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**Statement of
G. Warren Hall
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National Aeronautics and Space Administration
before the
Subcommittee on Investigations and Oversight
Committee on Science and Technology
U.S. House of Representatives**

Mr. Chairman and Members of the Subcommittee, thank you for the opportunity to appear before you today to discuss my technical knowledge of the duPont Aerospace Company's DP-2 aircraft program.

My testimony today is based on my background as the Chairman of the NASA Ames Research Center's Airworthiness and Flight Safety Review Board (AFSRB), which evaluated the DP-2 aircraft while funded by two Congressional earmarks to NASA; one in FY 2002 for \$3 million, and the other in FY 2003 for \$4.5 million. Separate from the funding directed by Congress, NASA has never included funding for the DP-2 in the Agency's budget requests. For the Subcommittee's information, I have appended to my testimony a copy of NASA's July 2003 report from the AFRSB, which I chaired.

I continue to serve as a member of the Navy's Airworthiness Review Panel, which is currently overseeing the flight requirements for the DP-2 program. My technical expertise was, and is, paid for by the Navy via a reimbursable work agreement, which means that the Navy has paid NASA for my travel related to my activities as a technical advisor since FY 2004. NASA also has provided the Navy with other technical expertise and loaned equipment on a short-term basis related to the DP-2 program via the same reimbursable work agreement.

In the invitation to testify, you asked that I address five issues. The remainder of my testimony addresses these five issues as outlined below.

1. Please provide an overview of your role with the DP-2 program as Chairman of the DP-2 Airworthiness Review Panel and when and why the panel was created.

NASA became involved with the duPont DP-2 aircraft in FY 2002 when Congress earmarked \$3 million to NASA, for the "purchase of two upgraded jet engines requiring configuration changes to the DP-2 Vectored thrust testbed aircraft." NASA has well-defined requirements that must be met for NASA-related aircraft projects. One of these is that all aircraft used to conduct flight operations with NASA personnel or NASA equipment on board must meet NASA approved airworthiness and operational safety standards. This policy requires that an AFSRB oversee

aircraft operations, with the board having final approval authority for all flight operations. NASA is one of the few agencies with the authority to certify aircraft.

The funding directed by Congress was managed by NASA's Glenn Research Center (GRC), making GRC responsible to meet the NASA requirements for the AFSRB approval for the duPont DP-2 aircraft. Given that the aircraft was located on the West Coast and given that NASA believes that work should be located wherever there is technical expertise, GRC requested that NASA's Ames Research Center (ARC) accept responsibility for evaluation of the DP-2 by ARC's standing AFSRB because ARC has technical expertise in vertical lift aircraft and is located in Mountain View, California.

In FY 2003, Congress again earmarked funding to NASA of \$4.5 million for the "DP-2 Vectored Thrust Program."

In 2003, I was chair of the NASA Ames' AFSRB. As chair, I have the authority to identify experts to serve as board members to accomplish a comprehensive flight safety review. A highly qualified team was assembled for the DP-2 review. The AFSRB has the authority to allow a project to proceed or require further documentation or demonstrations to satisfy any airworthiness and flight safety concerns of the Board. The NASA AFSRB review occurred at the duPont facility on July 29-31, 2003. Teleconference calls were more frequent, but they were not considered a part of the formal AFSRB review process.

NASA did not receive further direction from Congress regarding the DP-2 aircraft following the FY 2003 earmark. Consequently, the NASA requirement to provide airworthiness authority over the DP-2 was no longer required. Once the Navy was solely financially responsible for the DP-2 program, the Navy's Airworthiness Review Panel, through the Office of Naval Research (ONR) had, and continues to have, the responsibility for the final flight approval either through the Naval Air Systems Command or through the Federal Aviation Administration.

However, the Office of Naval Research and duPont believed the NASA AFSRB was doing a good job and thus asked some of the AFSRB members, myself included, to continue serving as technical experts to the DP-2 program given that the Navy was continuing to receive Congressional earmarks for the program. In February 2004, the Navy and NASA entered into a Space Act Agreement, which included a provision for the Navy to reimburse NASA for my travel spent as a technical expert on the DP-2 program. NASA also has provided the Navy with other technical expertise and loaned equipment on a short-term basis related to the DP-2 program via the same reimbursable work agreement.

