F-35 Flight Test Program

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Abstract

The F-35 flight test program started flying in 2006 with the first F-35, designated AA-1, along with the Cooperative Avionics Test bed (CATB), a modified 737. These two are but the first of many flight test aircraft for the Joint Strike Fighter (JSF) Program that will be flown for System Development and Demonstration (SDD). Five more conventional aircraft, five short takeoff vertical landing (STOVL) aircraft, and four carrier variant aircraft will be completed and flown in the next several years. An aggressive flight test program is planned for the next six years to develop the initial capabilities of this stealthy strike fighter not only for the US but also for many foreign partners and customers as well. Challenges in engineering, manufacturing, as well as flight test obviously arise when working with companies not only in the US but from around the world.

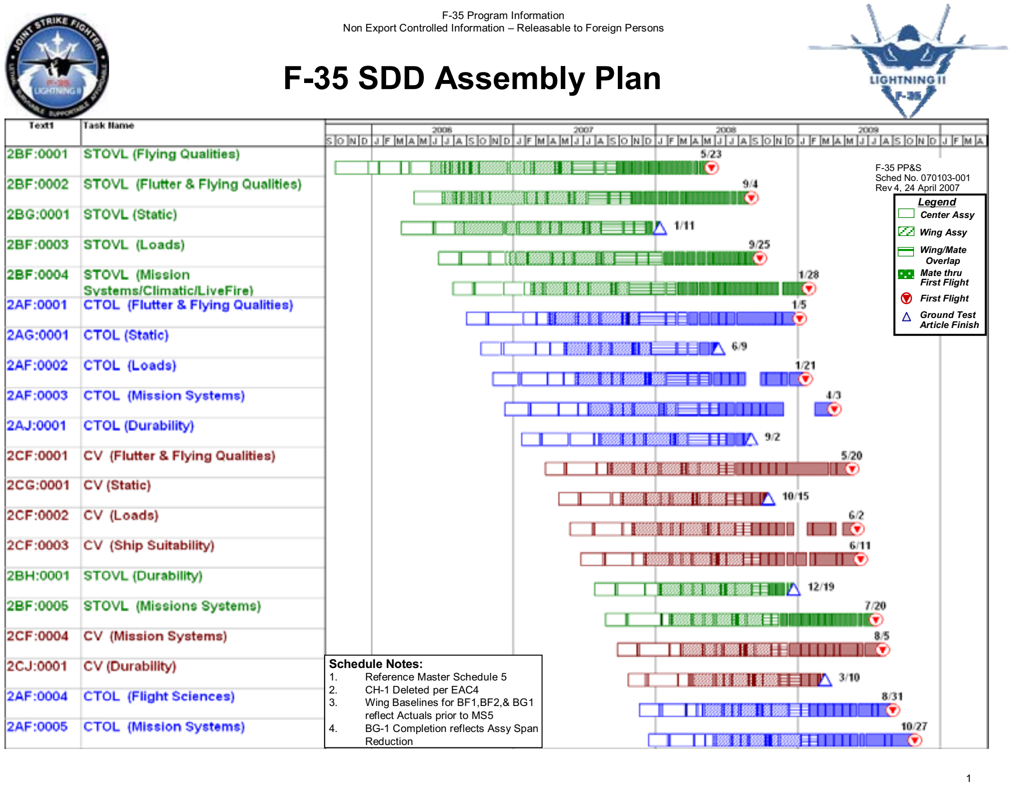
The first development test flight of the F-35 program took off in December 2006 in Fort Worth, Texas. Five years of planning and coordination following the contract award led up to that moment. A worldwide team and multiple suppliers working with multiple customers and each of their objectives has culminated in the attainment of that milestone. The road to first flight has been challenging and has taken a few unexpected turns. For the most part, the flight test program envisioned several years ago is still in place but a few major changes have had to be made on flight test philosophy as the F-35 team matures and adapts to the resources and constraints at hand.

