Special Report: Paris Air Show

Tu-144 Aimed at World Market

Soviets to seek U.S. certification for supersonic transport, may ask Boeing aid in major drive to beat Concorde for sales

Paris--Soviet Union will attempt to certify its Tupolev Tu-144 supersonic transport in the U.S. and is expected to ask Boeing for assistance as part of a major drive to beat out the Anglo-French Concorde SST for world markets.

Redesigned Tu-144 on display at the recent Paris air show (ANN.ET May 28, p. 23) demonstrated the Soviet desire to meet all international performance and noise standards and to match Concorde in advanced avionics and controls.

Soviet officials at Paris declared that Aeroflot, the Russian national airline, will absorb all of the first three years' production of the aircraft and that export sales would not be expected to begin until about 1977.

In the meantime, the Tu-144 has been designated the future standard aircraft for long-range passenger travel in the USSR, and will supplement, and later largely supplant, the Tu-16 and Il-62 on many trans-Siberian and central Asian routes.

U.S. certification is viewed by the Soviets as more than a political move. By teaming with a U.S. firm, the Soviets would be in position to provide necessary technical support for the use of the Tu-144 there.

Major design approach to the Tu-144, as evidenced by the aircraft on display at Le Bourget, involves the following factors:

- High degree of cockpit automation, making a three-man crew possible. Automatic controls on the yoke permit the pilot to punch in a variety of flight regimes on the aircraft computer, with autothrottle and computerized takeoff, cruise, approach landing and missed approach modes available. Crew consists of pilot, co-pilot and engineer.

- Greatly improved low-speed and airfield maneuverability, largely achieved by addition of retractable canard surfaces high on the forward fuselage immediately back of the cockpit. Canards have variable-camber trailing edge surfaces that correct for yaw and other factors.
and reduce approach speed by an estimated 15-20 kt to approximately 170 mph. Touchdown speed is ±150 mph. They also provide added lift on takeoff, reducing thrust demand and therefore noise.

- Advanced Kuznetsov NK-144 powerplant that has a low bypass ratio and provides thrust of approximately 44,000 lb compared with 38,580 lb with the original engine. Blow-in doors on the sides of the engine nacelles provide additional air for takeoff. Cruise speed has been increased from slightly more than Mach 2 to approximately Mach 2.2. Soviets expressed the cruising speed as 1,550 mph, and the range as slightly more than 4,000 mi.

- Attempt to achieve all-weather capability with improved on-board radar and an inertial navigation system, with all avionics built to international standards.

In addition to basic design improvements, the Tu-144 exhibited at Paris reflected planning for future competition for the passenger dollar. Cabin interior was divided into three sections to minimize the tunnel effect of a long, narrow fuselage. Configuration currently approved by Aeroflot, though subject to further change, involves an 11-seat first-class compartment with nine seats arranged 2-1 with a 1-1 rear-facing pair at the forward end of the compartment. Removable tables are located between the rear-facing seats and the first row of forward-facing seats.

Behind the first-class compartment bulkhead is the forward tourist-class compartment with 30 seats arranged in a 3-2 five-abreast configuration. Tourist class seats have been made somewhat narrower than those used in conventional Soviet transports in order to accommodate the five-abreast arrangement.

Service section containing a tourist-class wardrobe, toilet and kitchen divides the two tourist seating sections. Rear
Tourist section will have 15 rows of 3-2 five-abreast seats and six rows of 2-2 seating in the narrower rear sections.

Tu-144 will have three tourist-class toilets and one in the first-class section. First-class kitchen will be able to serve hot meals, but current plans call for cold meals only to be served from the tourist-class kitchen.

Aeroflot has ordered special colors for the Tu-144 interior, mainly bright reds and oranges, following a study.

Western experts at Paris expressed some surprise at the contrast between the production Tu-144 and the prototype put on display two years ago. “When we saw the prototype we were asking ourselves why they were even bothering,” said one U.S. engineer. “We kept telling ourselves that they had to know better than that, and now it is apparent that they do.”

Soviets at Paris described the prototype as a “test airplane for proving aerodynamic conceotions and the principles of component assembly.”

It was the consensus of Western engineers that the Tu-144 contains approximately all the capabilities of the Concorde in terms of cockpit automation, although there is considerable question as to its ultimate operating economy, as is the case with the Concorde.

