appreciated. The AIAA is a tremendous forum for exchange of ideas, learning, advocating for our industry, and networking – we try to emulate that within the GTTC as we work hard, enjoy each other's company, and have fun. We're increasingly using our web site (within the AIAA Engage platform https://engage.aiaa.org/home) for communication and posting of our latest information – please check it out if you get a chance. If you have any questions or want more information about the GTTC, please contact myself by email at victor.a.canacci@nasa.gov or by phone at 216-536-7845.

GTTC Leadership



Pictured Left to Right: (Vice-Chair/ Stephanie Simerly, Secretary/Ryan Kew, & Chair/Vic Canacci).

Thank you,

Vic Canacci

GTTC Chairman

The World's Forum for Aerospace Leadership

Upcoming GTTC Conferences

AIAA SciTech 2019
7 - 11 January 2019 | San Diego, California

AIAA AVIATION 2019
17 - 21 June 2019 | Dallas, Texas

AIAA SciTech 2020
6 - 10 January 2020 | Orlando, Florida

About the GTTC

The GTTC is one of more than 60 technical committees sponsored by the American Institute of Aeronautics and Astronautics (AIAA). It is made up of approximately 50 professionals working in various areas of the ground testing world.

Our membership addresses important technical issues that affect ground testing through several means, including the development of guides and standards, dissemination of information through technical sessions at conferences, and the development and sponsorship of short courses.

The GTTC also participates in Congressional Visits Day, which is a vital tool for making sure that aeronautics and space-related research and testing are supported at required levels.

One of the primary functions of every technical committee is the sponsorship and development of conferences and technical sessions. The GTTC supports two conferences each year. Every January, the GTTC meets at the AIAA Science and Technology Forum and Exposition (AIAA SciTech), where we sponsor several technical sessions (typically a dozen or more). In the summer, the GTTC also attends and sponsors sessions at the AIAA Aviation and Aeronautics Forum and Exposition (AIAA AVIATION).

Best Paper Award

The AIAA Ground Testing Technical Committee hosts sessions in the summer AVIATION and winter SciTech conferences. GTTC annually recognizes several outstanding papers from both the AVIATION and SciTech conferences. These "Outstanding Papers" are reviewed each spring to select one "Best Paper" for the entire year. The recipient(s) of the 2019 Ground Testing Best Paper Award will be recognized during the AIAA awards luncheon held at the 2019 AVIATION conference in Dallas, TX.

The Outstanding Paper from AVIATION 2018 was:

AIAA-2018-4050, "Uncertainty Quantification in Steady State PSP Using Monte Carlo Simulations at AEDC", Michael A. Nelson.

AIAA Ground Test Award

The Ground Test Award is given to an individual or team that has made significant contributions to the field of ground testing in the aerodynamic and propulsion disciplines during their careers. Recipients are selected based on several criteria including: excellence in technical or managerial ground testing, participation in professional societies, authoring publications and papers, and teaching or mentoring activities. The AIAA Ground Test Award winner will be recognized during the AIAA awards luncheon held at the 2019 AVIATION conference in Dallas, TX.

Anyone can submit nominations for the Ground Test Award. Simply login to your AIAA account at http://www.aiaa.org and click "Honors and Awards" to start a new nomination for the Ground Test Award. Nomination packages must be submitted no later than October 1 of a given year to be considered for the following years' Ground Test Award. Please contact Vic Canacci (victor.a.canacci@nasa.gov) for more information.

Focus Groups

The primary function of a focus group is sharing of information within the ground-test community. Focus groups typically meet twice a year at AIAA conferences where members share the free exchange of ideas, lessons learned, and build technical knowledge. Membership is open to anyone!

Current GTTC Focus Groups

- US Industry Test Facilities
- Statistically Defensible Test Methods
- Turbine Engine Test
- Dynamics Space Simulation
- Technical Quality Writing

Active Working Groups

GTTC working groups are established to address technical needs in the aerospace ground testing community. These provide a forum for discussion and the development of solutions and standardization in technical areas. Members include GTTC, non-GTTC, and non-AIAA industry and academia experts. Meetings are held to coincide with GTTC meetings. Anyone interested in these working groups are encouraged to attend the meetings, including non-GTTC members! Go to the AIAA conference registration desk and ask for a “Committee List” with meeting rooms and times. The active GTTC Working Groups include:

Dual Flow Reference Nozzle

Chair: David Myren - ASE FluiDyne
Vice-Chair: Kevin Mikkelsen - ASE FluiDyne

Develop a recommended practice AIAA document for defining a standard configuration for dual flow reference nozzles.

Future of Ground Testing

Chair: Steven Dunn – NASA Langley
Vice-Chair: John Micol – NASA Langley

Experimental ground testing subject matter experts working to develop a roadmap for non-engineers demonstrating the importance of experimental and computational tools necessary to support aerospace mission requirements.

Internal Balances Technology II

Chair: Ray Rhew - NASA Langley
Vice-Chair: David Cahill - Sierra Lobo, Inc.

Investigate a wide variety of technical issues associated with the use of internal strain-gage balance technology for wind-tunnel testing.

Model Attitude Measurement

Chair: John Hopf - AEDC
Vice-Chair: Kenneth Toro - NASA Langley

Develop a recommended practice that discusses methods to measure model attitude in wind-tunnel testing.

Model Deformation

Chair: Martin Wright - ETW
Vice-Chair: Melissa Rivers - NASA Langley

Develop a recommended practice that discusses methods to measure model deformation and twist in wind-tunnel testing.

Measurement Uncertainty Analysis

Chair: Erin Hubbard - NASA Glenn
Vice-Chair: Tyler McElroy - NASA Glenn

Develop best practices and/or standards for the measurement and reporting of experimental uncertainty associated with wind-tunnel testing.

Wind Tunnel Flow Quality

Chair: Ben Mills - AEDC
Vice-Chair: Rajan Kumar - Florida State Univ.

Develop best practices and/or standards for the measurement and reporting of unsteady or fluctuating flow parameters related to wind-tunnel testing.

High Speed WT Calibration

Chair: Matt Rhode - NASA Langley
Vice-Chair: Mike Mills

Develop a recommended practice AIAA document for the calibration of high speed (supersonic and higher) wind tunnels.

GTTC Task Subcommittees

Task Subcommittees (SC) are comprised of current GTTC members and are responsible for most of the duties necessary to operate the GTTC each year. This includes planning conference sessions, awarding outstanding papers and workers in the field of ground testing with nationally recognized awards, maintaining and generating new publication materials, recruiting and appointing new members, and coordinating student outreach and educational activities.

