

**75** AW&ST

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FLIGHT TEST  
MECCA  
OF THE 90s**  
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## Le Bourget '91: A Hearty Vintage

The 39th Salon de l'Aeronautique et de l'Espace survived a series of negative preshow events, including a global aerospace turndown and a Middle East war, to complete a 11-day run here last week with its reputation as the world's premier air and space exhibition firmly intact.

Naysayers and detractors notwithstanding, the venerable Paris air show demonstrated again that it essentially has a life of its own.

### SPECULATION DEBUNKED

Preshow speculation was rampant that the Operation Desert Shield buildup in the Middle East late last year and the ultimate outbreak of hostilities early this year would derail the exhibition. But as opening day loomed, the exhibit halls were jammed, a fair number of aircraft were parked on the static display ramp, and all but a few of the hospitality chalets were filled.

The weather did not cooperate, as intermittent rain swept the Le Bourget exhibition grounds throughout the 11-day run. And a furtive visit by French President Francois Mitterrand late in the afternoon on opening day, followed by a helicopter departure into glowering storm-filled skies, left many Le Bourget veterans feeling this year's show would be a bust. Tepid flight displays and thin attendance on the first weekend public days reinforced that impression.

But it is not possible to crowd several thousand members of an entity as dynamic as the global aerospace industry into an area as small as the Le Bourget exhibition grounds without striking sparks. As the show's second week began, it was evident the action was centered in the exhibition halls and chalets, and that the high-decibel distraction of a full-blown aerial demonstration program was hardly missed.

It was only on reflection that many show attendees realized that one element was missing—the perennial show-stopping British Aerospace Harrier VTOL fighter whose thunderous exhaust noise has smothered air show conversations for more than 20 years.

This year's exhibition marked a distinct shift at Le Bourget toward an aerospace trade fair with barely a nod to the air show aspect. This is more a reflection of the state of the industry, which has few totally new aircraft in development, than a conscious decision to deemphasize flying. When the next development cycle generates new designs, they will take their turns in the sky over Le Bourget.

The U. S. government decided at the last minute to send a gaggle of Operation Desert Storm combat aircraft to this year's show and told their builders they were expected to support the aircraft at Le Bourget. This forced several U. S. companies to scramble for remaining chalet

and display space, and the occasional austere arrangement reflected the short amount of time some companies had to plan their participation.

Staging the Desert Storm display was an inspired move, and the Pentagon officials who planned it deserve kudos. The biggest crowd pleaser, of course, was the U. S. Air Force/Lockheed F-117A stealth attack aircraft, which was making its first international show appearance at Le Bourget. The F-117A pilots, at least one of whom is fluent in French, were besieged by the media. By late last week, they had given more than 600 interviews and were a credit to the uniforms they wear and the nation they serve.

Widespread disappointment about the decision to not fly any of the U. S. military aircraft, most of all the F-117A, ignited a lobbying campaign at the show that included an AVIATION WEEK & SPACE TECHNOLOGY letter dispatched to President George Bush. Bowing to the pressure late last week, Defense Secretary Richard B. Cheney directed the F-117 pilots to join the flight demonstrations on Friday, the final trade day, and Saturday, the first of two final public days.

As to the overall value of the exposition, unofficial surveys of show partici-

pants produced reactions as diverse as the number of people queried. What it boiled down to is that this year's show, as with previous exhibitions, provided some participants with opportunities to work specific business agendas, while others believed they were wasting their time and their company's money.

### EUROPEAN UNITY A SUBTHEME

The focus of European unity emerged as an interesting subtheme of this year's show. Germany's Deutsche Aerospace group staged an impressive showing in the exhibit halls and on the chalet line, projecting an intent to be recognized as a major player in European aerospace circles. Behind the scenes, DASA continued to press its plans to develop an all-new 80-130-seat regional transport that could land it in a three-way competition with evolving designs in Britain, the Netherlands and throughout the multinational Airbus Industrie consortium.

Individual rivalries notwithstanding, European aerospace leaders visiting Le Bourget readily acknowledged the need to band together to achieve a domestic market critical mass on the continent that matches what their American counterparts have in the U. S.

At the same time, however, it should be evident to company managers on both sides of the Atlantic, and in the Pacific region as well, that universally shrinking defense budgets and the rising costs of civilian development efforts dictate more rather than less cooperation. It is in this kind of an environment that the true vintage of the Paris air show becomes evident.