Lockheed Martin is the F-35 prime contractor, while Northrop Grumman and BAE Systems are principal partners in the project. Engine manufacturers include Pratt & Whitney, General Electric and Rolls Royce. All F-35 flight testing planned through mid 2010 will be with the Pratt & Whitney F135 engine but plans are in place to flight test the F136 GE Rolls-Royce Fighter Engine Team engine on the CTOL in the third quarter of 2010, then on the CV in the second quarter of 2011 followed by the STOVL in the third quarter of 2011. While Rolls-Royce is a member of the Fighter Engine Team with GE on the F136, they are also subcontracted to Pratt & Whitney on the F135 to provide the Shaft Driven Lift Fan (SDLF) for the F-35. Lockheed Martin developed the idea for a Short Takeoff/Vertical Landing (STOVL) lift system that uses a vertically oriented SDLF. A two-stage, low-pressure turbine on the engine provides the horsepower necessary for the fan to generate a column of relatively cool air that provides nearly 20,000 pounds of lifting power using variable inlet guide vanes to modulate the airflow, along with an equivalent amount of thrust from the downward-vectored rear exhaust to lift the aircraft. The Lift Fan utilizes a clutch that engages the shaft-drive system for STOVL operations. Because the lift fan extracts power from the engine, exhaust temperatures are reduced by about 200 degrees compared to traditional STOVL systems. The SDLF was one of several systems successfully demonstrated during the Concept Development Phase (CDP) flight testing of the X-35B demonstrator aircraft during the summer of 2001.

Lockheed Martin draws its fighter aircraft expertise from its experience with the F-22, F-16, F-117 and F-2. Northrop Grumman draws from its aircraft experience on the B-2 and several carrier aircraft such as the F/A-18 along with extensive radar and electronic systems experience on fighters. BAE Systems provides its aircraft experience from the AV-8 Harrier, Hawk, Tornado and Eurofighter and fighter aircraft system experience with helmets and head up displays and electronic warfare suites. Obviously, the F-35 can draw from a wealth of experience although there have been challenges with diverse opinions on test philosophies.

At this time, the SDD period involves the development and testing of the entire aircraft system including its manufacture. During SDD, the team will build a total of 22 test aircraft. Fifteen will undergo flight testing, six will be used for non-airborne test activities, and one will be used to evaluate the F-35's radar signature. Flight testing will primarily be conducted at Edwards Air Force Base, Patuxent River Naval Air Station and Fort Worth.

The F-35 is now embarked on a 12,000-hour flight-test program designed to validate tens of thousands of hours of testing already completed in F-35 laboratories. "The F-35 will enter service as the most exhaustively tested, most thoroughly- proven fighter system in history," according to Dan Crowley, Lockheed Martin Aeronautics Executive Vice-President and General Manager of the F-35 Program



Like most aircraft development programs, the F-35, also known as Lightning II, has had to balance the constraints of cost, schedule and risk. A flight test engineer will idealistically go into a program trying to make it as risk-adverse as possible. Minor increments are considered for every expansion of the envelope. Every method of data acquisition is sought and processing and analysis of all data is considered. However, once that is set to schedule and priced it becomes clear that customer milestones for acquisition and budget cannot be met. Costs must be slashed and timelines readjusted. Once an approved plan is put into place, constant adjustments are required as budgets shrink and requirements are clarified and changed. In addition to these planned events there are always unexpected problems which will surface during a development program. During the early stages of a development program the greater the likelihood difficulties will arise. Lightning II was no exception and in this case the showstopper was weight.

As the aircraft progressed through numerous redesigns, affordability, lethality, survivability and supportability were the primary objectives. Budget goals were being met, the aircraft was moving toward its technical goals as an all-weather, air-to-air engagement aircraft and air-to-ground precision strike aircraft. The aircraft was stealthy and capable of high performance to extract itself from a variety of critical scenarios. The aircraft was also being driven to set new standards for reliability and maintainability enabling lower maintenance costs and easier upgrades than legacy aircraft. But the F-35B STOVL aircraft was not meeting its weight goals and a design was put on hold until a solution was found. Weight had been a critical consideration since the inception of the program, because it costs money and degrades STOVL performance. As an example, the aircraft was designed with the diverterless inlet which lightened the overall weight of the aircraft by eliminating all the moving parts in the inlet. Those initial design efforts were not enough and the F-35 redesign necessitated an update in both schedule and budget.

After detailed analysis of many creative solutions, the weight issues were solved as more than a ton was shed. Among the solutions: The weapon bays and vertical tail were shrunk, the wing mate joint was redesigned and the aircraft skin was thinned (Fulghum, David ; Wall, Robert 19 Sep 2004 USAF Plans for Fighters Change; Aviation Week and Space Technology) .

A critical decision had to be made. The first aircraft, known as AA-1 and designed for conventional takeoff and landing (CTOL) was too far into the production process to react to the design changes. Should the aircraft be designated as a ground article and used for spare parts or should this one of a kind aircraft be built to completion?