GTTC Steering Committee

Chair: Victor Canacci – Jacobs, GRC
Vice-Chair: Stephanie Simerly – NASA Glenn
Secretary: Ryan Kew – Calspan FMS

The Steering committee provides the bulk of the administrative efforts for the GTTC. The Steering committee reviews policy, AIAA business and all matters of global interest to the GTTC. The Steering committee is composed of the GTTC chair and vice-chair as well as the Primary and Tasks subcommittee chairs and vice-chairs.

Awards and Upgrades

Chair: Matt Rhode - NASA Langley
Vice-Chair: John Micol - NASA Langley

The Awards and Upgrades Subcommittee coordinates and participates in the selection process for the annual Ground Testing Award presented by AIAA. This award is presented for outstanding achievement in the ground testing field. In addition, the committee encourages GTTC members to upgrade their membership status, as appropriate. Finally, the committee manages the Outstanding Paper Award process. The Outstanding Paper Award recognizes the technical quality, technical relevance, presentation, and readability of papers presented at the various GTTC sessions.

Conferences

Chair: Ben Mills – AEDC
Vice-Chair: Pat Goulding II – NFAC

The Conference Planning Subcommittee, as its name implies, plans and organizes GTTC conferences and sessions. The committee plans and organizes the GTTC-sponsored sessions for the annual SciTech forum in the winter and the AVIATION forum in the summer. Planning and organizing activities include electing conference chairs, selecting session chairpersons, the conference program, and the site meeting room; preparing the Call for Papers; and planning of coordinated short courses, tours, luncheons, and special exhibits.

Education and Student Activities

Chair: Paul Kelly - QuantiTech, Inc.
Vice-Chair: John VanHorn – NASA Ames

The Student Activities Subcommittee encourages interaction between GTTC members and their local schools. New ideas for experiments and/or testing kits for students who want to learn about flight and aviation are always needed.

Membership

Chair: Stephanie Simerly - Jacobs, GRC
Vice-Chair: Ryan Kew – Calspan FMS

The Membership Subcommittee, which is comprised of the vice chair of the GTTC and the vice-chairs of the Aerodynamics and Propulsion subcommittees, strives to provide a balance in the technical background and represented organizations when reviewing applications for new members. Selected new members are notified in March. Applicants who are not selected in the year that they apply are eligible for consideration the following year.

Publications

Chair: David Chan – NASA Langley
Vice-Chair:

The Publications Subcommittee promotes the efforts of the various GTTC subcommittees through dissemination and publication of technical information, journal articles, and use of other forms of media. In addition to the annual Aerospace America Highlights article, the committee is responsible for preparing the GTTC newsletter and maintaining the technical committee's web site. Ground-testing-related articles and news items for use in Aerospace America Highlights and the GTTC newsletter are solicited from current and former GTTC members and others in the ground testing community.

Standards

Chair: Chris Jorgens – Boeing
Vice-Chair: Brianne Williams – Aerospace Corp.

The Standards Subcommittee oversees the AIAA standards, recommended practices, and guides that are published by the GTTC.

AIAA Standards, Recommended Practices & Guides Published by the GTTC

AIAA Recommended Practice for Wind Tunnel Testing — Part 1 (R-092-1-2003e)

AIAA Recommended Practice for Wind Tunnel Testing — Part 2 (R-092-2-2003e)

AIAA Recommended Practice for Calibration and Use of Internal Strain-Gage Balances with Application to Wind Tunnel Testing (R-091-2003e)

AIAA Recommended Practice for the Calibration of Subsonic and Transonic Wind Tunnels (R-093-2003e)

Assessment of Experimental Uncertainty with Application to Wind Tunnel Testing (S-071A-1999e)

AIAA Guide to Assessing Experimental Uncertainty — Supplement to S-071A-1999 (G-045-2003e)

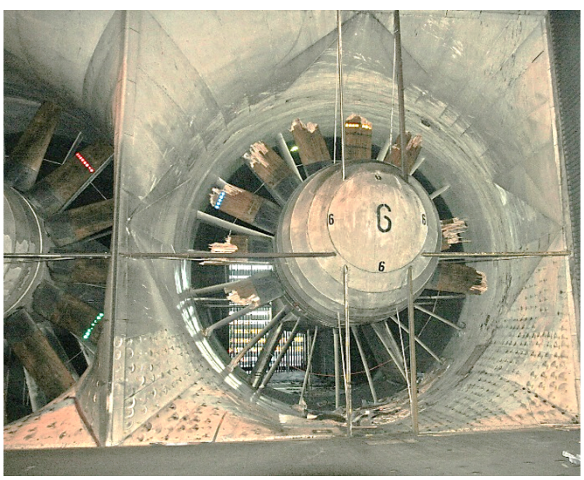
AIAA Guide to Nomenclature and Axis Systems for Aerodynamic Wind Tunnel Testing (G-129-2012e)

AEDC's NFAC Facility Returns to Service Following Major Mishap

By: Pat Goulding II, AEDC

The Arnold Engineering Development Complex (AEDC) is pleased to announce its National Full-Scale Aerodynamics Complex (NFAC) has returned to operational status as of June 2018 following more than a year of repair and reactivation activities to recover from a Class A mishap suffered on 9 June 2017.

The facility was operating its 80- by 120-foot Wind Tunnel (80x120)—the largest wind tunnel in the world—when a portion of transition ramp cladding on the interior of one of the tunnel side walls separated into the air stream and was ingested into the tunnel fan drive system. The NFAC fan drives consist of six 40-foot-diameter drive motors, each fitted with 15 variable pitch fan blades built from multiple types of wood, primarily spruce. The incident completely destroyed all the fan blades on one of the six drive fans and caused extensive damage to the shrouds and other structures on several more.



All 15 blades on Fan Motor 6 in the NFAC fan drive were severely damaged in the June 2017 mishap, requiring total replacement.

Potential clean up and recovery efforts stood down for several months to allow the USAF and NASA to conduct detailed mishap investigations and root cause analyses. Once authorized by the various investigative board presidents, AEDC began clean up and recovery efforts with the intent of returning to operational capability as soon as possible.

