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F-35
Year in Review
2004

Rising to the Challenge

RISING TO THE CHALLENGE

by Robert Elrod

F-35 JSF PROGRAM MANAGER
LM AERO EXECUTIVE VICE PRESIDENT

and Tom Burbage

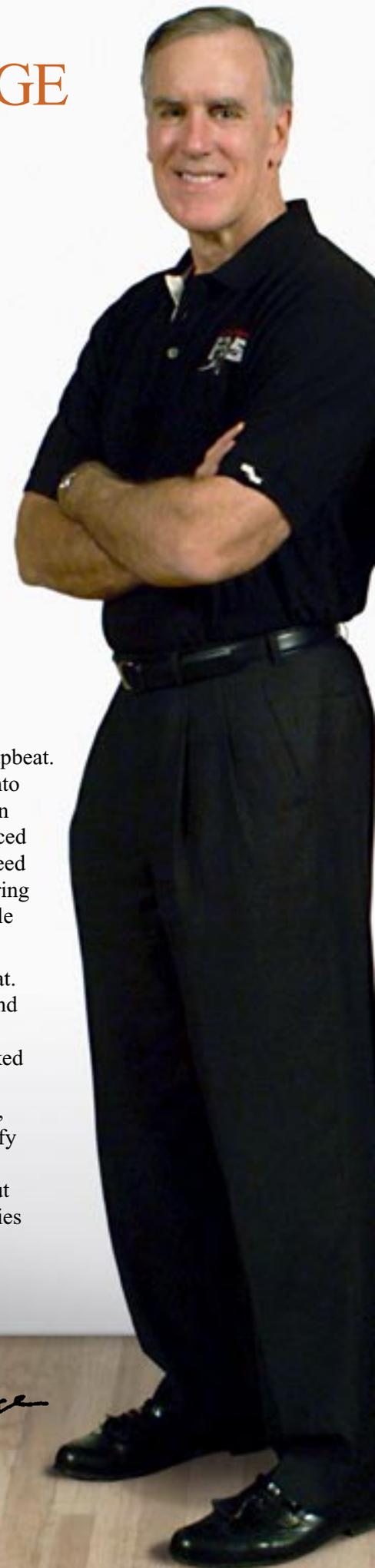
F-35 JSF PROGRAM INTEGRATION MANAGER
LM AERO EXECUTIVE VICE PRESIDENT

F-35 Joint Strike Fighter is the most complex fighter program ever undertaken. Amid such complexity, serious issues can arise with remarkably short notice, as demonstrated in 2004. More remarkable, however, has been our team's immediate and unequivocal response to adversity. The imposing technical challenges of 2004 have revealed our collective ability to resolve, overcome and move on. Such character has helped us lay a strong foundation for 2005.

The F-35 team ended 2004 with great confidence, but the outlook was not always upbeat. By February, dark clouds were gathering, and it was clear that the team was sailing into stormy technical waters. As detailed design progressed, weight estimates from early in the design phase were found to be overly optimistic. Program leadership was soon faced with the grim reality that the short takeoff/vertical landing (STOVL) variant would need to lose as much as 3,000 pounds to meet performance requirements. This was a sobering development, and there were more than a few who said that a fix was either impossible or too expensive and time-consuming.

To get the weight out, you do it the old-fashioned way: through hard work and sweat. Program leadership wasted no time in forming a specialized team of 500 engineers and managers, the STOVL Weight Attack Team (SWAT), with the single-minded purpose of hauling the aircraft back into its required-performance envelope. The SWAT attacked weight issues with intellectual ferocity and an open mind to suggestions from across the program. Motivation from program management, customer support and guidance, and the dedication of thousands of individual team members helped the SWAT identify a design path to a STOVL F-35 that meets or exceeds its performance requirements. The team not only excised more than 3,000 pounds of unwanted estimated weight, but also improved structural integrity, optimized load paths and brought greater efficiencies to the overall aircraft. Propulsion engineers, meanwhile, made adjustments to the F-35B's auxiliary engine inlet and exhaust nozzle to improve thrust by more than

Tom Burbage



600 pounds without making changes to the engine itself or the way it operates. All of this was accomplished in about six months – far shorter than anyone had predicted. Because of their shared basic architecture, all three F-35 variants will benefit from the SWAT-generated design enhancements. A combination of very hard work by very smart people has put the F-35 on schedule for first flight in late 2006.

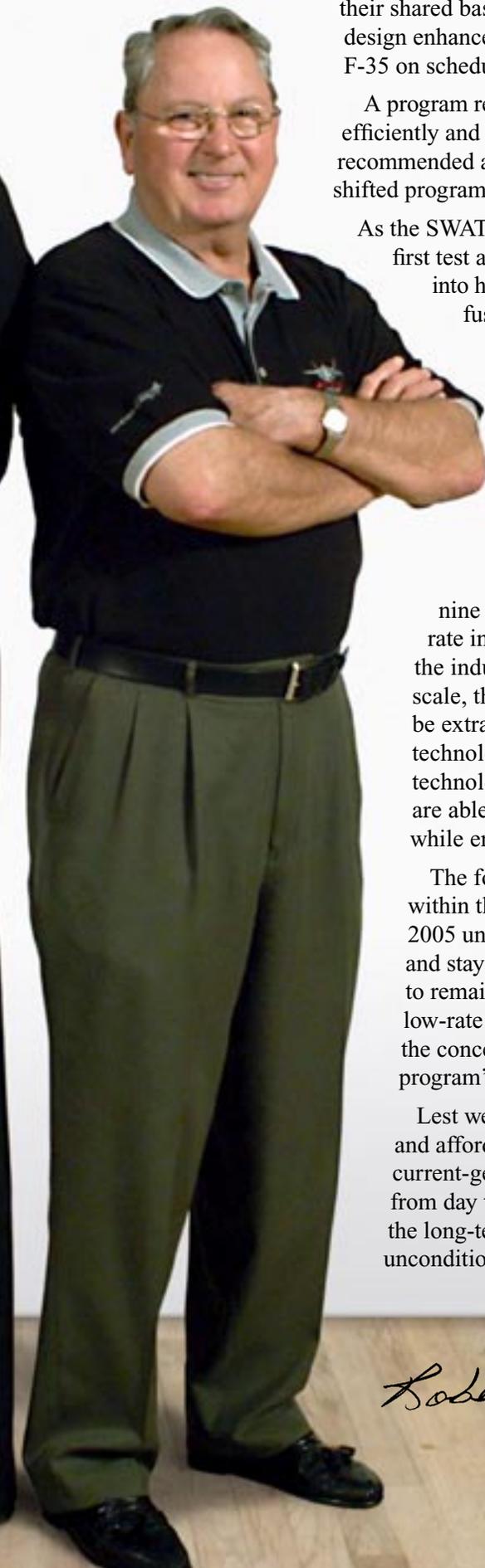
A program replan was required to ensure that the design improvements were implemented efficiently and on a realistic timetable. In October, the Defense Acquisition Board met and recommended approval of both the design upgrades and the replan. The updated schedule shifted program milestones about one year beyond their original dates.

As the SWAT closed in on the solution for an optimized F-35, assembly activities for the first test aircraft – a conventional takeoff and landing (CTOL) F-35A – were shifting into high gear. By the end of 2004, the wing structure was complete and the forward fuselage's composite skins were attached at Lockheed Martin's Fort Worth, Texas, plant. Northrop Grumman in Palmdale, Calif., started manufacturing the center fuselage and, by year's end, was closing in on completion of the major mate of the upper and lower assemblies and the start of hydraulic, fuel and electrical systems installations. At BAE SYSTEMS' new F-35 plant in Sarnesbury, England, the empennage was well under way and taking shape as 2005 approached. Northrop Grumman and BAE SYSTEMS will ship their completed subassemblies to Fort Worth in late spring, and final assembly will commence shortly afterwards.

2004 also was the first year in which companies from every one of the nine F-35 partner countries were under contract for program work. With low-rate initial production set to begin in 2007 and full-rate production in 2014, the industrial pie will get much bigger. Because of the program's expansive scale, the potential economic benefit for all F-35 partner countries continues to be extraordinary. Meanwhile, work is ongoing at the government level to ease technology-transfer restrictions while protecting sensitive or classified U.S. technologies. Such modifications of existing regulations will ensure that our allies are able to produce the F-35 systems and components that their contracts require, while enabling them to operate and maintain their F-35 aircraft without difficulty.

The following report details some of these issues, other key accomplishments within the program's Integrated Product Teams, and the challenges laid out for us as 2005 unfolds. This year, we are especially focused on completing the program replan and staying on track for the first flights of our test aircraft. We are also dedicated to remaining on schedule for our Air System Critical Design Reviews and our low-rate initial production contract awards. That commitment extends to finalizing the concept of operations for F-35 Global Sustainment, as well as improving the program's horizontal and vertical integration.

