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From Farnborough to Kubinka

An American MiG-29 Experience

Benjamin S. Lambeth

RAND

This research was supported by RAND using its own research funds.

ISBN: 0-8330-1191-X

Published 1991 by RAND
1700 Main Street, P.O. Box 2138, Santa Monica, CA 90407-2138

R-4000-RC

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PREFACE

At the September 1988 Farnborough Air Show, the author of this report met the chief test pilot of the Mikoyan Design Bureau, Valery Menitskii, who had accompanied the Soviet team to supervise the first flight demonstrations of the MiG-29 in the West. That contact led to several further encounters between the author and Menitskii during the ensuing year, culminating in an invitation from Menitskii to the author to fly the MiG-29. On December 15, 1989, the author flew with Menitskii at Kubinka Air Base near Moscow (see Fig. 1). In so doing, he became the first U.S. citizen to fly the MiG-29 and the first Western pilot invited to fly a combat aircraft of any type inside Soviet airspace since the end of World War II.

This report documents that experience in detail. By reason of its subject matter and style, it does not represent a typical RAND research effort. Rather, it chronicles a predominantly personal sequence of events. The most extensive part of the report is the author's account of his MiG-29 flight and what that experience revealed about the

Fig. 1—MiG-29UB Before Taxi with Aft-Cockpit Periscope Extended. Note Right-hand Inlet Door Closed, Indicating Right Engine Running. Note Also Melted Snow Beneath Fuselage Caused by Engine Bleed-Air Exhaust

aircraft's technical features, cockpit layout, and handling characteristics. Special effort has been made as well, however, to include the equally important political and human side of the story, since it is this latter dimension that bears most directly on how and why the flight occurred in the first place.

This report has been prepared with several different audiences in mind. These include, among others, the Western fighter pilot and test pilot community; specialists in military aviation and the Soviet aircraft industry; and government and military officials, both American and Soviet, concerned with U.S.-Soviet relations and the future of military and defense industry contacts between the two countries.

The experiences and research reported here were supported by RAND, using its own funds. A portion of this document appeared previously as "Pilot Report: MiG-29" in the April 1990 issue of *Air Force Magazine*.

ACKNOWLEDGMENTS

Many people played a part in the story told in the following pages. On the Soviet side, I am indebted first to Mikoyan's chief test pilot, Valery Menitskii, who took the lead in gaining approval for my MiG-29 flight, and to Rostislav Belyakov and Anatoly Belosvet, general designer and deputy general designer at Mikoyan, who lent their personal support to it throughout. I also wish to express my thanks both to the Minister of Aviation Industry, Appolon Systsov, for authorizing my flight and to the Soviet Air Force for allowing it to take place at Kubinka. Finally, Major General Vladimir Sokolov, the air division commander at Kubinka, and his staff went out of their way to support my flight during a two-day period when all other operations had been cancelled because of inclement weather. I am grateful for their congeniality and the special efforts they exerted on my behalf.

James A. Thomson, the President of RAND, has my thanks for having backed this enterprise from the beginning, both in spirit and with the necessary financial support. I am indebted as well to Air Chief Marshal Sir Michael Armitage, RAF, and to Jeremy Wooding and Don McClen of the British Aerospace Corporation, whose sponsorship enabled me to establish my initial contact with Menitskii at Farnborough that eventually led to my flight.

General George Lee Butler, USAF, at the time Director of Strategic Plans and Policy (J-5) on the Joint Staff, and Brigadier General Graham E. Shirley, then-Director for Regional Plans and Policy on the Air Staff, were instrumental in handling the necessary coordination within the U.S. government regarding my flight. I am grateful to them for their assistance and guidance, as well as to Colonel Lonnie O. Ratley III, at the time assigned to the Europe/NATO Division on the Air Staff, who helped with the details of this coordination.

I wish to acknowledge my RAND colleagues John Hines, Eugene Rumer, and Sergei Zamascikov, as well as my Russian tutor, Ian Serbin, for helping me in multiple ways to prepare for my trip and to assure its success. Don Brown, Michael Gomez, Lon Nordeen, and YF-23 test pilot Bill Lowe at the McDonnell Aircraft Company in St. Louis gave generously of their time when I visited the plant to fly an F-15 simulator in preparation for my MiG-29 flight. I am grateful also to the National Guard Bureau, and particularly to Colonel John Lee, Lieutenant Colonel Michael Tice, and Captain Arnold Balthazar

of the 154th Composite Group, Hawaii Air National Guard, for the unrelated opportunity they provided me to sharpen my proficiency in an F-15 prior to my trip.

The highlights of this report have been briefed to numerous U.S. and allied audiences, including the Inspector General and Director of Operations, Hq United States Air Force; the Assistant Chief of Naval Operations for Air Warfare; the Director of Net Assessment, Office of the Secretary of Defense; the Directorates of Operations (J-3) and Strategic Plans and Policy (J-5) on the Joint Staff; the Commander of the Air Force Flight Test Center; the Deputy Chief of Staff for Operations, Hq Air Training Command; the Vice Commander in Chief, U.S. Pacific Fleet; the Vice Commander in Chief and Deputy Chief of Staff for Plans, Hq Pacific Air Forces; the Commanding Officers of Carrier Group Seven and Fighter/Airborne Early Warning Wing, Pacific; the Commander and staff of U.S. Naval Air Forces, Pacific; the Commandant of Cadets at the U.S. Air Force Academy; staff officers at Hq United States Air Forces in Europe and Hq Allied Air Forces Central Europe; the Commander of the Air Force Reserve; the Chief of Staff of the Royal Australian Air Force; the USAF Test Pilot School; the USAF Fighter Weapons School; the USAFE Air-Ground Operations School; the SAC Bomber Tactics School; the Royal Air Force Central Tactics and Trials Organization; numerous fighter units in the USAF, U.S. Navy, Air National Guard, and Royal Air Force; and several aerospace industry groups. Their wide-ranging reactions and questions prompted improvements in a number of key portions of the report.

Many outside readers offered comments on all or parts of an earlier manuscript. These include General Michael P. C. Carns, Vice Chief of Staff, USAF; Kevin R. Dwyer, senior experimental test pilot at General Dynamics; Brigadier General Frank K. Everest, Jr., USAF (Ret.), former X-2 speed-record holder; John F. Farley, former British Aerospace chief Harrier test pilot; Colonel (Brigadier General-selectee) Patrick K. Gamble, Executive Assistant to the USAF Chief of Staff; Colonel Carl D. Goembel, chief of USAF Officer Exchange Programs (Europe and Middle East); Lieutenant General Bradley C. Hosmer, Superintendent, U.S. Air Force Academy; Major General James A. Jamerson, Deputy Chief of Staff for Operations, Hq United States Air Forces in Europe; E. R. Jayne II, President, McDonnell Douglas Missile Company; Colonel Gordon L. Jenkins, USAF (Ret.), flight test operations manager, Northrop Aircraft Division; Professor C. W. Kaufman, Department of Aerospace Engineering, University of Michigan; Lieutenant Colonel Chuck Killberg, deputy chief of the

F-15E Combined Test Force, Air Force Flight Test Center; Colonel Donald E. Madonna, USAF (Ret.), former commandant of the USAF Test Pilot School; Lieutenant General Thomas E. McInerney, Commander, Eleventh Air Force; Colonel (Brigadier General-selectee) George K. Muellner, Assistant Deputy Chief of Staff, Requirements, Hq Tactical Air Command; Oberstleutnant Harald Riedel, Assistant Air Attaché at the German Embassy in Washington; Major General Peter D. Robinson, Commander, Air Force Operational Test and Evaluation Center; Brigadier General Donald E. Shepperd, Assistant Director, Air National Guard; and Terry D. Stinson, Group Vice President at Textron. I have unfailingly taken heed of their collective suggestions and inputs, and this report is more authoritative and technically sound for their help. The Mikoyan Design Bureau also had an opportunity to comment on an earlier draft. And my RAND colleagues Jeremy Azrael, Fred Frostic, and Jonathan Pollack provided some useful feedback.

Last, I am indebted to Edward T. Schneider, experimental test pilot at the NASA Dryden Flight Research Facility, and particularly to my RAND colleague Jack Craigie, a former instructor at the USAF Test Pilot School, for their thorough and exacting technical reviews of the present report. Because of this unusual breadth of expert assistance and advice, I am all the more obliged to note that any remaining errors of fact or interpretation in the pages that follow are entirely my own.

I wish to dedicate this work to the memory of Don Madonna, a special friend of rare warmth and helpfulness to Valery Menitskii and me both, to say nothing of the international aviation community as a whole. Don was killed on January 10, 1991, in a civil-registered Folland Gnat jet trainer near Shreveport, Louisiana, during a routine ferry flight.

ABBREVIATIONS

AC	Alternating Current
ADI	Attitude Director Indicator
AFB	Air Force Base
AGL	Above Ground Level
AOA	Angle of Attack
ATF	Advanced Tactical Fighter
BFR	Biennial Flight Review
C	Centigrade
CAS	Control Augmentation System
DC	Direct Current
DME	Distance Measuring Equipment
ECM	Electronic Countermeasures
FAA	Federal Aviation Administration
FCS	Flight Control System
FL	Flight Level
FOD	Foreign Object Damage
FTIT	Fan Turbine Inlet Temperature
GCI	Ground-Controlled Intercept
HSI	Horizontal Situation Indicator
HUD	Head-Up Display
ICS	Intercockpit Communication System
IFR	Instrument Flight Rules
IISS	International Institute for Strategic Studies
ILS	Instrument Landing System
IMC	Instrument Meteorological Conditions
IOC	Initial Operational Capability
IR	Infrared
IRSTS	Infrared Search and Track System
LRU	Line-Replaceable Unit
MCAS	Marine Corps Air Station
MSL	Mean Sea Level
NAS	Naval Air Station
NASA	National Aeronautics and Space Administration
NATO	North Atlantic Treaty Organization
OKB	Experimental Design Bureau
PACAF	Pacific Air Forces
PD	Pulse Doppler
RAF	Royal Air Force

RPM	Revolutions per Minute
RSBN	Short-Range Beacon Navigation System
RWR	Radar Warning Receiver
SDI	Strategic Defense Initiative
SETP	Society of Experimental Test Pilots
TACAN	Tactical Air Navigation
TsAGI	Central Aerohydrodynamics Institute
UB	Combat Trainer
USAF	United States Air Force
USAFE	United States Air Forces in Europe
VDC	Volts Direct Current
VHF	Very High Frequency
VMC	Visual Meteorological Conditions
Vmc	Minimum Controllable Airspeed
V/STOL	Vertical/Short Takeoff and Land

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1. PROLOGUE

The Soviet Union first demonstrated the MiG-29 to a Western audience at the Farnborough Air Show in September 1988.[1] Since then, the Soviet aviation industry has made a steady effort to sustain its new policy of international outreach. As a result of this openness, made possible by President Mikhail Gorbachev's political reforms initiated in 1986, the Mikoyan Design Bureau, under the leadership of its general designer, Academician Rostislav Belyakov, has become an increasingly visible presence in Western aerospace circles.

Flight demonstrations of the MiG-29 were also prominent attractions at the Paris Air Show in June 1989 and at the Abbotsford Air Show near Vancouver, Canada, the following August. In connection with the latter event, the Soviet fighters transited Elmendorf AFB, Alaska, for refueling en route to and from Abbotsford, in a historic first appearance of Soviet combat aircraft on American soil.

As a result of personal contacts I established and maintained over the course of these three events with Mikoyan's chief test pilot, Valery Menitskii, I received an invitation from him to fly his company's MiG-29UB two-seater.[2] The invitation was tendered by Menitskii during the return transit of the MiG-29s on August 16, 1989, through Elmendorf AFB, where I was on hand to assist with the official greeting as a guest of Lieutenant General Thomas McInerney, commander of the Alaskan Air Command (now Eleventh Air Force).

Upon our meeting at Elmendorf, Menitskii informed me that he had sought and received permission to fly me on my next trip to the Soviet Union. There was a precedent for this invitation in that the day before at Abbotsford he had flown Major Bob Wade, a Canadian Forces F-18 pilot.[3] After much preparation and planning, my flight

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[1]The first public exposure of the aircraft outside the USSR was at Kuopio-Riisala Air Base in Finland on July 1, 1986, when six MiG-29s from the Soviet Air Force's flight demonstration unit at Kubinka Air Base, led by Colonel (now Major General) Vasily Longinenko, paid an exchange visit to the Finnish Air Force's Karelia Wing, which operates the MiG-21. See "Soviets Display MiG-29 During Exchange Visit With Finland," *Aviation Week and Space Technology*, July 7, 1986, p. 28.

[2]UB is an abbreviation for *uchebno-boyevoi*, or "combat trainer."

[3]Major Wade, at the time assigned to 441 Tactical Fighter Squadron at CFB Cold Lake, Alberta, had become known earlier to the Soviets as the lead Canadian Forces F-18 demonstration pilot. He also led the Canadian F-18 escort of the MiG-29s on their last leg from Elmendorf AFB into Abbotsford. See "Soviets Let Canadian CF-18 Pilot Fly MiG-29 Trainer at Air Show," *Aviation Week and Space Technology*, August 21,

occurred on December 15, 1989, at Kubinka Air Base southwest of Moscow. At a Mikoyan-hosted dinner afterwards, Academician Belyakov informed me that I was the first American to fly the MiG-29 and the first pilot from the West to have been invited to fly a combat aircraft of any type in Soviet airspace since the Lend-Lease missions of World War II. The occasion for my flight was a RAND-sponsored research trip to Moscow with two colleagues to discuss trends in Soviet-American relations with members of the Institute of the USA and Canada. That trip followed an earlier visit to RAND by the institute's deputy director, Dr. Andrei Kokoshin, and retired Major General Valentin Larionov, also on the institute's staff.

This report will describe my flight in the Soviet fighter in detail and will offer my best recollection of how the aircraft performed. It will not, however, attempt a formal evaluation of the MiG-29, for three reasons. First, I am not a test pilot and lack the training and experience required to appraise the finer points of an aircraft's handling characteristics (see "Two Caveats," below). Second, it was not my purpose to conduct a technical assessment of the MiG-29's capabilities, nor was that the basis on which the invitation was extended for me to fly it. The most important aspect of my flight was simply the fact that it occurred. As such, it should be regarded, first and foremost, not as an aeronautical event, but rather as a footnote to the improved political relationship between the United States and the Soviet Union that has dominated world affairs, despite ups and downs, since Gorbachev's assumption of leadership in 1985.

Third, because of the severe winter weather in which I flew, I was able to sample only a small portion of the aircraft's overall operating envelope. Menitskii had intended to show me the full range of the MiG-29's aerodynamic capabilities and handling qualities. Because of concern that we might have to divert to an alternate airfield in case Kubinka went below landing minimums, however, we did not select afterburner at any time during the flight, in the interest of conserving fuel. That prevented me from coming anywhere close to extracting maximum performance from the airplane.

1989, p. 32, and David Pugliese, "West's First MiG-29 Pilot: Aircraft is a 'Tremendous Performer,'" *Armed Forces Journal International*, October 1989, p. 46. The first Westerner to fly a current-generation Soviet fighter was French Air Force General Jean-Loup Chretien, who flew the Sukhoi Su-27UB with test pilot Viktor Pugachev at the Paris Air Show on June 16, 1989. See *Air International*, March 1990, p. 132.

TWO CAVEATS

To bound my credibility with the reader and to be fair to the story that follows, I need to be candid at the outset about my qualifications to report on this experience and, more important, about the limits on those qualifications. To begin with, I am not a former military pilot and have had little formal training in tactical fighter flying. I am primarily a specialist in international security affairs, with a secondary research interest in tactical air operations and training.

With respect to the latter work, however, I am a civil-rated pilot with 800 hours total time. As a part of that experience, in connection with my RAND studies for the United States Air Force and other sponsors, I have had the opportunity since 1976 to log, at this writing, 240 authorized sorties for a total of some 380 hours in over thirty different fighter, attack, and jet trainer aircraft types.[4] The bulk of this flying experience has been in the F-100, F-4, A-4, F-5, A-7, F-15, and F-18.

In acquiring this background, I have had hands-on exposure to nearly every type of air-to-air and air-to-ground mission event in the tactical fighter employment repertory, including missile firings and live weapons drops on tactical targets. I have also flown with all the principal USAF, Navy, and Marine tactical air arms, including the Air National Guard and Air Force Reserve, as well as with the Royal Air Force; the Canadian Forces; the German Luftwaffe; the Royal Australian Air Force; the Royal Netherlands Air Force; and the Israeli Air Force.

In addition, I have had a modest amount of front-seat and left-seat experience, including tactical range missions in the F-104 and F-5 with the Canadian Forces; a PC-9 advanced handling flight with the chief of staff of the Royal Australian Air Force; formation training flights in the T-37 and T-38 with the Air Training Command; and extended tactical mission profiles in the F/FB-111 with the Strategic Air Command and the Royal Australian Air Force. Most notably in this regard, I was privileged in 1988 to take a formal initial qualification course, including the appropriate academic syllabus blocks and simulator check rides, culminating in a front-seat flight in

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[4]My logbook entries encompassing this experience include the T-33, T-37, T-38, F-100, F-101, F-104, F-105, F-106, FB-111, F/RF-111C, F-4C/D/E/F, RF-4, F-5B/F, F-14A/A-plus (including two arrested landings aboard USS *Kitty Hawk*), F-15B/D, F-16B/D, F-18, Mirage IIID/5B, Kfir TC-2, TA-4, EA-6B, A-7K, TAV-8B, A-37, CT-114, T-2C, Aermacchi MB 326H, PC-9, OV-10, Alpha Jet, MiG-29, Hawk T1, Harrier T4, and Tornado GR1.

the F-18 Hornet with No. 2 Operational Conversion Unit of the Royal Australian Air Force.

Last, I have spent some time in the fighter academic environment. This includes the USAF's Tactical Fighter Weapons and Tactics Course at Nellis AFB, Nevada, which I attended in 1977; the Aerospace Defense Command's Senior Officers' Course at Tyndall AFB, Florida, which I took in 1978; a week of advanced air-to-air academics and F-5 syllabus flights with the U.S. Navy Fighter Weapons School (TOPGUN) at Naval Air Station (NAS) Miramar, California, in 1980; and the defensive air warfare phase and associated F-18 syllabus flights in the Marine Weapons and Tactics Instructor's Course at Marine Corps Air Station (MCAS) Yuma, Arizona, in 1986.[5]

This is an unusual tactical air background for a civilian analyst, and I believe it played a major part in helping me establish the seriousness in the eyes of the Mikoyan Design Bureau that I needed to make my MiG-29 flight possible. Also, needless to say, it accounts entirely for whatever there may be of merit in the technical description of that flight which follows in this report.

That said, however, I am under no illusion that any of this background makes me a trained fighter pilot, let alone a test pilot equipped to gain the fullest value from my brief exposure to the MiG-29. For that reason, to underscore a comment noted earlier, I have made every effort not to judge the MiG-29, but simply to reconstruct my flight in the fullest possible detail so that readers better equipped than I might be able to form their own more authoritative views.

As for the second caveat, I should note that although I was the first American to fly the MiG-29, I have no claim to any uniqueness in the experience described below beyond that. The initial novelty of my flight has long since been overtaken by events. Besides Major Wade, who preceded me, a number of Westerners have since flown in Mikoyan's UB demonstrator with Valery Menitskii. Less than two months after my flight, the managing editor of *Aviation Week*, David North, flew the aircraft at Kubinka in only slightly better weather

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[5]I have also taken the U.S. Navy's deep-water environmental survival training course at NAS North Island, California; high g-tolerance centrifuge training at the USAF School of Aerospace Medicine, Brooks AFB, Texas; and periodic high-altitude indoctrination, dynamic ejection seat, and jet water survival refresher training courses as necessary to meet U.S. Air Force and Navy aircrew currency requirements.

conditions than I did.[6] Later that June, Menitskii flew General Bernard Norlain, commander of air defense forces for the French Air Force, during an invitational visit to Kubinka by six Mirage F1 fighters to commemorate the fiftieth anniversary of the founding of the Normandy-Nieman squadron.[7]

During the MiG-29 Goodwill Air Show circuit through Canada and the United States in July 1990, Menitskii flew Terry Stinson, then-president of Hamilton Standard (now group vice president at Textron) and a former USAF F-100 pilot; Captain Pat Moneymaker, the commanding officer of the U.S. Navy's Blue Angels flight demonstration team;[8] Ed Mechenbier, a General Electric employee and A-7 pilot with the Ohio Air National Guard; and Tim Gaffney, a reporter for the *Dayton Daily News*.[9]

Finally, at the 1990 Farnborough Air Show, Menitskii flew John Farley, the former chief Harrier test pilot for the Royal Aircraft Establishment and the British Aerospace Corporation. During a 40-minute demonstration flight in the Boscombe Down restricted area, Farley

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[6]For an account of that flight, see David M. North, "Aviation Week Editor Flies Soviet-Based MiG-29 Fighter," *Aviation Week and Space Technology*, February 26, 1990, pp. 36–48.

[7]"A Hosting of the Normandy-Nieman Squadron by Soviet Aviators," *Aviatsiia i kosmonavtika*, No. 9, 1990, pp. 28–29. This famed unit consisted of a small number of free French pilots dispatched to the USSR by General de Gaulle, after Hitler's occupation of France in 1940, to fight the Wehrmacht alongside the Soviet Air Force on the eastern front. The unit flew Soviet-provided Yak fighters, participated heroically in the Battle of Kursk in 1943, and accounted for 273 German air-to-air kills during the course of the war. For more details, see Marshal N. Ogarkov, ed., *Sovetskaia voennaia entsiklopediia* (Soviet Military Encyclopedia), Vol. 5, 1st edition, Moscow, Voenizdat, 1978, p. 632.

[8]In return for Captain Moneymaker's flight, Menitskii was invited to fly in the Blue Angels' F-18B two-seat demonstrator with the team's narrator, Lieutenant John Foley. That flight was approved within Navy channels and later prompted displeasure at higher levels of the U.S. government. Since the MiG-29 first took to the international air show circuit in 1988, the question of an approved exchange of flights between Soviet and American military and industry pilots has been a thorny one in Washington. It remains buffeted by a complex set of unresolved intergovernmental bureaucratic and policy considerations which I will address at the end of this report. See, however, "A Gesture Long Overdue," *Aviation Week and Space Technology*, July 16, 1990, p. 9.

[9]See Tim Gaffney, "Lessons Learned from MiG-29," *Dayton Daily News*, July 25, 1990. In a groping first attempt to cash in on its newly found access to the American marketplace, the Mikoyan Design Bureau sold the last two flights for the sum of $4500 each, the proceeds of which were then used to underwrite subsequent business transactions in the West. Apparently so determined to bolster its hard-currency reserve as to be undaunted by the appearance of commercialism presented in Western eyes by this practice, the design bureau is reportedly now more than doubling its price and asking $10,000 for a ten-minute MiG-29 ride during its next U.S. air show circuit beginning in late summer of 1991. See "MiG Barnstorming," *Aviation Week and Space Technology*, July 29, 1991, p. 17.

explored the MiG-29's high-angle-of-attack handling characteristics and assessed the aircraft's engine responsiveness in that aerodynamically critical regime. I have drawn liberally on his authoritative account of that experience to supplement my own observations later in this report.[10]

Any remaining questions about the MiG-29 are now being rapidly answered as a result of the German Luftwaffe's recent acquisition of the former East German Air Force's 24 MiG-29s, which came as a windfall byproduct of the unification of the two Germanys. Luftwaffe fighter pilots and test pilots have flown the aircraft extensively at its base at Preschen near the Polish border, as well as at the German Air Force's Flight Test Center at Manching near Munich, where some initial performance comparisons have been flown against F-16s of the Royal Netherlands Air Force.[11] USAF and other NATO pilots have also had an opportunity to fly the MiG-29 at Manching, as well as against it in routine air-to-air training sorties over the NATO air combat maneuvering instrumentation (ACMI) range at Decimomannu, Sardinia. At this writing, Germany's MiG-29s are undergoing tactical evaluations at the Luftwaffe's operational fighter base at Wittmund. So far, details on the technical insights gained from this experience have been slow to appear in the public domain. It is probably only a matter of time, however, before the essentials of the MiG-29's aerodynamic and weapons performance capabilities will become common knowledge among Western fighter pilots as a result of this expanded access.[12]

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[10]See John Farley, "Supreme Soviet," *Flight International*, October 10, 1990, pp. 36–40.

[11]See "Germans Test Their Latest Jet—a Soviet MiG," *Washington Post*, November 16, 1990, and "MiG-29 Downs F-16 in Mock Dogfight," *Jane's Defense Weekly*, November 10, 1990, p. 922. The latter account noted that Luftwaffe analysts were said to be "surprised" by the MiG-29's radar capability and that the aircraft had scored a theoretical kill on an F-16 at a range of 60 km, presumably with a semiactive radar missile launched at maximum range in a nonmaneuvering front-quarter setup.

[12]As perhaps an indication of more to come, a German reporter was recently given two orientation rides in a MiG-29UB by the aircraft's former East German Air Force parent unit, the Vladimir Komarov Wing (Jagdgeschwader 3) at Preschen. See Stefan Petersen, "Ist der MiG-29 für die Luftwaffe eine Alternativ? Wir flogen mit dem sowetischen Superjaeger," *Flug Revue*, No. 12, 1990, pp. 9–14. See also Joris Janssen Lok, "MiG-29 is 'Better Than F-15C,'" *Jane's Defense Weekly*, April 6, 1991, p. 526.

ORGANIZATION AND STRUCTURE

This report begins with an overview of my initial contacts with Valery Menitskii and others at the Mikoyan Design Bureau that led to my invitation to fly the MiG-29UB. It then summarizes the steps I took to coordinate with the U.S. government and to make myself as proficient as possible for the flight. Finally, it offers a comprehensive account of the flight itself, which is the intended main purpose of the report. In that account, I have tried wherever possible to supplement my remarks with reinforcing or gap-filler information from other Western pilots who have flown the aircraft, so as to offer the fullest possible appreciation of the MiG-29 as a flying machine.

Appended to the report is a detailed technical portrait of the MiG-29 that gives an overview of the aircraft's performance capabilities, design characteristics, and development prospects. This appendix is based on open sources, ranging from Soviet industry and press comment to direct contact with the aircraft by myself and other Westerners since the MiG-29 was cleared to go public on the international air show circuit in 1988. Also appended is a translation of an article on my flight which appeared in the Soviet press shortly after my return from Moscow.

The initial sections below on the events that led up to my flight have been included because the flight set a precedent for an American citizen and, as such, demanded considerable probing of unexplored terrain on both sides to bring about. They are offered to convey a sense of the many steps that went into arranging the flight, as well as an appreciation of some of the politics and possible Soviet motivations associated with it. These portions also describe an unusual experiment in personal diplomacy and the gradual formation of a real friendship between two professionals whose entire careers had previously been devoted toward advancing their respective sides' interests in the East-West military competition. The reader who is solely interested in the flight itself is invited to skip this material and proceed directly to Sec. 4.

2. INITIAL CONTACTS

When I first noticed a report in a European aerospace journal that the Soviets would be bringing the MiG-29 to Farnborough, I was incredulous that *glasnost* had come this far.[1] Once I saw that report confirmed in the Soviet press, however, it became clear to me that, as one who had studied Soviet tactical airpower professionally for more than a decade, I had an obligation to be on hand for whatever opportunities there might be to learn from this unprecedented event.[2] At the time, I felt that if I had a chance merely to get some good photography of the aircraft in the static display area and to converse briefly with one of the pilots, the trip would more than justify itself. I had no idea that things would turn out as rewardingly as they did.

FARNBOROUGH, SEPTEMBER 5–9, 1988

During my stay in London, I was a house guest of Air Chief Marshal Sir Michael Armitage of the Royal Air Force. Upon learning of the planned MiG-29 presence at Farnborough, I had written to Sir Michael requesting any help he could provide me in gaining access to the MiG-29 and, more important, to the pilots who would be accompanying it. Air Chief Marshal Armitage was aware of my interest in Soviet fighter aviation from numerous conversations we had had over the years, and his support opened several doors. One was the opportunity to be hosted at Farnborough by the senior management of the British Aerospace Corporation.

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[1]Ian Goold, "MiG-29 Will Fly at Farnborough," *Flight International*, June 11, 1988, p. 2. An earlier report on June 9 noted that the Soviet Embassy in London had confirmed the planned display the previous day. It added that the Soviet decision had come after representatives of the Society of British Aircraft Companies, the sponsoring organization for the air show, had proposed to Colonel Aleksei Sazhin, at the time the Soviet air attaché to Great Britain, that it might be "fun" if the Soviets brought some MiG-21s to Farnborough. The eventual response that the Soviets would send two MiG-29s came as a total surprise. See Harvey Elliott, "Russians Will Sell MiGs at Farnborough," *The Times* (London), June 9, 1988. Later hearsay reports indicated that the final approval had been given by President Gorbachev himself.

[2]See, for example, my "Moscow's Lessons from the 1982 Lebanon Air War," in Air Vice Marshal R. A. Mason, ed., *War in the Third Dimension: Essays in Contemporary Air Power*, Brassey's Defense Publishers, London, 1986, pp. 127–148. The first Soviet media reference to the impending display of the aircraft was A. Gorokhov, "MiG-29: First Time at the Show," *Pravda*, August 14, 1988.

Chris Yeo, the chief test pilot at British Aerospace, was able to provide me with a line pass into the flight operations area where all the aircraft on the flight demonstration schedule, including the MiG-29s, were parked. These passes are normally reserved for aircrew and essential ground personnel. On Tuesday afternoon, September 6, I went to the north side of the field with Jeremy Wooding, a British Aerospace vice president for regional marketing. We were cleared into the restricted area and found the two MiGs parked on the ramp next to the F-16.

Standing close by were several Mikoyan technicians and a Soviet supervisor dressed in a business suit. The man in the suit reacted guardedly to my attempt to engage him in Russian but otherwise made no effort to prevent us from walking around the two aircraft. The single-seater had the canopy open and a boarding ladder placed alongside (see Fig. 2). I asked the superviser if we could climb up and have a look inside the cockpit. He responded by asking if he could do

Fig. 2—Author Beside Single-Seat MiG-29 in Farnborough Flight Operations Area

the same with the F-16. I told him that I was not empowered to grant that authorization. He said likewise to me in return. When I gently pressed him again a bit later, he said I would have to wait until the pilot arrived.[3] By the time that happened an hour or so later, there was enough preflight activity going on around the aircraft that it would have been inappropriate for me to wade in with such a request. Meanwhile, despite my inability to get into the cockpit, I had unobstructed access to both the single-seater and the dual for well over an hour.

British Aerospace further invited me to a dinner the following Friday evening, September 9, to which the three MiG-29 pilots had also been invited. This dinner was in honor of the RAF's Red Arrows flight demonstration team. The Soviet pilots had initially responded that they needed to get higher approval before they could accept, and several days went by without an answer. During the wait, I proceeded south with several RAF friends to Brighton, where I was scheduled to participate in the 30th annual conference of the International Institute for Strategic Studies (IISS). Three days later, at noon on Friday, British Aerospace advised me that the Soviets had been granted permission to attend the dinner and would be there. At that, I chartered a taxi to get me back to Farnborough for a 1900 show time.

During the two-hour taxi ride, I began composing in my mind a list of the many questions I hoped I might put to the Soviet pilots. It quickly dawned on me, however, that this was an ill-advised approach. The Mikoyan pilots had almost certainly accepted the invitation with the understanding that the dinner would be a social event. In light of that, there was every chance that they would be put off by anything that appeared even remotely to involve probing on sensitive operational or technical matters. I thus swore to refrain from any questions that went beyond safe generalities about fighter aviation, life under *perestroika*, and broad trends in East-West relations. I made a special point not to bring up anything that might sound as though it came from somebody else's list of collection requirements. Instead, suspecting that I might be the only Russian speaker in attendance, I began composing some appropriate words to be offered as an after-dinner toast.

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[3]This individual turned out to be Konstantin Aleksandrovich Ushkintsev, who escorted me more than a year later on my visit to Kubinka to fly the MiG-29. Ushkintsev has traveled with the Mikoyan entourage on all of its foreign air show deployments. His business card describes him as a deputy director of Mikoyan's manufacturing facility.

I arrived at the British Aerospace chalet promptly at 1900 and was met by retired RAF Air Commodore Don McClen, the company's chief of public affairs, who had invited me to the dinner. I told McClen about my toast idea, which he warmly endorsed. He then added that although the Mikoyan pilots would be coming with an interpreter, he was counting on me for help with translation and had seated me at his table. This put me with the chief test pilot, Valery Menitskii, to my left, Roman Taskayev to my right, and Anatoly Kvochur (who had flown most of the MiG-29 demonstrations) directly across from me. As we waited for the Soviets to arrive, I began quietly preparing myself for what was about to occur.

The three pilots arrived at 1930 just in time for dinner. They were accompanied by Alexander Velovich, an avionics engineer from the Mikoyan Design Bureau who spoke excellent English and who was serving as the translator for the Soviet delegation. We took our seats and commenced introductions around the table as wine was being poured. I was introduced by Don McClen (with Velovich, at this point, doing the interpreting) simply as "Dr. Benjamin Lambeth, a friend of British Aerospace from the United States."

Nothing was said up to that point about my professional interests or my affiliation with RAND. No doubt their wheels were spinning rapidly at this point, as all four Soviet guests wondered why they were seated with a Russian-speaking American in a room otherwise populated entirely by British nationals. Whatever they may have thought, they were totally open (in Menitskii's case even garrulous) as the discussion proceeded around the table at a rapid-fire rate in both Russian and English. Before long, Velovich found himself repeatedly bombarded by translation requests from both the Mikoyan pilots and the three British guests at the table. At one point, with good humor, he threw up his hands in mock frustration and said: "Please! Give me a break! I only have a single-target track fire control system!"

Menitskii was by far the most engaging of the three pilots. He clearly was in command and appeared natural and relaxed in the role. I quickly established an animated dialogue with him, and our conversation ranged far and wide. Among other things, I told Menitskii about what I did at RAND, about how I had come to learn Russian, and that I had grown up as the son of a U.S. Air Force pilot. I added that I had been disqualified for military pilot training because of deficient eyesight, but that I was a civilian aviator who specialized in both tactical airpower and Soviet political-military affairs. I also outlined the

highlights of my modest fighter background, noted that I was a long-time student of Soviet tactical airpower, and generally tried to let him know that I was a devoted fighter pilot in spirit. All in all, I was completely aboveboard about who I was, what I did, and why I was there.

In return, Menitskii told me a bit about his own background and what it was like to be a Soviet test pilot. I learned during this discussion that all three pilots were civilian employees of the Mikoyan Design Bureau. They had been trained by the Soviet Air Force, identified early in their military careers as potential test pilots, and then selected, relieved of their service obligations, and ultimately taken on by the design bureau after completing test pilot school and a stint as production test pilots with the Ministry of Aviation Industry.[4]

At one point in the conversation, I remarked to Menitskii that I hoped to lead a small RAND delegation to Moscow within the coming year in connection with some research I was doing on the subject of changes in Soviet defense policy under Gorbachev. I asked if it would be possible for me to see him again in Moscow should any such trip occur. Menitskii readily assented, told me to be sure to let him know when we were coming, and scribbled a postal designator on his business card through which he said I could send him a letter.

I then told Menitskii, partly to signal my interest but mainly out of curiosity to see what reaction it prompted, that I had a real desire to be the "first American analyst" some day to fly the MiG-29. Rather than rejecting the idea forthwith, as I had half expected, he immediately responded in full seriousness that "things are changing so fast in the Soviet Union that this could just happen some day." When I countered that I would be content even for a trip in the MiG-21, he then replied: "As long as you're going to do it, you might as well strive for the best!" We left this tantalizing line of discussion at that.

Next came the traditional exchange of odds and ends. I had brought along three F-18 tie clips which I gave to the three pilots, explaining that the Hornet had a special meaning for me because of the front-seat checkout I had received in it from the Royal Australian Air Force earlier in the year. Menitskii then began pinning all sorts of Mikoyan

[4]In the course of a brief library search into Menitskii's background which I conducted upon my return home, I learned that he had been born in Moscow of military parentage on February 8, 1944; graduated and was commissioned a lieutenant in the Soviet Air Force by the Tambov Higher Military Aviation Academy for Pilots in 1965; and was awarded the title of Hero of the Soviet Union for "courage and heroism" displayed during an inflight emergency that occurred on February 2, 1982. Cited in General of the Army I. Shkadov, ed., *Geroi Sovetskogo Soiuza* (Heroes of the Soviet Union), Vol. 2, Moscow, Voenizdat, 1988, p. 71.

paraphernalia on me—a lapel pin which he removed from his suit coat and several other company *znachki*, one of which he said I was the "first American" to receive.

By this time, dessert was over, the cognac had been poured, and I was invited by Don McClen to render my welcoming toast in Russian for the Soviet guests. With Velovich doing the translating for the British audience, it went roughly as follows: "Let me say to the pilots of this outstanding Soviet fighter which we have seen fly in the sky over Farnborough this week: Welcome to Great Britain. Please come back. And I hope that someday soon you will also come to the United States." Then, raising my glass, I added: "Long live *glasnost*. To peace and friendship in the skies among pilots of all nations. And last, but very important, we have an expression in English which I will try to translate into Russian: Fighter pilots do it better!"

Then it was Menitskii's turn. Not to be outdone, and revealing his fighter-pilot instincts to the core by shamelessly pandering to the assembled wives of the Red Arrows, he began by saying (with Velovich translating): "When I first learned that I would be coming to the West, I expected to encounter many surprises. But there has been no surprise quite like the unbelievable number of lovely ladies in this room!" After the laughter and applause had subsided, he put his hand on my shoulder and added: "And if you want to know more about us, just read Ben's report." More laughter. He was nobody's fool.

Menitskii continued with a few more well-chosen words, after which the commanding officer of the Red Arrows, Squadron Leader Tim Miller, presented Menitskii with a model of the British Aerospace Hawk in Red Arrows livery (see Fig. 3). Then a free-for-all ensued. The Mikoyan pilots became inundated by Red Arrows salvoing questions and trying to swap neckties, wives asking for autographs, and me trying my best amidst the commotion to help interpret. Shortly thereafter, the MiG-29 pilots expressed their thanks and departed. The last thing I told Menitskii was that he could count on hearing from me again in due course.

After a brief follow-up with Don McClen, I returned to my chartered taxi and mentally debriefed myself during the long ride back to Brighton. Lieutenant General Brad Hosmer, a USAF fighter pilot who was at the time President of the National Defense University, was, by previous arrangement, waiting for me in the hotel lounge to help me organize my impressions. General Hosmer was likewise in Brighton to attend the IISS annual conference, and he graciously indulged me

Fig. 3—(Left to right) Squadron Leader Tim Miller, Alexander Velovich, and Valery Menitskii (standing); Author and Don McClen (seated)

in an animated midnight reconstruction of what had transpired earlier that evening at Farnborough.

In January 1989, I finally wrote to Menitskii in an attempt to sustain our contact and to update him on my plan to come to Moscow. The business card he had offered me gave no mailing address for the Mikoyan Design Bureau, and the abbreviated postal designator he had written on it (which looked like *Aviazagranpostavka*) made no sense to me or anybody else I asked.[5] So I took a gamble and sent my letter by registered mail to Menitskii in care of the Ministry of Aviation Industry, for which we *did* have a valid address (16 Ulanskii Pereulok in Moscow). I also sent him a 1990 RAND calendar and, under separate cover, a RAND Project AIR FORCE coffee mug.

[5]I later learned that Aviazagranpostavka was the old term for what has since been renamed Aviaexport, a subsidiary of the Ministry of Aviation Industry through which various Soviet aircraft design and production entities interact with the Western business community.