There were cost arguments for not delivering AA-1 as the first flight test article. As a result of the redesign, the AA-1 airframe is unique. It may look like an F-35, and it has many of the systems and characteristics of a CTOL, but its airframe and handling qualities are unique. As a result personnel and resources which could have been devoted to one of the three variants to be fielded would have to support a fourth airframe. Models and simulations in the areas of flutter, flying qualities and loads would have to be adjusted for this one-of-a-kind configuration. Budget was allocated to support this additional testing and the schedule was impacted as additional test points were added to the program.

Those cost arguments could be countered by many sound arguments for using AA-1 as a flight test aircraft. There was the cost that had been sunk into the aircraft. It would be hard to justify all that expense to make it a ground test aircraft or a spare parts bin. There was also a very sound technical reason for retaining the aircraft. The aircraft would be a flying test bed for multiple F-35 technologies. If schedule goals were met, the aircraft could be airborne by the end of 2006 and offer the opportunity to demonstrate and validate multiple systems in a dynamic environment. Ground laboratories have become quite sophisticated and the laboratories at Fort Worth are state of the art. But no ground laboratory at that time could completely duplicate all the environmental conditions of an airborne test vehicle. Given all the disciplines which desperately needed air time to develop their new cutting-edge technologies there were more than enough requirements to keep the aircraft flying constantly for months. Finally, in terms of risk this early set of tests enabled the F-35 program to better assess problems in the early stages of development and fix them prior to start of production.

Several objectives had been identified for AA-1 flight test. They included risk reduction, air data validation, subsystem functionality, vertical tail buffet validation, environment testing and aerial refueling. Testing to support the primary test objective of risk reduction would address the Power and Thermal Management System including emergency mode transition, propulsion system testing including airstarts, high angle-of-attack testing up to 35 degrees and flutter testing out to 1.6M

On-aircraft ground testing began in earnest with engine runs in September 2006 with an Integrated Power Package (IPP) run and idle power engine run followed by a high-power engine run. Final preparations started with a ramp taxi and a 30-knot taxi test on 7 December. This was followed by taxi tests of 65 knots, 80 knots and 110 knots from 9 December though 12 December. As a final test, the 100- knot high-speed taxi was completed on 14 December and the aircraft was deemed ready to go.

Preparation for first flight of an aircraft is not only the most anticipated time in a program but also the most stressful. There are a multitude of unknowns, very high expectations and countless eyes upon your team. History has not been very kind to first flight experiences and on a few occasions they have ended in disaster.

On the Lightning II, safety was given the highest priority. People on the program understood the need to progress cautiously and consider every possibility which could lead to failure. The resources of all the teammates and the JSF Program Office were made available to check every system on the aircraft and plan for every contingency. State-of-the-art flight test instrumentation was employed to monitor the aircraft flying qualities.

The flight of the CTOL F-35 variant began at 12:44 p.m. CST at Lockheed Martin in Fort Worth when the jet lifted off and began a climb-out to 15,000 feet. Test pilot Jon Beesley then performed a series of maneuvers to test aircraft handling and the operation of the engine and subsystems. He returned for a landing 35 minutes later. Two US Air Force F-16s and a US Navy F/A-18 served as chase aircraft.

Photo courtesy of Richard Wolf

Perhaps the most remarkable feature of the first flight was the lack of anomalies as all systems, other than a degradation noted in the air data system, worked as anticipated. No matter how many precautions are taken invariably something unexpected happens, but to the relief of the engineering team nothing unusual happened.

Plans for AA-1 consist of testing multiple systems common to all variants. Among those systems are the fuel system, IPP, helmet mounted display (HMD), cockpit, bay ventilation, electro-hydrostatic actuators, electrical system and multiple components of the propulsion system.

The IPP is a combination of the Environmental Control System, Emergency Power System and Auxiliary Power Unit – three systems with a long history of failures on fighter aircraft. One of the biggest successes of the early testing of AA-1 has been the reliability of the IPP with no failures to date.

Perhaps the most valuable testing has been the engine testing. Months prior to first flight the first engine run of the F135 afterburning turbofan was conducted in the airframe. Days later the tests were completed after a static run with full afterburner. The engine runs were the first time the F-35 was completely functional on its own power systems. (Lockheed Martin news release 2006-09-22). During its fifth flight, AA-1 went to afterburner and by the tenth flight of AA-1 the aircraft went to afterburner for 20 seconds. The first afterburner takeoff was demonstrated on the very next flight. By April, the engine successfully supported three test flights in a 48-hour period including back-to-back flights on April 26. Rated at more than 40,000 pounds of thrust the F135 is the most powerful fighter engine ever built. The engine consists of a three-stage fan, a six-stage compressor, an annular combustor, a single stage high-pressure turbine, and a two-stage low-pressure turbine.