In short, my current role on the Navy's DP-2 Airworthiness Review Panel is as a test pilot/flight controls/safety representative and as its chairman.

2. As Chairman of the DP-2 Airworthiness Review Panel, please describe the key technical and safety factors inhibiting the successful flight of DP-2.

Below are some observations as a technical expert in this field:

- The complex flight control system is the biggest technical problem. The flight control system in the DP-2 is mechanically simple, but dynamically complex. Unlike most airplanes the DP-2 has what is known as a "non-minimum phase zero" response to a control input. This means the aircraft starts in the wrong direction for almost a full second before it goes in the direction requested. While not an Achilles heel, the flight control system requires very high frequency

inputs to reduce this delay to a flyable time. The control system responses are also highly coupled, in that a control input in one axis creates an attendant movement in another axis.

- It is not obvious that the current composite materials will withstand the high temperature environment required to provide aircraft lift and control.
- The required expertise to accomplish the task does not currently exist at duPont Aerospace.

3. Please describe the key management factors that you believe are attributable to the duPont Aerospace Company that have hindered the success of the DP-2 program.

While the DP-2 vertical-lift aircraft may be an interesting concept worth exploring, I do not believe the duPont company has the necessary technical expertise required for this project. While a flight control simulation model now exists, it has yet to be proven that it represents the real airplane. DuPont's insistence in trying to fly the airplane within the current restrictions of the tethered area has resulted in several hard landings. NASA's AFSRB and the follow-on Navy Review Panel have consistently requested that duPont increase the usable flight test area by a significant amount. Many of the recommendations of the AFSRB were ignored. For example, the Board was very specific that the only time a pilot would be in the aircraft was to start the engines and accomplish checkout at idle. The pilot clearly exceeded the idle limits during the incident on November 16, 2004, when a structural failure occurred.

4. Please briefly describe each specific mishap or accident with the DP-2 aircraft and the technical and management factors that contributed to each event.

My expertise as the AFSRB chairman is of a technical nature, and therefore I am best qualified to comment on the technical issues related to the following mishaps and accidents:

1. November 2, 2003 – The DP-2 airplane experienced a hard landing resulting in damage to the left and right main landing gear attach points and the thrust vectoring mechanisms beneath the fuselage. Additional damage to both wing tips and the left tether attachment point was sustained. It was concluded that the loss of the dGPS carrier signal, combined with the simultaneous reading of zero for the height rate signal caused the accident. The AFSRB concurred with this finding.
2. November 16, 2004 – An internal structural failure resulted in damage to the nozzle box, keel, cascade mechanism, thrust vectoring controls, cabin floor, cabin door latch mechanism, pilot's seat floor mounting brackets, and a computer cooling fan blade. One or both lower doors were jammed against the nozzle box floor preventing full motion of the cascades resulting in keel failure. The most probable cause was debonding in the area of the carbon insert encapsulating the "Dog Bone." While not related to the structural failure, the pilot exceeded the AFSRB's instructions that engine rpm shall not exceed idle RPM when a pilot is in the cockpit. The AFSRB concurs with this finding.
3. April 25, 2006 – The DP-2 experienced a failure in a carbon composite insert and a titanium piece which holds the cascade pivot and cascade actuator. The failure resulted in damage to the nozzle box keel, left nozzle box sidewall, control rod for thrust vectoring controls, cabin floor, the cabin door and frame and the number two engine inlet. The AFSRB concurred with this finding.

4. August 8, 2006 – The DP-2 experienced a hard landing resulting in damage to the wing skin near the landing gear attachment. The most probable cause was an unknown altitude rate bias in a loaner Inertial Navigation System causing excess rate of climb. The AFRSB concurred with this finding.

5. Since the DP-2 Airworthiness Review Panel was established in 2003, what has the duPont Aerospace Company accomplished on the DP-2 program?

Based on my continued advisory role, I can summarize some of the program's accomplishments as follows:

- The structural components have been improved;
- The hot gas ingestion problem has been recognized and tests performed to help reduce its deleterious effect in hover; and,
- An improved flight controls simulation model now exists. However, the short hover times have precluded confirmation that the model matches the real airplane.

Mr. Chairman and Members of the Subcommittee, thank you for this opportunity to appear before you today. I would be happy to answer your questions.