Months went by with no reply other than the registered mail receipt, which confirmed that my letter and package had at least arrived in Moscow.

Naturally, I was disappointed that my effort to reestablish contact with Menitskii had gone unrequited. Yet I could imagine several plausible reasons why this may have reflected something other than indifference on Menitskii's part. Mindful of that, I set about planning to seek him out at the upcoming Paris Air Show, where a MiG-29 presence was scheduled and where Menitskii was likely to turn up.

The first question on my mind when I saw Menitskii again at Le Bourget the following June was whether he had received my letter. He indicated that he indeed had, along with the coffee mug, and asked if I had received the ornamental porcelain samovar from the village of Gzhel which he had sent to me in return. To his consternation, I told him I had not seen a trace of it. He said he had requested personally that this piece of folk art be delivered to me via the American defense attaché's office in Moscow, and he was quite unhappy to learn that it had not been passed along as promised. Whatever may have come of the samovar during the transmittal, the point that mattered was that Menitskii had received my material and had been quick to reciprocate. It was in that spirit that our second encounter in Paris began.

LE BOURGET, JUNE 10–13, 1989

I arrived in Paris with much the same outlook I had taken to Farnborough the previous September: High hopes, but no expectations and little clue as to how things might turn out over the ensuing days. Thanks to Tim Beecher, the Director of Public Affairs at the McDonnell Douglas Corporation, I was able to use the McDonnell hospitality chalet as a base of operations during my four days at Le Bourget. Since the McDonnell facility was located just a stone's throw from the Soviet chalet, this eased matters greatly.

There was a contingent of F-18 pilots from the nearby Canadian base at Baden-Soellingen, West Germany, who were also using the McDonnell chalet as a rendezvous point. I asked Captain Kirk Leuty, the F-18 demonstration pilot, if he would pass my business card to the Mikoyan team at the next daily all-pilots' briefing. He said he would give it to Alexander Velovich, who was again with the Mikoyan delegation as interpreter. Velovich accepted my card the following morning. He said that the Mikoyan pilots remembered me from Farnborough and would be happy to see me again.

Shortly after lunch that day, Captain Leuty and I walked over to the Soviet chalet. As we were standing in the reception area looking for a familiar face, I saw Menitskii in the adjacent room and called out his name. When he finally caught my eye, he rushed over with a smile to shake my hand. We then launched into the exchange about the letter and samovar, mentioned above. Once that was over, Menitskii pulled me, with Captain Leuty in trail, into an adjoining room and began introducing me around, beginning with Academician Belyakov, the general designer of the Mikoyan Design Bureau, and Mikhail Waldenberg, the chief designer of the MiG-29. Also included in the flurry of introductions was retired Soviet Air Force Major General Vladimir Petrov, who was attached to the Soviet delegation as a military adviser to the Ministry of Aviation Industry.

Menitskii explained to Mr. Belyakov that I was the American he had met at the British Aerospace dinner the previous September. That introduction gave me a chance to tell the general designer a bit about my work at RAND and to express my hope that I might be able to see him as well on my next trip to Moscow. Menitskii then sat me down with Velovich, who had walked over to join us in the meantime, and dashed off to fetch me a color print of the MiG-29, which he autographed with a warm expression of good memories and best wishes. He also gave me a handful of MiG odds and ends (more lapel pins, a key chain, and a necktie with the Mikoyan logo). By this time, Captain Leuty had to leave so he could prepare for his afternoon flight demonstration.[6] Menitskii then invited me out to the static display area for a private walkaround of the MiG-29.

The aircraft was cordoned off and surrounded by onlookers. Menitskii strode through the crowd, opened the barricade, and let me in, closing the gate behind him. It was the two-seater with the canopy open and the boarding ladder positioned alongside. I asked Menitskii if I could sit in the cockpit. With apologies, he replied that the cockpit was off limits at that moment, since the UB was still being certified to fly its first air show performance following the loss of the single-seater in an accident during its flight demonstration three days earlier. Menitskii promptly assured me, however, that if I came back the

[6]Earlier that week, Captain Leuty had been among the first air show spectators to rush out to the crash site to attend to a severely, if temporarily, incapacitated Anatoly Kvochur following Kvochur's harrowing low-altitude ejection when his right engine failed catastrophically during a low-speed pass directly in front of the onlookers (see Sec. 4 for a fuller account of that accident). Sad to say, Captain Leuty himself lost his life the following spring in an F-18 midair collision during a maneuvering air combat training engagement near Karlsruhe, West Germany.

following day, he would make it happen. He was plainly proud of the airplane and guided me all around it, pointing out the detached fuel tanks that had been used for the ferry flight and various other design features.

The next morning, I arrived at the Soviet chalet accompanied by Major Allen Clovis, who was at the time assigned to the office of the Deputy Chief of Staff for Plans and Operations at USAF headquarters. Major Clovis had sought my help several years earlier while he was writing a master's thesis on Soviet tactical airpower at the Naval Postgraduate School, and we had later worked together as members of the USAF's European Tactics Analysis Team (ETAT). Although I was concerned at first that bringing along a stranger might undermine the bona fides I had established with Menitskii so far, the Soviet presence at Le Bourget seemed far more relaxed and open than it had been at Farnborough the year before. More important, the Mikoyan pilots had already met a fair number of their NATO counterparts by then. I decided that those facts, plus Major Clovis's Russian-language training and his credentials as a fighter pilot, would overshadow any concern by Menitskii that I was trying to take advantage of his friendship.

Major Clovis and I entered the Soviet chalet to find Menitskii surrounded by a mob of visitors. He was about to lead this group out to the flight line for a previously scheduled inspection of the MiG-29. It was obviously a bad time for us to try to get his attention, so we wandered out to the static display area by ourselves to see what might happen next. When we arrived at the MiG-29, Menitskii was at the foot of the ladder shepherding spectators up and down for a quick look. He was sporting the USAF pilots' sunglasses that I had given him the day before and seemed quite relaxed about the way he was letting people in and out. He only insisted that visitors remove their jackets and any personal items like tie clips or pens that might get dislodged and disappear somewhere in the cockpit.

As the minutes went by, Major Clovis and I remained frustrated outsiders looking in. I managed to get Velovich's attention, but he was also preoccupied with keeping track of the group and made no offer to invite us inside the barricade. Soon, however, Menitskii appeared to be trying to unburden himself of his visitors and usher them out. I finally caught his eye. With a subtle gesture, he signaled that he still had his hands full, but for us to sit tight and that he would get to us as soon as he could.

Sure enough, once the crowd had dissipated, Menitskii walked over, opened the barricade, and invited Major Clovis and me in. He took us straight to the ladder, asked me to give my coat to the crew chief, and told me to climb on up. I did so and settled in, after which Menitskii parked himself on the left canopy sill beside me.

In all, I probably spent fifteen minutes in the cockpit, with Menitskii providing a running description of every major panel, instrument, and switch from left to right. When I asked him how to start the aircraft, he pointed toward what looked like battery and engine start switches on the right console. Some placard markings were in English. When I asked the reason why, Menitskii replied that the MiG-29 was available for export and that this particular aircraft was a demonstrator model.

Actually sitting in the aircraft altered a major impression I had formed from my earlier looks at photographs of the cockpit. When I first saw the pictures taken on the occasion of Secretary of the Air Force Aldridge's trip to the Soviet Union in July 1988, the MiG-29 cockpit looked for all the world like a plumber's tool box, with round dials and toggle switches everywhere, bulky life-support hoses and fittings, and little sign of any serious effort at human engineering.

That impression quickly vanished once I was actually ensconced in the jet. Bringing my hands down from the windshield bow to the stick and throttles, it was immediately obvious that I was sitting in a modern fighter. It was not an F-18 cockpit with an array of digital display indicators, to be sure. But the controls needed merely to fly the aircraft all seemed to fall very comfortably into hand.

One item I noted in particular was that the seeker head for the infrared search and track (IRST) system just forward of the windshield on the right-hand side presented no noticeable obstruction to vision over the nose, even though it had appeared to me earlier from the outside that it might seriously impair the pilot's field of view in the lower right-hand quadrant (see Fig. 4). After a few moments of getting acclimated to my surroundings, I playfully invited Menitskii to hop into the rear cockpit so we could crank and get going. He noted my desire to get airborne and just smiled.

All in all, it was quite an experience, for a long-time observer of Soviet tactical aviation from a distance, to be sitting in the cockpit of a current-generation Soviet fighter with the chief test pilot of the firm that had designed it as my guide. Once my politeness meter told me that it was time to move on, I expressed my thanks and climbed out

Fig. 4—MiG-29 Infrared Search and Track Sensor

so that Major Clovis could have a chance at the same. While Major Clovis took his turn in the front seat, I had a few minutes to peer into the aft cockpit. It was much busier than the rear cockpit of either an F-15 or F-16, with an alphanumeric keypad in place of the radar display but what appeared otherwise to be virtually a complete duplicate of the forward cockpit minus the head-up display (HUD).

Altogether, I spent several hours with Menitskii over the course of my three days at Le Bourget. In addition to the MiG-29 cockpit tour, Menitskii arranged for Major Clovis and me to accompany him to the Mikoyan press conference, which was held inside the giant Antonov 225 space-shuttle transporter. This was the gathering at which Academician Belyakov spoke about future development plans for the MiG-29 and Anatoly Kvochur reconstructed his ejection sequence and the circumstances that had led up to it several days earlier.[7]

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[7]For highlights of the latter, see Robert R. Ropelewski, "*Glasnost* Gusto Invigorates Paris Air Show," *Armed Forces Journal International*, July 1989, pp. 56–58, 84.

Also, in response to a request I had made of him the day before, Menitskii arranged for Major Clovis and me to sit in the cockpit of the Su-27 interceptor, which was on display in the West for the first time and was thus a star attraction at the Paris Air Show. Through Menitskii's intervention, we were given a personal walkaround and cockpit orientation on the aircraft by Konstantin Marbashev, the chief designer of the Su-27. In retrospect, I believe this effort put Menitskii on the spot a bit and obliged him to spend some corporate political capital on our behalf, since I now appreciate better than I did at the time that a tremendous institutional rivalry exists between the Mikoyan and Sukhoi Design Bureaus.

Finally, on the morning of my last day at Le Bourget, I expressed my hope that Menitskii might soon be able to visit the United States, where I could return his hospitality by hosting him at a gathering of some of my American fighter pilot friends. At that, Waldenberg informed me that Mikoyan would be sending two MiG-29s to the Abbotsford Air Show in Vancouver in early August, and that this might offer a logical next step toward such an opportunity.

On parting late that afternoon, I told Menitskii that the cockpit orientation he had given me the day before was a professional experience I would never forget. I added that I felt a special kinship with him and looked forward to our next encounter. He was equally warm and expressed again his disappointment that I had not received his gift of the porcelain samovar. I assured him that I would do what I could to track it down, but that it was his thought that mattered most.[8] We affirmed that we would meet again, either in Vancouver or in Moscow. With that, and a heartfelt round of handshakes, Major Clovis and I bid him goodbye.

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[8]I later queried the U.S. defense attaché on this directly and asked if he had any knowledge of the samovar's whereabouts. He said that he had no personal recollection of it and speculated that it might have gotten lost somewhere in UVS (*Upravlenie vneshnikh snosheniei*, or External Relations Directorate), the Soviet Defense Ministry's point of contact for dealing with foreign attachés in Moscow. Some months later, Menitskii assured me that as an employee of the Ministry of Aviation Industry, he had not worked through the Defense Ministry but had handed the package directly to a USAF representative during a meeting in Moscow to discuss airspace transit issues connected with an upcoming air show deployment. Whatever may have happened to the samovar, the point that matters is that I took Menitskii at his word and followed up on my promise to try to locate it.

ELMENDORF AFB, AUGUST 16, 1990

En route home, as I contemplated traveling to Abbotsford to meet Menitskii again in August, I realized that a great circle route from Chukotka to Vancouver—the course the MiG-29s would have to fly to get to the air show—passed directly over Anchorage, Alaska, where Elmendorf AFB was located. It then occurred to me that this might offer a timely opportunity for the U.S. government, if it saw fit on policy grounds, to invite the MiG-29 entourage to stop at Elmendorf for fuel and a brief exchange with the USAF F-15 community there.

With that in mind, I called Lieutenant General Tom McInerney, the commander of the Alaskan Air Command headquartered at Elmendorf, to advise him of my contacts with the Mikoyan group and ask what he thought about the idea. Upon so doing, I learned that the Soviets had already made such a request and had received approval from the U.S. government. I was then invited by General McInerney to come to Elmendorf to be a part of his official greeting party. I was especially pleased at this prospect, since it promised to offer me my long-awaited opportunity to greet Menitskii on American soil. I thus decided to skip the Abbotsford Air Show and to meet Menitskii instead at Elmendorf on August 16, when the MiG-29s passed through on their return flight to the Soviet Union. I was joined on this trip by my RAND colleague Eugene Rumer, who is a native Russian speaker and who later accompanied me on my visit to Moscow in December.

I had a second incentive to visit Elmendorf in that I was also at the time in the midst of a RAND study for the United States Air Forces in Europe on ways of extracting better training value from the fighter sorties flown by that command. One option under consideration was to make greater use of the unrestricted airspace and range space available in Alaska, particularly for night low-level training. With General McInerney's support, my trip to Elmendorf afforded me a chance to fly an F-15 sortie and to take a comprehensive look at the tactical ranges and target arrays available in Alaska. It also allowed me to greet Menitskii this time in a flying suit rather than a coat and tie.

About an hour after Anatoly Kvochur and Roman Taskayev had landed their MiG-29s at Elmendorf, the Tu-154 carrying the rest of the Mikoyan entourage, including Menitskii, arrived and was met by General McInerney and his party (see Fig. 5). I was on hand to welcome Menitskii as he came off the airplane, at which point he immediately said to me in Russian: "When you come to Moscow, you are going to fly. I have taken care of that."

Fig. 5—(Left to right) Velovich; Author; Menitskii; Lieutenant General McInerney; Anatoly Belosvet, Mikoyan Deputy General Designer; and Valery Novikov, Mikoyan Manager of Flight Test Operations, at Elmendorf AFB

Those were literally Menitskii's first words to me. I offered a remark in reply to the effect that he must have remembered my comment at Farnborough that I hoped to become the "first American analyst" to fly the MiG-29 some day. I added, needless to say, that I would be honored to fly with him were any such opportunity to occur. But the fact is that I was caught almost completely off guard by his statement, since I had never made anything like a direct request to fly the MiG-29 and was scarcely expecting such an invitation.

Of course, I had learned just that morning that Menitskii had flown Major Wade at Abbotsford the previous day, so there was a precedent that removed his apparent invitation from the realm of pure political science fiction. Yet I could scarcely believe my ears. As soon as I found a suitable opportunity, I took General McInerney aside, told him what I had heard, and asked what he thought about it. General McInerney replied that Menitskii appeared, in his judgment, to be in

full control of his design bureau's flight activity and would scarcely express such an offer were he not prepared to back it up. Hearing that gave me some encouragement, and I began for the first time to believe that a MiG-29 entry in my logbook might actually come to pass some day.

The subject arose again shortly thereafter at a dinner at the Elmendorf Officers' Club, where Eugene Rumer and I were seated at the head table with General McInerney, Menitskii, Alexander Velovich, and Anatoly Belosvet—the deputy general designer of Mikoyan and a senior executive of the firm whom I had not met before. Menitskii first allowed that had I attended the Abbotsford Air Show, I would have flown the MiG-29 there. This immediately told me that something fundamental had occurred inside the Soviet decisionmaking loop in the wake of the Paris Air Show, in which Menitskii had made an approach on my behalf and received a green light from the appropriate Soviet authorities.

Menitskii then said to General McInerney: "When I fly with Ben, he will have the controls as soon as the canopy comes down." He also noted that he intended to let me fly the aircraft from the front cockpit and that he would show me the "full performance capabilities" of the MiG-29. By this time, I was convinced beyond doubt that I was hearing things correctly. Eugene Rumer later confirmed to me his own impression that Menitskii had held out "not just an invitation but a promise."

The question then arose concerning what I needed to do to make this flight occur. I certainly was not extended anything like a formal visit invitation by the Mikoyan Design Bureau. Menitskii knew from my earlier comments at both Farnborough and Le Bourget that I had planned to visit Moscow in any case in connection with some ongoing RAND research. The apparent understanding was that I would get myself to Moscow independently on that business and that the Mikoyan Design Bureau would then see to arranging the flight once I was there. Deputy general designer Anatoly Belosvet, who had been entirely supportive of all this throughout our dinner conversation, told me that I needed merely to get in touch with him through Aviaexport once my travel plans had solidified, and that he would take care of everything else from there.

After dinner, the commander of Elmendorf's 21st Tactical Fighter Wing, Colonel Shel Storer, presented Menitskii with a Nomex flight jacket emblazoned with a personal nametag and the appropriate unit patches. I then gave Menitskii a videocasette of the movie *Top Gun*

as a gift to the Mikoyan Design Bureau's pilots. In response to the first present, which he donned on the spot, Menitskii said he was honored by the gesture and would welcome a chance to be a lieutenant again flying F-15s in such a unit for a day before moving back to the MiG-29 and his current responsibilities.

As for the videotape, Menitskii remarked that Soviet fighter pilots were well aware of the movie *Top Gun* and the powerful effect it had had in bolstering popular respect for military aviation in the United States. He added that the Soviet Air Force was facing a serious problem in recruiting and retaining quality people and was in real need of something like it to rekindle such enthusiasm among Soviet youth. By such repartee, it was becoming increasingly apparent to all Americans present that Menitskii was not just an accomplished test pilot, but also a virtuoso ambassador without portfolio.

After a quick tour of the base exchange, Belosvet, Menitskii, and the other Mikoyan personnel were driven back to the flight line where Kvochur and Taskayev were making final preparations to launch on their last leg from Vancouver to Chukotka. Once the MiGs and their F-15 escorts were airborne, we returned to the Tu-154 for a final exchange of gifts and farewells. This time, Belosvet gave me his office telephone number. I told him that the ball was in my court and that I would get back to him as soon as I could with a proposed time for arriving in the USSR. My parting words to Menitskii were that I had met many a Russian during my career, but that he was the first whom I had come to consider a friend. We agreed to meet next in Moscow.

3. ORGANIZING FOR THE MOSCOW TRIP

After the Mikoyan entourage had departed, I returned to the Elmendorf Officers' Club with General McInerney to review the evening's events and to consider next steps toward following up on Menitskii's invitation. The challenge now before me was how best to bring this flight off.

Since my first encounter with the Mikoyan contingent at Farnborough in September 1988, I had been in recurrent touch with then-Lieutenant General Lee Butler, the Director of Strategic Plans and Policy (J-5) on the Joint Staff and the senior U.S. officer responsible for working-level Soviet-American military-to-military contacts. I had known General Butler (now commander in chief of the Strategic Air Command) since he was a lieutenant colonel in 1974, and I wanted to keep him apprised of my contacts with Menitskii and to share with him the highlights of what had taken place over the course of our developing relationship.[1]

At one point during that period, I asked General Butler if he knew who would be the first American pilot to fly the MiG-29. At the time, there was a pending issue before the U.S. government, which continues to be unresolved, regarding the possibility, first broached in public by the Soviets at the 1989 Paris Air Show, of an exchange of fighter flights between selected Soviet and American test pilots.[2] In light of that continued irresolution, coupled with my own gathering involvement with Menitskii and the Mikoyan Design Bureau, General Butler replied: "Who knows? It might be you." In response, I told him that I was indeed of a strong mind to take advantage of any such opportunity that might come my way, and I asked whether he felt this would present any problem for the U.S. government. General Butler said he could see no reason why it should, and we left the matter at that—still purely an academic question.

Now that I had a real situation on my hands, General McInerney agreed that I could not treat Menitskii's offer as simply another

[1]As it turned out, General Butler beat me to Kubinka by more than half a year when he led a U.S. military delegation to the Soviet Union in May 1989. While there, he was allowed to sit in a MiG-29 for over 20 minutes with the canopy closed.

[2]This proposal was reportedly made by Mikhail Simonov, general designer of the Sukhoi Design Bureau, to General Bernard Randolph, then-commander of the U.S. Air Force Systems Command. See "Soviets Propose USSR, U.S. Pilot Exchange," *Aviation Week and Space Technology*, June 6, 1989.

routine invitation to go flying. For an American citizen to get airborne in *any* fighter aircraft in the Soviet Union would constitute both a precedent and an event with foreign policy ramifications. That being the case, General McInerney's counsel was that I make sure that I had RAND's corporate approval and, at the same time, that I fully apprise the Air Staff and General Butler of my invitation.

I promptly did both upon my return from Elmendorf. Because I am not a government employee, I had no formal obligation to seek government approval to accept Menitskii's invitation. Nevertheless, considering RAND's close relationship with the national security establishment, I certainly had a professional responsibility to coordinate any such flight with the appropriate authorities, if only to make sure that my flying the aircraft would not pose any problems for related, but still undecided, initiatives between the two governments, such as the proposed pilot exchange noted above.

I thus informed General Butler and the relevant working-level people on the Air Staff of my invitation to fly, explained the immediate background and circumstances that had led up to it, and stated that I was open to any government guidance that might be deemed advisable in the circumstances. The basic message I got in reply was that I was at liberty to accept the invitation with the best wishes of the United States Air Force, but that my flight would have to be conducted purely as a civilian-to-civilian event, so that no reciprocity obligation, actual or potential, might be incurred by the government as a result.

Obviously Menitskii and those farther up the Soviet approval chain were aware of my non-governmental status. They also appreciated that I did not have personal access to an F-16 with which I could return their favor for accepting a flight in the MiG-29. Indeed, there was not the slightest hint of such reciprocity in Menitskii's invitation. Whatever motive the Soviet military and defense industry authorities may have had in approving my flight, it could not have been informed by any serious anticipation that this would, in and of itself, lead to a similar opportunity for Menitskii or any other Soviet pilot.

Those on the Soviet side, from Menitskii upward, must also have appreciated that it would scarcely constitute a balanced exchange from an American perspective for them to fly a U.S. defense analyst with less than 400 hours of mostly back-seat fighter time in return for our flying one of their most accomplished test pilots, with nearly 5000 hours in over 70 different aircraft types. I would not be surprised, however, if one objective behind the approval was to show by example the Soviet government's readiness in principle to fly an American (see

the Soviet press article describing my flight appended to this report, which suggests as much), perhaps in the hope that this might help break the logjam and facilitate an eventual pilot exchange between the two countries.[3]

There is also little doubt in my mind that I was a reasonably well-known entity to the Soviets by the time my invitation had been approved by the relevant authorities. For one thing, Menitskii almost surely made a routine report of his initial contact with me at Farnborough, just as I was obligated to do in the case of my own encounter with the Mikoyan group at the British Aerospace dinner. There is an even further likelihood that once my registered letter to Menitskii arrived in Moscow in January 1989, a determined dossier search was run by the pertinent Soviet authorities on this curious American who seemed to have such a persistent interest in establishing a dialogue with the MiG-29 pilots. However much of that detail Menitskii himself may have been given, he must have known that he was not dealing simply with a random American who knew Russian and had a passing interest in fighter aviation.

Indeed, Menitskii all but said so at the very outset when he had offered his counter-toast at the British Aerospace dinner the previous September. He later told me that he and Belyakov, in seeking authorization to fly me, had to overcome in addition a hurdle thrown up by some skeptical higher-ups in the Soviet bureaucracy concerning the fact that RAND, by the tone of its published analyses and its contributions to the American defense effort over the preceding four decades, had not exactly distinguished itself as a friend of the USSR.

In all events, the feedback I got from my Pentagon contacts meant that my trip to Moscow had to be supported entirely by RAND. Beyond that, official Soviet sponsorship was needed in order for me to be granted a visa. As for the latter requirement, I had long planned in any case to visit the Institute of the USA and Canada with several RAND colleagues to exchange views with some of the staff there on a variety of issues concerning Soviet-American relations, the changing

[3]Earlier at Abbotsford, the Soviet delegation had extended an invitation for the leader of the USAF Thunderbirds flight demonstration team to fly the MiG-29 in return for a flight by Menitskii in the F-16. This opportunity had to be declined, however, because the American government was not prepared to reciprocate the Soviet offer (see Sec. 5 for further discussion). Likewise, the Soviets had initially proposed to fly Major Wade in the MiG-29 in return for a flight by Menitskii in the F-18, and the Canadian government had similarly declined the Soviet proposal. In that instance, however, the Soviets then offered to fly Wade in any case, and he was eventually granted his government's permission to accept the invitation.

European security scene, and developments in Soviet military doctrine and national security policy. Earlier in the year, I had hosted a visit to RAND by the institute's deputy director, Dr. Andrei Kokoshin, and by a prominent Soviet military scientist on the institute's consultant roster, retired Major General Valentin Larionov.[4] At that time, I had discussed with Kokoshin my desire to pay him a return visit before the year was out if possible. My invitation to fly the MiG-29 thus presented an opportunity to kill two birds with one stone.

Kokoshin readily assented to offer visa support for my RAND colleagues John Hines and Eugene Rumer and me. He also agreed to engage us on a list of discussion topics which I had proposed to him in a letter. Once I had received this consent from Kokoshin, I then contacted Mikoyan's deputy general designer, Anatoly Belosvet, by telephone to inform him that we had a concrete plan for coming to Moscow and to ask what would be the most convenient time for him and Menitskii to have us arrive.

On so doing, I learned that both Academician Belyakov and Menitskii, along with Velovich, would be coming to the United States within a month to take part in a conference on the history of aircraft design sponsored by the Department of Aerospace Engineering at the University of Michigan. Belosvet added that the group was scheduled to be hosted by the General Dynamics Corporation in Fort Worth, Texas, following the Michigan conference. In addition to Belyakov, Menitskii, and Velovich, the Soviet delegation was to consist of the Minister of Aviation Industry, Mr. Appolon Systsov; the general designer of the Antonov Design Bureau, Mr. Peter Balabuyev; and the head of Moscow's renowned Central Aerohydrodynamics Institute (TsAGI), Dr. German Zagainov.[5] Their trip was to take place during the first two weeks of November, after which the Mikoyan Design Bureau would be free to receive me in Moscow.[6]

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[4]General Larionov was a prolific writer on Soviet military doctrine during the 1960s and was chief coordinator of the landmark volume edited by Marshal V. D. Sokolovskii, *Voennaia strategiia* (Military Strategy), Voenizdat, Moscow, 1962.

[5]TsAGI is roughly comparable to the aeronautical component of the National Aeronautics and Space Administration (NASA) in the United States. It incorporates an extensive wind-tunnel and engineering research complex with capabilities analogous to those of NASA Langley and NASA Ames. This sprawling enterprise dominates the town of Zhukovskii south of Moscow and is staffed by some 10,000 personnel, of whom over 2000 are scientific and technical workers.

[6]Interestingly, as I later learned from an article in a local Moscow paper, Belosvet was being interviewed by a reporter in his office at the time my call came in. The subject of the interview was the impending 50th anniversary of the Mikoyan Design Bureau. As the article noted in conclusion: "Toward the end of my conversation with Anatoly Alekseyevich Belosvet, the phone rang on his desk. My interlocutor picked up

Upon learning of this impending trip, I immediately invited the Soviet delegates to visit RAND as well. Aside from the Minister of Aviation Industry, who had to return to Moscow early from Fort Worth, they quickly accepted and, under Academician Belyakov's leadership, participated in three days of productive interaction with both RAND staffers and invited members of the Society of Experimental Test Pilots, plus a few representatives from the local aerospace industry. This visit of the Soviet group to Santa Monica gave me an opportunity, along the way, to discuss with Menitskii some of the details of my upcoming flight with him in the MiG-29.

Menitskii had assured me all along that I needed to do nothing by way of preparation for our flight. I did, however, study some published MiG-29 cockpit photographs to familiarize myself with the main control and instrument locations. I also had an unrelated chance to fly an F-15 sortie with the Hawaii Air National Guard on November 4 during the course of a briefing visit to PACAF headquarters at Hickam AFB. When I mentioned to the group commander that I had been invited to fly the MiG-29 with Menitskii, he put me on a scheduled mission that would allow me ample time to preview some of the events that I might experience on my MiG-29 flight. During this productive sortie, which I flew with Captain Arnold Balthazar, an F-15 weapons instructor, I performed numerous advanced handling maneuvers, including slow flight and flight with the control augmentation system (CAS) disengaged, 1-g stalls, hard level turns, multiple tail slides, a 200-kt afterburner loop, and a timed acceleration run from near-stall to 600 kts.

Immediately upon greeting Menitskii on his arrival at Los Angeles International Airport a week later, I made a special point to tell him that I had recently had a chance on this flight to get my proficiency sharpened a bit so that I would not to have to worry about falling on my face (*"chtoby ne udarit v gryaz litsom"*) when I flew the MiG-29 with him. He was entertained by this expression and jokingly passed my remark along to Belyakov, after which he added reassuringly that I would find flying the MiG-29 a piece of cake. Since this was the first time I had seen or spoken to Menitskii since our meeting at

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the receiver and was frankly surprised. 'They're calling from California,' he whispered. They indeed were calling from California, from a firm called the RAND Corporation, to announce that their representatives would soon be arriving in Moscow. I thought to myself: Only five to seven years ago, such a call would have caused quite a stir in this secret establishment and in other organizations tasked with protecting that secrecy. But today, this is considered normal in the age of *perestroika*." G. Davydov, "MiGs Known and Unknown," *Vecherniaia Moskva*, November 30, 1989.

Elmendorf, I also made a point to tell him I had received approval from my superiors to fly with him. He then confirmed, with a smile, that he had received a similar okay from his authorities. That, above all, was what I wanted to hear him say.

Through the help of Randy Jayne, at the time F-15 program manager at McDonnell Douglas and now president of the McDonnell Douglas Missile Company, I also had an opportunity a week before leaving for Moscow to spend an hour in an F-15 visual flight simulator in St. Louis getting reacclimated to a fighter front-seat environment and practicing some of the maneuvers that Menitskii had indicated to me that we would perform in the MiG-29. I also had an extended phone conversation with Major Bob Wade at Cold Lake, who shared with me the highlights of his flight with Menitskii at Abbotsford (some details of which are recounted in the following section). Relatedly, I had a tutorial session with Don Madonna, a close friend and former commandant of the USAF Test Pilot School, who gave me some useful pointers on things to look for during my flight.

Last, but important to my state of mind going into this experience, I took a long-overdue Federal Aviation Agency (FAA) biennial flight review (BFR) from an instructor at a local airfield and got recurrent in a Piper PA-38 Tomahawk, after several years of having been away from the light aircraft world. Since my invitation was to fly the MiG-29 from the front cockpit and with the understanding that it would be my airplane until Menitskii felt a need to step in, I wanted to recapture a positive pilot-in-command mind-set.

Toward that end, after I completed my BFR just a few days before my departure and made myself legal again in the eyes of the FAA, I got back into the Tomahawk and shot four solo landings in silent anticipation of things to come. Granted, the PA-38 is not a MiG-29. But there is a certain truth to the saying that all airplanes are pretty much the same at bottom ("pull back on the stick and the houses get smaller, push forward and the houses get bigger"). And there is a huge difference in attitude and situation awareness between being somebody else's passenger and knowing that the responsibility is entirely one's own. To that extent, although I fully understood that Menitskii would be far more than just "monitoring" my flight in the MiG-29, this proved to be a helpful exercise in rounding out my preparations.

Finally, it bears noting that I spent three months in intensive Russian language drill with a private tutor prior to my departure for Moscow to help enhance my conversational fluency and to familiarize

myself with basic fighter operations and cockpit terminology.[7] This proved to be perhaps the most valuable time of all that I spent in preparation for my flight. Not only did it make my preflight discussions and intra-cockpit communication with Menitskii that much more productive, it also helped to heighten my awareness of the many activities that went on around me at Kubinka the day I flew.

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[7]As study materials for this effort, I used the aeronautical sections from Colonel V. Zlomanov, ed., *Illiustrirovaniy voenno-tekhnicheskii slovar'* (An Illustrated Military-Technical Dictionary), Voenizdat, Moscow, 1968, and a collection of fighter-related terms and expressions which I built from E. Smirnov, *Vybiraiu aviatsiiu: dlia tekh, kto khochet stat' ofitserom VVS* (I Choose Aviation: For Those Who Want to Become an Air Force Officer), Voenizdat, Moscow, 1989. For reading practice, I concentrated mainly on the memoirs of Marshal of Aviation E. Savitskii, *Polveka s nebom* (A Half-Century With the Sky), Voenizdat, Moscow, 1988.

4. A MIG-29UB PILOT REPORT

I arrived at the Sheremetevo-2 International Airport in Moscow the night of December 10 with my RAND colleagues John Hines and Eugene Rumer. After two hours of negotiating our way through security and customs, we were met by Alexander Konovalov of the Institute of the USA and Canada and by Menitskii, with whom I had spoken by telephone a few days earlier to pass along our flight number and scheduled arrival time. The USA and Canada Institute had arranged for us to stay at the Krasnopresnenskaia Hotel near Red Square, which was a non-Intourist hotel used largely by the Moscow City Party Committee. We spent much of the following day in discussions with Kokoshin, Konovalov, and General Larionov at the institute, while Menitskii worked to try to undo a serious complication that had arisen in connection with my flight since we had last seen each other.[1]

It turned out that after my initial approval to fly had been granted by the Minister of Aviation Industry, the management of General Dynamics had proposed, during the Soviet delegation's visit to Fort Worth, that Menitskii be allowed to fly in the company's F-16B demonstrator aircraft. Predictably, given the still-unsettled pilot exchange issue within the U.S. government, this request was turned down by Washington. That prompted the Minister of Aviation Industry to develop second thoughts about allowing me to fly with Menitskii. It was truly nip and tuck for several days as Menitskii and Belyakov worked hard behind the scenes to get their original invitation back on track. During the tense waiting period, we were taken by Belyakov's executive assistant on a day-long trip to the Russian orthodox monastery in Zagorsk. We also had a productive interchange with Dr. Alexei Arbatov and several of his colleagues at the Institute of World Economy and International Relations (or IMEMO, in its Russian acronym).

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[1]Some of the insights gained from our discussions at the USA and Canada Institute and elsewhere in Moscow during this visit are reflected in the following three RAND reports: Benjamin S. Lambeth, *Is Soviet Defense Policy Becoming Civilianized?* Santa Monica, California, RAND R-3939-USDP, August 1990; Eugene B. Rumer, *The End of a Monolith: The Politics of Military Reform in the Soviet Armed Forces*, Santa Monica, California, RAND R-3993-USDP, August 1990; and John G. Hines and Donald Mahoney, *Defense and Counteroffensive Under the New Soviet Military Doctrine*, Santa Monica, California, RAND R-3982-USDP, 1991.

On our third night in Moscow, Menitskii called to inform me that he and Belyakov had finally succeeded in making their case with the Minister and that my flight was on. Needless to say, it was a relief for all of us to have this cliffhanger put behind us once and for all. I also learned during this conversation that we had been invited by Dr. Zagainov to visit TsAGI the next day, and that we would be taken out to Zhukovskii for this tour in a vehicle provided by Mikoyan once our appointments at IMEMO were finished.

The following afternoon, Anatoly Belosvet confirmed to me during our visit to TsAGI, where he was on hand to help Dr. Zagainov with the hosting, that my flight had received the final approval of the Minister of Aviation Industry and the Soviet Air Force.[2] Weather permitting, it was scheduled to take place on Thursday morning, December 14, at Kubinka Air Base. The plan was for Menitskii to ferry the two-seat MiG-29UB company demonstrator from the Soviet flight test center at nearby Ramenskoye, which I could not visit for security reasons, to Kubinka, which was the home of the Soviet Air Force's MiG-29 flight demonstration team (see Fig. 6) and a base that had routinely hosted various Western delegations since the beginning of *perestroika*.

At a private dinner that evening in Moscow attended by my two RAND colleagues, Menitskii and his family, and Belosvet and his wife, Menitskii described to me some of the events and maneuvers he planned for us to perform, including a fully developed stall with the throttles at idle and the stick pulled all the way back to override the mechanical angle of attack (AOA) limiter. The next morning, however, it turned out that we had been weather-cancelled even before we arrived at Kubinka. With blowing snow and visibility barely adequate to make out a line of MiG-23s parked on the ramp across the runway, Kubinka was closed to flight operations. Menitskii was likewise weathered-in at Ramenskoye. Since we had already made the trip out to Kubinka, my two colleagues and I spent several hours conversing with the base commander, Colonel (now Major General) Vladimir Sokolov, and the deputy air commander for the Moscow Military District, Major General Gennady Shchitov, both of whom were on hand to host us (see Fig. 7). Following lunch and a tour of the air museum at Kubinka, we were sent back to Moscow with encouragement and hopes that luck would treat us better the next day.

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[2]Our impromptu visit to TsAGI was interesting in its own right and featured access to several facilities which, we were told, no Americans had ever seen before. Among other things, we were taken into three operational wind tunnels, saw an advanced version of the MiG-31 undergoing stress and fatigue testing, and were shown a vacuum chamber in which a forward section of the Soviet space shuttle was being tested.

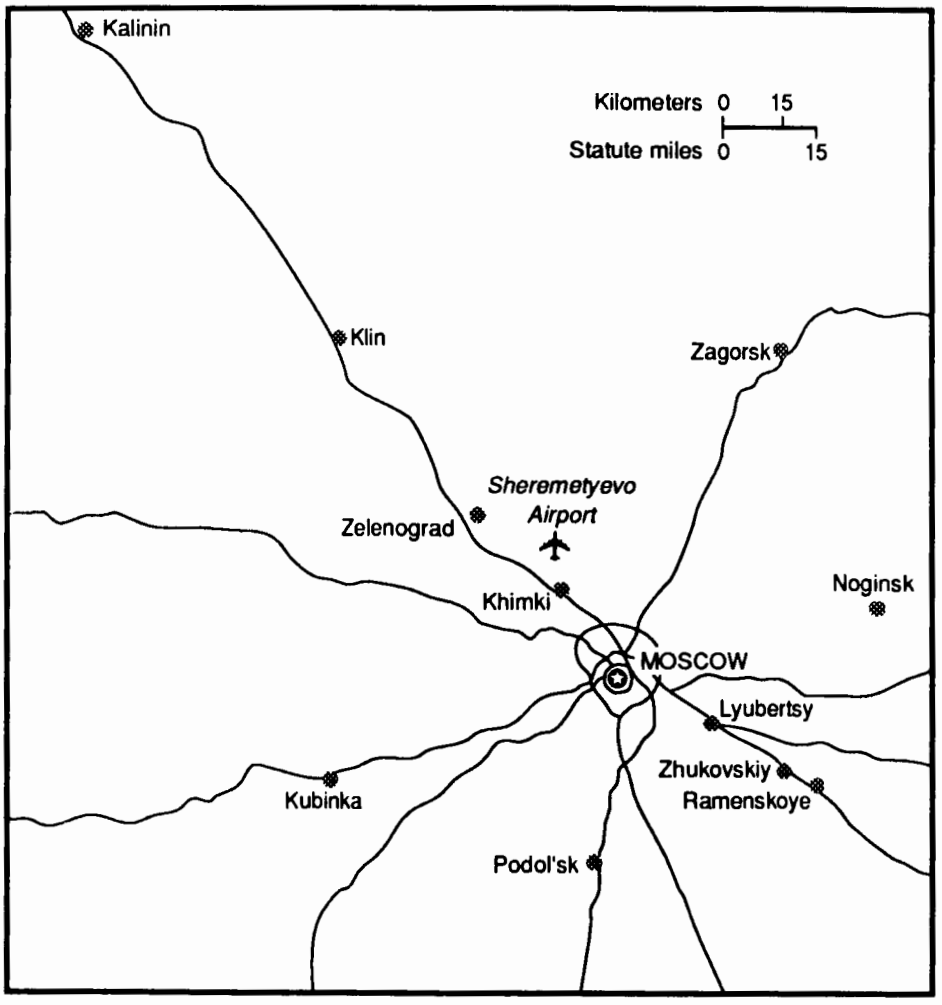

Fig. 6—Moscow and Environs

Fig. 7—(Left to right) John Hines; Author; Colonel Sokolov; Major General Shchitov; Konstantin Ushkintsev; and Unidentified Soviet Air Force Officer at Kubinka

FLIGHT PREPARATIONS

The morning of December 15 dawned with guarded promise under a high broken overcast. Our drive from Moscow back to Kubinka, however, took us into progressively deteriorating weather. The evening before, Menitskii had underscored his full determination to get us airborne this time if at all possible. As we approached the gate, it appeared that the field had adequate landing minimums, but no more.