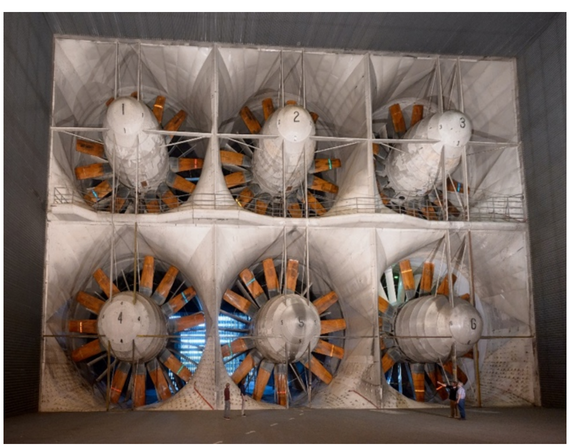
The team conducted an extensive suite of inspections and checkouts to characterize the complete extent of the damage sustained in the incident and determine whether additional areas or systems warranted more attention. This included completing comprehensive electrical checks on the drive motors, measuring shaft run-out on the damaged drive fans to ensure the drive shafts had not been deformed, and conducting detailed inspections of tunnel structure and cladding to determine other potential failure points. These efforts revealed that damage to the fan drives was limited almost exclusively to the blades and shrouds. A number of mitigations were established to address minor areas of concern in the tunnel circuit and structure.

All fan blades on one of the six drive motors had been completely destroyed and the facility did not possess sufficient spares to repopulate the drive. The crew therefore explored two options to return to operations while waiting for additional blades to be built. The first option involved leaving the remaining five drive motors in their normal state and operating with the sixth drive acting as a flow-through nacelle. AEDC's computational experts created a model to simulate this configuration using CFD. This investigation revealed that significant reverse flow developed in the empty shroud, causing large flow disturbances and high loads. Blocking the entrance to the shroud likewise created large flow asymmetry in the circuit and this idea was quickly abandoned.

The team next explored redistributing healthy and repaired blades from the remaining five drives to equip all six motors with 12 blades each. The drive hubs are designed to accommodate 15 blades, meaning that the new configuration required a "gap-toothed" arrangement with three "pods" of four blades each to maintain a balanced configuration. CFD simulations revealed increased loads on the leading blade in each "pod," but these loads were still within acceptable limits, proving concept feasibility. CFD simulation work was summarized in AIAA-2018-3873 presented at the 2018 Aviation Forum.

The team next conducted isolated runs on one of the undamaged drive motors, first with 15 and then with 12 blades, and obtained a vast array of detailed performance and health information to further establish confidence before redistributing to 12 blades on each motor. Final acceptance testing on the repopulated drive was completed between May and June of 2018, revealing surprisingly little degradation in overall tunnel performance.

The new configuration has allowed AEDC to resume testing in support of customer programs in the 40- by 80-foot Wind Tunnel (40x80). Reactivation efforts continue in the 80x120 with the hopes of returning that tunnel to service within the next year. AEDC is in the process of designing and procuring a complete set of new fan blades to restore the NFAC to its baseline capability and extend the service life of the fan drive.



Tunnel operations crew members inspect the reconfigured drive fans at AEDC's NFAC following the recent repair and recovery efforts.

AEDC Develops a Capability for Pre-Test Predictions of Facility-Model Wake Interactions at NFAC

By: Chris Nykamp & Pat Goulding II, AEDC

The National Full-Scale Aerodynamics Complex (NFAC) experienced a Class-A mishap during operation of its 80- by 120-foot Wind Tunnel (80x120) on 9 June 2017. The wind tunnel, a geographically separated unit of the Arnold Engineering Development Complex (AEDC), was supporting flight qualification testing for the NASA/Jet Propulsion Laboratory (JPL) Mars 2020 parachute system at the time of the incident. The mishap occurred while the inflated parachute was flying in the tunnel when a section of panels on the facility wall released into the airstream and passed through the fan drives causing severe damage to the fan blades. This resulted in roughly one year of downtime while investigations, assessments, repairs, and recovery efforts were undertaken to bring the facility back to operational status.

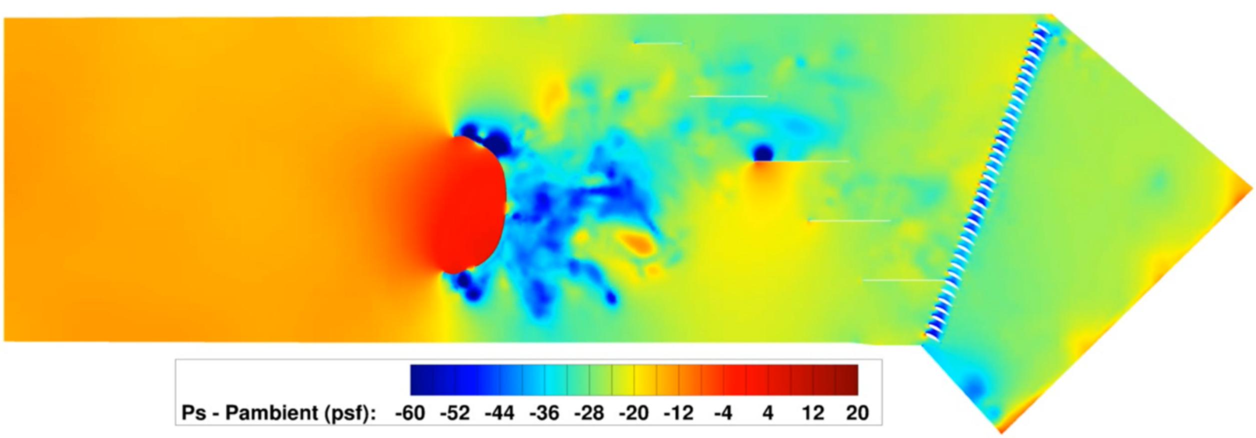
Mars 2020 canopy in flight in the NFAC 80- by 120-foot Wind Tunnel.

NASA and JPL have utilized the NFAC's 80x120 several times over the last 20 years to assess parachute performance, qualify flight assets, and verify workmanship on parachute systems for numerous programs including Mars Exploration Rover, Mars Science Laboratory (Curiosity), and the Orion Capsule Parachute Assembly System. The unique size and speed regime of the 80x120 are particularly well-suited to this type of testing, allowing parachute researchers to simulate actual inflation loads on full-scale and flight-lot canopies. The 80x120 is the only facility in the world large enough to accommodate these test assets, making it a critical link in NASA's space exploration mission.

The mishap raised the question as to what, if any, role this regular parachute testing had played in potentially contributing to the panel failure. One recommendation of the investigation teams was to conduct pre-test simulations to better assess the loading all tests impart on the facility walls and structure, particularly those which constitute a high blockage and/or produce large and dynamic loads. This led to a need for a robust and accurate facility model using Computational Fluid Dynamics (CFD). AEDC developed a high-fidelity solid model of the wind tunnel and partnered with colleagues at NASA and the Lawrence Livermore National Laboratory (LLNL) to assemble the required inputs for the simulation effort.