Engine changes, wing and fuselage stretch and addition of canards and the canard mechanism added considerable gross weight to the aircraft, which has apparently been partially offset by the use of lighter seats and interior fixtures. Gross takeoff weight was given by the Soviets as 180 metric tons or slightly less than 400,000 lb. Takeoff weight of the prototype was approximately 395,000 lb.

New baggage-handling configuration, with front and rear cargo hatches located in the belly, will permit intermediate stops of 30-40 min. and a terminal turnaround time of 1 hr., the Soviets have said.

Takeoff run was given as 6,210 ft. and landing run as 5,500 ft. Skin temperature at supersonic speeds reaches a maximum of 130 deg. centigrade, the Russians declared. Special ventilating ducts bring cold air into the wheel housings for both the nose and main landing gear during flight in order to cool the rubber, which is located very close to the hot skin of the aircraft.

Air Show Coverage

Paris air show is being covered by an AVIATION WEEK & SPACE TECHNOLOGY editorial team consisting of Robert B. Hotz, editor-in-chief; William H. Gregory and Cecil Brownlow, executive editors; Herbert J. Coleman, London bureau chief; Barry Miller, senior avionics editor; Donald C. Winston, European editor, and Robert R. Ropelewski, Paris bureau chief. Photographic coverage is by James H. Pickrell.

Instrument panels, consoles and controls of new Tu-144 show high level of avionics, making a three-man crew possible. Push button panel in center of control yoke is automatic flight regime selector with autotrottle and computerized takeoff, cruise, approach and landing, and missed approach modes available. Automatic pilot controls are in center console.
The chalet flags were drooping limply at half staff in mourning for the six-man Russian crew of the Tupolev Tu-144 supersonic transport and the French citizens killed by its fatal plunge as the thirtieth Paris air show passed into history. The sense of tragedy over the loss of the crew and the villagers of Guissainville was made more poignant by the loss of a fine aircraft that had aroused the professional technical admiration of the designers of many nations who observed it for the first time at Paris.

The Tu-144 that appeared at Le Bourget two weeks ago was a far different aircraft than the prototype that made its Western debut in 1971. The speed, determination and skill with which the Tupolev design bureau had corrected the obvious deficiencies of the early prototype excited admiration from Western counterparts who studied the 396,000-lb. gross weight, Mach 2 giant. Soviet aircraft production ministry officials said soon after the Tu-144 crash that their supersonic transport development program would continue. And so it should. For the circumstances that tore apart the pre-production model over Le Bourget would never be met in the severest transport operations and no civil aircraft could withstand stresses imposed on the Tu-144 in the final phase of its demonstration at Le Bourget.

Aside from the Tupolev tragedy, the 1973 Paris air show lacked some of the effervescence of its earlier stagings. Exactly which qualities were missing elicits varying opinions, but virtually all agree that something was missing and it was a less exciting occasion than formerly.

Some observers felt that the change came from a shift in emphasis from developing exciting new technology to the more mundane business of trying to sell existing technology to hard-nosed markets. There was certainly plenty of that going on in the rows of chalets and the usual abundance of customers from the far reaches of the globe that makes the Paris show unique. Other observers felt that the sobering effects of the American industry's recent recession and the dimming of once bright European prospects to make profitable inroads into the international civil market produced the more sombre tone.

In contrast, the management of the show was never better. The new permanent construction exhibits, the new chalets and the drainage and pavements effected long needed improvements. Col. Henry Lafont, director of the show, deserves considerable credit for his efforts that bore fruit in 1973.

There also was new technology, if not in the exciting quantities that gave previous shows a champagne effervescence. The dramatic Apollo-Soyuz docking display of flight-type hardware linked as it actually will be in space was the star attraction of the static show. Equally interesting was the manner in which a U.S. team headed by Charles Biggs of NASA's Johnson Space Center in Houston and a Russian Academy of Sciences team in Moscow headed by Igor Pochitalin worked together in two languages and two countries to join their spacecraft above the crowds at Le Bourget.