Shortly before our arrival at Kubinka, Soviet Air Force personnel had replowed the parallel taxiway and cleared enough snow and ice from the approach end of the runway to ensure a safe landing for Menitskii and for my flight to follow afterward. Similar efforts, we were told, were being made at Ramenskoye, which otherwise was closed to flight test operations due to inclement weather. It was becoming increas-

ingly apparent to me that extraordinary efforts were being exerted by many people to bring this event off.

As we waited for the ceiling to lift sufficiently to allow Menitskii to launch out of Ramenskoye, Sokolov and Shchitov briefed me on some of the cockpit instrumentation and displays that I would be using. They touched on basic HUD symbology, navigational systems orientation, instrument landing system (ILS) operation, and the six aircraft flight control system modes of which, they said, we would be using at most only two or three. The select buttons for the six automatic flight control system modes are located on the lower left-hand corner of the main instrument panel. They are marked in Russian shorthand, respectively, *demp* ("damper"); *uvod* ("drift"); *stab vys* ("altitude hold"); *ap* ("autopilot"); *traek upr* ("flight path"); and *povt zakhod* ("missed approach"). The "damper" mode engages the aircraft's stability augmentation system and is analogous to the pitch, roll, and yaw damper switches on the CAS control panel in the F-15.[3]

The HUD symbols they sketched out for me appeared similar to those on the F-15 HUD, with airspeed and altitude readouts on the left and right sides of the combining glass, respectively, and attitude reference lines running up and down the center section. They also sketched what looked to me like a "center the dot" feature, which, as best I could tell from their fast-paced explanation in Russian, indicated on course for a selected steerpoint or on glideslope and centerline for an ILS approach, depending on which mode was selected. (See Fig. 8 for a possible representation of the navigation mode symbology displayed on the MiG-29's HUD. This sketch derives from the recollections of General Dynamics test pilot Kevin Dwyer, who flew an advanced simulator incorporating the MiG-29's general cockpit layout during a visit to the Research Institute of Aerospace Medicine in Moscow in May 1990.) Colonel Sokolov and General Shchitov further noted that, weather permitting, my flight would take place directly over the base, so that RSBN navigation would not be a factor.[4]

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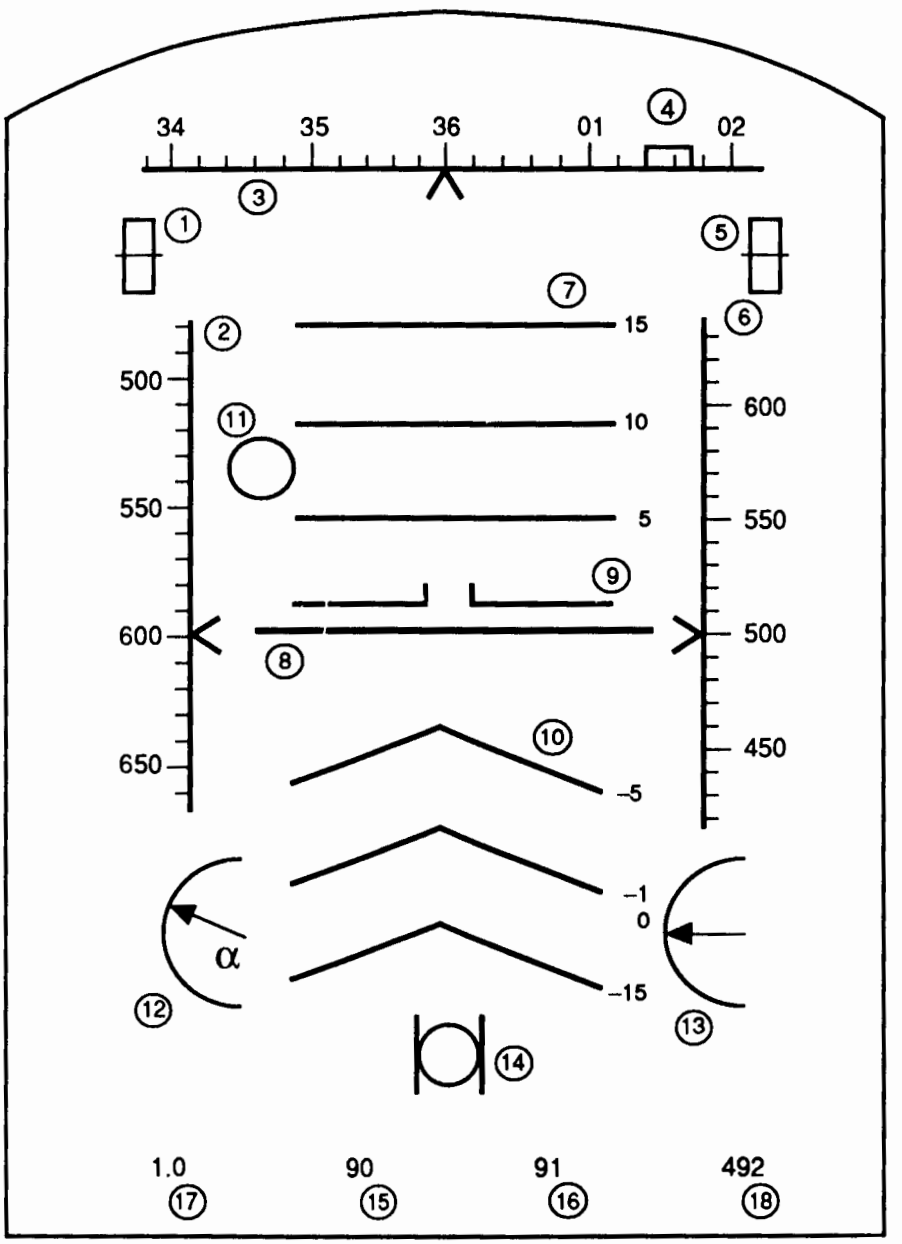
[3]According to one report, Mikoyan representatives at Farnborough in 1988 stated that the MiG-29's flight-control system includes an autoland capability down to a height of 50 ft. See John Fricker, "MiG Fulcrum: Pinnacle of the Last Generation?" *Air International*, December 1988, p. 289.

[4]RSBN is a Russian abbreviation for *radiotechnicheskaia sistema blizhnei navigatsii* (short-range beacon navigation system). According to one report, the system has a 200-mile range tolerance and a bearing accuracy comparable to the American tactical air navigation (TACAN) system. It also is said to feature an air-to-ground data link capability for passing aircraft bearing and distance to a ground air defense command post. See Jim Bussert, "Soviet Military Air Navigation, Part I: Fighter-Interceptors," *Jane's Defense Weekly*, November 7, 1987, p. 1049.



SOURCE: K. Dwyer, General Dynamics.

1. Acceleration/deceleration cue
2. Airspeed scale
3. Heading scale
4. Course to selected steerpoint
5. Ascent/descent cue
6. Altimeter scale
7. Pitch scale (positive)
8. Horizon line
9. Aircraft symbol
10. Pitch scale (negative)
11. Selected steerpoint marker
12. Angle of attack scale
13. Vertical velocity scale
14. Sideslip indicator
15. Engine rpm (left)
16. Engine rpm (right)
17. Load factor
18. Radar altitude

Fig. 8—Notional MiG-29 Navigation-Mode HUD Symbology

Shortly before noon, the command post received word that Menitskii was airborne and would be on the ground at Kubinka within fifteen minutes. I was invited at that time into the base commander's office to be outfitted with flight gear. Menitskii had advised me earlier not to bother bringing my own personal equipment, since the Soviet Air Force would provide me with everything I needed. I did, however, bring along my own USAF-issue Nomex flight gloves.[5]

I began with full long underwear, directly over which went the g-suit. In contrast to Western practice, Soviet pilots wear their g-suits underneath their flight suits rather than on the outside (see Fig. 9). I had seen pictures in Soviet aviation journals showing fighter pilots outfitted in this manner, and I had often wondered how they could be comfortable wearing that equipment around the squadron for hours at a stretch when there was no need to. The Soviet g-suit, however, is notably lighter and thinner than the standard USAF g-suit. The one I wore was constructed of nylon and zipped from the top down, just like my own. It fit me snugly but not uncomfortably and felt like just another layer of clothing once I had it on. I soon forgot that I was wearing it.

Next came heavy socks and a turtle-neck shirt, a set of Farmer John-type flight overalls, and a splendid pair of Soviet flight boots with full-length zippers on the inner sides. Atop that I wore a summer-weight flight jacket, a heavy, fur-collared winter jacket, and finally helmet, mask, and gloves. I did not ask whether the flight garments were made of flame-retardant material, but it was obviously quality-manufactured gear.

Considering its larger size compared with ours, the helmet was surprisingly light and comfortable. Shortly after the 1988 Farnborough Air Show, it had been reported that the helmet worn by the Mikoyan pilots was twice the weight of the standard USAF helmet.[6]

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[5]The oddness of suiting up in such an unlikely environment prompted a realization on my part of the controlled and circumscribed nature of my visit. All of my preflight discussions and preparations took place in the conference room and adjoining base commander's office in the headquarters building. There was a row of fighters parked on the ramp in front of several low buildings on the opposite side of the runway, but I was not taken there and never saw anything resembling an operational squadron setting. Nor did I meet any of the line fighter pilots assigned to the air garrison at Kubinka.

[6]See "Heavy, Cumbersome Helmet Could Hinder MiG-29 Pilot in Defensive Air Combat," *Aviation Week and Space Technology*, September 26, 1988, p. 49.

Fig. 9—Lightweight Soviet Cutaway G-Suit Being Donned by Author

This report appears to have been in error. The helmet I wore at Kubinka looked exactly like the helmet the Mikoyan pilots had worn at Farnborough, yet it was at least as light and comfortable as my own.

The helmet contained an internally mounted visor that could be raised and lowered with a single motion of the left hand. It also had an inner liner of some sort that provided a form fit once the technician made an adjustment on the back (see Fig. 10). The helmet was cut farther back on the top and sides than the standard U.S. helmet, which allowed for an unobstructed field of view all around. It also seemed to have a slightly different center of gravity from my own helmet. But there would have been no problem wearing it comfortably in a high-g maneuvering environment. I later learned that the visor is

Fig. 10—Soviet Air Force Officer Adjusting Author's Helmet

designed to lower itself automatically upon receipt of an electrical signal during initiation of the ejection sequence.[7]

The oxygen mask was similar to my own USAF-issue mask, although it was covered with a harder material and featured a felt liner where the mask contacted the face. This made for a snug but comfortable fit. The mask was fitted on either side with bayonet clips, which worked very much like those used on USAF equipment except for a feature that allowed the mask to hang at chest level from the first notch of each clip. I had difficulty disengaging the right clip so that the mask would lie off to one side, and I found it a bit bothersome to have the mask dangling in front of my face as I was working to get squared away in the cockpit.[8] I also wore a strap-on throat microphone. In contrast to the very sharp intercom and radio voice quality characteristic of most Western military aircraft I have flown, the equipment in the MiG-29 made for somewhat more muffled, but still clearly understandable, radio voice communications.[9]

At about the time I had finished suiting up, Menitskii landed, taxied off the runway, and parked on the parallel taxiway in front of the headquarters building where we were awaiting his arrival (see Fig. 11). A Yak-40 transport aircraft had followed him from Ramenskoye carrying essential ground-support equipment and personnel. This punctuated the fact that my flight was a civilian operation from beginning to end, with the Soviet Air Force essentially providing only a runway and ramp space. As well as I could gather, the Mikoyan Design Bureau even paid for the fuel consumed on my flight.

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[7]It has also been reported that the helmet was designed to be aerodynamically compatible with the headrest of the K-36 ejection seat so as to reduce aerodynamic interference between the two and thus increase the safety factor for the pilot in high-speed ejections. See Jeffrey M. Lenorovitz, "Soviet Ejection Seat for Buran Shuttle Qualified for Deployment at Up to Mach 4," *Aviation Week and Space Technology*, June 10, 1991, p. 44.

[8]One reason for this mounting arrangement, as well as for the throat microphone, may be to allow the pilot to fly with his mask unconnected within close reach. Interestingly, Major Bob Wade, who led the Canadian F-18 escort of the MiG-29s from Elmendorf AFB into Abbotsford in August 1989, reported that when he joined up on the Soviet aircraft at 37,000 ft, both pilots had their masks off and kept them off throughout a cruise climb to 43,000 ft. This indicates that the MiG-29 operates on a very different cockpit pressurization schedule from that of most Western fighters, which typically maintain only a 2.75 psi cabin pressure differential at high altitude.

[9]Following his MiG-29 flight at Abbotsford the previous August, Major Wade had complained about an excessively high cockpit noise level which interfered with ICS and VHF reception. I suspect that this may have simply reflected a poor helmet fit, which he also admitted. I experienced no such problem on my own flight and found the headset reception very distinct.

Fig. 11—Menitskii in MiG-29UB on Parallel Taxiway at Kubinka After Landing

The quiet authority which Menitskii exuded when he strode into the headquarters building both surprised and impressed me. I was well aware of his special standing in the Soviet fighter community owing to his status and equivalent rank of Major General as Mikoyan's chief test pilot. I was not prepared, however, for the instant deference and respect he appeared to command from all the Soviet Air Force officers who were on hand to assist with my flight. Although Menitskii was completely relaxed and unassuming in his demeanor, there was nevertheless a perceptible sense of the Red Sea parting when he arrived on the scene at Kubinka. It was quite something to behold, and if I interpreted it correctly, it spoke volumes about his professional stature in his own country.

One of the first things that caught my eye when Menitskii walked in out of the cold was his local area chart and some other flight-related publications (probably instrument approach plates and a pocket checklist for the MiG-29) which he had stuffed into his helmet (see Fig. 12). I had a fleeting urge to take a quick look at these, if only to contrast their format to that of their counterpart Western flight

Fig. 12—Menitskii on Arrival in Headquarters Building at Kubinka

publications. However, I had long beforehand decided not to ask any questions or make any requests, to Menitskii or anyone else associated with my flight, that might appear to be unseemly prying into matters that, in their view, I had no business knowing about. On reflection, I suspect that had I voiced an interest, Menitskii would have readily allowed me to examine this material. I did not ask him, however, and thus missed any such opportunity.[10]

Because the weather was threatening to put the airfield below landing minimums at any time, Menitskii was eager to get us airborne as soon as possible. As a result, our flight preparations were highly perfunctory. Menitskii literally briefed me on the back of an envelope, writing down some key words that he said I could expect to hear on the radio, along with some important airspeeds that I needed to remember (see Fig. 13). By this time, our ambitious flight plan had reduced to simply getting airborne and checking to see how much of what we had originally agreed upon would prove workable in light of the weather.

Menitskii next told me that because of the marginal weather, he would be occupying the forward cockpit. This naturally came as a major letdown, since I had spent four months preparing myself to fly a full profile from the front seat. That said, however, I could hardly fault Menitskii for his decision, considering that the MiG-29 was an unfamiliar aircraft to me and that I would be flying in unfamiliar airspace, with a foreign language to contend with and the added possibility of having to divert to an alternate airfield in case the ceiling at Kubinka went below landing minimums.

On top of that, we were preparing to launch into a thoroughly disagreeable weather environment in which to cope with any inflight emergency that might arise. With the solid overcast that extended in all directions, there would be no way to execute an overhead precautionary landing in case of trouble. In these circumstances, coupled with snow and ice on the runway, the front seat was clearly not the most advisable place for me to be. I had complete respect for the

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[10]Perhaps, on balance, it was better that I did not ask after all. I later read in a press interview with the head Soviet military mapmaker that military topographic maps with a scale of 1:1,000,000 (called a *millionka*) had been ordered declassified by the Defense Minister in 1986, but that maps in the scale of 1:500,000 and 1:200,000 (which would encompass a typical low-level navigation chart) were still in the gray area. See Major V. Zyuvin, interview with Major General A. I. Losev, Chief of the Topographic Service of the USSR Armed Forces, "Shall We Declassify the Maps?" *Krasnaia zvezda*, July 22, 1989.

Fig. 13—Menitskii and Colonel Sokolov Briefing Author on Flight Details, with Eugene Rumer Observing

pressure that Menitskii was under. There is also no doubt that I would have made the same decision had I been in his situation.[11]

My emergency procedures briefing was likewise conducted on the run. Menitskii simply told me how to arm and safe the seat, adding that if we had to get out in a hurry for any reason, the ejection handle was between my legs. The thought that we might actually experience a problem with the aircraft did not seem to concern him. This reflected powerfully on his confidence in the airplane and in himself. It also meant, however, that anything I wanted to know about emergency procedures I had to ask for specifically.

In that spirit, I asked Menitskii how I could eject him out of the front cockpit in case he took a bird strike through the windshield and became incapacitated. To this, he replied with a wave of dismissal: "Don't worry about it. The birds are walking today."[12] In our rush to get the flight airborne, I did not think to ask him also about emergency ground egress procedures. When I recalled this important item after we had landed, it occurred to me that had we experienced an engine fire during start or any other ground emergency that necessitated our abandoning the airplane quickly, I would have had an interesting time trying to undo all the various unfamiliar straps and lanyards that secured me to the seat.

The Mikoyan ground personnel had nearly finished preparing the aircraft when we arrived. The taxiway where the aircraft was parked was covered with hard-packed snow. The outside air temperature hovered at around 25 deg Farenheit, with light-to-variable winds and an increasingly heavy snowfall. Visibility had decreased to the point

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[11]In fact, as I told Menitskii later at dinner that evening, had it been my call, I probably would have suggested that we simply head for the bar and sit tight for a better weather day. Menitskii replied that he had flown the MiG-29 many times before with pilots who had never previously been in the airplane, but never in such unspeakable weather—to which his wife reacted in mock (or maybe real) horror: "Why do you tell me these things?" There is little question that Menitskii was pressing it as close as his professional judgment would allow. He also was clearly relieved to get the flight behind him. After we had landed and shut down, one of my RAND colleagues overheard him quietly exhale to one of the Mikoyan crew chiefs as he came down the boarding ladder: *"Slava bogu,"* or "thank God" nothing untoward had occurred during our high-profile flight. Reminiscing on this experience ten months later at the 1990 awards banquet of the Society of Experimental Test Pilots in Beverly Hills, Menitskii told me that the runway surface conditions at Kubinka that day had been at the outer limits for safe steering and braking.

[12]I had learned earlier from Major Wade that the MiG-29 has a sequenced ejection capability and that either ejection handle can fire the other seat, with the aft seat going first in either case. This left open, however, the question of how the command select function worked.

where the tree line across the runway was no longer discernible. The ceiling had also descended noticeably (Menitskii later indicated that it had gone as low as 300 ft, with a broken to solid high overcast topping out at around 30,000 ft).

It was eerily quiet, and I was surrounded by whiteness. I felt as though I could almost hear the snowflakes hitting the ground. As I stood alone with my thoughts for a moment while Menitskii conferred with his crew chief, I had a fleeting recollection of one of the winter scenes from *Dr. Zhivago*. Never before had I flown in anything like this kind of weather.

While the maintenance crews were closing up access panels and attending to their last remaining preflight items, I conducted a brief walkaround of the MiG-29UB, trying to note the things one would typically inspect during an F-15 preflight, but mainly just taking advantage of the few extra minutes to get a more studied look at the jet I was about to fly. In close trail behind me was a congenial Soviet Air Force major. He was interested in whatever I was interested in and followed me all the way around the airplane. Somewhat to my surprise, Menitskii did not conduct any preflight inspection of his own that I was aware of. Nor did he consult and initial any maintenance records, either before or after our flight. All in all, it was about the most casual workup to a fighter sortie I have ever experienced.

I did note several minor apparent oddities during my walkaround. For one thing, the aircraft did not have an anticollision light. It also had slick tires, which may have been a design feature to help prevent the slinging of rocks and dirt against the aircraft during takeoff. Finally, the aircraft did not have a tailhook. This prompted me to wonder how the pilot would keep the aircraft from running off the end of the runway in case of a high-speed abort during takeoff, or during a landing with a brake failure. Since the brakes operate on compressed air, a utility hydraulic system failure would not cause a loss of brakes. But an accumulator failure presumably would. Perhaps the Soviet Air Force uses a barrier that can be erected at the end of the runway to accommodate such a situation.[13] Whatever, there was no way I could tell that the aircraft could take a cable arrestment.

By the time I climbed up the ladder to strap in, I had serious doubts as to whether this flight was ever going to get airborne. Blowing

[13]Reference was made to such an "emergency arresting barricade net" at Soviet military airfields in an article on flight safety by Major V. Parkhomenko, "This Is What Flying Means to Me," *Aviatsiia i kosmonavtika*, No. 11, November 1989, p. 11.

snow was now driving hard into the cockpit and piling up in my lap. In general, the weather was as unconducive to flying as any I could remember (see Fig. 14).

The K-36 ejection seat sits at an angle of some 10 deg and is not reclined to offer extra g-tolerance, as is the seat in the F-16. I noticed upon entering the cockpit that the ejection handle was made of bright red polyurethane and seemed considerably smaller and less cumbersome than the orange-colored rubber handle that I had recalled seeing earlier in published photographs of the MiG-29's cockpit (see Fig. 15). I later read in the monthly magazine of the Soviet Air Force that this retrofit had been decided upon for the K-36 seat not long beforehand as a mandatory modification to be installed in each aircraft during scheduled depot maintenance. This modification was prompted for safety reasons because of a problem with the rubber grips occasionally splitting at the base of the ejection handle as a result of repeated bending loads placed on the handle by pilots and mainte-

Fig. 14—Final Preparations of MiG-29UB for Flight

Fig. 15—Early-Model K-36 Ejection Handles in a MiG-29 Single-Seater

nance technicians routinely bumping against it in the course of moving about in the cockpit.[14]

The seat is equipped with an integrated harness. The strap-in procedure was much like that for the Martin-Baker seat in the F-18, except that the harness was bulkier and came together at a chest connector rather than on a lap belt (see Fig. 16). The K-36 seat does not feature leg restraining garters, but instead is equipped with steel cables which run around the rudder wells and retract upon ejection to snug the legs against the seat to prevent flailing. Aside from its simplicity, this arrangement has the added virtue of reducing the time

Fig. 16—Author after Strapping In. Holes in Helmet Help Ensure Helmet Retention During High-Speed Ejection

[14]The article added that the modification was eventually imposed because of the "cavalier attitude" which some Air Force personnel had displayed toward the problem of cracks in the rubber ejection handle. "In violation of all regulations," it noted reproachfully, "attempts are made to repair the rubber grips by wrapping them with duct and electrical tape so as to 'make it through' to the next scheduled maintenance." Lieutenant Colonel V. Vasiliev, "Making It Through to... Repairs," *Aviatsiia i kosmonavtika*, October 1989, p. 46.

that would otherwise be required for the pilot to strap in during an alert scramble.

The MiG-29's egress system is extremely fast-reacting, as was dramatically shown during Anatoly Kvochur's low-altitude ejection at the Paris Air Show in June 1989 when his aircraft experienced a catastrophic failure of the right engine during a high-AOA flyby, most likely as the result of a surge or some sort of foreign-object ingestion. At his low airspeed (below single-engine Vmc), Kvochur did not have sufficient rudder authority, even with a full pedal deflection, to offset the uncommanded rolling moment caused by the resultant asymmetric thrust. He also lacked sufficient altitude to deselect afterburner on the good engine, dump the nose, and fly out of the maneuver for a single-engine recovery.

As Kvochur later recalled, once he was confident that his airplane would not veer into the observing crowd, he pulled the ejection handle with his left hand at the last instant. He cleared the cockpit at 270 ft above ground level (AGL) in an 80-deg inverted dive and hit the ground two seconds later only 90 ft from the fireball with a barely inflated parachute at a sink rate of over 30 ft/sec.[15]

Sometime later, I heard that a Martin-Baker representative had watched the entire ejection sequence and had remarked at the time that he knew of no seat in the West that would have saved a pilot in similar circumstances. Having watched a video replay of Kvochur's ejection sequence myself many times, I was totally persuaded of the capabilities of the K-36 seat, even though my briefing on it before we walked to the airplane had been rudimentary.[16]

The seat height-adjust motor operated on DC power. External power was already connected to the aircraft, so I brought the seat to the fully-up position as soon as I had finished strapping in. A press-to-test button on the right-hand side wall illuminated the integrated caution and warning panel and other indicator lights in the cockpit.

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[15]For further details, see A. Gorokhov, "When Seconds Count... About the Accident at Le Bourget," *Pravda*, June 30, 1989. See also V. Belikov, "Le Bourget Air Show: The Pilot Was Not at Fault in the Accident," *Izvestiia*, June 11, 1989; N. Dombrovskii, "One Fleeting MiG Moment: A Black Box Epilogue to the Accident at Le Bourget," *Sovetskaia Rossiya*, June 14, 1989; and Colonel A. Andriushkov, "Cause—Engine Compressor Stall," *Krasnaia zvezda*, June 18, 1989.

[16]According to manufacturer's information provided at the 1989 Paris Air Show, the K-36 is standard to all currently produced Soviet fighters, as well as to the Tu-160 bomber, and has a safe operating envelope of from zero to 82,000 ft and zero to 800-plus kts. See "Soviet K-36 Ejection Seat Has Wide Operating Range," *Aviation Week and Space Technology*, June 19, 1989, p. 34.

The system included a red master caution light at the top of the instrument panel, red fire and overheat lights atop the annunciator panel, and a bank of assorted green and yellow advisory lights arrayed below them. Since this was an export demonstrator aircraft, some of the cockpit switch and control placards bore English markings. All of the caution and warning lights, as well as the instruments and most other controls, were marked in Russian.

The cockpit felt quite roomy despite the bulky winter flying gear I was wearing. It seemed about like sitting in an F-5 in terms of elbow room and all-around field of view out of the cockpit. The layout of the instrument panel was reminiscent of USAF F-105/F-4 vintage design, with mainly round analog dials and some vertical readouts on the lower right-hand side to indicate oxygen flow and quantity, hydraulic and pneumatic pressure, and inlet ramp position (see Plate 1 at the end of the report for schematic drawings of the main instrument panel and cockpit side consoles).

G-suit, oxygen, and communications leads were all on the left side, with what appeared to be a regulator at the connect point and a small two-position lever on the left console for normal or 100 percent oxygen. I was surprised to note that the instrument panel lacked either a fuel-flow gauge or afterburner nozzle-position indicators. Also, the threat warning display was almost buried behind my right knee. This struck me as an odd location for such a vital piece of mission-related equipment.

Both the instrument panel and the control stick were noticeably higher than what I was accustomed to from my experience in Western fighters. The stick grip, in particular, was mounted several inches farther up than in the F-15 or F-18 (see Fig. 17). It had an electric trim switch in the center for roll and pitch trim. There was also a button on either side, the left one to disengage the autopilot and the right one to return the aircraft automatically to level flight in case the pilot became disoriented. As I was getting accustomed to the cockpit layout, it occurred to me that the taller stick might make it a bit hard, even with the seat raised to the fully-up position, to fly relaxed close formation using a technique I had once been taught by anchoring my right forearm to my leg and making small corrections with wrist action.[17] Nevertheless, I

[17]On the subject of formation technique, I had noted earlier while watching a videotape from an escorting F-15 of Roman Taskayev flying wing on Anatoly Kvochur during their initial approach into Elmendorf that only the right-hand nozzles on Taskayev's aircraft were moving. This indicates that he was maintaining position using single-throttle movements only.

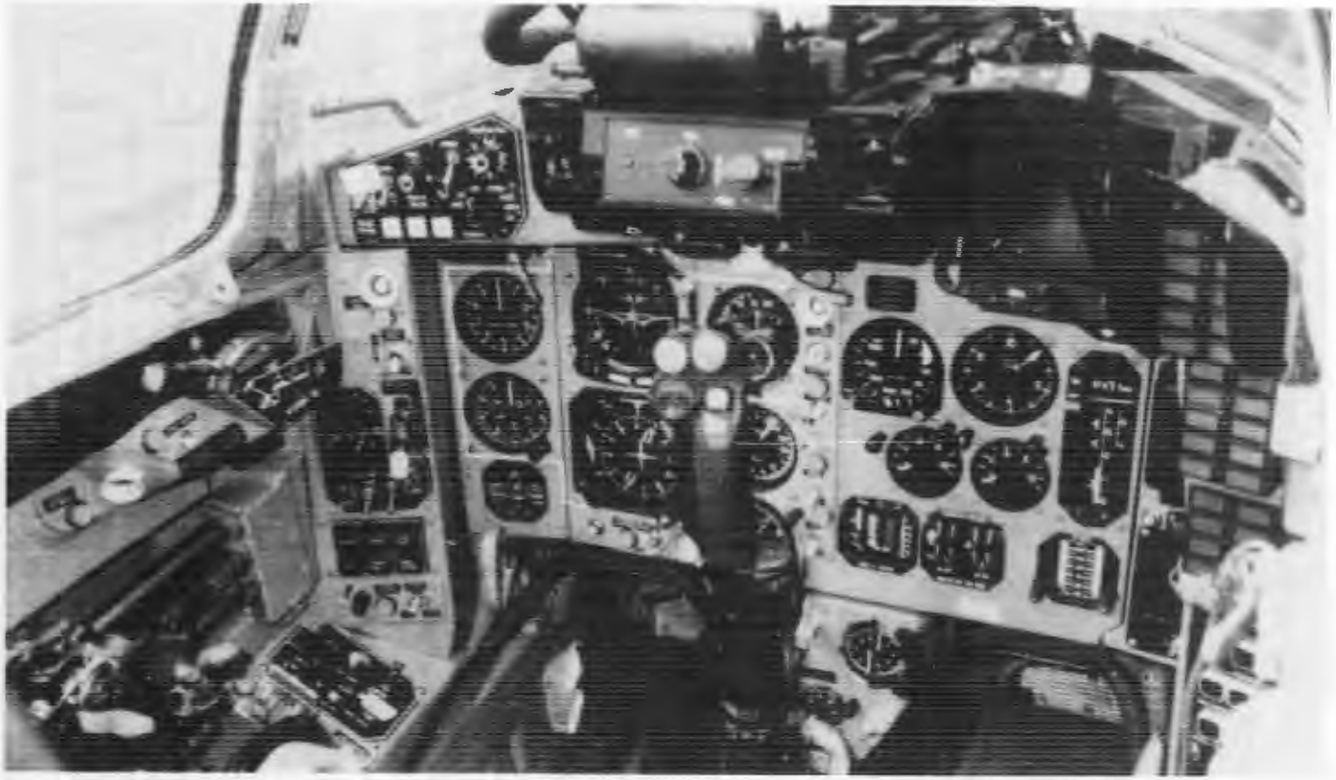

Fig. 17—MiG-29 Instrument Panel and Control Stick

quickly began to sense that with a couple of sorties, this would be a very easy and enjoyable airplane to fly.

The throttles moved forward and aft along horizontal bars mounted against the left-hand side wall, with about five inches of travel in the military power range and another two inches in afterburner. The throttles have buttons to move them out of the cutoff detent into idle (called *stop* and *malygaz* in Russian, respectively) and fingerlifts to advance them from military power (*maksimal'no*) into the afterburner range (called *forsazh*). Located on the inboard throttle were a speedbrake switch and a push-to-talk button for the intercockpit communication system (ICS).[18] The aircraft did not have a hot microphone capability. Throttle friction was controlled by a crank just aft of the throttles in the front cockpit. The VHF radio control panel on the left console appeared to be limited to ground preset channels only.[19] The brake system utilizes accumulated compressed air and is engaged by a hand lever mounted on the control column. The brakes emitted an audible hiss as Menitskii checked them.

When I had sat in this same aircraft at the Paris Air Show the previous June, I had noted what looked like a radar display screen on the upper right-hand corner of the instrument panel in the forward cockpit. Since the trainer version of the MiG-29 is equipped only with a rangefinder radar, in contrast to the single-seat version with the full air-intercept radar capability, this screen may simply have served as a HUD repeater or a backup infrared search and track (IRST) display. Whatever the case, since it was a part of the aircraft's mission employment equipment, I did not break my personal protocol rules and ask about it. The rear cockpit had no radar display. In its place was an alphanumeric key pad with a small digital annunciator

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[18]I never extended the speed brake during my flight. Major Wade did, however, to kill off some excess airspeed as he rolled into his final approach at Abbotsford. He recalled that this produced no apparent pitch trim change, but also no noticeable effect in reducing his airspeed.

[19]British test pilot John Farley reported an experience during the pre-taxi checks for his flight with Menitskii at Farnborough that would seem to confirm this: "At my request, the rear-cockpit radio controller had been programmed to the complete list of frequencies for the ATC agencies we would need to work. The first one I tried gave the tower, not ground. My thumbs down to the crew rapidly produced an interpreter, followed equally quickly by a screwdriver being applied to a single fastener just ahead of the controller. This done, it came out in one movement. I held up my pad of frequencies to the mechanic, and two grunts and a couple of clicks later it was replaced, relocked and the mechanic and his ladder were gone." "Supreme Soviet," *Flight International*, October 10–16, 1990, p. 37. On a related point, German Air Force and industry personnel who have tested the MiG-29 at Manching and elsewhere have noted that steerpoints for the inertial navigation system (INS) can only be loaded into the aircraft on the ground from outside the cockpit.

below it. I assumed that this was a control panel for the inertial navigation system.

As soon as Menitskii had finished strapping in, he brought the canopy down to the partially closed position. I then heard what sounded like a terminal flight service information report. The weather was looking increasingly ragged. A short conversation then ensued between Menitskii and the command post. My Russian was good enough to tell me that we were definitely not going flying. Sure enough, the canopy came back up and a Mikoyan technician repositioned the boarding ladder and helped unstrap me.

At this point we faced some hard choices. It was after midday, with a rapidly dwindling amount of daylight remaining. One option was to try again the next day. I could sense that Menitskii was not enthusiastic about the idea of leaving the company aircraft at Kubinka overnight. A second option was for me to postpone my departure from Moscow until the weather broke, at which time I could fly from the front cockpit on a clear day as we had originally planned. Aside from deferring indefinitely my return to Los Angeles, which was scheduled for the next day, that would have meant additional burdens on Menitskii's and the Mikoyan Design Bureau's time in a situation in which they had already gone to exceptional lengths to get this flight airborne.

I decided at that moment, and so told Menitskii, that my primary purpose in being there was to fly the MiG-29 regardless of which cockpit I was in or what we did; that I felt I had used up enough of his and his firm's graciousness and hospitality already; and that if the weather eased sufficiently for us to launch that day, we should take whatever we got.

At that, we repaired to the aircrew dining hall for a luncheon hosted by Major General Shchitov and Colonel Sokolov, while Menitskii stage-managed a nonstop sequence of phone calls and weather updates to weigh options and possible alternate airfields. Two that were openly mentioned were Klin and Kalinin, both situated along a northwesterly line away from Moscow (see Fig. 6) where better weather was expected. Since I kept myself at a polite distance from this deliberation, it was never entirely clear to me whether the issue at hand was using these bases as divert options in case Kubinka's weather went below minimums, or as alternate airfields from which Menitskii could show me more of what he had hoped out of the MiG-29. Because it was getting late in the day, I suspect that it was the former. In any case, I overheard a fair amount of talk about climb schedules and idle descent profiles to maximize fuel economy.

Interestingly, there seemed to be no concern expressed about whether I, as an American national, was authorized to land at either of those operational bases.

Within an hour, the ceiling had lifted to the point where Menitskii was ready to give it another try. We gathered up our gear and proceeded back to the aircraft. The Mikoyan technicians had just cleared it of fresh snow as we arrived, and without delay we strapped in again for a second attempt.

With external power back on and the canopy again down to the cracked position, Menitskii and I did a quick ICS check. We then got the local flight service information, had a terse exchange with the command post, and began the engine start sequence as Menitskii brought the canopy fully closed. Our call sign for the flight was 817.[20]

The engines in the MiG-29 can be started only from the forward cockpit. As Major Wade (who had flown the aircraft from the front seat) described the procedure, a button on each throttle had to be pressed to move the throttles out of the cutoff position and into idle, after which a three-position start consent switch located on the right-hand console was selected to the "both" position for an automatic start (see Fig. 18). Then, with both throttles in idle and the battery selected on, a switch was actuated to fire the engine start accumulator. The right engine turned first with a loud rush of compressed air. This was followed immediately by commencement of the left engine start sequence (most likely using cross-bleed air from the right engine) once the right engine had stabilized in idle at around 70 percent rpm.

The fan turbine inlet temperature (FTIT) gauges showed no movement in the rear cockpit, even though we had a steady rpm rise and it was obvious that we had accomplished a good lightoff on both engines. When I informed Menitskii of this, he replied that he was getting a good indication up front.[21] Major Wade later recounted to me that the FTIT had peaked at about 750 deg C on each engine during start and then stabilized at around 450 deg C at flight idle.[22] He also recalled an oil pressure rise at about 10 percent and an engine temperature rise at 25–30 percent rpm. The attitude indicator did not require caging and appeared to operate on AC power, since I seem to

[20]Since the tail number for Mikoyan's MiG-29UB demonstrator was 304, I assume that this call sign was either Menitskii's pilot number or else a mission number assigned to our flight by the Soviet Air Force.

[21]John Farley ("Supreme Soviet," p. 36) likewise noted when he flew the airplane at Farnborough the following September that both the engine temperature and fuel quantity gauges in the rear cockpit were either inoperative or disabled.

[22]Each FTIT gauge has a yellow caution line marked at 750 deg C.