*Naysayers notwithstanding, the venerable Paris air show demonstrated again that it has a life of its own*

# F-117A's Performance Boosts Wide Range of Improvements

DAVID HUGHES, JEFFREY M. LENOROVITZ/LE BOURGET

U.S. Air Force and Lockheed are upgrading the F-117A in a broad-ranging effort that includes installation of new avionics, modification of the engine exhaust system, changeout of wheels, tires and brakes, and replacement of metallic tail fins with composite ones.

Program officials said upgrades for the stealth aircraft stem from a variety of factors, and represent steps to further improve operability, maintainability and to minimize support costs—rather than fix shortcomings in the aircraft.

Some of the work is underway or about to be started. Additional upgrades would be implemented under a plan for which funding now is being considered by Congress.

The F-117 fleet upgrades were detailed to AVIATION WEEK & SPACE TECHNOLOGY by program officials who were here at the Paris air show along with an F-117 brought in to Le Bourget Airport for the stealth aircraft's first international air show appearance. The amount of information provided on the previously classified aircraft at one time was unprecedented. It demonstrated extensive USAF and government support in showing U.S. stealth capabilities to an audience of international experts.

The rework to the engine exhaust system involves the use of a new bottomside to the shelf-like extension over which the



exhaust passes. The modification involves the use of new heat shields, better seals, new airflow paths, and new, high-temperature thermal protection "bricks" at the edge of the exhaust system.

Paul W. Martin, F-117A program manager at Lockheed's "Skunk Works" Advanced Development Co., said the modifications represent "fairly simple" changes.

"The exhaust system handles very hot,

USAF Tactical Air Command F-117A was parked at Le Bourget behind two security fences after its arrival. During most days at the show, huge crowds gathered in front of the aircraft.

very fast-moving air. In contrast to other aircraft, the F-117 blows hot air through the airframe structure itself," Martin said. "The exhaust system was designed 10 years ago, and it has become one of the more burdensome areas of the airplane."

According to Martin, modifying the exhaust system will improve maintenance, leading to a reduction of maintenance man hours per flight hour. He added that the changes do not affect the F-117's infrared or radar cross-section characteristics.

Another modification is replacement of the F-117's two metallic, all-moving tail fins with ones made of graphite thermoplastic materials. This change results from the loss of one fin from an F-117 about four years ago during a flight test. According to officials, the tail fin "fluttered off" during a weapons evaluation while the aircraft was in an unusual flight condition with a large side slip and carrying a 2,000-lb. store. The aircraft landed safely despite the loss of the fin.

F-117A's novel exhaust system blows hot, fast-moving air through the airframe itself. Some proposed improvements would make it easier to maintain the exhaust area.



The following stories and photographs on the 39th Paris air show were prepared by an AVIATION WEEK & SPACE TECHNOLOGY editorial team at Le Bourget led by Editor-in-Chief Donald E. Fink and including European Editor Jeffrey M. Lenorovitz, London Bureau Chief Carole A. Shifrin, Bonn Bureau Chief Michael Mecham, Northeast U.S. Bureau Chief Dave Hughes and Assistant Managing Editor Joseph S. Caramanico. Photos are by Robin Adshead, Bryan Thomson and William F. Bennett.

As a result of the incident, some restrictions were placed on the F-117's angle of attack and maneuver rates until the new fins are fitted.

Jack S. Gordon, executive vice president of Lockheed's Advanced Development Co., said the tail retrofit has been performed on about half of the F-117 fleet, and he noted the program was interrupted by the aircraft's deployment to the Persian Gulf region.

## INCREASING MTBF

Avionics changes likely to occur soon in the F-117 include installation of a ring laser gyro and global positioning system receiver on the aircraft. The basic inertial navigation system now on the aircraft is the SPN/GEANS—a highly accurate system that also is used on USAF/Boeing B-52 bombers, but which no longer is in production.

"Our plan is to achieve a much higher mean time between failure rate with an RLG [ring laser gyro] without sacrificing accuracy," Martin said.

"In addition, support costs for SPN/GEANS are rising since the system no longer is being produced, so we hope to see a reduction in spending because of the changeover to the new equipment."

USAF will provide the ring laser gyro as government-furnished equipment. It is holding a competition for the supplier. The plan is to have a contract issued this year for integration of the unit within three years. Program officials said global positioning system hardware could be acquired and fitted on the F-117 fleet within the same time frame.