In addition to the new design Tu-144 supersonic transport, the most interesting aircraft at the show was the Navy's Grumman F-14 Tomcat fighter powered by two Pratt & Whitney TF30-P-412 engines and flown by a Navy fighter team with Capt. L. R. Taylor in the front seat and Lt. K. Y. Strauss in the rear cockpit. This Navy team flew almost every day of the show in skillful performances that demonstrated eloquently the remarkable flying qualities of this aircraft. It was a tonic to the U.S. industry at the show to see its superb performance as well as an eye-opener for the international observers. It was obvious at Le Bourget that, underneath the bales of legal and financial controversy that have hampered this aircraft's development, the U.S. has again produced a superb new generation of fighter aircraft. Other notable flight performances were by:

- Capts. Gunnar Stahl and Anders Levert of the Swedish air force with their twin Viggen routine.
- Ron Gellaty and Roy Moxan of the Westland flight test staff for their performance in the Lynx helicopter.
- Robert W. Fizer and Hartwig A. Baier for their demonstration of the maneuverability and short-field capability of the Cessna Citation.
- John Farley and Andy Jones of Hawker Siddeley for displaying still more capability in the oft-demonstrated Harrier V/STOL fighter.
- Siegfried Hoffman for his flights in the Boelkow Bo.105 helicopter.

Bob Hoover contributed another chapter to his growing stature as an international folk hero with a four-a-day flight routine demonstrating the Northrop F-5E for the first time and repeating his incredible energy control technique with the Rockwell International Shrike.

The U.S. Navy Blue Angels, the Patrouille de France and the British Red Arrows all flew beautifully precise and imaginative aerobatic routines with the Blues having only a slight edge over their international competitors who were in as fine form as we have ever seen them.

The U.S. flight line suffered greatly from interdepartmental bureaucratic fumbling that kept several highly exportable military aircraft out of the show. It is obvious that the U.S. government needs some perceptive top-level policy direction for its aerospace exports to thwart the tin minds of entrenched civil servants that blunt the thrust of so many excellent ideas.

There appear to be three major lessons to be learned from the 1973 Paris air show.

First, technology is no longer enough. It must be accompanied by shrewd market analysis from design stage to production for any sales success in the tough international competitive markets.

Second, new patterns of international cooperation are necessary to open new international markets, with customers demanding a share in new technology as part of their price.

Third, transport aircraft should be demonstrated in the flight regimes for which they were designed. No useful purpose was served by French and Russian pilots dueling in their supersonic transports like giant pterodactyls in a flight regime that should be reserved for high-performance fighters. —Robert Hotz
Sequence of the crash of the Soviet Tu-144 supersonic transport at the Paris air show are low pass in landing configuration (1, lower right); pull-up into steep climb (2, upper right); abrupt steep dive from peak of climb (3, upper left); aircraft inverted after left wing and tail separated and the aircraft snap rolled after attempt to pull-out of dive (4, left); end fire ignited along point where wing panel separated outboard of nacelles and at tail (5, below left) as disintegration continued. Right wing also failed in break-up.

Steep Climb, Dive Preceded Disintegration of Tu-144
Pieces of the disintegrating Tu-144 rain down on the town of Goussainville as the fireball from the first impact of what large structure remained appears at center (above). Large sections (arrows, above and below) are probably wing skin panels.

Black fireball mushrooms from ground (below) as last large segment of the aircraft strikes the ground. Debris is still descending at right. All Tu-144 photos in this issue, except one credited otherwise, are by James H. Pickerell for AVIATION WEEK & SPACE TECHNOLOGY.
Soviet Tu-144 transport taxis out in front of crowd at Le Bourget airport before its Paris air show flight that culminated in crash. Heat from engine exhaust blurs background behind aircraft. Anglo-French Concorde supersonic transport is beginning a pass along show runway at left. Tu-144 was next aircraft in the program.

Tu-144 Taking Off at Paris Air Show

Afterburners are lighted on the Tu-144's NK144 engines as the aircraft lifts off and initiates a steep climbout. Landing gear bogies rotate inward before the gear retracts forward into bays between engines.

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Final pass over Le Bourget airport by the Soviet Tu-144 supersonic transport was preceded by an awkward set of S-turns. The sequence, counterclockwise on these two pages, begins at top right with the aircraft completing a high-speed pass in front of the Paris air show crowd. Aerodynamic treatment of the wing and nacelles can be seen, instead of limiting this right turn to 90 deg., the aircraft continued for a full 180 deg., lowered its landing gear and nose vise to landing configuration in the process. The airplane then made another tight right-hand turn, bringing it close in to the runway, and then started a left-hand circle (above, center and left) to initiate a pass along the show runway from the left. Because of its close-in position to the runway, the turn became low and steep (below, left). The aircraft, its forward canards extended like huge ears, rolled out (below) and started its last pass over the field. Its steep climb-out and crash followed.
Tu-144 Crash Poses Complex Questions

Some observers cite flight demonstration competition between Soviet SST and Concorde in chain of events leading to crash

By William H. Gregory

Paris—First a steep dive, then an attempt at recovery and finally disintegration in the air of the Soviet Tupolev Tu-144 during a Paris air show flight demonstration were compressed into seconds, but the chain of events that multiplied into the crash began days before.