Lest we forget, each milestone represents another step toward a fleet of advanced and affordable stealth strike fighters with capabilities that are simply unavailable in current-generation aircraft. Our progress sometimes seems small and incremental from day to day, but we are always aware that our ultimate responsibility is enormous: the long-term security of the United States and much of the free world. We are unconditionally committed to doing our part.



Robert S. Eason



Air Vehicle Development

Bobby Williams
VICE PRESIDENT,
F-35 JSF AIR VEHICLE DEVELOPMENT

The Air Vehicle team faced – and resolved – many significant challenges in 2004. The STOVL Weight Attack Team (SWAT) was created and led a massive assault to reduce the weight of the aircraft by more than 3,000 pounds and improve the propulsion system’s installed performance. The Air Vehicle team successfully integrated these SWAT-driven ideas into the STOVL configuration, yielding an optimized aircraft design.

The replan allowed the entire team to pull together, taking a largely complete configuration through a redesign effort – in an astonishingly short time frame. Adding to the complexity of this task, the Air Vehicle team maintained focus on conventional-takeoff-and-landing (CTOL) design commitments. Understanding the need to sustain momentum through a number of important development milestones, the Air Vehicle team was up to the challenge, working significant amounts of overtime for a prolonged period of time.

Vehicle Systems’ software and hardware integration began in 2004, moving toward the F-35 “Power On” milestone in September 2005. Other key software-related reviews were conducted in 2004. The Mission Systems and Vehicle Systems Critical Design Reviews were both



Electrohydraulic actuators in the Vehicle Systems Integration Facility.

completed in March. Another key milestone was reached in August, when the Vehicle Systems team achieved hardware-in-the-loop simulation in the Vehicle Systems Processing/Flight Control System Integration Facility. This facility provides an integration test bed for our subsystem hardware and software prior to flight release. To reach these challenging goals, all team members worked toward a common vision with the same Guiding Principle: Expect the Exceptional!

Many of the key 2004 targets, commitments and milestones were being achieved even as new tools, software models and processes were being defined through lessons learned from legacy programs. Continued focus on providing team members the best tools possible is essential for Air Vehicle’s integration efforts planned in 2005.

The scale of the JSF program is what separates it from every other legacy program. Our team, which consists of the best and brightest within the aerospace industry, recognizes the scope of effort that lies ahead and has laser-sharp vision on the hardware, software and system-integration tasks for 2005.

2004 was a year of transition for the F-35 Air Vehicle team. Our focus on short-takeoff/vertical-landing (STOVL) weight reduction has been very successful and promises to yield benefits to both the CTOL and carrier variant (CV) aircraft configurations. 2005 brings a new set of challenges, as we build and integrate the software that breathes life into the F-35 aircraft. Building on the successes of 2004, our team remains vigilant in its day-by-day quest for flawless execution of program tasks and milestones for designing a highly effective and affordable fighter.



F-35 full-scale pole model testing.



Autonomic Logistics Development

Don Searles

DIRECTOR, F-35 JSF AUTONOMIC LOGISTICS DEVELOPMENT

Concepts for the support of the F-35 are as revolutionary as the fighter itself. Starting with on-aircraft systems that are extremely reliable, continuously monitored and accurate in detecting and isolating faults, the Autonomic Logistics (Autolog) System analyzes and manages the support operations to a level of efficiency and effectiveness unimaginable on legacy weapons systems. These capabilities are being developed through systems engineering methodologies to ensure a comprehensive design approach. Every aspect of operations and support is addressed as the Autolog team plans for the life of the aircraft – from training pilots and maintainers, to spare parts, to integrating the information systems for total life-cycle systems management. The team is essentially designing and building an entirely new logistics system – a major cornerstone in maintaining affordability for the life of the JSF program.

The F-35 operates with a suite of Prognostics and Health Management capabilities enabling accurate system status and accurate maintenance tasking. Combined with improved reliability and simplified maintenance tasks, fewer parts will be needed in inventory and far fewer people will be required to support the aircraft. The F-35 contains the capability to transmit the Prognostics and Health Management system status prior to landing, enabling preparations for services and maintenance.

This will permit technicians to meet the aircraft with all the necessary consumables, tools, people and spares to turn the aircraft quickly for its next sortie.

The year 2004 was outstanding for the Autolog team, operating within cost schedules and performance commitments. The team also passed its scheduled Critical Design Review in April.

During 2004, there were 46 new items of support equipment released to the manufacturing line and 49 LM Star™ Stations (depot test equipment) delivered to F-35 partners and suppliers. Additionally, the supply services provider, Honeywell/CAT Logistics, was selected on schedule to provide inventory and distribution services. Three Autonomic Logistics labs were up and running in Fort Worth, Texas, and Orlando, Fla., working on a wide range of analyses and simulations of the Autolog systems and serving as development environments. Autolog Information Systems selected commercial off-the-shelf tools for early implementation to support flight test readiness and released a Fault Recording and Corrective Action System capability for use by reliability and maintainability engineers and suppliers.

With more than 800 students trained to date, training of personnel to support flight testing operations is on schedule.

As a result of the replan, the Autolog team participated in the assessment of tasks and costs across the System Development and Demonstration period and worked closely with the JSF Program Office to develop a successful baseline at an acknowledged level of risk.

Customized Autolog tools were developed to enable rapid analysis of the impact of design changes, as the Autolog team worked to support aircraft design efforts and influence modifications that further helped to control costs. A major goal of these efforts has been to satisfy the JSF Key Performance Parameters of sortie-generation rate and logistics footprint.

The U.S. Air Force and Navy approved the F-35 depot source-of-repair process providing a strategy agreement for allocating work among the U.S. government depots. Concepts developed for a Global Sustainment strategy continue to be a focus for the team, including maturation of the business-case processes, performance-based logistics strategies, and partnering agreements with commercial and government agencies.

In 2005, the Autolog team will continue development to support first flight and the flight test program, deliver the capabilities supporting manufacturing operations, and continue to prepare and plan for low-rate initial production.





Chief Engineer

George Law
F-35 JSF CHIEF ENGINEER

Decision-making responsibility shifted greatly as part of the JSF program replan. The Chief Engineer's office, a team of 12 people headed by one of the original chief engineers of the JSF X-plane program, was organized for the sole purpose of assuring technical integrity on the JSF program. The role of the team is to solve technical issues as they surface.

In 2004, the chief engineer – a primary problem solver – became a key member of critical decision boards, including the Configuration Review Board, Configuration Control Board and Air System Board. From this perspective, most proposed configuration changes fell under the view of one small group that could deliver a fast, comprehensive response.

This had the effect of expediting and streamlining decision making. Schedules were smoothed by faster resolution of challenges that emerged in weight-reduction efforts. Though the chief engineer assumed duties in July 2004, well after the replanning began, the program swiftly picked up momentum toward a number of ambitious, but realizable, goals in 2005.

These include delivering a complete layout early in the year and entering the build-to-package phase for the STOVL variant by the second quarter. The build-to-package phase is expected soon thereafter for the CTOL variant. All are expected to be on track by a second-quarter Interim Design Assessment.

The creation of a new team under a seasoned chief engineer has had many tangible, positive effects. A process developed through a tightly knit group has made it possible to produce a faster measure of progress against a specific baseline. Team members are working with an Integrated Master Schedule that allows them to move forward with both short- and long-term goals, and to measure baseline progress. Many milestones lie ahead, but for 2005 the Chief Engineering team is focused on its ultimate goal: making a good technical product.



F-35 forward fuselage.



Systems Engineering

Matt Maxwell

DIRECTOR,
F-35 JSF SYSTEMS ENGINEERING

the executability of the program. Additionally, in October, the Air System Board approved a revised Systems Engineering Management Plan. In December, Systems Engineering held a successful review of progress made over the course of the year with selected government Independent Review Team members and the JSF Program Office.

Entering 2005, the Capability Maturity Model Integration is being developed and applied to F-35 to refine processes, track process execution and ensure a systems-engineering culture has been integrated across the F-35 team. Systems Engineering's support of the SWAT bore fruit in the shape of an optimized F-35 design.

No member of the Systems Engineering team will deny that 2004 was a year to remember. Daunting challenges arose and were achieved with the principles that guided the team throughout the year. A Guiding Principle – Expect the Exceptional – helped engineers open the door to 2005 with the realization that the F-35 is a far better aircraft.