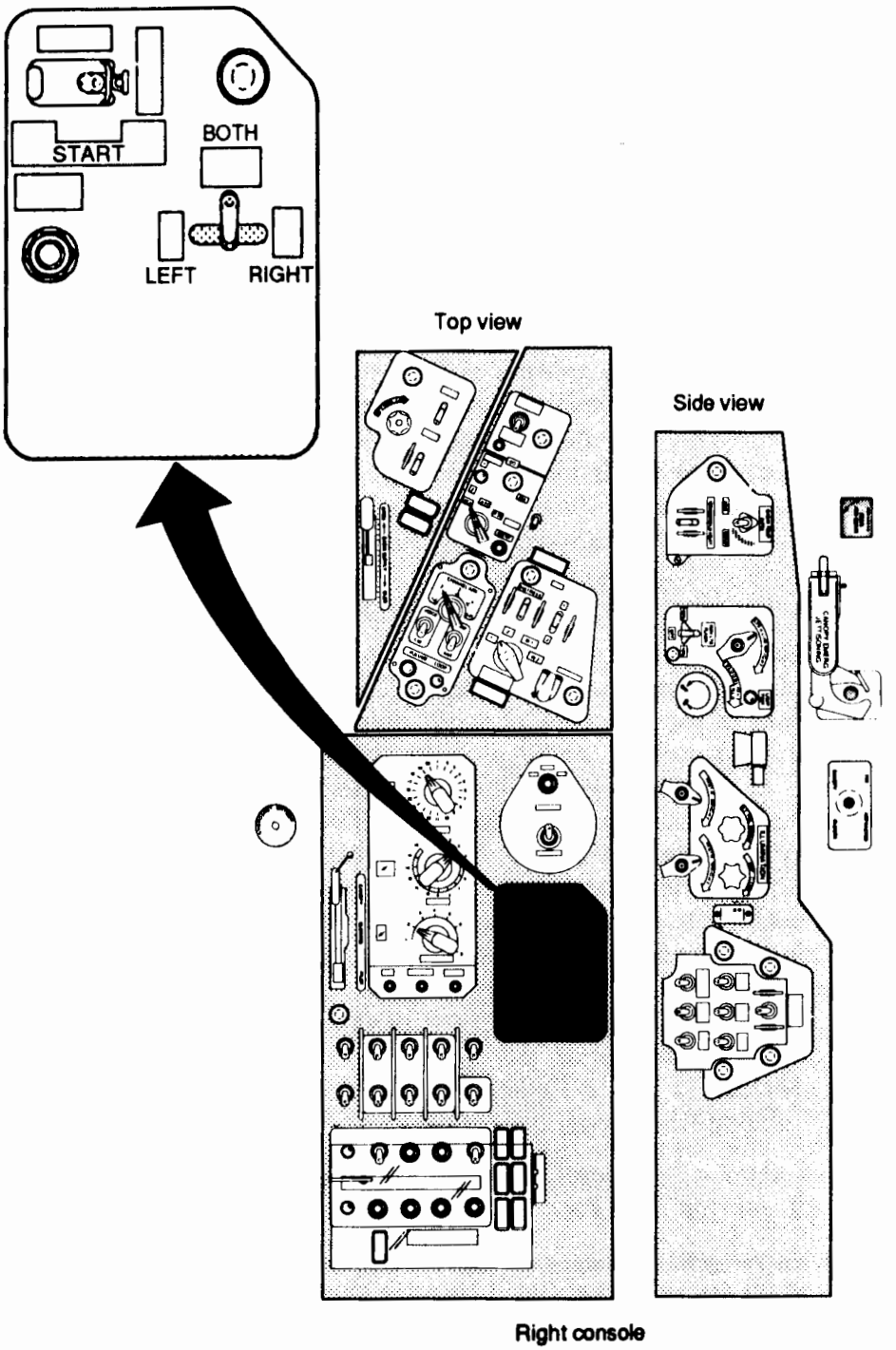

Fig. 18—MiG-29 Engine Start Panel (forward cockpit only)

recall that it erected itself as soon as the right-hand generator came on the line. This suggested that it was not tied in with the inertial navigation system.

TAXI, TAKEOFF, AND CLIMBOUT

Both engines attained idle rpm within less than a minute after the start sequence began. Once the generators came on the line, the inlet foreign-object damage (FOD) prevention doors cycled shut and the auxiliary air louvers on each wing root leading-edge extension opened (see App. A for an explanation of this system). We got taxi clearance and rolled out of the chocks no more than four minutes after the start sequence began. My first thought was either that Menitskii had entered a stored heading into the INS prior to shutting down upon his arrival at Kubinka or that the aircraft had a very fast-aligning inertial platform. I later recalled that external power had been connected to the aircraft while the maintenance technicians were preparing it to fly. Most likely they were prealigning the INS at that time.

Once the canopy was down, a periscope mounted atop the canopy center frame popped open and a small rectangular mirror extended downward to permit a view of the taxiway and runway over the nose from the aft cockpit (see Fig. 1, in the Preface). The image was focused at infinity, with the horizon in the mirror precisely aligned with the true horizon. This gave the effect of looking through the ejection seat headrest in the front cockpit. Use of the periscope is optional, and it must have been preselected for me by Menitskii, since I did nothing to open it.[23] The periscope closes automatically upon gear retraction and reopens when the gear is selected down. Its main purpose seemed to be to help an instructor correct a student's landing technique on final approach or, perhaps more likely, to help him see and avoid obstructions on the runway and taxiway. This feature is also provided in the two-seat variants of the MiG-21, MiG-23, and Su-15, among other Soviet fighters.[24]

It took about a 5–10 percent increment of thrust above idle to get the aircraft moving (see Fig. 19). Menitskii taxied down the parallel

[23]John Farley later informed me that the periscope is engageable by means of a switch in the rear cockpit and that it cannot be controlled from the forward cockpit (personal letter, April 21, 1991).

[24]This appears to be almost a unique Soviet design feature. The only other jet aircraft I know of with a periscope in the rear cockpit are the Swedish Viggen and the French Fouga Magister, both of which feature very poor over-the-nose visibility from the back seat.

Fig. 19—MiG-29UB Taxiing for Takeoff

taxiway to the departure end of Runway 04, then taxied the full length of Runway 04 before executing a 180-deg turn at the end for a planned takeoff on Runway 22. Final external inspection of the aircraft must have been accomplished by the Mikoyan technicians before we left the parking area, since we did not receive a last-minute check in the hold-short area of the runway, as is normal USAF practice.

During the taxi out for takeoff, I spent a minute or so trying to decipher the vertical fuel-quantity indicator. It featured several pointers whose function was not clear to me, although the left-hand scale appeared to be a totalizer which topped out at 4000 kg (see Fig. 20). After a few moments of this, I abandoned the effort and later found myself, like any concerned back-seater, periodically asking Menitskii about our fuel state while we were airborne. Invariably, like any self-respecting pilot, he would laconically answer: *"Normal'no."*

Except for a small strip of concrete at the approach end which had been cleared to some 50 ft on either side of the centerline, the runway

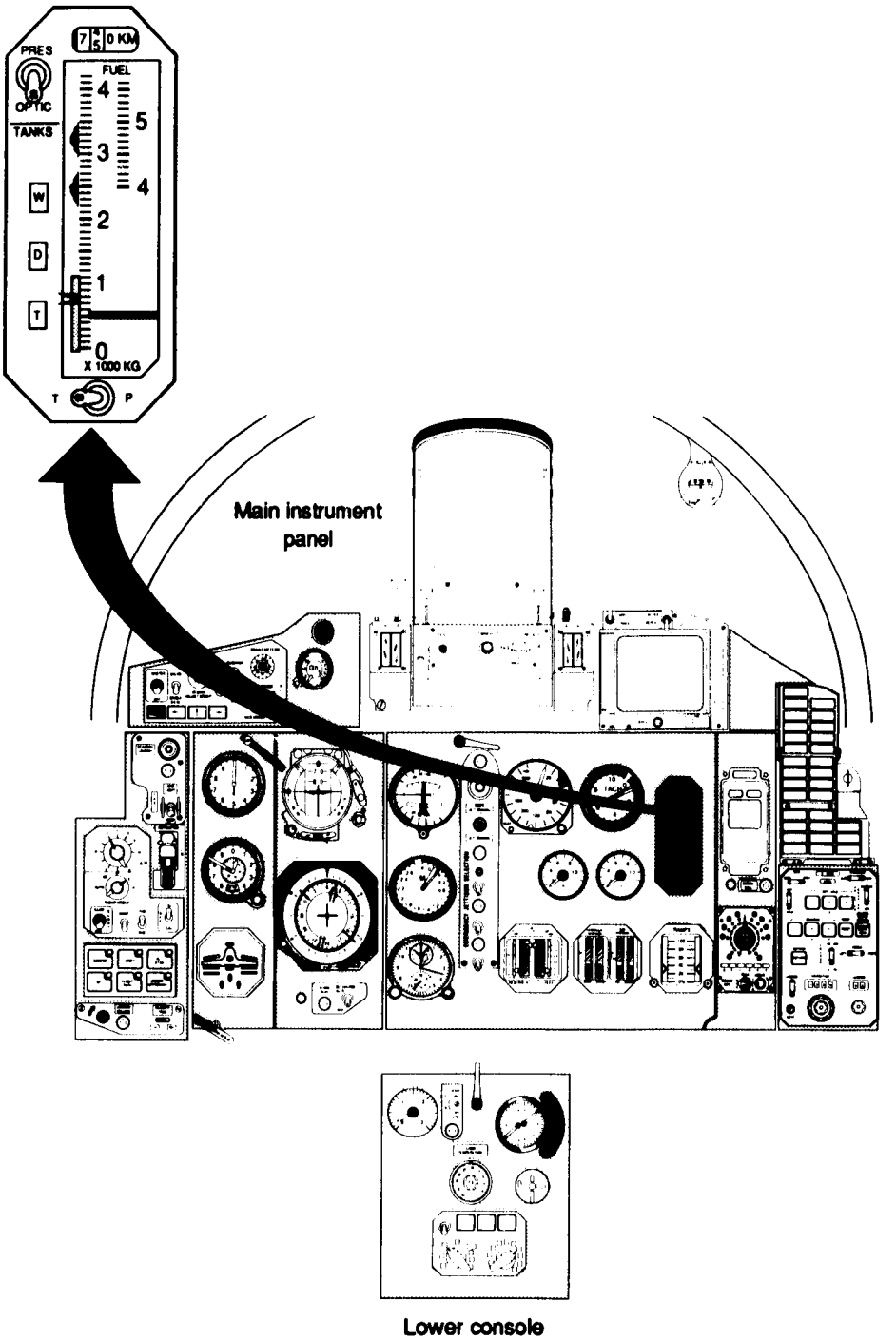

Fig. 20—MiG-29 Fuel Quantity Gauge

and taxiway were covered with packed snow and ice. Menitskii held the brakes and advanced the power briskly, causing the nosewheel oleo strut to compress noticeably from the added thrust. I do not recall whether the rpm on both engines was at 100 percent during the engine checks. (Major Wade said that when he flew, Menitskii ran the throttles up to 80 percent. When I later watched Menitskii fly an American newspaper reporter at the Dayton Air Show in July 1990, he appeared to check each engine separately at 100 percent and then run them both up to 100 percent prior to brake release.) In all events, the engine response was extremely impressive, with the rpm spool-up almost as fast as the rate of throttle advance. With the brakes held, there was no tendency for the aircraft to creep forward on the runway.

Most likely because of the poor weather and Menitskii's desire to save fuel for the possible need to divert to an alternate airfield, we made a non-afterburner takeoff. During our taxi to the end of the runway, Menitskii had said to me over the ICS: *"My sdelayem vzlyot vmestye"* ("We'll do the takeoff together"). I could tell that he was mindful of the poor runway conditions, and I assumed that I could expect to feel him leading me on the flight controls throughout. After a quick scan of the engine gauges, Menitskii released the brakes and I came on the controls as briefed. As far as I could tell, I performed the takeoff sequence by myself. I have no doubt that Menitskii was very close to the controls with me throughout the takeoff roll. But if he made any control inputs, I could not detect them.

The aircraft is equipped with nosewheel steering, which had been selected by Menitskii to a low-gain mode.[25] I seem to recall that it took considerable rudder pedal movement to keep the nose centered during the first few seconds of takeoff roll, although this may have simply reflected overcontrolling on my part rather than any intrinsic characteristic of the airplane. The aircraft accelerated rapidly in military power and the rudders became effective almost immediately. As briefed, I brought the stick back at 200 km/hr (108 kts) indicated and rotated the aircraft to a takeoff attitude. It took a noticeable tug on the stick to bring the nose up. The aircraft flew itself off the ground at around 230 km/hr (124 kts) indicated.

At that instant I ceased thinking "MiG-29" and simply told myself that I was flying a generic fighter, with selected briefed airspeeds and

[25]A nosewheel steering button on the throttle gives a low-gain option of 8 deg to either side of center when momentarily depressed, and a high-gain option of 30 deg when held down.

other flight parameters to monitor. Earlier, with a little help from some test-pilot friends, I had built myself a short list of data points that I had planned to try to look for and remember. During the takeoff roll, however, I put all that aside in favor of just concentrating on flying well and enjoying this sortie for which I had worked and planned so hard. I decided that I would simply focus on showing Menitskii my best technique and try to note any distinctive handling features of the MiG-29 as they caught my attention.

As the aircraft accelerated in a gradual climb, Menitskii selected gear and flaps up. The maximum flap extension speed is 350 km/hr (189 kts). The maximum gear-down speed is 500 km/hr (270 kts). We were at or beyond that as we approached the end of the runway. Menitskii called for a right turn out of traffic, which I executed, noting as I looked back that we were pulling a slight smoke trail (see Fig. 21).

I had barely rolled wings level on a northeasterly heading when we entered solid overcast at about 600 ft AGL. At that point I heard

Fig. 21—Nonafterburner Takeoff of MiG-29UB, with Engines Producing a Definite Smoke Trail

Menitskii talking to someone over the VHF who I assumed was a Moscow-area military controller. I could feel him overriding me on the flight controls from time to time, most likely to stay on his desired heading, as I continued an en route climb on instruments.

Although my Russian was more than adequate for routine social communication, I really began to feel the effects of the language barrier at this point, even though I had made a determined effort for weeks beforehand to master basic fighter operations terminology. For that reason, I did not maintain the same running banter with Menitskii over the ICS that would have been normal had the language factor not been a problem. Instead, I had to be very deliberate in whatever I asked, although Menitskii always understood me and I likewise understood his replies.

The horizontal situation indicator (HSI) in the MiG-29 is similar to the standard USAF HSI, with an analog distance-measuring equipment (DME) readout in kilometers in the upper left-hand window and an RSBN needle inside the compass card to indicate the heading to the selected station. It felt reassuring to have this, since we were either in or between heavy cloud layers for nearly all of the flight. As it turned out, however, we never ventured more than about 15 nautical miles from Kubinka during the entire sortie.

The rear cockpit also featured an American-style altimeter which indicated in feet. This had been installed in the company aircraft so that the pilot could comply with air route traffic control directives during IFR transit through international airspace to and from the various air shows abroad where the MiG-29s had performed. I found little problem in orienting myself to unfamiliar airspeed indications in kilometers per hour, since I needed only fly the numbers I had been given by Menitskii and observe the appropriate restrictions and minimums. I found it comforting, however, to have a "real" altimeter that read in feet. Particularly when one is in a nose-low attitude close to the ground, such as in a split-S recovery. it helps to know instantaneously just how much altitude one has left without going through the mental exercise of converting meters to feet. Because of that, I found myself referring mostly to that altimeter throughout the flight.

THE FLIGHT PROFILE

We broke out at around 4500 ft mean sea level (MSL) and found ourselves in visual meterological conditions (VMC) between heavy cloud decks, with no blue sky and no horizon reference to speak of. I noticed a lighter area off the left wing and suggested to Menitskii that we might work to the north in search of a hole or partial clearing.

It quickly became apparent that we were not going to find any better flight conditions. At that point, Menitskii indicated that we should press ahead and make the best of what we had. The maneuver sequence we flew consisted of these events: (1) three low-speed loops, one flown by Menitskii and two by me; (2) a split-S performed by Menitskii and then a second one by me; (3) four consecutive high-rate aileron rolls by me, followed by three maximum-rate aileron rolls and 10 sec of inverted flight by Menitskii; (4) an unloaded roll by me; (5) two hammerhead turns, with Menitskii first demonstrating and me then repeating; and (6) a hard level turn at 7.5 g by me. This aerobatic routine came nowhere close to extracting the maximum performance out of the airplane, but it was evidently the best that the prevailing weather, in Menitskii's judgment, would allow. The maneuver sequence did, however, provide me with a good appreciation of the low-speed stability and control characteristics of the MiG-29.[26]

Once Menitskii completed the first loop, I resumed control of the aircraft and got us established wings level at 6000 ft MSL for the next one. With the throttles advancing to military power and the airspeed accelerating through 550 km/hr (297 kts), I initiated an easy 4-g pull and immediately began looking for a horizon reference.[27] The effect was like flying inside a milk bottle. In the absence of a distinct horizon and with no ground reference other than the barely discernible

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[26]Throughout this section and in portions of App. A, I frequently make reference to three terms that call for a brief explanation here. "Performance" concerns such things as lift, thrust, drag, and related considerations that bear on how high and fast, how far, and with what payload an aircraft can fly. "Stability" and "control" typically refer to the flying qualities of an aircraft in the longitudinal, lateral, and directional axes. These qualities govern the pilot's ability to maneuver the aircraft and the relative ease with which he can carry out various maneuvers. For more on this, see the very good introductory chapters entitled "Airplane Performance" and "Stability and Control" in H. H. Hurt, Jr., *Aerodynamics for Naval Aviators*, Washington, D.C., Aviation Training Division, Office of the Chief of Naval Operations, NAVAIR 00–80T-80, 1960 (revised January 1965), pp. 95–200 and 243–324, respectively.

[27]Some of the airspeeds noted for the various maneuvers I performed are only approximations based on my best recollection of the angle at which the indicator needle was pointed when I glanced at the gauge. I am confident, however, that they are accurate to plus or minus 50 km/hr (27 kts) or less.

cloud tops below, I brought my eyes back into the cockpit to cross-check the attitude director indicator (ADI).

Although I had been advised about it beforehand, I nevertheless found the attitude reference system in the MiG-29 to be unlike anything I had ever seen before, with a drum that rotated in the vertical plane to indicate pitch attitude and a separate airplane symbol superimposed on top, which rotated through 360 deg of arc to indicate bank angle (see Fig. 22). One had to combine those two inputs mentally to get a complete picture of the airplane's attitude, and I found that a bit confusing at first.[28]

It also seemed to me that considerable rudder input was needed to hold the nose in a constant plane as I maneuvered the aircraft past the vertical. I could feel Menitskii continuously adding rudder corrections as the airspeed bled off coming over the top. As we approached the halfway point, I looked back outside and rolled wings level to the nearest horizon, which was a ragged ceiling at around 12,000 ft. We came over the top inverted at around 200 km/hr (108 KCS) and completed the loop sequence, with no apparent tendency of the aircraft to fall out of the maneuver even at that slow an airspeed. I applied more back stick during the bottom half of the recovery than Menitskii thought was necessary, but the aircraft never exceeded 4–5 g and I experienced no sensation of buffet at any point throughout the maneuver.

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[28]During a visit to the Research Institute of Aerospace Medicine in Moscow in May 1990, Kevin Dwyer of General Dynamics had a chance to fly a simulator for what was described as an "advanced cockpit design" aircraft. He reported that it was basically a MiG-29 cockpit with conventional flight instruments in the center and two cathode-ray-tube displays. His account of the simulator's ADI operation was reminiscent of my own experience in the MiG-29: "The horizon line on the simulator display was airplane-stabilized, not earth-stabilized (as in Western displays). The aircraft symbol relationship to the horizon line is the same as in our aircraft, i.e., a 30-deg right bank places the right wing 30 deg below the displayed horizon. However, the different horizon stabilization means that the aircraft horizon reference is at variance with the true horizon, and the displayed airplane symbol position relative to the earth's horizon is actually twice the true bank angle" (informal trip report, July 2, 1990, p. 7). During the question-and-answer session following his address on MiG-29 prototype testing at the September 1990 symposium of the Society of Experimental Test Pilots, Menitskii observed that Mikoyan had experimented with Western ADIs in some of its aircraft and had found the Soviet ADI to be preferable. One possible advantage of the latter is that it may give a more precise representation of the aircraft's bank angle as pitch attitude approaches the pure vertical. John Farley seemed to conclude as much based on his September 1990 MiG-29 flight experience at Farnborough: "I decided that I should treat the airplane symbol as if it were an aircraft ahead of me that I was tailchasing. Then the pitch ladder became the world and all I did in my head was fly the aircraft in front. Seemed to work for me, and I think it was much less confusing when going through the vertical than our systems" (personal letter, April 21, 1991). That said, the gauge would still take some practice for a pilot trained on Western ADIs to get comfortable with it.

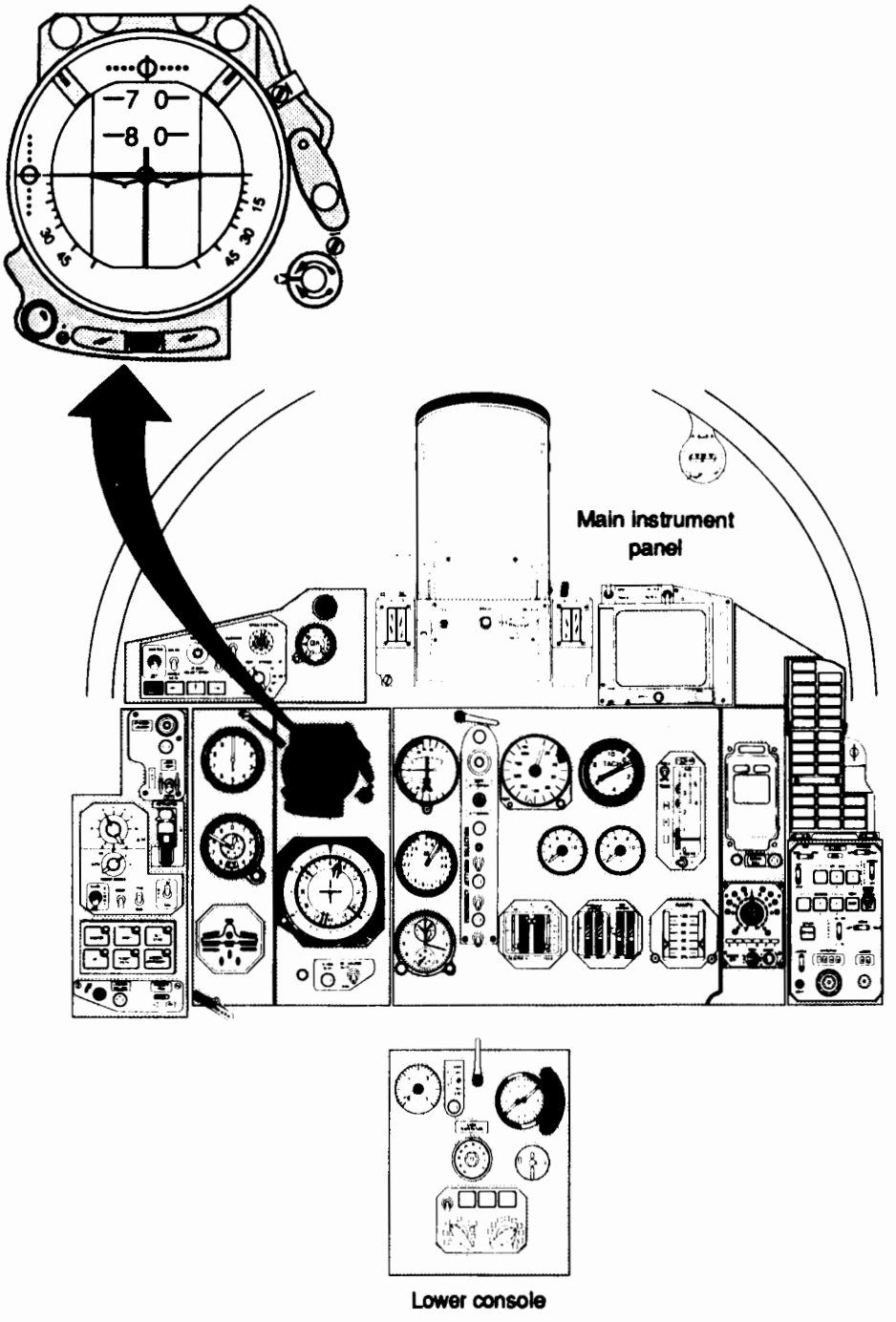

Fig. 22—Soviet Attitude Director Indicator (ADI)

Evidently the aircraft does not automatically trim to 1-g flight as does the F-15/16/18 class of fighters, since I recall having had to trim during airspeed transients both during the loop and at other times during the flight. Although this added somewhat to the workload, I definitely had the sensation that I was handling a current-generation, high-performance fighter.

I could observe the automatic maneuvering flaps sequencing on the flap-position indicator (see Fig. 23). Since it was impossible for me to see any part of the wing from the aft cockpit, even with the seat raised to the fully-up position, I was unable to monitor the leading-edge flap position visually. Nor could I determine whether the ailerons washed out at high angles of attack, since all I could see was the top half of the vertical stabilizers through the large rear-view mirrors mounted on either side of the rear canopy bow.

Visibility out of the aft cockpit was notably poorer than from the rear seat of any of the current generation of American fighters (see Figs. 24 and 25 for a contrast between the MiG-29 and the F-16). Visibility from the front seat (or out of the single seater) is undoubtedly better, although it continues to be limited by high canopy rails and an obstruction to vision within the five to seven o'clock cone created by the aft canopy bulkhead (see Fig. 26).[29]

This is not entirely surprising, however, when one considers that the MiG-29 has been designed to a very different operational philosophy from that of Western fighters—at least up to now. The Soviet concept of fighter employment remains heavily tied to off-board command and control, either from a ground-controlled intercept (GCI) site or an airborne command post. Under this arrangement, the mission controller will continue to give steering commands to the pilot until the terminal stages of an intercept are attained and he is near weapons parameters.[30]

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[29]Soviet press commentary on the MiG-29 has frequently referred to the aircraft's "great visibility out of the cockpit." See, for example, "Our Arsenal: The MiG-29 Fighter," *Sovetskii voin*, Illustrated Supplement, No. 1, 1989, p. 8. This is a relative assessment which reflects the substantial improvement of the MiG-29's cockpit visibility over that of the earlier MiG-23. As a testament to its relativity, one of Menitskii's first reactions to an American reporter who had asked about his impressions of his F-18 flight with the Blue Angels in July 1990 was a special word of praise for the excellent field of view out of the Hornet's cockpit.

[30]One of several reasons why the German Air Force has decided not to integrate its recently acquired MiG-29s into its operational inventory stems from the aircraft's basic incompatibility with Western concepts of fighter employment, as attested most notably by its limited search-volume radar and its dependence on offboard command and control to get the most from its admittedly impressive aerodynamic and weapons capabilities.

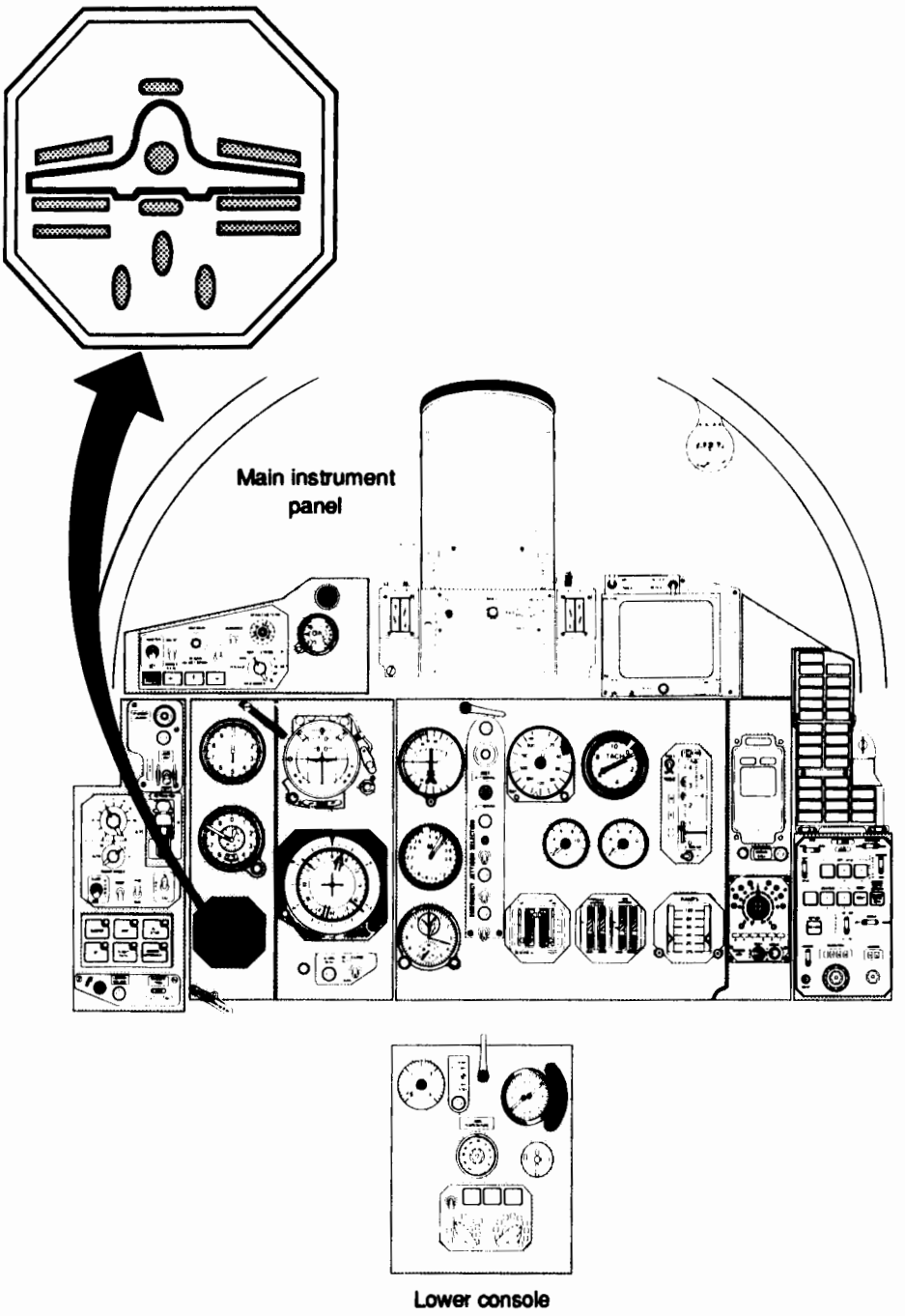

Fig. 23—MiG-29 Landing Gear, Speed Brake, and Flap Position Indicator

Fig. 24—F-16C Canopy Permitting Unrestricted 360-Deg Field of View

Apparently in keeping with this employment doctrine, the MiG-29's cockpit and avionics are not very well configured to maximize pilot situation awareness. The typical engagement profile will most likely feature a high-speed slashing attack followed by a blow-through, rather than a pitchback to engage the opponent in a turning fight. In addition to the restricted visibility,[31] the absence of handgrips around the cockpit to help the pilot look back over his shoulder under a heavy g-load suggests that the MiG-29 may not be routinely operated by the Soviet Air Force with a lot of high-g wrenching and turning in free-form air combat maneuvering, even though the aircraft possesses outstanding performance characteristics for that regime.[32]

[31]Rearward visibility from the Su-27 is noticeably better than that from the MiG-29 and is roughly comparable to that offered by the F-15. The pilot also sits considerably higher in the Su-27 than in the MiG-29. One Western writer has speculated that the canopy size and configuration on the MiG-29 reflects a design compromise between transonic drag and radar size, which required that the pilot's visibility had to suffer somewhat as a necessary tradeoff. See Bill Sweetman, "Close-Up on Flanker," *International Defense Review*, No. 3, 1988, p. 243.

[32]Of course, the absence of handgrips in the cockpit does not "prove" anything one way or the other about how the MiG-29 may be employed by the Soviet Air Force.

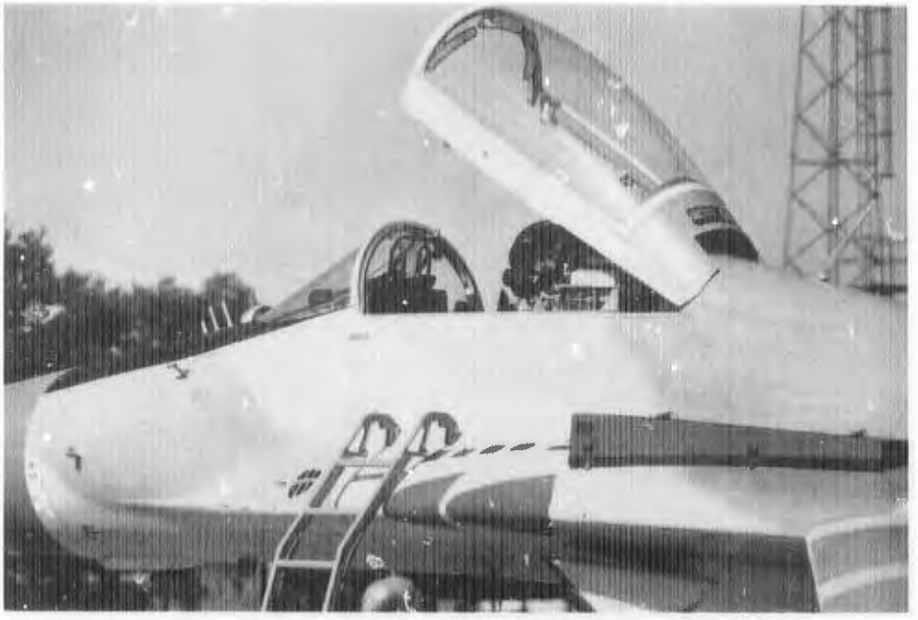

Fig. 25—MiG-29 Cockpit and Canopy Arrangement

After completing the loop and split-S sequence, I accelerated to 600 km/hr (324 kts), the maximum speed I recall on the flight, pulled the nose 20 deg above the horizon, and executed four consecutive high-rate aileron rolls to the left. I did not apply any rudder coordination and noticed a slight tendency of the nose to hunt around the velocity vector. My control input (less than full stick deflection) produced a roll rate of what I initially perceived as around 270 deg/sec. However, on later reflection, I concluded that it was probably more on the order of 220 deg/sec.[33]

However, such handgrips are standard equipment in the F-14, F-15, F-16, and F-18, and they are very useful in giving a pilot extra leverage to check his six-o'clock position in a dynamic, hard-maneuvering air combat situation. Considering that the Soviet Air Force is widely believed not to train vigorously for this sort of fighter employment as a matter of standard practice, the fact that the MiG-29 lacks them is at least an interesting coincidence.

[33]Several months after my return from Moscow, I had occasion to be back at PACAF headquarters to brief the Vice Commander in Chief and his staff on my MiG-29 experience. That visit afforded me a chance to fly a repeat F-15 sortie with the Hawaii Air National Guard, during which I sought to replicate each of the maneuvers I had previously flown in the MiG-29. When Captain Balthazer and I reviewed our HUD tape during the mission debriefing afterwards, I noted that my four consecutive aileron rolls produced almost exactly the same sight picture that I recalled from my similar evolution in the MiG-29. My roll rate was 220 deg/sec.

Fig. 26—Anatoly Kvochur at Farnborough with MiG-29 Canopy in Cracked Position, Showing High Canopy Rails and Restricted Field of View

Menitskii then took the aircraft and performed three consecutive maximum-rate rolls, cracking my helmet against the canopy and generating a roll rate of better than 300 deg/sec. During both Menitskii's and my consecutive roll sequences, I detected no apparent roll coupling tendencies on the part of the aircraft. Immediately thereafter, Menitskii trimmed to level flight and proceeded to roll inverted, sustaining this attitude for around 10 sec as we hung in the straps.

Next, Menitskii demonstrated his well-known hammerhead turn, which Major Wade had earlier told me Menitskii had performed at Abbotsford with a virtuosity that would "do any crop duster proud." I was not aware that a modern fighter with limited rudder authority at slow speeds was capable of performing this maneuver, at least not without a large application of asymmetric thrust to help drive the nose around the yaw axis.[34] After Menitskii completed his demonstration, I took control of the aircraft. With no instruction from him

[34]The twin vertical stabilizers of the MiG-29 are mounted considerably farther apart than those on either the F-15 or the F-18. This may help to account for the aircraft's exceptional low-speed rudder power.

and having never attempted this maneuver in a high-performance aircraft before, I simply tried to emulate Menitskii's example by replicating my own last hammerhead turn, which I had performed in a Beechcraft T-34A primary trainer over ten years earlier.

At 500 km/hr (270 kts) indicated, I began a 4-g pull and continued bringing the nose up until the aircraft reached an 80-deg pitch attitude, at which point Menitskii said *"stop"* (which is Russian for "stop"). I then held that nose position without changing the throttle setting and let the airspeed decay to around 250 km/hr (135 kts), at which time I briskly applied full left rudder and enough opposite aileron to keep the outside wing from picking up as it generated extra lift in the yaw.

I could feel Menitskii on the controls with me intermittently throughout the maneuver. The nose of the aircraft carved an effortless arc around the yaw axis during the float from right to left as the airspeed continued to bleed off, reaching a low of around 100 km/hr (54 kts) at the apex of the reversal. I felt in full control of the MiG-29 throughout this maneuver and could vary the yaw rate by playing the amount of rudder input. By this time, I could see enough of a horizon to complete the maneuver symmetrically using outside visual references. I allowed the nose to fall through as we headed back downhill, left the power where it had been set at the time of entry, and executed a 4-g pull to a wings-level recovery on a reciprocal heading.[35]

We had briefed in detail two events which I did not, in the end, get to perform, I assume because of Menitskii's reluctance to attempt aggravated flight regimes in such heavy weather. The first was a full aft-stick, wings-level stall, with the angle of attack pegged at 30 deg (the redlined maximum indicated), throttles back to idle, and the stick held back to override the stall warning system. The other was the

[35]Three months later, I tried several times to duplicate this maneuver during my repeat F-15 flight with the Hawaii Air National Guard. Each time I applied rudder to initiate the reversal, the aircraft would roll off over the top, even with opposite aileron introduced to check that rolling tendency. The flight control computer had simply negated my intended roll input, most likely because of its pro-spin tendencies at that pronounced an angle of attack. Although this control response has little bearing on the F-15's very respectable low-speed air combat capability, it does reflect a different flight control system philosophy from that incorporated in the MiG-29. After we landed, Captain Balthazar and I reviewed this abortive attempt and concluded that had we disengaged the CAS, we probably could have successfully performed the hammerhead maneuver—but would have regretted having done so had we departed the aircraft during the reversal. Shortly thereafter, prompted by my recounting of this experience, Kevin Dwyer of General Dynamics tried the same maneuver in an F-16 and discovered that as long as enough forward stick were applied to hold the AOA down, the aircraft had enough rudder authority to bring the nose around smoothly and controllably.

tail-slide maneuver that had attracted worldwide attention when it was first demonstrated at the Farnborough Air Show by Anatoly Kvochur in 1988.

During his visit to RAND the previous month, Menitskii had spoken proudly of the MiG-29's docile handling characteristics in the tail slide and told me that I could anticipate completely controllable and predictable aircraft responsiveness throughout it. I mentioned in reply that this could hardly be considered a serious aerial combat maneuver, since it would be the height of folly to sacrifice all of one's energy in such a manner, even in a last-ditch situation. I was prompted to offer this remark because of a flurry of uninformed Western commentary, at the time of the 1988 Farnborough Air Show, that the tail slide was actually a planned Soviet defensive air combat tactic intended for use in breaking a pulse-doppler (PD) radar lock. This idea was evidently sparked by a comment by one of the Mikoyan pilots that the tail slide could indeed produce such an effect—which is technically correct as far as it goes. The notion that the maneuver has a tactical application in the Soviet Air Force was further reinforced by a later statement by Alexander Velovich and a colleague that "once the signal comes on indicating that the aircraft has been illuminated by enemy radar, the pilot shifts to a vertical climb, then slips downward on his tail. Prior to this, the aircraft is motionless for seconds relative to the ground, and the return signal from it is lost."[36]

The problem with this idea is that at the same time the enemy's PD lock is temporarily broken when the MiG-29 stops in midair at the apex of the maneuver, the aircraft in question has lost all of its combat potential. To make matters worse, once gravity takes over and the aircraft resumes movement (that is, begins to fall out of the maneuver), the enemy's radar contact is promptly reacquired, with the engaged MiG-29 pilot now completely out of energy and tactical options.[37] Without going through all the arguments, Menitskii

[36]A. Velovich and L. Egenburg, "MiGs at Farnborough," *Tekhnika i molodezhi*, No. 2, 1989, p. 33. See also A. Smolyarov, "Why Are the 'Cobra' and 'Bell' Needed?" *Sovetskii patriot*, No. 4, January 1991, p. 4. "Cobra" refers to an aerodynamic braking maneuver that has been performed at Western air shows by both the Su-27 and the MiG-29 (see App. A for further discussion). "Bell" (in Russian, *kolokol*) is the term used by the Soviets to denote the MiG-29's tail-slide maneuver.