The F135 is also currently in an SDD phase. The F135 is using the lessons learned from the F119 engine core and the JSF119 during the CDA stage to reduce risk in SDD. During SDD the F135 test engines will undergo a range of ground and flight tests to simulate various mission profiles. In these tests the system demonstration engines will be run for hours throughout various flight envelopes to ensure they meet performance requirements.

Another system evaluated during the early test flights on AA-1 was the air data system. The first flight provided the necessary data to modify the air data system prior to flight number 2. Limited to half-stick inputs through its first eight flights the air data system was calibrated on 5 March and was able to receive full-stick inputs by Flight 9.

In addition to air data system evaluation, another goal achieved during the second flight was the successful retraction of the landing gear. About ten minutes into the flight, the aircraft's landing gear was retracted to further test handling qualities in the face of changing aerodynamics. The F-35A climbed from 15,000 to 20,000 feet to evaluate engine operation and cruise performance. The handling tests included rolls, turns, angle-of-attack changes and engine-throttle changes. The final test point was the successful extension of the landing gear and smooth landing. The flight lasted 62 minutes and was executed as planned.

Once the aircraft was cleared for full-stick inputs, the HMD was ready to be tested.
Early flights were very challenging as the F-35 was the first fighter since the Vietnam era without a head-up display. For the first few months of testing, the pilot was limited to a head-down display on the multi-function display. This proved to be challenging to the test pilots who had grown accustomed to the convenience of available information as they looked outside the cockpit. The next generation Helmet Mounted Display System (HMDS) is made by Vision Systems International (VSI) - a joint venture between EFW Inc. (an Elbit Systems of America company) and Rockwell Collins was flown for the first time on the JSF aircraft during Flight 10. It offers standard HMD capabilities such as extreme off-axis targeting and cueing. In addition, the new HMDS fully utilizes the advanced avionic

architecture of the F-35 to offer pilot video with imagery in day or night conditions. Combined with precision symbology, the pilot is given unprecedented situational awareness and tactical capability. Also, by virtue of new precise head tracking capability and low latency graphics processing the HMDS provides the pilot with a virtual HUD. Feedback from that flight and subsequent flights has provided the details for further refinement of the system.

The F-35 flew eight times in April including three missions in two days on 26 and 27 April. In addition to the propulsion testing, multiple test points were achieved including envelope expansion as the aircraft reached an altitude of 38,000 feet. Pilot evaluations continued and included the use of the glass cockpit. The F-35 cockpit is unique in its touch screen menu – a finger-on-the-glass concept in lieu of buttons and switches.

For the genesis of a test program, AA-1 has achieved a very good flight rate despite the limitations of its unique configuration and an extremely stormy and wet spring which led to many weather cancellations.

A scheduled software modification downtime and maintenance period was begun a few weeks earlier than planned because of an electrical power system anomaly during flight 19 on 3 May.

AA-1 began its planned maintenance lay-up period in June 2007. Highlights during the lay-up included: FTU-2 software loading and ground regression testing, air refueling receptacle proof testing, Emergency Mode Transition (EMT) pod fit and operational checks and EMI testing, environmental orifice replacement, weapon bay door actuator replacement, UV blockers installation, IPP inlet restrictor plate installation and several instrumentation upgrades/improvements. Flight testing is scheduled to resume in August/September 2007.

Concurrent with the testing on AA-1, the program is also flying several other aircraft with F-35 systems. The Lockheed Martin Cooperative Avionics Test Bed (CATB) will integrate and validate the performance of all F-35 sensor systems before they are flown on the first Lightning II aircraft.

CATB is a Boeing B-737-330 originally built in 1986. It was purchased by Lockheed Martin from Lufthansa Airlines in 2003 with about 35,000 hours logged on it. BAE Systems, with support from Lockheed Martin, designed and installed structural and electrical modifications to the CATB at their facility in Mojave, California. Structural modifications included a new nose to accommodate the F-35 Lightning II radar and electro-optical targeting system (EOTS), sensor wings and strakes for the electronics warfare (EW) system, and canoe and spine structures to hold F-35 antennas and distributed aperture system (DAS) cameras. The original B-737 generators were replaced and the electrical system modified in order to provide double the electrical capacity for the CATB mission systems. Other structural changes included a 13-foot canard to emulate the F-35 wing and external structures on top and bottom to hold F-35 avionics equipment. Approximately 1,500 wiring harnesses were installed to connect and link the various mission system sensors

The CATB flew 21 times from Mojave for more than 60 flight hours in early 2007. This initial flight test program verified the handling qualities of the CATB structural modifications and tested the electrical system. The CATB was flown to Lockheed Martin in Fort Worth in early March 2007 and then flew twice locally.