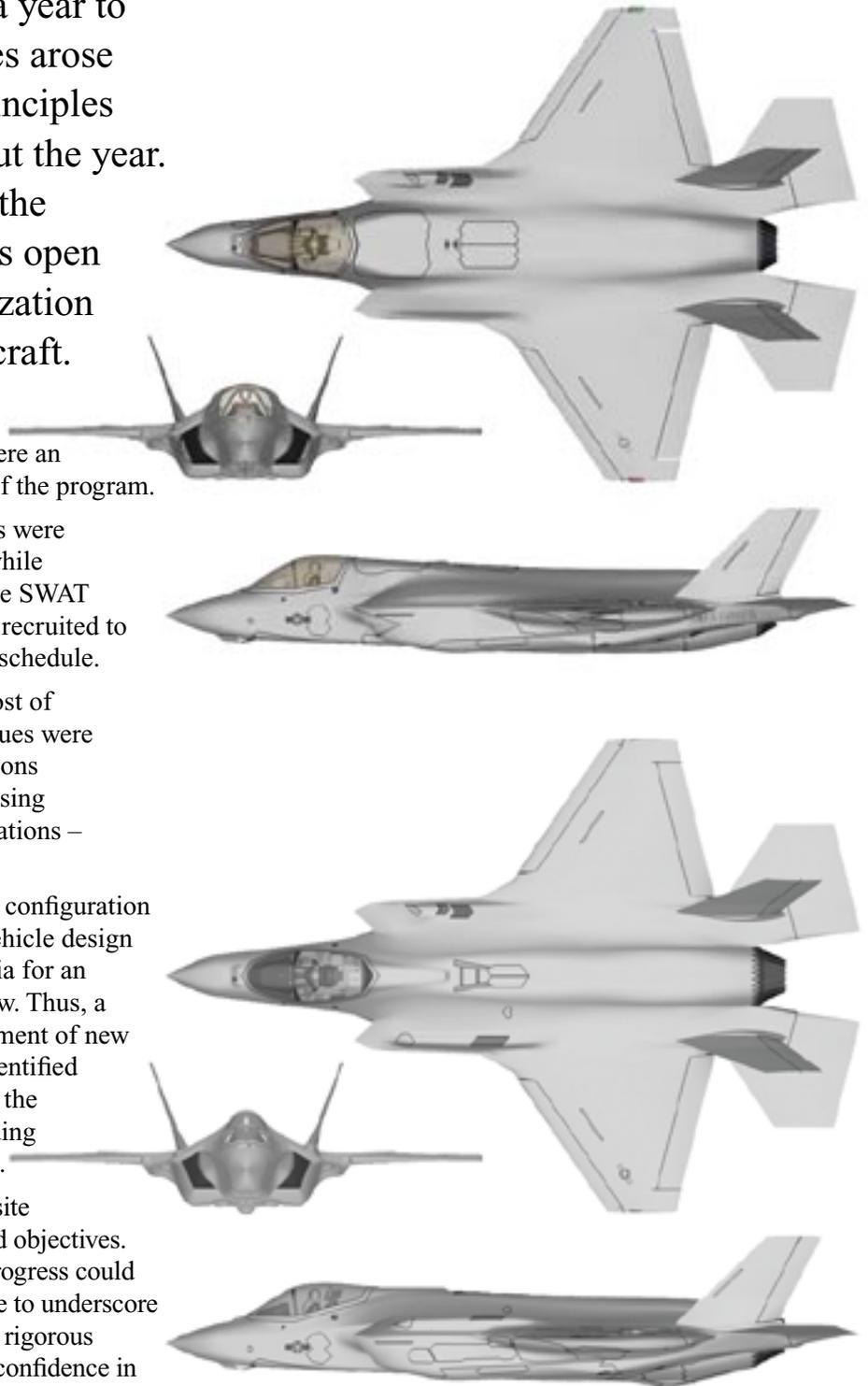
The STOVL weight issues that greeted Systems Engineering at the onset of 2004 were an unwelcome component on a critical aspect of the program.

Processes and decision-making procedures were streamlined to maximize weight reduction while maintaining critical technical controls. As the SWAT worked, additional technical personnel were recruited to help develop a replan integrated with a new schedule.

The team was consoled by the fact that most of the program remained on track as weight issues were being addressed. Planned production operations were being proven viable, and digital links using design-to-factory links were meeting expectations – parts were emerging as anticipated.

Weight issues and significant fundamental configuration changes forced the conclusion that the air vehicle design was insufficiently mature to satisfy all criteria for an upcoming Air System Critical Design Review. Thus, a new culture emerged that involved establishment of new indicators of progress, directed by clearly identified goals for the 2004–2005 time frame. Expect the Exceptional became much more than a Guiding Principle – it was a daily operating principle.

Systems Engineering held three pivotal offsite conferences to set the timeline with scheduled objectives. Metrics were aligned with the processes so progress could be immediately measured. The program chose to underscore a systems engineering culture and implement rigorous detailed technical planning to ensure greater confidence in





Chief Test Pilot

Jon Beesley

F-35 JSF CHIEF TEST PILOT

As the F-35 Joint Strike Fighter program continues on the path to first flight in 2006, F-35 test pilots have an increased level of involvement. The F-35 Test Pilot team includes members from Lockheed Martin, BAE SYSTEMS, the U.S. government and the Royal Navy. It is significant that the government has provided pilots from the onset of the program.

The team faced many challenges in 2004, but all pilots agree: the F-35 that emerged from the SWAT efforts is a better aircraft than it was before. Part of that success can be attributed to one of the program's Guiding Principles – Seek To Connect – which ensured the pilots were fully engaged in the SWAT efforts and the daunting task of redesigning an aircraft.

Pilots also worked with SWAT to assure that any design changes did not compromise the integrity of the aircraft's outstanding handling and maneuverability. Pilots worked with SWAT to initiate changes in the weapons bay, fuel systems, landing gear and flight control surfaces to reduce weight while creating a better fighter. The fighter may

resemble the F-16 and F/A-18 in size, but the ordnance and fuel provide a significant increase in capability.

In 2004, test pilots were involved with the continuing development of the F-35's control system, improving the aircraft/pilot interface and control functions. This included numerous simulations in Fort Worth, Texas, and a monthlong effort in the large motion simulation at NASA Ames Research Center, at Moffett Field, Calif., to refine control law design. Additionally, two evaluation periods were completed in the vectored thrust aircraft advanced control (VAAC) aircraft in the United Kingdom. This is a specially modified Harrier used to evaluate control concepts for the STOVL aircraft. The NASA Ames facility and the VAAC aircraft allow testing of the design handling qualities in the most realistic environments possible.

The team already is developing electronic flight manuals that describe how the aircraft operates, as well as emergency procedures. This effort continues with test pilot and engineering interaction across all systems on the F-35. We are completing the A-1 procedures and developing procedures for the follow-on aircraft.



Assessment of boarding ladder.



Customer assessing cockpit simulator.

Inset: Customer assessing Pilot Vehicle Interface.

Pilots have been testing helmet-mounted display systems developed specifically for the F-35. This includes flying in an aerobatic Pitts aircraft to evaluate helmet weight and center of gravity effects in a high-g environment. We are also assisting in design concepts and trade-offs for mission systems' capabilities.

Looking ahead to 2005, the pilot team plans to complete flight manuals and finish preparations for first flight in 2006. Team members will continue to participate heavily in the development of complex mission systems and integration issues – in a very real sense, beginning test flights before the aircraft actually flies.



Government/ LM Propulsion

Fran Ketter

DIRECTOR, F-35 JSF PROPULSION
SYSTEM INTEGRATION MANAGER

With identification of the weight issues that led to the organization of SWAT, attention focused not only on the airframe, but also on the propulsion system. All Propulsion team members — Pratt & Whitney (P&W) and the GE Rolls-Royce Fighter Engine Team — would soon become a powerful part of a solution to what had begun as an air vehicle weight problem.

As SWAT attacked the problem from every angle, development of the propulsion systems continued on pace. The team reached a significant milestone when Rolls-Royce, makers of the LiftFan™ system, celebrated the opening of a new test facility in Indianapolis, Ind., in January. The \$20 million facility is specifically dedicated to the development and testing of System Development and Demonstration (SDD) and production lift fans. The first SDD lift fan initiated testing in early February, and acceptance testing of the first lift fan to be tested with the complete STOVL propulsion system was finished in early April. On April 7, the first dynamic clutch engagements were achieved at the facility, followed by the success of the first F135 STOVL test propulsion system at Pratt & Whitney's West Palm Beach, Fla., test facility. The first dynamic clutch engagement at idle power was completed on April 14.

Meanwhile, P&W and GE were continuing to develop the F135 and F136 engines to the requirements that both had to be physically and functionally interchangeable across all F-35 aircraft and the JSF Autonomic Logistics System. Early in January, a significant milestone was reached when the F135 engine achieved the first Max Zone 3 afterburner run. In early April, a Last Bolt Ceremony was held commemorating the completion of the F135 STOVL propulsion system at P&W's West Palm Beach facility. This was closely followed by the first SDD STOVL propulsion system initiating testing on April 13.