[37]During a presentation on the MiG-29 to some instructors and students at the Air National Guard's Fighter Weapons School shortly after the 1988 Farnborough Air Show, I mentioned in passing that some members of the Soviet delegation had been peddling the notion that the tail slide was a standard Soviet defensive countermove. To which they immediately responded: "Great! Tell them to keep it up!" It bears noting, however, that even though the tail-slide maneuver would almost certainly prove suicidal were it resorted to as a last-ditch defensive maneuver, it reflects an aero-

essentially concurred with this assessment and said that the point in performing the tail slide was to demonstrate the exceptional aerodynamic efficiency of the aircraft.[38]

After the hammerhead sequence, Menitskii resumed control of the aircraft, contacted the local military approach controller, and reentered the weather on an en route descent back to Kubinka. We broke out at around 800 ft AGL two miles northwest of the airfield headed toward the runway at a crossing angle of about 45 deg. Menitskii took us down to 200 ft as we overflew the headquarters building, at which time I shook the stick, took the aircraft back, and asked if I could fly a short low-level route. I was prepared to take the airplane down to 100 ft for a circuit of the base if Menitskii would let me, but he said that low flying in the area adjacent to the airfield was prohibited.

Menitskii also was not inclined to let me take the aircraft out to its redlined normal load limit of 9.5 g. When I asked if I could do that just to fill the square before we had to land, he replied *"ne nado"* ("there's no need to"). I believe he was just eager to get the jet back on the ground as soon as possible, although it did occur to me much later that such a maneuver would have offered me a ready way to

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dynamic attribute of the MiG-29 that could be centrally important in determining the outcome of an engagement that degenerated into a slow-speed scissoring showdown. As John Farley has observed: "To me, what the tail slide showed was an amazing consistency of behavior at ultra-slow speeds and up to 90 alpha [90 deg AOA] as the nose fell through. This meant that their aerodynamics were very advanced and that their engine intake, afterburner, and fuel management systems were remarkable. The operational significance of all this was not the maneuver itself, but the way it showed they could afford to hang in there in a zooming, turning fight until the opposition flew out of it because their aircraft was not benign if they let it get too slow. That is, it ruled out a tactic that we might have hoped to use against them. It did not mean that the MiG-29 guy was going to go around stopping all the time. Far from it . . . . The point being not that they want to use 90 alpha in a fight, but that they can guarantee to use five alpha *more* than the other guy's alpha-limited jet (whatever his alpha limit is), and that could make all the difference, everything else being equal" (personal letter, April 21, 1991).

[38]Although I did not get to do the tail-slide maneuver during my flight, Major Wade performed it twice at Abbotsford. As he recounted later, he entered at about 5000 ft AGL, brought the nose up to the pure vertical, retarded both throttles to idle, allowed the airspeed to bleed to zero, and then advanced the throttles from idle to full afterburner in a single movement once the aircraft had settled into a fully developed tail slide. He reported achieving a simultaneous lightoff of both afterburners within two seconds and was easily able to bunt the nose forward out of the maneuver for a nose-low recovery, with a minimum loss of altitude, full stabilizer authority throughout, and no tendency of the aircraft to roll off at any time.

determine the MiG-29's corner velocity in clean configuration at combat weight.[39]

Menitskii did, however, allow me to execute a hard level turn to the left just below the cloud deck, continuing through about 270 deg of turn and peaking at 7.5 on the g meter. I sensed the g-suit starting to inflate at about 3 g but otherwise was rarely aware of its operation. With constant g maintained throughout most of the turn, the airspeed bled from 550 to about 400 km/hr (297 to 216 kts). I detected absolutely no buffet, either then or at any other time during the flight.[40] I also noticed no major variation in stick forces during the more pronounced airspeed and g transitions I experienced.[41]

At this point, Menitskii again took control of the aircraft with the airfield at our right four-o'clock position. He set us up for an ILS approach on Runway 22 and allowed me to resume control as he extended the gear and flaps. I was instructed to maintain 300 km/hr (162 kts) on the approach. The pitch and bank steering command bars worked just like ours, except that they were on the HSI rather than on the attitude indicator (see Fig. 27). Since we were now in visual flight conditions beneath the overcast, I spent most of the remaining time with my head outside the cockpit and flew a long

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[39]Corner velocity is the minimum airspeed at which an aircraft can sustain its maximum allowable g. It is a very important measure of a fighter's turning performance—and hence of its maneuvering air combat capability.

[40]I should note here that buffet is not an inherently undesirable aerodynamic characteristic in a fighter. On the contrary, it is typically incorporated consciously into an aircraft's design from the outset to give a pilot instantaneous references to his energy and stability state. John Farley ("Supreme Soviet," p. 38) definitely flew the MiG-29UB into heavy buffet with some hard stick snatches in the 400–500 km/hr (216–270 kt) regime. However, I cannot recall having experienced buffet at any time I applied g to the airplane at a more deliberate onset rate.

[41]According to one account, the Mikoyan pilots remarked at Farnborough in 1988 that "stick forces actually become progressively lighter with increasing g." See Jon Lake, *MiG-29: Soviet Superfighter*, Osprey Publishing Limited, London, 1989, p. 57. This report almost certainly reflects a misunderstanding of what the Mikoyan pilots actually said. Although I lack the refined "hand sense" of an experienced test pilot, I can emphatically state that I encountered no such tendency on my flight and, if anything, recall the stick forces having shifted perceptibly in the opposite direction as the load factor mounted during my 7.5 g turn. As my RAND colleague Jack Craigie, a former instructor at the USAF Test Pilot School, pointed out to me in reviewing an earlier draft of this report: "Stick force lightening with increasing g describes a pitchup tendency, which is a *very* unsatisfactory state of affairs in handling qualities. The stick force *gradient*, that is to say, additional pounds of force per increment of g loading, is what might decrease with increasing g loading, although even that is considered unsatisfactory. In any event, if a pitchup tendency were there, a less experienced pilot would be *more* likely to put himself into a pitchup. Your 'hand sense' was okay, I would say . . . . If that airplane had strong pitchup tendencies of this type, the pilots wouldn't survive those air shows."

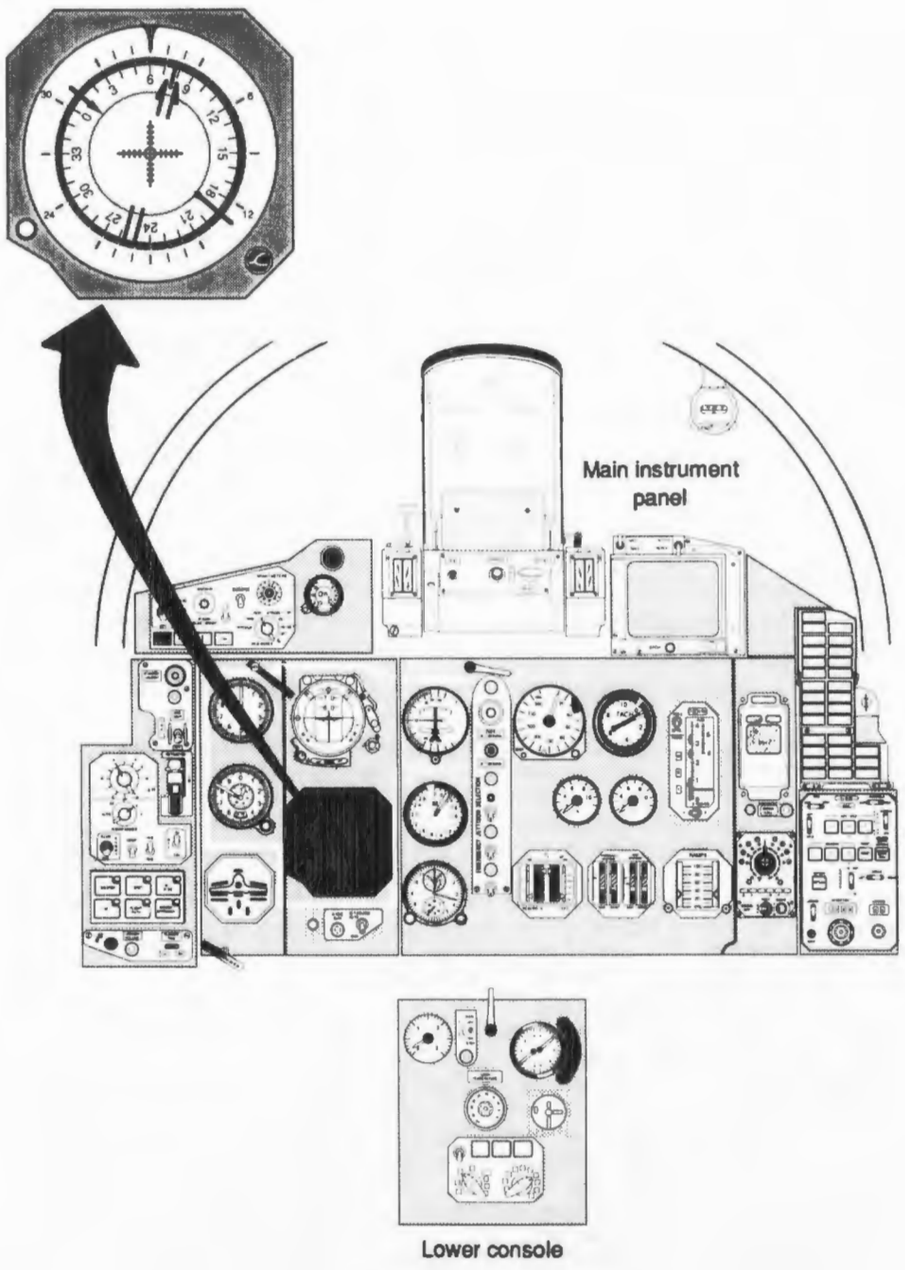

Fig. 27—Horizontal Situation Indicator (HSI) Showing ILS Pitch and Bank Command Steering Bars in Center

straight-in approach once I had the runway in sight. I did not detect any visual approach-slope indicator (VASI) alongside the runway at Kubinka, although there were bright white mercury vapor-type threshold lights and a row of red lights leading up to the runway centerline to assist with lineup. I could barely make out the runway over the nose once we were inside a mile from touchdown, so I continued to monitor the ILS while visually cross-checking the airfield environment until I lost the runway under the nose altogether.

I assume that the computer-assisted flight control system had been operating in the basic control augmentation, or "damper," mode throughout most of the flight. Apparently Menitskii had additionally called up a system-monitored ILS mode for the approach, however, because at one point I heard a female voice warning say *"glissad opasno"* ("glideslope is dangerous"). On cross-checking the HSI, I noted that we were about one bar-width low, so I added power to reintercept the glideslope. As we neared the airfield perimeter, Menitskii took the aircraft back and executed a perfect spot landing on the cleared portion of the snow-covered runway. We touched down at 240 km/hr (130 kts) indicated.

This was a fairly hot approach for the MiG-29, considering that Major Wade had been briefed to hold 210–215 km/hr (113–116 kts) on final and to touch down at 190 km/hr (103 kts) with 1000 kg of fuel remaining. Perhaps our fuel state was higher than that. Whatever, Menitskii made no attempt at aerodynamic braking and promptly lowered the nosewheel for a firm touch on the runway.[42] After a few seconds into the rollout, he deployed the drag chute just as I had hit the ICS button to ask if we would be using it.

Total elapsed time from engine start to shutdown was 42 minutes. I did not record our takeoff and landing times, but we were airborne for about a half an hour. Menitskii seemed pressed to get his aircraft back to Ramenskoye while there was still remaining daylight. For that reason, we did not debrief the flight and had only a short period of ceremonial pleasantries afterward (see Figs. 28 and 29) before the aircraft was refueled and Menitskii took off from Kubinka for the return flight.

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[42]The aircraft does, however, aerobrake nicely, as was repeatedly demonstrated by Roman Taskayev during the July 1990 Goodwill Air Show circuit of the MiG-29 through Canada and the United States. At both the Rockford and Dayton performances, I watched Taskayev hold the nose off the runway down to approximately 50 kts, using the classic F-15 landing technique.

Fig. 28—Author Exiting MiG-29UB After Flight, with Mikoyan Maintenance Chief Utkin Assisting

IMPRESSIONS OF THE AIRCRAFT

I stressed at the outset of this report that I would not attempt a formal appraisal of the MiG-29, because I lack the credentials of a test pilot and also experienced only a limited sampling of the aircraft's handling and performance characteristics. That said, however, I feel obligated to offer at least an impressionistic overview of my flight and what I learned from it.

During my preparations for the trip to Moscow, it had occurred to me that one quid pro quo my Soviet sponsors might want to exact for my flight would be to make it a media event and to have a Moscow television crew on hand to interview me once Menitskii and I had landed. Ultimately, this contingency never came to pass. But at the time, it seemed sufficiently plausible to incline me to think through several answers ahead of time to some of the tougher questions with which I might be confronted. One such question was: "Now that you've flown the Soviet Union's finest, how would you say it compares with America's finest?"

Fig. 29—(Left to right) Author; Utkin; Major General Shchitov; Menitskii

Although I was spared the challenge of having to answer that question on the spot, it remains a fair one. And I believe that the fairest reply is that the question cannot be very usefully answered in the abstract. During my flight with Menitskii, I got a fleeting look at some of the low-speed stability, control, and performance characteristics of what is, by all accounts, a fine airplane. Yet the formula for success in air combat includes many factors, of which aircraft performance is only one. Any balanced appraisal of a fighter must also take into account such additional—and often more pivotal—considerations as the aircraft's armament and avionics capabilities; its command and control system and associated aids to situation awareness; and all the other ingredients that go into giving one fighter a decisive edge over another in aerial combat. There is no way I can even begin to venture an informed guess regarding how the MiG-29 would stand up in this regard, based solely on what I saw during my flight and on the vicarious insights I have acquired from talking to others who have flown it.

I can, however, offer at least an opinion on how a properly flown MiG-29 might fare in an isolated one-on-one maneuvering engage-

ment against any of its closest American equivalents.[43] Starting from a tactically neutral visual setup in a guns-only fight (that is, a setup that would purely pit one airplane against the other without any consideration for avionics or weapons), an engagement between a MiG-29 and either an F-15, an F-16, an F-18, or an F-14 with the General Electric F110 engines would probably be decided, first and foremost, by which fighter was flown by the more accomplished air-to-air pilot. Indeed, were such a fight against an F-16 allowed to stagnate into a flat or vertical-rolling scissors that put the F-16 against its pitch limiter, an aggressively flown MiG-29 could prevail in that engagement.[44]

Granted, one would have to compare detailed performance curves for each aircraft to render a judgment that was more than purely impressionistic, as this one clearly is. Such an assessment would undoubtedly reveal comparative advantages for each aircraft that could be exploited against the opponent's disadvantages in a one-on-one fight.[45] For example, the MiG-29 enjoys a thrust-to-weight advantage

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[43]By "properly flown," I mean taken aggressively to all corners of its performance envelope by an experienced air-to-air pilot with the Soviet equivalent of U.S. Air Force or Navy fighter weapons school qualifications. I do not mean by a typical captain in a typical Soviet Air Force regiment, who continues to be trained to deficient standards when measured by a Western yardstick. Even Menitskii has implied as much in several public statements, most recently in an article on pilot training published in the Soviet Air Force's monthly journal. In this article, Menitskii stressed the criticality of superior airmanship skills in determining combat outcomes and the consequent need to assure that capable aircraft like the MiG-29 are placed in "reliable hands." Yet he went on to note how too many unit commanders, "remaining prisoners of old concepts and directives, still cover themselves with slogans about increasing the formal classification levels of pilots and about concerns for flight safety, while shifting the actual combat training of pilots to the back burner." Valery E. Menitskii, "On the Back Burner, Why?" *Aviatsiia i kosmonavtika*, No. 2, February 1991, pp. 4–5.

[44]Bearing in mind, of course, that the F-16 might retain superior roll-rate performance in that regime which could, in the right hands, be used to counter the MiG-29's high-AOA pitch-rate advantage—and not forgetting also that a careful F-16 pilot, like any careful fighter pilot, will always strive never to get that slow in a combat situation to start out with.

[45]In a helpful refinement of this point, Kevin Dwyer of General Dynamics has suggested that the outcome of the sort of engagement described above will be determined by whichever pilot "best knows his own airplane *and* his adversary's airplane and fights the best plan" (personal letter, January 7, 1991). A blunter rendition was offered some years ago in the following admonition by retired Navy Captain Jerry O'Rourke: "A fighter pilot must use his airplane right up to its limits in his routine flying, be it combat or training for combat. These fine edges between what the plane can do and what it cannot are his ballpark. The mark of the true professional is his ability to get into that ballpark and to drive his enemy out. So he must *use* his airplane and his weaponry right up to those limits. If he doesn't—if he reserves a little cushion for safety, or for any lack of personal confidence—he's not really a fighter pilot, and, when combat comes, he'll soon be beaten by one who is." Captain Jerry O'Rourke, U.S. Navy (Ret.), "Fighters That Never Got to the Fight: Part II," *U.S. Naval Institute Proceedings*, April 1982, pp. 76–77.

over its front-line Western counterparts, which would give a properly trained pilot a definite performance edge in a close-in maneuvering engagement. This would also require him to accomplish a quick kill to be successful, however, since any Western fighter could probably run the MiG-29 out of fuel with any sustained use of afterburner in such an engagement.[46] Whatever the case, the point that matters is that the Soviet aircraft industry, with the MiG-29 and the Su-27, has fully closed the gap with currently deployed USAF and Navy fighters in terms of air-vehicle performance. In some respects (notably in acceleration, sustained turn rate, and stability at slow speeds), the MiG-29 is reported to surpass its Western counterparts.[47]

Based on the many conversations and debriefings I have had with Western aircrews since my flight, I believe that most fighter pilots would concur with this assessment. To cite just one example, Major Bob Wade, who got a brief exposure to the MiG-29's maximum performance capabilities at Abbotsford, was full of superlatives afterward, using words like "awesome" and "incredible" to describe the aircraft's excess thrust. He reported accelerating from 800 to 850 km/hr (432 to 459 kts) during a sustained 9-g, 360-deg level turn below 5000 ft. He also described the rapid rate of engine spool-up and afterburner light-off during the tail slide as a capability he had not seen in any other fighter.[48]

Another strong suit of the MiG-29, noted by an experienced Western test pilot and perhaps borne out by me, with my less-developed level of proficiency, is the aircraft's exceptional resistance to departing from controlled flight at slow speeds and high angles of attack. After his flight in the MiG-29UB at the 1990 Farnborough Air Show, British test pilot John Farley went so far as to conclude that "no skill is needed to fly this aircraft at its aerodynamic limits."[49] This design attribute has a twofold tactical application. It enables a pilot to concentrate all his attention on defeating the opponent without having to worry about losing aircraft control in the process. It also permits him

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[46]For example, the F-15 and F-18, likewise twin-engine fighters in the same general performance category, carry 11,500 and 10,200 lb of internal fuel, respectively, in contrast to only 6,600 lb for the MiG-29.

[47]See, for example, Roy Braybrook, "MiG-29 vs. F/A-18: Keep Out of Dogfights," *Pacific Defense Reporter*, February 1989, pp. 50–52.

[48]A similar accolade was offered by Colonel Helmut Ruppert of the German Air Force, who flew the MiG-29 in November 1990 shortly after unification and found it "impressive" and "easy to handle." Quoted in "German Air Force Impressed With MiG-29 After Flight Test," *Soviet Aerospace and Technology*, December 3, 1990, p. 3.

[49]John Farley, "Supreme Soviet," p. 40.

to correct or recover safely from handling errors that could prove fatal in a less forgiving aircraft.

One of the most frequent questions put to me during the many presentations on my flight that I have since given to Western pilot audiences has concerned what it physically felt like to handle the MiG-29. Although my relevant fighter experience is, unfortunately, as shallow as it is extensive, the best summary answer I can offer is that the aircraft's lateral control forces seemed substantially lighter than its longitudinal forces.

In pitch, the MiG-29 reminded me most closely of the F-104 in terms of the back pressure required to bring the nose up. The aircraft definitely had a heavy stick in pitch compared with the F-15 and F-18. The difference between the two was not pronounced, but it was noticeable. And, as I noted earlier, I needed to apply continual pitch trim inputs to keep the stick forces zeroed out during airspeed transitions.

In roll, by contrast, the force gradient felt much like that in an F-106, or even a T-33 trainer with the aileron boost on. The amount of force required to move the stick laterally in the MiG-29 was considerably less than in pitch. In fact, I would say that stick forces in the roll axis were very light, although—as in the case of the T-33—the stick required a fairly large displacement to produce a rapid aircraft roll rate.[50] The same was true with regard to rudder pedal deflection. The maximum throw of the pedals seemed to be some six to eight inches. This is considerably greater than in the F-15 or F-18, and I recall having applied a large amount of pedal input during the low-speed/high-AOA portions of our maneuver sequence.

Again, lest my remarks be overdrawn, these are relative differences only with respect to Western aircraft. They certainly did not add up

[50]It is worth noting here that aircraft companies in the United States have long harbored basic philosophical differences with regard to what stick-force gradients are most desirable in a fighter. Republic Aviation, for example, tended to emphasize controls requiring a heavier force application by the pilot, as attested by the F-84F and the F-105. North American Aviation, by contrast, was inclined to design its flight controls with lighter stick forces, as attested by the F-86 and the F-100. This contrast explains why some fighters, like the F-100, are typically characterized by pilots as "sports cars," whereas others, like the F-105, are described more as "Cadillacs." Because of the central role played by the Soviet Air Force, by TsAGI, and by other aviation research institutes in enforcing uniform design and production standards for Soviet military aircraft (see App. A for additional discussion), it is possible that fewer differences in handling characteristics obtain among the various Soviet fighter design bureaus, although I cannot state this for a fact. In all events, I am indebted to my colleague Jack Craigie for calling this point to my attention.

to a major increase in cockpit workload. Indeed, they may reflect a generic Soviet design philosophy intended to give the pilot a lot of play room before he reaches the point of maximum control surface deflection. Most important, once a desired control input was introduced, the MiG-29 responded very much like an F-18 in a similar situation.

5. EPILOGUE

My flight experience at Kubinka was not an end in itself. Rather, it was a benchmark in a continuing relationship with Menitskii and the Mikoyan Design Bureau. In the summer of 1990, Mikoyan brought its two demonstration MiG-29s back to North America for a month-long series of air show performances in Canada and the United States.[1] The Soviet delegation was again led by Anatoly Belosvet, and the aircrew contingent included Menitskii, Roman Taskayev, and a young design bureau test pilot, Marat Alykov. This tour gave me an opportunity to lay the groundwork for a subsequent trip by Menitskii to broaden his contacts with the American test pilot community that he had first established during his visit to Santa Monica in 1989.

With the support of Kevin Dwyer at General Dynamics, likewise a friend of Menitskii's going back to the 1988 Farnborough Air Show, I had taken the lead earlier in urging Menitskii to seek approval to attend the next symposium of the Society of Experimental Test Pilots (SETP), scheduled to be held in Beverly Hills in September 1990, and to offer a technical paper on flight testing in the Soviet Union. Kevin Dwyer and I had vetted this idea with SETP beforehand and had received the unqualified encouragement of its symposium committee.

After some initial diffidence on Mikoyan's part, Menitskii was given a green light to submit a paper on MiG-29 prototype and high-angle-of-attack development testing. He arrived in Los Angeles for the SETP symposium accompanied by retired Major General Grigory Sedov, a former Mikoyan chief test pilot and later head of the MiG-23 design and development team. Among his many other aeronautical achievements, General Sedov had flown the first flights of the MiG-19 and MiG-21.[2] As de facto host for Menitskii and General Sedov during

[1]Although this air show tour was approved by the U.S. State and Defense Departments and the MiG-29s were provided American fighter escort during their transits through U.S. airspace, it was not sponsored by the American government. Rather, it was a commercial enterprise taken on by the Mikoyan Design Bureau; was organized and supported by Leading Edge Productions in Portland, Oregon; and was funded by the various air shows at which the MiG-29s put in an appearance.

[2]General Sedov clearly ranks among the most distinguished test pilots in the history of Soviet fighter aviation. During World War II, he performed flight tests in all Soviet fighter aircraft and evaluated many allied aircraft as well, including the P-38, P-39, P-47, P-51, Spitfire, and Hurricane. He also evaluated captured German aircraft, including the Me-109, FW-190, Me-110, and Me-262. Following the war, he was involved in the test and evaluation of the first generation of Soviet jet aircraft, includ-

this visit, I was able to bring them to RAND as well for an informal roundtable discussion on flight testing issues. This gathering was attended by a large number of staff and students from the USAF Test Pilot School at Edwards AFB. It produced a wide-ranging and candid exchange of views in the best professional tradition on both sides.

Participation in the SETP symposium also allowed Menitskii and General Sedov to be privately briefed on X-29 high-AOA testing by a group of NASA test pilots from the Dryden Flight Research Facility at Edwards. This impromptu meeting likewise yielded a worthwhile mutual learning experience, as did a specially arranged visit by Menitskii and General Sedov to the National Test Pilot School (NTPS) in Mojave. There, the two Soviet pilots compared notes with the school's staff on test pilot selection and training practices in the United States and the USSR. They also were given an airborne look at the Edwards AFB flight operations complex from an NTPS twin Beech, which Menitskii flew from the left seat.

Some of the highlights of Menitskii's SETP paper are outlined in App. A immediately following this section. A translation of the paper was read by Don Madonna to a packed ballroom of members and associates, with Menitskii on stage to field questions. Menitskii's open and engaging colloquy prompted an unprecedented standing ovation from the audience. The following evening at the awards banquet, his paper was cited as one of five semifinalists for best paper read at the 1990 symposium. Although Menitskii's contribution was widely regarded as having easily been on a professional par with that of his Western counterparts, there is little doubt that much of this response was simply a reflection of who he was, where he had come from, and what his appearance at SETP had symbolized about the changing Soviet political scene.[3]

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ing the Yak-15, Yak-23, and Yak-30. He joined the Mikoyan Design Bureau's flight test staff in 1950 and flew the experimental aircraft series designated M and SM-1 through SM-9 leading to the MiG-19 configuration, after which he flew the first MiG-19 prototype. He also flew the Ye-series of experimental aircraft beginning in 1954, eventuating in his piloting the prototype of the first-generation MiG-21F. General Sedov later became Mikoyan's chief test pilot and finally retired from active flying in 1959, at which time he became involved in advanced fighter design and ultimately took over the design team for the MiG-23 and MiG-27 series, which he continues to head today.

[3]Grigory Sedov was accepted with equal warmth by SETP's leaders. Indeed, on Kevin Dwyer's later nomination, they unanimously selected him to become an Honorary Fellow of the society, putting him in league with such aviation luminaries as Jimmy Doolittle and Charles Lindbergh. General Sedov is the first Soviet pilot among some sixty selectees to have achieved such recognition by SETP.

The following summer at the 1991 Paris Air Show, Terry Stinson and I organized a private dinner for Menitskii and Belyakov. In attendance also was Lieutenant General Oleg Anisimov, the commander of fighter aviation for the Soviet Air Defense Forces (PVO).[4] General Anisimov proved an urbane and sophisticated conversationalist, and he freely joined in a wide-ranging discussion around the table on such topics as evolving approaches toward fighter-pilot selection and the ideal cockpit design for a next-generation trainer.[5]

The opportunity for an American defense analyst to engage such a senior member of the Soviet military establishment in this manner, to say nothing of being able to recount the story etched out in the preceding pages, would have been unthinkable before the sweeping transformation of Soviet life that was first sparked by President Gorbachev's reform initiatives. The experiences described in this report have paralleled similar breakthroughs of other RAND colleagues in gaining high-level access to the foreign-affairs establishment, the Soviet armed forces, the Supreme Soviet and its various committees, and the uppermost levels of the now-flourishing democratic reform movement in Moscow. They confirm that despite occasional foot-dragging and an understandable slowness to change on the part of both government bureaucracies, contacts are steadily expanding among professional communities in the two countries.

THE QUESTION OF A SOVIET-AMERICAN PILOT EXCHANGE

As noted earlier, my MiG-29 flight took place within the context of an ongoing debate within the U.S. government about whether to authorize a formal exchange of fighter flights between suitably credentialed

[4]General Anisimov is operationally current in the MiG-31 and has a distinguished background, having previously commanded an award-winning interceptor regiment and later the aviation component of the Moscow Air Defense District. He has occupied his current position since early 1991. For some recent insights into his professional outlook, see Lieutenant General O. Anisimov, "Whose Job Is It to Create Tactics? On the Qualitative Parameters of Training Aviators," *Vestnik protivovozdushnoi oborony*, No. 1, 1990, pp. 13–16. See also his comments on exercise planning and operational training at the regiment level in Colonel A. Yurkin and Lieutenant Colonel G. Falichev, "A Roundtable: Military Reform and the Air Defense Forces," *Krasnaia zvezda*, June 25, 1991.

[5]The day before at a British Aerospace luncheon at Le Bourget, I had a similar, albeit much briefer, opportunity to be introduced by Dr. Zagainov to Appolon Systsov, the Minister of Aviation Industry, who had initially approved my MiG-29 flight, and to Yury Matsak, the deputy chairman of the Military-Industrial Commission (VPK) of the USSR.

American and Soviet aviators. Such an exchange was first raised as one of a number of suggested events to be conducted in connection with a developing series of contacts between the two military establishments initiated during the summer of 1988 by Admiral William Crowe, then-Chairman of the Joint Chiefs of Staff, and Marshal Sergei Akhromeyev, then-chief of the Soviet General Staff.[6] These contacts were also to include exchange visits by each of the two countries' service chiefs and reciprocal port calls by capital ships of the two navies, among other things.[7]

According to one published account, the U.S. military has repeatedly sought within the framework of this developing relationship to gain Defense Department approval for an exchange arrangement that would permit Soviet military pilots to fly American fighters, under properly controlled circumstances, in return for U.S. military pilots' flying Soviet fighters under a comparable set of ground rules.[8] Such an exchange has been resisted thus far by the National Security Council (NSC), not so much out of concern for a potential compromise of sensitive technology as because of a reported feeling that the Soviet reform process has not progressed far enough to justify such a gesture.

This controversy has not had much public visibility, largely because the issue it involves is less momentous than other, higher-level dealings between the two countries that are either now under way or being contemplated. Nevertheless, it is an issue that continues to divide the American national security bureaucracy at the working level. It promptly became transformed from a largely academic consideration into an immediate decision problem for the U.S. government when Mikoyan's two MiG-29s appeared in North America, first at the Abbotsford Air Show near Vancouver in August 1989 and later during the Goodwill Air Show tour through the United States in July 1990. On both occasions, the Soviet delegation offered a MiG-29UB orientation flight to the leader of the U.S. Air Force's Thunderbirds flight demonstration team in return for a similar flight in a Thunderbirds F-16 two-seater by Menitskii.

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[6]For more details on the background of this exchange arrangement, see the interview with Marshal of the Soviet Union S. F. Akhromeyev, "USSR-United States: The Dialogue Continues," *Krasnaia zvezda*, July 17, 1988. See also John G. Roos, "Military to Get Closer Look at Soviet Counterparts," *Armed Forces Journal International*, August 1988, p. 25.

[7]On the first round of naval exchanges, see Benjamin F. Schemmer, "Soviet, U.S. Ships Exchange Port Calls," *Armed Forces Journal International*, August 1989, p. 41, and Schemmer, "Soviet People Open Hearts to U.S. Navy in Sevastopol," *Armed Forces Journal International*, September 1989, pp. 56–66.

[8]"A Gesture Long Overdue," *Aviation Week and Space Technology*, July 16, 1990.

When so confronted on these occasions, the U.S. government chose to avoid having its hand forced and summarily declined the opportunity. It was in light of that decision that the Defense Department and the NSC were so discomfited when Roman Taskayev was nevertheless taken on an impromptu F-4 ride in good faith by representatives of the Oregon Air National Guard at Abbotsford, without the latter having checked first through Guard Bureau channels with the civilian establishment in Washington. It is also the reason why the Defense Department later refused to allow General Dynamics to fly Menitskii with test pilot Kevin Dwyer in a company F-16B when the Soviet aviation industry delegation visited the Fort Worth plant in November 1989. Most notably, it explains why the Pentagon and the White House "reportedly went ballistic" when Menitskii was extended a flight in an F-18B with the Blue Angels at Kalamazoo, Michigan, during the 1990 Goodwill Air Show tour, again without prior coordination with the U.S. government outside of normal Navy approval channels.[9]

It bears noting that such opposition to flight exchanges is not altogether a monopoly of the American security bureaucracy. An article in a leading Soviet military journal recently singled out the Soviet aviation industry for special criticism because of its alleged compromise of potentially sensitive military secrets occasioned by its offering of high-performance fighter rides and its candor in discussing front-line Soviet combat equipment with foreigners. In an angry broadside against the one-way leakage of secrets allegedly created to the detriment of Soviet security by *glasnost* and its excesses, the author of this article lambasted the "fruitful cooperation" that was being so eagerly pursued by the Ministry of Aviation Industry, whose leaders were said to "want to appear as 'good guys' at the expense of our military pilots." The writer then disparagingly contrasted Major Wade's MiG-29 flight with Roman Taskayev's ride in an "out-to-pasture" American Phantom and noted darkly how the Ministry's would-be "partners in information exchange" have steadfastly refused to offer a Soviet pilot a flight in a current-generation American fighter like the F-16 or F-18. Not only that, he added, these are aircraft which "they don't even let us get close to."[10]

There is little mystery behind the Soviet aviation industry's interest in fostering a Soviet-American flight-exchange relationship. That

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[9]Quoted from the CBS Evening News, July 22, 1990.

[10]Colonel V. Nikolayev, "*Glasnost* and Secrecy," *Morskoi sbornik*, No. 7, 1990, p. 10. Considering that this article appeared in the main professional journal of the Soviet Navy, the identification of the author as a colonel suggests that he works either for the KGB or for military intelligence.

interest is not rooted, first and foremost, in any narrow-minded quest for technology exploitation. The Soviets know just as well as the U.S. flight test community does that they have little to gain from a data-collection point of view out of a flight, or series of flights, in an American fighter in which operationally sensitive capabilities are not demonstrated. What they are mainly seeking through such an exchange relationship is Western affirmation of their professionalism and their technical rectitude.

In addition, although they would never admit to this, they even appear to be seeking something like a silent cachet from the Western fighter and test pilot communities. After expressing his thanks for his happenstance opportunity to fly with the Blue Angels, Menitskii himself implied as much in a preamble to his 1990 presentation to SETP: "Both I and my country's aviation community as a whole hope that barriers to further exchange flights of this sort will soon break down and that we can get on with strengthening our professional ties by flying with each other more often, obviously under properly planned circumstances on both sides."[11]

This push comes at a time when the Soviet aircraft industry is facing severe economic and structural difficulties on the home front and is in dire need of increased contacts with the West to secure hard currency and otherwise shore up its long-term institutional vitality.[12] In this regard, Deputy Minister of Aviation Industry Maksimov remarked in an interview shortly before the 1988 Farnborough Air Show that the main reason for the planned Soviet display of the MiG-29 at that event was to demonstrate Soviet military-technical prowess at first hand and thereby lay an essential foundation for serious economic and technical cooperation with the West.[13]

This leaves unanswered the question of what the United States might stand to gain from such a flight exchange. Obviously it is imperative that any such arrangement take appropriate measures to safeguard sensitive technical and operational data.[14] Yet it is unlikely that an

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[11]Valery E. Menitskii, "MiG-29 Prototype and Development Flight Tests: General Overview and High Angle of Attack Investigation," *1990 Report to the Aerospace Profession: Proceedings of the Thirty-Fourth Annual Symposium*, Lancaster, California, Society of Experimental Test Pilots, 1990, p. 218.

[12]For a good accounting of some of the reasons for this, see Arthur J. Alexander, *Perestroika and Change in Soviet Weapons Acquisition*, Santa Monica, California, RAND R-3821-USDP, June 1990.

[13]"Soviet Industry Bares Its Soul," *Flight International*, November 12, 1988, p. 1.

[14]As my colleague Jack Craigie remarked on this point shortly after Academician Belyakov and his delegation had visited RAND in November 1989: "I would like to

exchange of fighter flights would have been endorsed by the U.S. Air Force in the first place had its leaders not concluded beforehand that any such compromise could be easily averted. If anything, given the substantial informational asymmetries between the two societies, notwithstanding *glasnost*, the United States would very likely stand to be the greater beneficiary of such an exchange.

But that is not the point that matters. The more powerful case for proceeding with flight exchanges is that they would help break down the entrenched threat image of the United States that has long been harbored by Soviet aviation professionals as a result of their years of isolation and nonstop exposure to propaganda deprecating the West. Such a program would open up to the Soviet Union's most prominent test pilots the folkways and practices of their American counterparts in a manner calculated to send them home with indelible impressions. This might contribute at least marginally toward further accelerating the gathering forces for reform and democratization that are now under way in the Soviet Union. As two respected American policy experts have recently commented along these lines: "We should recognize that events in the Soviet Union present a historic window of opportunity. People in the Soviet Union have concluded that their society has failed. They believe that the economic and political democracies of the West have succeeded. They truly aspire to be a 'normal society.' They know that they do not fully understand what that means, or how it can be achieved. They believe that people in the West do know. They thus stand at a 'learning moment,' eagerly receptive to the lessons of Western experience in normal societies."[15]

Granted, the Soviet aviation community may not represent the most lucrative channel through which to nurture such a change in Soviet perceptions and incentives. Yet aviation professionals in both countries have long played a leading role in pioneering the development of closer Soviet-American relations aimed at enhancing mutual trust and understanding. The Apollo-Soyuz joint space-flight project conducted during the mid-1970s offers a particularly telling example in point. And the growing number of personal ties between Soviet and American aviators highlighted in this report has a clear precedent in the close and enduring bond established between U.S. Air Force Lieutenant General Thomas Stafford and Soviet cosmonaut Alexei Leonov as a result of the Apollo-Soyuz experience.

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know the Cold War is over and that the likelihood of a hot one is negligible before I would suggest lending a helping hand to as formidable an organization as the Mikoyan Design Bureau."

[15]Graham Allison and Robert Blackwill, "America's Stake in the Soviet Future," *Foreign Affairs*, Summer 1991, p. 94.

Even more important, it is evident to almost every Westerner who has participated directly in this process that the net effect of such opened doors on Soviet pilots, engineers, industry managers, and other aerospace professionals has been nothing short of revelation. A Soviet-American pilot exchange could only further contribute to such altered outlooks. Even if nothing else were gained by the United States from a technical or economic point of view, that in itself would serve an important national goal.

There remains the question of what "message" such an exchange might inadvertently telegraph to domestic critics of U.S. defense programs or to various allies. The Bush administration's concern on this score is both appropriate and understandable. Yet there is no reason why a flight exchange need be either high-profiled in a manner guaranteed to provoke such reactions or otherwise freighted with excessively symbolic expectations. This has not been a problem with the many other Soviet-American military-to-military interactions already carried out, including reciprocal visits to once-sensitive military installations in both countries. Such an exchange would need only to be initiated out of a clearly defined notion beforehand of why it makes sense from a national *policy* perspective—as opposed to merely from a "sounds like a great idea" viewpoint.