## MINIMIZING DISTORTION

The F-117's offensive capability also is being improved through the addition of Honeywell color multi-function displays with the capability to integrate a digital moving map made by Harris Corp. to give pilots greater situational awareness. Martin said he believes this offensive capability improvement program represents one of the first operational uses of a military-qualified digital moving map in a fighter-category aircraft.

The two cathode ray tube-based multi-function displays can be used to call up digital maps, target photos or target identification diagrams. A liquid crystal dis-



Movable portions of the two metal fins on the F-117A tail are being replaced with graphite thermoplastic ones. About half of the fleet has been retrofitted so far. This change results from the loss of one fin during a flight test.

play-based data entry panel allows the pilot to select from 256 avionics functions.

This new cockpit equipment is designed to minimize the chance of disorientation which was suspected as the cause of two accidents involving operational F-117s. Once enough aircraft are equipped with new cockpits, they will be introduced to the operational squadron, entailing changes in pilot procedures and training.

Autothrottles will be added to the F-117 to provide arrival at a precise time over a point or target—an important element in the type of missions flown by the aircraft. None of the seven F-117s equipped so far with the autothrottle and other cockpit improvements flew in Operation Desert Storm.

An upgrading of the mission planning system has been identified by Congress as a possible additional part of the F-117 improvement program. Martin pointed out that such an upgrade would be aimed at making the system more flexible to cope with mission and tasking changes.

"One of the lessons learned from Desert Storm was flexibility—you need to be able to change the aircraft's tasking al-

most as you are walking to the airplane," Martin explained. "So we need to make the mission planning system be able to support this."

The mission planning system was developed by Lockheed with the goal of easing the pilot's workload as he operates the single-seat, night attack aircraft. Lockheed developed it in time to be delivered with the first aircraft.

The integration of low probability of intercept communications equipment and hardware for all-weather mission capability is under consideration. These upgrades have not yet been approved by the Senate Armed Services Committee, but there seems to be agreement in principle on the issue, program officials said.

Lockheed managers declined to say

F-117A needs four pitot tubes to provide accurate air data, but it is not possible to coat the tips to reduce radar reflectivity. Lockheed officials said this presented one of the most difficult design problems in the program.



whether all-weather capability meant radar. However, they did point out that the original F-117 specification called for radar, and the aircraft has the power and cooling needed to accommodate one, but not the Group A cabling. It would be possible to mount a low probability of intercept radar in the F-117 with today's technology.

Existing steel brakes are being replaced by carbon/carbon brakes. The maximum energy absorbing capability of the old brakes can be accommodated by the new brakes using only 60% of their capacity. The added capability will be useful considering the high elevation of the Tonopah airfield. The aircraft also is being fitted with new F-15E size wheels and tires.

The F-117's targeting is performed by a Texas Instruments sensor and designation system that was designed specifically for the stealth aircraft. The F-117 has a forward-looking infrared system on the upper fuselage and an underfuselage downward-looking infrared. Together, they form the infrared acquisition and designation system (IRADS). "The laser is slaved to the IRADS and is an integral part of the infrared system, so there are no handoff inaccuracies," Gordon said.

Spot size of the laser on the ground at normal ranges for the F-117's release of weapons is usually on the order of 12-18 in. The spot is stabilized by the IRADS.

"This is one reason that may help ex-

plain why pilots were able to put a bomb down an air shaft [during gulf war attacks]," Martin said. "That is why they were able to pick very specific points to hit—like air shafts and identified structural weak points on buildings."

To minimize the expense in developing and producing the F-117, many off-the-shelf items were used in the aircraft, including an environmental control system from Lockheed's C-130 transport, while the jet engines and auxiliary power units were taken off the McDonnell Douglas F/A-18.

#### PROBLEM OF PITOT TUBE

A Kaiser Electronics head-up display used on the F/A-18 was modified slightly for the F-117. Adaptation of this head-up display kept costs down, program officials said.

For the protective screen that covers the IRADS sensor targeting turret, Lockheed devised a closely knit screen of copper wire that provides electrical continuity across the IRADS cavity. This prevents the cavity from becoming a radar-reflective resonator.

This item cost \$7,000 instead of the projected \$500,000 for a gallium arsenide or germanium window. The screen has to allow a broad spectrum of infrared and laser energy to pass through it.

Radar-absorbing coatings fully cover the aircraft, with the exception of the tips of the four pitot tubes. It was not feasible

to coat the tips due to the erosion problem and dimensional changes this would entail on the tips themselves.

Lockheed officials said the pitot probes turned out to be one of the most difficult developments in the aircraft. The F-117A needs extremely accurate and reliable air data, which requires precise alignment of the four probes.