By April 30, P&W had measured uninstalled specification-level STOVL vertical thrust on the C-12 test stand in West Palm Beach. On May 12, an F135 CTOL engine began its first run at the Arnold Engineering Development Center in Tullahoma, Tenn., to acquire critical altitude engine performance data.

The GE Rolls-Royce Fighter Engine Team achieved a major milestone on July 22 by successfully firing the F136 First Engine to Test. By August 17, the F136 engine had achieved 105 percent corrected fan speed transiently three times to acquire engine aeromechanics data. On August 24, the team completed F-35 Program Event No. 6, the Alternate Engine Readiness Review, in Fort Worth. This event demonstrated the readiness for the entry of the F136 Fighter Engine Team into SDD.

Engine testing was well along when F-35 Propulsion team members identified a new requirement: find ways to increase installed propulsion efficiency as part of the SWAT effort to improve STOVL variant short-takeoff distance and vertical-lift bring-back capability. Ultimately, the Propulsion team succeeded through a number of improvements, including optimization of the STOVL nozzle design to generate more STOVL mode thrust. As a product of this activity, the installed vertical hover thrust was increased by almost 700 pounds and the short-takeoff roll axial thrust was increased by 2,800 pounds.

In addition, the Propulsion Integration Team has had a very successful and busy year starting with the completion of the F-35 Propulsion Integration Critical Design Review in January. Other propulsion integration testing successfully completed included: full-scale inlet/engine compatibility testing in March, STOVL low-speed wind tunnel inlet testing in May, core nozzle testing in June, up-and-away jet effects testing and static inlet testing in August, hot gas ingestion testing in September, STOVL inlet and force moment testing in October, and a full-scale plume survey testing in December. The Propulsion Integration Team finished 2004 by successfully completing the F-35 Propulsion Integration Technical Interchange Meeting, which reviewed progress made since the Propulsion Integration Critical Design Review in January 2004 and set the team objectives and priorities for 2005.

Moving into 2005, Propulsion engineers are now working toward timely qualification of the CTOL and STOVL propulsion systems. Challenges remain, but the success in solving weight/propulsion issues early demonstrates confidence in a replan that calls for CTOL engine installation in the first F-35 flight test aircraft in January 2006 and flight test initiation in the third quarter of 2006.



Integrated Test Force

Paul Metz
VICE PRESIDENT,
F-35 JSF INTEGRATED TEST FORCE

If some tasks require big thinking, the Integrated Test Force directs its focus in a different direction . . . and thinks very small. Team members measure their working world in terabytes and petabytes as they integrate instrumentation systems into the most densely packed aircraft ever built – one that changed significantly in 2004 and challenged the Integrated Test Force to meet requirements for what will be the smartest aircraft in the world.

Instrumentation planning was nearing completion when the weight issues and replanning task made it necessary to replan the effort significantly to accommodate design changes. Individuals focused on the first aircraft – A-1 – and began to anticipate the requirements for B-1, which reflects the full scope of the weight reduction effort. The differences between the two – in terms of instrumentation and wiring – are significant.

The effort to literally transform the integration planning for the second aircraft proceeded alongside significant milestones for the first. All instrumentation was completed for the forward fuselage. The F-35 Flight Test Data Processing Facility was opened in Fort Worth, Texas.

Construction was begun for the Edwards Air Force Base, Calif., and Patuxent River, Md., test sites. Preliminary Design Review for the Flight Test Instrumentation Ground Support Unit was demonstrated with only minor changes required.

Meanwhile, in-flight simulation studies of the F-35 JSF vectored aircraft advanced control Harrier roll-axis were successfully completed. And extensive modifications to a Boeing 737-300 – internally and externally – continued for avionics testing to begin in 2005. The aircraft will allow technicians to mimic precisely the F-35 relationship with its avionics, allowing tests and validations to proceed for virtually all systems. An F-35 “cockpit” inside the aircraft will allow more than 20 engineers to perform diagnostics in flight.



Replanning has prompted a significant increase in the planned flight test program. Evaluations of how many flight tests to conduct versus modeling/simulation tests continue. As with all teams, extensive focus is being given to first power-on, when all data systems will be activated for the first time.

One of the most significant milestones related to the Integrated Test Force is actually a landmark for military aviation history. Never before have all services and partners, with different testing parameters and methodologies, come together in a single team to work together in the development of systems for one fighter.



Ground breaking at Patuxent River, Md.



Material Management

Art Price

DIRECTOR, F-35 JSF
SUBCONTRACT MANAGEMENT

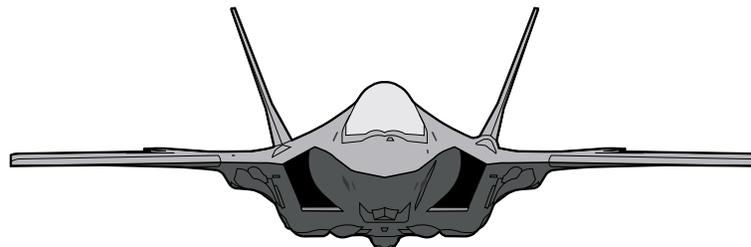
In 2004, Material Management worked to assure that it was being responsive both to the international-partner countries' supplier community and to the domestic small-business community. Considerable progress was made in meeting the international-participation challenge, and the extended team continued toward meeting our stretch goal of 30 percent small-business participation over the life of the program. Reports submitted to the Joint Strike Fighter Program Office at the end of November show 13.58 percent small-business participation in System Development and Demonstration, with 22.42 percent forecast for production.

Subcontractors showed further evidence of their willingness to cooperate and work hard to keep the F-35 affordable. The effort was evident in their response to allocation of Estimate at Completion (EAC) "should cost" targets associated with the replan and their support of SWAT. In the first round of subcontractor engagements aimed at achieving an executable System Development and Demonstration program, the top 14 suppliers, representing 89 percent of the subcontracted task, responded that they would execute to the new EAC dollars. They also provided more than 200 cost-cutting suggestions. Those recommendations are being vetted by the Air Vehicle team through the Air Vehicle EAC Reconciliation Team process instituted by Bobby Williams, the Air Vehicle team lead.

The balance of the subcontractors will then be engaged using the vetted suggestions as a basis for discussion and implementation. Vehicle Systems has engaged its entire supplier base, and Mission Systems is formulating its engagement plans. SWAT suggestions approved from the subcontractor community totaled 610 pounds in weight reduction. These improvements should be confirmed in 2005.

During the 2004 execution period, Material Management's discussions with the program partners led to the installment of Unicode – an interim solution to assure the controlled movement of teammate-furnished equipment. Unicode enables a single software product or a single Web site to be targeted across multiple platforms, languages and countries without re-engineering. It allows data to be transported through many different systems without corruption. Deliverables have been mapped and incorporated into the appropriate implementing language in systems and principal subcontracts.

The year 2005 will see continued focus on maturing the Supplier Strategic Advisory Council and on Joint Product Assessment Team forums. Additional interaction with suppliers will prepare the extended team for an effective execution of low-rate initial production.



F-35 JSF

GLOBAL INDUSTRY TEAM



Production Operations

Ed Linhart

VICE PRESIDENT, F-35 JSF
PRODUCTION OPERATIONS

Production facilities for the world's most revolutionary fighter program were completed at Lockheed Martin in Fort Worth, Texas; Northrop Grumman in Palmdale, Calif.; and BAE SYSTEMS in Sarnesbury, England. Major subassemblies from those centers will be mated during F-35 final assembly at Fort Worth. The machines at the three principal production sites will be used for the most highly automated assembly ever developed for a fighter aircraft.



Precision Milling Machine.

In Fort Worth, an array of advanced and extraordinarily precise manufacturing machines was finished for the production of the F-35 forward fuselage and wing. Some of the equipment is the largest that has ever been built. The huge Flexible Overhead Gantry, for example, will mill the inside surface of the F-35's composite skin to ensure that the aircraft's outer form is exact – a critical step in assuring stealth performance. Accurate to 50 microns (one micron equals one-millionth of a meter) and working in both horizontal and vertical motions, the machine is unprecedented in its size and purpose.

The Precision Milling Machine, also accurate to 50 microns, is built with an equipment enclosure that is temperature-controlled to plus/minus 1 degree Fahrenheit. Such consistency helps assure a much higher degree of precision in the manufacturing process.

The sheer size of both of these machines – whose cost represents a large portion of the capital investment – posed significant challenges, since scaling up existing models had the effect of enlarging specific problems. Software issues required the arrival of a special team from the manufacturer in Germany. Parts shortages also challenged engineers as they worked through adjustments for tolerances on both the machines.