The CATB will undertake development and verification of one of the F-35's most important capabilities – the ability to collect data from multiple sensors and fuse it into a coherent situational awareness display - all within a dynamic airborne environment. Modifications feature a high fidelity F-35 cockpit that will enable pilots to operate and monitor the new fighter's integrated sensor suite in an airborne environment and allow sensor inputs to be displayed as they would be in the fighter itself. The CATB will carry all five of the F-35 mission systems – radar; electro-optical targeting system; communications, navigation and identification; electronics warfare, and distributed aperture system cameras. In addition, CATB will include an F-35 cockpit simulator. These five systems can be tested individually or in combination by a crew of 20 test engineers and an F-35 pilot on flight test missions lasting up to four hours.

The CATB is projected to see service on the F-35 test program through 2012 at this time. Its modular design and relatively low flight hours will allow it to be used on other flight test programs far into the future. The CATB is now undergoing a second stage of modifications in Fort Worth which will install and check out the F-35 mission systems. Flight testing will resume in the fourth quarter of 2007.

During second-phase modifications in Fort Worth, Lockheed Martin will install test stations in the main cabin and instrumentation to monitor and measure the in-flight performance of various installed sensors. Workers also will complete the installation of electrical and cooling support systems. The CATB will incorporate a high-fidelity F-35 cockpit that will enable pilots to operate and monitor the fighter's integrated sensor suite in an airborne environment.

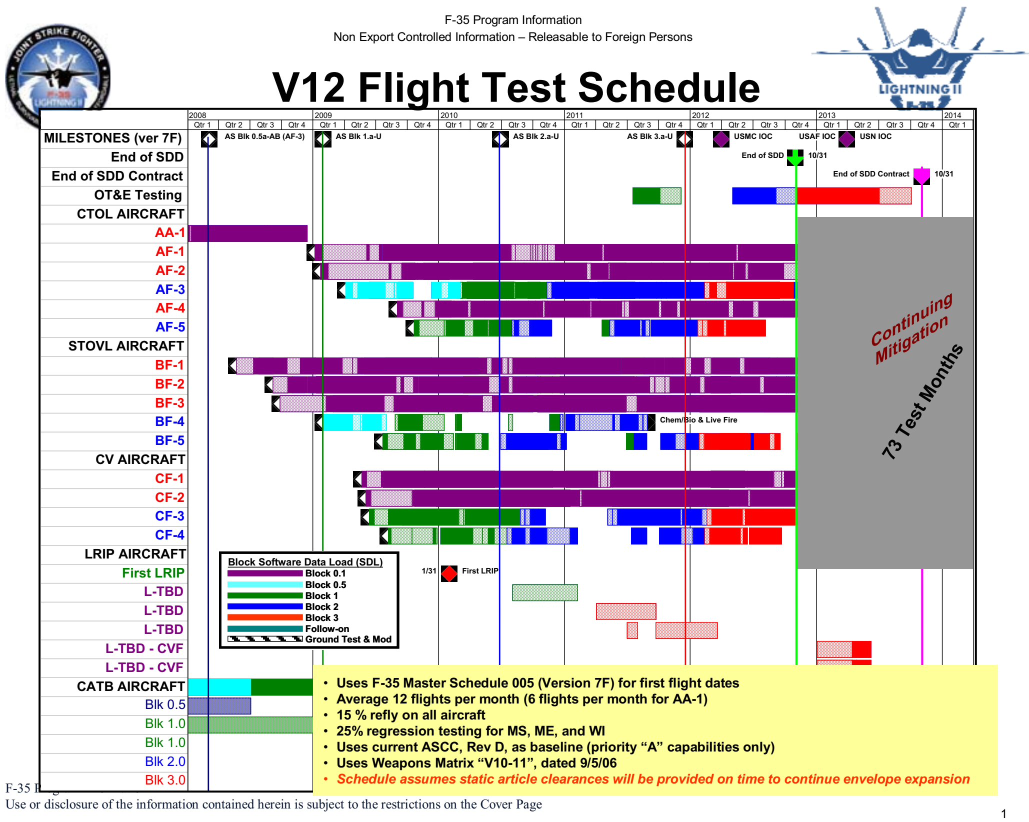
"Today's milestone initiates a phase of unprecedented integrated avionics test capability," said Eric Branyan, Lockheed Martin vice president of F-35 Mission Systems. "The rigorous testing performed on board the CATB will ensure that mature functionality is delivered to the F-35 Lightning II."