AEDC computed simulations both with and without the parachute installed and the team compared these results against test data acquired during the test program in order to help validate and verify the fidelity of the CFD simulations. The team also ran additional studies to investigate the sensitivity of the facility wall loads to differences in prescribed canopy motion and higher test section velocities. The results are promising and generally tend to provide a conservative estimate of the facility loading imparted by these tests. This is largely due to the limitations in CFD with respect to accurately modeling the near-floor boundary layer created by the facility's unique acoustically-treated flow liner and due to simplifications in modeling the parachute as a rigid body with prescribed motion. Future work is planned to expand this capability to simulate and predict loads from rotor testing in the NFAC's 40- by 80-foot Wind Tunnel.

Ultimately, this work will help to establish a reliable capability that AEDC can use to predict test loads and set safe operational limits on future test programs in the NFAC facility. It will also eventually allow for more accurate pre-test performance predictions that future customers can leverage to better assess and understand the research data gathered, thus increasing the utility of the facility to the ground test community.



An unsteady time-accurate simulation of the Mars 2020 canopy with prescribed motion in the NFAC 80- by 120-foot Wind Tunnel. This is a frame from the CFD animation results showing dynamic pressure of the flow field at the mid-plane of the tunnel. Results produced by AEDC with CREATE-AV Kestrel.

JAXA's Bird Strike Test Facility

By Masahiro Hojo, JAXA

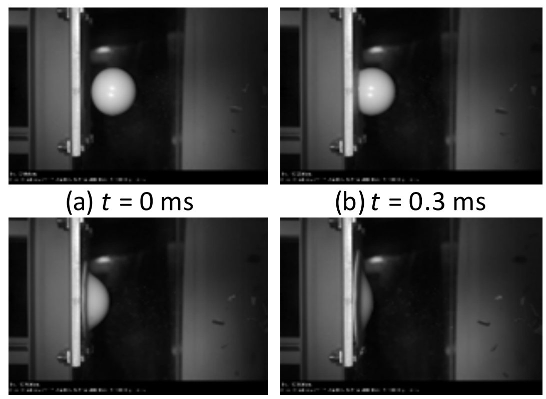
Submitted by Keiichi Okai, JAXA

A single stage gas gun system manufactured by Physics Applications, Inc. to conduct bird strike tests of full-scale fan blade models was installed in the JAXA Chofu aerospace center in March 2018.

The gas gun system has a gas reservoir filled with air or helium gas with pressure up to 1.0 MPa. At the moment of firing, a fast valve opens to expose the gas from the gas reservoir to a projectile located at the launch tube inlet. Expansion of the gas accelerates the projectile within the launch tube.

Gelatin ball held in sabot

A gelatin ball is usually used as the projectile for the bird strike tests of fan blade models in order to adjust its stiffness and density. The stiffness of the gelatin ball can be adjusted by mixture ratio of the gelatin powder to water. The density of the gelatin ball can be also adjusted by amount of added micro balloons. The gelatin ball is held inside the polyethylene sabot and is designed for high pressure. The gelatin ball is separated from the sabot by the sabot stopper mounted on the outlet of the launch tube. The gas gun enables the gelatin ball to fly at velocities in the range of 50 to 400 m/s. In order to measure the velocity of gelatin ball, two pairs of HeNe laser/detector are mounted at the launch tube outlet. The test chamber has large polycarbonate windows and the dynamic behavior of the fan blade model can be visualized using high-speed video cameras. The multi-channel signal conditioner and the high-speed data acquisition system can acquire the time history of strain gage output attached to the surface of fan blade model.



(a) t = 0 ms (b) t = 0.3 ms

(c) t = 0.6 ms (d) t = 0.9 ms

Time history deformation of a gelatin ball shot to rigid wall

Currently, JAXA is working to improve the gas gun system and the bird strike test method. The figure above shows an example of high speed visualization results of the gelatin ball shot to the rigid wall to understand the dynamic response of the gelatin ball.

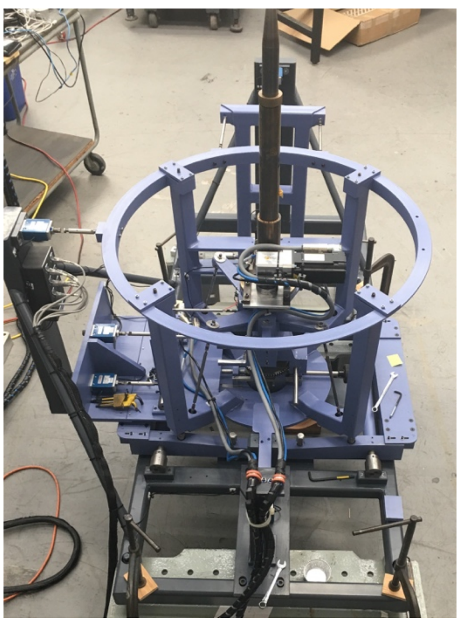
Bird Strike test facility at JAXA

Calspan FMS Helps University Improve Testing Capability

By Adam Ferrarelli, Calspan FMS

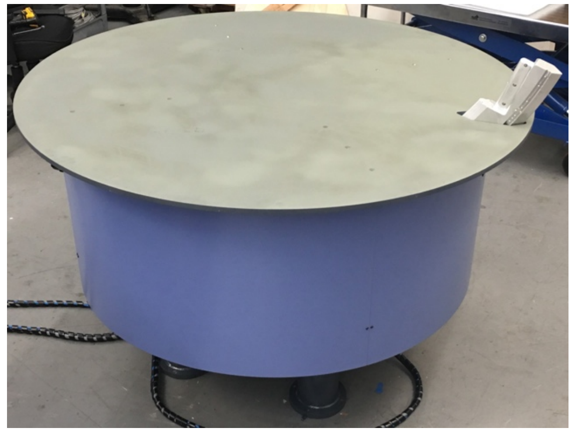
Calspan - Force Measurement Systems (FMS) developed three balance / model positioning systems for use in two test sections of a new wind tunnel. This effort was comprised of a Pyramidal External Balance with a Single Strut mount for the wind tunnel model, a Crescent Model Positioning System with a sting mounted internal strain gauge balance, and a Side-Wall Balance /model positioning system.

The Pyramidal External balance was designed to operate in the smaller high speed section of the wind tunnel. It has a single strut configuration in which the models are mounted along the tunnel centerline. The pitch mechanism is contained within the single strut assembly allowing for a compact design that allows for high angle settings and resolution.



Pyramidal External Balance and integrated positioning system during build up.

The Crescent style model positioning system (MPS) was designed to be located in the larger low speed test section of the wind tunnel. The internal strain gauge balance is fixed to the sting and mounted to the crescent arm which allows the model to be pitched and yawed in the test section by remote control. Roll angles can be manually set in 15 degree increments at the aft end of the sting. The crescent can be retracted beneath the tunnel floor and stored internal to the MPS system, leaving a clean test section for tunnel calibration.