Production start-up was achieved on time, despite these obstacles. Components for A-1, the first F-35, have been completed on schedule, including structures for the forward fuselage and the wing. Parts had the lowest rejection rate of any program in the company's history, and required fabrication hours have been cut in half. No tolerance issues have emerged on what everyone recognizes as the first fully digital fighter ever developed.

Much of the credit for this success goes to a team organized specifically to resolve production problems. The Tiger Team includes engineers, tooling specialists and procurement personnel, as well as other technical specialists. The team has attacked problems as they emerge, and all members are given a voice in proposing solutions.

Looking ahead, Production Operations is focused on upcoming final engineering release dates. The F-35 mate station is near completion with the first mate planned for the spring of 2005. The team is also addressing supply chain issues that are anticipated during high-rate production in 2014.



Flexible Overhead Gantry machine.



Business Management

Craig Happel
DIRECTOR,
F-35 BUSINESS MANAGEMENT

No one doubted that executing a complete program replan would involve schedule adjustments. Business Management's role in 2004 focused on implementing the changes in a reasonable, achievable baseline while maintaining the program's primary goal: affordability. Despite the impact of making the replan changes, Contract Progress Reports were delivered on time.

The program maintained fiscal discipline as was recognized when full funding was granted late in 2004.

This success reflected Business Management's increased visibility in the program during 2004. The team helped to establish manpower targets through a streamlined organization. By working with all Integrated Product Teams, the Business Management team was able to identify cost allocation requirements that could be more efficiently met across the organization. Meanwhile, the team also worked to solidify customer relationships through the Joint Strike Fighter Program Office, as contract changes were navigated through an emphasis on open communications.

If Business Management's functional responsibility was greater in 2004, it is gaining even more prominence in 2005. The team that found tremendous operational efficiencies is geared to find more, as other areas in the program become increasingly active with the approach of several milestones. Those include upcoming reviews such as first power-on and first flight in 2006. Each is important for planning another milestone that grows closer each day: low-rate initial production.





International Programs

Mike Cosentino
DIRECTOR, F-35 JSF
INTERNATIONAL PROGRAM OFFICE

A fighter program with such international scope represents a challenge unto itself, as nations around the world have signed on at various levels of partnership. The task of managing these relationships grew in complexity and size throughout 2004 – and will continue to do so in 2005.

Maintaining confidence in the team’s progress on a range of technical issues – many of which were gaining attention in the worldwide press – meant assuring all partners that the issues were being successfully addressed early in the program. This, in turn, mandated continuous communication as the technical members of the team developed solutions to the most prominent issue: platform weight.

Singapore and Israel joined the team in 2004 as Security Cooperation Participants. This, too, helped secure confidence that challenges were being successfully resolved. Engineers in Denmark, Italy and Turkey were integrated deeper into the program, and industrial cooperation programs were more fully developed, with partners getting ready to participate in production. Export licensing data was secured. Support relationships gained momentum, as parts-supply plans and global-sustainment systems continue to be refined.

Looking ahead to 2005, International Programs will be heavily engaged in addressing the closeout of industrial program participation and will focus on weapons systems and additional supply-chain management issues. The team will continue to nurture a culture that seeks to expand collaboration with partners.



Denmark Terma signing ceremony at Farnborough Air Show.

Inset: Cosentino and Burbage meet with Kale Kalip, a Turkish supplier.



Global Sustainment

Luke Gill

VICE PRESIDENT, F-35 JSF
GLOBAL SUSTAINMENT

Created during the reorganization of the JSF program, Global Sustainment emerged as a new Integrated Product Team in 2004. A resulting milestone occurred soon after, when F-35 Global Sustainment was selected as a potential pilot program by Management Initiative Decision 917 issued by the Department of Defense. MID 917 directs potential pilot programs to test revised contracting, programming, budgeting and financing processes for performance-based logistics agreements. The selection itself brought a level of credibility to the JSF program and reaffirmed the program pillars of supportability and affordability.

At first glance, the effort to build a support structure for a fighter not yet in production, or one that hasn't even completed its first flight, would seem premature. But it follows a mandate to develop strategic relationships for support of the F-35 – an extended engagement with services, countries and partners to begin to identify requirements and establish the framework for total life-cycle support.

Looking to the commercial airline industry as an example, the team realized that a legacy support structure for a variety of aircraft is extremely costly and inefficient. Those companies that operate fewer aircraft models enjoy a commonality in logistics support that slashes operation and support costs. Commonality is, of course, one of the key pillars of the F-35 – a fighter that will perform for services around the world. A planned Global Sustainment structure will make the most of this element of the program.

Implementing a Global Sustainment structure for the F-35 is a great undertaking. It is already anticipated that a 20 to 30 percent cost savings will occur in operations and support over the total life cycle of the weapon system, saving significant customer resources and supporting the program pillar of affordability.

This kind of performance-based support structure is rapidly capturing the attention of partners and suppliers, and the education effort continues. In 2005, the team will participate in a variety of symposiums and conferences, while senior logistics leaders visit Fort Worth to learn more about Global Sustainment initiatives.

Global Sustainment will help to implement more effective, less costly solutions for the warfighter. Discussions will continue with partner nations, industry leaders and others. In 2005, the team will continue to mature the Global Sustainment concept through building performance-based agreements with its customers and developing the sound business case that customers will need to make strategic decisions.





Business Development

Jim Grant

DIRECTOR, F-35 JSF
BUSINESS DEVELOPMENT

Business Development (BD) has a vital and challenging role on JSF: Keep the program sold! Budget pressures, technical challenges and changes in key leadership all provided challenges in 2004, but in the end, the program is funded and tracking to meet warfighter requirements. Through a nonstop series of meetings, briefings, visits, trade shows, demonstrations and liaison activities, BD interacted with all levels of our customer community to maintain confidence in, and funding for, the JSF program.

Winning the System Development and Demonstration down-select in 2001 was not the end of the JSF competition; it only shifted the focus to a different arena. Each year we must prove ourselves worthy of continued customer confidence, support and funding. It is a BD responsibility to lead the implementation of strategies that reinforce the “value” of the F-35 in meeting both U.S. and international needs – politically, economically,

operationally and technically. Fortunately, the program secured full funding for 2005 and is currently on track to be fully funded in 2006.

Domestically, weight issues and the subsequent schedule replan required constant interaction with all members of the customer base. BD focused on the services, the Office of the Secretary of Defense, and Congress to keep them informed and supportive of the program. Using all available venues – including plant visits, trade shows, base visits and media briefings – the BD team advocated the benefits of the F-35. Likewise, recognizing the need to expand stakeholder interest in the program, BD developed a series of briefings to explain the benefits of the F-35 as a close air support asset. These briefings were presented at the very highest levels of the U.S. Army and are helping shape joint/coalition warfare.

Internationally, BD enhanced the commitment of the eight partners and two participant nations by advocating how the JSF program and the F-35 aircraft will meet each country’s national objectives. The partner nations are beginning to formalize their purchase plans, and BD, working in lock step with the Joint Strike Fighter Program Office and our International Program Office, is solidly focused on strategies that ensure international users remain a prominent and continuing part of the JSF program. Beyond the partner nations, international interest in the F-35 remains high as public awareness on the program increases and emphasis on coalition warfare gains momentum.

As we shift focus to a new year – budget pressures from the war, deficit-reduction initiatives, and other competing service and national priorities will bring new challenges to the BD team. The team will remain focused on making sure our customers’ needs are fully understood and the program receives the full funding necessary to execute on schedule.





Strategy Integration

Paul Leamer
DIRECTOR,
F-35 JSF STRATEGY INTEGRATION

Every nation that operates the F-35 will enjoy the economic rewards of commonality in a very high performance aircraft. Yet, every nation also has individual needs and requirements. These are being addressed by the Strategy Integration team.

In addition to its responsibility for integration of strategy elements, this team is working on the future of the program. It works with various domestic and international customers through the Joint Strike Fighter Program Office

to understand specific Air System needs and execute related special studies. These studies cover a broad spectrum – from operations in severe environments, such as icy runways, to the stressful heat/humidity conditions of the Persian Gulf; unique vehicle or mission-system requirements; carriage/employment of new or unique country weapons; or peculiar support-system needs. Approximately 20 studies were initiated in 2004, while 40 to 50 are anticipated in 2005. Every study is important to the sponsoring customer and, therefore, to the entire JSF program team because of shared interests.