DP-1 Airworthiness Review Panel July 29 – 31, 2003

Panel Report

This report presents a summary of the Airworthiness Review Panel (ARP) findings following the meeting at the duPont Aerospace Company (DAC) on July 29 – 31, 2003. The report is presented in two sections. The first section contains the principal findings regarding testing of the DP-1 aircraft and the second section contains suggestions/recommendations that DAC may wish to incorporate into their program plan.

I. Principal Findings: Flight Safety Action items and Approval for test

1. DAC is authorized to conduct tethered unmanned autopilot controlled hover, OGE and IGE. – The GFR (Major Temper) must still sign and approve the day-to-day flight release documents and the tests should be conducted in accordance with the Test Plan for Tethered Hover dated 2 July 03, with Change 1.
2. The current level of design and testing of the DP-1 aircraft is not mature enough to allow manned flight – tethered or untethered. Another panel review must be accomplished prior to tethered manned operation.
3. In preparation for the next test block approval (manned tethered hover, OGE, and IGE), DAC must address each of the following action items and present the results to the ARP at the next review meeting. This review should concentrate on the DP-1 vehicle only.
 - a. A strong configuration management program is required and very close attention must be paid to how a configuration change might affect the characteristics of the original configuration. It has always been a good philosophy to test what you fly and fly what you test. With the limited amount of testing proposed, it is vital that the implications of any change, especially as it might affect safety, be fully evaluated. As part of this program, identify DP-1 aircraft and engine configurations for different tests (already accomplished and in the future).
 - a. Present data obtained from the autopilot controlled unmanned tethered hover tests. Establish through these tests and information that the DP-1 aircraft can be safely and reliably controlled in hover with the autopilot installed and operating.
 - b. Implement a viable Safety and Quality Assurance Program that includes Test Hazard Analysis and Failure Modes and Effects Analysis (FMEA).
 - c. Establish normal and emergency procedures to be followed during the manned tethered hover testing.
 - d. Develop a means to ensure that the air quality in the aircraft is acceptable for extended occupancy under test conditions.

e. Convincing evidence must be presented to the panel on the measured forces and moments that will be available to control the aircraft with the cascade locked at 90° and the control box moving. The lack of hard information in this area leads the panel to question the validity of the flight simulator.

There is also a need to further verify the validity of the fixed based simulator by comparison with flight test data from tethered hover, autopilot installed and operating. The need is to demonstrate that the aircraft can be safely and reliably controlled by the pilot in hover through the use of pilot-in-the-loop simulations with and without the autopilot operating. Present the results of test practice in the piloted simulation, updated to reflect the results of testing to date. A valid flight simulator is required for pilot training and flight test preparation. It is imperative that any configuration changes that influence the handling qualities be documented and included in the simulation. This is a major safety of flight action item.

[It will be desirable to hear a report from Ron Gerdes if he has an opportunity to fly and assess the simulator before the next ARP meeting.]

f. Provide information and results on the methods used to determine the thrust loss through the cascade plus control box. An independent measurement(s) [other than the current flow analysis] could give greater confidence in the thrust loss values. It is suggested that DAC consider the suggestions presented in Section II, item 8, of this report.

g. Complete for review an updated stability analysis of the aircraft and control system, and control analysis including the most up-to-date actual control system characteristics. [Suggest using Geneva's 6 degree of freedom simulation.] Include stability analysis of altitude control, as well as lateral position/attitude control. Include cases with a man-in-the-loop model. Show time histories of simulated control scenarios. Include Monte Carlo analysis to show the cumulative potential effect of all tolerances and uncertainties.

It may be difficult to develop a control scheme that will handle the long non-minimum phase response to a control input. Observations of the pilot flying the simulator without the autopilot were indicative of an acceleration controller, a difficult control system to fly because of the requirement for continuous attention to control. The excellent stability of the autopilot mode, however, indicates there was an acceptable method of handling the non-minimum phase response but it was never revealed what it was. Past experience with fly-by-wire systems indicates that a simple response lag of 0.1 to 0.2 seconds often resulted in limit cycles or unstable responses.

h. Update the test plan, limits document, and training plan.

i. Provide substantiation (analyses, tests, similarity, etc.) of the structural limits of the landing gear and its attachments when subjected to a high sink, sideslip, or one wheel landing, that could occur during hover testing.