Crescent model positioning system.

The Sidewall system was designed to operate in either the high speed or low speed test section. To meet this requirement it has a rolling cart which mounts to the base and allows for easy movement of the system between both test

Sidewall model positioning system with the model block adapter installed.

sections. The five component balance for this application was configured as a left hand wing to support semi-span type model testing.

FMS utilized their assembly lab for the build and calibration of each of these systems. In doing so, an extensive multi-component manual calibration was performed on the Pyramidal External balance. It was calibrated so the balance moment reference center would coincide with the center of the single strut bayonet at the tunnel center. The Sidewall semi-span balance and internal sting balance were calibrated using the Automatic Balance Calibration System (ABCS). This machine allows for all 6 aerodynamic load components to be loaded individually or applied simultaneously with hydraulics.

This project will culminate with a factory acceptance test at the FMS facility in San Diego prior to hardware delivery to the customer's facility.

NASA Ames UPWT Successfully Completes Second Round of Check Standard Model Testing

By Jonathan Vanhorn, NASA Ames

The Unitary Plan Wind Tunnel (UPWT) at NASA Ames Research Center recently completed its second round of testing a newly designed check standard model in the 11-ft Transonic test section.

The Ames Check Standard Model (ACSM) is a 6.5-foot wingspan model representative of a transonic commercial transport. It was developed from the NASA Common Research Model (CRM) design.

An 83-hour wind tunnel test series was completed in June 2018. The objectives of the test were to: utilize IR Thermography to better understand the natural and coerced transition and to validate correct sizing of the transition dots; obtain a set of force data to develop the process for defining 3-way control charts for

Ames Check Standard Model Installed in the 11-ft Transonic Wind Tunnel at NASA Ames

tracking stability of the UPWT test process; and calibrate a Flush Air Data System mounted on the nose. All planned test runs were successfully completed, including all lower priority runs.

Check Standard testing is a valuable process for evaluating the stability of the 11-ft wind tunnel test process by acquiring repeat data sets at select test conditions. Future tests will allow the UPWT to evaluate repeatability and reproducibility of its data using the analysis methods of statistical process control.

Testing this model also allows the wind tunnel to evaluate new procedures, instrumentation, test techniques or the effect of changes made to the wind tunnel. Future plans for this model include having a dedicated high-accuracy balance designed and fabricated. This test entry is just one of the over 2,700 Occupancy Hours that the NASA Ames Unitary Plan Wind Tunnels supported in 2018.

For more information on the Ames Check Standard Model testing, see paper:

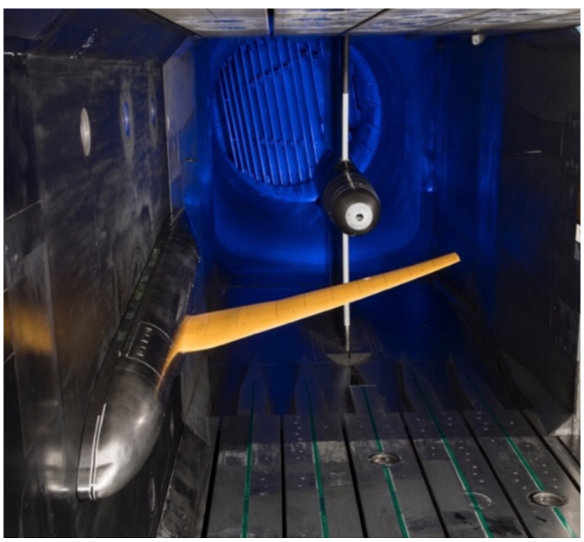
AIAA-2019-2193, "*A Preliminary Investigation of the Check Standard Model in the NASA Ames Unitary Plan Wind Tunnel*"

Preliminary Experimental Confirmation of a Natural Laminar Flow Design Method

By Michelle Lynde, Neal Watkins, & Melissa Rivers, NASA LaRC

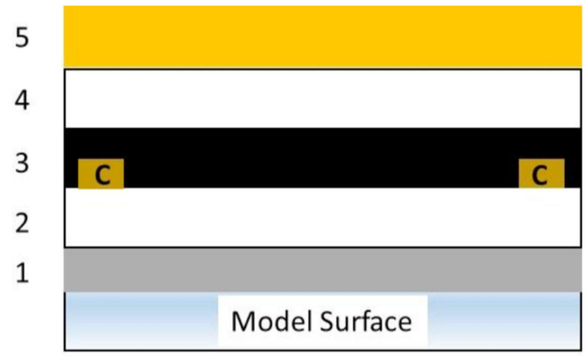
Submitted by David Chan, NASA LaRC

An experimental investigation of the Common Research Model with Natural Laminar flow (CRM-NLF) in the National Transonic Facility (NTF) at the NASA Langley Research Center was completed on October 18, 2018. The 5.2% scale semispan CRM-NLF model was designed to experimentally validate a new transition delay method, referred to as Crossflow Attenuated Natural Laminar Flow (CATNLF).



The 5.2% scale semispan model of the CRM-NLF installed in the NTF

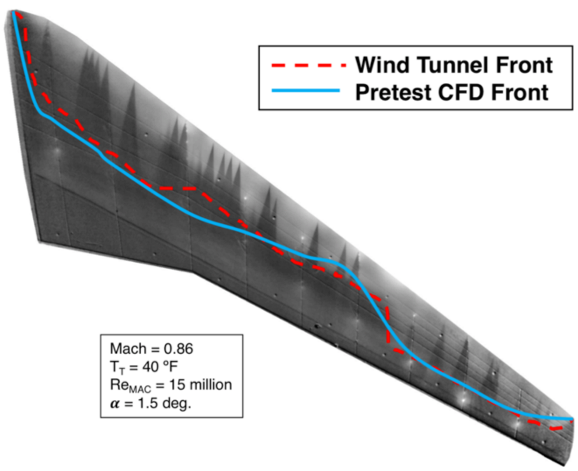
The CATNLF method was developed to address the challenges associated with obtaining laminar flow on highly-swept transport aircraft wings. The primary challenge that the method addresses is the growth of crossflow instabilities in the laminar boundary layer, often causing transition very near the leading edge. The CATNLF method carefully designs the leading-edge shape of the airfoils to generate specific pressure distributions that naturally damp this crossflow growth.