The Strategy Integration team is also supporting the Joint Strike Fighter Program Office with long-range planning for major capability upgrades such as Block 4 and beyond. While Block 4 is targeted for possible authorization in the 2009–2010 period, these plans typically look into the future 10 to 20 years. This is driven by the long acquisition process associated with the planning, budgeting, contracting, development and production/retrofit incorporation of a given upgrade. Lockheed Martin and its partners Northrop Grumman and BAE SYSTEMS are also assessing F-35 derivative concepts such as a two-seat variant and an electronic-attack variant. This long-term planning is focused on making certain the F-35 is always the system of choice to satisfy our customers’ changing needs.





Northrop Grumman

Janis Pamiljans

VICE PRESIDENT AND F-35 PROGRAM
MANAGER, NORTHROP GRUMMAN

Northrop Grumman has marked a year of significant progress for the F-35 Joint Strike Fighter Team, the highlight of which was the start of production. With assembly of the center fuselage under way, Northrop Grumman ushered in a new era for this already dynamic program and forged the way for the team to meet its goal of building the most advanced tactical fighter aircraft in history on the most advanced production line ever built.

Our delivery of one of the aircraft's key mission systems test stations further exemplifies Northrop Grumman's critical role on this team. The stations will enable users to test software on the same hardware platform that will host the software on the aircraft – significantly reducing risk prior to domain and system integration.

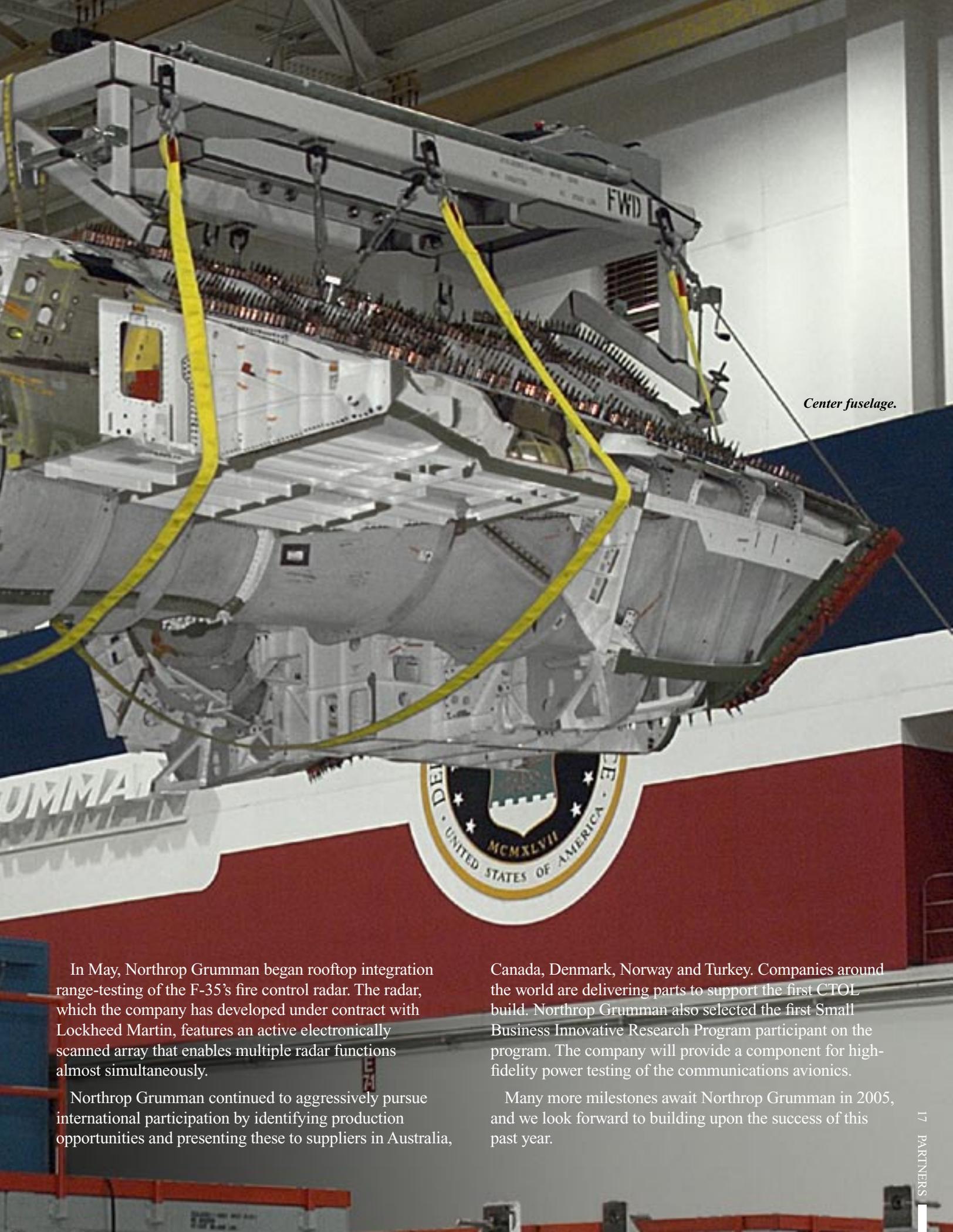
After completing a successful comprehensive review in February 2004, Northrop Grumman made the first significant delivery for the F-35 mission systems segment. The communications navigation and identification (CNI) radios for the F-35's first flight were delivered to the Lockheed Martin Mission Systems Integration Lab in

Fort Worth, Texas. Initial tests of the F-35's first-flight CNI system were flawless. This demonstrates Northrop Grumman's spiral development approach that allows hardware and software integration years earlier than in previous programs and ensures system stability and robustness.

Northrop Grumman also delivered and tested a fully instrumented, full-scale inlet model that will determine engine propulsion system characteristics; performed radar cross-section tests on a full-scale inlet model used to verify propulsion system performance; delivered a vertical-tip antenna designed to verify communications requirements; and initiated qualification testing on the fire-protection system and weapons-bay door drive to ensure system functionality requirements are met.

Also in 2004, the company continued laying critical groundwork for the aircraft's operational effectiveness by conducting a weapons-loading demonstration with military ordnance crews from the United Kingdom. The demonstration – similar to a weapons-loading exercise with U.S. ordnance crews in December 2003 – involved personnel from the Royal Air Force and Royal Navy loading mock-ups of several weapons into a full-scale mock-up of the F-35's internal weapons bay. The participants later provided evaluations of the process to the F-35 design team. Involving operational users early in the design of key aircraft components is unprecedented in military aircraft programs.





Center fuselage.

In May, Northrop Grumman began rooftop integration range-testing of the F-35's fire control radar. The radar, which the company has developed under contract with Lockheed Martin, features an active electronically scanned array that enables multiple radar functions almost simultaneously.

Northrop Grumman continued to aggressively pursue international participation by identifying production opportunities and presenting these to suppliers in Australia,

Canada, Denmark, Norway and Turkey. Companies around the world are delivering parts to support the first CTOL build. Northrop Grumman also selected the first Small Business Innovative Research Program participant on the program. The company will provide a component for high-fidelity power testing of the communications avionics.

Many more milestones await Northrop Grumman in 2005, and we look forward to building upon the success of this past year.



BAE SYSTEMS

Tom Fillingham
F-35 JSF DEPUTY PROGRAM
MANAGER, BAE SYSTEMS

At the start of the year, we knew this was going to be a very important 12 months for BAE SYSTEMS and our involvement on the JSF program. On January 1, we understood the weight challenges that faced our team and realized resolution of the weight issue would be a major factor in ensuring the future success of the program. As a team, we can be pleased with the results of our efforts in that direction.

Certainly the most significant development during 2004 is the element that undoubtedly affects us all the most – the rebaselining of the program. Without the commitment of everyone on the team, we would not have been able to restructure the program, ensuring that we could, in fact, deliver what the customers require. We now need to deliver to that new schedule.

From a BAE SYSTEMS' perspective, three major steps forward were achieved during 2004. In February, we started production of the first U.K. F-35 components. This commenced at one of our U.K. suppliers, Hyde Precision, and was quickly followed by BAE SYSTEMS Design and Manufacturing Centre at Samlesbury, England. I, along with Tom Burbage, were fortunate to be there when the first component was being produced, something I'll never forget.

The next major development was the signing of Technical Assistance Agreement Amendment 9, which gave us access to all the technologies needed to complete our System Development and Demonstration workshare.

The third major step forward was the start of assembly on A-1's aft fuselage at Samlesbury. We achieved this milestone on time, August 22, delivering in line with the original schedule we had set months before. It is that sort of commitment to schedule and on-time delivery that will be critical for ensuring success of BAE SYSTEMS and the overall program.

Looking forward, 2005 will be just as challenging as the past 12 months. The key to success lies in two areas. One is performing against the revised schedule, and the second is controlling the costs of the program and maintaining its affordability.