Composites represent about 5% of the aircraft structure by weight. Composite elements include the weapons bay doors and the landing gear strut doors.

Company officials said Lockheed follows the F-117's operations on a day-by-day basis, allowing the contractor to monitor overall and system-level performance.

Martin said he receives a daily morning report on every problem written up on the F-117 fleet and reviews it with his personnel. Summaries are kept, permitting them to identify systems or hardware that become a burden in flying or maintaining the aircraft.

According to Martin, total development costs from the initial F-117 contract award in 1978 to today—including new cockpits—is about \$2 billion. Martin noted that this is quite a bit less than major auto companies are spending these days to develop a new car.

Lockheed has about 12 technical support personnel stationed at Tonopah, where the 37th Tactical Fighter Wing functions with two operational squadrons and one training squadron.

The Lockheed F-117A stealth fighter's tailpipe section uses a honeycomb sandwich made of a nickel alloy to reshape exhaust gases.

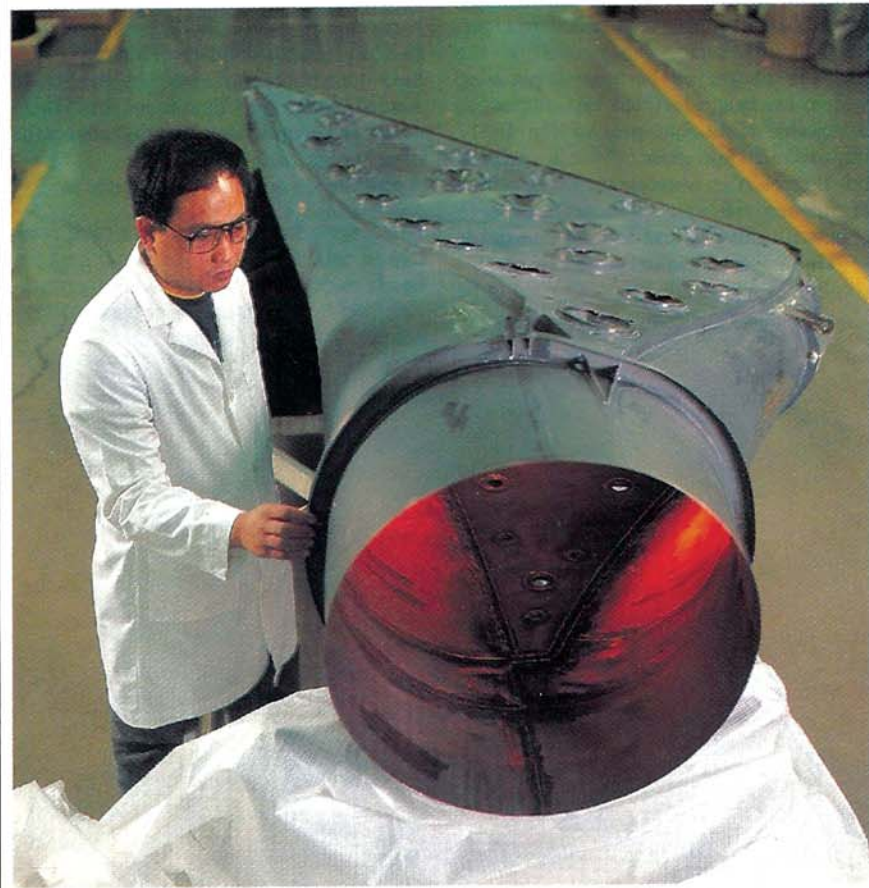
ASTECH/MCI Manufacturing, Inc., of Santa Ana, Calif., gave a photo of the formerly classified F-117 component to AVIATION WEEK & SPACE TECHNOLOGY last week at the Paris air show (left).

The nickel alloy 718 honeycomb material provides the tailpipe with needed resistance to deflection by exhaust gas. The material also is resistant to acoustic stress and heat. The tailpipe shapes the jet exhaust from a traditional circular outflow by funneling it into a slot at the tapered trailing edge of the fuselage.

The firm started designing the tailpipe in July, 1979, and the first article was delivered for testing on May 2, 1980. The structure is reinforced with a series of vertical posts.

An ASTECH official said the company only learned that the U.S. Air Force would allow release of the photo three weeks before the show.