Schematic of TSP/heating system layer

A carbon-based resistive heating layer was used in conjunction with Temperature Sensitive Paint (TSP) for the detection of flow transition. The TSP/heating layer system consisted of several layers which are illustrated in the above figure and described below. First, an adhesion layer (1) was applied to the model surface and allowed to cure in air. Next, a white polyurethane layer (2) was applied to act as an electrical insulation layer. This layer can be either air cured overnight or cured at 70ºC for 2 hours. After this layer is cured, the electrical connections (C) are applied. For this work, simple copper tape was employed. Then the carbon-based polyurethane heating layer (3) was applied and allowed to cure in air overnight. Next, another layer of the white polyurethane was applied (4). This layer is needed as the heating layer is black in color. The white layer serves to scatter more of the emission light away from the surface for collection by the camera. Finally, the TSP topcoat (5) was applied and allowed to air cure. In this work, a thicker layer of TSP was applied to mitigate the possibility of leading edge damage. With a suitable thickness of TSP, the layer could be polished as needed without removing the entire TSP layer.

Preliminary results from the test in the NTF confirm both the CATNLF concept and the design procedure. The extents of laminar flow seen in the transition front images acquired during the test agree well with the pretest computational predictions. The extents of laminar flow (represented by transition Reynolds number) that were obtained on this model are nearly twice the previously known maximum for any natural laminar flow technology at comparable wing sweep angles.



TSP image with the approximated transition front shown (red dashed line). The pre- test CFD transition predictions at corresponding CFD conditions for a critical N-factor of 6 is overlaid on the image.

More information can be found in papers:

AIAA-2019-2298, “*Preliminary Results from an Experimental Assessment of a Natural Laminar Flow Design Method*”

AIAA-2019-2189, “*Experimental Investigation of the NASA Common Research Model with a Natural Laminar Flow Wing in the NASA Langley National Transonic Facility*”

AIAA-2019-2191, “*Transition Detection at Cryogenic Temperatures Using a Carbon-Based Resistive Heating Layer Coupled with Temperature Sensitive Paint*”

High-Lift Aerodynamic Wing Design Tested At NASA Langley 14- by 22-Foot Subsonic Tunnel

By Eric Gillard, NASA LaRC

Submitted by Ray Rhew, NASA LaRC

New ways to fly aircraft more efficiently and safely are always being put through their paces at the facilities of NASA’s Langley Research Center in Hampton, Virginia. For example, one model is being tested to assess the feasibility of practical high-lift aerodynamic design and optimization.

In order for a modern transport aircraft to safely operate at slow speeds for landing and takeoff operations, a high-lift system consisting of slotted flaps on the trailing edge of the wing is used to achieve the required lift performance. However, the slotted flaps and the associated subsystems are complex and protrude under the wing such that they increase air resistance, and consequently fuel burn, during cruise.

10-percent-scale High-Lift version of the NASA Common Research Model (CRM-HL) in Langley’s 14-by-22-Foot Subsonic Tunnel

A 10-percent-scale High-Lift version of the NASA Common Research Model (CRM-HL), shown in the photo, is currently being tested in Langley’s 14-by-22-Foot Subsonic Tunnel. The CRM-HL geometry is a generic representation of a modern transport aircraft’s high-lift system and is available to aerospace industry and academia for research and development purposes.

The NASA Advanced Air Transport Technology (AATT) Project is sponsoring the current research effort aimed at reducing the fuel burn of modern transport aircraft by replacing a conventional slotted flap with a simple-hinged flap featuring an integrated active flow control (AFC) system. The current AFC devices consist of two rows of pneumatic-based actuators embedded on the shoulder region of the simple-hinged flap. These actuators provide various combinations of steady and/or unsteady blowing using arrays of miniature jets that keep the airflow attached over a highly deflected flap, resulting in lift enhancement.

The goal of the AFC-equipped simple-hinged flap system is to achieve a level of lift equal to or better than that of a conventional slotted flap system while using as little pneumatic power as possible.

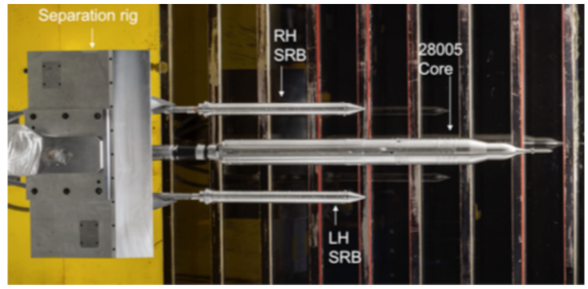
More information can be found at: https://www.nasa.gov/image-feature/langley/high-lift-aerodynamic-wing-design-tested-at-nasa-langley-tunnel

Laser-based Flow Visualization Techniques Utilized During Space Launch System Booster Separation Wind Tunnel Testing

By Courtney Winski & Paul Danehy, NASA LaRC and Todd Lowe, Virginia Tech

Submitted by David Chan, NASA LaRC

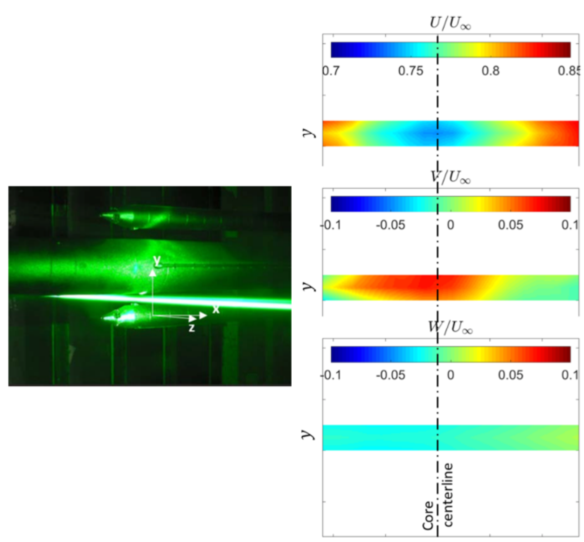
A wind tunnel test was run in the NASA Langley Unitary Plan Wind Tunnel (UPWT) simulating the separation of the two solid rocket boosters (SRB) from the core stage of the NASA Space Launch System (SLS). The test was run on a 0.9% scale model of the SLS Block 1B Cargo (27005) configuration and the SLS Block 1B Crew (28005) configuration at a Mach of 4.0. High pressure air was used to simulate plumes from the booster



SLS 0.9%-scale Booster Separation model installed in the Langley UPWT

separation motors located at the nose and aft skirt of the two boosters. The main objective of the test were to obtain force and moment data on both SRBs and on the core stage.

Cross-correlation Doppler global velocimetry (CCDGV) developed at Virginia Tech was used to measure spatially-resolved mean flow-field three-component velocities during the test. The flow was probed using a continuous wave, single-frequency laser and imaging was achieved by collecting light scattered by ice particles within the flowfield using fiber optic bundles. The principle of CCDGV was employed by scanning the frequency of the laser over a band of approximately 4 GHz, covering a single optical transmission trough in iodine, which was used as a spectral filter for the measurements.