The major deliverable for BAE SYSTEMS during 2005 is the first aft fuselage and empennage, which will be delivered to Fort Worth, Texas, for final assembly in the summer. When you consider we had just cut metal on the aft fuselage in February 2004, it reinforces the message that the pace of the JSF program is unprecedented.

Another major development, particularly from a U.K. perspective, is the first Exchange of Letters Technology Agreement, scheduled to be signed in the third quarter of next year. This agreement between the U.K. and U.S. governments will represent an immensely significant advancement in terms of technology transfer between the two countries and further signify a step towards U.K. commitment to an F-35 production contract.



Burbage and Fillingham watch the first cut.



First assembly begins on the aft fuselage.

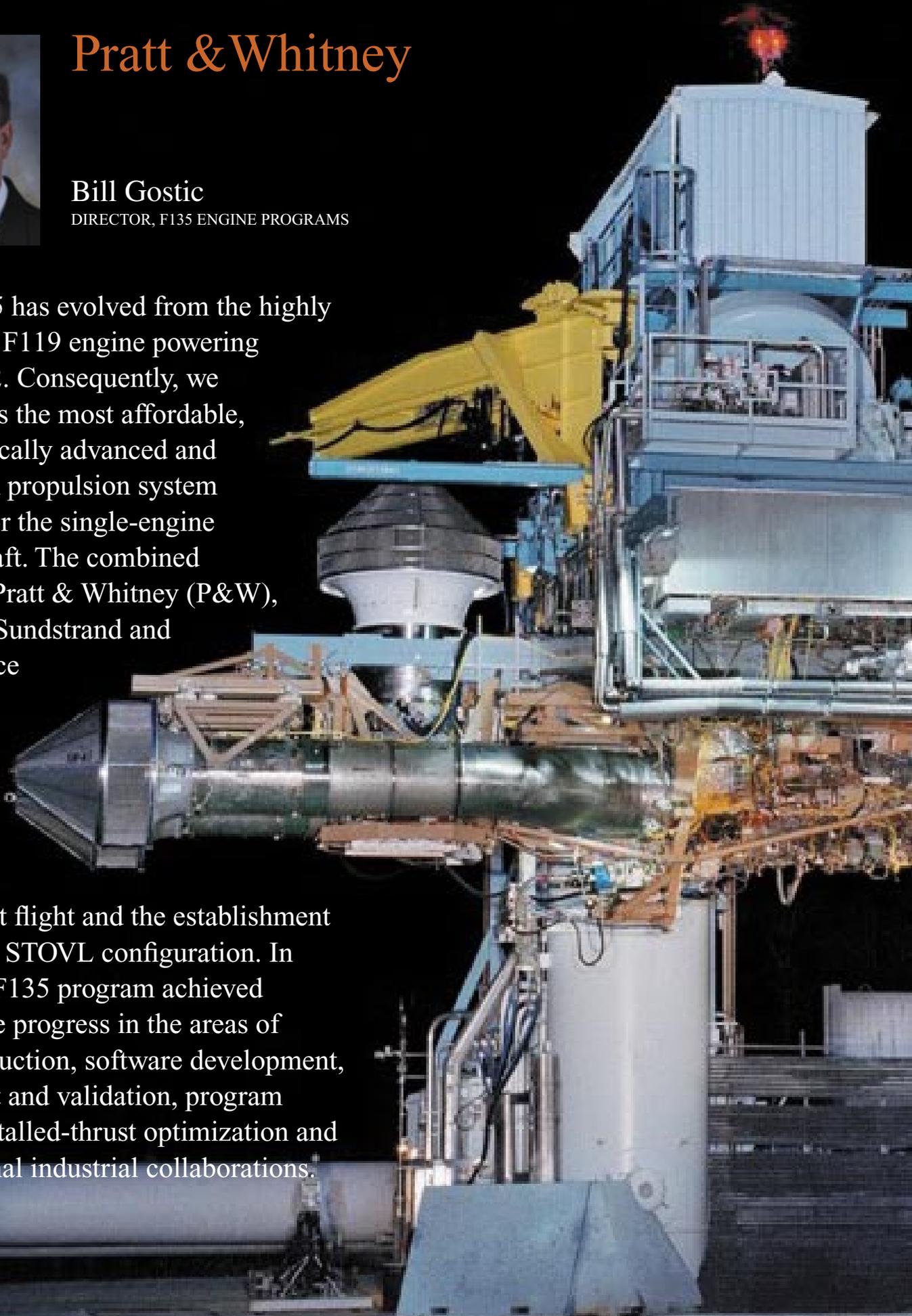


Pratt & Whitney

Bill Gostic

DIRECTOR, F135 ENGINE PROGRAMS

The F135 has evolved from the highly successful F119 engine powering the F/A-22. Consequently, we believe it is the most affordable, technologically advanced and lowest risk propulsion system solution for the single-engine F-35 aircraft. The combined efforts of Pratt & Whitney (P&W), Hamilton Sundstrand and Rolls-Royce resulted in the F135 program making significant strides toward first flight and the establishment of a viable STOVL configuration. In 2004, the F135 program achieved remarkable progress in the areas of weight reduction, software development, engine test and validation, program replan, installed-thrust optimization and international industrial collaborations.



FX643 in afterburner.

Both the CTOL/CV and STOVL systems showed marked improvement in weight reduction. Current estimates show the CTOL/CV and STOVL configurations are below specification weight. The F135 program has plans in place to realize further reductions in 2005 and beyond.

P&W celebrated a record year of software accomplishments. Software versions critical to the operation of the F135 STOVL propulsion system, including the operation of the clutch and the thrust split, were developed and implemented into the F135 engine-validation program.

The F135 SDD test program continued to make tremendous progress on the road to qualification for first flight. The team delivered the program's first STOVL propulsion system, FX641, to test, as well as STOVL propulsion systems FX640, FX642 and FX643. The CTOL/CV-configured FX632 was delivered to the Arnold Engineering Development Center in Tullahoma, Tenn., for altitude testing, for a total of seven assets in the test program.

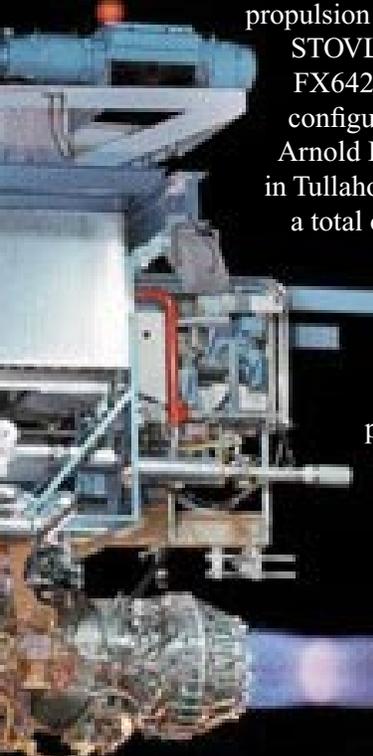
Over the course of the year, the F135 test program accumulated almost 1,700 total hours. At the same time, Rolls-Royce made tremendous progress in testing of the lift fan, accumulating more than 1,000 test hours. Both the CTOL/CV- and STOVL-configuration engines have demonstrated

specification levels of thrust in excess of 39,000 pounds. This unprecedented level of testing has validated predictions, as well as identified maturation issues to be resolved prior to initial flight release (IFR) qualification.

To assist the JSF program in achieving a viable STOVL configuration, improvements required to achieve higher thrust have been incorporated into the F135 propulsion system and program. These improvements, currently in the design phase, include an optimized STOVL nozzle and the addition of "roll post modulation." Thrust increases will be achieved in both vertical-powered lift mode as well as the short-takeoff mode.

Pratt & Whitney has also implemented a plan to maximize F135 industrial activity within the JSF partner countries. This multifaceted plan has the support of P&W leadership and involves many organizations across the enterprise. A cornerstone of the plan is the direct engagement with international companies to match capabilities with potential opportunities. Pratt & Whitney's efforts have led to contracts with more than 40 suppliers in all eight of the JSF partner nations. The team will continue to complement this success with additional international industrial contract awards in 2005.

As we move into 2005, the F135 program will look to build upon the sound foundation of 2004 accomplishments to accumulate the test hours required for CTOL IFR. Furthermore, P&W will deliver the first CTOL flight test engine in the fourth quarter of 2005. The production-readiness process is in full gear to support engines for flight testing, recognizing that single-engine safety is paramount to the success of the program. The F135 program is focused on providing the most technically advanced, reliable and safest propulsion system for the F-35's first flights in 2006.



Engine test site, West Palm Beach, Fla.



GE Rolls-Royce Fighter Engine Team



Bob Griswold
PRESIDENT,
GE ROLLS-ROYCE FIGHTER ENGINE TEAM



Tom Hartmann
SENIOR VICE PRESIDENT,
GE ROLLS-ROYCE FIGHTER ENGINE TEAM

2004 was the year that both the GE Rolls-Royce Fighter Engine Team (FET) and the F136 engine left the drawing board and became a reality.