These terminal seconds came at the end of a steep climb. The climb had been initiated with afterburners bellowing after a low, slow pass in front of a crowd of 350,000 on the second and final of the two public flying days closing the international salon.

Even before the final dive, the Tu-144 during its earlier two flight demonstrations had raised questions by watching pilots and engineers about the aircraft's handling.

The Tu-144 made its final pass along Runway 03 at Le Bourget Airport at 300 ft.—or possibly lower. Looking like a mammoth prehistoric bird with head arched and claws out, the aircraft followed an awkward S-turn series with a final steep bank low over the industry hospitality chalets.

The aircraft was in landing configuration, with its landing gear down, canard surfaces extended from the fairings that housed them behind the cockpit and the nose visor drooped for improved cockpit visibility.

At the apex of the climb from the final pass, the Tu-144 seemed to hang suspended under the broken overcast that had fluctuated that afternoon close to 5,000 ft. Its tail-view cross section was faintly visible from that distance, about 2 mi. beyond the runway at an altitude estimated at 4,500 ft.

The flight path looked much like that of the Anglo-French Concorde's touch-and-go landing on the same runway 10 min. earlier. The Concorde had climbed out steeply after its liftoff and its engine smoke trails painted a truncated parabola at the top as the aircraft nosed over and settled slightly before gaining airspeed for level flight.

Waiting at the end of the runway for takeoff clearance, the crew of the Tu-144 would have had a front row seat at the Concorde's landing and steep climb out, flown by Concorde chief test pilot Jean Franchi, who has been with the program from its initial phases.

To test pilots and industry engineers watching the Tu-144's performance from chalets at the end of Runway 03 or from the flight line across the runway to the north, it looked as if the Tu-144 gained more altitude than the Concorde. Then the script changed abruptly.

Nose of the Tu-144 dropped, exposing what some in the crowd remembered as a flash of full belly planform. Almost simultaneously the airplane rolled left about 90 deg., accelerating rapidly in a 70-80 deg. nose-down attitude. From the ground, the sequence looked exactly like a classic full stall. One French engineer said he saw the aircraft yaw just before the nose went down. Others said the left wing had dropped first, then the nose.

At the instant the nose dropped, an experienced demonstration pilot watching from a chalet shouted: "He's going in." There was a gasp in unison from the crowd. Because of the steepness of the dive at such a low altitude for a big airplane, it was obvious in the first second or two that the Tu-144 was in dire trouble.

The Tu-144 at the show, the No. 3 airplane built close to production configuration, had a fuselage stretched to 215 ft. from the prototype flown at Paris in 1971. It had a 95-ft. span double-delta wing and a design gross weight of 396,000 lb.

Some technical witnesses said they saw pieces fly from the airplane when the nose dropped. It was still largely intact, however, when the crew attempted to pull out of the dive, probably at no more than 2,000 ft.

Its dive angle flattened, but at most to about 45 deg. At that instant the left wing separated. The airplane snap rolled onto its back, but now almost in a level attitude.

At some point, either just before or just after the outer left wing panel separated from the airplane, the fin and rear fuselage closure also separated. It was probably after, from the torsional forces of the half snap roll.

Next, the right wing left the airplane. The droop nose visor also carried away. Wing panels broke into smaller pieces. Fuselage skin panels, seats, a cloud of fragments signalled the virtual disintegration of the rest of the airplane.

Flies broke out at the point where the wing outer panels and tail had separated. There was a white puff of smoke when the first part of what intact structure remained struck the ground, and a larger...
Experts Search for Clues in Tu-144 Crash

Paris—French and Russian aviation experts were still searching late last week for clues to the cause of the crash of a Russian-built Tupolev Tu-144 supersonic transport on the last day of the Paris air show.

According to rules of the International Civil Aviation Organization (ICAO), investigation of an aircraft accident is the responsibility of the nation in which the accident occurred, with provisions for assistance from the nation in which the aircraft was registered.