BSM jets-off measurement example for small core and booster gap.

The setup resulted in a spatial resolution of 3.8 mm and particular attention was paid to obtaining measurements between the booster and core when these are in close proximity. The results indicate that this region has a complex, three-dimensional flowfield with substantial velocity gradients due to both the booster separation jets and interactions with the freestream flow.

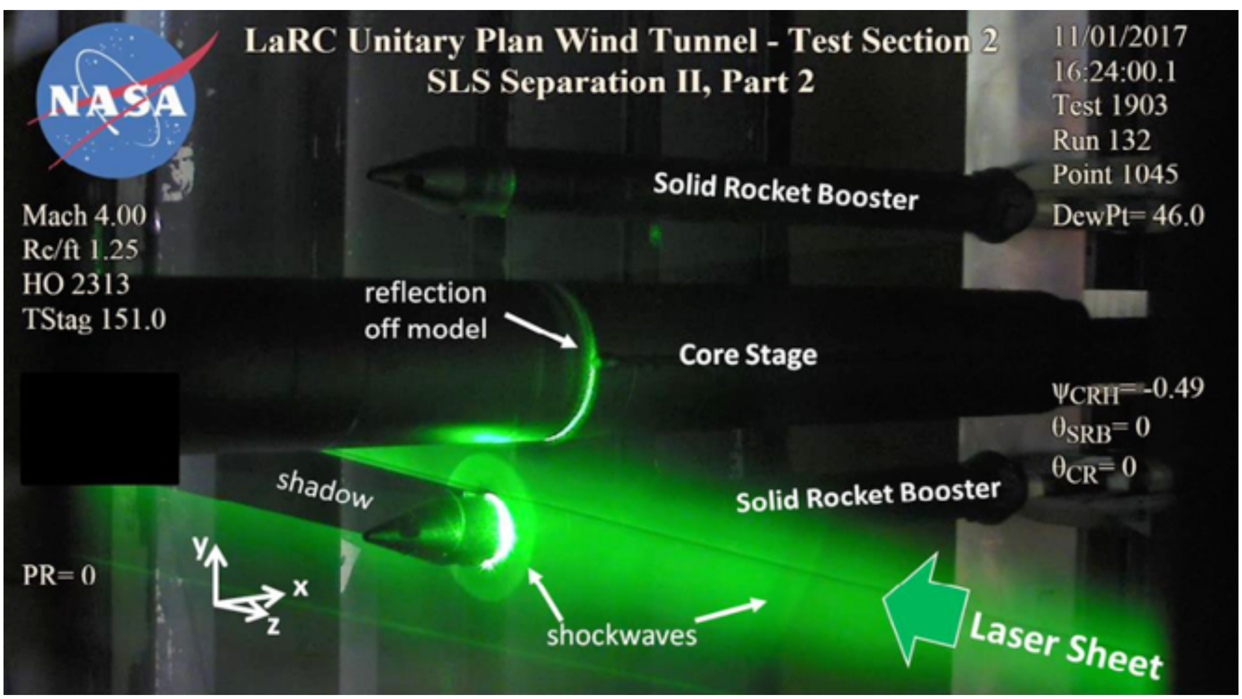
Additionally, planar flow visualizations were obtained during the test using the laser-light-sheet method. This method uses a laser to illuminate fine particles generated in the wind tunnel to visualize flow structures. The facility freestream was seeded with water vapor, which condensed and froze into small ice crystals in the tunnel nozzle expansion. A continuous wave green (532 nm) laser sheet was used to illuminate the ice crystals, and the resulting Mie-scattered light was collected with a camera. The resulting images clearly identify shock waves and other flow features including BSM plume shapes. Measurements were acquired for different BSM pressures and booster separation locations.

More information can be found in papers:

AIAA-2019-2311, "*Space Launch System Booster Separation Supersonic Powered Testing with Surface and Off-body Measurements*"

AIAA-2019-2312, "*Cross-Correlation Doppler Global Velocimetry Measurements for Space Launch System Booster Separation*"

AIAA-2019-2313, "*Laser Light Sheet Flow Visualization of the Space Launch System Booster Separation Test*"



Annotated video image showing laser light sheet and visualization of shockwaves in the flow

Unique Force Measurement System for SRB Loads During Space Launch System Liftoff & Transition Wind Tunnel Testing

By David Chan, NASA LaRC

Low-speed wind tunnel testing for the liftoff and transition environment of the Space Launch System (SLS) was recently completed in the NASA Langley Research Center 14- by 22-Foot Subsonic Tunnel using 1.75%-scale models of three SLS vehicle configurations. During the liftoff testing, the primary objective was to evaluate the aerodynamic forces and moments on the SLS launch vehicles, as the vehicle, launch tower, and mobile launch platform were subjected to ground winds from all directions at varying heights for the vehicle off the launch pad. Additionally, aerodynamic forces and moments were acquired for all three SLS vehicles during the transition phase from liftoff to ascent that covered a wide range of angles of attack and angles of sideslip.

A unique force measurement system (FMS) was applied during the test where two subminiature six-component load cells were installed in each Solid Rocket Booster (SRB) to acquire forces and moments for each SRB separately from the full vehicle forces and moments measured by the main strain gauge balance.