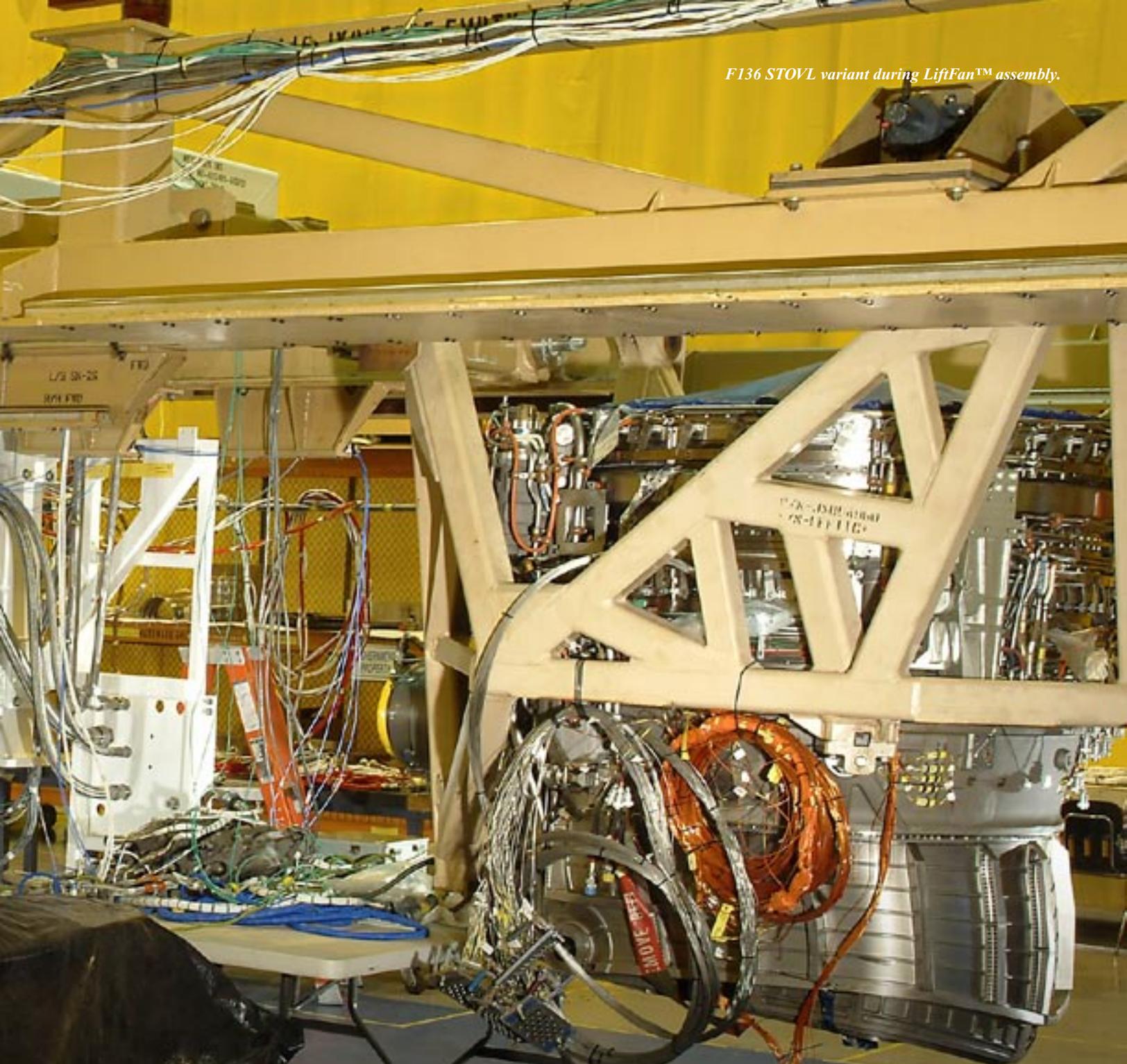
The FET demonstrated an unprecedented level of cooperation, unwavering commitment and unyielding determination to produce and successfully test its first revolutionary F136 propulsion system for the F-35 Joint Strike Fighter. Within months of this milestone, the joint venture received official recognition for the first time with the placing of the Transition Award Contract with the FET.

Building on the successes of 2003, the FET took the F136 interchangeable engine from vision to reality. On July 22, 2004 – the 1,000th day of the JSF program – FET successfully performed its first ground test at the GE Aircraft Engines Evendale, Ohio, facility, achieving the high-water mark of our Phase III, pre-System Development and Demonstration (SDD) contract. Engine 625-002, in the

conventional takeoff and landing (CTOL) configuration, demonstrated two soft light-offs and smooth transition to idle for a total of 1 hour and 17 minutes of testing. During follow-on testing, engine 625-002 demonstrated smooth starts, throttle transients, low vibration levels and stall-free operation. In mid-August, 625-002 achieved 105 percent maximum design speed. An additional 300 to 400 hours of endurance testing is planned for 2005.

In keeping with the hectic pace of the overall JSF program, the second F136 engine was assembled and delivered soon afterwards. This is our first short takeoff/vertical landing (STOVL) engine (625-003); it will be tested in early 2005 at the GEAE Peebles, Ohio, facility. Testing of this engine will close out our highly successful Phase III, pre-SDD contract and propel the team forward toward our anticipated Phase IV SDD award contract in 2005.

In our quest to reach SDD Phase IV, the FET achieved yet another first on November 1, when our Transition Award Contract began. This event is significant to the F136 program because it is the first contract officially awarded to the GE Rolls-Royce Fighter Engine Team.



This contract is designed to fund the F136 program incrementally until our SDD contract award is authorized in the third quarter of 2005.

On the global front, the FET has worked hard to incorporate key technologies from the eight partner nations (United Kingdom, Italy, Netherlands, Turkey, Canada, Denmark, Norway and Australia) participating in the JSF program. Eight summits were held in 2004 with the goal of identifying key companies. Industrial participation by all nations is anticipated for the SDD phase.

As a further commitment to international partners, Rolls-Royce has joined with Delft University of Technology in the Netherlands to launch an international

internship program to support the F136 program. In this ongoing program, the dual goals of knowledge-sharing with partner nations and helping young engineers as they start their careers are realized.

The year 2004 was excellent, but 2005 is looking sensational! Testing is ongoing with our two engines, hours of steady-state data are being recorded, and all key performance parameters are being met. Our objectives are clear and our team resolute. We will continue to play our part in manufacturing a first-class, affordable propulsion system that will power F-35s all over the world well into the 21st century.



2005 Outlook

Rear Admiral Steven L. Enewold
DIRECTOR, JOINT STRIKE FIGHTER PROGRAM

As we look ahead, our biggest challenge will be carrying out our commitments within the newly restructured Joint Strike Fighter program. To ensure success, the JSF Government and Industry Leadership Team established the following near-term strategies.

Program Priorities

- Complete Replan
- Track to First Flights
- Track to Air System Critical Design Reviews
- Track to Low-Rate Initial Production Contract Awards
- Finalize Global Sustainment Concept of Operations
- Improve Horizontal and Vertical Integration

Each of these priorities must be emphasized without “dropping the ball” on all the rest of the countless important ongoing and planned tasks. Further, we need to execute all tasking in a balanced manner using the “JSF Guiding Principles” to govern our behaviors.



JSF Guiding Principles

Inspire Excellence

We recognize and reward excellence in both our teammates and the product. Our actions and attitudes provide positive and motivating examples to our teammates. We continually strive to achieve our vision, program objectives and priorities.

Expect the Exceptional

We expect the exceptional from our leaders, our teammates and ourselves. We embrace change and innovation. We stand by our commitments and hold each other accountable for our actions.

Seek To Connect

We integrate and collaborate across organizational boundaries, providing the right information to all stakeholders who need it to perform their jobs. We promote two-way communication and recognize that both the good news and bad news will help us accomplish our objectives.



Foster Trust and Respect

We create an environment where the perspectives of our teammates are heard, listened to and honored. Each person's contribution is valued. We are honest by representing ourselves and our intentions truthfully.

Value the Individual

To take advantage of the "best of the best," we strive to incorporate the talents of the entire enterprise. We take the time to mentor, develop and empower our people to participate, lead and make decisions. We balance the demanding nature of the program with time for personal growth and renewal.

So, as we proceed into 2005, we will measure our progress toward these priorities to help keep the F-35 on track to first flight in 2006.

Lockheed Martin

Northrop Grumman

BAE SYSTEMS

Pratt & Whitney

GE Rolls-Royce Fighter Engine Team



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