j. Present a structural substantiation and service history to date for the items in the jet exhaust (especially vanes, pushrods and attachments). Emphasis should be placed on the expected service life of these components.

k. Identify flight critical items and insure that any that are replaced and/or modified are reviewed for time at power settings to determine safest configuration for manned tethered flight. Only fly an approved configuration with particular attention to the operating times of components especially those subjected to high temperatures. A criterion for critical parts should be established and adhered to. As part of this action item, identify required inspections of cascade box, vanes and control box and vanes prior to manned tethered flight. The panel believes there should be an "endurance" test of the power train, including cascades and control vanes. Toward this end DAC should specify the time and power for this endurance test for ARP approval.

l. Present a further review (including analyses and simulation results) of emergency procedures that will be used in the event of an engine failure while in the tethered hover mode (IGE or OGE).

m. The control system configuration must be carefully managed. If the system to be used in tethered hover testing does not have all surfaces, artificial feel packages, conventional flight trim system hardware, etc. installed, then this must be consistently replicated in all analyses and simulations since these items may influence the response of the control system in the hover mode. Prior to free flight all these devices must be in the aircraft, and if this is different from the tether test configuration the tests must be repeated.

4. The current level of engineering substantiation and program planning and control fall well short of what will be necessary to conduct safe and productive free flight (both thrust-borne and conventional) tests. The risk mitigation provided by the tethers allows tethered testing to proceed for the time being. However, prior to free flight tests substantial progress must be made. The following are areas that require action.

a. Testing and analyses to substantiate airworthiness in all functional areas (structures, aero, propulsion, flight controls, subsystems, flutter, avionics, etc) is needed

b. A further review of aircraft systems will be required including FMEAs (for the planned flight conditions) and the results of any systems tests - specifically identifying single point failures and their risk mitigation.

c. Additional reviews will also be required in the following areas:

- Aircraft maintenance program
- Aircraft software validation and verification plan
- Flight test program history and reliability

d. Quality control plan developed and fully implemented.

e. All aircraft components individually reviewed for airworthiness; compiled in a database with airworthiness rationale (environment established and suitability by qual test, similarity, etc.) All parts exposed to an endurance test in the jet exhaust should be inspected prior to manned flight. (see also item 3k).

f. Complete test documentation (detailed test plan, test hazards analysis, training plan, normal and emergency ops, limits document)

g. From a structural integrity perspective, the following will be needed.

Low speed (< 200ktas) – detailed review to include:

- external flight and landing loads
- composite material qualification data
- stress analyses of airframe and flight control system
- test data from coupons, elements and subcomponents
- proof load test plan and results
- aeroelastic substantiation (flutter, divergence, aileron reversal) - include consideration of balance weights in the control surfaces
- an aircraft structure Failure Modes and Effects Analysis including hazard analyses

High speed (>200 ktas) – A repeat of items in the above list, except a more stringent requirement. Loads analyses should include aeroelastic and compressibility effects. Rational flutter analysis and a ground vibration test will be recommended. A variable frequency inflight excitation system, with appropriate frequency range will be recommended for envelope expansion above 200 ktas. A telemetry system with appropriate sensors will be recommended.

h. A Failure Modes Analysis of the software should be accomplished to identify any unsafe failure modes. Critical paths should be identified and shown to be reliable and controllable. This is especially important since the autopilot system is single string. It should be demonstrated that the autopilot design is adequate and reliable prior to piloted flight.

i. More information will be needed on pilot emergency escape systems and procedures. Serious consideration should be given to the addition of an ejection seat system. And a good field-of-view is highly desirable during the “build down to V/STOL (powered lift) flight conditions at altitude.

j. More analysis and substantiation data is need on the fuel management system and CG control. Automated fuel transfer is required to reduce pilot workload and assure proper CG location as fuel is being consumed, especially during V/STOL operations. A center of gravity vs fuel consumption diagram should be provided.

k. It doesn't appear that the DP-1/DP-2 configuration has a VTO OEI capability, and the engine failure “dead zone” analysis seems overoptimistic. Calculate actual dead zone dimensions for takeoff, landing and hover cases using updated data. Include control effects: loss of directional control, and need to roll away from dead engine to maintain control.