In addition to its F-35 SDD fleet and the CATB, the Lightning II program has been employing several other flying testbeds to develop its systems. The EOTS Sabreliner accomplished its first flight on 17 May 2007 in Phoenix, Arizona. The LM Sabreliner modified with the Electro-Optical Targeting System (EOTS) sensor, window and workstation equipment has completed its airworthiness testing and has begun the evaluation phase. Subsequent flights will test the laser and other targeting systems functions though the end of the year.



The F-16 remains one of the primary concept demonstrators for the F-35. Programs continue for the testing of Automatic Air Collision Avoidance System (AutoACAS) to improve aircraft safety, and the aircraft served as one of the primary platforms for helmet development. The F-16 is the principal aircraft for use as a chase and target for F-35 production acceptance flights and local flight test.

Additional flight testing has occurred in Maryland with Northrop Grumman's support of radar development with its BAC1-11 aircraft. This advanced multi-function radar has also gone through extensive flight demonstrations during the JSF CDP.



Testing on AA-1 is proposed to continue well into 2008. Prior to the completion of this testing, the remaining SDD aircraft will begin to roll off the assembly line at a steady rate. Full-scale testing of the SDD aircraft will begin in the middle of 2008 as the first of 14 flyable SDD aircraft will be delivered to its designated test site. Current planning envisions a comprehensive test program of more than 6000 sorties and about 12,000 flight hours for STOVL and CV aircraft testing at Patuxent River and CTOL testing at Edwards AFB. Special mission requirements such as multi-ship testing and unique ranges will result in the deployment of those aircraft to other locations. Most of the ground test operations, CATB operations, and several follow-on modifications of the SDD flight test aircraft will be centered out of Fort Worth. In addition to the three primary sites specialized testing will lead to deployment to up to ten other test locations. Additionally, the STOVL and CV variants will undergo sea trials aboard American, British and Italian aircraft carriers. Sea trials will evaluate the continuous tailhook-to-nose-gear structure and catapult-compatible nose gear launch system which has been strengthened for catapult and arresting loads.

Aircraft will be designated as Flight Sciences or Mission Systems. Mission Systems testing will be accomplished on two of each variant and Flight Sciences testing will be dispersed among the other eight aircraft. The Flight Sciences aircraft will evaluate flying qualities, stability and control, high angle of attack, environmental, propulsion, flutter, loads, dynamic response and store separation. STOVL handling and carrier suitability will be unique testing for the applicable variants. Mission Systems testing will be primarily focused on interoperability, store integration and avionic integration.

In terms of interoperability testing, the F-35 will have the most robust communications suite of any fighter aircraft built to date. The F-35 will be the first fighter to possess a satellite communications capability that integrates beyond-line-of-sight communications throughout the spectrum of missions it is tasked to perform. The F-35 will contain the most modern tactical datalinks which will provide the sharing of data among its flight members as well as other airborne, surface and ground-based platforms required to perform assigned missions. JSF partner nations have been working together to achieve a goal of common communications capabilities and web-enabled logistics support.

Store integration testing will continue to evolve over the course of the aircraft's life. The F-35 will employ a variety of US and allied weapons. With air-to-air capability, air-to-ground capability and air-to-sea capability to defend itself and to attack, the F-35 has been designed to carry, either internally or externally, a large array of weapons.

Mission system testing will focus on the integration of the Distributed Aperture System (DAS); EOTS; Multi-Mission Active Electronically Scanned Array (AESA) Radar; HMDs; Integrated Communications; Navigation and Identification Avionics, Multi-Function Display System (MFDS), and a sophisticated glass cockpit.

The Distributed Aperture System will provide pilots with a unique protective sphere around the aircraft for enhanced situational awareness, missile warning, aircraft warning, day/night pilot vision, and fire control capability. The system is a joint effort with Lockheed Martin Missiles and Fire Control and Northrop Grumman Electronic Systems which will provide key electronic sensors for the F-35. Both companies are jointly providing key electronic sensors for the F-35 to include the EOTS. The internally mounted EOTS will provide extended range detection and precision targeting against ground targets plus long range detection of air-to-air threats.