In this case, the investigation is being led by French officials from the Direction Technique des Constructions Aeronautiques (DTCA), an arm of the French defense ministry that is responsible for all aircraft activities, both civil and military, up to certification.

Total French segment of the investigating team includes four engineers and two test pilots—one civil and one military.

Soviet contingent investigating the crash has eight members, including Vassili Kazakov, vice-minister of Soviet aeronautical industry, Alexei Tupolev, manufacturer of the aircraft; N. D. Kuznetsov, manufacturer of the Tu-144 engines, and five other members.

Total number of deaths has now been put at 13, including the six crewmembers and seven villagers, mostly children who were playing outdoors at the time of the crash. Twenty-eight others were hospitalized.

Officials say 109 homes were damaged in the crash, and 14 were destroyed.

Searchers initially were concentrating on finding the flight recorder carried in the aircraft, as well as an 8-mm. camera believed to have been carried by one of the crewmembers. By late last week, however, only some small pieces of the flight recorder box had been found with no sign of the flight data tape itself. Appeals were being broadcast on radio and television to anyone who might have found and made off with the tape. There were early reports that the wreckage was only casually guarded for the first day following the crash, and spectators were able to pilage the ruins to carry off souvenirs.

Most observers and tower personnel who witnessed the crash agreed that the performance of the Tu-144 appeared erratic during much of the flight demonstration that preceded the crash.

Tower personnel said there were no conversations with the crew of the aircraft at any time during the demonstration or in the moments before the crash.

Chief of the control tower at Le Bourget, who was in the tower at the time, also said the aircraft had not violated any of the minimum altitude restrictions placed on flight demonstration aircraft at the show. Final turn for a low pass over Runway 03 at Le Bourget—an unusually tight turn for a large aircraft like the Tu-144—was made at about 500 ft., he said, dropping to around 200-250 ft. over the runway.

There were reports from witnesses that some small pieces of the aircraft were seen falling to the runway during this final low pass, but a search of the runway failed to locate anything to verify these reports.

Tower personnel said the cloud ceiling over Le Bourget at the time of the crash was about 5,000 ft., with scattered patches of clouds beginning about 4,000 ft. The aircraft remained visible at all times, indicating it never reached an altitude higher than this.

Flight demonstration of the Tu-144 was officially over when it made the last pass along the runway, and the final climb should have been for the purpose of entering a right downwind leg for landing on Runway 25 at the airfield, according to tower controllers.

A key question that remains unanswered is whether the aircraft canard wings were still extended at the top of that steep climb. A top design engineer from Avions Marcel Dassault-Breguet Aviation who witnessed the Tu-144 flight said he saw the aircraft yaw at the top of its climb. This, he said, could have been enough to cause the canard facing into the yaw to stall, giving the attitude and probable low airspeed of the aircraft, and could have led to the pitchover that followed.

The Soviets studied extensively the canards used on the Dassault-Breguet Mirage IIIA delta-wing fighter before they adapted the devices on the Tu-144, the Dassault official said.
Landing attitude of the Tu-144 with canards extended is seen in photo above. Touchdown here during its first flight demonstration followed a low, final approach and the main wheels reached the asphalt only a few feet from the runway end.

looked as if the crew had turned too tightly early in the approach and had to compensate for this to get the airplane lined up with the runway.

When the Tu-144 turned from this leg onto final, it looked low and flat. It skimmed over the grass in the runway overrun in what one pilot called a "worm-burner" approach, or a "grass cutter." It did touch down on the asphalt, but only a few feet from the end.

One pilot questioned the airmanship displayed. Others in the technical audience thought that the crew might have been trying to show spectacularly the degree of low-speed control on approach for a delta-wing aircraft that the canard surfaces provided. These reduce approach speed 10-20 kt. to 145 kt. and touchdown speed to 130 kt.

The next day, June 3, the Tu-144 rotated and lifted off before the mid-point of Runway 03, but climbed straight ahead to 800-1,000 ft. before starting its left turn. Again, the airplane made a landing configuration pass with wings rocking, though not to as high a bank angle as its first flight. It looked like the start of a more circumspect performance than the previous day's.

This pass was along Runway 03 toward the northeast. After it was completed, the airplane turned left climbing, was cleaned up and then started a circle to the right at altitude for a second pass, this one to the southwest.

For some reason not apparent to the spectators the airplane seemed to drift too far to the south. To bring the Tu-144 back to the centerline and avoid violating show flight regulations by flying over the crowd south of the runway, the crew had to make a sharp turn back, losing precious seconds in the process.