In this regard, strict reciprocity, at least in the initial stages, will probably be unavoidable. It is on this point that *Aviation Week* misspoke when it suggested, after managing editor David North's MiG-29 flight at Kubinka in January 1990, that simply because Mikoyan had now flown a Canadian fighter pilot, a RAND analyst, and an American aviation journalist, it was time for the American government to "reciprocate" by flying Menitskii and the chief test pilot of Sukhoi, Viktor Pugachev, in a front-line American fighter.[16] The motivation behind that proposal was undoubtedly well-intended. Yet this is not a sort of exchange that would have much chance of garnering any serious official support. A more seemly trade for an American F-16 or F-18 flight by Menitskii would be a flight in a Soviet MiG-29 by a comparably seasoned U.S. industry test pilot.[17] A simi-

[16]"Let the Soviets Fly U.S. Fighters," *Aviation Week and Space Technology*, February 26, 1990, p 9. The case for Pugachev was based on the fact that he had just given a front-seat flight at the Asian Aerospace '90 Air Show in Singapore to Air Marshal Ray Funnell, the chief of staff of the Royal Australian Air Force. On that event, see Colonel A. Andriushkov, "Australian Marshal Pilots the Su-27," *Krasnaia zvezda*, February 20, 1990.

[17]In fairness to the Soviet side, it bears noting that both Mikoyan and Sukhoi have expressed their readiness for such an exchange from the very beginning.

lar rule would apply, with possible variations among aircraft types, for an exchange between American and Soviet military pilots.

It is also important to keep clear the distinctions between and among the various categories of flight exchanges that might be contemplated. The most vocal and determined Soviet effort to seek a pilot exchange has emanated from the Ministry of Aviation Industry and from design-bureau test pilots. Yet the Soviet Air Force also maintains a serious interest in pursuing a pilot exchange.[18] When it comes to the question of military vs. civilian involvement in such arrangements, there is a tangle of mixed incentives, plausible rationales, desired outcomes, and potential liabilities on the American side that will need sorting out by the government in the course of settling on a comprehensive policy. Clearly, however, this is an issue that reaches beyond the narrow confines of the military-to-military relationship.

For that reason, there is a compelling case for considering separate rules to be applied to Soviet *military* pilots (both fighter pilots from operational units and test pilots from the military's flight test facility at Ramenskoye) and to *civilian* pilots attached to the Gromov Flight Research Institute (LII) and to fighter design bureaus like Mikoyan. The decision criteria that may be pertinent to one category may not be equally applicable to the others. Were a blanket veto arbitrarily applied without reference to these distinctions, opportunities that might otherwise yield worthwhile payoffs to the United States could be left to founder on the shoals of bureaucratic adherence to an inappropriate general rule.[19]

Furthermore, American policy with regard to flight authorizations and exchanges should appear to be consistent. It is one thing for the

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[18]The commander in chief of the Soviet Air Force, Colonel General Yevgeny Shaposhnikov, noted in an interview more than a year ago that many American pilots had expressed to him during a visit to the United States that they would welcome a chance to fly Soviet aircraft as a part of a military-to-military exchange. As for this possibility, he added that "we are conducting negotiations right now" and expressed his belief that "we will probably reach an agreement on reciprocal aircraft exchanges." Quoted in an interview by Yelena Agapova, "The Height of Flight," *Krasnaia zvezda*, January 27, 1990.

[19]There may be a valid argument that any civilian exchanges (such as between industry pilots and between government pilots working for NASA and LII) will have to take a back seat to a military exchange, since it has been within the military-to-military context where most of the planning, as well as the most heated controversy, has thus far taken place. On the other hand, the Soviet-American relationship has become such a fast-moving train at this writing that almost *any* pilot-exchange arrangement could conceivably come to fruition in the immediate future.

government to refuse, as a matter of principle, to fly experienced Soviet test pilots in current-generation American combat aircraft just because the Soviets have flown an American journalist, a corporate executive, and a RAND research analyst. It is more difficult, however, for the government to justify such a stance when, in other contexts, it has allowed a very different policy line to be pursued.

To cite a particularly notable example, during a week-long visit to the United States in February 1990 by a delegation from the Supreme Soviet's Committee on Defense and State Security, deputy committee chairman Valery Ochirov was given an "extended demonstration flight" in an AH-64 Apache attack helicopter while the delegation was visiting the headquarters of the U.S. Army's III Corps at Fort Hood, Texas.[20] Significantly, Ochirov is an active-duty Soviet Air Force colonel and an experienced helicopter pilot. He is also a Hero of the Soviet Union who served a much-heralded combat tour in Afghanistan. Likewise, in 1990 NASA administrator Richard Truly led an American delegation to the USSR to visit various research and operational facilities in response to a long-standing invitation from Soviet space officials. The two sides were said to be interested in flight exchanges between U.S. and Soviet personnel.[21] In light of apparent inconsistencies like these, it is not surprising that the American government has seemed to telegraph a mixed message to many Soviet audiences.

Finally, there is the question of what might be called basic attitude toward the flight-exchange issue on both sides. Those in the Soviet aerospace community who have campaigned most intently for such exchanges with the United States need to suspend their annoyance and injured pride long enough to understand that there are serious American interests that require reconciling before any such program can take place within the framework of a coherent national policy. By

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[20]This orientation flight was one of two agenda items added during the group's visit at the last minute "in response to special requests from Soviet delegates." Mark M. Lowenthal, *The New Soviet Legislature: Committee on Defense and State Security*, Report of the Committee on Armed Services, House of Representatives, 101st Congress, Second Session, April 11, 1990, p. 26. The Soviet delegation was being hosted in the United States by its nominal sister organization, the House Armed Services Committee, and specifically by the committee's chairman, Congressman Les Aspin.

[21]See "NASA Chief Leads Delegation to Soviet Union," *Soviet Aerospace and Technology*, October 22, 1990, p. 4. Relatedly, there has been a resurgent discussion of joint Soviet-American space flights as both governments have reportedly "moved gingerly in recent years to chip away at bureaucratic barriers to cooperative space activities." See Kathy Sawyer, "U.S.-Soviet Space Swap Revived as Summit Nears," *Washington Post*, June 30, 1990.

the same token, the American bureaucracy ought to have an interest in not appearing to be churlish or otherwise maladroit in its ad hoc posturing on this issue in the continued absence of a settled national policy. Such was the impression left when, upon learning of Menitskii's unauthorized flight with the Blue Angels at Kalamazoo in 1990, the Pentagon was prompted to issue an ostentatious ruling that Soviet pilots would henceforth not be allowed to fly in any U.S. aircraft and that no American military pilots would be permitted to accept offers to fly in Soviet aircraft.[22] It was even more palpably the effect generated by the subsequent explanatory comment of an unnamed White House spokesman that "it's not the signal we want to send to the Soviets just yet."[23]

As this issue continues to be adjudicated, the U.S. government could do worse than to adopt a proactive stance aimed at shaping, to its own advantage, the ongoing Soviet-American dialogue among aviation professionals. The alternative is a continuation of internal bureaucratic division and stolid temporizing that portrays at least parts of the American government as being still mired in the Cold War. Shortly after Menitskii's 1990 presentation to SETP, *Aviation Week* remarked in an editorial that Soviet pilots can be excused for wondering why they continue to be barred from flying in high-performance U.S. aircraft, when they have opened their own cockpits not only to Western analysts and journalists, but also to the most experienced American military and civilian test pilots. "As government officials struggle with the pros and cons," the editorial pointed out, "the issue of reciprocity could soon be outpaced by events. . . . Granted, all concerned should proceed cautiously to ensure that national interests—on both sides—remain consistent with the spirit of cooperation and new relationships. . . . However, those who stand in the way of such people-to-people progress definitely risk being overrun by events."[24]

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[22]Upon learning of this ruling, one American representative to the Soviet air show delegation was moved to say: "I think it's kind of sad. What started off as a breakthrough in Kalamazoo was treated as cold shoulders in Dayton." Quoted in "Pentagon Bans Soviets from Flying U.S. Aircraft," *Santa Monica Evening Outlook*, July 24, 1990. Another press account that missed the policy point completely but nonetheless put the government in a needlessly embarrassing light remarked: "There's a sort of youthful innocence about it. Boys and their toys. What's all the fuss about?" See "That's Far Enough," *Washington Times*, July 24, 1990. See also Gregory Vistica, "Washington Frowns on Blue Angels' Overture to Soviets," *San Diego Union*, July 21, 1990.

[23]Quoted on the CBS Evening News, July 22, 1990.

[24]"Breaking Down Barriers," *Aviation Week and Space Technology*, October 8, 1990, p. 9. To give several examples of such events, Menitskii was allowed to fly the Mirage III with the Swiss Air Force during a MiG-29 marketing tour at the time the Swiss government was considering buying some of the Soviet aircraft as a next-generation

Fortunately, with high-level military-to-military ties between the two countries continuing; fitful movement toward reform in Soviet domestic affairs showing resurgent progress; conventional and nuclear arms-reduction treaties completed and signed by the two countries; and a successful round of summitry recently concluded in London and Moscow between Presidents Bush and Gorbachev, the atmosphere for supporting such exchanges seems more conducive today than ever before. With the collapse of the Berlin Wall, the unification of Germany within NATO, and the dissolution of the Warsaw Pact, only diehards can deny that the Cold War is finally over. Perhaps most important, Moscow's unwavering support of UN resolution 678, which provided a major contribution to the allied coalition's successful campaign against Saddam Hussein in Operations Desert Shield and Desert Storm, heralds a more cooperative Soviet role in world affairs in the coming decade. In light of these developments, there is little prima facie reason any longer why a properly managed set of flight exchanges, as yet another benchmark of progress in the Soviet-American relationship, should remain obstructed by old habit patterns and reflexive bureaucratic resistance to change.

For such exchanges to yield the greatest benefit for the United States, it would be best if their symbolic import were pared down to realistic proportions and their payoff understood mainly in terms of their capacity to help stimulate a more trusting dialogue between aerospace professionals in the two countries. A helpful outlook toward this end was articulated by a Canadian reporter, Mark Rushton, after Major Wade's MiG-29 flight at Abbotsford in 1989, when he wrote of the genuine good will among Soviet and Western airmen that appeared to dominate the airfield during that period. He added: "It is possible that this air show will not strengthen the international situation and will not send us skipping through a flower-filled

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fighter. Relatedly, the chief of staff of the RAF, Air Chief Marshal Sir Peter Harding, was given a front-seat flight in the Su-27 at the 1990 Farnborough Air Show. Afterward, he said that his pilot, Viktor Pugachev, would be permitted to fly the Tornado or Harrier or "anything he wants." Citing his flight as "a real example of *glasnost*," he added: "Two years ago it could never have happened. We must ensure that the process continues" ("RAF Flies a Flanker," *Flight International*, September 19–25, 1990, pp. 42–43). I noted earlier the visit of six French Air Force Mirage F1s to Kubinka in June 1990, a flight-exchange event that was recently reciprocated when the Soviet Air Force's MiG-29 flight demonstration team, the *Strizhi* ("Swifts"), visited the French fighter base at Reims in May 1991. For more on these latter events, see Bernard Thouanel, "Des Mirages à Moscou," *Air Fan*, June 1991, pp. 35–39, and Christophe Levent, "Des MiG en Champagne," *Air Actualites*, June 1991, pp. 10–11. There is a gathering groundswell of such flight-exchange arrangements between the Soviet Union and the West that can only gain momentum, whatever the American government's official stand regarding them may be.

meadow hand in hand. But I firmly believe that it will damned well undermine the situation in which people sit on different sides of the fence and exchange political and ideological insults."[25]

A PERSONAL NOTE

Although this report has been, first and foremost, about a MiG-29 flight experience, one of the main byproduct lessons of that experience concerns the people who created and operate this aircraft. Until my contact with Menitskii at Farnborough and my subsequent access to Academician Belyakov and Dr. Zagainov, my sole first-hand experience with Soviet officialdom had been with foreign-policy specialists from the various research institutes of the Academy of Sciences whose main objective, at least throughout the Brezhnev era, seemed to be to harangue their Western interlocutors and to seek to score debating points in whatever dialogue that took place. By contrast, Menitskii and Belyakov struck me as practical people with a high regard for their own abilities and a strong determination to make things happen—even, if it had to be so, within a political system that severely stifled their initiative and creativity.

Rostislav Belyakov is a giant in the pantheon of Soviet aircraft designers. His tenure with the Mikoyan Design Bureau goes back to the 1940s, when he worked on the landing gear and flight control systems for the MiG-9 and MiG-15. He was the head of the engineering team that produced the MiG-21, and it was under his leadership that the MiG-23, the MiG-25, and the MiG-29 were developed.[26] If there is any Soviet counterpart to Lockheed's Kelly Johnson, the father of the F-104, the U-2, and the SR-71, it is surely Belyakov. Beyond his obvious engineering talents, he appears a man of considerable managerial ability and human warmth.

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[25]Quoted in Lazar I. Egenburg, chief aircraft designer, "On the Road to Confidence," *SShA: Ekonomika, Politika, Ideologiia*, No. 8, August 1990, p. 43. As this report goes to press, a news item has noted that Major General Gennady Shchitov, the deputy air commander for the Moscow Military District, recently flew a Royal Air Force Hawk jet trainer at RAF Finningley with the commandant of the RAF's Central Flying School, Air Commodore Bruce Latton. General Shchitov was visiting the United Kingdom to coordinate the upcoming Western debut of the Soviet Air Force's Su-27 aerobatic team at two RAF bases in September 1991. See "Russian Knights Meet RAF," *Flight International*, July 31–August 6, 1991, p. 32.

[26]A good, if cursory, overview of Academician Belyakov's career highlights during his long incumbency at Mikoyan is presented in Colonel General of Aviation A. N. Ponomarev, *Sovetskiye aviatsionnye konstruktory* (Soviet Aircraft Designers), 3rd edition, Moscow, Voenizdat, 1990, pp. 106–110.

Much the same can be said of Valery Menitskii. Everyone who has come into contact with him has described him as a fighter pilot's fighter pilot. He has consistently presented himself with self-assurance, a sense of humor, and unquestionable mastery of his material.[27] Even with due allowance for his exceptional flying experience and professional stature, he is light-years removed from the image common in some Western aviator circles of the Soviet fighter pilot as a stereotyped and largely unthinking automaton.

On this point, one could not cite a better testimonial than the following editorial comment by *Aviation Week* shortly after he became the first Soviet pilot to deliver a technical paper to SETP: "Menitskii proved he could hold his own among the best of his breed, confidently handling technical questions and displaying a warmth and wit that few had expected. . . . The feelings that 'this guy is one of us—same concerns and same approach to test flying'—were new ones for many of the attendees. Most had spent the bulk of their careers developing a war machine to counter the Soviet threat. Yet, on a personal level, Menitskii was clearly one of their own. He had become another professional ambassador, breaking down age-old barriers by interacting with peers who shared a common enthusiasm for flight."[28]

In the end, the Soviet government's authorization for the MiG-29 to be shown abroad and the Mikoyan Design Bureau's determination to establish itself as a credible institution in the eyes of the West were mainly responsible for the train of events that ultimately made my flight and those by other Westerners possible. These factors deserve

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[27]During a dinner with some A-7 pilots from the Colorado Air National Guard which I helped host at the Rockford Air Show in July 1990, Menitskii delivered himself of a story which I have since used regularly in my MiG-29 flight briefing to demonstrate the point that fighter pilots the world over represent a transnational personality type. The story involves an all-pilots meeting convened by the political officer of a Soviet fighter regiment. As Menitskii tells it, the political officer stands before the assembled pilots and, with hands on hips, says: "Comrade pilots, there is a disturbing trend afoot that causes me grave concern. It is well known that in third place next only to movie actors and rock stars, fighter pilots are the world's most vain, arrogant, self-important, boisterous, lecherous, hell-raising debauchers. Upon careful study, I have traced this deplorable state of affairs to three factors: Cigarettes, whiskey, and women. So in a spirit of communist morality and combat readiness, I urge each of you to face yourselves coldly, ask how each of these factors plays in your lives, and take appropriate measures to clean up your act." Whereupon a straight-laced deputy regimental commander stands up and replies: "Not so fast, comrade political officer! I have flown jets in this air force for 25 years. I have never smoked a single cigarette. I have never touched a drop of alcohol. I have never put my hands on the body of a single woman. I therefore take the strongest objection to your characterization of us." This prompts a young lieutenant in the back row to pipe up in a loud stage whisper: "Right. And it's people like him who are responsible for keeping us in third place!"

[28]"Breaking Down Barriers."

a lion's share of the credit as well for the unprecedentedly detailed reportage on the MiG-29 that this report and other Soviet and Western accounts cited throughout it have been able to provide. In a reflection on this turn of events shortly after the 1988 Farnborough Air Show, a British aerospace journal noted that the Soviets had shown no urge to claim their own superiority, but appeared to resent deeply any suggestion that their equipment was "no better than boilerplate standard."[29] The journal then added that the frankness and accessibility of the Mikoyan team at Farnborough seemed to emanate from "fierce pride in their product, confidence in its capabilities, and a transparent passion to have nothing but the truth written about it."

My own experience with Mikoyan's leaders throughout the past two years bears this out. They have been uniformly open in allowing me to learn from them about the MiG-29, in full awareness that any resultant analysis would be shared with a larger audience. In return for that solicitude, I have tried my best in this report to present my impressions of the MiG-29, without sentiment or prejudice, in terms that its designers and pilots will accept as objective and fair-minded.

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[29]"Glasnost on the Wing," *Flight International*, September 17, 1988, p. 1.

Appendix A

MEET THE MIG-29

The MiG-29 is a supersonic, all-weather air superiority fighter roughly in the same size and class category as the U.S. Navy's F-18 Hornet.[1] It is the latest operational product of the Mikoyan Design Bureau, an organization that has become synonymous with leading-edge fighter development in the USSR since the early 1940s.[2] Although the aircraft is capable of employing beyond-visual-range air-to-air weapons, its primary mission is typically described by Soviet sources as close-in aerial combat. The aircraft is also equipped with hardpoints for bombs and rocket packs and can perform ground-attack missions in a secondary role.

First flown on October 6, 1977, by the Mikoyan Design Bureau's then-chief test pilot, Alexander V. Fedotov, the MiG-29 was initially designated RAM-L by Western intelligence to denote the sequence in which it was first observed at the Ramenskoye flight test center.[3] The aircraft bears the NATO Air Standards Coordinating Committee designation of FULCRUM. According to a recent Soviet account, it entered series production in 1982.[4] The MiG-29 has been fully operational with the Soviet Air Force since 1985, with more than 500 aircraft having been delivered to various operating units to date.

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[1]In fact, the aircraft is somewhere in between the F-16 and F-18 in size and is regarded by Mikoyan's designers and pilots more as an F-16 than an F-18 counterpart. The avionics fraction for Soviet fighters is typically larger than that in the case of Western aircraft. This probably accounts for the bulk of the size and weight differential.

[2]Strictly speaking, the MiG-31 is the latest Mikoyan designator, but that aircraft is in fact a product improvement on the MiG-25, with a two-man crew, upgraded avionics, and a reduced top speed from Mach 3 to about Mach 2.5. The MiG-29 and developmental variations on it are currently the design bureau's most advanced products.

[3]At about the same time, the Sukhoi Su-25 FROGFOOT was designated RAM-J and the Sukhoi Su-27 FLANKER was labelled RAM-K. Fedotov, who also flew the first flight of the MiG-25, was a distinguished chief test pilot of the Mikoyan Design Bureau during the 1970s and early 1980s. He was killed in a routine test flight of a MiG-31 on April 4, 1984. Shortly thereafter, Fedotov was replaced as chief test pilot by Valery Menitskii. Menitskii was the second pilot to fly the MiG-29. A thoughtful reminiscence about Fedotov and the ironic circumstances that led to his death was recently offered in Vladimir Voronin, "An Angle of Attack Outside the Envelope," *Krylia rodiny*, July 1990, pp. 9–10.

[4]Viktor Bakurskii, "MiG-29," *Krylia rodiny*, March 1990, p. 20.

The MiG-29 is also the leading Soviet export fighter and is currently operated by the air arms of Germany, Yugoslavia, Poland, Bulgaria, Romania, India, North Korea, Syria, Iran, and Cuba.[5] It was the premier combat aircraft of Iraq's Air Force as well until Saddam Hussein lost most of his front-line fighters during Operation Desert Storm.[6]

The export flyaway cost of a MiG-29 has often been quoted by the Soviets at $20–22 million or more, which would not make it very competitive internationally with the slightly lower-priced F-16. One report, however, has noted that the aircraft was sold to the Indian Air Force at some one-third to one-half the cost of the IAF's less capable Mirage 2000s.[7] Evidently, as in the case of previous Soviet fighter exports for hard currency, the price sought for the MiG-29 by the Soviet government is probably more a function of political considerations than actual unit cost.[8]

The Mikoyan Design Bureau itself was founded in autumn 1939 by two young aviation engineers, Artem Mikoyan and Mikhail Gurevich, who at the time were on the technical staff of the design bureau of Nikolai Polikarpov. As prized students of Polikarpov, they were initially given their own advanced high-altitude development project. They then went independent as a separate design entity and chose the three-letter MiG designation (a contraction of Mikoyan and Gure-

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[5]I am not aware of any Soviet nickname for the aircraft other than simply *dvadtsat' devyaty* ("twenty-ninth"), which is how the designers and pilots refer to it. However, it is called *Baaz* (Falcon) by the Indian Air Force and *Lovac* (Hunter) by the Yugoslav Air Force. The UB variant, like all Soviet two-seat trainer versions of fighters, is colloquially called the *sparka* (literally, "paired"), in reference to the dual cockpit arrangement.

[6]Prior to the Gulf war's outbreak, the Iraqi Air Force was reported to have received some 48 MiG-29s, including 10 two-seat UBs with no radars and limited combat potential ("Paper Tigers?" *Flight International*, January 9–15, 1991, p. 20). Of the 33 confirmed air-to-air kills accomplished by USAF pilots during the war, five were MiG-29s. All were downed in the first two days of fighting by F-15Cs, the first four by AIM-7 missiles and the fifth by being forced to fly into the ground ("U.S. Air Force's 33TFW Eagles Top Gulf War Hit List," *Flight International*, April 24–30, 1991, p. 9). There was no serious Iraqi countermaneuvering reported in any of these engagements. The remaining MiG-29s that were not destroyed in their shelters by coalition air strikes fled to Iran, where they were (and remain) impounded by the Iranian government. Soviet commentators are on solid ground in insisting that the capabilities of the MiG-29 were in no way demonstrated by the way it was operated by the Iraqis.

[7]See Avinash Nigudker, "India's Fulcrums in Service," *Defence*, May 1988, p. 364.

[8]According to one report, India paid a low of $11 million apiece for its MiG-29s as a "privileged purchaser of Soviet weaponry," whereas Iraq was charged $28–29 million each for the same type of aircraft. See "Market Successes for the MiG-29," *Defense Electronics*, September 1988, p. 11.

vich), setting up shop on December 25, 1939, in the No. 1 Moscow *Osoaviakhim* Aircraft Plant.[9]

Over the decades since, the firm has steadily evolved into a closely knit organization in which senior management, the various design subgroups, and the flight test staff, under the leadership of Academician Belyakov, have come to work together almost as an extended family, with high morale and real pride in the company's product.[10] These individuals, collectively known as *Mikoyanovtsy* (or *Migovtsy*), command a special place in the Soviet aviation industry. In December 1989, the bureau celebrated its 50th anniversary at a ceremony held in the Kremlin's Palace of Congresses.[11]

DIMENSIONS AND PERFORMANCE SPECIFICS

The MiG-29 has a wingspan of 37 ft, a length of 57 ft, a tail height of 16 ft, and a wheelbase of 10 ft (see Fig. 30). According to information provided in a Mikoyan marketing handout, the aircraft has a normal takeoff gross weight of 33,000 lb and a maximum takeoff weight of 39,000 lb.[12] In the latter configuration, it carries a semi-conformal centerline fuel tank and two pylon-mounted external wing tanks in addition to a nominal weapons load.

The aircraft is powered by two Isotov RD-33 turbofan engines developed in the Klimov Design Bureau.[13] Each engine is capable of

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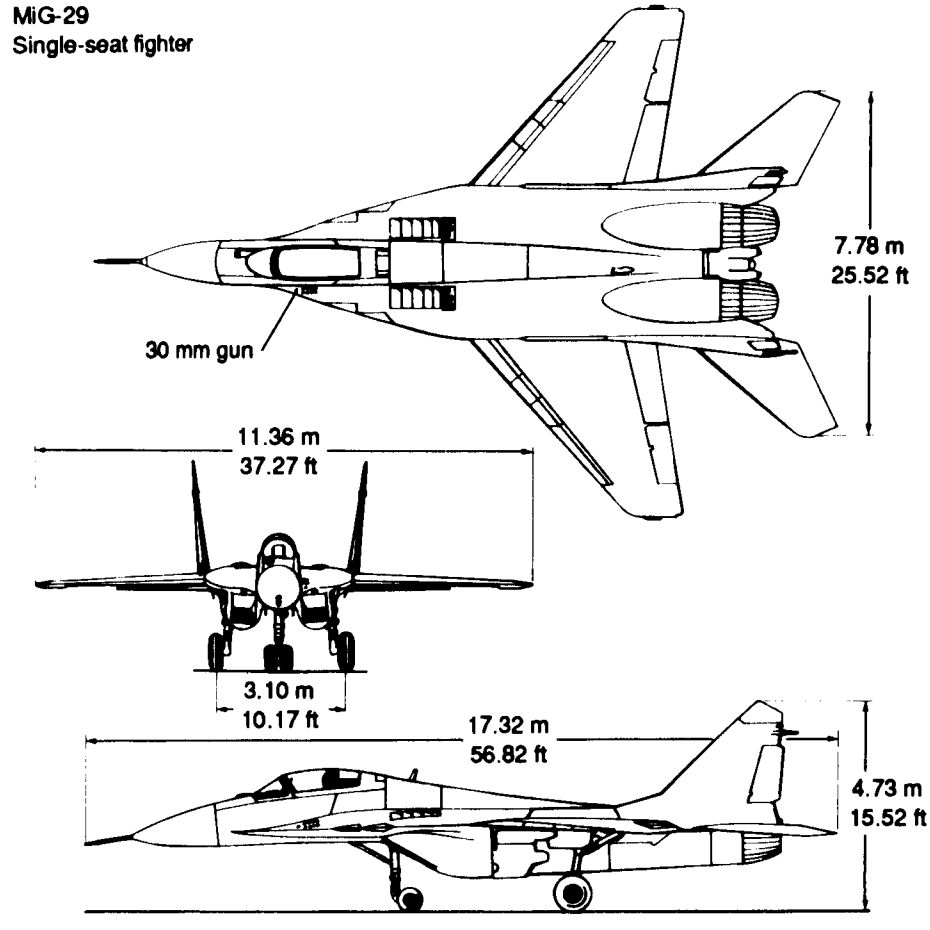
[9]By a convenient coincidence, the word *mig* in Russian means "instant" (for example, *v odin mig*, or "in a twinkling"). It is used in common parlance to denote speed.

[10]"Firm" is a term of art used in Soviet aviation circles to describe a design bureau. It does not denote a business enterprise as it is understood in the West. For further discussion of the Mikoyan Design Bureau and a well-researched history of the MiG fighter series, see Piotr Butkowski, with Jay Miller, *OKB MiG: A History of the Design Bureau and Its Aircraft*, Midland County Publications, Leicester, 1991.

[11]The design bureau has issued a commemorative 50th anniversary report that is replete with inside information on the firm's history, products, and personnel. See Anatoly A. Belosvet, ed., *OKB imeni Artema Ivanovicha Mikoyana: 50 let*, Moscow, Vneshtorgizdat, 1989.

[12]*Mikoyan Design Bureau MiG-29*, Vneshtorgizdat, Moscow, 1988. The present section and the one that follows both draw heavily on material provided to me by a British aviation journalist, Jon Lake, who interviewed Belyakov and other members of the Mikoyan delegation at length during the 1988 Farnborough Air Show.

[13]Representatives of the engine's design bureau who attended the 1990 Farnborough Air Show stated that the RD-33 has a bypass ratio of 0.55, an engine pressure ratio of 23, and an airflow capacity of 73 kg/sec. The afterburner is reportedly ignited by a hot streak of fuel through the turbine section (Reuben F. Johnson, informal trip report, August 25, 1990, p. 40). Westerners who have visited the MiG-29 production line in Moscow have also reported that the RD-33 appears to have only hydromechanical controls, with no indication of electronic engine controls.



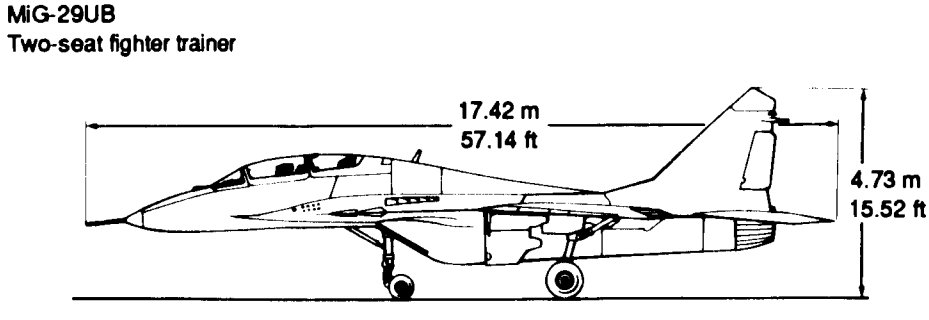


Fig. 30—MiG-29 and MiG-29UB Three-View Drawing

delivering 18,200 lb of sea-level static thrust in full afterburner.[14] This makes for a takeoff thrust-to-weight ratio of better than 1:1 with the aircraft in clean configuration with a full air-to-air missile loadout. It also permits a takeoff roll of less than 1000 ft and a maximum initial sea-level climb rate in excess of 65,000 ft/min. With the aid of a drag chute mounted in a canister between the engine tailpipes and an anti-skid brake system, the aircraft can accomplish a full-stop landing in less than 2500 ft on a dry runway.

The MiG-29 does not feature a fuselage as such. Rather, the aircraft consists of an integrated wing and forward airframe section coupled to two slung engine pods with dual vertical stabilizers, loosely comparable to the layout of the U.S. Navy's F-14. Extensive use is made of composite materials, particularly in the control surfaces and vertical tails.[15] The inboard sections of the wings contain internal fuel tanks. The wings also feature thick-chord leading edges with full-span automatic maneuvering flaps. The latter incorporate a slight underside camber to enhance lateral stability at high angles of attack.

Pre-IOC prototype modifications included eliminating the ventral fins under each horizontal stabilizer (initially installed as added insurance for lateral stability) and moving the nose landing gear several feet back. All but the earliest production aircraft have rudders with some three inches of extended chord aft of the vertical stabilizer trailing edge. This post-IOC improvement was evidently made to provide increased rudder authority at high angles of attack. A later variant of the aircraft has a hump-backed configuration, much like the F-18, to provide increased fuel capacity or additional avionics space.[16]

Service ceiling of the MiG-29 (the maximum altitude at which the aircraft can sustain level flight) is 56,000 ft. The aircraft has a maximum indicated airspeed of 800-plus knots, is redlined at Mach 2.34,

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[14]The articulating engine nozzles incorporate two concentric rings of titanium tailfeathers, between which engine bypass air is possibly channeled to help reduce the infrared signature of the exhaust gas.

[15]Seven percent of the aircraft's overall empty weight is made of composite materials. See Richard DeMeis, "Aerospace Glasnost," *Aerospace America*, January 1989, p. 23.

[16]See "Fulcrum Charlie Leaves East Germany," *Flight International*, December 5–11, 1990, for a photograph of a MiG-29 with this new dorsal-hump configuration. The aircraft, which was spotted outside its shelter at Finow Air Base just before the Soviet Air Force's withdrawal from East Germany, was armed with two AA-10 and two AA-11 air-to-air missiles.

and is cleared for maneuvering out to 9.5 g.[17] It can also attain a speed of Mach 1.1 at sea level. This low-level dash capability, according to Mikoyan spokesmen, is slightly less than that of the MiG-23.

The MiG-29 has a maximum cruise range of 1130 nmi.[18] Internal fuel capacity is reported to be only 1153 gallons (6600 lb), and the aircraft is not equipped with any provision for inflight refueling.[19] This is a low fuel capacity for a twin-engine fighter. It contrasts markedly with that of the Su-27, which carries over 20,000 lb of internal fuel—although the long-range intercept mission of the latter aircraft places a higher premium on endurance.[20]

Tacit indication of the MiG-29's range limitation was offered in Anatoly Kvochur's statement at Farnborough in 1988 that his flight demonstration, which lasted three and a half minutes (mostly in afterburner), was flown with 75 percent internal fuel. That amount, he said, would permit completion of the show with sufficient remaining fuel to allow a diversion to an alternate airfield 100 km away if

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[17]The MiG-29 does not have a g-limiter, and it is possible to exceed maximum allowable g simply by pulling excessively on the control column at airspeeds above corner velocity. A Mikoyan representative told me that the aircraft is capable of experiencing up to 12 g without damage to the aircraft structure. In response to a question from the floor at the 1990 SETP symposium, Menitskii stated that the MiG-29 is the only fighter in the world cleared to 9 g at takeoff weight. A group of RAF officers who visited Kubinka in the summer of 1989 were told by Soviet Air Force briefers there that the maximum permissible load factor is reduced to 8 g when all six weapons stations are armed with missiles, and to an unspecified level with fuel remaining in the centerline tank. (On this point, Kevin Dwyer of General Dynamics notes that the F-16 in clean configuration with six air-to-air missiles has always been cleared to 9 g at takeoff weight.)

[18]Presumably this is in clean configuration. Major Wade stated that the airspace reservation filed by the MiG-29s when he escorted them from Elmendorf to Abbotsford was for a 1250-nmi routing, which would have put them at the outer edge of their range capability even with the three external tanks they were carrying (about half the size of an F-18's pylon tanks, with an apparent capacity of only around 1000 lb of fuel). As added evidence, Major Wade noted that the MiG-29s initiated a cruise climb 350 nmi out of Abbotsford from Flight Level 370 through 390 and 410, ending up at FL 430 prior to their en route descent into Abbotsford.

[19]During a May 1990 visit to Mikoyan by a group from General Dynamics, test pilot Kevin Dwyer was told that a probe-and-drogue refueling capability was being investigated in connection with the naval variant of the MiG-29. There is no evidence, however, of any plans to retrofit Soviet Air Force or export versions of the MiG-29 with such a capability.

[20]The Su-27 has a reported unrefueled range of 2500 nmi on internal fuel. This dispenses with the need for external tanks, and the aircraft lacks any provision for external fuel carriage. See "Gallery of Soviet Aerospace Weapons," *Air Force Magazine*, March 1990, p. 74.

necessary.[21] This suggests that the aircraft has little combat endurance and would most likely not be utilized on escort missions or offensive fighter sweeps.[22]

AVIONICS AND ARMAMENT

The MiG-29 single-seater mounts an NO-193 coherent pulse-doppler air-intercept (AI) radar with a forward-hemisphere lookdown/shoot-down capability. This system can reportedly detect a fighter-sized target out to 54 nmi.[23] The radar is coupled with an infrared search and track system (IRSTS) collimated with a laser rangefinder and helmet-mounted sight for off-boresight aiming of weapons.[24] The aircraft is also equipped with the Sirena III radar warning system.

As in the case of Western AI radars, a dummy load can be fed into the MiG-29's radar by the pilot's selecting a standby mode to prevent the radar from emitting. If the IRSTS is blinded when the aircraft enters a cloud bank, the radar will automatically switch to the transmit mode, unless preinhibited, by means of a cue provided by the IRSTS cloud sensor. The radar is automatically slaved to the IRSTS even when it is not transmitting.

A group of RAF officers who visited Kubinka in the summer of 1989 were told by their Soviet hosts that the MiG-29's radar has a track-while-scan capability with an autoprioritization feature and can simultaneously track up to ten targets.[25] The radar is backed up by the IRSTS and the laser rangefinder. With this combination, the MiG-29 can run a passive intercept against a target, in accordance

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[21]"MiG Impresses Western Observers," *Flight International*, September 17, 1988, p. 6.

[22]See "Gallery of Soviet Aerospace Weapons," *Air Force Magazine*, March 1989, pp. 90–91. Both the single-seater and the UB took on the same amount of fuel during their return stopover from the Abbotsford Air Show at Elmendorf AFB, Alaska, in August 1989. This would seem to indicate that some sacrifice other than fuel, perhaps in avionics, was made in order to accommodate the second cockpit.

[23]The German Air Force's recent experience with the MiG-29 has confirmed this. The two-seat MiG-29UB carries a range-only radar and accordingly has limited applicability for advanced tactical training. It is probably used in Soviet Air Force squadrons mainly for transition training and such related functions as instrument and proficiency checks. According to former East German pilots, the UB was built without a radar so that it would have the same handling characteristics as the single-seater. It is, however, fitted with the IRSTS, laser rangefinder, and radar warning receiver.

[24]The last American fighters to be equipped with an IRSTS were the USAF's F-106 and the Navy's F-8 of 1950s vintage.

[25]Trip notes provided by Group Captain Andrew Vallance, Director of Defense Studies, RAF Staff College, Bracknell, August 1989.

with Soviet tactical employment doctrine, with its radar in standby and the pilot following close-control vectors from GCI or data link. Using the IRSTS to help achieve the initial setup, the pilot can wait to activate his radar until he approaches weapons parameters. How effectively this may work in practice depends heavily on the extent to which the aircraft's IR sensor can provide the pilot accurate target tracking data in a tactical environment.[26]

Principal air-to-air armament on the MiG-29 consists of an internal GSh-30 single-barrel 30mm cannon mounted in the left wing root leading-edge extension and up to six AA-10 ALAMO (Soviet designator R-27R) and AA-11 ARCHER (R-73) air-to-air missiles. The aircraft is also capable of carrying the AA-8 APHID (R-60) and AA-9 AMOS missiles.[27] For air-to-ground missions, the aircraft can carry bombs and pod packs of 57mm, 80mm, or 240mm unguided rockets.

During the RAF visit to Kubinka in 1989 noted above, Soviet briefers quoted the AA-10 semiactive radar homing missile as having a maximum launch range of 60 km head-on and 20 km in the stern, and minimum ranges (presumably in its infrared variant) of 3–5 km head-on and 500 meters astern.[28] The fire control system was described as having an effective weapons-employment capability against targets up to 10,000 meters above the MiG-29's altitude (in a high-speed, front-quarter snap-up launch) and 6000 meters below it. The Soviets added that the AA-8 can be launched at more than 8 g and is capable of being fired off-boresight by means of the helmet-mounted sight. They further noted that the gun weighs 42–45 kg (which is extremely light), is capable of firing 1800 rounds/min, and carries a total of 150 rounds.

The chief designer of the MiG-29, Mikhail Waldenberg, has stated that the gun is so accurate when coupled with the laser rangefinder that were he to redesign the aircraft, he could comfortably halve the number of cannon rounds carried.[29] He has added that the fire

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[26]As a rule, current-generation IRST systems are said to be capable of providing at least rough range estimates, but they lack sufficient sensitivity to permit precise ranging. See Francis Tusa, "Europeans Suffer Stealth Sticker Shock Syndrome," *Armed Forces Journal International*, February 1991, p. 24.

[27]A commonly observed air-to-air loadout has been two AA-10s on the inboard wing pylons and four AA-8s on the intermediate and outboard pylons.

[28]For additional details, see "AA-10 Alamo Missile in Close-Up," *Jane's Defense Weekly*, July 25, 1987, pp. 145–146.