Northrop Grumman Electronic Systems is developing the multi-mission AESA Radar for the F-35. The radar will enable the F-35 JSF pilot to effectively engage air and ground targets at long range, while also providing outstanding situational awareness for enhanced survivability.

Northrop Grumman Space Technology's integrated communications, navigation and identification avionics satisfy the requirements for greatly increased functionalities within extreme space and weight limitations via modular hardware that could be dynamically programmed to reconfigure for multiple functions. This "smart" box approach delivers increased performance, quicker deployment, higher availability, enhanced scalability and lower life cycle costs.

The F-35 cockpit provides its pilot with outstanding situational awareness, positive target identification and precision strike under any weather condition. Integrated mission systems and outstanding over-the-nose visibility features are designed to dramatically enhance pilot performance. Inside the cockpit, Rockwell Collins's 8"x20" MFDS will employ leading edge technology in projections, engine architecture, video, compression, illumination module controls and processing memory. One-gigabyte-per-second data interfaces will enable the MFDS to display six full-motion images simultaneously. The adaptable layout will be easily reconfigurable for different missions or mission segments. Projection display technology will provide a high-luminance, high-contrast and high-resolution picture with no viewing angle effect.

Two types of flight test instrumentation architectures are being implemented during the F-35 build process to support mission systems testing and flight sciences testing. In turn, each design is uniquely tailored to meet the specific test requirements of the aircraft.

The Mission Systems aircraft will concentrate most of their group B flight test instrumentation in the Data Acquisition and Recording (DART) pod which is designed and manufactured by TERMA. Cockpit controls and displays, antennas and group A will make up most of the on-aircraft installations. The DART pod fits in the left weapon bay without interfering either physically or operationally with the aircraft The enclosure and environmental control system provides an environment which allows the data system to operate and function properly in all flight regimes. The DART pod is easy to remove and reconfigure and the flight data is easily accessible while it is installed in the weapon bay. Weight can be added to the pod to make it simulate a 1000-lb weapon. Ground testing of the DART pod has begun at TERMA Aerostructures facility and will continue in Fort Worth in 2008. The first flight with the pod is scheduled in early 2009. Instrumentation on mission systems aircraft will be capable of telemetry and recording of video and data sources including time-correlated high-speed avionic data bus acquisition. The aircraft will be capable of internal Time Space Positioning Indications (TSPI) and re-radiation (re-rad) capability. High-speed data acquisition for the AESA, EOTS and DAS will be accomplished with the Firehose pod also manufactured by TERMA which is secured in the opposite bay as the DART pod. Firehose pod deployment will trail the DART pod by a few months.

Flight Sciences aircraft will not have fully functioning avionics and therefore will be able to use the space currently planned for those boxes. The internal weapons bay will be available for all of its intended store loadings and the systems will be more tailored to specific missions given the constraints of space. Store environment and separation testing use high-speed digital cameras which can be housed on the aircraft or on AIM-9X shapes. Flutter, loads and dynamic response testing require embedded strain gages, store instrumentation kits and a flutter excitation system. Stability and control and high angle of attack testing are supported with a spin/stall recovery system, an instrumented noseboom, an auto-maneuver test aid and an authority-limit test aid. Flight test data processing facilities will be unique because of the "linked" nature of the system designed to share data between the test sites and with the end users.

The F-35 is designed to replace aging fighter inventories including U.S. Air Force A-10s and F-16s, U.S. Navy F/A-18s, U.S. Marine Corps AV-8B Harriers and F/A-18s, and U.K. Harrier GR.7s and Sea Harriers. The F-35 combines the stealth capability of the F-22 and F-117, the survivability of the A-10, the versatility of the F-16, the lethality of the F/A-18 and the maneuverability of the Harrier and will add to that numerous next-generation technologies.

Three versions of the F-35 are under development: a conventional takeoff and landing (CTOL) variant for conventional runways, a short takeoff/vertical landing (STOVL) variant for operating off small ships and near front-line combat zones, and a carrier variant (CV) for catapult launches and arrested recoveries on board the U.S. Navy's large aircraft carriers.

As a result of its versatility, the F-35 can be used in a variety of scenarios. By meeting numerous roles and missions, the F-35 will reduce defense spending with volume purchases. With a high percentage of common parts and systems among the three variants, costs can be reduced by creating single supply lines. This is also advantageous during the production phase as common tooling and equipment can be used in the aircraft manufacture. Operation and support costs will be reduced with requirements for unprecedented reliability, common maintenance procedures and common spares among the variants. This will also allow common upgrades and consequently common testing especially in the area of software upgrades.