Since the nose visor was raised, there was speculation that the crew might have become disoriented because of the lower visibility from the cockpit in this configuration.

An earlier visit to the cockpit on the ground demonstrated, however, that the new nose design in this aircraft with added forward windows, had improved visibility over the prototype.

The airplane made the next pass in clean configuration and started what appeared to be another standard 90-270-deg. reversal for a third pass down Runway 03. Instead of a 90 deg. turn, the right turn became a 180-deg. turn, with the Soviet airplane parallel to Runway 03 but approximately a mile north of the field.

During this turn, the airplane had been slowed down and returned to landing configuration. While the crew could have continued this circle around the field, the slow speed probably would have exhausted its remaining flight time without another pass.

What followed then was another 180-deg. turn that brought the airplane to a downwind position to Runway 03 but close in. Rolling out of this reversal, the crew started another tight turn back toward Runway 03 to begin either a pass or perhaps to land. The Concorde had made its touch-and-go landing in this direction just before.

To the spectators in the industry chalets, the turn back to the runway looked steep and low. According to the show control tower, though, the airplane did not drop below the 300-ft. minimum altitude for passes at any time in its performance. In any event, when the turn steepened to what looked like 60 deg., it sent a few spectators in the chalets scrambling for cover.

When the airplane rolled out of this
turn—its response to control seemed to be no problem—it appeared to be too far to the right of the runway to touch down, if that was the crew's plan. There was no transmission to the tower to clarify this point.

As the airplane flew over the crowd on this pass, the steep climb in afterburner was initiated, which culminated in the crash. Watching pilots raised several possibilities to account for this sequence:

- **Cockpit confusion.** Did the crew become disoriented with the nose raised, or rattled by time problems so that it slipped off its flight program plan and had to improvise a solution? That was, was the crew fulfilling behind, not staying ahead of, the airplane?

- **Cockpit distraction.** Was there a system malfunction that might have taken the full attention of the crew away from flying the airplane? Again, there was no transmission to the tower to indicate so.

- **Cockpit intention.** Had the crew planned the flight this way to show off the low-speed handling qualities of the Tu-144 with its canard surfaces, a source of pride to the Soviets in their conversations with industry groups during the show?

Rarely, if ever, has a large transport aircraft crashed in view of so many technically experienced witnesses. They agreed closely in their description of the crash sequence, but there were varied theories to explain why it happened:

- **Stalling or structural failure** of the canards. With the canards extended, the elevons are set 2-3 deg. nose down normally, in effect, acting as flaps. If the canards stalled, this amount of nose-down control would be enough to produce a violent pitch down.

- **Some combination of g-forces, flow and angle of attack** at the top of the climb caused one or more engines to flame out at a critical airspeed.

- **Control system failure** caused a hard nose-down elevator signal.

- **Structural failure** other than the canards. The Soviets told at least one visiting group about turbine blade problems, raising the possibility of a turbine wheel failure that might have caused damage to the wing or flight controls.

- **Operation close to or out of the performance envelope of the airplane.** Lighting of the afterburners would produce a pitch-up force that may have left the crew with marginal forward control force. This would have left the crew with the dilemma of continuing an uncontrollable pitch-up with afterburners left on, or shutting them off at a critical combination of airspeed and angle of attack.

While a delta wing does not stall in the conventional sense—it normally resists without the nose dropping—a delta with a canard would be a different situation. Past experience with canards dating to the 1930s is that when they do stall, the pitch-down that follows is violent because of the combination of flap or elevator that is used to offset their added lift at the nose.

There is no confirmation at this point that the canards were extended at the top of the climb. The landing gear had been retracted, and the canards also may have been.

According to the show tower, the crew had planned to follow what was a usual closing demonstration pattern at the show. This was a climb to altitude straight ahead from Runway 03, followed by a right turn and righthand approach and landing to Runway 25, clearing the show runway for the next aircraft on the schedule.

Experience of the flight crew was not available immediately, but Molchanov, the copilot, told one group at the show that he had only accumulated 3,000 hr.

because much of his background had been with a Soviet acrobatic team flying Yak-18 piston-powered monoplanes.