[29]That is quite a claim. General Designer Belyakov was quoted at Farnborough as having said that the ammunition canister holds 250 rounds, in contrast to the 150 rounds attributed above by a Soviet Air Force briefer (Ivan Ozero, "Fulcrum Focus," *Aircraft Illustrated*, December 1988, p. 662). Either number, however, is very small,

control system has good computer algorithms and uses the IRSTS for precise angle-tracking and the laser to provide range information. "It is much, much more precise than radar," he observes. The radar, IRSTS/laser rangefinder, and helmet-mounted sight can work independently but are normally linked by the fire control computer to the HUD, which provides displays for all three systems.[30]

The tail fin leading-edge extensions contain dispensers for upward-ejecting chaff and flares and were not a part of the original design. According to Waldenberg, they were added later in response to a Soviet Air Force requirement for this capability. They serve no aerodynamic purpose and no aerodynamic penalty is exacted by them. Since there is no requirement for this feature on the trainer, they have been deleted from the UB version. The sequencer for ejecting chaff and flares is located in the fairing behind the cockpit.

How effective in practice all of this equipment may be obviously cannot be established with any confidence by the sort of anecdotal evidence cited above. It may be worth noting, however, that Mikoyan's pilots reportedly admitted at Farnborough in 1988 to continued problems with the avionics and weapons integration on the MiG-29.[31] Other Mikoyan representatives have likewise conceded freely, including at RAND in November 1989, that avionics packaging and integration remain one of the great weaknesses of the Soviet fighter development community.

DISTINCTIVE FEATURES

During my initial hands-on exposure to the MiG-29 at Farnborough in 1988, as noted earlier, the aircraft was parked next to the U.S. F-16 demonstrator on the flight operations ramp. I immediately did several slow figure-eights around the two aircraft in close succession

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and *half* of either would appear to be cutting things quite closely. As Kevin Dwyer pointed out in commenting on an earlier draft of this report, the weakness of Mikoyan's case for fewer gun rounds lies in weapon aiming: "The fire-control system, IRSTS, radar, laser range finder, helmet-mounted sight, HUD, and pilot may all know exactly where the target is, but the pilot still has to fly the aiming symbol to the target and squeeze the trigger at the right time. Moving targets, especially jinking targets, make aiming and timely firing even more difficult. And since cannon shells are still unguided, a larger pattern/longer burst will improve the probability of getting hits from a well-aimed firing pass" (personal letter, January 7, 1991).

[30]"MiG Impresses Western Observers," *Flight International*, September 17, 1988, pp. 6–7.

[31]See "MiG-29 Cockpit Contains Fewer Advanced Features Than F/A-18," *Aviation Week and Space Technology*, September 19, 1989, p. 32.

in an attempt to conduct some first-impression "comparison shopping."[32] In the process, I was struck by the creative blend of innovative and traditional design features, often with a distinctive Soviet flavor.

The first contrast that caught my eye was the wide disparity in workmanship and apparent manufacturing quality between the two aircraft. The F-16 was notable for its exceptional cleanness of finish and tightness of fit along its skin joints and access panels. The MiG-29's exterior, by contrast, showed a surprising crudeness, including what Jeremy Wooding of British Aerospace, who accompanied me, characterized as "agricultural-quality" rudder actuators (see Fig. 31); exposed rivet heads throughout the aft part of the airframe; evidence of spot-welding in places; skin bulges where internal plumbing was simply built over after the fact; and enough skin rippling over the entire aircraft to suggest that the various hatches, panels, and other aerodynamic surfaces were almost literally pounded together by a team of garage mechanics with ball-peen hammers (see Fig. 32).[33]

This brute-force approach was further evident in the absence of any serious concern for the form drag created by such protuberances as wingtip navigation lights and RWR antennas. Two massive aileron actuator hinges, each the size of a man's elbow, simply hung out into the slipstream. One would think that this would exact a significant parasite drag penalty, especially at higher Mach numbers. The aircraft also featured hand-adjustable trim tabs on the ailerons to permit manual rigging adjustments as required.

In fairness to the MiG-29's designers, one can overstate the importance of these apparent shortfalls in manufacturing elegance. As has always been the case in Soviet fighter design, the MiG-29 has been built first for simplicity, reliability, and ease of maintenance by conscripts with limited technical training. This philosophy, which has long

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[32]There had been a published report a month prior to Farnborough that the Soviets would probably be bringing sanitized aircraft with some key operational equipment removed ("MiG Pilots Reconnoiter UK," *Flight International*, August 13, 1988, p. 17). Whether or not the aircraft had their radar and ECM gear removed, both the single-seater and the UB did come equipped with the IRSTS dome and sensor installed, along with the radar warning antennas.

[33]Reuben F. Johnson, who accompanied a General Dynamics group on a tour of the MiG-29 production plant in Moscow in May 1990, has observed in this regard that "the MiG-29 is basically a 'cut-to-size and file/pound-to-fit' airplane. Each aircraft on the assembly line has to be assembled with almost the same depth of labor-intensive handiwork as the original prototypes. With the exception of the canopies and a few other parts, the concept of interchangeability is all but unknown to the MiG-29 production line" (informal trip report, August 6, 1990, p. 226).

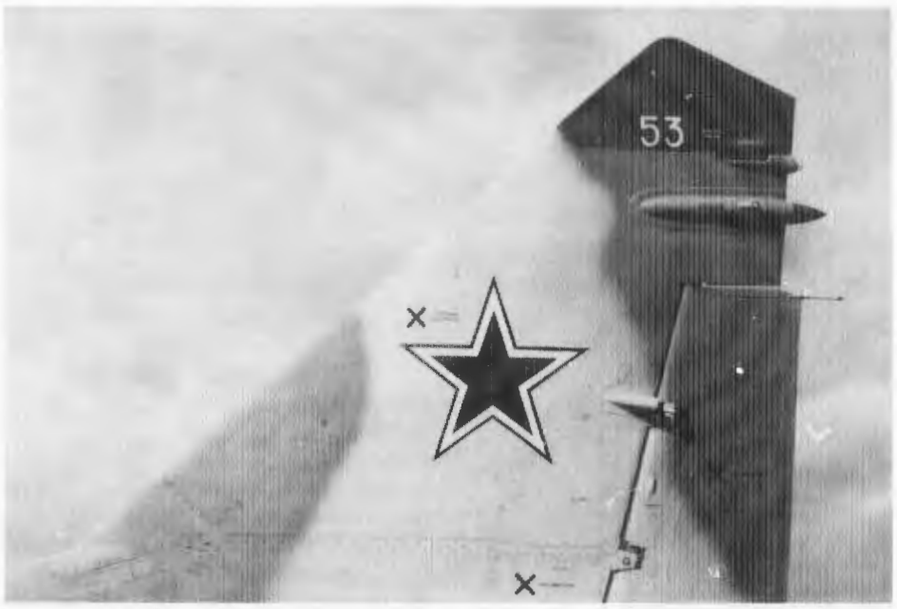

Fig. 31—MiG-29 Vertical Stabilizer with Extended-Chord Rudder. Note Large Exposed Rudder Actuator Hinge and Rear-Hemisphere Threat Warning Antennas

characterized Soviet aircraft construction, was reflected, perhaps unconsciously, in a response by Menitskii to a query at the British Aerospace dinner at Farnborough where we first met. One of the Red Arrows pilots asked him why the designers did not provide aerodynamic fairings over the aircraft's control-surface actuators. "Who needs them?" replied Menitskii. "Just look at our performance."[34] The designers simply offset the resultant drag penalty with more thrust.

[34]Menitskii's point is hard to dispute. As John Farley noted in commenting on an earlier draft of this report, "the 'agricultural engineering' comments of our Western friends say more about them than about Russian engineering. We traditionally over-engineer and over-specify some parts of our aircraft. . . . Indeed, it has been the norm for so long that when somebody tries to break out from it, the ignorant are aghast and think something is wrong. An example would be our Hawk rear fuselage, where, because of the thickening boundary layer (which every aircraft has), we saw no point in flush riveting. Let's have some nice dome-head jobs, we said, they will be simpler, cheaper in manufacture, lighter because we can use thinner skin and stronger for fatigue into the bargain. When it was rolled out, you should have heard the derogatory remarks of those who did not understand" (personal letter, April 21, 1991). In his technical review of this report, my colleague Jack Craigie offered a related observation: "The difference in workmanship between the MiG-29 and the F-16 reminds me of an air show I attended at Wright-Patterson Air Force Base in the late 1940s. Our P-80

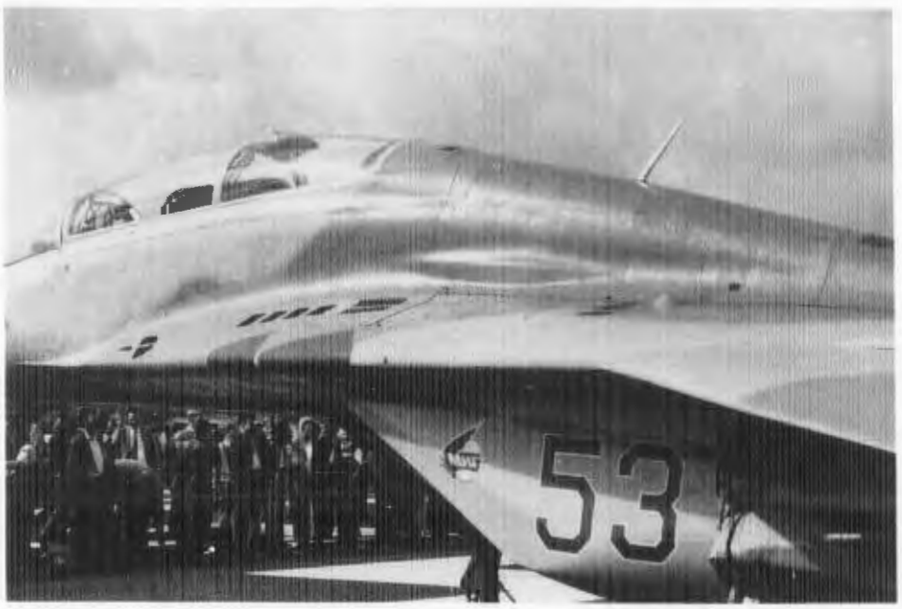

Fig. 32—MiG-29UB at Farnborough Showing Fuselage Bulge and Rough Finish of Aerodynamic Surfaces

Elsewhere on the MiG-29, Mikoyan has been highly attentive to engineering fineness when it has been essential to the aircraft's performance. The multisegmented inlet ramp, for example, is a complex system which constantly moves to control airflow and the inlet shock wave during airspeed transitions in the transonic and supersonic region. This largely accounts for the higher end-speed capability of the MiG-29 (Mach 2.3) compared to that of the F-18 (Mach 1.8) and the F-16 (Mach 2), both of which are equipped with fixed inlets. There are also refined design features on the inlet lips and other aerodynamically critical parts of the aircraft.

Another notable characteristic is the air intake foreign-object damage (FOD) prevention system. This entails hydraulically actuated inlet doors which automatically cycle shut once the engines are started and the AC generators come on the line, at which time spring-loaded suck-in louvers atop the wing root leading edge extensions open. This

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and the German Me-262 could be compared in exactly the same way.... The early P-80s actually had a lacquered finish, whereas I recall the impression that if I ran my hand across the Me-262 I would have drawn blood. Our performance margin? Nada!"

allows the engines to breathe adequately with the inlet doors closed all the way from idle power through the full afterburner range (see Fig. 33). The doors remain closed throughout taxi and takeoff until weight comes off the nose gear during rotation, at which time the louvers close and the inlet doors cycle open. During landing, the anti-FOD ramps close again as soon as weight on wheels occurs, and then reopen once AC power is lost during engine shutdown.[35]

In contrast to U.S. military practice, which traditionally has been to secure the operating environment around the aircraft from FOD, the Soviets have apparently chosen, at least with this generation of fighters, to make the aircraft inherently FOD-proof by means of the inlet doors.[36] The Soviets are not nearly as fastidious as the U.S. military is with regard to debris on runways, taxiways, and ramps. The accompanying Mikoyan maintenance personnel, for example, showed no concern about conducting a FOD walkaround when the two MiG-29s cycled through Elmendorf AFB in August 1989.

Anatoly Kvochur remarked to a reporter at Farnborough in 1988 that the inlet doors are not essential to the aircraft's effective operation, but were incorporated into the design from the outset because the development team wanted to leave no chance for FOD ingestion during ground operations. "The doors do not affect engine handling at all," Kvochur said. "You can go from zero to full thrust, or full to zero with the doors open or closed. It's no problem." Mikoyan pilots have indicated that the doors can fail to the closed position in flight with no threat to safety. One would think that a route abort would be recommended were this to occur during an operational mission, however, considering the reduced inlet efficiency that such a failure would

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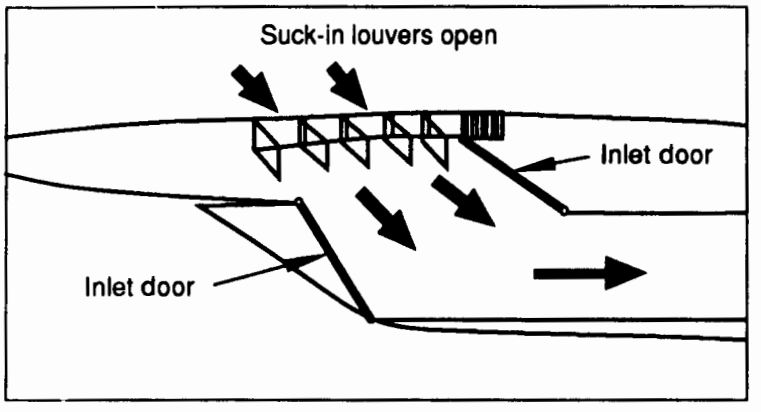
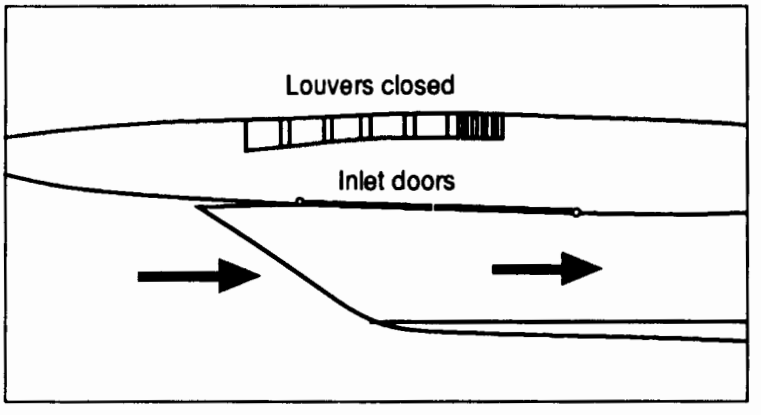
[35]Several Soviet press articles have reported that the MiG-29's inlet doors are actuated by a weight-on-wheels sensor (see, for example, "Our Arsenal: The MiG-29 Fighter," *Sovetskii voin*, Illustrated Supplement, No. 1, 1989, p. 8, which states that the doors operate as a function of nosewheel contact with the runway). However, in his account of his flight in the MiG-29UB at Farnborough in September 1990, John Farley ("Supreme Soviet," *Flight International*, October 10, 1990, p. 37) said he was briefed that the doors would open fully on an airspeed signal at 200 km/hr (108 kts). He also said that they would cycle through various positions while in flight during low and medium airspeed transitions, and he suggested that this probably had a bearing on the aircraft's smooth engine response at high angles of attack. It bears noting, though, that the navalized MiG-29 lacks the wing-root louvers and inlet doors of the standard production version. At a minimum, this would seem to indicate that the returns are not yet in on how this unique design feature is intended to operate.

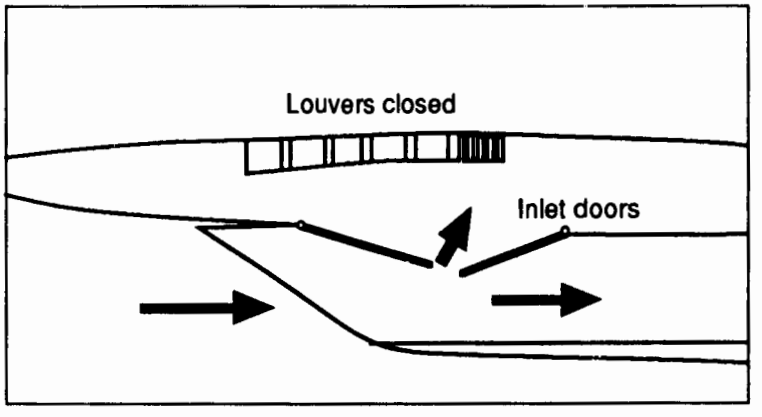
[36]The Su-27 has a similar arrangement, only with internal inlet screens rather than doors and leading-edge extension louvers.



A. During ground operations



B. During normal flight



C. During supersonic flight

Fig. 33—MiG-29 Air Intake Operating Modes

create at higher Mach numbers and at low speeds and high angles of attack.[37]

It is doubtful that the MiG-29 was ever seriously intended to be operated from dirt or gravel airstrips, as some Western articles have reported. Working from battle-damaged runways, however, can definitely present a debris ingestion problem, and the MiG-29's inlets are situated fairly close to the ground. On this point, Kvochur cited the example of two aircraft making takeoffs at close interval and the danger of dirt or rocks being blown into an inlet of the trailing aircraft as a typical justification for having incorporated the inlet doors.

The camouflage scheme employed on the aircraft is novel to the MiG-29 and has not appeared elsewhere, either on previous or current Soviet fighters. The two-tone gray paint finish is semi-glossy. This imparts what would seem to be an undesirable tendency for it to throw off a sun glint in some lighting conditions. On the plus side, the color pattern appears to change to a mottled gray-green appearance under light variations. It can also present false cues regarding the aircraft's nose position when viewed from certain aspect angles. This may be an intended design feature. The overall result is almost certainly an effective air-to-air camouflage arrangement.

GROUND SERVICING

Like the MiG-23, the MiG-29 is equipped with a NATO-compatible single-point refuelling port in the left main landing gear well. Presumably this feature was provided to enable the aircraft to be serviced at a NATO fighter base that had been overrun or captured intact during a war, without the need to await the arrival of Soviet ground-support equipment. USAF maintenance technicians who assisted the Soviets in turning the aircraft at Elmendorf AFB during its two stopovers en route to and from the Abbotsford Air Show in August 1989 noted that the MiG-29's hydraulic fittings were also identical to those of U.S. fighters and that the aircraft had similar electrical power requirements, although its DC bus operated on

[37]In an interview shortly before the 1988 Farnborough Air Show, Menitskii observed that even if an engine fails in the MiG-29, "air combat can be continued in most cases" (*Krylia rodiny*, October 1988, pp. 32–35). This is hard to understand unless he is referring to a "no way out otherwise" situation. It would be dicey enough to press willingly into a maneuvering fight even with an empty external tank that could not be jettisoned. To enter such an engagement with the degraded thrust that would result from an engine out would make sense only as a desperation tactic against a high-priority target.

27VDC as opposed to 28VDC, as in the American case. The MiG-29 uses gaseous rather than liquid oxygen and was serviced at Elmendorf with a small portable tank.

Not only the single-point refuelling port but all other essential servicing needs of the MiG-29 proved to be compatible with U.S. ground support equipment. This included the communications headset to enable the crew chief to talk to the pilot; the ground power cart employed to supply electrical power to the aircraft's AC and DC bus; and the air compressor used to charge the aircraft's engine start accumulators (which were filled to 1500 psi).

Other observed features of the aircraft, however, raised questions about how fast it could be turned in a combat setting. For example, the wheels and tires did not appear to be designed with a rapid change in mind. Similarly, the many access panels along the forward sides of the nose section, as well as the refuelling supervisory panels, were mounted with Nelson-type fasteners, which require a half-turn with a screwdriver to open or close. The large number of these fasteners on each panel indicated that ground maintenance technicians may not be readily able to pull and replace a failed LRU after engine start in sufficient time to assure an on-time scheduled takeoff.

Finally, notwithstanding its single-point refuelling feature for the fuselage tanks, the MiG-29's servicing procedures observed at Elmendorf appeared to experienced USAF maintenance supervisors to be reminiscent of practices that went out of fashion on U.S. fighters in the late 1950s. If these reflect current Soviet Air Force practice, they revealed that it would take some 35 min to fully refuel the aircraft, as opposed to about 12 min for a U.S. fighter. The external drop tanks, for example, had to be separately refuelled over the wing, and the internal wing tanks had to be filled through separate single points that required at least three nozzle reconnections. Furthermore, there appeared to be no way the aircraft could be hot-refuelled with the engines running, and no way it could be combat-turned in much less than an hour, even if weapons were simultaneously uploaded during servicing.[38]

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[38]Corroborating evidence for this assessment may have been provided by the fascinated reaction of onlooking Soviet Air Force maintenance technicians to the way the RAF's Red Arrows ground crews refuelled and prepared their ten Hawks for flight in 45 minutes during a goodwill visit by the flight demonstration team to the USSR. "That would take us three hours," said one of the Soviet crew chiefs. See Mike Gaines, "Soviets See Reds," *Flight International*, August 29, 1990, p. 31.

HANDLING AND HIGH-ANGLE-OF-ATTACK CHARACTERISTICS

The MiG-29 has been designed with excellent stability and control characteristics. Much like the hard-wing F-4, the earlier MiG-23 was highly susceptible to entering a spin out of a poststall gyration. This required the pilot to concentrate a large portion of his attention toward scrupulously applying the proper control inputs during maneuvering engagements at high angles of attack. With the more forgiving MiG-29, as in the case of the F-15, the pilot is now free to devote that attention entirely toward employing his aircraft and weapons effectively and aggressively, without fear of losing control in the high-alpha (AOA) regime.

Menitskii has stated that several MiG-29 prototypes were lost to nonrecoverable departures from controlled flight during the early phases of the program before the commencement of full stall and spin testing. Subsequent departure-region testing showed that the aircraft experienced aileron reversal effects above 25 degrees AOA. This problem was explored by means of a test routine to determine maximum allowable rolling AOA. The test technique consisted of moving the control stick laterally to a predetermined position and then pulling it fully aft and maintaining that input to the point of stall or spin entry.[39] Once maximum permissible AOA was established in this manner, a mechanical stall prevention system was developed for incorporation on the production aircraft.[40]

A related modification intended to enhance departure resistance at high AOA was the installation of an arrowhead-shaped vortex

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[39]Valery E. Menitskii, "MiG-29 Prototype and Development Flight Tests: General Overview and High Angle of Attack Investigation," *1990 Report to the Aerospace Profession: Proceedings of the Thirty-Fourth Annual Symposium*, Lancaster, California, Society of Experimental Test Pilots, 1990, p. 220. See also William B. Scott, "Menitskii Briefs SETP Meeting on MiG-29 Flight Test Techniques," *Aviation Week and Space Technology*, October 8, 1990, p. 77. In an earlier discussion of the Mikoyan approach to lateral control assessment during a conference on aircraft design practices which he attended at the University of Michigan, Menitskii indicated that this test routine allows the aircraft to continue rolling while AOA builds up, and that the rolling eventually slows down and reverses direction as aileron authority decays. "After 40 seconds of this," he added, "the pilot looks forward to departure." Presentation at the Aeronautical Design Symposium, Department of Aerospace Engineering, University of Michigan, November 2, 1988.

[40]In an interview shortly before the 1988 Farnborough Air Show, Menitskii described this system as incorporating a "stick kicker (*ottalkivatel-storozh*) which works to prevent the attainment of excessive angles of attack.... If the pilot overrides the kicker, the aircraft can assume large angles." Interview with Yevgenii Pavlov, *Krylia rodiny*, October 1988, pp. 32–35.

generator alongside the pitot tube some two inches wide and eight inches long, starting at the point where the sensor shaft protrudes from the radome. As general designer Belyakov remarked at Farnborough in 1988, "this is where the aircraft's aerodynamic performance starts."[41] Evidently this simple fix was a major flight-test breakthrough in controlling the vortex lift pattern at high angles of attack. It almost certainly accounts for much of the predictability and departure resistance of the tailslide and cobra maneuvers routinely performed by the MiG-29 during air-show demonstrations.

Further improvements include a computer-aided aileron-rudder interconnect to allow the rudders to augment roll rate and nose-positioning performance at high angles of attack, and an artificial feel system to signal reduced areas of control. Observed control-surface movements during the pre-taxi flight control system check on the MiG-29 revealed pronounced differential stabilizer deflections, indicating that roll rate is further assisted by asymmetric slab action in certain flight regimes. The result of these pre-IOC modifications was to add 8 degrees to the maximum allowable AOA and to increase the maximum available roll rate at high alpha by some 40–50 percent. Since then, according to Menitskii, no MiG-29s have been lost to nonrecoverable departures in the entire service history of the aircraft.[42]

It has been widely reported in the Western trade literature that the MiG-29 does not have a fly-by-wire capability, but simply uses a straightforward hydromechanically actuated flight control system.[43] Anatoly Kvochur helped to inspire this conclusion when he remarked at Farnborough that "this aircraft will permit the pilot to do anything," without limiters or any FCS computer votes to inhibit his

[41]Quoted in Jeffrey M. Lenorovitz, "MiG-29 Design Merges Old, New Technologies," *Aviation Week and Space Technology*, September 26, 1988, p. 41.

[42]The AOA gauge in the MiG-29's cockpit is redlined at 30 degrees, its maximum indicated value. The slow-speed, high-alpha pass performed by the aircraft during air-show demonstrations is typically flown at 25 deg AOA and 110 kts. Partly because of its forward center of gravity and partly because of its efficient aerodynamic design, the MiG-29 is capable of maximum-performance maneuvering at low speeds without exceeding 25–30 deg AOA. Western fighters with more relaxed stability margins and fly-by-wire flight control systems are capable of matching the MiG-29's performance throughout most of this regime, but only at higher angles of attack with a resultant degradation in aircraft controllability.

[43]Representative of this initial perception was the comment attributed to a senior European aircraft industry test pilot that "the MiG-29 doesn't do anything that the F-16, F-18, or Mirage 2000 can't do, but it does it without a fly-by-wire system or flight control computer, and that's remarkable." "Air Show Highlights Advanced Fighters," *Aviation Week and Space Technology*, September 12, 1988, p. 18.

control inputs.[44] Whatever the pilot asks of the aircraft, said Kvochur, is what the aircraft will deliver.

In a presentation at RAND in September 1990, Menitskii qualified this by saying that it was not, strictly speaking, correct to say that the MiG-29 has a purely hydromechanical flight control system, since there is a built-in computer interface that increasingly governs control surface movement as angle of attack increases. As he pointed out two days later in his technical report to SETP, this stability augmentation system automatically changes the scheduling of the leading edge flaps and interconnected control surface deflections, with the positions of these surfaces more and more determined by computer-driven control actuations as alpha increases. Thanks to these and other development modifications, the aircraft will not enter a flat spin and is resistant to entering a normal spin. Spin recovery technique is simply to neutralize the controls.[45]

Supermaneuverability and post-stall handling characteristics of the MiG-29 were investigated by the Mikoyan Design Bureau several years ago. At first, Mikoyan preferred to demonstrate maneuvers by the MiG-29 at air shows that can be flown by the average aviator, and not just by experienced test pilots. However, the so-called "cobra maneuver" first displayed in public by the Su-27 at the 1989 Paris Air Show can also be performed by the MiG-29. This maneuver consists of a snap pitchup to more than 90 degrees AOA from a level 250-kt pass, immediately followed by an abrupt pitchdown of the nose back to level flight with no change in the aircraft's flight path. Entry into the maneuver is generated by pilot action. Recovery is effected by aerodynamic forces upon release of stick back pressure.

Menitskii has downplayed this maneuver as a "circus event" that has little tactical utility. If properly timed, however, it could offer an effective last-ditch means of forcing an overshoot against a close-in gun attacker.[46] Menitskii has stated that the pilot must override the

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[44]Kvochur added that he intentionally extends the landing gear while inverted during a roll underneath out of a turn onto downwind entry for landing at the end of his display sequence to demonstrate that the MiG-29 experiences no pitch trim change when the gear cycles down.

[45]As if to bear this out, the MiG-29's cockpit lacks the vertical white stripe down the middle of the instrument panel that was standard on previous MiGs to tell the pilot where to position the control stick in case of a departure so as to best effect a recovery. See the photograph of the MiG-23's cockpit in Stefan Petersen, "MiG-Flug Exklusiv," *Flug Revue*, Stuttgart, October 1990, p. 21.

[46]I say "last-ditch" because the pilot would be out of energy and further options upon completion of the maneuver. That some in the Soviet Union may be thinking of this tactical application was suggested in a Soviet television remark that the cobra

aircraft's mechanical AOA limiter to accomplish the maneuver. He has also admitted that it remains prohibited for operational MiG-29 pilots in routine training, although this ban may be lifted in the future.

DESIGN PHILOSOPHY

The MiG-29 incorporates an amalgam of features that appear more than superficially similar to those on the comparable generation of U.S. fighters. Indeed, one could buy scale-model kits of the F-14, F-15, F-16, and F-18 and, from the combined parts, build an airplane that looked very much like a MiG-29.[47] As noted earlier, the aircraft has the slung inlets and podded engines of the F-14. It also has a blended wing and airframe joint similar to that of the F-16, the wing-root leading-edge extension of the F-18, and a planform so similar in outline to that of the F-15 that from some aspect angles, distinguishing the MiG-29 from friendly F-15s in a swirling, multiparticipant engagement would be very difficult.[48]

Mikoyan executives, however, take strong exception even to the intimation that the MiG-29 derives in any way from Western fighter concepts.[49] In a Soviet press interview shortly before the 1988 Farnborough Air Show, Menitskii invoked the term "mirror technology," which, he said, often appears in the foreign media. He then disagreed sharply with the associated inference that "they" are creating something new and that "we" then copy it and improve upon it. "That is

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maneuver is properly termed "dynamic braking" (Moscow television service in Russian, September 19, 1990). It would be interesting to know what would happen to the airplane if this maneuver were attempted during a level turn.

[47]It would help to have two models of the MiG-23 as well, since the twin tails of the MiG-29 show a certain lineage to that aircraft.

[48]This last impression is reinforced by observing the inflight video footage of Alaskan Air Command F-15s accompanying the MiG-29s into and out of Elmendorf AFB in August 1989. In many cases, only a trained eye can tell the two aircraft apart. In commenting on his initial intercept of the MiG-29s en route to Abbotsford, Major Wade noted that he had to close to within 9000 ft before he could clearly distinguish the MiG-29s from their F-15 escorts. The main give-away signatures, he said, were the contrasts in distances between the tailpipes and vertical stabilizers of the two aircraft.

[49]They have been notably silent, however, on the matter of the MiG-29's fire control system, which benefited from information on the Hughes APG-65 radar for the F-18 that was gained by Soviet intelligence through the Bell-Zacharsky spy operation nearly a decade ago. The MiG-29's radar has recently been discovered by the German Air Force to indeed be a hybrid version of the APG-65. See Heinz Schulte, "The Aim of Military Intelligence—the Unification of Germany Revisited," *Jane's Intelligence Review*, June 1991, p. 278.

simply not true," he said. "Our aircraft offer certain advantages, while theirs offer others."[50]

Menitskii has a valid point. It has recently been acknowledged by the Soviets that their fighter design bureaus are obliged to accept broad development guidelines derived from aerodynamic research investigations conducted at TsAGI. It is also a fact that the MiG-29 shares a number of basic design features with the Su-27. This prompted one Western commentator to suggest—it turns out, correctly—that "some central authority, perhaps the famous TsAGI Central Aerohydrodynamics Institute, may be exerting greater influence on design than was the case in the era of the late Artem Mikoyan and Pavel Sukhoi."[51] During his 1989 visit to RAND, Academician Belyakov indicated, in the presence of German Zagainov, the head of TsAGI, that aeronautical concepts proof-tested by TsAGI indeed constitute major inputs into new Soviet fighter designs.

At the same time, it is well known that Soviet fighter design philosophy tends to place greater emphasis than that in the West on minimizing technological risk. This means incorporating proven concepts that will assure high reliability with a minimum of growing pain once an aircraft is ready for operational service. A general designer is unlikely to endorse a radical new idea proposed by one of his engineers unless it can be demonstrated to his satisfaction that someone has validated that concept sufficiently to warrant the gamble. As an enforcing tool, the Soviet defense industry maintains large catalogues of components and subsystems, including major ones like engines, that have been formally certified as reliable enough for inclusion. No such system can be incorporated into a new aircraft intended for procurement by the Air Force unless it has first been qualified for entry into one of these catalogues.[52]

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[50]Interview in *Krylia rodiny*, October 1988, pp. 32–35.

[51]John W. R. Taylor, "Fulcrum: A Close Look," *Jane's Defense Weekly*, August 2, 1986, p. 164.

[52]Richard Ward of General Dynamics has neatly summarized the nature and practical impact of this process. "Design constraints for the designer," he has written, "are formalized in a series of 'handbooks' supplied by the applicable research offices of the Ministry of Aviation Industry. These handbooks itemize the approved aerodynamic shapes, approved materials, and manufacturing processes allowed the designer. With these handbooks, the designer has little leeway in design choices, making his principal function to apply the handbook standards as efficiently as possible. Therefore, to the Soviet designer, the best design innovation is one that results in the simplest solution to the handbook constraints." Richard D. Ward, *Soviet Doctrinal Approach to Combat Aircraft Design*, MRD 879, General Dynamics Corporation, Fort Worth, Texas, 1989, p. 14.

Not only that, there is mounting evidence that both the formal issuance of military requirements for new Soviet combat aircraft and the actual design characteristics of those aircraft are directly responsive to development initiatives in the West. On the first count, Soviet engineers have repeatedly remarked in conversations with Westerners that Soviet fighters have long been developed and deployed in reaction to U.S. aircraft. One stated flatly that the Su-24, Su-25, Su-27, and MiG-29 were produced as direct Soviet "answers" to the F-111, A-10, F-15, and F-16. "Without the F-15," he said, "there would never have been a Su-27. Without the F-16, there would never have been a MiG-29."

On the second count, the Soviet tendency in the case of major new aircraft initiatives is to emulate what has already been successfully demonstrated elsewhere. This inevitably results in a systemic lag in the appearance of new aircraft intended to offset their Western counterparts. In this regard, a former engineer with over 18 years of helicopter design experience has written that new Soviet aircraft developments "are usually authorized, financed, and supported only after they have actually been realized in the West. The military first receives all new information on Western developments, and fear of dropping behind spurs them into swift and energetic action. New ideas are then supported and financed, and the R&D assumes national importance."[53]

Taken together, these two facts go a long way toward explaining why the MiG-29 first flew almost four years after the F-16 did. It also probably accounts for at least some of the general U.S. fighter design signatures appearing on the MiG-29, which TsAGI undoubtedly noted—and duly incorporated as its engineers saw appropriate—in creating its own baseline counterpart fighter development rules.

To be very clear on this, my point is not that TsAGI or Mikoyan consciously strove to "copy" U.S. fighters, but rather that they were bound by resource constraints to follow a cautious development path and, for that reason, had natural incentives to take advantage of whatever proven or high-confidence examples they could find. As John Taylor has noted in this regard, the MiG-29 and the F-15 "were look-alikes because they were designed . . . to do much the same job. . . . Why devote time and effort to being different when somebody

[53]Lev Chaiko, *Helicopter Construction in the USSR*, Falls Church, Virginia, Delphic Associates, Inc., 1985, pp. 70–71.

has already found a perfectly good way to design anything, from a component part to a complete aircraft?"[54]

Granted, in both the MiG-29 and the Su-27, TsAGI and the respective design bureaus relied less on evolution from earlier fighter types than they had in any previous Soviet fighter development experience. Their concurrent application of new airframes, engines, fire control systems, and weapons in these aircraft represented a sharp departure from the entrenched conservatism of previous generations of Soviet fighter design practice. Nevertheless, there remain powerful constraints imposed on the Soviet aircraft industry by risk-minimizing rules and procedures mandated by the pertinent ministries in the state bureaucracy. As long as these rules continue to hamper the innate creativity of firms like the Mikoyan Design Bureau, the Soviets will remain consigned to lagging as much as a generation behind the United States in fighter development and modernization.

As if to punctuate this, the Lockheed/General Dynamics/Boeing YF-22 ATF prototype first flew from Palmdale to Edwards AFB on the same day that Menitskii presented his technical paper on MiG-29 flight testing at SETP. As I will discuss in more detail presently, it is likely to be some time yet before a comparable Mikoyan product lifts off the main runway at Ramenskoye.[55] Although there is an active program in train to develop and field improved variants of both the MiG-29 and the Su-27, there is no hard evidence that a serious next-generation Soviet fighter program is currently in full-scale development.

DEVELOPMENT TRENDS

Academician Belyakov has frequently pointed out in press interviews that the MiG-29 still has considerable potential for growth. The highly successful MiG-21 evolved through numerous product improvement cycles over a 30-year period, after all, and there is no reason not to expect the MiG-29 to have a comparable experience.[56]

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[54]John W. R. Taylor, "Fulcrum, Flanker, Fact and Fantasy," *Jane's Defense Weekly*, May 4, 1985, p. 756.

[55]Major General Grigory Sedov agreed with a proposition put to him during a roundtable discussion at RAND that, as in the case of the U.S. ATF, the cost and development complexity likely to be associated with any Soviet counterpart program could require a selective pooling of Mikoyan's resources with those of other Soviet design entities.

[56]A rich and lavishly illustrated history of the MiG-21 program is presented in Bill Gunston, *Mikoyan MiG-21*, Osprey Publishing Limited, London, 1986. See also Anna

At present, two variants of the MiG-29 are known to be in advanced development and flight testing. The first has a so-called "glass cockpit" featuring four F-18-type multifunction displays in place of the traditional round analog dials. It is also equipped with a digital fly-by-wire flight control system. This aircraft is said to feature a new slab configuration, a somewhat altered wing position, and a center of gravity displaced aftward, all intended to permit higher cruise efficiency and AOA limits at the cost of making it statically unstable. It is also described by Mikoyan spokesmen as offering more agreeable handling characteristics in all three axes of flight. Anatoly Belosvet concedes that the aircraft is heavier than the standard MiG-29.[57]

There appears to be a difference of view between the Mikoyan Design Bureau and the Soviet Air Force on where the line should be drawn with respect to design overinsurance in the case of the fly-by-wire follow-on. In his paper at SETP, Menitskii indicated that there are two possible approaches in this regard. One is to develop a fighter with forgiving flight characteristics within a limited performance envelope. The other is to seek a wider performance envelope and intentionally accept some degradation in handling characteristics at higher angles of attack. Menitskii held that the second approach, "not always shared by the Soviet Air Force," allowed one to extract greater potential from the aircraft. This assertion was consistent with an earlier report that the Mikoyan Design Bureau prefers to use modern technology to allow its aircraft to fly safely outside the region of aerodynamic stability rather than to build limiters into the flight control system which would force its aircraft to stay within those boundaries. Menitskii added that this second approach demanded greater pilot proficiency and naturally dictated "more effort in terms of increased flying hours, more dedicated training in free air combat maneuvering, and flight into critical handling regimes."[58]

Slomovic, *MiG-21 Fishbed: A Case Study in Soviet Weapons Acquisition*, The RAND Corporation, P-7359, July 1987.

[57]"MiG-29 Starts Fly-by-Wire Tests," *Flight International*, May 23–29, 1990, p. 8.