The vertical take off procedure is to first lift to a 10-ft hover followed by a transition to forward flight with thrust vector (cascade) movement. In the event of an engine failure, the procedure is to nose down a little and vector-out. -- A 2 to 10 second thrust decay is assumed in the calculation. At 10-ft, the aircraft is probably still in ground effect, which would reduce single engine performance. A mechanical failure would be more instantaneous and nosing over in combination with 'vector out' would probably cause the aircraft to fall to the ground. This is OK on a long runway, but hazardous when operating from a pad for instance.

l. An accurate and sensitive air data system is needed during V/STOL flight test for a number of important reasons: 1) for pilot reference, especially during the build-down to powered lift flight, 2) for flight test data documentation and analysis, 3) for control room flight test monitoring, and 4) for autopilot and SCAS air data input requirements. Details on the proposed system will be needed.

m. There will probably be other "unknown Handling Qualities Issues" that must be addressed. The following is a short listing of other issues that could impact handling qualities

- Tether-induced moments
- Ground effect induced forces and moments
- Control actuator bandwidths - dynamic response
- Autopilot and/or SCAS failure control transients
- Control servo or boost failure controllability

n. A stall in one engine may interact with the inlet of the other engine. When one engine goes out, it leaves pressure surges in various places that could potentially interrupt the operation of the nearby second engine. Likewise, the failing engine could also leave vacuum like conditions in various places that could influence the behavior of the second nearby engine. DAC needs to address this, probably by running test stand tests, and perhaps by analysis.

o. Demonstrate that the $C_{M\alpha}$ inversion around 12° to 20° angle of attack is not a serious concern with respect to very low speed flight. As reported by DAC at the meeting, this inversion was observed on other F-8 supercritical wing data and seems to be very Reynolds number sensitive. So much so that for the full scale Reynolds number corresponding to conventional flight of the DP-1 aircraft it appears that the inversion is almost wiped out. But as the aircraft is slowed down (as it transitions to hover with lower and lower Reynolds numbers) there is a possible pitch up.

Note that panel member Ron Gerdes flew one (the last) evaluation flight in the Vought F-8 SCW aircraft which included approaches to stall and other slow flight evaluations. The longitudinal flight control system of the basic F-8A was modified (command augmentation system or CAS) with an apparent rate command + attitude hold system to 'stiffen the pitch axis.'

p. Hot gas ingestion and suckdown have been major issues on practically every VTOL plane to date. It was very troublesome on Harrier and JSF, although the thrust levels on these two types of planes were much higher than DP-1. In ground effect testing must be designed to address this:

- (1) Test Airplane DP-1 must sit on its landing gear which in turn sits on the ground.
- (2) The "FLAT" ground must extend out for hundreds of feet in all directions.
- (3) Ground surface under, and near the plane, should be solid.
- (4) Accurate force and moment measurements must be taken as described in paragraph 3.e. above.

(5) Optical and IR measurements should be taken to more thoroughly characterize the hot gas flows. (NOTE: NASA GRC has volunteered to help with these measurements).

II. Suggestions, Additional Recommendations and Comments

The following are suggestions that may prove helpful in managing the program or conducting tests.

1. Suggest the use of DP-1A to represent the aircraft as it existed with P&W 530 engines, DP-1B same as 1A with 535A engines, DP-1C new fuselage, MOD wing attachments and 535A engines, etc.
2. Identify DP-1 Master Test Plan with aircraft configuration (DP-1A, DP-1B, etc.) and put major milestone accomplishments into phases
3. In addition to the Master Test Plan mentioned above, an overall integrated program plan is needed that shows all testing, including building block tests (e.g. wing proof test) and configuration changes (e.g. fuselage change, cascade change)
4. All data presented should include standard legend: configuration, date, test conditions.
5. Aircraft instrumentation appears to be very limited. Analysis to substantiate test progression, envelope expansion and performance prediction will be severely hampered if test data are incomplete.
6. Measurements of the mechanical distortions of the cascade and control box while the engines are running would help in further sensitivity studies using the Genevas's 6 degree of freedom simulation that is set up with the automatic flight control system.. At the present time we are guessing at what these mechanical distortions may be and it would appear that a few measurements could lead to many beneficial runs on the simulator – thus saving run time on the test stand. At the very least it would be very desirable to instrument the control surface positions while the engines are operating.
7. Wind tunnel measurements of the gas flow in the cascades would be useful. As the cascade is retracted from 90 degrees the flow entering the cascade will be at some off design angle. The possible flow separation and blockage effects for these off design positions could be determined from a well designed set of wind tunnel tests. The side walls could be made of transparent material for optical visualization of the flow. This would be helpful in determining the cascade effectiveness at these partially retracted positions; and these measurements could also include tests with the control box installed to help determine the exit flow angles.
8. Perform wind tunnel tests of the flow mixer under realistic flow conditions to determine effectiveness of the mixer design and temperature uniformity and levels of the flow upstream of the cascade. The tests can be done on a scaled down model however the Mach number ratio and temperature ratio must match those for the real engine.