The Tu-144 crew had flown on the Concorde during demonstrations on the first Sunday of the Paris air show, and a tentative proposal had been made that Concorde crews, including Aerospatiale chief test pilot Andre Turcat, would fly on the Tu-144 the following Sunday, the day it crashed. This was never accepted by Turcat, one reason being that he wanted to observe the Tu-144 in supersonic flight and would not have been able to do this during the show demonstrations.

A final proposal being considered in the last days of the show was for Turcat and possibly some other Concorde test crew members to go to Moscow to fly the Tu-144.

**U. K. Weighs Effect of Tu-144 Crash on Concorde Sales Push**

London—Reaction of the British government and industry officials to the crash of the Soviet Tu-144 supersonic transport is colored with restrained optimism that the accident will not seriously damage sales prospects of the Anglo-French Concorde.

Accent is on the damage the crash could do to the intensified Concorde marketing and sales drive now underway, since it is generally agreed that the test program has demonstrated its safety and reliability.

Official who have watched slowdown film of the crash are unanimous in their belief that the Tu-144 was flown outside its envelope and that eventually this will be the principal finding as the crash cause.

But experts believe the sharp pushover from the steep angle of climb could have initiated the subsequent in-flight breakup by cracking the wing structure, or by causing compressor stalls in one or more of the engines.

One government official pointed out that contrary to Concorde's extensive test publicity, little is known about the Tu-144's static and strength test program, particularly in the fields of metallurgy and heat resistance.

He indicated a possibility of metal fatigue aggravated by the extreme stresses of the pushover as a contributing factor to the crash.

The Soviets said the airplane at the show had made 100 test flights. This was interpreted by some Westerners as equal to 200-300 flight hours.

The Concorde structure is 72% aluminum alloy, 4% titanium, 16% steel—mainly the landing gear—and 8% other materials.

The alloy itself is specially developed for resistance to high temperatures over long periods.

The Soviet contingent at the Paris air show told one industry group visiting the Tu-144 that its structure was 25% titanium, including the wing leading edge and wing and fuselage structure around the engine nozzles.

Strength tests of Concorde are conducted by the French and a major fatigue test rig has been built at the Royal Aircraft Establishment, Farnborough, to test ground and flight loading actions combined with thermal cycling.

Four Concordes now flying have accumulated 2,000 hr. in flight tests and development. Test pilots have flown Tu-144s at inc. +23.6 deg. and at g-loading ranging from -0.3 to +2.8. Low-speed handling characteristics have been cleared and were initially explored by an aircraft specially built for the project, the Handley Page 115 Delta.

From an airline standpoint, the Tu-144 crash almost certainly will delay planned trilateral talks between Britain, France and Russia on the use of supersonic transports across Siberia. Technicians from airlines are expected to keep close tabs on the accident investigation, primarily a French responsibility as the host country of the air show.

In the sales field, marketing specialists have conceded that the existence of Concorde has been a plus factor in convincing world airlines that supersonic travel is inevitable, and that the crash will erode this posture considerably, at least until official findings are released.

U. K. Aerospace Minister Michael Heseltine said that any data gained from the Tu-144 crash would be fed into the Concorde safety program as a matter of course, but he stressed that the airplanes are not similar, and there had been no exchanges of technical information between the design teams.
Soviet Tu-144 Canard Surfaces Detailed

Design details of retractable canard surfaces on the Soviet Tu-144 that crashed at the Paris air show include a high aspect ratio (above). This raised questions among engineers after the crash that the canards might have failed structurally in flight, causing a violent pitch down by the aircraft. The surfaces had two pairs of slots, one on the leading edge and the other set on the trailing edge. The Soviets referred to the trailing edge surfaces as flaps, and the detailed photos here show that the camber, and hence the lift, of the canards could be varied considerably in flight. They improve controllability of a delta wing aircraft at low speeds and high angles of attack. The Soviets said they cut approach speed to 145 kt. for the Tu-144. They also provide additional lift on takeoff, reducing thrust required and therefore noise (AWST June 4, p. 15). Spectators at the air show considered the Tu-144 noslier than the Anglo-French Concorde, but, based on subjective, not instrumented measure, not greatly so.
Canard surfaces on the Soviet Tu-144 shown at Paris retract aft into housings behind the cockpit (above) and fair over smoothly for supersonic cruise operation. Nose visor is partly visible in drooped position. The canards are double slotted at both leading and trailing edges (below, right). Movable trailing edges vary the camber of the airfoil. Soviets studied the French Milan canards before installing them in the Tu-144.