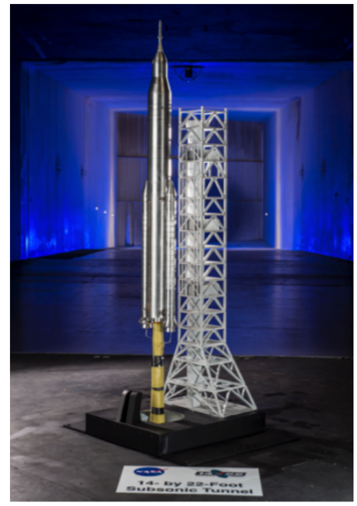
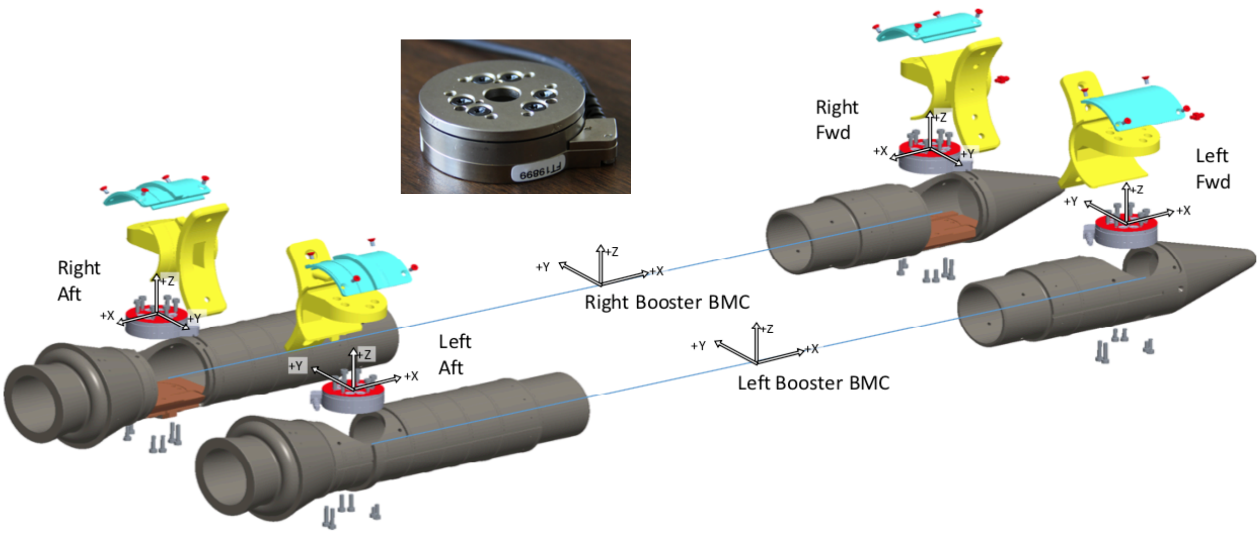


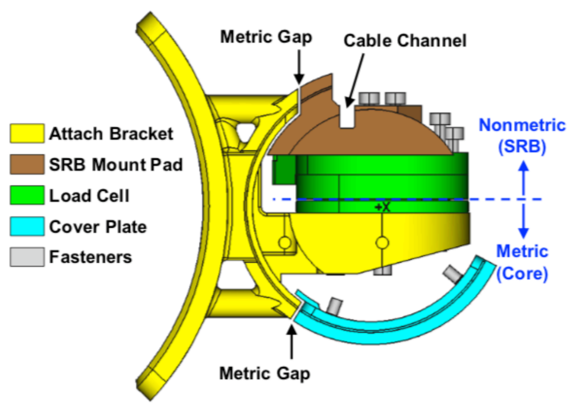
Photo of SLS Liftoff and Transition model in the 14- by 22-Foot Subsonic Tunnel

The Mini45-ERA Force/Torque transducer from ATI Industrial Automation (ATI-IA) is a sub-miniature, pancake-style, 6-component F&M load cell typically used in industrial robotics applications. These load cells were attractive for various reasons: the compact design allowed it to fit inside the SRBs, the load cells could measure all six F&M components, and factory calibrations for each load cell were provided



Two subminiature six-component load cells (Mini45-ERA from ATI-IA) installed in each SRB to allow measurement of SRB loads separate from full vehicle loads upon delivery. The combination of the two load cells in each SRB essentially acted as a separate six-component balance with the moment center at the midpoint between the two load cells. An in situ system calibration was be performed after model assembly to remove any misalignment effects encountered during assembly.

While this load cell concept seemed viable, the challenge was how to integrate them into an existing model with minimal modifications. A design concept was devised where each load cell would be sandwiched between an SRB attach bracket and a mount pad in the SRB as shown in the figure using the right SRB aft attach bracket as an example. Provisions were made to allow the routing of the load cell cable underneath the mount pad and a small gap between the SRB and the attach bracket was included to preserve the load cell measurement metric break.



Integration of load cells into SRB attach bracket and SRB body

This new SRB FMS was very successful as the aerodynamic data from the SRBs showed reasonable magnitudes and trends and exhibited symmetry as expected. It also allowed isolation of component loads, which provided insight into the cause of the large asymmetric lateral loading experienced by the core stage at midrange total angles of attack.

More information can be found in paper:

AIAA-2019-1839,"*Aerodynamic Characterization and Improved Testing Methods for the Space Launch System Liftoff and Transition Environment*"

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Ground Testing Paper Sessions: American Institute of Aeronautics and Astronautics (AIAA) SciTech 2019

Monday January 07, 2019

GT-01: Presentations Selected from the 11th International Symposium on Strain Gauge Balances (Invited)

Chair: Ray Rhew (NASA Langley) **Co-Chair:** Martin Wright (ETW)
9:30 AM - 12:00 PM; Cityview B

Tuesday January 08, 2019

GT-02: Application of Statistical Methods to Ground Testing (Invited)

Chair: Matthew Rhode (NASA Langley) **Co-Chair:** Pete Parker (NASA Langley)
9:30 AM - 12:30 PM; Cityview B

GT-03: RDT&E Capabilities: Defining RDT&E Experimental/Computational Capability and Workforce Challenges (Invited)

Chair: Steve Dunn (NASA Langley) **Co-Chair:** Dan Marren (AEDC)
2:30 PM - 5:00 PM; Bayview

GT-04: Ground Test Facility Data Acquisition, Processing, Corrections, QA, and Presentation

Chair: Erin Hubbard (NASA Glenn) **Co-Chair:** Chris Jorgens (Boeing)
2:30 PM - 5:30 PM; Cityview B

Wednesday January 09, 2019

GT-05. High Reynolds Number Aerodynamics and Testing (Invited)

Chair: Roman Paryz (NASA Langley) **Co-Chair:** Martin Wright (ETW)
9:30 AM - 12:30 PM; Cityview B

GT-06: National Partnership for Aerospace Testing (NPAT) Mini-Facility Users Meeting (FUM)

Chair: Stephen Helland (NASA Glenn) **Co-Chair:** Jeff Balding (AETC)
9:30 AM - 12:30 PM; Bayview

Thursday January 10, 2019

GT-07: Development, Application, and Validation of Flow Diagnostics in Ground Test Facilities

Chair: William Humphreys (NASA Langley) **Co-Chair:** Stephanie Simerly (NASA Glenn)
2:30 PM - 5:30 PM; Harbor A

GT-08: Design/Development/Performance of New/Modified Ground Test Facilities and Subsystems

Chair: Pat Goulding II (NASA Ames) **Co-Chair:** John Hopf (AEDC)
2:30 PM - 5:30 PM; Bayview

Friday January 11, 2019

GT-09: Overview of NASA CRM and Check Standard Research Model Testing, Test Techniques, Test Management, and EFD/CFD Integration

Chair: David Chan (NASA Langley) **Co-Chair:** Rajan Kumar (FSU)
9:30 AM - 12:30 PM; Cityview A

The GTTC would like to officially thank our sponsor; Calspan, for printing this newsletter.