9. DAC should consider measuring engine N1 (plus P&W cycle deck), fuel flow, and aircraft weight to obtain an accurate measure of the vertical thrust coefficient. A bigger payoff would be obtained by installing load cells on solid piers that are mounted down through the test stand into the hard ground below. Force measurements on those load cells should provide accurate thrust measurements and those values could, in turn, be used to calculate the control moments acting on the aircraft.
10. Before low speed taxi tests are begun, and prior to being moved to the flight test facility, the DP-1 aircraft could be disassembled, fitted with the improved fuselage, and have all of the new flight test instrumentation and wiring installed
11. The basic objective of demonstrating VSTOL performance, stability and control from hover through transition to and from conventional flight could be accomplished without the degree of envelope expansion contemplated for the conventional flight test program, i.e. Mach 0.95, VCAS 355 kts, altitude 50,000 ft. In order to approve the DP-1 for these tests, considerably more substantiation, involving analysis and test, will probably be required.
12. It might be noted that the use of a steel grid platform only slightly larger than the aircraft overall length and wingspan, located approximately 10 feet above the ground may not be a valid representation of true out of ground effect operation.
13. It was not obvious that the wind tunnel data was applicable to the DP-1 configuration. Additional wind tunnel data would be very useful.
14. Any person who has to be near the engine inlet at above idle power must be tethered.
15. The final decision with respect to flight risk assessment by DAC should rest with the Test Pilot, Larry Walker.
16. The overall programmatic/demonstration approach outlined by DAC appears reasonable, namely:
 1. Tethered hover out of ground effect, no pilot on board
 2. Tethered hover in ground effect, no pilot on board
 3. Tethered hover in and out of ground effect, pilot on board with autopilot and pilot only
 4. Low speed taxi tests
 5. Free flight hover tests from lift off to 20 foot altitude
 6. High speed taxi tests
 7. Conventional flight tests, envelope expansion
 8. Transitions from conventional flight to jet-borne flight
 9. Vertical takeoffs and landings

Biography

G. Warren Hall, NASA Ames Research Center

After graduating from the University of Virginia in 1960, with an undergraduate degree in Aeronautical Engineering, Mr. G. Warren Hall became a Naval Aviator logging more than 300 carrier landings in the F3B Demon and F4B Phantom II aircraft.

Mr. Hall began his flight test career in 1965 as an Engineering Test Pilot with Cornell Aeronautical Laboratory of Cornell University where he logged over 100 hours in the Bell X-22A V/STOL aircraft. While at Cornell, he completed a Masters Degree in Aerospace Engineering. He also has a MBA from the State University of New York at Buffalo, New York.

Mr. Hall joined NASA's Ames Research Center in 1977 as a Research Test Pilot. He has flown over 65 different types of aircraft including the X-14B, XV-15 and the unique Rotor Systems Research Aircraft. He is a Fellow in the Society of Experimental Test Pilots. At NASA he has served as the Director of the Flight Research and Airborne Science Directorate and the Safety, Environmental and Mission Assurance Directorate. He is currently the Assistant Director for Aviation at Ames. He was awarded a NASA Exceptional Service medal in 1994 and a NASA Outstanding Leadership medal in 2000.

He completed 28 years of military service before retiring as the Commander of the California Air National Guard's 129th Rescue and Recovery Group at Moffett Field, California with the rank of Colonel. He was awarded the Air Force Legion of Merit in 1989.

Professionally, he has authored 28 Technical Reports and 45 Technical Papers or Journal Articles.

In December 2003, the San Francisco Chapter of the American Institute of Aeronautics and Astronautics designated Mr. Hall as a "Living Legend of Aerospace." In November 2004, Mr. Hall was inducted into the Virginia Aviation Hall of Fame.