An ASTECH/MCI official said many employees were surprised when they were allowed to watch as the tailpipe was taken out of its crate. They had watched the crates pass through the factory for nine years but had never seen the tailpipe. □



## PLANNED AND PROPOSED F117 IMPROVEMENT PROGRAM



**\*\* 1.** Exhaust system, for maintainability.

**\*\* 2.** Graphite thermoplastic fins (moveable surfaces only).

**\*\* 3.** Offensive capability improvement program. Honeywell multi function displays and Harris Corp. digital moving map.

**\*4.** GPS using the antenna from the ATF.

**\*5.** Secure, low probability of intercept comm radios. Pilots in Panama were unable to discuss changes in attack plans.

**6.** Larger F-15E size wheel, tire and brakes. Carbon brakes will replace existing steel ones.

**7.** Upgraded mission computer, four times the input.

**8.** Ring laser gyro (RLG) replaces Honeywell SPN/JEANS electrostatically suspended gyro used on B-52. SPN/JEANS uses a spinning beryllium ball that comes within five millionths of an inch of being perfectly round. High accuracy, but 400 hr. MTBF and rising cost are encouraging USAF to use a RLG with 2000 hr. MTBF. Funding in Fiscal 1992.

**9.** More user friendly features in F-117A mission on ground.

**\*10.** All weather capability.

**\*Proposed by House Armed Services Committee, not approved by Senate yet. \*\*Installation in progress.**

All of the 37th TFW's operating aircraft and six of the ones used for training were sent to Saudi Arabia before the war began. Only six of the Lockheed personnel went along, but hundreds of USAF personnel supported the F-117 effort.

The F-117 squadrons are organized to operate at remote sites, and the aircraft need little in the way of ground support equipment. The stealth fighter requires

about the same number of maintenance man hours as the F-15C, according to program officials.

Maintaining the radar-absorbing material (RAM) only takes about as much time as it takes to support the braking parachute system, Lockheed engineers said. During the F-117's development, there had been some thought to inspecting its overall radar signature prior to the aircraft's departure on each mission.

However, it was determined that this was not necessary. A simple visual inspection of the RAM coating usually suffices to verify low-observable features are intact, program engineers said.

Repairs are made by applying more RAM with a hand-held spray gun. They can be checked using a "Jost gun"—a device named after its designer, engineer Paul Jost. The device is called a gun because it looks like a police radar gun.

# Conflict Between CAAC and CATIC Delays China Trunkliner Program

DONALD E. FINK/LE BOURGET

The target date for launching development of China's 100-seat Trunkliner commercial transport has been extended one year to allow Chinese aviation industry officials and Civil Aviation Administration of China managers time to agree on the conditions under which the aircraft will be built and operated there.

McDonnell Douglas' Douglas Aircraft Co. and Boeing Commercial Airplanes Co. are jockeying for position in the 150-aircraft Trunkliner project, which is seen as a key element in China's long-term air transport market.

The Chinese government recently ordered China National Aero-Technology Import & Export Corp. (CATIC) to open final Trunkliner contract talks with Douglas, which has an ongoing MD-82 assembly program in China at CATIC's Shanghai Aviation Industry Corp. facility. Douglas is offering China a smaller MD-90 version for Trunkliner production.

The start of this next negotiating phase does not mean Douglas has won the competition, according to CATIC Vice President Tang Xiaoping, who led China's industrial delegation at the Paris air show here.

"We want to move the Trunkliner ahead and expect to make a decision by the end of this year," Tang said. "We have been working at this for four years so far, and we want to get the development program started."

But Tang said there still is a possibility the contract could go to Boeing, which is offering to build a version of its 737 twin-engine transport in China to meet the country's domestic airline needs. The aim is to resolve the issue in time to have the first Chinese-built Trunkliner flying in 1995. Trunkliner service would begin in 1997.

Boeing is pursuing the Trunkliner program more actively after initially expressing little interest in establishing a final assembly line in China. Boeing, which has sold a wide variety of aircraft to the Civil Aviation Administration of China (CAAC) and its operating airlines, has a close working relationship with the Xian Aircraft Co. as a supplier of parts and subassemblies for several Boeing aircraft.

But Boeing sees a strong near-term market in China and favors delaying the Trunkliner decision to keep those market options flexible.

The Trunkliner is more of an industrial development program than one for airline equipment, Tang said, so a means has to be found to satisfy both the requirements of CATIC and CAAC.

The intent is to reach a compromise that will enable CATIC to use the Trunkliner project to accelerate development of China's advanced technology industrial base and yet not saddle CAAC's airline operators with a long-term commitment to an aircraft before they are certain it will suit their requirements.