[58]Menitskii, "MiG-29 Prototype and Development Flight Tests," pp. 220–221. In this, as in several earlier statements, Menitskii tacitly confirmed a point long argued by Western experts that Soviet operational style, with its emphasis on top-down control and heavy supervision, tends to inhibit military pilots from getting the most out of their aircraft. For example, in May 1989, he made this remarkable comment in the Soviet Defense Ministry's daily newspaper: "There is no doubt that mastering flying skills is a difficult and thorny path. However, it is the only path to perfecting the mastery of equipment.... Almost all pilots understand this, but, unfortunately, not all commanders share their point of view.... Such commanders oversimplify tasks in all kinds of ways... trying in this manner to reduce the number of near-accident situations in the air. By doing this, they train pilots not to be creative and do not

The second MiG-29 variant now undergoing development testing is a navalized version. This aircraft, which began making arrested landings and non-catapult takeoffs from the ski-jump bow of the carrier *Tbilisi* (later renamed *Admiral of the Fleet Kuznetsov*) in late November 1989, exhibits some notable external differences from the standard MiG-29. Obviously equipped with a tailhook and strengthened landing gear, it also mounts the old narrow-chord rudders and lacks the anti-FOD inlet doors and wing root louvers of the production aircraft.[59] The vertically ejecting chaff and flare dispensers have also been deleted, and the aircraft has upward-folding outer wing panels to facilitate deck storage.[60]

The first MiG-29 arrested landing aboard the *Admiral Kuznetsov* was performed by Menitskii's deputy, Takhtar Aubakirov.[61] Since then, Anatoly Kvochur has joined the naval test program. As of mid-September 1990, the aircraft had made 40 arrested landings, including four at night, and numerous intentional bolters (touch and go landings on the carrier deck with the tailhook retracted).[62]

In its 1990 edition of *Soviet Military Power*, the U.S. Defense Department predicted that the *Admiral Kuznetsov* would enter operational service with the Soviet Navy's Northern Fleet with an air wing of 20

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develop their ability to act in extreme conditions." V. Menitskii, "Flying Skills: The Key to Victory," *Krasnaia zvezda*, May 11, 1989.

[59]It could be that the navalized MiG-29 demonstrator is an adaptation of one of the original doorless prototypes built for the initial MiG-29 takeoff-and-landing and basic airworthiness trials back in 1974 and 1975. This would account for the narrow-chord rudders. It would also explain the absence of the inlet FOD-prevention doors, considering that a carrier flight deck is a fairly easily controllable FOD-prevention environment. More than that, the inlet door system reportedly exacted a sizeable penalty in the MiG-29's internal fuel capacity. A maritime variant of the aircraft operating beyond diversion range to a shore base could definitely use the additional fuel that would be made possible by eliminating that system. I am indebted to John Farley for suggesting this.

[60]During my visit to TsAGI in December 1989, Dr. Zagainov gave me a photograph of a full-scale MiG-29 in a low-speed wind tunnel which displayed Fowler-type extensions on the wing flaps (see Fig. 34). These are non-standard to the production airplane, suggesting that they may have been connected with the navalized MiG-29 and intended to reduce the angle of attack on landing approach so the pilot might have a better sight picture of the deck over the nose. Alternatively, or in addition, they could be used to provide a means for lowering the aircraft's final approach speed. Anatoly Belosvet later told me, without further elaboration, that this flap modification was an "experimental" application.

[61]See V. Chebakov, "Thunder Over the Deck," *Pravda*, November 22, 1989.

[62]An article in the Soviet press has referred to the naval version as the MiG-29K. Most likely the "K" stands for *korabel'niy*, the Russian word for "ship-based." See Lieutenant Colonel B. Dolgishev, "MiG-29: The Known and the Unknown," *Aviatsiia i kosmonavtika*, May 1990, p. 24.

Fig. 34—MiG-29 in Low-Speed Wind Tunnel to Test Nonstandard Trailing-Edge Flap Extension

to 40 fighters by 1991.[63] It now appears that this will take considerable doing at best, in light of continued development problems faced by the Soviet naval fighter program. The navalized test variants of the MiG-29 and Su-27 remain hand-built prototypes, with no evidence of a series production effort yet in train. The Soviets have also admitted to continued difficulty in devising an adequate lighting system for night visual landings.

Beyond this is the more fundamental question of whether the declining Soviet resource base for force modernization will permit a serious effort to develop a large-deck attack carrier program, at least in the near future (although the sister ship of the *Admiral Kuznetsov*, the *Varyaga*, is now in fitting-out and is undoubtedly destined for fleet service). In commenting on the MiG-29 and Su-27 shipboard tests, American naval aviators have frequently pointed out that it requires more than simply hanging a tailhook on a fighter to give it a carrier operations capability. There is also the problem of corrosion control,

[63]*Soviet Military Power: 1990*, U.S. Government Printing Office, Washington, D.C., 1990, p. 89.

as well as hundreds of other considerations that bear on making an aircraft properly suited for the hostile maritime environment. It took the U.S. Navy and the British Royal Navy fifty years to accumulate the corporate experience they now have in the field of carrier aviation. Undoubtedly the Soviets have gone to school extensively on that experience. Nevertheless, they will hardly be able to stake a claim to a credible naval air attack capability overnight—or even in a few years—from their current early beginnings.[64]

Beyond the fly-by-wire and naval variants of the MiG-29, the Mikoyan Design Bureau has been researching vectored thrust and recognizes its advantages in enhancing aircraft maneuverability and controllability at slow speeds and high angles of attack. This may indicate that at least some in the Soviet fighter development and operations communities are starting to give increased attention to high-AOA tactical applications in a close-in fight, such as the flat and vertical-rolling scissors maneuvers, which demand flying the aircraft aggressively at the outer edge of the AOA envelope.

As for low observables, Belyakov has, at least in public, portrayed stealth as merely one among many other important "ilities" that a modern fighter design should seek to maximize. He has said that "a designer should bear in mind the stealth characteristics of any combat aircraft, but the amount of attention paid to this side of the design must vary according to the program." He has added that the relative weight assigned to stealth as a design feature must stand "in line with other requirements" such as "optimization of cost effectiveness," coupled with high reliability and adequate turnaround rates, the ability to match or outfly Western aircraft, and the ability to operate in rough conditions.[65]

Not surprisingly, the same perspective has been echoed by other Mikoyan representatives. Alexander Velovich, for example, was asked by a reporter at the July 1990 Dayton International Air and Trade Show what the Soviet visitors thought of the USAF's F-117

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[64]To note a related case in point, the Yak-41 naval V/STOL fighter, the intended successor to the currently operational Yak-38, is said to be behind schedule because of interservice politics associated with declining Soviet defense budget resources. This is of particular concern to the Soviet Navy because the Yak-38's attrition rate has proven unacceptably high as a result of reliability problems with its automatic stabilization system. A Soviet press account noted that the pilots on one carrier hung a sign on a Yak-38 on deck declaring that the airplane was "unfit for human use." See Norman Friedman, "World Naval Developments," *U.S. Naval Institute Proceedings*, September 1990, p. 139.

[65]"MiG Chief Discusses Design Philosophy," *Interavia Aerospace Review*, December 1989, pp. 1161–1162.

stealth attack aircraft, which was on static display there. Velovich replied, with the now-familiar company line, that Soviet developers do not believe in concentrating all of an aircraft's design features on one performance parameter (in this case, low radar and heat signatures). He then allowed that in the case of the Northrop/McDonnell Douglas YF-23, which had just recently been unveiled in a public roll-out ceremony, it appeared that a better tradeoff may have been achieved between stealth and the more traditional indices of fighter performance.

There is undoubtedly some merit to the Soviet observation about the dangers of putting too many of one's eggs into one basket, as in the given example of the F-117—although Belyakov was right that the amount of emphasis on a particular parameter is highly dependent on an aircraft's assigned mission, and the mission of the F-117 is one that places heavy stress on unobserved entry into a well-defended target area. Having said this, one can fairly wonder whether the Mikoyan Design Bureau and other Soviet aviation professionals are not simply trying their best to make a virtue out of necessity in their general deprecation of the tactical value of low observability.[66]

The same can be said with regard to a recent report that Soviet officials have claimed that it would be easier and cheaper to counter enemy stealth aircraft than to design and build their own.[67] This argument is of a piece with the earlier Soviet line toward the U.S. Strategic Defense Initiative (SDI), which likewise maintained that it would be easier and cheaper to end-run any American SDI system than to try to emulate the program with one of their own.[68] On this point, it is enough simply to recall that Stalin likewise deprecated the U.S. atomic bomb until he got one of his own.

IS THERE A MIKOYAN FOLLOW-ON IN THE WORKS?

This leaves open the question of what may lie on the drawing boards at the Mikoyan Design Bureau or under wraps at the company's flight

[66]They would be on stronger ground if they were to argue instead that the importance of stealth might be at least marginally lower for air-defense fighters intended for employment over one's own turf than for penetrating bombers or air-superiority fighters intended for use over enemy territory.

[67]David A. Fulghum, "Report Lacks Details on New Fighters, Reflects Changed Post-Cold War View," *Aviation Week and Space Technology*, October 8, 1990, p. 50.

[68]See Benjamin Lambeth and Kevin Lewis, "The Kremlin and SDI," *Foreign Affairs*, Spring 1988, pp. 755–770.

test facility at Ramenskoye.[69] When my two colleagues and I were hosted at TsAGI in December 1989 by Dr. Zagainov two days before my MiG-29 flight, we were taken into a supersonic wind tunnel and shown a test model that was sufficiently shrouded in canvas to make it impossible to discern its outlines. Although I cannot say for sure, it would be a reasonable guess that the model represented some sort of advanced fighter concept that was being investigated by TsAGI as a preliminary to issuing a development requirement to the design bureaus.

Whether there is anything approximating rubber-on-the-ramp by way of a Mikoyan ATF that will fly in the foreseeable future is a question that cannot be answered with any confidence here. One can be forgiven a fair amount of skepticism, however, at least with regard to the near term. In response to a question at SETP about whether there was a MiG-29 successor in the works, Menitskii replied tantalizingly: "Well, I'm still getting paid, so there must be something going on." Most likely anything of this nature now flying out of the design bureau's stable is, at most, a derivative of the MiG-29, albeit possibly one in line to receive a new designator which the outside world has yet to be told about.[70]

Several years ago, the U.S. government predicted that two Soviet follow-on aircraft, then generically labelled the air superiority fighter

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[69]At an early point in the MiG-29's development, Mikoyan came up with another aircraft concept which it called the Ye-33. This design had a blended wing-body configuration and bore a loose planform resemblance to the F-16, with a single engine and a split inlet mounted under the fuselage. It was intended to provide a low-cost fighter for the Soviet Air Force and for the export market to replace the MiG-21. If developed and produced, it would have been designated the MiG-35. In the end, the Soviet Air Force rejected the concept in favor of full concentration on the twin-engined MiG-29 and Su-27. See "Soviets Display Ye-33 Model," *Aviation Week and Space Technology*, July 1, 1991, p. 15. This belies an earlier speculative report that a MiG-35 had actually been built for the Indian Air Force and flown by IAF pilots (Nick Cook and Yossef Bodansky, "Indians Fly New Soviet MiG-35s," *Jane's Defense Weekly*, August 13, 1988, p. 235).

[70]In this regard, Mikoyan's management has disclosed that the firm is now at work on a MiG-29 successor prototype which embodies the MiG-29's aerodynamically stable airframe, but which is fundamentally new in every other important respect (see "Mikoyan Flight-Tests Fulcrum Follow-On," *Flight International*, October 3, 1990, p. 32). This may be the aircraft which Menitskii, in his biography given to SETP, indicated with the designator "M" as one in which he had recently flown the first flight. "M" is an abbreviation commonly used in Soviet aircraft type designators to denote *modifitsirovanniy* ("modified"). It may also be the new-generation Mikoyan product that reportedly incorporates a multichannel fiber-optic flight control system (see "New MiG Uses Fiber-Optics," *Aviation Week and Space Technology*, October 1, 1990, p. 15). In his presentation at RAND in November 1989, Academician Belyakov noted that a new MiG-series designator number is not assigned to a new aircraft developed by his firm until the aircraft has first been formally accepted by the Soviet Air Force.

(ASF) and the defensive counterair fighter (CAF), would begin series production in the mid-1990s. More recently, Soviet aerospace officials have led Westerners to believe that the only fighter prototypes they are currently working on are developmental variants of the MiG-29 and Su-27.[71] The 1990 edition of *Soviet Military Power* simply noted that the possibility of a completely new Soviet fighter appearing sometime after the turn of the century "remains a concern."[72]

There is a logic to support the notion that this latter point is an honest statement of current reality. During the visit of a Soviet aircraft industry delegation to RAND in November 1989, Academician Belyakov suggested that the combination of declining defense resources and the new Soviet defensive orientation might well lead to increased pressures to curtail, or even forgo altogether, the deployment of successor-generation aircraft of all types. In the face of this, he said, it would remain essential to continue pursuing new designs very aggressively, since that is where technological advancement ultimately stems from. Belyakov went on to note, however, that it would become increasingly difficult to proceed from such technology demonstrators to series production without a very convincing military rationale.

If this outlook persists, the Soviets could skip deployment of their next-generation fighter altogether. On the other hand, should the general pattern of emulative responsiveness in Soviet fighter modernization described above remain true to form, a full-scale deployment of the USAF's F-22 might well assure that the Soviet Defense Ministry will soon be driven to initiate an offsetting ATF program of its own—if, indeed, it has not already done so. Academician Belyakov left no doubt about his own thinking on this score when he said at the 1991 Paris Air Show: "We know how the F-22 will perform. Therefore, we must also have a new fighter. It is our task."[73]

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[71]This prospect was underscored most recently in a remark by the Soviet Air Force's commander in chief, Colonel General Yevgeniy Shaposhnikov, that the USSR plans to field two new fighter types during the second half of the 1990s. General Shaposhnikov hinted that these aircraft would be step upgrades of the MiG-29 and Su-27. Soviet officials at the 1991 Paris Air Show suggested to reporters that they are already either in or approaching preliminary flight testing. See Nick Cook, "Soviets to Deploy Two New Fighters," *Jane's Defense Weekly*, July 27, 1991, p. 132.

[72]*Soviet Military Power: 1990*, U.S. Government Printing Office, Washington, D.C., 1990, p. 80.

[73]Quoted in Michael D. Towle, "Stealth Jet Doesn't Overawe Soviet Expert," *Fort Worth Star-Telegram*, June 21, 1991. How the Soviet military and defense industry might be able to sustain and pay for such an ATF program at a time of deepening economic crisis, general force reductions, and gradual conversion of defense industry to civilian production remains a separate question that will bear watching.

Whatever the case regarding the near-term prospects for a full-fledged Soviet ATF, there is every likelihood that a much-improved variant of the MiG-29 (possibly called the MiG-33, following the pattern of the MiG-27 and MiG-31 derivatives of the MiG-23 and MiG-25) will be revealed to the West well before Valery Menitskii is ready to hang up his g-suit as Mikoyan's chief test pilot. If the foregoing analysis suggests anything, it is that the MiG-29 is a remarkable airplane—and one with a lot of room to get better.

Appendix B

"WE FLY IN THE SAME SKY"

V. Makhlin[1]

"Just three years ago, I was a hardcore anti-Soviet. If only you could have read my reports, Valery. Now I'm something else. Not a 'Red,' of course. Not a Soviet. Just something else. Most likely we've all grown wiser, both Russians and Americans, because we've come to understand one another better. And today, I realize that we are on the right path, and that it would be disastrous to return to the old one. . . ."

They walked away from the two-seat MiG-29UB fighter trainer, still hot after a half-hour of aerial acrobatics, themselves flushed by the hard flying in the solid cloud cover of the December sky over Moscow. They were Benjamin Lambeth, a 46-year-old doctor of sciences, a specialist in the field of planning air combat operations, and a program director at the American firm the RAND Corporation, and Valery Menitskii, a 45-year-old Hero of the Soviet Union and distinguished test pilot of the USSR. Since the day they were born, no pilot from the West had ever flown a combat aircraft in the skies over Moscow.

How quickly mankind sets out on the path of confrontation (remember Powers, the Cuban missile crisis, Vietnam, and Afghanistan), and how long, arduous, and complex is the return to a peaceful state of affairs. Menitskii's and Lambeth's children are now full grown, and it's time to start thinking about grandchildren. It turns out that it has taken a whole lifetime for a Russian and an American, whose parents were allies during World War II, to fly together for a half an hour in a two-seat trainer.

Even now, I must honestly admit, the writer of these lines cannot escape a sense of the unusual nature of this connection between the two establishments where Menitskii and Lambeth work. The A. I. Mikoyan Experimental Design Bureau develops ultra-modern aircraft that have repeatedly participated in air combat engagements against American-made fighters in theaters of military operations in various

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[1]From *Moskovskaia pravda*, December 27, 1989. Also published as "A Breakthrough in the Academy of Death," *Krylia rodiny*, No. 5, 1990, p. 14. Translated by Benjamin S. Lambeth.

countries (Korea, Vietnam, the Middle East). The design bureau's chief pilot, Valery Yevgenievich Menitskii, has received state awards and titles (on top of everything else, he is a Lenin Prize laureate) for preparing numerous types of MiGs to emerge victorious in combat against a potential enemy.

For its part, the RAND Corporation is an independent, as it calls itself, "private company that belongs to no one." This firm, which has gathered under its wing the pick of American political analysts and military specialists, generates recommendations for the federal government on the most sensitive issues of international relations, including the planning of combat operations. Benjamin Lambeth has become a noted scholar in his field, is a certified pilot, and has flown 24 types of fighters for the purpose of seeking an "antidote" against MiGs and other Soviet aircraft.

This was the crew of the two-seat aircraft that performed advanced aerobatic maneuvers over the military airfield at Kubinka.

"I was recently in the United States as a member of a delegation of Soviet aviation specialists," says Menitskii. "During a visit to the General Dynamics plant, there emerged a mutual desire to conduct a joint Soviet-American flight in an F-16 two-seater. There were no apparent roadblocks to this. However, the flight did not occur. The Pentagon or somebody else vetoed it. In the opinion of American pilots, the military bureaucratic machinery in the United States is being restructured even more slowly than in the USSR. Then we decided to take an American on a flight in our company trainer anyway. Especially since they had once remarked with spite at the RAND Corporation: We tell you everything you ask, but you only tell us what you are allowed to say. That is how they have grown accustomed to reacting to our decades of secrecy and closure. In this respect, Americans have no less reason for mistrust than we have. Such stereotypes have to be dismantled, and not just by the top leadership, but also by experts on whose opinions the information level of the governments of both countries and the climate of international political-military relations largely depend."

To the credit of the Ministry of Aviation Industry and our armed forces, they responded to arranging such a flight with understanding. The command authorities of the Moscow Military District air forces and at the Kubinka air garrison gave their okay despite the foul weather. It was snowing, the visibility was 800–1200 meters, and the cloud cover started at 100 meters above the ground and didn't break up until 10,000 meters.

There were no scheduled flights that day. The military cleared a narrow portion of the concrete runway especially for the company two-seater, which Menitskii had ferried in from his airfield. Lambeth later compared the takeoff and landing environment to that of an aircraft carrier.

The American specialists waiting on the ground at the air base especially valued the accuracy of the information about what was taking place in the air. A steady stream of reports followed, one after the other. Menitskii first demonstrated and then Lambeth repeated advanced aerobatic maneuvers: Low-speed loops, hard turns, rolls and reversals in level flight, hammerhead turns, and half-loops. The hammerhead maneuver, in which the airspeed was minimal and slip angles were great, came as a total surprise to Lambeth. The American specialist thought that this could only be done in a sports plane. This puts an inordinate demand on the engines and control systems of any fighter—any fighter, that is, except a MiG.

"The flight came off as we had planned it," recalled Menitskii. "The only change we had to make was due to the marginal weather conditions. The forward cockpit had been intended for Ben, but we decided at the last minute that I should sit up front."

"What was the reason for this flight? Did we help an American specialist studying Soviet tactical airpower to enhance his qualifications, to better understand our weapons and ways of conducting air combat?"

"We flew without the weapons complement, and I demonstrated only those maneuvers that are well known to any pilot. MiGs have been exported for a long time and are quite familiar to Western experts. In short, there was no compromise of classified information."

"Was it advertising, then?"

"RAND is not involved in commercial activities."

Evidently I was not the only one who fell prey to these kinds of doubts. The organizers of the flight themselves elected to publicize the fact that the flight had taken place only a week after the event. Beforehand, a mutual distrust had eaten away at us as we spoke to one another in a conspiratorial whisper, as we so love to do, about "news not for the press." The net result is most lamentable—news ceases to be news.

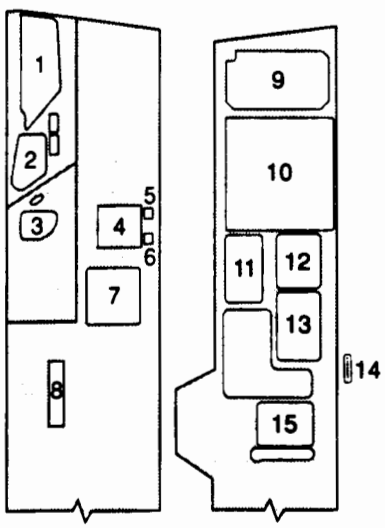
Lambeth had already returned home, so I had to satisfy myself with a brief interview with his colleagues. Dr. John Hines is a leading

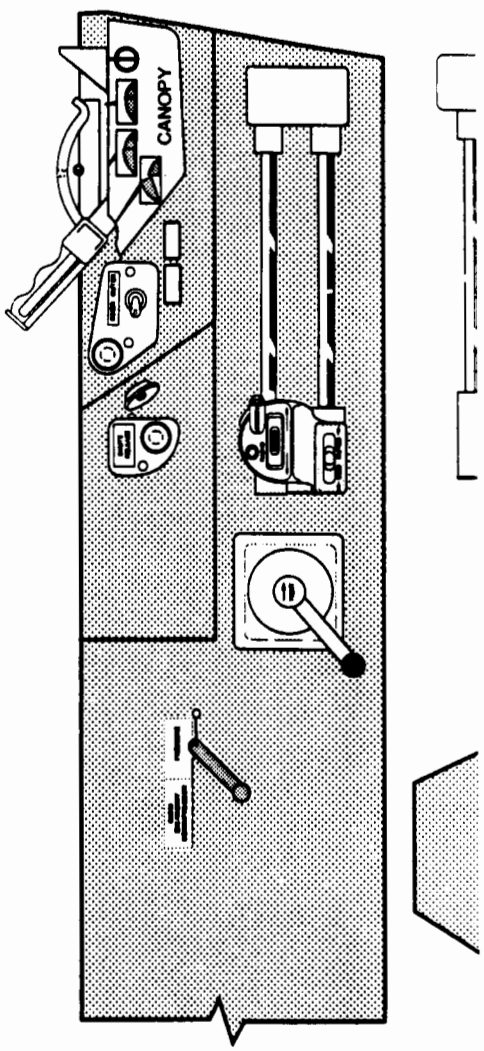
expert on Soviet military art and a former signal officer in an artillery corps, armored division, and infantry division who served for nine years in the Federal Republic of Germany and who fought in Vietnam. This was his fifth trip to Moscow (his fourth was ten years ago). Dr. Eugene Rumer specializes in the field of military policy and international security. He emigrated from the USSR twelve years ago and, in his words, never thought he would end up in Moscow again. From them I learned the following.

RAND stands for "research and development." In jest, some people amend this to mean "research and no development." This is a sad joke from years past, when it seemed that research was leading down a blind alley rather than to development. The corporation was established in 1946. It is run by a board of trustees that includes three former U.S. secretaries of defense. There is also a reverse connection: Schlesinger became Secretary of Defense after having worked at RAND. The main principle is moral and material independence from the Pentagon and the military-industrial complex, and no private enterprise activities. The firm's reputation depends on this, for it is called upon to provide objective advice to the federal government. It also gets assignments from states and local governments in the field of domestic policy.

"You see," John Hines explained to me, "it is one thing to be an armchair analyst. But when you experience for yourself the real situation, you get to know the object of your research better. We have visited the Central Aerohydrodynamics Institute, the USA and Canada Institute, the Institute of World Economy and International Relations, and the All-Union Scientific Institute for Systems Research. But our most powerful impression came from visiting Kubinka and meeting with military pilots. And I understand Lambeth, for whom it was personally important to fly in the cockpit of a Soviet fighter, in Soviet skies, in the place of a Soviet pilot."

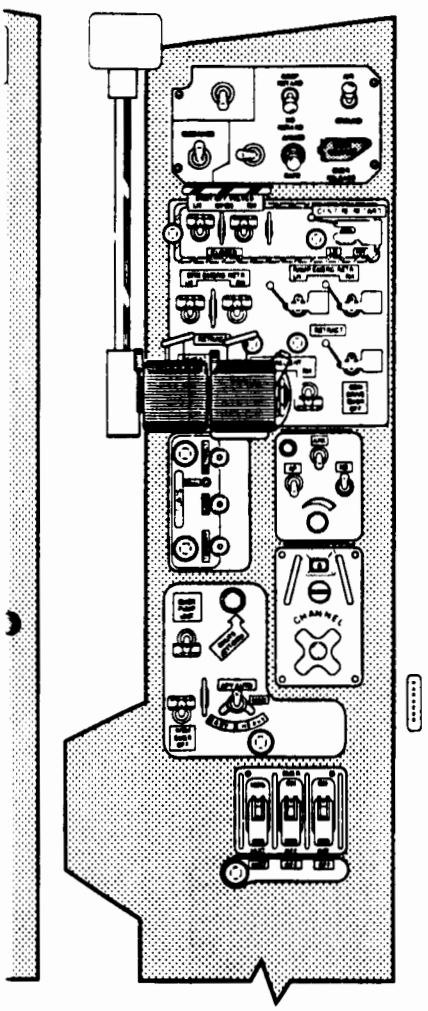
Well? Perhaps there is something to this after all. In any case, RAND, which once earned for itself the title of the "Academy of Death and Destruction" in our newspapers, has worked very hard during its time to generate an image of the enemy and has succeeded in this effort. If the impressions brought out this time around help the American Sovietologists to reject their previous conclusions, I wouldn't quarrel with our even offering them a flight on the *Buran*. You see, we have changed also during the course of *perestroika*. "Closed doors are not worth a nickel, locks cost a pretty penny"—let us sing this song together.

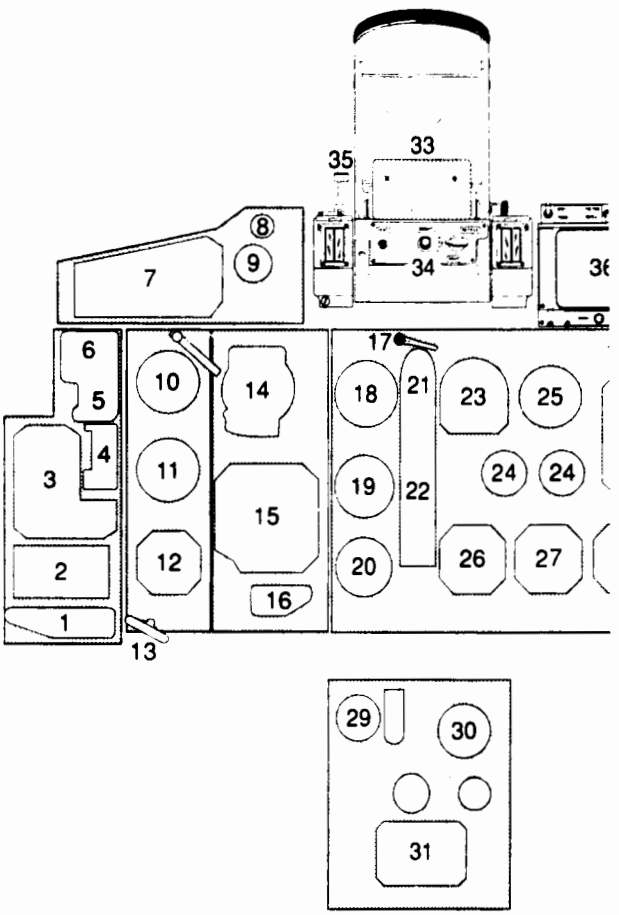




Left console

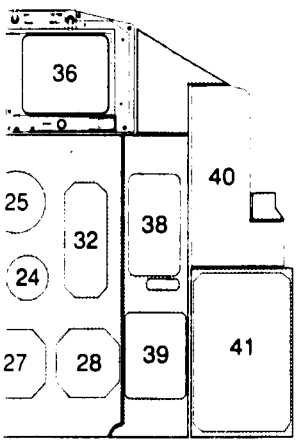
1. Canopy control handle
2. Inboard-outboard wing station select panel
3. Drag chute deploy button
4. Throttles
5. ICS and VHF transmit buttons
6. Speed brake switch
7. Throttle friction control handle
8. Cockpit air control handle
9. Armament control panel
10. Engine and fuel control panel
11. Flap control panel
12. Navigational aids control panel
13. VHF radio channel select knob
14. Emergency harness release
15. ECS and oxygen control panels

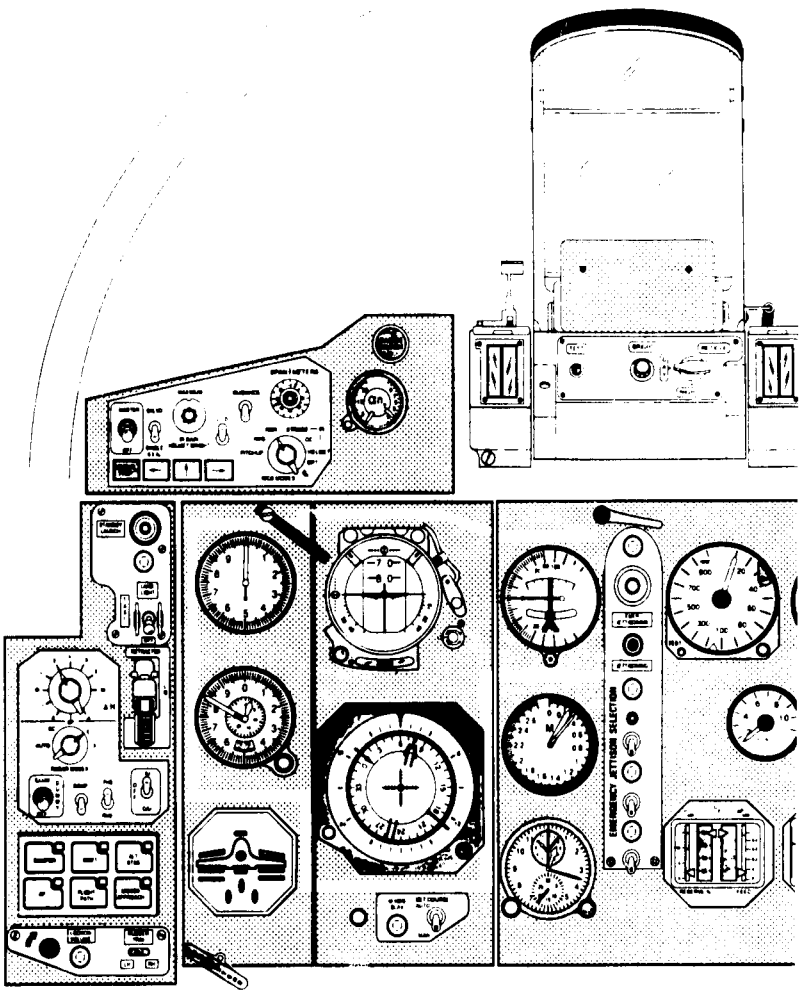




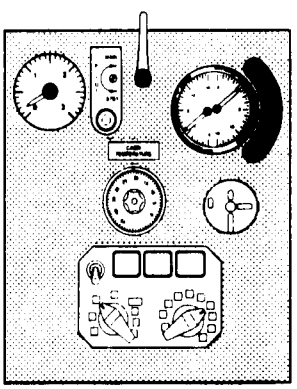
Main panel

1. Rudder trim panel
2. Flight control system panel
3. Radar mode select panel
4. Landing gear control handle
5. Taxi and landing light switch
6. Standby launch panel
7. Fire control sensor mode select pan
8. Master caution light
9. Angle of attack and g indicator
10. Airspeed indicator
11. Altimeter
12. Gear, flap, and speed brake position
13. Emergency gear extension handle
14. Attitude director indicator (ADI)





15. Horizontal situation indicator (HSI)
16. Navigation system select panel
17. Parking brake handle
18. Turn and slip indicator
19. Mach meter
20. Clock
21. Master jettison button
22. Jettison select switches
23. Radar altimeter
24. Fan turbine inlet temperature indicators
25. Engine tachometers
26. Oxygen quantity and flow
27. Hydraulic and nitrogen indicators
28. Inlet ramp position indicator



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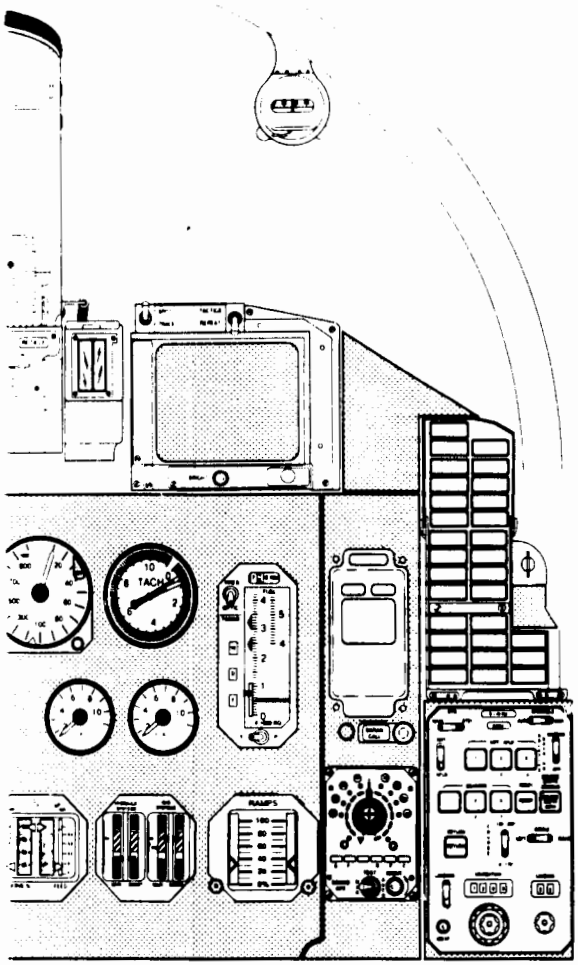
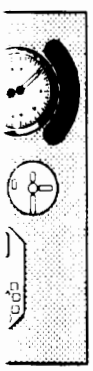
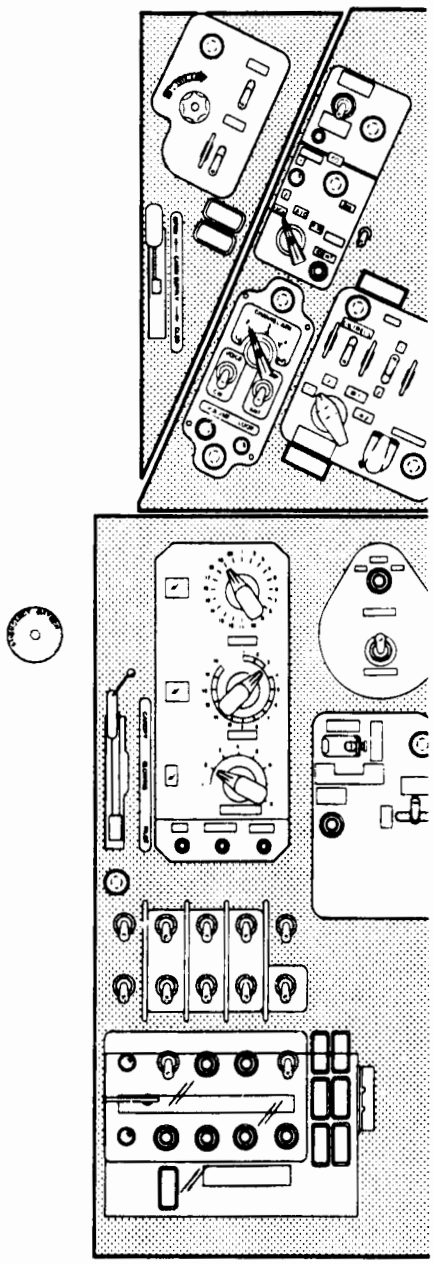
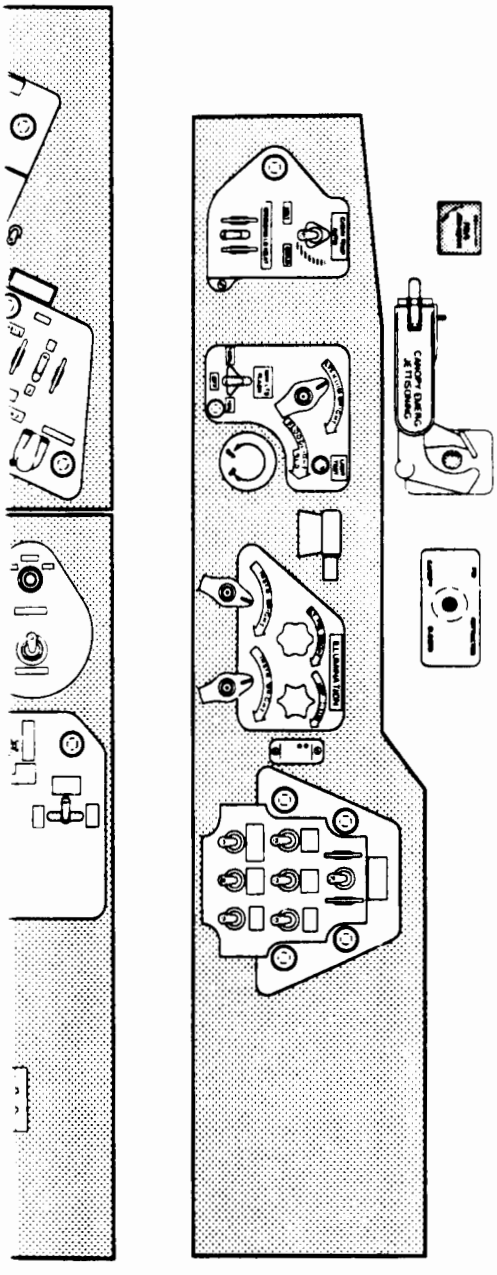
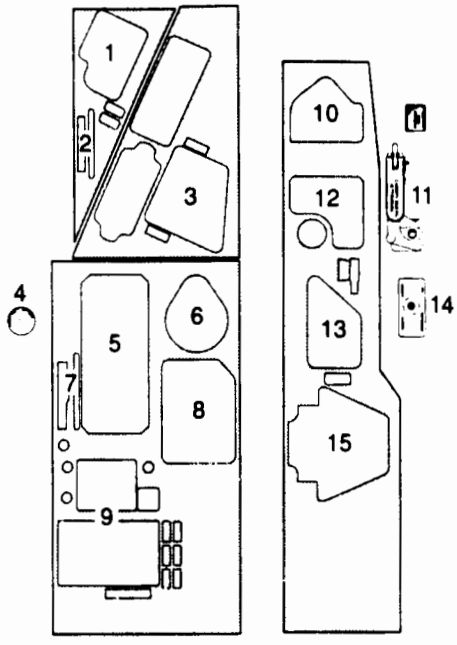




29. Voltmeter
30. Engine oil pressure indicator
31. Systems test panel
32. Fuel quantity indicator
33. Head-up display (HUD) combining glass
34. HUD control panel
35. HUD sun shield control lever
36. Radar and IRSTS display unit
37. Standby compass
38. Data link display unit
39. Threat warning display unit
40. Master annunciator panel
41. Inertial navigation system control panel







Right console

1. Radar warning receiver control panel
2. Cabin pressure dump lever
3. IFF control panel
4. Emergency oxygen supply handle
5. Data link control panel
6. Radio compass control panel
7. Emergency canopy defrost lever
8. Engine start control panel
9. Circuit breaker control panels
10. ECS control panel
11. Canopy jettison handle
12. Exterior lights control panel
13. Interior lights control panel
14. Canopy locked indicator
15. Electrical system control panel

Plate 1: MiG-29 Cockpit (Typical)