As a single-development program, improvements can be leveraged across the three variants. Duplications of efforts will be avoided, technology is more efficiently shared and greater economies of scale will be achieved. From ongoing production today through testing and full service in the future, the F-35 will seamlessly incorporate the latest technological advancements as they emerge. Its design is specifically developed with room to grow, room that will continue to ensure that the F-35 will be a highly adaptable platform ready to accommodate rapidly changing technologies.

At this time, the F-35 has nine countries involved in the aircraft development. The F-35 will create a truly global, highly effective fighter force. As the first U.S. combat aircraft acquisition program to have had international participation from its inception, the JSF allows the U.S. and its allies to ensure that coalition forces will be able to tackle heavily defended targets alongside U.S. forces. The U.S., United Kingdom, Italy, the Netherlands, Turkey, Canada, Denmark, Norway and Australia are partners. Partnership in SDD entitles those countries to bid for work on a best-value basis and participate in the aircraft's development. Additionally, Israel and Singapore have agreed to join the program as Security Cooperation Participants.

The F-35 will be extremely lethal. An integrated airframe design, advanced materials and an axisymmetric nozzle maximize the F-35's stealth features. It will have excellent aerodynamic performance and advanced integrated avionics. Its next-generation stealth, superb situational awareness and reduced vulnerability will make the F-35 challenging to locate, difficult to target and even more difficult to terminate.

Brooks Faurot

Brooks is the F-35 Flight Test Engineering Staff Specialist for New Business, Proposals and Estimates for the last 18 months. He is primarily supporting the proposal for Operational Test and Evaluation with the F-35 Low Rate Initial Production aircraft. Previously he was the F-16 Flight Test Engineering Specialist for New Business, Proposals and Estimates for 18 years. During his tenor he supported the proposal preparation of the flight test program for more than 27 countries and countless US programs. Brooks also was the flight test conductor for F-16 integration programs in the Netherlands, Norway, Ft. Worth and Edwards.

Brooks graduated from Embry Riddle Aeronautical University with a BS in Aeronautical Engineering. He also has an MS in Operations Research and a BA in Economics from State University of New York at Stony Brook. He has been President of the North Texas Chapter of SFTE since 2005 and co-chaired the Technical Paper committee of the 2005 Symposium and has been an active member of the chapter since 1994. He was also Treasurer of the Student Chapter of AIAA at Embry Riddle.

James Sergeant

James is the F-35 Flight Test Engineering Manager at Lockheed Martin in Fort Worth. James wrote the proposal for the X-35 flight test program and then served as a test director at Palmdale, Edwards AFB, and Patuxent River for the concept demonstration program that eventually received the Collier Trophy for demonstration of the unique Short-Takeoff Vertical Landing (STOVL) system. Previously he was the FTE for the development of the Variable Stability Inflight Simulator Test Aircraft (VISTA) F-16 that provides in-flight simulation and training. He also was the FTE for the Multi-Axis Thrust Vectoring (MATV) F-16 that developed and demonstrated air-to-air, post-stall maneuvering for the F-16 and tactical evaluations by the USAF Fighter Weapons School. The F-16 MATV flight test program was awarded the 1994 SFTE Kelly Johnson Award. James also worked and flew as an FTE on the EC-130V aircraft (C-130 with E-2C Hawkeye rotodome), YF-22A (first flight test conductor), F-16 Reconnaissance (Recce), Cessna 208 Recce, and several other F-16 test programs.

James graduated from the University of Texas at Arlington with a BS in Aerospace Engineering in 1983 and is a Senior Member of SFTE and AIAA. He has published four technical papers at SFTE Symposiums on the "F-16 MATV Flight Test Program" in 1994, the "VISTA/F-16 Flight Test Program" in 1995, the "X-35 Flight Test Program" in 2001, and the "F-35 Flight Test Program" in 2007. He also co-presented "Flight Test Rehearsal Using Computer Connectivity to Increase Flight Test Safety" at the 2001 SFTE/SETP Flight Safety workshop. He served as president of SFTE from 1998-2000, two terms as a Director on the International Board from 1994-1996 and 1996-1998, and North Texas Chapter president from 1991-1994. James received the SFTE Directors Award in 2006 and was recently selected as an SFTE Fellow. He has chaired the last two SFTE International Symposiums in Fort Worth in 1996 and 2005 and will be chairing the symposium again next year in Fort Worth.