At issue is CATIC's need to take a long-term approach to the Trunkliner project—production would stretch out to 2010—and CAAC's desire to pursue its fleet upgrade program on a normal five-year cycle.

## PROPOSALS DUE THIS SUMMER

Both sides will present their proposals to China's State Planning Council this summer, and the final decision is expected to be made at the prime minister's level.

Meanwhile, Douglas is discussing several related options with China that depend on the Shanghai final assembly facility. It was certified by the U.S. Federal Aviation Administration as part of the MD-82 program.

Douglas is offering Shanghai the option of building more MD-82s beyond the 30 currently approved. Any additional MD-82s would have to be equipped with new dual tandem main landing units to enable the aircraft to operate from the many airports in China that have older lightweight runways. Adding the new lower footprint gear would make it possible for MD-82s to serve more airports throughout China, Tang said.

Douglas also has asked China to consider assembling a new, smaller MD-95 100-seat transport in which Northwest Airlines has expressed an interest. Northwest's requirement for only 100 aircraft makes it uneconomical for Douglas to build the aircraft at its Long Beach, Calif., facility.

But Douglas officials think China's lower labor rate would make it practical to assemble the MD-95 in Shanghai. A memo of understanding to pursue this option was signed by Douglas and CATIC officials here last week.

As an extension of this agreement, CATIC companies also would be given subcontracts to build more portions of the MD-95 than they currently produce for the MD-82. □

## Aerospatiale Nuclear-Armed Missile Designed for Speed, Radar Evasion

LE BOURGET

Aerospatiale's ASLP nuclear-armed cruise missile is designed for high-speed flight and low radar detectability.

The missile, which was shown in model form at Aerospatiale's outdoor exhibit here, will succeed the company's ASMP, which is in service with the French air force and navy.

ASLP will be powered by an integral rocket/ramjet and have a high supersonic speed. Its range will be several times that of the ASMP, which can be fired at distances of about 150 km. France will deploy ASLP in the next decade for use on land and carrier-based versions of Dassault Aviation's Rafale combat aircraft. □



# Soviets Demonstrate MiG-31 During Final Days of Air Show

JEFFREY M. LENOROVITZ/LE BOURGET

The Mikoyan MiG-31 long-range interceptor joined Paris air show's flight demonstrations during the final days of the salon, performing flybys and some basic aerobatic maneuvers using the power of its two 34,162-lb.-thrust D36F6 turbofan engines.

Photos in the middle of the page show the Soviet aircraft in a flyby and during maneuvering. The MiG uses two drag parachutes to slow its landing roll. The parachutes deploy from a centerline spine that runs atop the fuselage (AW&ST June 24, p. 70).

A photograph of the MiG-31 during taxi (below) shows the interceptor's two underfuselage speedbrakes extended ahead of the main landing gear. Speedbrakes can be extended throughout the MiG-31's flight envelope, and Mikoyan test pilot Valery Menitsky said their deployment does not result in significant pitch changes to the aircraft. The main landing gear bogie on the interceptor has the outer wheel positioned ahead of the inner one. Nose landing gear has two wheels and mudguard.

The MiG-31's extendable aerial refueling probe, located just below the forward part of the front cockpit windshield frame, is in its retracted position. Maximum gross takeoff weight of the 74.4-ft.-long aircraft is over 90,000 lb., increasing to nearly 102,000 lb. with a full combat load and two external fuel tanks. □



## Yakovlev Displays Propfan Testbed At Paris Air Show

LE BOURGET

Yakovlev Design Bureau brought its Yak-42LL engine testbed aircraft to Le Bourget midway through the Paris air show and parked the aircraft on the static display line.

The aircraft is a production Yak-42 that has had its normal right-hand Progress Engine Design Bureau D-36 engine replaced by a prototype D-236 tractor propfan (right). Flight testing is being performed to evaluate performance of the D-236 in different flight regimes, as well as to determine the acoustic and vibration levels produced by the propfan engine.

The D-236 is a geared, contrarotating design with eight blades in the front row and six in the back row (below). The engine also has been flight tested on an Ilyushin Il-76 testbed aircraft (AW&ST June 6, 1989, p. 51).

Yakovlev Design Bureau also brought a full-scale, high-fidelity mockup of its Yak-112 four-seat general aviation aircraft to Le Bourget. The high-wing aircraft will be powered by either a Western- or Soviet-built 200-hp. piston engine and carry a maximum payload of 270 kg. (595 lb.). □

